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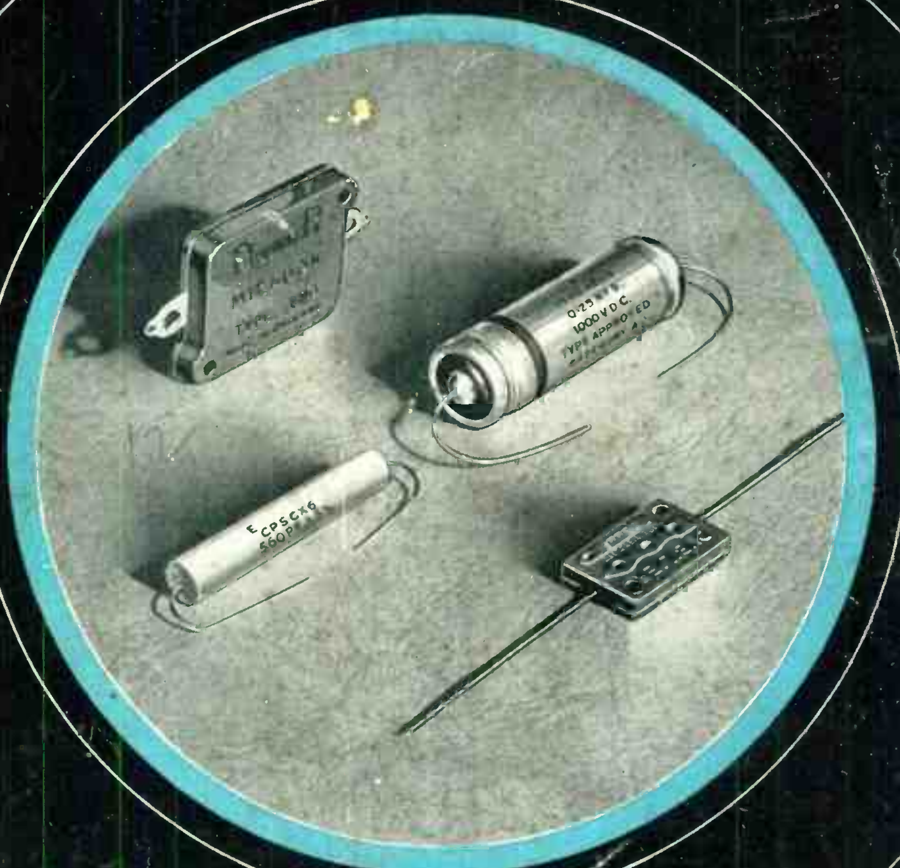

JAN. 1945

1/6

Vol. LI. No. 1

IN THIS ISSUE: HEATING IN DIELECTRICS

THE Services and war-time industry are familiar with the high standard of dependable accuracy of "AVO" Electrical Testing Instruments. They will be an equally dominant factor in the post-war rebuilding of our great industries and the advancement of amenities worthy of a world at well-earned peace.

In the belligerent interim, orders can only be accepted which bear a Government Contract Number and Priority Rating.

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A portable self-contained 50-cycles bridge of exceptional accuracy and utility for direct measurement of all normal values of condensers and resistances. Facilities also provided for condenser power factor measurements and leakage tests by the flashing neon method, resistance, capacity and large inductance measurements against external standards. May also be used as a highly efficient valve voltmeter indicator for measurement of both audio and radio frequency voltages.

THE ALL-WAVE "AVO" OSCILLATOR

An inexpensive, accurate modulated oscillator covering a continuous fundamental frequency band from 95 Kc. to 40 Mc. A harmonic calibration extends the range to 80 Mc. A large clearly marked dial is directly calibrated throughout, accuracy being within 1%. Externally modulated, internally modulated, or R.F. signals obtainable at will. Calibrated double attenuator enables signal to be varied from a few microvolts to 50 millivolts, with a force output of 1 v. Self-contained, fully shielded.

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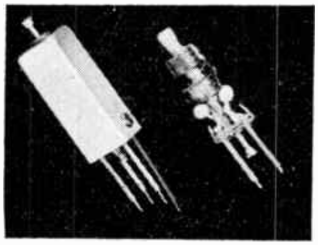

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They fit inside a delicate ring, they are so small; but they are mighty in dependable performance for hearing aid apparatus. Long lived with low battery drain, RAYTHEON Flat hearing aid tubes give quality performance for electronic hearing aids.

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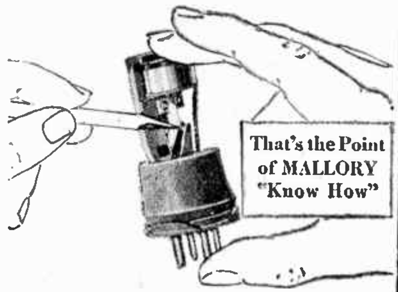

Contacts in a vibrator take a lot of punishment. They must operate under widely varying conditions of temperature and must "make and break" 115 times a second. Small wonder that alert engineers think of contacts first when selecting a vibrator!

For over 20 years, Mallory has been industrial headquarters for every type of electrical contact. It has introduced new contact compositions . . . evolved better designs . . . formulated improved surface finishes.

As a result of this wide experience, Mallory equips its vibrators with special grade tungsten contacts which are cut in its own plant from material made to its own specifications. They give longer life, are subject to a minimum of erosion and transfer.

Mallory is ready to apply its special vibrator "know how" to your specific applications.

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Radio and Electronics Division

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GENERAL ELECTRONIC VACUUM CONDENSERS

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Register your name now for full details which will be sent you when supply conditions again permit.

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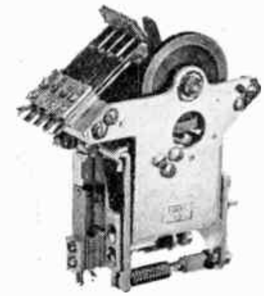

WHEN the mission of complete victory is accomplished, General Instrument will help "Win the Peace" by making the best use of still greater knowledge and experience in the manufacture of variable condensers and drives.

THE GENERAL INSTRUMENT CORPORATION
ELIZABETH, N.J., U.S.A.

TWO-WAY radio communication systems, like the plastic-cased beauty illustrated, are one of the new developments leading industrial designers are thinking of to speed the work of a busy post-war world. Applications of this compact, plastic-cased 'walkie-talkie' are almost unlimited. Naturally, this is only one of thousands of uses plastics will be put to after the war, but it will serve to remind you that post-war planning is being done . . . Kurz-Kasch designers, engineers, tool-makers and moulders . . . specialists for a generation in plastic planning and moulding will help you with your problems.

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Planners and Moulders for the Age of Plastics
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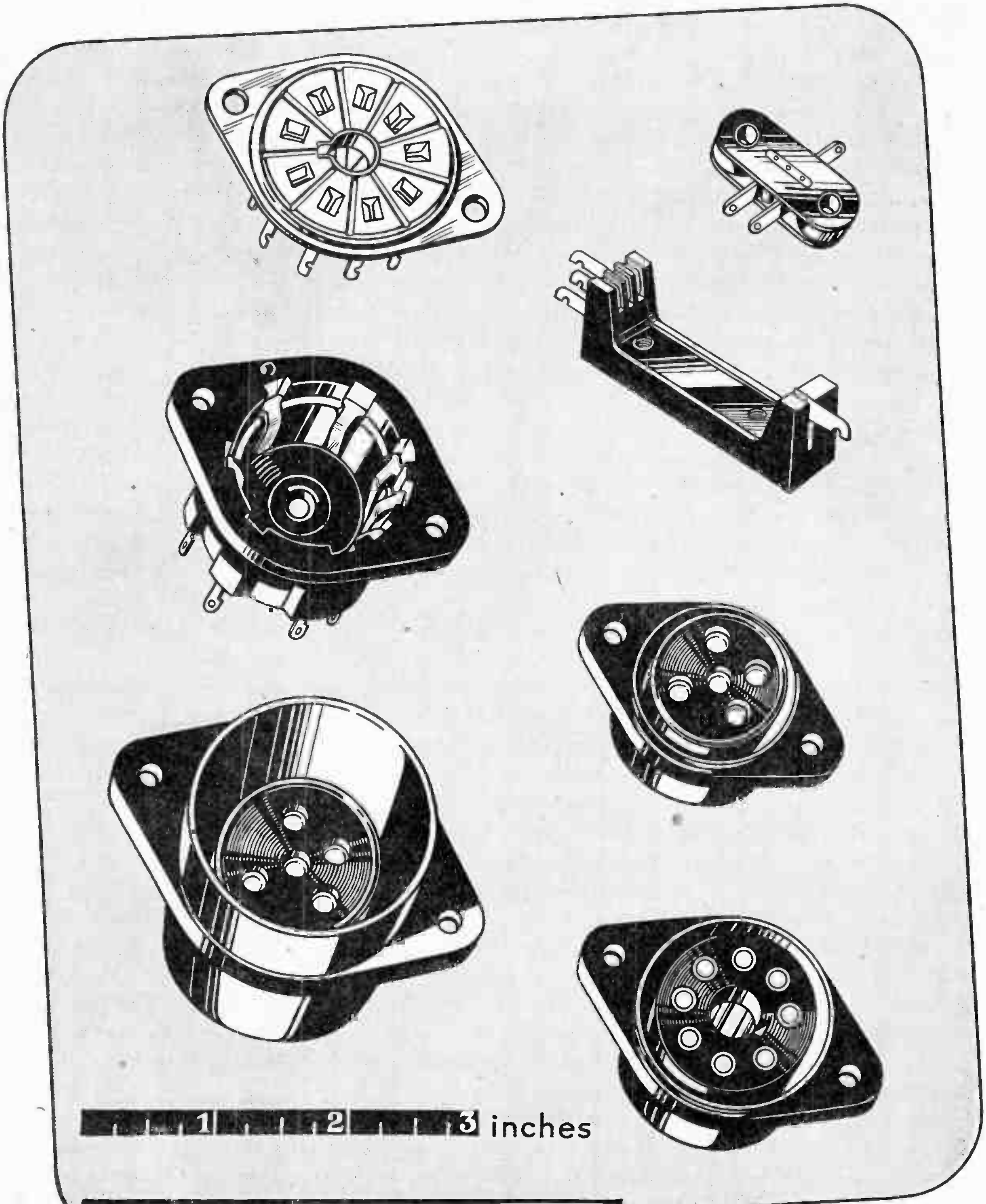

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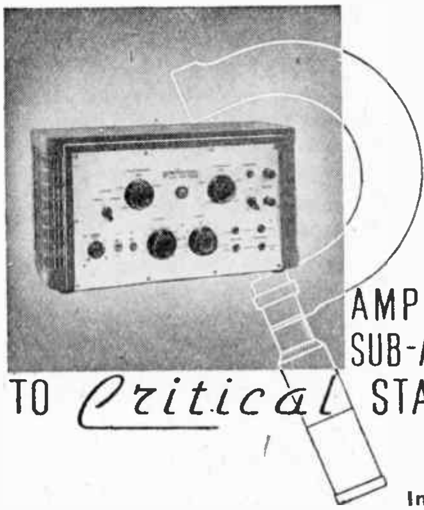

AUDIO AMPLIFIERS & SUB-ASSEMBLIES TO *Critical* STANDARDS

In addition to Standard Amplifiers the activities of Acoustical include Special Amplifiers for Industrial Applications, Microphones, Transformers, Coil Winding, Sheet Metal Work, Stampings, Switch Assemblies, etc.

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MANUFACTURING Co. LTD.
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TO ALL OUR FRIENDS IN THE TRADE

Greetings
for
Christmas

and our best wishes for a very early return to peacetime production in

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N.B.—We shall be back with a still bigger range of Collaro specialities — electric Fan Heaters, Sunray Lamps, electric Gramophone Motors, Automatic Record Changers, Pickups, etc., as soon as post-war reorganisation allows.

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VALLEY WORKS, LANGLEY MILL, NOTTINGHAM

LINAGLOW LIMITED extend Christmas and New Year Greetings to their many thousands of satisfied customers

Listed below is a comprehensive stock of radio and electrical components at exceptionally keen prices.

3-wave band 4-valve **T.R.F. CONSTRUCTOR'S KIT,** 17/2,000 metres, aluminium screened coils, excellent short-wave reception (the special coils used in this circuit give a performance equal to a superhet), 4½ watts output, complete with loudspeaker, all parts, wiring and theoretical diagram—nothing extra to purchase. Chassis dim. :—12in. × 8in. × 6in. to top of dial. 200/250 v. A.C. Including tax. **11½ Gns.**
Case and packing 5/- extra.

VALVES. American types at B.O.T. controlled Retail Prices. For replacement purposes only. 6F5, 12F5, 12J5, 12SF5, **9/2** ; 5Y3, 25Z6, **11/-** ; 6Q7, 12Q7, **11/7** ; 6F6, 6K6, 6K7, 6L7, 12J7, 12SJ7, 36, **12/10** ; 6A8, 6B7, 6SA7, **14/-**.

Also British Valves at manufacturers' List Prices. 6X5, UU4, UU6, UU7, **11/-** ; HL41DD, TDD4, **11/7** ; AC/VP2, CL4, EF39, KTW61, Pen 45, SP41, SP42, T41, VP41, **12/10** ; D1 diode 1in. Peanut Valve with valveholder, **12/10** ; ECH3, FC13, X63, 12Z3, 25Z5, 35Z4, **14/-** ; AC6Pen*, EL35, Pen 46*, U21, **18/3**.
* Post Office Permit necessary.

Prices include Purchase Tax. Add 3d. per valve post.

VALVEHOLDERS—AMPHENOL TYPE. International or English Octal, chassis mounting, **1/-**. English Wafer type, 4-, 7-, 8-pin, 6 for **2/6**.

CAR AERIALS. Telescopic scuttle fixing, extending to 4ft. 6in. Ebonite Insulators, nickel finish, **22/6** each.

WANDER PLUGS in 2 colours, **3/-** per doz.

ELECTRIC SOLDERING IRONS, 60 watt, 200/250 v., AC/DC. Chrome-plated, usually 13/9, **9/6**.

LOUDSPEAKER FRETS. Coppered brass, 8½ × 7in., **3/6** ; 14½ × 9½in., **8/9**.

SCREENED INTERLACED FLEXIBLE MICROPHONE CABLE, Twin, 6 yards for **6/9**. Single, **1/-** per yd.

SPECIAL OFFER. Best Galvanised Bolts and Brass Nuts, 0, 2, 4, 6 B.A. Large assorted packet, **3/6**.

IRON LEADS, with connector, 23/36 circular flex, **3/6** each.

LINE CORDS, 3-way heavy duty, .3 amp., 360 ohms, **9/6** ; 480 ohms, **13/6** ; 600 ohms, **15/9**. 2-way 360 ohms, **5/6** ; 480 ohms, **7/6** ; 600 ohms, **9/3**.

CONDENSER DRIVES, slow motion, ¼in. spindle, 3 : 1, **1/6** each, extension spindle, ¼in., **9d.** each.

FUSE BOXES, twin, best bakelite, with two glass fuses, **2/6** each.

5-WATT PORTABLE P.A. AMPLIFIER. Specifications: 4-valve Amplifier Unit in metal cage, microphone, one speaker, all cables, contained all in one cabinet and collapsible type tripod, floor stand, AC/DC 200/250 v. 5 watt maximum, suitable for hall averaging 600 people. Input jack provided, transverse current carbon type microphone, separate volume controls for microphone and gramophone input. Variable tone control, **29 Gns.**

40-WATT AMPLIFIER—SIX ONLY, fitted in metal cabinet. Mike and Gram. inputs, special fader control, tone control, 8-valve, 200/250 v., A.C., **35 Gns.**

S.M. & L. TRF COILS, Philips, best quality in screened aluminium cans, 17-51, 200-585, 725-2,000 metres. (These coils equal the performance of superhet.) Complete with circuit diagram, **9/6** the pair.

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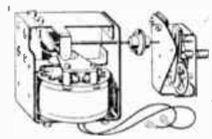
10in. B.T.H. MODEL R.K. MAINS ENERGISED LOUDSPEAKERS, 1,000 ohms field, 15 ohms speech, weight 28 lbs., reconditioned as new, **£6.6.0.**
Ideal for P.A. work.

DIRECTIONAL BAFFLE for R.K., 3ft. × 2ft. 6in. × 1ft. 6in., felt lined with suspension hooks, made from 1in. ply, as new, **£3.15.0.**

7 v. Superhet Constructor's Kit. The **"LIBERTY SEVEN" ALL-WAVE** 16-50 m., 200-560 m., 1,000-2,000 m. Brief Specification : Frequency changer with two valves, separate oscillator, M.E. tuning indicator, 465 kc. Iron-cored I.F.s. Separate tone and volume controls, 5-watt output. 8in. P.M. speaker with baffle and output transformer, all valves, chassis, Practical and Theoretical diagrams, Parts List, Nuts, Bolts and Wire, ready to assemble, 200/250 volts A.C. **£17.17.0**
Case and packing 5/- extra.

SYNCHRONOUS MOTORS
50 CYCLE



200/250v. A.C. 12 m.a. suitable for electric clocks, etc. Supplied complete with gears, ea. **27/6**

RELAYS complete with circuit breaking switch. 200/250v. A.C. 60/80v. D.C. 300 m.a, 1S amp. switch ... ... each **7/6**

Relay and Metal Rectifier and Mains Transformer complete. Input 200/240v. A.C. Output 12v. D.C. 150 ohm. 20 m.a. **35/-**

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10/15 amp. in Ebonite containers, suitable for Thermostatic control of Electric Water Heaters and relay circuits ... ... each **6/6**

VIBRATORS. 4-pin 6 volt, best quality American ... ... each **15/6**

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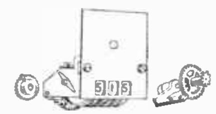

0-999 with gear drive and gears ... each **3/6**

ELECTRIC POWER METERS, 200/250v. A.C. 50 cycle, as new, pre-war manufacture, 1/- in slot type, suitable for electric fires, cookers, etc. Ideal for boarding houses, hotels. Complete less locking key. Maker's price 70/- each **35/-**

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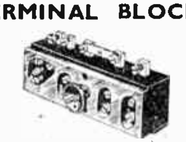

9 point heavy contact, best bakelite with metal cover ... ... each **2/6**

WESTINGHOUSE METAL RECTIFIERS, type H1. 2½ V.D.C. 10 m.a., bargain, **3/6.** 22 V.A.C.—12 V.D.C. 1 amp., suitable for battery chargers, etc., **18/6.**

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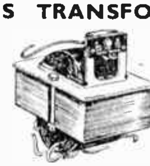

300-0-300, 4v. 6 amp., 4v. 2 amp., 2v. 1.S amp., 100 m.a. Heavy Laminations, pre-war stock, see illustration, bargain ... ... each **27/6**
350-0-350, 6.3v. 3 amp., 5v. 2 amp., 100 m.a. each **32/6**

"LIBERTY SIX" ALL-WAVE 6-VALVE CONSTRUCTOR'S KIT, 16-50, 200-560, 1,000-2,000 metres. Brief Specification : Frequency Changer with two valves, separate oscillator, **SIX TUNED CIRCUIT,** 465 kc. iron-cored I.F.s. Separate tone and volume controls, 5-watt output, 8in. P.M. Speaker with baffle and output transformer, all valves, chassis, Practical and Theoretical diagrams, Parts List, Nuts, Bolts and Wire, ready to assemble. 200/250 volts A.C. Including Purchase Tax **£16.16.0**
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RADIO MECHANICS LONG-NOSE PLIERS, insulated, ex Government stock, reconditioned like new, exceptionally cheap, **4/-** each.

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HIGH VOLTAGE BRAIDED SLEEVING, 1 and 1½mm., first-class quality, **3/6** per dozen yards.

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LOUDSPEAKER TRANSFORMERS. Pentode output 40 : 1, 50 m.a., **4/6.**
Midget Multi Ratio, 60 : 1, 80 : 1, 40 m.a., **8/6.**
Multi Ratio, 60 : 1, 70 : 1, 75 : 1 & push-pull, 75 m.a., **10/6.**
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PORTABLE REXINE-COVERED AMPLIFIER

carrying cases, fitted with baffle for 8in. or 10in. speaker and microphone holder, metal corners protecting plates, rubber buffers, suitable for auditorium extension loudspeaker or amplifier construction, size 15in. × 16in. × 10in. Price £2.19.6.

Pentode Output, 12/15 ohms, 100 m.a., **12/6.**
Heavy Duty, Multi Ratio, 24 : 1, 41 : 1, 48 : 1, 58 : 1, 82 : 1, 116 : 1 and P.P., 80 m.a., **15/6.**

LOUDSPEAKERS. 3-ohm Voice Coil. 6½in. Celestion, with transformer, **30/-** ; 8in. Rola, **19/6** ; 8in. Plessey, **18/6** ; 8in. Goodman, **22/6** ; 10in. Mains Energised 250, 500 and 1,200 ohms, **35/-**. See Transformers above to suit.

AERIAL & OSCILLATOR COILS. Best D.S.C. wire wound, colour coded on bakelite formers, Short, Medium and Long Wave, 16/50 m. ; 200/550 m. ; 1,000/2,000 m. ; with circuit diagram, **15/-** the set.

I.F. TRANSFORMERS. 465 kc. iron-cored Litz wound, aluminium can. Limited quantity, **17/6** ; matched pair, **9/6** each.

WIRE END CARBON RESISTORS, new, ex-television ¼, ½, 1 and 2-watt. Assorted parcel of 100, **30/-**.

1-WATT CARBON RESISTORS. Manufacturers' type, values unmarked, but ranging 20,000 ohms to 2 meg. Unique opportunity, **7/-** per 100.

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L.F. SMOOTHING CHOKES, finest quality, 20, 40 & 60 henries, 150 m.a., **16/9** each.

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Constructors' Kits. Designed by prominent well-known radio engineer. All parts supplied—theoretical and practical wiring diagrams and full instructions for assembly and operation. All parts new, ex manufacturer's pre-war stock. Demonstration model can be seen working. Specification : Magnetic deflection and focussing. C.R.T. 7in. screen. Multi-stage amplifier and linear time base incorporated. Mains input 200/250 v. 50 cycles. Anode potential 5,000 v. Oscilloscope when completed is in chassis form, mounted on tubular metal frame **£22.17.6**
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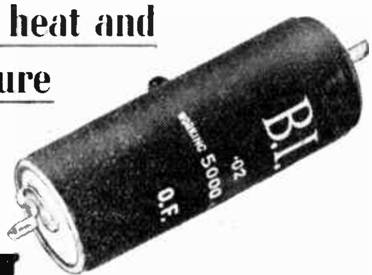

B.I. MOULDED TUBULAR CONDENSERS

Manufactured in a wide range of capacities and for working voltages up to and including 6,000 D.C. For high-voltage operation they provide the most effective solution where size and weight are important considerations and are designed to operate continuously in extremely arduous conditions of temperature and humidity. Manufactured in three sizes and supplied with soldering tags at each end, or alternatively with one soldering tag and a stud for base fixing.

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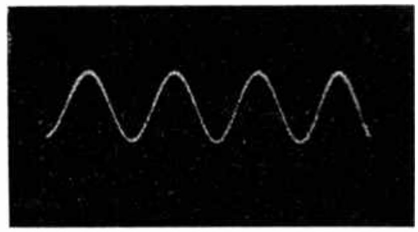

B.S.R. STANDARD SINE WAVE SOURCES

TYPE LO.800A. OSCILLATOR

—an actual oscillogram of output voltage is illustrated—gives good waveform even below 10 c.p.s. This necessitates a minimum "pull-in" between the two H.F. oscillators. Superlative design results in an almost perfect waveform from the lowest to highest frequencies. The output voltage is constant to within a few per cent. over the frequency range. This Model is chosen as a Standard by most Departments. Stable, reliable. Indispensable to all serious workers.

Output up to 5 watts. Three range output voltmeter incorporated—0-250, 0-50, 0-10. Four output impedances, 5000, 1000, 600 and 15 ohms. Frequency ranges (3 models), 0-15000, 0-25000 and 0-50000 c.p.s.

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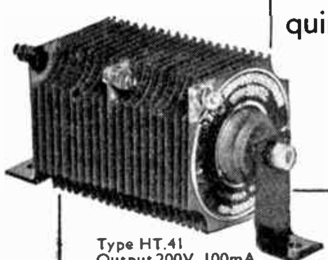
WESTALITE *Rectifiers*

For D.C. POWER SUPPLIES

to operate all electronic devices requiring a steady and reliable supply of direct current from an A.C. source.



Type HT.41
Output 200V. 100mA

Available with outputs from microwatts to Kilowatts, there is a suitable

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metal rectifier to meet the demands of any electronic application, including such purposes as H.T., L.T. and G.B. supplies to amplifiers, receivers, transmitters, oscilloscopes, etc.

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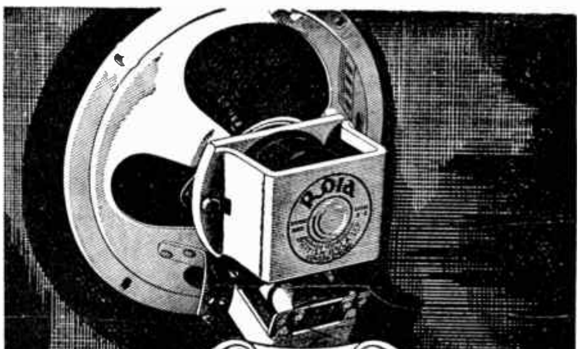

The
LOUDSPEAKER
YOU KNOW BY EAR
now making
EVERY WAR EFFORT

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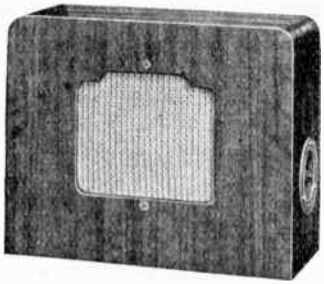
Wharfedale "MERITOR" EXTENSION SPEAKER



This popular model is fitted with an 8 inch Unit, with ALNICO Magnet 7,000 lines.

We are still making a few Extension Speakers in good quality Cabinets. These are supplied in small numbers to old customers. The "Meritor" here shown retails to-day at 57/6

(without transformer)

WHARFEDALE WIRELESS WORKS

HUTCHINSON LANE — BRIGHOUSE, YORKS.

'Phone : Brighouse 50. 'Grams : Wharfdel.

TAYLOR VALVE TESTER

This new and improved Taylor Valve tester measures the Mutual Conductance of all types of amplifying valves and also checks the emission of Diodes and Rectifying valves

Two ranges of Mutual Conductance measurement are available being 3 mA/V full scale and 15 mA/V respectively. Anode and Screen Volts can be adjusted to suit the valve under test and a variable supply of Grid Volts is also available. A switch gives a choice of 17 different filament Volts covering from 1.1 Volts to 117 Volts

Sixteen valve holders are provided to cover all the popular British, American and Continental types. Separate tests are available for checking Continuity, Element Shorts and Heater to Cathode Leakage

The three selector switches ensure that the correct voltage is applied to every pin of the valve under test.

A comprehensive book of instructions is issued with each instrument, complete with a valve chart giving settings for over 2,000 valves of all makes

The instrument is operated from A.C. Mains and a mains adjustment is provided covering from 200-250 Volts at 40-100 cycles.

Model 45A/S

Price £17 . 0 0

Please write for technical brochure.

Taylor electrical instruments Ltd

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offer only material of the highest specification and give immediate delivery from stock. All items new and all prices nett.

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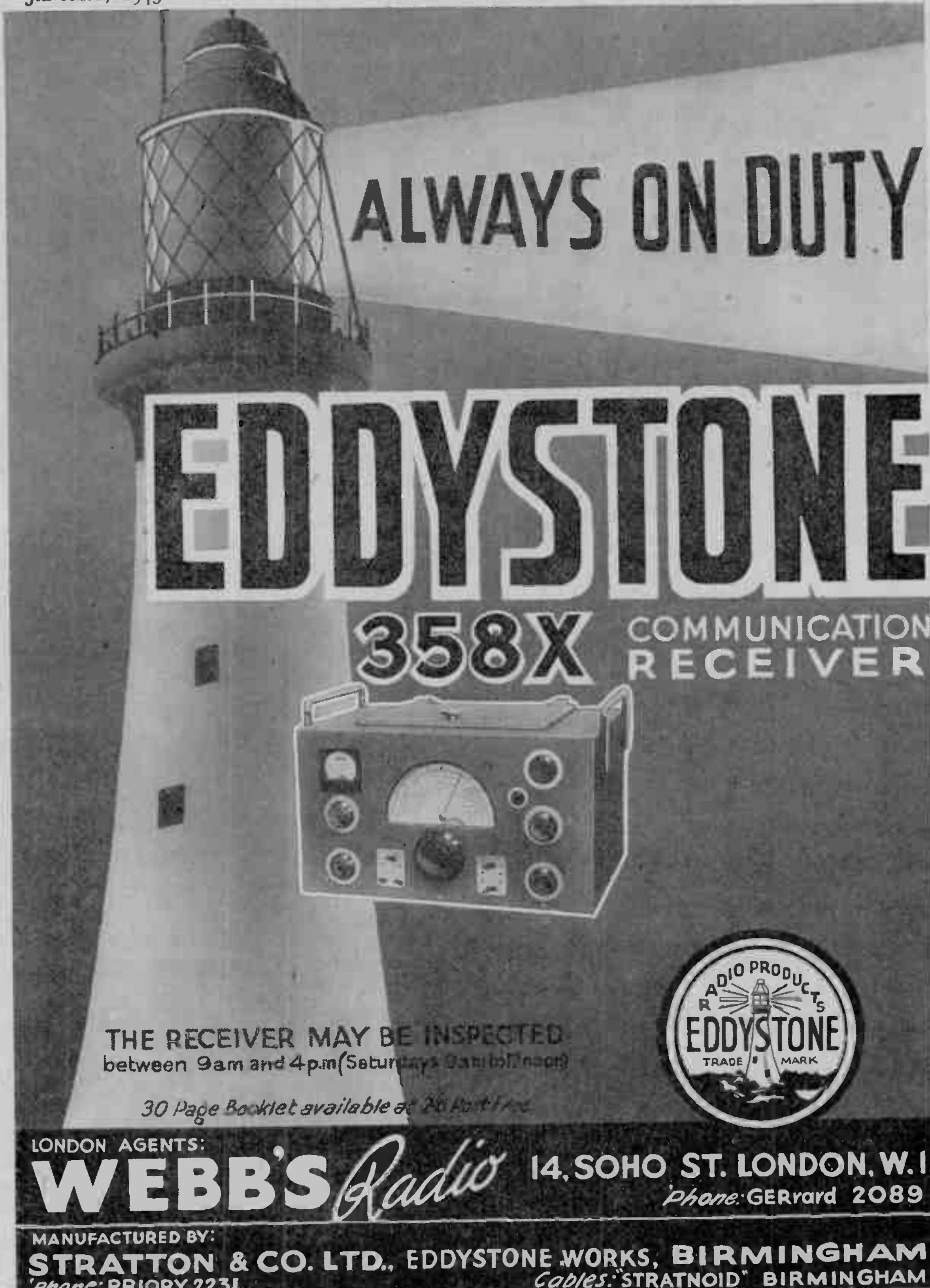
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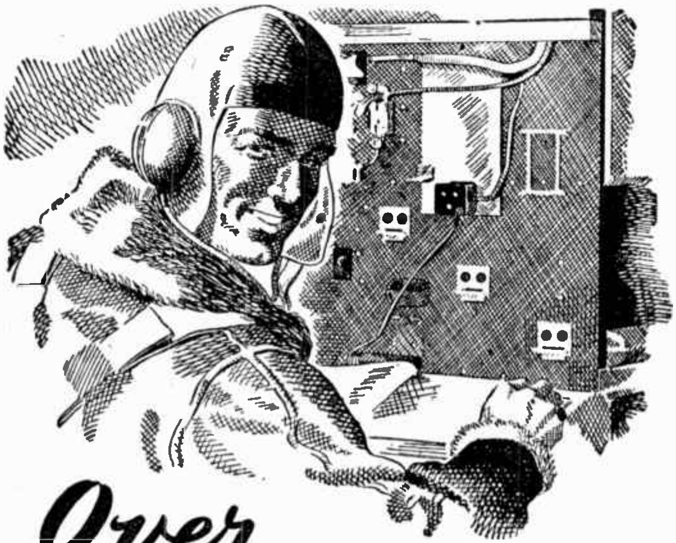

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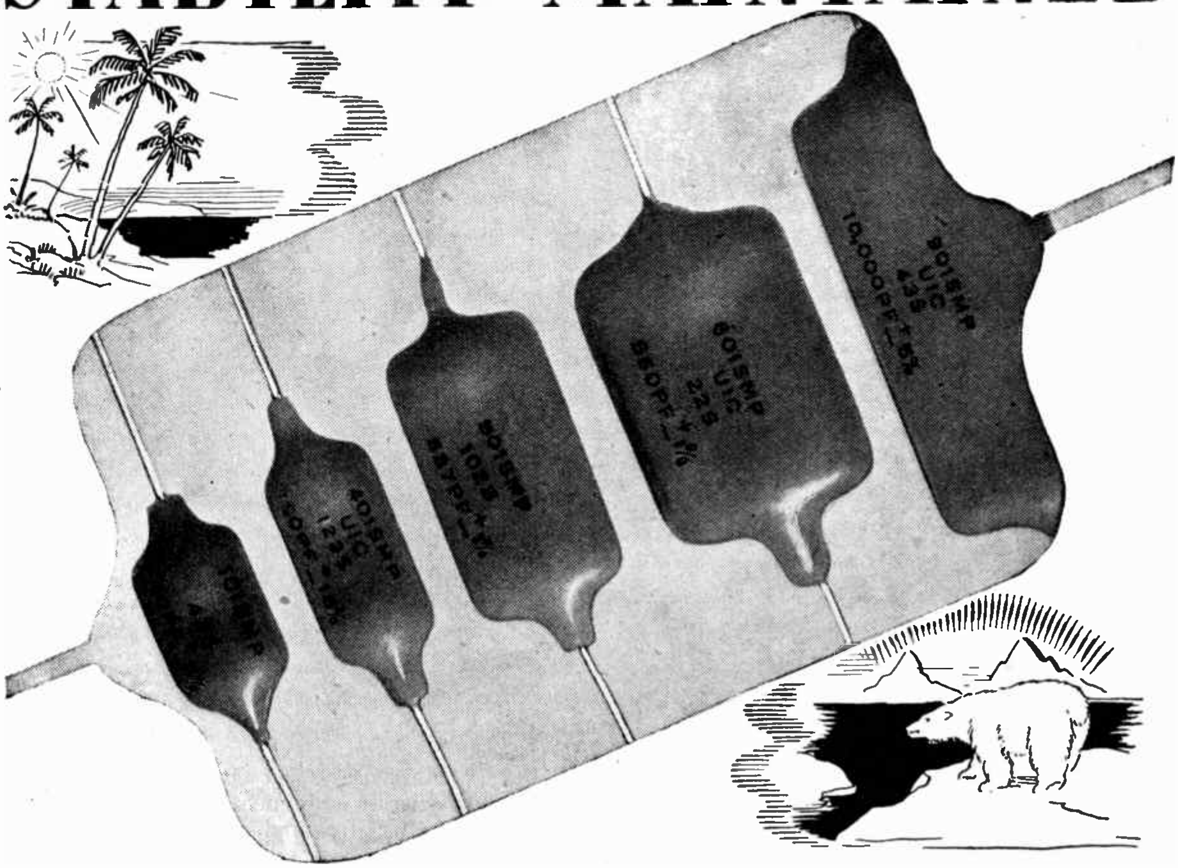

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Monthly Commentary

Obligation to Students

On another page a reviewer says some hard things about certain recently published textbooks for students of radio engineering. It is true that the demand for elementary books brought about by the war has produced a flood of such literature, and many of the works bear all the marks of having been dashed off in a hurry. "Easy writing makes devilishly hard reading," and nowhere is unnecessarily hard reading less forgivable than in books offered to those in the throes of acquiring specialised knowledge.

All our sympathy goes out to the unfortunate student, who must be bewildered and frustrated by some of the misleading, badly arranged, and often inaccurate books that are put before him. It would be unreasonable to demand a high standard of literary elegance in technical books, but clarity is essential. In many books the unfortunate reader's line of thought is constantly interrupted by ambiguous phrases, or worse.

Technical training in general is closely linked with this question of textbooks. We agree with the opinion expressed in the Brit. I.R.E. Report on education (summarised on another page) that syllabuses and, indeed, methods of training in general, are due for an overhaul. The Report recommends the setting up of a Radio Education Advisory Board. We sincerely hope that admirable suggestion may bear fruit, and that the Board, when it comes into being, will set a shining example to all other bodies of its kind. Good teaching will make good technicians; this country has in the past played a worthy part in wireless development, and the future depends on the students of to-day.

✦ ✦ ✦

Anti-Interference Legislation

It is good to read that, according to a report published elsewhere in this issue, members of the Radio Section of the Institution of Electrical Engineers have expressed virtually unanimous acceptance of the principle that legislation is needed to control all radiation likely to interfere with wireless reception. Even better is the implication in the report that less insistence is now being laid on the necessity for precise specification of limits of interference that should be allowed by law. That has always been a stumbling block; interference suppression has fallen into the hands of the highbrows. Arguments on the more complex technical details of the less tangible aspects have tended to obscure the real issue, which is: Should there be a legal obligation to take all reasonable precautions to prevent or minimise the radiation of interference?

The random and sometimes intangible nature of interference makes it dangerous to aim at too-rigid specification, and any law on such a basis would probably prove a bad one; doubly bad, indeed, because it could not be enforced. We cannot make the possession of a defective electric light switch a hanging matter! A law founded on the broad principle that failure to take reasonable precautions to avoid causing interference is an offence would probably prove more effective. It would certainly stand some chance of getting on the statute book before it is too late.

✦ ✦ ✦

A Brand-new Industry

The self-governing Dominions of the British Commonwealth already have well-organised broadcasting systems, but in most of the Crown Colonies and Protectorates there are virtually no means of reaching the indigenous population. To help the more backward peoples of the Colonial Empire to attain a higher standard of life, broadcasting is a virtual necessity, and its extended use after the war seems almost certain. Great quantities of equipment will be needed; indeed, a brand-new industry may be opened up, and there is no reason why it should not be a British industry. But the technical and economic problems involved in distributing broadcasting over vast tropical areas inhabited by peoples of a low cultural level are considerable.

Elsewhere in this issue some of these problems are discussed, and the tentative suggestion is made that distribution should be by "long-short" wave radio (in the 60-90-120 metre tropical broadcast bands) in conjunction with community receivers developing into local wired relay systems. These problems should be closely studied by the Colonial Office and its advisers—in collaboration, we hope, with the British wireless industry.

Mechanism of

DIELECTRIC HEATING

Modern Theories and Their Application to Practical Problems

By L. HARTSHORN, D.Sc., A.M.I.E.E.

THE main business of the radio engineer is to generate, control, transmit and receive electromagnetic energy in that portion of the spectrum ranging from wavelengths of a few miles to a few millimetres, so that it becomes available for any desired purpose. To deal with various problems encountered, this energy is visualised in various ways. In transmission problems it is visualised as progressive electromagnetic waves, but in circuits such as generators and receivers, it is more convenient to consider simply two forms: electrokinetic energy, that is to say the energy of the magnetic fields associated with the currents in inductive coils, and electropotential energy, or the energy of the electrostatic field associated with charges on condensers. Thus inductive coils are regarded as reservoirs of magnetic energy, and condensers as reservoirs of electrostatic energy.

The problem of the radio heating engineer is to transform this electromagnetic energy into heat in some given body. This can be done in two ways. On the one hand there is the induction heating of metals, which is performed by simply placing metals in alternating magnetic fields; as is well known, the metals absorb the energy of the field in virtue of the eddy currents generated within them. In an analogous way, dielectrics absorb some of the energy of an electric field in which they are placed, but the mechanism of this dielectric heating is not so obvious to those accustomed to consider currents and voltages only, as the eddy current mechanism of induction heating.

Some insight into the character of this mechanism is necessary to every radio engineer, since although not everyone is concerned with exaggerating the process for the purpose of industrial heating, all are concerned with that unavoidable heating which occurs in all radio circuits, and which is usually considered under the heading of power loss. In the present article it is proposed to give a general working idea of the mechanism of dielectric heating so far as this can be done without entering into abstruse mathematical details.

Dielectrics and Electrostatic Energy.—Consider a piece of insulating material placed between two conductors. The combination of conductors and insulating material can be regarded as a condenser, but this is not essential. If a difference of potential is applied between the two conductors the material becomes situated in an electric field, the field strength at any point being equal to the voltage gradient at that point. As is well known, any electric charge at that point experiences a force proportional to the voltage gradient and to the charge, and this force acts in the direction of the field or in the opposite direction according as the charge is of the positive or negative sign.

Now all matter consists of positive and negative electrical charges locked together in more or less stable equilibrium by the attractive forces between them. Thus when the voltage is applied, all the positive charges in the material experience a force in the direction of the field and all the negative charges on the opposite direction. The applied field therefore tends to separate the positive and negative charges which are displaced until the increased attractive forces called into play prevent further motion.

This displacement of the charges may be visualised in various ways. We may, for example, regard the atoms and molecules as being distorted by the field; alternatively, it is possible that there are some more or less free ions in the structure, and the displacement may be regarded as the translatory motion of these ions along some conducting path. This translatory motion may set up accumulations of charge, in which case it will be the back EMF due to such accumulations or polarisations which will set a limit to the displacement, and cause it to collapse as soon as the applied field is removed. Whatever the nature of the process, work must be done in creating the displacement; that is to say, energy is put into the material just as it is put into a condenser on charging; and on removing the voltage this energy can be recovered from the material just as it can be recovered by discharging the condenser.

If the applied field is alternating, then the displacement produced will also be alternating, the charged particles in the structure of the material being set into forced vibration. The energy relations in this system are analogous to those of a spring set into forced vibration, or of a compressible gas in a cylinder closed by a piston in reciprocating motion. It is well known that if for this case we plot displacement against force, we obtain an indicator diagram. If this diagram consists of a straight line; that is to say, if the displacement is always in phase with the force, the energy put into the system on creating the displacement is all returned to the source when the displacement falls to zero, and there is no net loss of energy in the cycle. If, however, the displacement lags behind the force the indicator diagram becomes a more or less open loop (Fig. 1), and the area of the loop is proportional to the net loss of energy in a complete cycle of operations. The ideal dielectric gives a straight-line diagram, but as is well known, all real dielectrics show a finite loss of energy in each cycle, and loops of the kind shown in Fig. 1 have been obtained experimentally. Considering the problem from this point of view, the permittivity of a material is a property which is proportional to the energy put into the material when a given field is applied. The power factor of the material is the property which is proportional to the fraction of this energy absorbed by the material when the applied field is carried round a complete cycle. The relation may be written

$$\frac{\text{Energy absorbed}}{\text{Total input energy}} = \text{decrement} = \pi \tan \delta$$

tan δ being the loss tangent of the dielectric, which for most materials is the same as the power factor.

This absorption of energy from an electric field by a dielectric is an experimental fact, and the basic fact of dielectric heating. It means that the displacement produced in the dielectric by the applied field is not in phase with the field, but lags by an angle δ. The current, which is the rate of change of displacement, and is therefore in quadrature with the displacement, must differ in phase from the field by an angle 90° − δ. On account of this angle of lag of the displacement, the absorption of energy has been ascribed to a process of dielectric hysteresis, but this name is merely another way of describing the lag between displacement and force; it suggests an analogy with the process of magnetisation which is not altogether sound in spite of the resemblance of the indicator diagram of a dielectric to the hysteresis loop of a magnetic material, the chief difference being that remanence in a magnetic material has no counterpart in ordinary dielectrics, that is to say the electric polarisation always falls to zero when the applied field is removed, provided sufficient time is allowed; for example, a condenser always loses the whole of its charge after it is short-circuited for a long time. It should be remarked that this process of dielectric hysteresis occurs at low frequencies as well as at radio frequencies, and indeed the power factor of many materials is higher at low frequencies than at radio frequencies; nevertheless, the heating effect is usually negligible at low frequencies even when it is very considerable at radio frequencies. The reason for this becomes obvious in the light of the previous discussion. If the frequency is 50 cycles per second, then the energy corresponding to 50 hysteresis loops is absorbed by the material in each second; but if the frequency is 1 megacycle per second, then the material absorbs in each second energy corresponding to one million hysteresis loops, and although the power factor and size of the loop varies with frequency as will be shown later, they are usually of the same order of magnitude at all frequencies in the electrical range.

Electronic, Atomic, and Molecular Mechanisms.—It has been mentioned that several types of electric displacement or polarisations are possible. There is first the displacement of electrons with respect to the positive nucleus in each atom, and secondly the displacement of the atoms in each molecule with respect to one another, or the displacement of atoms in a crystal lattice. These two kinds of displacement occur in every material; they can be visualised as a distortion of the atoms and molecules respectively, so that atoms and molecules which are ordinarily symmetrical in structure are no longer so when the field is applied. It is known, however, that many molecules are unsymmetrical in their structure even in the absence of any applied field, and this means that there is on the whole a preponderance of positive charges near one end of the molecule, and of negative charges near the other. Such a molecule when placed in an electric field will be exactly analogous to a small magnet in a magnetic field. In the absence of any field, the molecular axes are orientated at random and the resultant polarisation is therefore zero in every direction. When the electric field is applied each molecule experiences forces tending to turn it into line with the field: uniform orientation is, of course, prevented by collisions with neighbouring molecules, that is to say by the forces of molecular agitation, but the orientation will no longer be random, and there is a definite polarisation in the direction of the field. With fields of ordinary magnitude the force tending to orientate the molecule is very small compared with the force of molecular agitation and the polarisation is therefore proportional to the field strength and quickly returns to zero when the field is removed.

The above three kinds of electric displacement or polarisation occur in pure homogeneous materials. There remains yet another kind, which occurs in materials that are not homogeneous, but consist of two or more components. Fig. 2 (a) represents a slab of such a material, in which one component (unshaded) has zero conductivity, and the other (shaded) possesses considerable conductivity. This second component may, for example, include a number of free ions in its composition; frequently this second component is water or a material that is water absorbent. Any small volume of homogeneous material can be represented electrically by a small capacitance in parallel with a resistance propor-

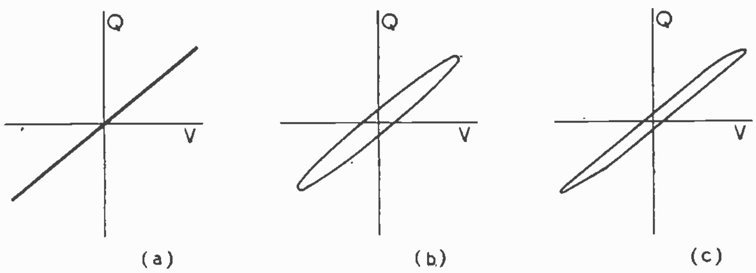


Fig. 1. Typical indicator diagrams for dielectrics. (a) Perfect dielectric (b) Empire cloth ; (c) Glass (Thornton).

Mechanism of Dielectric Heating—

tional to its conductivity; thus a composite material can be represented by a network of capacitances and resistances as shown in Fig. 2 (b). Suppose now a voltage is suddenly applied to such a material; the whole system first takes an instantaneous charge depending only on the component capacitances; each of the small condensers shown becomes charged, the distribution of charge and potential throughout the system depending only on the dielectric constants of the components. These instantaneous charges are the resultant of the electronic and atomic displacements so far considered. As a consequence of the difference of potential thus established currents begin to flow in the resistances; that is to say ionic conductions occur in the components of high conductivity, and as these currents reduce the potential difference which causes them, they diminish more or less rapidly, until finally the p.d. across the resistance falls to zero, after which no further current flows, so long as the applied voltage, and therefore the potential-distribution remains constant.

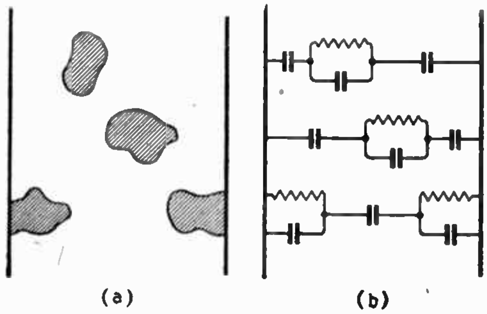


Fig. 2. Model of an inhomogeneous dielectric. In the case shown there will be considerable absorption of power in alternating fields although the DC insulation resistance is infinite.

These currents flowing in the resistors are frequently described as absorption currents; they increase the charge and the p.d. on the condensers of zero conductance, so that the whole system acquires a larger charge than the instantaneous charge. This increase of charge due to the transport of ions in the conducting component is evidently an electric displacement of another kind. When the voltage is removed this displacement falls to zero, just as do the previous kinds. For example, if the whole condenser is short-circuited, all the accumulated charges are released and recombine in the short-circuiting link, but only a part of them can do so instantaneously. The absorbed charge can only be released at a rate determined by the internal resistances.

Summarising, we see that there are four possible kinds of electric displacement or polarisation—electronic, atomic, molecular orientation (or dipole rotation), and the drift of ions. It now remains to consider how these various types affect dielectric heating.

Relaxation Time.—The part played in dielectric heating by a displacement of any one kind will obviously depend on the nature and magnitude of the forces restricting this displacement. Heat will be generated only when the movement of the particles constituting the displacement agitates the whole structure of the material; when, for example, the motion is restricted by collision with either atoms or molecules, or in other words, when the displacement is restricted by forces of the kind which give rise to friction and viscosity.

A quantity that can be regarded as an index of the forces controlling a displacement of this kind, i.e., one in which the motion is so highly damped as to be aperiodic, is the relaxation time, which can be regarded as the time required for a displacement of that particular kind to occur when any given force is applied, or alternatively the time required for that displacement to disappear when this force is removed. The following considerations will show how the relaxation time of any particular displacement determines the extent to which this displacement gives rise to energy absorption under the influence of the alternating field.

Suppose in the first instance that the frequency is very high, the voltage will then only be applied in any one direction for a very short time, namely, half a complete period or $1/2f$. If this time is very much shorter than the time of relaxation of the displacement, then the particles will hardly have begun to move before the force is reversed; the displace-

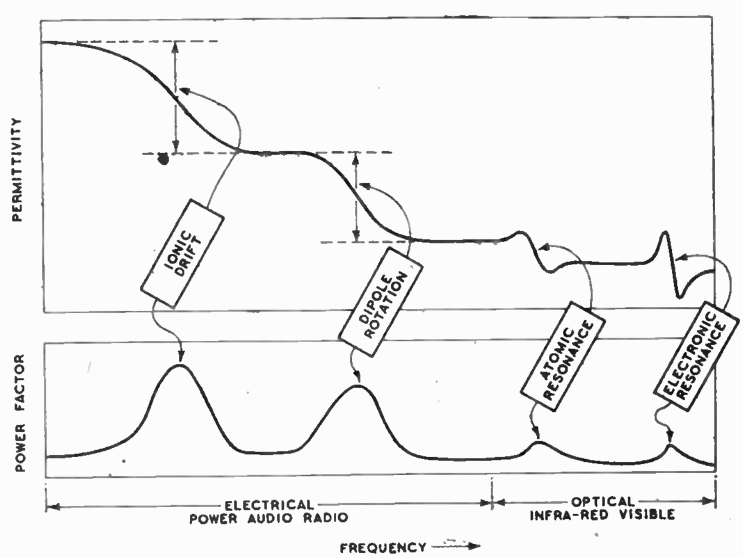


Fig. 3. **Diagrammatic representation of absorption bands of four kinds in the range of electrical and optical frequencies.**

ment will therefore be negligibly small and there will therefore be no absorption of power.

If, on the other hand, the frequency is very low, then the voltage will be applied in one direction for a time, which will be very large compared with the relaxation time; the displacement will therefore have no difficulty in keeping pace with the applied force and there will be no appreciable time lag between displacement and force. Thus the hysteresis loop will be a straight line and the power factor will be zero, and again there will be no energy loss, although the displacement will be much larger than in the previous case; that is to say, the permittivity will be larger but there will still be zero power loss.

Consider now an intermediate frequency at which the half period is of the same order as the relaxation time. The displacement now will never have time to reach its full value in any one direction before the force is reversed; the value will, however, be appreciable, and it will increase as the frequency falls. Also, it will not be able to keep pace with the applied force, but will lag by a finite angle. The indicator diagram will therefore be an open loop and there will be appreciable power loss.

We have shown that the power factor must fall to zero at both lower and higher frequencies. It must therefore pass through a maximum value in this region. The conditions, therefore, for a maximum power factor is that the frequency shall be such that half the periodic time of the applied field is of the same order of magnitude as the relaxation time of the displacement. The power factor curve will show a maximum value in this region of the frequency spectrum; the permittivity on the other hand, in this region, will show a value intermediate between the high value characteristic of low frequencies and the low value characteristic of high frequencies. Fig. 3 shows diagrammatically the form of the power factor and permittivity curves for a material that is characterised by two relaxation times in the electrical range of frequencies, one in the power and audio section, and one in the radio section; there is a power factor maximum or an absorption band corresponding to each time of relaxation, and the permittivity curve shows a step down when passing through each of these bands in the direction of increasing frequency.

It is not possible to calculate the various times of relaxation with accuracy, but some idea of their magnitude can be obtained from considerations of general physical properties. It is found that the interpretation of these properties in terms of the four polarisation mechanisms each associated with a characteristic time constant, throws considerable light on the phenomena of dielectric heating. A few examples will make this point clear.

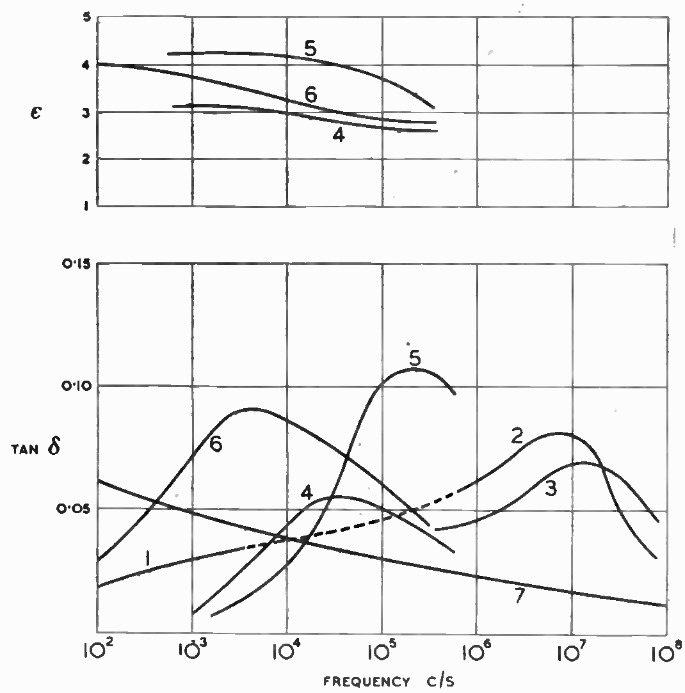


Fig. 4. The permittivity and power factor of typical polar thermoplastics in the electrical range of frequencies. (1) Cellulose acetate plastic (Hartshorn and Rushton); (2) Cellulose acetate plastic (C. F. Hill); (3) Celluloid (C. F. Hill); (4) and (5) Vinyl ether plastics, (5) having a higher concentration of polar groups than (4) (F. H. Müller); (6) Vulcanised rubber, 12% sulphur (Scott, McPherson and Curtis); (7) Methyl methacrylate plastic.

Hydrocarbon Plastics. — Consider first the electrical properties of the pure hydrocarbons, including such important commercial materials as polystyrene, polythene, pure rubber, paraffin wax, Vaseline, transformer oil, etc. The molecules of all these materials are symmetrical in structure, and when pure the materials are free from water and ions; it follows that only the electronic and atomic polarisations are possible and therefore the dielectric properties of these materials must be characteristic of these two polarisations. These properties are very well known. The materials all have a permittivity of 2.2 to 2.6 at all frequencies in the electrical range, and this value is very nearly equal to the square of the optical refractive index, which may be regarded as the permittivity at optical frequencies. The power factors of all the materials are also vanishingly small, say 0.0002 at all frequencies in the electrical range; in other words, these materials show no absorption band at any electrical frequency, and it follows that the time constants of the electronic and atomic polarisations must lie wholly in the optical portion of the spectrum. Moreover, these materials are nearly all optically transparent; it follows that even in the optical range of frequencies energy absorption is small. The

Mechanism of Dielectric Heating— frictional forces opposing the displacement must evidently be small, and, indeed, there is good reason to believe that the electronic and atomic displacements are periodic, in contrast to the other types of displacement which are aperiodic. It follows that the permittivity curve takes the form of the familiar N curve characteristic of resonance, when passing through an absorption band arising from electronic and atomic displacements, instead of the step down already discussed as characteristic of aperiodic displacements (see Fig. 3).

Polar Thermoplastics. — Consider next a few typical thermoplastics, the molecules of which are known to be unsymmetrical and therefore electrically polar. A few typical curves for these materials are shown in Fig. 4. Notice that the permittivity of all these materials is almost twice as large as that of the hydrocarbon plastics, which is evidence that there is a considerable polarisation of some kind, other than the electronic and atomic. The power factor curves all show maximum values which are very large compared with the power factors of the hydrocarbons. It is known that these properties occur even when the materials are pure and homogeneous, so that there is no likelihood of ionic displacement. The polarisation is therefore to be ascribed to molecular orientation or dipole rotation. It has been shown experimentally that the maximum value of power factor increases with the number of polar groups in the molecule of these materials; for example, in the rubber-sulphur compound (vulcanised rubber) the power factor increases with the sulphur content, and experiments of this kind provide strong evidence supporting the view that the dielectric properties of these pure resins are mainly determined by dipole rotation. It is interesting to note that Perspex, which has a decidedly high value of power factor at electrical frequencies, is remarkably transparent to light waves, and therefore must have a very low power factor at optical frequencies.

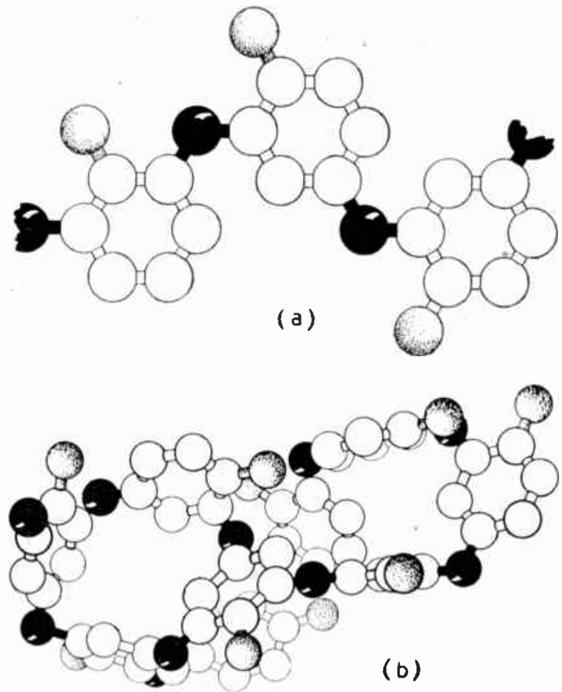


Fig. 6. Molecular models of phenolic resins: (a) thermoplastic, (b) heat-hardened. Each spotted ball represents an OH group, which is the part of the molecule that is electrically unsymmetrical, and therefore behaves in an electric field like a small magnet in a magnetic field. It is capable of a limited rotation about its point of attachment and this motion gives rise to the absorption of power in alternating electric fields, and therefore to dielectric heating.

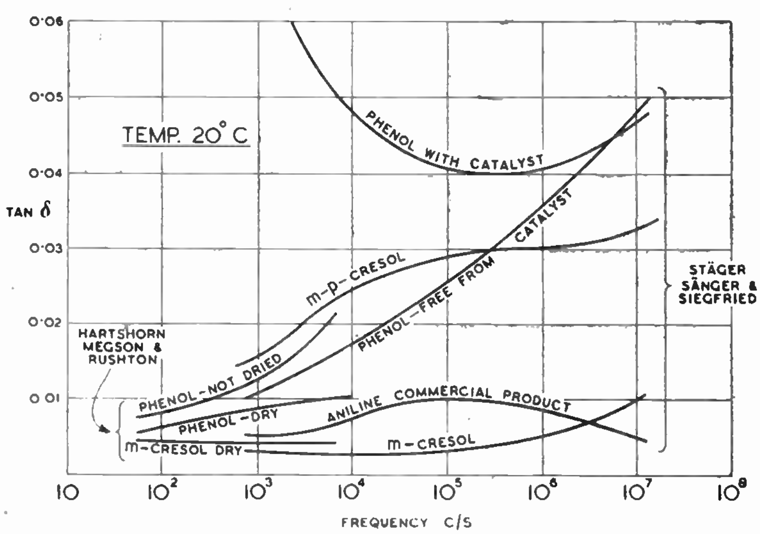


Fig. 5. Power factors of various heat-hardened synthetic resins in the electrical range of frequencies.

Thermosetting Plastics. — The thermosetting plastics include materials of the Bakelite type, important for compression moulding and for the manufacture of laminated sheets and tubes, as well as synthetic resin glues important in aircraft construction. Properties of typical resins of this kind are shown in Fig. 5. Here again we have the high power factor characteristic of polar materials, and there can be little doubt that this power factor arises from dipole rotation as in the case of thermoplastics. The peaks in the power factor curve are, however, very much less marked. It appears that these materials are probably not characterised by a single time constant, but by a band of time constants, which might arise because polar groups in different parts of the molecule are restricted in their motions to different extents. The power factor curve is therefore to be regarded as formed by the superposition of a number of peaked curves, the peaks being spread over a more or less wide band of frequencies.

Another point brought out by Fig. 5 is that the power factor of a pure resin is increased by the addition of the small quantity of water which it takes up from the atmosphere. There is also a very much larger increase of power factor if the resin contains an electrolyte. For example, the topmost curve was obtained with a resin prepared with NaOH as catalyst, and the subsequent washing was not quite complete, so that traces of NaOH remained in the resin. This material shows a very large rise of power factor at low frequencies, and there can be but little doubt that this arises from ionic displacement made possible by the presence of the electrolytic ions. The time constant of this ionic displacement can be estimated in terms of the equivalent resistances and capacities shown in Fig. 1, and such calculations confirm that the times of relaxation of displacements of this kind fall in the low-frequency region.

Conclusion.—It may be useful to conclude with a few practical considerations. It is obvious that for effective dielectric heating at frequencies low enough to be generated economically, materials of high power factor are wanted, and it is therefore always advisable to use polar materials if possible. If these are not available it will be necessary to work at the highest possible frequency, but with pure non-polar materials, even the highest available electrical frequency may fail to give appreciable heating at the voltages which are permissible; obviously the voltage must not be increased beyond the value at which flash-over begins to occur.

If selective heating is required it is obviously desirable to use one polar material in combination with a non-polar material; a good example of this is provided by the fabrication of laminated glass. Fig. 4 shows that the power factor of the transparent thermoplastic materials is very high in a certain range of frequencies. The power factor of plate glass is low and almost independent of frequency in the whole of the electrical range since it is not a polar material. It follows that if we place a sandwich of alternate layers of plate glass and a transparent thermoplastic material in an electric field of a frequency corresponding to the maximum power factor of the plastic, heat will be generated in the plastic at a much greater rate than in the glass, so that the plastic can be brought to the softening temperature without any unnecessary heating of the glass.

Dielectric heating in the lower frequencies can obviously be increased by an increase of ionic displacement which can sometimes be brought about by adding particles of an appreciable conductivity like graphite to the body to be heated. Alternatively, water or a small quantity of some electrolyte may be added; a procedure which will be obviously suitable for the synthetic resin glues. The result will be a composite dielectric which may be expected to show a peak in its power factor curve somewhere in the low-frequency range; the value is not likely to be calculable, but it is obviously a fairly simple matter to proceed by trial and error.

In conclusion, it is curious to note that although the heating of non-metals at radio frequencies is sometimes called "electronic heating," yet electronic displacements play no part in the process. Such heating might reasonably be described as "molecular" or "dipolar," but strictly speaking it is only the heating of metals that is electronic in character; and since this applies to the heating of metals at all frequencies as well as with direct current, it is best to avoid the term "electronic heating," and to describe the processes under discussion as the dielectric heating of non-metals and the eddy-current heating of metals.

INTERFERENCE SUPPRESSION

I.E.E. Views on the Post-war Position

LEGISLATIVE control of all radiation likely to interfere with wireless reception of any kind was generally accepted as a post-war necessity at a recent Discussion Meeting of the Radio Section of the Institution of Electrical Engineers. P. R. Coursey, who opened the discussion, considered the main changes to be expected after the war will concern the frequency range over which interference suppression is likely to be required; the types of apparatus that are likely to be in use as potential interference-generators; and the wider use of domestic electric equipment of generally well-known types.

For interference - suppression purposes the pre-war frequency range extended up to 1,500 kc/s; only the broadcast sound frequency band was effectively covered.

For post-war use it appears desirable to modify and improve the six British Standard Specifications already issued in order to satisfy changed requirements. First, it will be necessary to extend the frequency range upward, a maximum in the region of 600 Mc/s being at present envisaged. This increase in frequency range is required not only to cover the normal television transmissions and short-wave radio reception, but also to protect some of the newer radio and radar applications likely to be used as aids to navigation in civil aviation and in ships.

Industrial Interference

There is likely to be a considerable extension in the use of high-frequency equipment in many industrial electronic applications, apart altogether from a much wider use of electro-medical equipment, much of which is a source of interference. At present such apparatus, which frequently uses a high power and is troublesome in this respect, is prevented from doing any serious harm by purely wartime regulations requiring its complete screening, but other alternatives must be explored for the future.

Radiation from superheterodyne receivers can extend over a wide area, and it will almost certainly

Interference Suppression—

be essential for set manufacturers and designers to pay close attention to such a potential source of trouble.

One aspect of interference suppression, which affected radio manufacturers only slightly in pre-war days, may become very important in the future, namely, the measures taken in other countries to suppress interference. It would seem that a high degree of uniformity is very desirable, not only to assist the manufacture of apparatus for export, but also protect the listener.

Need for Legislation

In the general discussion that followed there was virtually unanimous agreement on the necessity for some kind of legal machinery for curbing electrical interference with radio reception, though there was some diversity of view as to the rigidity of the legal control that should be imposed. None of the speakers laid any great emphasis on the desirability of precise specification of legally permissible limits of interference, but many stressed the difficulty in the way of preparing such specifications. Suggestions for appropriate legal measures ranged from a plea for "enabling" legislation which would permit a properly constituted authority to issue regulations, to a proposal that radio interference should be treated as a "nuisance" in common law. In support of the latter contention, it was pointed out that in legal actions to abate nuisances from acoustic noise there is no obligation to specify precisely the levels of the noise.

Doubts were expressed as to the extent to which a law on a rigid quantitative basis could be enforced, and there was also the problem of ensuring proper maintenance of interference-producing devices. Much could be done by education, both of those responsible for interfering apparatus and the users of radio receivers. Co-operation between the various interests concerned on both sides was considered to be vitally important.

The use of broadcast receiving aerials of greater effectiveness than those commonly installed was urged, as was the use of screened down-leads. The directional properties of aerials might be more generally employed in improving signal/noise ratio in UHF reception.

Though it was generally believed that interference would increase after the war unless effective steps were taken to check it, the general opinion was that the trouble was not likely to be particularly serious at ultra-high frequencies. The physical size of the majority of interfering devices is such that most of the radiation is below 10 Mc/s. It was pointed out, however, that the radiation from ignition systems of motor vehicles covered a very wide frequency range. This was at present the most serious form of interference with UHF communication services, which often worked with low field strengths, and would need protection for frequencies at least up to 300 Mc/s. It was stated that capacitors with properties suitable for interference suppression at frequencies above 50 Mc/s would probably soon become generally available; existing designs were inadequate for this specialised purpose.

Radio Heating

Some speakers thought that the newly developed technique of radio-frequency heating for industrial purposes would prove a serious source of interference; in one case interference from an eddy-current heater had been experienced at a distance of half-mile from the source. Though it was agreed that the problem of suppressing radiation from equipment that might ultimately attain powers of the order of 1,000 kW and operate at frequencies up to 200 Mc/s was a formidable one, the view was expressed that a solution would be found by adopting a combination of known methods. These would include screening, which was quite practicable for small- or medium-powered equipment, and also a limited allocation of exclusive frequency bands. Pleas were made for the exercise of reasonableness in approaching the problem, and for taking local circumstances into account in estimating permissible radiated field strength. For example, there was no point in restricting radiation severely in circumstances where radiation at the particular frequency concerned could do no harm. Manufacturers of radio heating equipment should formulate their own code. A possible development of the future was for factories employing strongly interfering apparatus of any type to be built as screens.

In replying to the discussion, the opener expressed surprise at the unanimity of opinion in favour of legislative control. He agreed with the opinion that at first it would probably be necessary to accept a legally imposed low level of suppression.

EDUCATION AND TRAINING

THE second part of the Report presented by the British Institution of Radio Engineers on Post-war Development is devoted exclusively to the subject of education and training of wireless technicians and craftsmen of all grades. It is written from the premise that the standard of living of the country as a whole can only be raised by fitting each man to perform the task for which he has the most aptitude. A strong plea is entered for extending specialised educational facilities in general, and in more than one place doubts are expressed as to the soundness of present syllabuses and methods, which are thought to reflect obsolete practice.

The opinion is also expressed that the normal curriculum for training electrical engineers, modified by the introduction of a bias towards radio at the third-year level, is not suitable for producing radio engineers; a different approach is needed.

Demobilisation courses for engineers and technicians now in the armed Forces are advocated, not only that those who have lost touch with their peacetime work should be enabled to fit themselves to re-enter industry, but in order that they should be brought up to a standard in advance of that required for immediate employment.

The difficulty of providing adequate teaching staffs is discussed in the British I.R.E. Report and the desirability of industrial experience for teachers is touched upon. Finally, there is a recommendation that a Radio Education Advisory Board be established to examine the whole field impartially in the interests of national progress. The members of the board should include representatives of education, industry, commerce, appropriate professional associations and the Services.

COLONIAL BROADCASTING

"Long-short" Waves for Covering Tropical Areas?

THE British Colonial Empire covers one quarter of the area of the British Empire and contains 14 per cent. of its population. Its area is about 3¼ million square miles and its population nearly seventy millions. The African colonies form the major part of this Empire and Africans and people of African origin the bulk of the population.[1] In the two regions, East and West Africa, a population equal to that of the British Isles is rapidly becoming civilised. In consequence the cultural range of these peoples is probably even greater than the cultured range here at home. At the present time, however, this almost explosive growing-up is taking place practically unaided by broadcasting; yet broadcasting is an ideal way of knitting a community together. It is true that there is the Empire service of the B.B.C., but this caters rather for the sophisticated; for those who can own and operate that fairly complicated instrument, a short-wave receiver. In the post-war years both our Imperial responsibility and industrial self-interest demand that there shall be an adequate system of local broadcasting and a supply of listening means for the less advanced peoples.

Some Comparisons

In the British Isles broadcasting is organised on two main assumptions: the population has no "special classes" but is uniformly programme-worthy; and it is grouped in six main centres in which the density exceeds 500 persons per square mile. The average listener will spend some £2-£3 a year on receiver replacement and expects a field-strength of 10 mV/metre in electrically noisy towns, although in quiet areas about 2½ mV/m. is satisfactory. Even so, with a total radiated power of many hundreds of kilowatts, in some areas there is dissatisfaction. The great area of East Africa is served by one station, at Nairobi, of some 5 or 10 kW. In other regions—West Africa, the West Indies, the Far Eastern region round Singapore—the situation is not markedly different. Nor is it merely that transmitters and studios are lacking; even if these existed there are no receivers suitable for such backward peoples. Not only must "They" do something, but the radio industry must set to and produce.

The scope of the problem is seen more clearly if an artificial division of the population into four main classes is made. For the purpose of this article we will call them European town dweller, European settler, African town dweller, African villager. The chief factors which influence this division are contact with the idea of money, and availability of power supplies. It is the last class which presents most difficulty: the African in the town earns a money wage and there are power supplies; the European settler can afford a small supply plant; the African in a purely African village is not in a "currency area," nor can power be easily available. Yet it is this African who most needs broadcasting. It is this man who needs advice on scientific agriculture and stock-raising, if his standard of living is to rise. And, if he is to become a good citizen of the modern world, broadcasting must awaken in him a sense of his dual loyalty to the tribe and to the larger unit symbolised by the Imperial Crown.

Community Receivers

The solution to the listening problem must be one which provides for a logical growth structure. Initially each large village should have a single receiver, in the charge of an African who has had some training in the Army. These receivers should be mounted in strong sealed steel boxes, with only an on-off and channel-selecting switch and possibly a volume control. A robust loudspeaker of the "loud-hailer" type and a petrol-electric generator complete the station. When all the villages are equipped, extension loudspeakers should be added, so that there is the nucleus of a local radio-relay scheme. A combined servicing and petrol supply organisation complete the system. The reason for the relay idea is important. Listening groups should be small, to reduce the effect of that Gresham's Law in ideas which will retard the education of the listener. For small communities, battery sets of the same robust mechanical design, with automatic time switching, can be maintained by the servicing organisation.

So much for the "official" receiver arrangements: the transmissions feeding them will automatically set up a demand for individual receivers by the European settlers and the more affluent Africans. There will be a market for robust, tropical receivers with low current consumption. The standard British home-market receiver will not be adequate, especially if the frequences to be suggested later are used.

Tropical Atmospherics

The problems of transmission are not the familiar ones encountered in the British Isles. The Colonial Empire is a tropical empire; consequently the use of the usual medium-wave band, 1,500 kc/s to 55 kc/s, is impracticable, as the noise level due to atmospherics is very high. Three bands, nominally 60 metres, 90 metres and 120 metres[2] have been allocated for broadcasting services in tropical countries.

The range of ground-ray reception at these wavelengths will not be great, and although it is possible to envisage a twin-frequency system in which a station in the higher-frequency channel provides a sky-wave service beginning near the inner edge of the lower-frequency channel skip, the attenuation of such a sky-wave would be

[1] These facts are derived from "Colonies," by E. A. Walker (Cambridge University Press).

[2] The actual frequency bands allotted at the Cairo Convention for broadcasting in tropical areas are: 2.3–2.5 Mc/s; 3.3–3.5 Mc/s; 4.965–5.5 Mc/s.

Colonial Broadcasting—

high. It is, indeed, this high attenuation of both ground and sky-waves which restricts the noise to the purely local sources. Only a survey on the ground can determine whether such a scheme is practicable, or whether frequency modulation must be used.

This short survey provides an outline sketch of the problem: it will be realised that there are two bodies who can take action, the Colonial Office and the radio industry. It is the duty of the Colonial Office to expand broadcasting facilities; it is the opportunity of the radio industry to exploit the receiver market and thus force forward the transmitter development. The time for planning is now.

Book Reviews

PITY THE POOR STUDENT!

Heavyside's Operational Calculus Made Easy. By T. H. Turney, Ph.D. Pp. 96 + vi; Chapman and Hall, 37/9, Essex Street, London, W.C.2. Price 10s. 6d.

Radio Technique. By A. G. Mills. Pp. 170 + viii; Figs. 301; Chapman and Hall (as above). Price 12s. 6d.

THE writer of these reviews has known three generations of radio engineers. The Old Gang started before and during the last war, when techniques were primitive by present standards. Often they had little theoretical knowledge; they didn't realise that they were attempting the impossible, and they succeeded. The next generation came from the universities: they had physics or mathematics degrees, or, rarely, engineering degrees. Challenged by their elders, they cleaned up the theory—but with the expenditure of sweat and tears. Now a third generation is appearing, for whom things should surely be made rather easier. This generation is the product of specific radio courses at the polytechnics, and to cater for it a text-book literature is appearing at an alarming rate.

Both the books named are intended for the new type of student, and we should try to recapture an undergraduate outlook on them. This reviewer is left with a feeling of alarm; this is poor stuff to give the student. Basic books, rather than elementary books are needed: something on which the student can build when he comes to do his own original work. These books are blind-alley books; they have no past, no reference to any other papers or books which will amplify the detail. They have no future; no clear line along which the student can develop his knowledge. A text-book should be like the bole of a tree, rooted firmly in the ground, and leading upwards to a fine tracery of boughs and twigs: a bad text-book is like a derelict telegraph pole, lifeless, rootless, and leading nowhere.

A common feature of both books is deplorable style. Dr. Turney adopts a bedtime story manner which makes this reviewer wince; Mr. Mills has apparently no idea of how to write clear, simple English sentences. In both cases we see contempt for the reader, one writer talking down to him, the other too slovenly to choose his phrases.

Dr. Turney's book is an attempt to present the methods of operational calculus to young electrical engineers whose mathematical equipment is not adequate to cope with the more formal approach by Carson or Bush. The book begins with an introductory chapter which is a mixture of elementary circuit theory and simple calculus. The second chapter deals with Heaviside's operator p and introduces the idea of expansion in series: the method is applied to the usual simple examples. Chapters IV and V deal with the application of the method to the cable problem. In Chapter VI a discussion of Fourier's Integral leads to a short section on impulses. Chapter VII touches on the Laplace Transform, Carson's and Fourier's Integrals, and mentions contour integration.

The reviewer cannot agree with Dr. Turney's wholehearted following of Heaviside. Surely all the simple problems for which Heaviside's method suffices are now solved and in the books. The problems we now meet are those of complex circuits, with curious wave forms applied to them. One cannot do better than quote from Carson (*Bell System Technical Journal*, October, 1925):

"The power series expansions may be complicated, laborious to derive, and of such form that they cannot be recognised and summed by inspection."

In fact, as Carson shows, Heaviside's own approach involves, in the problem of a cable fed through a condenser, the discarding of one series completely. Carson also gives an example in which the Heaviside approach breaks down. On page 712 of his paper Carson gives a brief critical estimation of the scope and value of the power series solution. He reaches the conclusion that the use of definite integrals is preferable.

Mr. Mills purports to deal with The Structure of Matter, Magnetism, Motors, Measuring Instruments, Valves, Receivers, Transmitters, Aerials, Direction Finding, Sound Waves and Pulse Generators. This is merely a selection from the twenty-three chapter headings. There is little which is useful, much which is confusing, and some information which is definitely wrong. The circuit diagrams, for example, rarely give values; one which does (Fig. 73) describes what is implicitly a filter with a cut-off frequency of 1 Mc/s: the values given correspond to an 80 kc/s cut off, and include a 0.2H inductance. That such circuits are designed is not even hinted by the author. In another place the expression for radiation resistance is given as $\frac{320\pi^2 l^2}{\lambda^2}$, but it is not explained that l is the *effective* length of the aerial and equals $2l_0/\pi$, where l_0 is the actual length. Throughout we find filament batteries and grid bias batteries; the kinkless tetrode is not mentioned at all; neutralising, however, is discussed, although RF stage gains of two or three are apparently enough for the author.

It is unnecessary to labour these views: the reviewer has been through these books twice and will never open them again. He would plead for a new outlook, and the preparation and publication of books over which the author has sweated, and over which the student must be prepared to sweat in his turn: then we shall be beginning to train engineers. T. R.

CATALOGUES RECEIVED

LIST No. T 12 issued by Radio Instrument Co., 294, Broadway, Bexleyheath, Kent, contains technical data on the iron-cored components made by this firm, including the OP 12 K multi-ratio output transformer.

A.A. Tools, 197a, Whiteacre Road, Ashton-under-Lyne, have produced a new illustrated list showing some of the applications of their metal benders, which include special models for the radio trade.

General technical data relating to "Gecalloy" RF dust cores is contained in List 1944 which has been received from Salford Electrical Instruments, Ltd., Silk Street, Salford, 3.

STANDARDISED COMPONENTS

2—Properties of Capacitors

By THOMAS RODDAM

LAST month we discussed the properties of resistors, as defined by the specifications recently published in the BS/RC series. We shall now examine the properties of capacitors, which make up the second key component group in all radio equipment. "Capacitor" is now the official term for what the majority of us still call condensers; the writer must confess to a dislike of this new-fangled word, which no one but a specification writer ever uses. Has anyone ever confused a capacitor with a part of a steam engine? Perhaps the steam engine makers could adopt the term "precipitation inducer" and leave the radio engineer his condensers.

Before examining the specifications we must interpolate a word of warning; the properties defined in these specifications are test limits for capacitors for use by the Services; they are therefore the lowest-quality level permitted for the bulk production of good standard components. The cheapest components will, no doubt, be inferior to these; the best will probably be far superior. For example, mica is an imported material, and is available in many different grades from different sources. It is clearly desirable that the standard mica capacitor should not demand the use of "the best" mica: that would lead to enormous wastage. The specification therefore defines the properties which the average user requires, and thus permits the use of lower grades of mica; even these may have properties far superior to those demanded by the specification. We have taken mica as an example, but the same principle is true of ceramic and paper dielectrics: they may be much better than you expect.

In Fig. 1 is shown the classification of capacitors in the specifications. It is not proposed to discuss variable capacitors in this article, because they are so completely different in all respects from fixed capacitors, and we have therefore omitted the subdivision which would balance the diagram. Examination of the diagram shows that, as in normal practice, the first sub-division of fixed capacitors is by dielectric material. Fixed air dielectric components are omitted, presumably because they normally appear only in transmitters and in small numbers, and they are commonly made to measure. Plastic dielectric capacitors are mentioned once, but this is presumably a precaution intended to include them if ever they become available here, as they already are in America. No definition of their properties is given. There are left, therefore, four kinds of fixed capacitor, with electrolytic film, paper, mica and ceramic dielectrics.

Two Main Groups

It will be convenient in the examination of the properties of these components to separate them into two main groups. In the first we shall consider electrolytic capacitors and the larger sizes of paper capacitor; in the second we shall consider the smaller paper capacitors, mica and ceramic capacitors. There is no clear separating line, for the gap is bridged in practice by the paper capacitors. The first group is the power pack group, the second the circuit group.

Electrolytic capacitors are defined as members of one of two types, high voltage and low voltage. The peak voltage rating which separates these two types is taken as 100 volts. It is expected that the power factor of the low-voltage capacitors will be higher than that of the high-

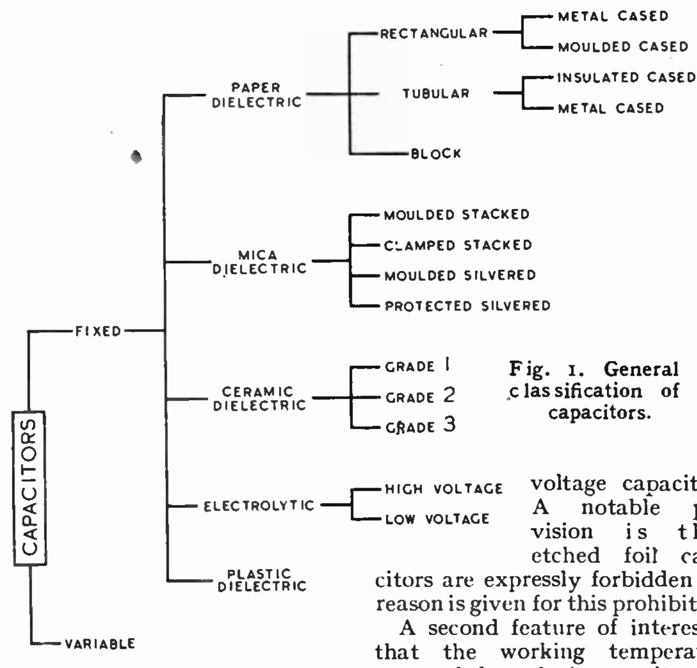


Fig. 1. General classification of capacitors.

voltage capacitors. A notable provision is that etched foil capacitors are expressly forbidden; no reason is given for this prohibition.

A second feature of interest is that the working temperature range of electrolytic capacitors extends only to −30 deg. C., instead of the usual −40 deg. C. This is surprising, for we should have expected that the increased power factor at these low temperatures would have resulted in sufficient heat to bring the capacitor up to a reasonable working temperature. The marking clause of the specification is somewhat unfortunate. Electrolytic capacitors are to be

Standardised Components—
marked with the month and year of manufacture, and with two voltage ratings; there is no requirement for any indication of capacitance! The two voltage ratings apply to maximum ambient temperatures of 71 deg. C. and 60 deg. C., of which the first is to be the principal marking. In the past, it was, we believe, the other way round.

Another example of loose thinking is provided by the requirement that the capacitors shall be capable of operating with an applied DC voltage equal to the peak rating together with a sinusoidal ripple, the RMS value of which shall be 12 per cent. of the peak rating at 50 c/s or 6 per cent. at 100 c/s. In all the tests applied, however, the DC voltage is only 80 per cent. of the peak rating, with a further 12 per cent. of 50-c/s ripple. This figure would seem to be the realistic one. A further point emerges when we consider the use of the capacitor. These figures are obviously related to the design of power packs for 50-c/s operation, both with half-wave and full-wave rectification. If a practical case is considered, however, we find that for a 300-volt full-wave power pack delivering 100 mA, the ripple across a 4 μF reservoir capacitor will be about 18 per cent. The specification does not help us here. Nor is this all: surely the Services quite commonly use supply frequencies much higher than 50 c/s. What is needed,

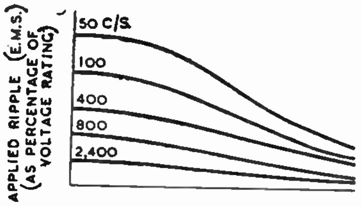


Fig. 2. Hypothetical rating characteristics of electrolytic capacitors.

and we would ask that the projected "guide" which forms part of the BS/RC series should incorporate it, is a set of curves of the form shown in Fig. 2, for which we have no adequate data. With such information the power pack designer would no longer be working in the dark.

Paper capacitors are more straightforward: they are classified according to the shape and case material; rectangular or tubular (cylindrical), metal or insulated case. This is in accordance with everyday usage and its only disadvantage would appear to be the lumping of moulded cases with waxed paper tubes. A qualified ban is imposed on the use of chlorinated naphthalene in the manufacture of capacitors. This material may be used only for large values (1 μF and over) and low voltages (below 250 volts). This prohibition will not interest the average user, who probably does not know whether his pre-war capacitors used chlorinated naphthalene or not.

The normal question for the power pack designer is whether he should use paper or electrolytic capacitors: this problem also arises for the decoupling stages of audio-frequency amplifiers. In Table 1 are given those properties in which differences appear. This table should help in the formation of a decision, although other factors, particularly bulk and cost, must also play a part. The writer's interpretation of this table is that the chief use of electrolytic capacitors is in "brute force" smoothing circuits in equipment which will not experience extremes of temperature. Although earlier in this article attention was drawn to the risks imposed by our ignorance of the behaviour of electrolytic capacitors with large ripples at frequencies well above 50 c/s, our knowledge of the safety margins for paper capacitors is almost equally small.

When we turn to the circuit uses of capacitors, we find that for most audio-frequency applications paper capacitors must be used. For filters it is possible to use mica capacitors, partly because we usually need special values and close tolerances. In amplifier circuits, however, our coupling and decoupling needs will commonly be met by paper. The chief factors are capacitance stability, which must be better than 10 per cent., and insulation resistance. The insulation resistance of a paper capacitor is permitted to fall, after cycles of humidity, to 100 megohm-microfarads. This means that a 1 μF capacitor connected from the anode of one valve at 250 volts to the grid of a second valve which

TABLE 1

COMPARISON OF STANDARDISED PROPERTIES OF PAPER AND ELECTROLYTIC CAPACITORS.

Property	Paper	Electrolytic
Capacitance tolerance	Given in preferred list; probably ± 20 per cent. at any frequency from 50 c/s to 2,000 c/s	+ 50% / − 20% at 50 c/s; DC applied
Power factor ...	Less than 0.01	Less than 0.15 for HV; 0.2 for LV
Voltage overload (voltage proof in spec.)	Three times working voltage up to wkg. V of 3,000 DC	Maximum peak voltage (during low-pressure test)
Insulation resistance	Not less than 2,000 megohm-microfarads or 10,000 meghoms, whichever is smaller. This may fall by 50 per cent. after one cycle of humidity	Leakage current is 0.15 CV microamp or 100 μA, whichever is greater (0.66 megohm-microfarads)
Behaviour at low temperatures	− 40° C.; Capacitance implicitly constant within ± 10 per cent.	− 30° C.; Capacitance may fall by 50 per cent., and impedance may increase to three times initial value

has a one-megohm grid leak, may apply a positive bias of 0.25 volt to the second valve. This seems to be trivial, for an equal negative bias would be applied by a grid-current of only 0.25 microamp.

In the vision-frequency stages of television amplifiers we must again use paper capacitors, for the low-frequency end of the spectrum demands large capacitance values; at the other end of the spectrum where the frequency is several megacycles, the inductance of the capacitor becomes appreciable. The specification states that tubular capacitors should not have inductance exceeding 0.025 μH per inch. This means that a 0.1 μF capacitor four inches long (with short leads) will resonate at about 1.6 Mc/s, and a 0.01 μF capacitor of the same size will resonate at 5 Mc/s. At higher frequencies the capacitor will have an inductive impedance, although this will be very small unless an anti-resonance is approached. Even this may not result in a high impedance, as it is most unlikely that the capacitor will have a good Q at such frequencies.

For more normal intermediate frequency and high-frequency circuits we are presented with an array of mica and ceramic capacitors. Ceramic capacitors are classified into three grades. This time grade is used to distinguish temperature coefficients; the writer commented last month on the dreadful confusion the use of this word is going to cause. Grade 1 ceramics are new. A series of positive and negative temperature coefficients with close tolerances is promised, and it is believed that the range from +180 to −750 parts per million per degree centigrade will be covered, and that a tolerance of ±20 p.p.m./degree C. will be available. If this is in fact so, these ceramic capacitors should prove very useful, both for compensation and for stability. Ceramic capacitors in Grade 2 are the familiar tubular types, with only a choice between −750 and +100 for the temperature coefficient. It would appear that the old types with 80 and 130 have now been lumped together. No temperature coefficient at all is specified for Grade 3, and we are told that the cup and disc types belong to this class.

Mica capacitors are classified according to their method of manufacture. Stacked mica capacitors are made by interleaving metal foil and mica sheets, alternate foils being brought out at opposite ends. The resulting stack may be moulded in a bakelite case, or clamps may be fitted to ensure good thermal cyclic behaviour, and the resulting capacitor sealed up in a metal, ceramic or moulded case. Silvered mica capacitors have the electrode deposited directly on the mica plates. Assemblies of such plates may be enclosed in mouldings or may be clamped, stiffened and then impregnated. This latter treatment is reported to permit of particularly fine adjustment.

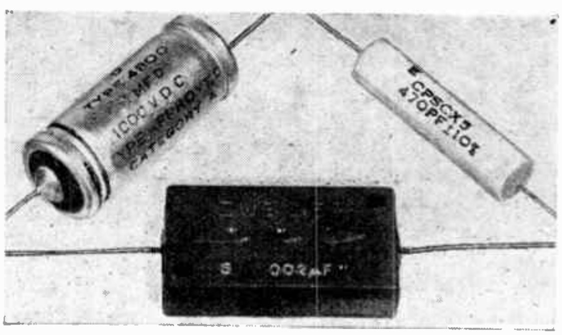
The writer always finds it difficult to decide whether to use mica or ceramic capacitors, and which particular variety to use. A comparative table is provided in Table 2. We do not see very much difference here, and we shall probably continue to rely on our personal prejudice. The reader is left to form his own.

The writer has not yet seen the lists of preferred values which will form part of the Radio Components Book. It is believed, however, that while ceramic capacitors are made to the logarithmic "preferred number" values,[1] all other capacitors are made in what are miscalled "popular" values. This opportunity for a wholesale rationalisation will never occur again; cannot all our numbers be made to

TABLE 2

COMPARISON OF STANDARDISED PROPERTIES OF MICA AND CERAMIC CAPACITORS

Property	Ceramic	Mica			
		Moulded Stacked	Clamped Stacked	Moulded Silvered	Protected Silvered
Power factor ...	Less than 0.003 for insulated types Less than 0.0015 non-insulated types	0.005	0.005	0.003	0.003
Insulation resistance	10,000 megohms	10,000 megohms or 2,000 megohm-microfarads			
Temperature Coefficient	See text: $\pm 20 \times 10^{-6}$ per degree C.	None given	$\pm 60 \times 10^{-6}$ per degree C.		
Stability under low pressure	1 per cent. (or 1μμF)	2 per cent.		1 per cent.	



Dubilier capacitors of types conforming to the specifications discussed; they include metal-cased tubular paper, ceramic and moulded mica patterns.

[1] The numbers are **10**, 12, **15**, 18, **22**, 27, **33**, 40, **47**, 57, **68**, 81, **100** . . . etc. Values in heavy type are 20% tolerance; others 10%.

Standardised Components—conform to the preferred number series? Capacitances and working voltages could both be brought into this form. Why not make the working voltages 220, 330, 470 and so on? Why not give us 4.7 μF and 6.8 μF capacitors? Indeed, let us go farther, and standardise 470 kc/s as our intermediate frequency, and 6.8 volts as our heater voltages. We urge a wide consideration of the extension of the use of these numbers.

Whilst writing this article an American advertisement caught the author's eye. The American Services have also been compiling specifications, and one manufacturer is issuing the specification as part of the catalogue of his products. Thus real performance data and blurb are brought together. This idea is commended to British sales managers, if and when they can find any paper for catalogues of their products.

OUR COVER

THE illustration this month shows a group of Dubilier capacitors of the types subject to wartime standardisation as discussed in the above article.

AIRCRAFT DF EQUIPMENT

1.—Some Recent Developments

By *CHARLES B. BOVILL,*
A.M.I.E.E., A.M.Brit.I.R.E.

Although the time has not yet come for describing the newest applications of radio to air navigation, it is possible to discuss some of the developments that have taken place in direction-finding technique. In next month's issue we hope to describe a highly developed DF equipment of which the operation is almost entirely automatic

THE main difficulties in the design of aircraft DF installations are associated with weight considerations involved in the receiving gear and restrictions in the permissible aerial arrangements due to the necessity for efficient streamlining. The design of aircraft direction finding receivers has therefore been centred around small loop aerials usually between 5in. and 10in. in diameter enclosed in streamlined housings.

The effective height of such loop aerials is of the order of 10 to 20 centimetres, making it necessary to use receivers of very high sensitivity. A further requirement is that the loop bearings can be "sensed" or checked for the 180 deg. ambiguity which occurs on any bearing taken with a simple loop. This is usually accomplished by the use of the "switched cardioid" system.

For those readers not familiar with this system it should be explained that this is achieved by combining the loop output with the output from a vertical aerial in the following manner. When the loop aerial is placed with its windings at right angles to the source of signal, no voltage appears across it owing to the currents induced in its sides being in phase opposition and cancelling each other; it will therefore be understood that if, for example, the no-signal or null position occurs at a reading of 100 deg. on the loop scale, the signal output at a reading of 120 deg. will be of opposite phase to the output which appears at 80 deg. If these outputs are combined with the output of a vertical aerial which has a substantially omni-directional polar diagram, and therefore of unchanging phase, in one position of the loop the phases of the loop aerial and vertical aerial will add, while in the other position of the loop they will tend to cancel out. The effects of this combination will be an increase in signal amplitude when the phases are similar and a decrease in signal amplitude when they are dissimilar. It is therefore only necessary, in order to check sense, to offset the loop in a predetermined direction from the null position (the convention being to increase the loop reading), connect the vertical aerial and note if an increase or decrease in signal strength occurs.

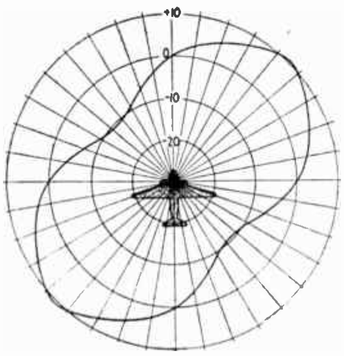


Fig. 1. Typical quadrantal error curve of an aircraft direction finder. (From "Principles of Aeronautical Engineering," by Sandretto.

Inherent Errors.—The aircraft loop installation is, of course, subject to the same errors which are found in ship and ground installations. For example, there are quadrantal errors, but these can be reduced by careful positioning of the loop, and are more symmetrical than on ships due to the clean structure of a modern aircraft. This type of error shows itself as a crowding and spreading of bearings observed on certain parts of the loop scale, and is due to interference with the directly received signal by signals reradiated after striking the metallic structure of the aircraft such as the wings, fuselage and propellers.

Due to the shortcomings of the non-radio navigational apparatus in aircraft exact determination of position and direction while in flight has been a difficult problem. This is partially due to the behaviour of compasses and gyroscopes in fast-travelling aircraft, and also to the large number of ferrous objects which of necessity must be part of the aircraft's equipment. It will therefore be appreciated that the accuracy obtainable with radio navigational devices was closely related to the accuracy of the normal navigational instruments, and that, except for the "beam flying" used in the United States of America, the radio navigational aid was generally looked upon as a secondary item of equipment for position finding, mainly to be used in emergencies.

Gyro Magnetic Master Compass. –The accuracy of aerial navigation has undergone a great improvement by the recent development by the Royal Aircraft Establishment of a much improved compass for airborne use, the Gyro Magnetic Master Compass. This device has the advantage of overcoming the weaknesses of the normal gyroscopic compass, which are due to the airspeed factor, by the substitution of a magnetic compass control in place of the gravitational control which gives the marine-type gyro compass its north-seeking properties.

The gyro magnetic compass is designed to be placed in any part of the aircraft fuselage, and can therefore be kept clear of serious interfering fields from ferrous parts and thus installation errors are reduced. It is also capable of being adjusted for magnetic deviation while in flight.

It has the very great advantage of being arranged for remote repetition of its readings in any required part of the aircraft; thus all the compasses in the aircraft will have identical readings without calculation, allowing for closer co-operation between various members of the crew, such as pilot, wireless operator and navigator, during a difficult navigational operation.

Visual Indication of Loop Nulls. —With the improvement in the basic navigational instrument of the aircraft parallel development has taken place in airborne DF apparatus. There is now a real incentive to increase the standard of accuracy of such devices and in any case the requirements of modern aircraft have become more exacting.

The acoustic noise level is in some military aircraft very high indeed, in some cases up to 120 db; the human ear, due to its AVC action, becomes desensitised under such conditions of overload, and hearing may be reduced by 60 per cent. Thus if an aural loop null is being taken on a weak signal the zero signal region and its approaching region may appear to be very broad; if the null is not symmetrical, a substantial error may be introduced. This can best be illustrated by stating that a null taken on a given signal on the ground with the engines stopped may appear to be ten times as broad when airborne, owing to the ear not being capable of detecting the weak signal when desensitised under the conditions of noise.

This difficulty has been overcome by the visual presentation of loop nulls in place of the aural indication. The visual indicator is also used for homing by the

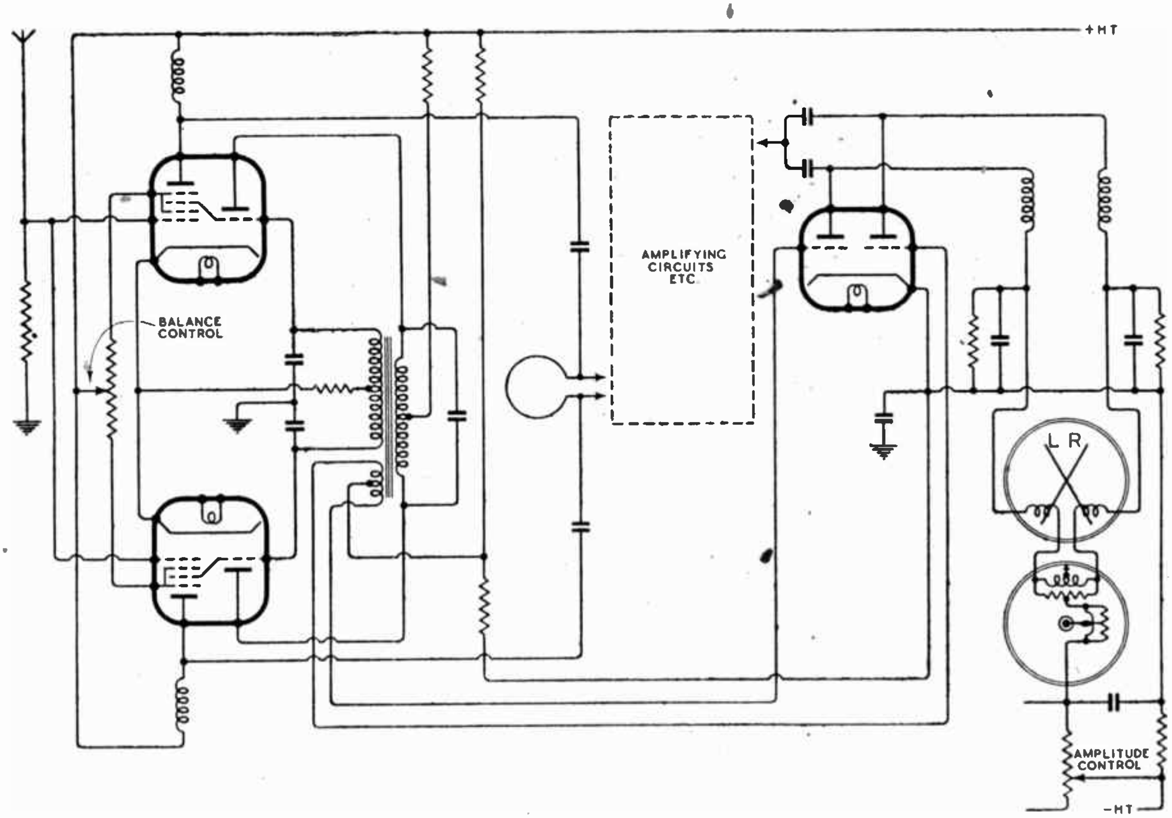


Fig. 2. Circuit diagram of a "switched cardioid" DF receiver with electronic switching.

Aircraft DF Equipment—

pilot, the usual arrangement being for two meters to be included in the circuit, one being for the wireless operator and the other for the pilot.

The visual indication of the loop null must give left, right and "on course" or local null indication. For this purpose the use of a centre-zero meter would appear to be the obvious choice; the modern tendency is, however, to use a twin-needle instrument which consists of two micro-ammeters with pointers intersecting in the centre of the dial face. Indication of direction is shown by both needles pointing in the same direction when off course and intersecting centrally when on course. This type of meter has various advantages. For example, when "on course" an increase in signal strength is shown by a rising of the needles up to the face of the dial as the source of signal is approached. Collapse of the needles when flying directly over the source of signal is due to "cone of silence" effect. It also indicates instantly if the signal being homed upon ceases, which would not be apparent on a centre-zero instrument.

Visual DF Circuits.—In the earlier types of visual-null aircraft receivers the switched cardioid arrangement was used, the vertical aerial phase being alternately switched by alteration of the point of connection from the top to the bottom of the loop; ganged to this switch mechanically a further switch connected the receiver output to the windings of a centre-tapped output meter. In this way the amplifier outputs were compared. The switching was done by a high-speed motor with commutators, but required constant maintenance and was not altogether satisfactory.

In a recently described aircraft DF installation[1] the switching of the aerial and the visual meter is carried out electronically; the basic circuit of the receiver is shown in Fig. 2.

Triode-hexode valves are used to provide the switching and diode valves to rectify the output from the amplifier in order to operate the visual null meter.

The circuit operates in the following manner: The triode-hexode valves have two functions, the triode sections being used as a push-pull oscillator and the hexode valves as isolator valves; if the amplitude of the oscillations of the push-pull oscillator is great enough, on each negative cycle of the oscillator grid the anode current of the hexode will be cut off, due to the triode grid being connected internally and in the electron stream, while at the same instant the grid of the other triode will be positive and its corresponding hexode will pass anode current. The hexode grids are connected in parallel and to the vertical aerial, the anodes being connected differentially to the loop, thus providing the switching conditions necessary for the aerial circuit.

The output diodes are switched by grids between cathode and anode, which alternately make them conduct and cease conducting. The controlling grids are connected to the push-pull oscillator, and the diodes are therefore synchronised with their respective hexodes.

The amplitude control in the meter circuit regulates the current passed by the diodes, and hence the height of the needles on the dial face. The balance control equalises the anode currents of the hexode sections of the triode-hexode valves.

Quadrantal Error Calibration.—Progress has also been made in research into quadrantal errors of aircraft installations, presumably due to the quantities of aircraft of the same type which have been available for such work. It has been found that the QE for a given type of aircraft is consistent enough to make it possible to eliminate the necessity for individual calibration of each loop installation, providing that the loop is accurately installed. The present-day technique is therefore to make a master calibration for a given type of aircraft and to use this for correction of readings. It is interesting to note that deviations from this calibration usually indicate a fault in loop installation or aircraft bonding.

[1] *The Marconi Review*, October-December, 1944.

FREQUENCY ALLOCATIONS

U.S. Recommendations and Present Frequencies Compared

FREQUENT reference has been made in recent issues of *Wireless World* to the proposed changes in frequency allocations in the United States. Many of the proposals have been those of individuals or organisations called to give evidence before the Federal Communications Commission during its sittings to investigate the frequency allocation problem before making recommendations to Congress.

Details have now been made available of the recommendations made by the Government's Inter-department Radio Advisory Committee (I.R.A.C.) and the Radio Technical Planning Board (R.T.P.B). In a recent issue of our Washington contemporary, *Broadcasting*, these recommendations, together with those of the American Radio Relay League (A.R.R.L.) for amateur frequencies, were compared with the present allocations to the various services.

In view of the inevitable post-war frequency re-shuffle in the Eastern, as well as the Western, Hemisphere, we give below a comparative summary of proposals.

Standard Broadcasting

Present: 550-1,600 kc/s.
I.R.A.C.: 540-1,600 kc/s.
R.T.P.B.: 520-1,600 kc/s.

FM Broadcasting

Present: 42-50 Mc/s.
I.R.A.C.: 42-54 Mc/s.
R.T.P.B.: 41-43 Mc/s (Educational), 48-56 Mc/s (Commercial).

Television

Present: 7 channels, 50-108 Mc/s; 11 channels, 162-294 Mc/s
I.R.A.C.: 54-108, 460-508 and 524-956 Mc/s; 180-192 and 206-218 Mc/s (mobile television and relay).
R.T.P.B.: 60-114, 144-156, 162-228 and 234-246 Mc/s (400-1,000 Mc/s experimental).

International Broadcasting

Present: 6.0-6.2, 9.5-9.7, 11.7-11.9, 15.1-15.35, 17.75-17.85, 21.45-21.675 and 25-27 Mc/s.
I.R.A.C.: No international broadcast channels. Suggests international point-to-point relays in following bands: 6.25-6.9, 9.2-9.985, 10.2-11.85, 15.015-16.2 and 17.15-17.6 Mc/s.
R.T.P.B.: Present allocations plus 25.6-25.75 Mc/s.

Broadcast Relay

Present: Bands from 1.606-39.82 Mc/s.
I.R.A.C.: 156-158 Mc/s.
R.T.P.B.: Present allocations plus 330-344 and 1,210-1,220 Mc/s.

Amateurs

Present: 1.75-2.05, 3.5-4.0, 7.0-7.3, 14.0-14.4, 28-30, 56-60, 112-116, 224-230, 400-401 Mc/s.
I.R.A.C.: 3.5-3.9, 7.0-7.4, 14.0-14.4, 21-22, 28-30, 144-149, 218-225, 420-460, 1,125-1,225, 2,500-2,700, 5,200-5,750, 10,000-10,500 and 21,000-22,000 Mc/s.
R.T.P.B.: 3.5-4.0, 7.0-7.3, 14.0-14.4, 21-22, 28-30, 56-60, 114-118, 224-230, 448-480, 940-960, 1,786-1,920, 3,600-3,850, 7,150-7,700, 14,250-15,400 and 29,200-30,000 Mc/s.
A.R.R.L.: 1.75-2.05, 3.5-4.0, 7.0-7.3, 14.0-14.4, 21-22, 28-30, 56-60, 112-116, 224-230, 448-480, 896-960, 1,792-1,920, 3.584-3,840, 7,168-7,680, 14,336-15,360, 28,672-30,720 Mc/s and above.

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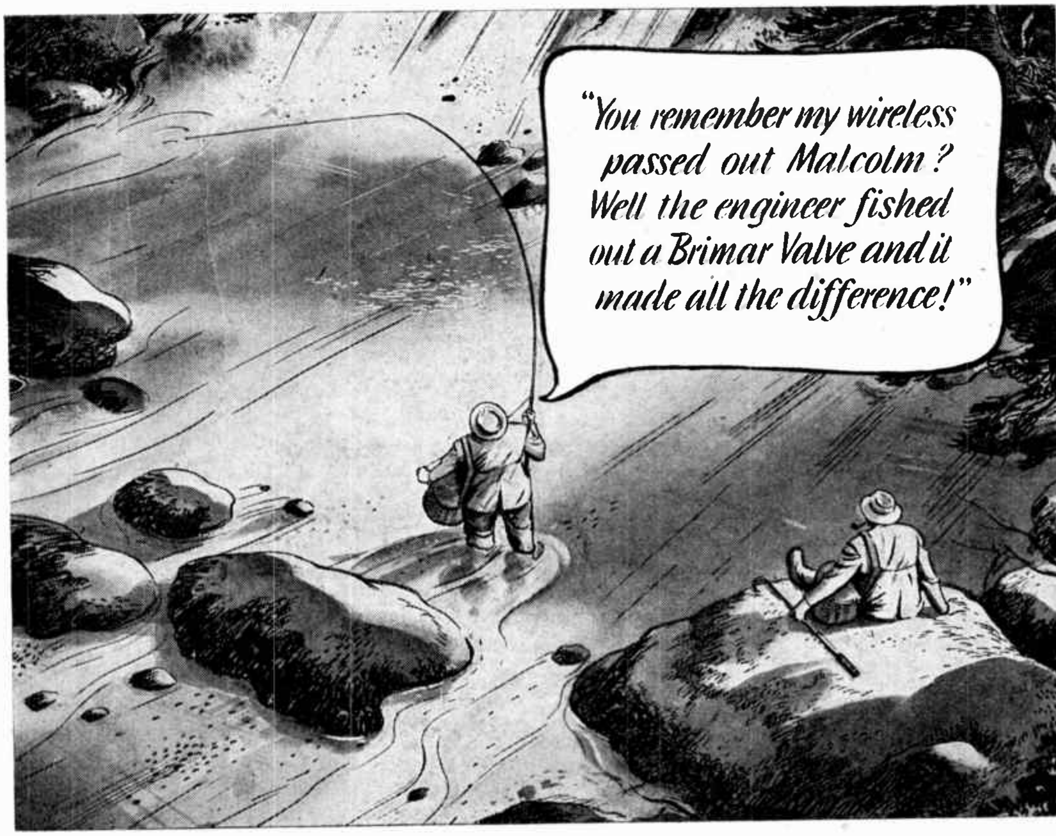

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Further Notes on a SMALL DIELECTRIC HEATER

Parallel v. Push-Pull Circuits : RF Meters

By L. L. LANGTON, A.M.I.E.E.

The circuit arrangement for a small dielectric heating equipment published in the September issue, has occasioned some comment on the fact that the oscillator valves are used in parallel instead of the more conventional push-pull arrangement. In this article the author discusses some of the reasons which influenced the choice of circuit arrangement and other points which arise in the design of equipment.

THE rate of heating in dielectric materials is proportional to the product, f (K cos θ), of frequency and loss factor. Since the change of loss factor with frequency (Fig. 1) is comparatively small it follows that the frequency of operation should be made as high as can conveniently be attained.

It is a well-known fact that valve interelectrode capacitances are effectively in series across the tuning inductance in a push-pull circuit, and this fact has been advantageously employed when striving for operation at high frequencies. For dielectric heating however the attainment of a high frequency of operation is not the only consideration. Power must be generated at this high frequency and for the latter requirement to be met a very different set of conditions prevail.

To obtain maximum power from any device employing a thermionic valve as a generator, there is an optimum value of anode load, it being in the case of an oscillator

$$\frac{\text{Max. oscillatory anode voltage}}{\text{Max, oscillatory anode current}}.$$

The value of both these quantities was dealt with in an article by the author in the April, 1944, issue in which it was also shown that the optimum anode load for push-pull operation was twice that for a single similar valve, as the oscillatory anode current during each half cycle is equal to that taken by one valve, while the oscillatory voltage across the tank circuit is twice that across either valve.

For parallel operation both the valves will be generating power during the same half cycle and the oscillatory anode voltage will be the same as that across one valve. The optimum anode load will now be one-half that required for one valve and hence one-quarter that required where the valves are operated in push-pull.

As the value of anode load at a given frequency is $Q\omega L$ the inductance of the tank coil will be four times greater in the case of push-pull than a parallel arrangement for the same value of loaded Q. Owing to the method by which the grid excitation voltage is obtained in a conventional Hartley push-pull oscillator (Fig. 2) the capacitance due to the valve electrodes is across more than half the tank coil. The LC multiple will be higher and hence the frequency of operation lower than if the two valves were employed in parallel.

It is worth while considering a simple numerical example in the case of two valves to be operated in push-pull and parallel. The peak grid voltage applied under Class "C" conditions will be assumed to have a not unreasonable value of one-quarter that across one valve. We will also assume that the interelectrode capacitance forms the total tank capacitance and compare the operating frequencies with each type of circuit.

If C = 1 represents the total interelectrode capacitance due to one valve and L = 2 the optimum anode inductance for parallel operation we have an LC multiple of 4 in the parallel case since the valve capacities are in parallel. With push-pull the optimum inductance will be L = 8, and since to obtain grid drive voltage each valve is across 5/8 of the coil the effective LC multiple will in this case be 5. Now the operating frequency is inversely proportional to $\sqrt{LC}$ so the frequency at which maximum power could be generated will be 11 per cent. higher in the case of parallel operation.

This example cites a somewhat exaggerated case, as in practice the interelectrode capacitance will not form the total tuning capacitance, but it must be remembered that when operating at high frequencies it will constitute a considerable proportion of it. Furthermore, the grid tap arrangement would be modified at high frequencies due to interelectrode

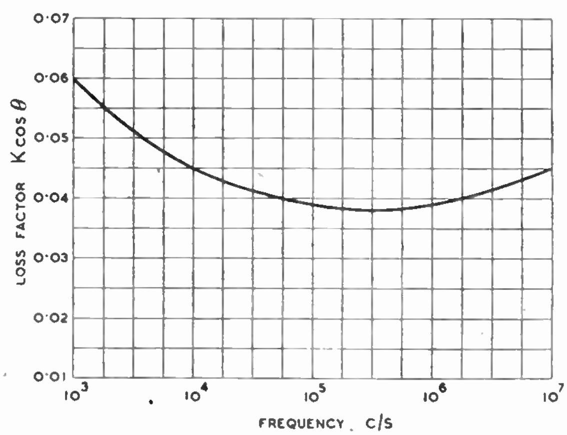


Fig. 1. Variation of loss factor with frequency for a typical phenolic resin.

Small Dielectric Heater—

feed back. Owing to this extra coupling circuit the mode of oscillation becomes somewhat complex when an attempt is made to work with the conventional push-pull Hartley oscillator at high frequencies.

The value of loaded and unloaded Q of the tank circuit determines the amount of power that can be transferred to the work. Calling the unloaded value Q_O and the loaded value Q_L the proportion of the total power of which the valve is capable that can be transferred to the work is $\frac{Q_O - Q_L}{Q^O}$. It will be seen that if Q_O is large Q_L may have a value of anything between 10 and 50 without greatly affecting the transfer of power.

For dielectric heating the value of Q_O can be several hundreds or even a thousand in the case of a well-designed tank coil, so the loaded Q value is hence not critical. On the other hand, with eddy current heating equipment the unloaded Q value will be fairly low as the inductively coupled work coil will itself load the oscillator considerably before work is included. Under such conditions the loaded Q value must for reasons of efficiency be as low as possible. The minimum practicable value is 10, as below this the harmonic content becomes prodigious.

Since the load presented to the valve by the tank circuit is $Q\omega L$ a considerable advantage accrues from the use of a higher loaded Q value in the case of dielectric heating. The value of L required to obtain the necessary load is lower for a high-Q circuit and the LC multiple due to unavoidable stray capacitance, such as that attributable to valves, will itself be reduced. This means that the work capacitance across the tank coil may be higher without depressing frequency or, if the work capacitance is low, the frequency may be higher than could be obtained with a lower loaded Q value.

An expression for the power absorbed in a dielectric was given in an earlier article and is here restated.

$$P = \frac{0.225\ \omega}{10^{12}}\left(\frac{E}{d}\right)^2 V\ (K \cos\theta)$$

where

d = electrode spacing in inches.

V = volume of dielectric in cubic inches.

It will be seen that the square of the potential gradient through the dielectric is an important factor in assessing the power absorbed. It may seem to some readers that a potential measuring device such as a valve voltmeter would be more useful than the indicator incorporated.

Owing to the prominence with which it figures in apparatus used during the last war, the thermal or hot wire ammeter may appear a somewhat archaic device, but it nevertheless has a definite field of application where a cheap and self-contained instrument is required for measuring RF currents.

Were a valve voltmeter placed across the work of a dielectric heater, conditions would be upset and any reading obtained liable to errors. The capacitance of the work is in many applications only a few micro-microfarads, and the input capacitance of a valve voltmeter of any conceivable type would considerably reduce the operating frequency and so create a fictitious set of conditions.

The voltage to be measured is very high, even in the case of the small dielectric heater described. The tank coil has an inductance of one microhenry, and the tank circulating current can reach a value of 10 amps if the equipment is pushed hard. The tank coil reactance at 30 Mc/s will be $2\pi \times 3 \times 10^7 \times 10^{-6} =$ 188 ohms and the RMS voltage across the work will be 1880.

It may be argued that the valve voltmeter could be tapped across a small portion of the tank coil and measure a correspondingly reduced voltage. The effect of valve voltmeter input capacitance would be somewhat masked by being tapped down the coil, but the precise value of the effective tap ratio would be very difficult to determine owing to unavoidable strays, which would be significant at a frequency of 30 Mc/s. A further point is that to reduce pick-up the screening of the input leads to the valve voltmeter would need to be thorough, as they would be situated in the strong field, due to the tank coil. With thorough screening the input capacitance would, of course, be much increased.

The voltage developed across the work is given closely by the expression $I/\omega C$, where I is the current flowing. The resistive component of the work is here neglected, but no large error results if the power factor of the work is low, and it is only one per cent. when $\cos\theta = 0.1$, a figure that is not likely to be exceeded in practice.

The expression for power absorbed in the dielectric may thus be rewritten simply—

$$P = \frac{I^2 \times 10^{12}}{\omega \times 0.225} \cdot \frac{d}{AK} \cdot \cos\theta$$

Note that in this case it is necessary to know the values of dielectric constant, K, and power factor $\cos\theta$ separately. The current I is in amperes, horizontal sectional area of work A is in square inches and distance between electrodes d is in inches.

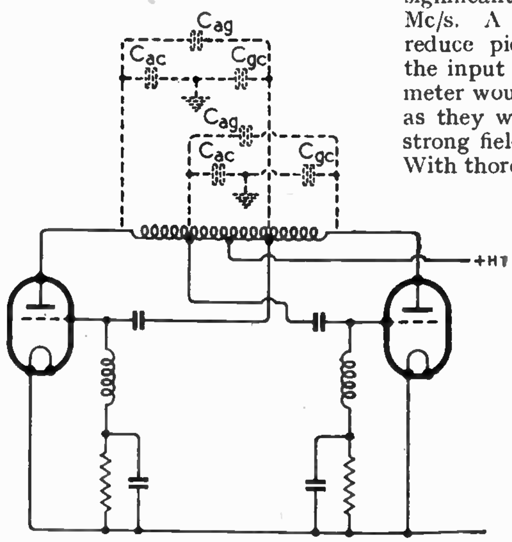


Fig. 2. Push-pull Hartley circuit showing disposition of nterelectrode capacitances.

THE "PHASE-COMPRESSOR"

A Resistance-Capacity Output Circuit Complementary to the "Phase-Splitter"

By D. H. PARNUM, B.Sc., A.R.C.S., Ph.D.

IN valve circuits the problem of converting a voltage, one side of which is earthed, to a push-pull voltage (i.e. one which is balanced to earth) is often encountered; a very common example is the provision of a push-pull voltage for driving the output stage of an AF amplifier.

The most obvious solution of this problem is to use a transformer. Since the primary winding is electrically isolated from the secondary, one end of the primary can be earthed to accept the earthed input voltage, and the centre point of the secondary can be earthed to provide a push-pull output voltage. For convenience, in what follows, the single-ended voltage will be spoken of as an "inphase" voltage, and the push-pull as an "antiphase."

The converse problem, that of converting an antiphase voltage to an inphase, is the subject of this article; but it will first be helpful to recapitulate the more usual solution of the first problem.

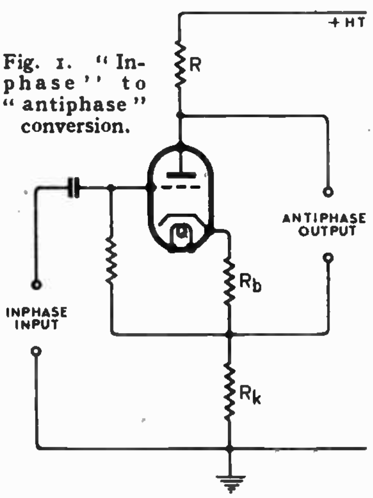


Fig. 1. "Inphase" to "antiphase" conversion.

Instead of using a transformer to convert inphase to antiphase, it is now customary to use some kind of valve circuit, of which the simplest is the well-known "phase splitter" shown in Fig. 1. The valve has equal anode and cathode loads. Bias is obtained by returning the grid to the lower end of the resistor R_b, while the AC input is applied to the grid through a blocking condenser. The DC voltage across grid and cathode is therefore that across R_b. Negative feedback in the cathode load R_k causes a voltage to appear across this load which is nearly equal to the input voltage. The change of anode current must be the same in both R and R_k, so that when these are equal the voltages appearing across them must also be equal. The phases of the two voltages are opposite, however, since a rise of anode current causes a rise in cathode voltage but a fall in anode voltage. Thus an antiphase voltage is produced at anode and cathode. The equivalent circuit, shown in Fig. 2, makes this quite clear. The top end of R can be regarded as earthed to AC of normal frequencies, so that it can be shown connected to the bottom end of R_k; and the valve becomes a generator feeding into a resistive load with the centre point earthed. An antiphase voltage is obviously developed across the ends of this load.

The merits of the phase-splitting valve are that it is cheap, even when considering its associated components; it has a really linear frequency response from practically zero frequency to far above the range of a transformer; and, since it works with 50 per cent. negative feedback, is practically free from distortion even at large outputs. As an example of this last statement, an MH4 delivering 45V peak across each load has about 0.2 per cent. distortion (the HT voltage being 350V). The fact that the valve gives no gain is not a disadvantage, since its function in this circuit is not to give gain but to convert inphase voltage to antiphase.

The problem of converting antiphase voltage to inphase is not so common; an example is the push-pull contrast expander, which must have its output voltage "compressed" before it can be used to operate a conventional amplifier. Other examples can be quoted from amplifiers used in scientific work. Once again the obvious solution is to use a transformer, in exact reversal of the previous case; the centre point

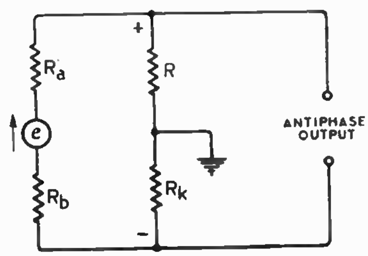


Fig. 2. Equivalent circuit of Fig. 1, R_a = internal valve resistance.

of the primary is earthed, and one side of the secondary. It is to be expected that an equivalent circuit using valves must exist, but this solution is not so obvious as in the first case. It is the purpose of this article to describe such a solution; but first of all it is desirable to make quite clear what it is we are trying to do.

The Function of "Phase-compression."—In Fig. 3 is shown a transformer whose secondary has the centre point earthed. The outer ends of the secondary thus provide an antiphase voltage, and it is desired to convert this to inphase. Where is the problem in this case? We have only to use one end of the secondary and the earthed centre point, and the problem is solved. It is clear that here there is no necessity for phase-compression.

The transformer of Fig. 3, however, is feeding a push-pull valve stage. Between the anodes of the two valves an amplified antiphase voltage is developed. Can we again compress this voltage by taking the output from either anode and earth? The answer is that we cannot if we

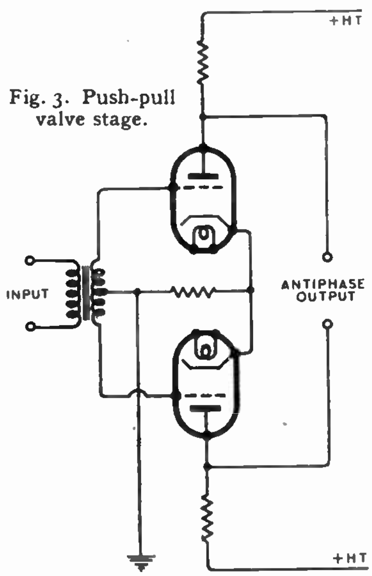
The "Phase-Compressor"—

wish to derive any advantage from the push-pull stage itself.

The difference between the two cases is that the output now consists of both inphase and antiphase voltages, whereas previously it was purely antiphase. Distortion in the valves produces harmonics of the input frequency, and simple consideration shows that the even harmonics are inphase at the anodes. Output taken from earth and one anode contains all these harmonics, whereas when the output is taken between the two anodes the harmonics cancel out (assuming equal distortion in the two valves). Any odd harmonics present are antiphase and cannot be eliminated by this process; but with triodes the percentage of odd harmonic distortion is small.

If a transformer is connected between the two anodes, the even harmonics cancel in the primary and the secondary is free from them. The secondary may then be used to provide either an inphase or an antiphase output. If it provides inphase output, with one end earthed, it is acting as the converse of a phase-splitting transformer; but it can now be seen that its function is quite different.

Fig. 3. Push-pull valve stage.



It is immaterial whether the transformer gives inphase or antiphase output; its essential function is to eliminate any inphase voltages present in the nominal antiphase input.

We can therefore define the two problems thus: the purpose of the phase-splitter is to reproduce exactly an inphase voltage as an antiphase. The purpose of the phase-compressor is to eliminate inphase voltages from a nominal antiphase input. If it does this, it is immaterial whether it gives output in either the inphase or antiphase form. The suggested name "phase-compressor" is thus something of a misnomer; but it is not much worse than "phase-splitter," and has the merit of shortness.

A valve circuit which fulfils the function of phase-compression will now be described.

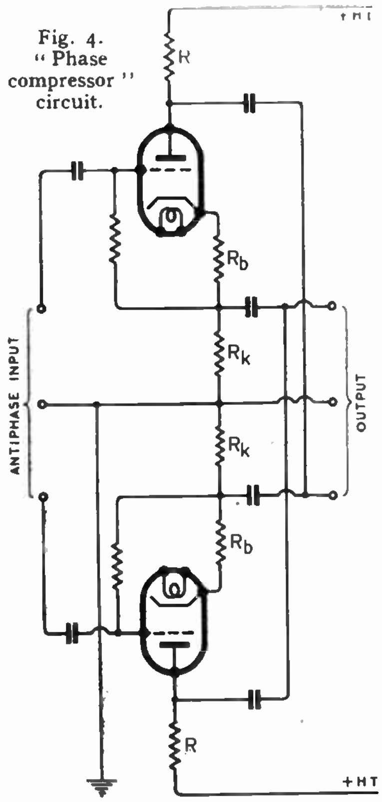
In Fig. 4 we have two valves, each connected with equal anode and cathode loads like the phase-splitter of Fig. 1. The anode of each valve is coupled back to the cathode load of the other through a centre-tapped condenser. The output is taken from the centre points and earth. The cathode bias resistors are unbypassed and are not included in the cathode load.

It will be assumed for the moment that the valves are identical linear amplifiers, the anode and cathode loads are all equal, the condensers are exactly centre-tapped, and the HT supply is of zero internal impedance. This latter condition means that the top ends of the anode loads can be regarded as earthed in the usual way.

Fig. 5 shows the equivalent circuit of Fig. 4. The effective voltages *e* and *e'* generated inside the two valves are shown in opposite phase, *e* being directed towards the anode load and *e'* towards the cathode load. (*e* and *e'* are the resultant generated voltages, i.e. they include the effect of feedback,) This therefore represents the antiphase case, corresponding to an antiphase input and is the case in which the valves are required to pass on the input voltage. The voltage *e* produces a voltage drop from A to B, A being positive with respect to earth and B negative (for the instantaneous phase shown in Fig. 5). The voltage *e'* produces a similar drop across B'A' B' being positive. The voltages *e* and *e'* are equal since the input voltages are equal and the valves are assumed to be identical. Hence the potential of the point A with respect to earth is the same as that of B', no current can flow through the coupling condenser, and the potential of C is the same as that of A and B'. Similarly, C' is at the same potential as B and A'.

For antiphase voltages there is

Fig. 4. "Phase compressor" circuit.



thus no interaction between the two valves, and the antiphase input is reproduced across the points C and C' with a gain of slightly less than 1. The loss is that normally produced by a phase-splitter, and is usually less than 10 per cent.

We now have to examine the case for an inphase input voltage, which is shown in Fig. 6. The effective voltages *e* and *e'* are helping round the outer net instead of opposing, and current flows through the coupling condensers as well as through the loads. If A is positive with respect to earth, B' is negative, as the diagram shows; and from the symmetry of the system A must be as much above earth as B' is below it. The coupling condenser between A and B' is thus an impedance with an antiphase voltage across its ends, and the centre-point of this impedance (i.e. the point C) must be at earth potential. Similarly the point C′ is at earth potential. Thus the inphase input voltage is eliminated at the points C and C′.

The circuit, therefore, does fulfil the function of phase-compression. Inphase voltages are eliminated and antiphase voltages are passed on with a gain of nearly 1. The output is provided in the form of an antiphase voltage ; but if an inphase output only is required, this is obtained between earth and either C or C′. The full advantages of phase-compression are not lost by doing so.

So much for the behaviour of an ideal circuit with matched components. It is now necessary to indicate what may be expected from a practical circuit. The complete mathematical analysis will not be given here, but the results will be quoted where necessary at the appropriate points.

Response to Antiphase Input.—The two factors here are the distortion produced, and the frequency response. The first factor is easily dealt with. For antiphase voltages all (or, with unmatched components, nearly all) the anode current flows through the loads, and there is 50 per cent. negative feedback as with a simple phase-splitter. This results in practically no distortion even at large inputs. As already stated, a single MH4 can handle 45V peak with only 0.2 per cent. distortion, so that a pair used in a phase-compressor can handle 90V total peak input. For lower inputs the distortion is proportionately smaller.

If the valves and components are matched, no current flows

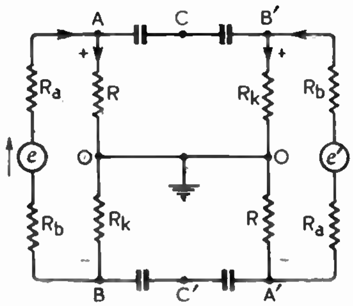


Fig. 5. Equivalent circuit for "antiphase" input. No current through coupling condensers.

through the coupling condensers at any frequency, so that although the reactance of the condensers varies with frequency the output at the centre point is constant. When matching is imperfect, however, the voltage across AB′ (and A′B) is not quite zero, and current must flow through the condensers. It would therefore appear that the voltage at C and C′ would vary slightly with frequency, the effect obviously being very small. Now the most likely example of mismatching will occur in the valves, since it is not difficult to select matched resistors and condensers. Analysis shows that, for small amounts of valve mismatching, the output at C and C′ is independent of the condenser reactance and hence of frequency.

It can therefore be said that the system has a truly linear frequency response. The upper limit is set in the usual way by valve and stray capacities, and is well outside the audio range ; at the lower end the rising impedance of the HT supply will have a small effect, but the system will still operate fairly well down to zero frequency.

It may be pointed out that if the two halves of the antiphase input are not equal, the two halves of the output are still equal. This result is true, however much the input is unbalanced.

Effect of Mismatching on Inphase Response.—Mismatching of any components must cause a slight transmission of inphase voltage, and the effect will now vary considerably with frequency. This does not matter provided the maximum effect is below the limit required. If valve variations are again considered, the worst case is at high frequencies. The factor controlling the inphase transmission is then practically the difference in mutual conductance of the two valves. If g_m = average mutual conductance, Δg_m = difference, R_b = cathode bias resistance, the percentage of input inphase voltage transmitted is $\frac{1}{2}(\Delta g_m/g_m)/(1 - R_b g_m)$. If we take as conservative figures R_b = 1,000 ohms, g_m = 3 mA/V, the percentage is $(1/8)\Delta g_m/g_m$. Thus a difference of 10 per cent. in g_m will give just over 1 per cent. inphase transmission. This example shows the importance of leaving the cathode bias resistors unbypassed. Negative feedback in these resistors has the effect of bringing unmatched valves much more in line with each other.

Mismatched resistors and condensers produce errors of the same order as the percentage of mismatching. In the case of the condensers the error is only apparent at low frequencies, since at high frequencies the reactance is negligible and the accuracy of centre-tapping unimportant. It must not be thought, however, that it is easy to drive the error below the audio range by using large coupling condensers. The condenser mismatch error becomes

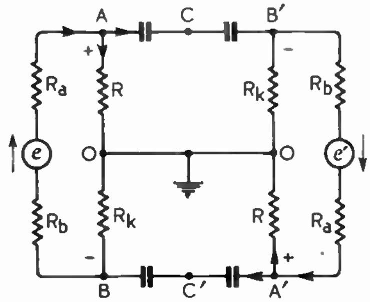


Fig. 6. Equivalent circuit for "inphase" input. Current flows through coupling condensers.

important, not at a frequency where the condenser reactance is comparable with the anode and cathode loads (as might have been expected), but at a frequency where it is comparable with the cathode bias resistor. For example if R_b = 1,000 ohms and we wish to drive the error down to about 50 c/s, each half of each condenser would have to be about 8μF. Not only are such large values impracticable, but they are objectionable for other reasons explained below.

At frequencies below this critical limit the percentage of inphase transmission is half the percentage difference between the two halves of the condenser.

Handling Capacity.—The handling capacity for antiphase voltages is so large that there is unlikely to be any limitation on this account ; the inphase handling capacity, however, varies with the frequency. This may be seen with the aid of Fig. 7, which shows the inphase case for high frequencies. At these frequencies the condenser reactance is negligible, the resistance loads are tied together, and each pair of loads can be replaced by a single load of half the value. The voltage e

The "Phase-Compressor"—

can be regarded as driving a current through the loads, but for inphase voltages e' drives an equal current through the loads in an opposite direction. The resultant load current is therefore zero, and there can be no negative feedback in either valve due to the loads. Current still flows through the cathode bias resistors, however, and these produce some negative feedback. The final result is that each valve will handle an inphase input equal to its normal input capacity (governed by the available length of straight characteristic) multiplied by the factor $(1 - R_b g_m)$. For the figures already quoted this amounts to 4 times its normal input capacity, or at least 10V for an MH4.

At low frequencies for which the condenser reactance is not less than twice the load resistance, all the current flows through the loads, and there is 50 per cent. negative feedback. The handling capacity is therefore the same as in the antiphase case, and is much larger than at high frequencies. From this point of view it is obviously not desirable to use very large values of coupling condenser. If the value is too small, however, there will be bass loss in the coupling to the next stage; the best compromise is the usual value of about 0.1μF.

The use of a phase-compressor with a push-pull contrast expander provides a case of practical interest. The voltage "flutter" which occurs when the control

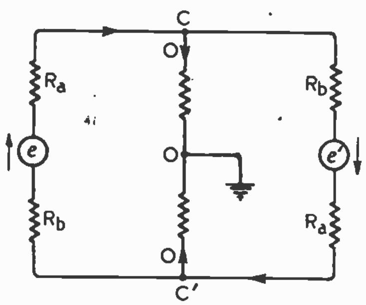


Fig. 7. Equivalent circuit for "inphase" input at high frequencies. Resultant load current is zero.

voltage alters has a frequency in the region of 10 c/s, and is of course an inphase voltage. Owing to the low frequency, full negative feedback will occur in the phase-compressor; the voltage is unlikely to exceed 50V, and so will be satisfactorily dealt with by the stage.

It need hardly be pointed out that, if the inphase handling capacity is badly exceeded, the danger is not so much failure to remove inphase voltage as distortion of the antiphase transmission. The inphase voltage may drive the valves so far into the cut-off or saturation regions that the response to antiphase voltage is quite spoilt.

There is one type of inphase voltage which the circuit does not eliminate: hum in the HT line, which is only reduced to half at the output points. In this respect the circuit is inferior to a transformer, which entirely removes hum. It follows for the same reason that the circuit must be decoupled.

Practical Details.—The valves may be any small triodes; alternatively, a double-triode (provided it has separate cathodes) should be quite satisfactory. The values of components are quite elastic, so long as they are well matched; loads of 10,000–25,000 ohms, cathode bias resistors to suit the working conditions, and condensers of about 0.1μF are suitable. It will be seen that the condensers isolate the DC anode voltages, and no further condensers are needed when coupling to the next stage.

A very satisfactory test has been carried out using a pair of MH41's, which happened to be available. The component values used were: $R = R_k = 10{,}000$ ohms; $R_b = 300$ ohms; coupling condenser (each side of centre point): 0.1μF; HT = 260V. Components were matched to within 2 per cent.; the valve mutual conductances differed by about 6 per cent. Using a 50 c/s input voltage, an inphase input of 4½V peak was reduced to about 1 per cent. at the output points. As the cathode bias works out to about 1V, this input voltage would hopelessly overload the valves if it were not for negative feedback; calculation shows that the resultant grid input voltage is about ¼V. A test with an antiphase input of 17V peak (to each valve) showed an undistorted output with a gain of about 0.95.

No attempt has been made in this article to sum up the advantages of the system as against those of a transformer. It is true that the transformer has inherent frequency and amplitude distortion, but this can always be reduced to low proportions by careful design and sacrifice of gain. On the other hand the phase-compressor is inherently free from such distortion. The best test is the practical one, and it is hoped that readers interested in the subject will try out the circuit in a high-quality amplifier.

"FEEDBACK AND THE LOUDSPEAKER"

A Correction

IT is regretted that an error occurred in the formula quoted and used in the article "Feedback and the Loudspeaker" in last month's issue, which may have misled some readers, and the author wishes to thank those who have written to him to point it out.

The error occurred in the formula $R'_a = \dfrac{R_a}{1 + M\beta}$ which was employed for calculating the effective R_a of the output valve with feedback. This formula should have read $R'_a = \dfrac{R_a}{1 + \mu\beta}$, where μ is the valve amplification factor. In the case of a pentode or tetrode output valve for which R_a is very large this formula may be approximately written as $R'_a = \dfrac{1}{g_m\beta}$.

Now the reduction in gain is given by $\dfrac{1}{1 + M\beta}$ as stated in the article. Substituting in this for β from the above expression, and putting $M = g_m R_L$ gives the approximate solution that the reduction factor is given by $\dfrac{1}{1 + R_L/R'_a}$ so that if we put $R_L = 2R_a$ as for a triode then the reduction becomes 1/3, which is much smaller than the value obtained in the article, 1/25. Certainly more feedback than this is necessary to damp the loudspeaker adequately. Needless to say this error, though unfortunate, does not in any way invalidate the logic of the arguments used in the article. S.W.A.

WORLD OF WIRELESS

B.B.C. LOOKS AHEAD

"THE B.B.C. has in the immediate post-war years no task more urgent and important than the stimulation of broadcasting within and about the Commonwealth. The British peoples, no matter how scattered they are, must get to know more about each other," said W. J. Haley, Director-General of the B.B.C., when addressing the Radio Industries Club recently.

For the fulfilment of such a purpose it is essential that the broadcasting organisations in the Dominions should discuss the question, pool their knowledge and experience, and thereby see how best they can make "Commonwealth broadcasting an even more useful service." It is with this purpose in mind that the B.B.C. has invited the chiefs of the Dominion broadcasting organisations to a conference in London in February.

The B.B.C.'s war correspondents will be succeeded by "peace correspondents," and Mr. Haley pointed out that it is the intention of the Corporation to have correspondents in the main centres and capitals of the world. He added: "It will be their duty to give impartial, objective, responsible information on matters of international moment. It will be our duty to broadcast these to our listeners at home so that from now on at least they shall be carefully informed on foreign affairs, as indeed they should be on home affairs."

The Director-General also outlined the rearrangement of the "home" service to be introduced as soon as possible after the end of hostilities in Europe, and indicated that FM may be expected in due course. The new service includes: The General Forces Programme on short waves only; two new Home Programmes—one capable of "regionalisation" on medium waves and a National Programme on long waves; and later a second National Programme.

TELEVISION RELAYS

THE action of the U.S. Federal Communications Commission in granting the Philco Radio and Television Corpn. permission to erect seven television relay stations in the areas of Philadelphia, Baltimore and Washington within a week of the application being made is indicative of the Commission's attitude towards television radio networks.

The power of these stations will be mostly 15 watts for vision and 10 watts for sound.

According to our Washington contemporary, *Broadcasting*, permission has also been granted to the R.C.A. for a 500-watt experimental portable relay station.

PROPAGATION DATA

RESTRICTIONS on the publication of data on the propagation of the higher frequencies, 8-100 Mc/s, has been lifted by the U.S. Joint Chiefs of Staff.

The ban is lifted on all data gathered in the U.S. or its possessions prior to October 16th, relating to vertical incidence measurements showing F region reflection at 10 Mc/s or higher, and E region reflection at 8 Mc/s or higher; and oblique incidence observations in the 40-100 Mc/s band, including multipath, shadow, or similar effects.

Data has also been made available by the Indiana State Police on skywave interference on FM.

OUR WAR EFFORT

THE Government's White Paper giving statistics relating to the war effort of the United Kingdom shows that the wireless industry's production of valves for civilian replacement purposes in 1943 was 3,500,000. In 1935 the total was 5,000,000. There were only 50,000 civilian sets manufactured in 1943, whereas in 1935 the industry's output was nearly 2,000,000.

The production of Army Signal Equipment has, of course, increased steadily since 1939, when the industry's output of Army "wireless stations," comprising both transmitters and receivers, was 3,000 for the period September - December. The total for the first half of 1944 had risen to 95,700!

INVASION "RADIO SHIP"

IT is learned from New York that during the landing of General MacArthur's troops on Leyte in October an American Army Signal Corps "radio ship" was used to transmit news of the action to the U.S. It was the first "radio ship" to be used for this purpose. The communiqué announcing the landing was beamed to the Army Communications Centre in San Francisco "via a series of booster transmitters."

WIDE BAND FM

MAJ. EDWIN H. ARMSTRONG, FM pioneer, has endorsed the recommendation of the U.S. Radio Technical Planning

World of Wireless—

Board for seventy-five 200-kc/s channels in the 41-56 Mc/s band for commercial and educational FM transmitters. For experimental transmissions a band in the higher frequencies is recommended.

He opposed the suggested reduction of the bandwith to 100 kc/s on the ground that it would adversely affect the signal/noise ratio.

ARMY FM SETS

IT is now revealed that the American Forces used FM pack transceivers during the Anzio landings, from which it may be gathered that they are now in general use. Reporting on the set, the U.S. War Department states that it "met and exceeded every expectation and established it as the most valuable item of radio equipment. . . . It is the most successful instrument yet developed for amphibious communications."

The SCR300, as it is known, is weather-proof and weighs about 35 lb.

VACATION WORK SCHEME

IN the ten years since the Vacation Work Scheme was inaugurated by the Imperial College of Science in 1934, the number of students registering for work during the summer vacation has increased from 31 to 477. The number of firms and research organisations taking part has increased from 17 to 214, among which are many of the major wireless concerns.

A total of 2,206 weeks of works experience was recorded by the 477 students during the 1944 summer vacation.

WHAT THEY SAY

RADIO PICTURE POSSIBILITIES.—It is the policy of Cable and Wireless to extend as rapidly as possible radio picture equipment to all our stations. . . . After the war the possibilities in this direction are boundless. Printed matter in page form will be flashed across the world permitting of simultaneous publication of newspapers from blocks made from the photographs of the page form. It will revolutionise the publication of news, opinion and advertisers' announcements and in respect of the latter it should play an important part in the development of trade overseas. . . .—*Sir Edward Wilshaw, chairman of Cable and Wireless.*

"PRAISE TO WHOM PRAISE."—Some day the story will have to be told in full of the wartime job of the B.B.C. . . . It is a story which, so far as broadcasting is concerned, cannot be paralleled in any other country in the world. It is a story which could not have happened if Britain had had a different system of broadcasting—if there had been no B.B.C.—*W. J. Haley, B.B.C. Director-General, addressing the Radio Industries Club.*

WHO TOLD HIM THAT?—The advance in radio progress is so great that it is almost frightening. They have got to the point in television where they could see and hear what was happening at distances and through heavy brick walls and what not. It is only another stage when we will be able to find out what people are doing when they do not want us to see and yet another stage we will find out what they are thinking when they haven't said a word. —*Herbert Morrison, Home Secretary, opening a Police Instructors' Course at Peel House, London.*

REALITY.—There has been some discussion as to how many cycles are good enough for the ordinary listener. I think the best way to state the difference between 10,000 c/s and 15,000 c/s is the difference between something which is good and something which is real.—*Major Edwin H. Armstrong, Professor of Electrical Engineering, Columbia University, the FM pioneer.*

MORSE ESSENTIAL.—Even if your chief interest is in voice operation, code knowledge is necessary. It's an essential part of amateur radio, properly required by the international treaties, and it will always be so. Besides, there are many things you can do on CW that you can't do on 'phone.—*American Radio Relay League.*

OUR DILEMMA, TOO!

"But if you don't explain radar to him, John, I'm afraid he'll pick it up from the boys on the street." *A. John Kaunus in the American magazine—"Collier's"*

PERSONALITIES

Sir Robert Watson Watt, Air Ministry Scientific Adviser (Telecommunications), headed the United Kingdom delegation to the British Commonwealth Conference on Radio for Civil Aviation which opened in Ottawa in November. The conference, which was the outcome of that held in London last February, was attended by 40 representatives from the U.K., Australia, New Zealand, Canada and Newfoundland.

Col. David Sarnoff, president of R.C.A., who is at present attached to General Eisenhower's headquarters as consultant on communications, has received the Legion of Merit.

Sir Murdoch MacDonald has agreed to extend his tenure as president of the Institution of Factory Managers and will preside at the extraordinary general meeting to be held in the Oak Room, Kingsway Hall, Kingsway, London, W.C.2, on Saturday, January 20th, at 2.30.

Professor William Wilson, who has recently retired from the Hildred Carlile Chair of Physics at Bedford College, was in his early years responsible for much of the experimental work on photo-electric emission and developed a quantum theory of thermionic emission. He was elected F.R.S. in 1923.

W. F. Higgins has been appointed Superintendent of the Physics Division of the National Physical Laboratory, in which capacity he has been acting since the death of the late Dr. G. W. C. Kaye. Mr. Higgins was also Secretary of the N.P.L. and he is succeeded in this office by G. S. Hiscocks.

Dr. K. R. Sturley has been appointed to the new post of head of the engineering training department of the B.B.C. He is at present assistant principal of the Marconi School of Wireless Communication, Chelmsford, and has frequently contributed to both *Wireless World* and *Wireless Engineer.*

A. G. Clark has been appointed chairman of the Plessey Company in the place of the late Henry Morgan.

D. Radford, who has for some time been works manager of E. K. Cole's radio and plastics factories at Southend, has been appointed general manager of the company's plastics division.

IN BRIEF

U.S. Cinema Television.—Proposals have been made by the U.S. National Theatre Television Service for the allocation of 75 channels of 20 Mc/s bandwidth for a cinema television network. It is learned from *Broadcasting* that the proposed frequencies are 600-760 Mc/s, 860-1,000 Mc/s, 1,900-2,200 Mc/s, 3,900-4,200 Mc/s and 5,700-6,300 Mc/s.

Ex-Servicemen Choose Radio.—Sir Herbert Hiles, Chairman of the South Wales Retail Traders' Licensing Committee, states that the retail wireless trade heads the list of applications for licences for businesses from ex-Servicemen.

Sets for the Blind.—Since the inception of the British Wireless for the Blind Fund 64,500 sets and relays have been supplied free of charge to the blind.

Voice of America.—Six new transmitters are now being used by the U.S. short-wave international broadcasting stations WLWL, WLWS and WLWR. Situated at Bethany, about 20 miles from Cincinnati, the 200-kW transmitters were built and are operated by the Crosley Corporation for the American Office of War Information and form what is claimed to be the most powerful group of short-wave broadcasting stations in the world.

Radio-minded U.S.—According to a census undertaken by the research department of the Columbia Broadcasting System the percentage of America's 36½ million families owning radio sets is 88.9. The book "U.S. Radio Ownership, 1944," shows that the most radio-minded of America's 48 States is Connecticut, with 98.2 per cent. of its 497,300 families owning sets. • New Jersey is second with 98.1 per cent., and California third with 97.5 per cent.

Leicester Radio Society has been re-started. Old members who are serving in the Forces have been made hon. members. The secretary is A. Folwell, 12, Rowsley Avenue, Leicester.

Training for Industry.—The suggestion that the industrial physicist should serve an apprenticeship similar to that expected, for example, of engineers, was made during a recent discussion on "The Selection and Training of Personnel for Industry" at the London and Home Counties' branch of the Institute of Physics. The opener was Major F. A. Freeth, F.R.S., of Imperial Chemical Industries.

Stroboscopic Illumination.—Apparatus for arresting the apparent motion of rotating or reciprocating parts, the measurement of speed and the observation of performance at any part of the cycle, is now being manufactured by Watford Instruments, Loates Lane, Watford, Herts, and known as Strobolyser Model B. Allocation of supplies is controlled by Ministry of Supply ES2C.

Exports to Turkey.—An importer in Turkey wishes to get into touch with a British manufacturer of broadcast receivers who is not already represented in that country. Letters addressed "Turkish Importer," c/o The Editor, will be passed on.

Made in India.—It was stated by Prof. S. K. Mitra, Ghose Professor of Physics, Calcutta University, at a recent conference attended by six Indian scientists visiting this country, that two major radio concerns had begun negotiations in India for establishing either an assembly plant or a factory for the manufacture of radio components in India.

MEETINGS

Institution of Electrical Engineers.

Radio Section.—Dr. R. L. Smith-Rose will open a discussion on "Frequency Allocation for Long-Distance Communication Channels" at a meeting to be held at the I.E.E., Savoy Place, London, W.C.2, at 5.30 on January 16th.

Cambridge and District Radio Group.—"High-Frequency Heating in Industry" is the subject of a paper to be given by D. Q. Fuller and A. V. Lord at a meeting to be held at the Technical School, Collier Road, Cambridge, at 5.30 on January 2nd.

North-Western Centre Radio Group.—H. Wood and J. F. Capper will open a discussion on "High-Frequency Heating" at a meeting to be held at the Engineers' Club, Albert Square, Manchester, at 6 o'clock on January 26th.

Radio Society of Great Britain.

The annual general meeting of the R.S.G.B. will be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, at 2 o'clock on December 30th, and will be followed by a lecture on "Communication Receiver Measurements and Standards of Performance," given by R. H. Hammans.

British Institution of Radio Engineers.

London Section.—The meeting to be held at the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, at 6 o'clock on January 17th, will take the form of a discussion on "Television Standards."

Midlands Section.—L. Grinstead will give a paper on "Radio-Frequency Heating" at a meeting at the University of Birmingham (Latin Theatre), Edmund Street, Birmingham, at 6 o'clock on January 25th.

UNBIASED

By FREE GRID

Radio Racket

No wireless needed.

OUR great industry has suffered far less from swindles and rackets than other industries of commensurate size, but now and again one does rear its ugly head, and I have vivid recollections of one about twenty years ago. In those days perhaps the greatest problems which beset technicians was to persuade HF valves to do any aitcheffing (I am no yes-man and refuse to be browbeaten by the Editor's gestapo and their rubber truncheons into talking about RF unless I want to). In most cases the HF valves of the early 1920s did nothing but oscillate unless the brakes were put on in the form of heavy damping by positive grid bias.

At length an allegedly new type of HF valve appeared which was tame and tractable without the application of damping. Its ability to amplify did not seem to fall short of that of other valves on the market and it did indeed seem to answer the designer's prayer. But its makers had the good sense to refrain from sending a specimen to be tested by the *Wireless World* laboratory. Even lesser technical journals soon rumbled it, and one of them remarked rather drily that it appeared to have an amplification factor of unity. This was not surprising, since the innards of the valve consisted of nothing but a small fixed condenser twixt grid and plate pins. It had no filament.

Back to 1924

We don't get such crude and gross deceits nowadays, but I am sorry to say that certain unscrupulous dealers appear to be sinking to almost equal depths of depravity. As you know, it is forbidden to sell second-hand wireless sets or any other goods at a greater price than they cost when new. In spite of the influx of American and wartime wireless receivers there is still what the stockbrokers call a strong market for old sets, and a dreadful foreboding seized me the other day when Mrs. Free Grid announced that she had succeeded in getting for me the prince of all radio receivers in the form of a ten valve set with no fewer than six stages of alleged HF amplification for the modest sum of fifty guineas.

My forebodings were more than fulfilled when the monstrosity arrived. No maximum price regulations had been infringed as the wretched thing did truly fetch this absurd sum way back in 1924 when the paucity of technical ideas was compensated for by the multiplicity of passenger bright-emitter HF valves employed. As for the controls, their number and variety can only be described as a government official's dream of heaven.

The trouble is that these multi-valve monstrosities with their voracious appetite for filament amps. and imposing-looking cabinets are seized upon by the untutored public who really think that they have got something out of the ordinary, as indeed they have. The whole business, which is rightly shunned by honest radio dealers, leaves a nasty taste in my mouth rather like powdered eggs.

Radio Hypnotism

WIRELESS has already celebrated its jubilee, and so may consider itself to be at least grown up. It is all the more deplorable, therefore, that at the present time there should be in the daily Press certain rather highly coloured accounts of the alleged use of wireless waves as a panacea for the various ills to which the flesh is heir. Mankind, when in a jam, always turns to us wireless people, but there is a limit to what we can be expected to do for ungrateful humanity.

When I first read about it I concluded that we were being treated to a dished-up version of ordinary radio therapy, full accounts of which have appeared from time to time in this journal. Closer investigation showed, however, that it was merely our old friend hypnotism in a new guise. I know nothing of the alleged curative powers of hypnotism, but anybody who has witnessed a wealthy tourist shelling out good money to a confidence trickster for the title-deeds of the Eiffel Tower can hardly doubt its existence.

The thing I object to is the misleading of the public with thinking that in some manner the use of "wireless waves" has introduced a new and wonderful element into hypnotic suggestion. So far as I can gather, all that has happened is that somebody sitting in a broadcasting studio has succeeded in persuading certain people sitting in a distant receiving room that they possessed certain ailments which have been dissipated by the power of hypnotic suggestion.

Surely there is nothing very new in this. Certain patent medicine advertisers have been doing this for years over the American broadcasting chains and, in pre-war days, from Radio Luxembourg, to say nothing of the hard-working and perspiring gentlemen who sell patent medicines in Petticoat Lane every Sunday morning and haven't even a vestige of radio to help them. I don't mind confessing that on one occasion I myself was very nearly hypnotised by one of these gentry into paying for a substance guaranteed to turn Mrs. Free Grid into a modern version of Helen of Troy, and I should have done so had I not discovered that I had had my pocket picked earlier in the proceedings and all my spare cash removed.

Letters to the Editor

Surplus Wireless Stocks • Contrast Expansion and Background Noise • Simplified Calculations

War Surplus Disposal

MAY I express my agreement with W. H. Cazaly's views in his letter published in *Wireless World* for November?

May I also suggest that he includes the many radio mechanics serving in the Forces, who, whilst not professionally engaged in radio before the war, have been enthusiastic amateurs, and have given their knowledge to assist in the war effort?

I hope I may be included among these, and earnestly hope that we, too, may be given at least the same consideration as the "professionals" and dealers in the matter of facilities for purchasing at reasonable prices the Government surplus radio equipment which will be available when the war ends. L. E. J. CLINCH.
R.A.F.

"New Thoughts on Contrast Expansion"

I HAVE studied with interest the article in the September issue. While I entirely agree that the transmitted range is already such that volume peaks will disturb one's neighbour, and that one's neighbour is equally liable to disturb the quieter passages, I do not feel that this is any justification whatever for condemning the contrast expander.

A symphony orchestra does not play on the local football ground because the quiet passages would be lost among the extraneous noises. For exactly the same reason one must not expect to listen to a broadcast programme with all its original attendant brilliance and range in noisy surroundings. The argument therefore holds good merely against the use of contrast expanders in unsuitable surroundings—it is not in any way an argument against expansion as such. One might equally well condemn the Philadelphia Orchestra because it is too large to play in the village hall.

Let us now turn to Mr. Roddam's further argument. The individual who visits the concert hall hears the full range of volume provided by the orchestra. He hears the most delicate inflexion of the soloist and the mighty power of the full orchestra. It matters not one jot to him that there are 1,999 other people in the hall listening to the same volume range. Why, then, if he has the facilities, should he not produce the full range when he is going to listen by himself?

To attune his ear to a more delicate volume range and imagine it to be the real thing, as the author proposes, is in my view absurd. It is in fact a parallel of the well-known case of the listener with an old and groaning receiver who has become so used to it that he thinks nothing else is nearly as good.

I feel that the most satisfactory practical arrangement is a wide-range expansion circuit with a degree of expansion continuously variable to zero. Only then can the listener select his fidelity (as far as volume range is concerned) to suit the circumstances.

JOHN B. RUDKIN,
Lieut., Royal Signals.
On Active Service.

[The author's argument against contrast expansion was based on the premise that the listener was compelled to tolerate a noisy background.—ED.]

Accuracy—Profitable and Unprofitable

IN last month's "Random Radiations" "Diallist" states that for most electrical and radio calculations 22/7 is a near enough approximation for π. It should be, seeing that it represents an error of barely 0.04 per cent.!

I am one of those individuals who can from memory recite the value of π to many places of decimals (35 in my case, and without the aid of mnemonics!), but I agree with "Diallist's" corre-

Letters to the Editor—

spondent who questions the value of "such a string of figures." It does not appear to be widely enough recognised that the substitution of 3 for π represents an error of less than 5 per cent., and how many of the components we use are guaranteed to the same degree of accuracy? $\pi^2 = 10$ within 1.3 per cent., and another useful approximation involving an error of only ½ per cent. is $\frac{4}{25}$ or $\frac{16}{100}$ for $\frac{1}{2\pi}$. This latter form is frequently cropping up in such formulæ as $\frac{1}{\omega C}$ and $\frac{1}{2\pi\sqrt{LC}}$, and the approximation I have given saves quite a lot of needless arithmetic and hunting for and through log tables.

The whole point is to appreciate what degree of accuracy is required and work accordingly. By all means use 3.141592653 . . . if one is satifying examiners (though they usually specify the value of π to be used); but to use the same figure in, say, calculating the capacity of a condenser to give a required amount of negative feedback when the condenser used may be a ±20 per cent. article is truly absurd.

J. M. SKELTON.
London, W.C.1.

Soldering Irons

REFERRING to the remarks by "Diallist" on electric soldering irons, contained on page 341 of the November issue, this company experienced a similar need for a suitable soldering iron for the manufacture of measuring instruments and similar small assemblies, and as a result developed the Metrovick "Lo-Volt" soldering iron.

This soldering iron weighs only 3.5 ounces and is only 8.5in. overall in length. The nominal rating is 25 watts at 10 volts, and control of bit temperature on AC may be obtained by a selection of tappings on the secondary winding of a small transformer.

The recommended bit temperature for the wartime 40/60 solder is about 280 deg. C. The nominal loading of 25 watts obtained on 10 volts give an idle-bit temperature slightly in excess of this, and is, therefore, suitable for light soldering work with this solder. For heavier work the loading may be increased as described above, the idle-bit temperature for a loading of 36 watts obtained on 12 volts being, for example, about 360 deg., which provides a bigger reservoir of heat.

In practice therefore the permissible loading (and hence the voltage applied to the iron) is determined solely by the nature of the work and may be adjusted within wide limits to provide a bit temperature, during working periods, near to that recommended for the solder in use. It has been found that during lengthy periods when the iron is not in use, it may be kept hot economically with a loading of 16 watts (obtained on 8 volts).

A. STEPHENSON,
Metropolitan-Vickers Elec. Co.
Trafford Park, Manchester.

Standardised Components

MY Committee has read with considerable interest the article in your November issue on "Properties of Radio Components."

Two points appear particularly to call for additional comment.

1. The operation of telephone and broadcasting systems in the Far East and in Russia with "non-tropical components" was in nearly all cases under specially favourable conditions, such as air-conditioned buildings, and was certainly not under conditions comparable with those of modern warfare in these areas.

2. My Committee is engaged on the preparation of an Inter-Service version of the Specification DCD.WT.1000, and reference to this M.A.P. Specification will therefore be superseded as soon as possible.

You may be interested to know that the Inter-Service Components Technical Committee consists of the senior officers primarily concerned with the development and use of radio components in the three Services and the G.P.O. Its documents are prepared by sub-committees representing all Services in collaboration with the Inter-Service Components Manufacturers' Council, which is a body representing the radio components industry. These documents are published by the British Standards Institution.

E. D. WHITEHEAD, Secy.,
Inter-Service Components
Technical Committee.

The Murphy "spot-welder" for joining plastic sheets and similar articles.

Cathode-follower Output

I HAVE been interested in the recent letters regarding the cathode-follower output stage. None of your readers appears to have suggested the use of an RF pentode as an AF amplifier, to provide the extra voltage output required to offset the overall reduction in amplification due to feedback, without transformer.

I have successfully used such an arrangement to feed a PP3/250 in a simple gramophone amplifier; the bass response on a good speaker is particularly "clean." The only shortcoming of the apparatus, which rendered it less satisfactory for radio purposes, was a noticeable falling-off at the higher audio frequencies; this was not displeasing when reproducing records. It would appear that Mr. Robb's suggestion regarding the capacity to earth of the filament winding of the mains transformer is probably correct, as in the original circuit of Mr. Mitchell, an indirectly heated output valve was used, with apparently no ill-effects at the higher frequencies. Perhaps some of your readers who have the necessary facilities could verify the performance of directly and indirectly heated valves in this interesting circuit.

C. GEORGE,
Northampton.

RADIO SEALING

THE growing use of plastic films and fabrics for the moisture-proof packing of perishable goods, and various stores for the Armed Forces has created a demand for a completely new type of machinery for handling these specialised jobs.

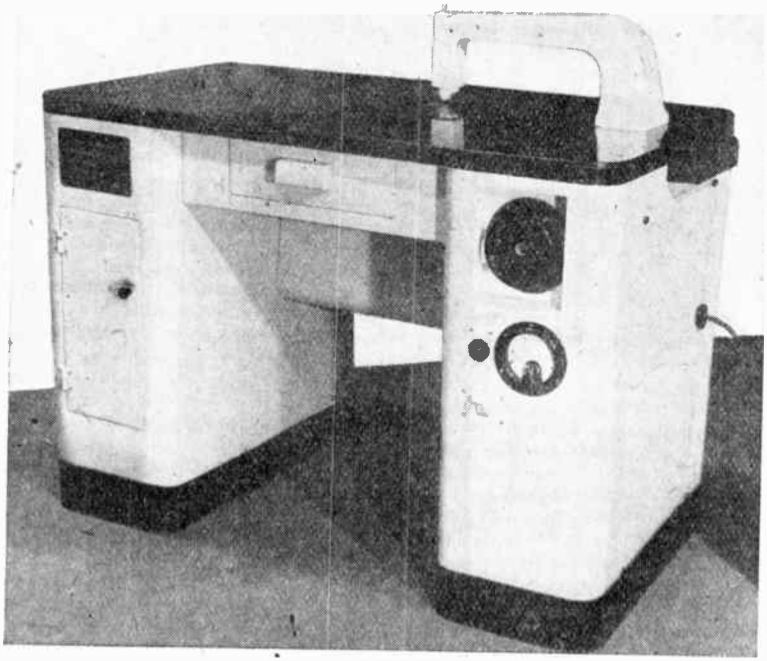
The latest apparatus produced for sealing plastic fabrics makes use of the dielectric loss principle. In the type of "sewing machine" developed by Murphy Radio the working head consists of a pair of electrodes in the form of small wheels to which the RF output of the generator is applied. The wheels also serve to guide the work through the machine. The speed at which the wheels turn, and the level to which the RF output is adjusted, are arranged to allow for the correct amount of heat to be generated in the plastic material being sealed. Obviously, different types of plastic and different thicknesses of work will require variations of these two factors.

A Murphy "spot-welder" designed for somewhat similar purposes is illustrated on the opposite page. The lower electrode is fixed, while the depression of a pedal lowers the movable upper electrode on to the work, switches on the power, and lights an indicator.

An interesting report on the practical side of this apparatus shows that the operators, in all cases women, take to these machines (particularly the "sewing machine") very naturally and without any nervousness. A woman who has any real proficiency with a sewing machine finds it a simple matter to perform quite complicated seaming operations.

When the manufacturers of these new and very attractive coloured plastic films and materials are able to release their products on the general market, it is obvious that RF sealing apparatus will really come into its own. When one considers the wide range of goods which can be cheaply and attractively packed in plastic containers—such as confectionery, cosmetics, foodstuffs and the like—no emphasis is needed to point out the part that apparatus of this type is going to play in many industries.

Many of the applications in which the sealing equipments have been used have been entirely new, and consequently much of the development work has been of a "pioneer" nature. This work has shown the need for increasing the working frequency, so that the Murphy equipments operate at higher frequencies than has been the usual practice. Frequencies up to 80 Mc/s are used, and the input power to the oscillator is about one kilowatt.



The latest Murphy "radio sealing" equipment; a self-contained "sewing machine" operating on the dielectric heating principle.

RANDOM RADIATIONS

By "DIALLIST"

Low-voltage Soldering Iron

To a Wallsend-on-Tyne reader I am indebted for a very neat design for a small soldering iron of the kind that one wants for wireless constructional jobs. I shall certainly make one up with a few slight modifications (did you ever know a workshop addict who could make up another fellow's design without "improving" it?) as soon as I get time for my own use. If readers are interested, I hope to be able to give a working drawing in *Wireless World*. Meantime, here are a few particulars. My correspondent has rightly decided that the full mains voltage is not advisable for small soldering irons owing to insulation difficulties. He had a transformer available with two 4-volt, 4-ampere windings. These he connected in series so as to have 8 volts available and then worked to that figure in making a design. He found by experiment that the current required to heat a suitable bit was 2.5 amps. Allowing for 0.5 V drop in the connections, this left 7.5 V available for the heating element, of which the resistance must therefore be 3 ohms. The heater he made from 8.35 inches of Nichrome wire, No. 30 SWG, wound into a helix.

A Neat Tool

He drilled a chisel handle $\frac{7}{32}$in. right through and passed into the hole a tightly fitting split tube made by rolling up sheet brass 10 thous. thick. Over the far end of the tube fits the bit, again a tight push fit. Down the tube, insulated by beads, runs a length of No. 20 SWG copper wire, to the far end of which one end of the heater helix is hard-soldered. The helix thus lies inside the end of this tube, which is itself inside the bit. Insulation for the heater is provided by rolling up a small sheet of 2-thous. mica and inserting it between the heater and the brass tube. One end of the double flex connecting the iron to the transformer is hard-soldered to the brass tube; the other to the central copper wire. The far end of the wire forming the heater helix is turned back over the end of the brass tube and pinched between it and the bit. The tube thus forms one conductor and the central wire the other. I like this design for many reasons. The iron is small, handy and light and the heater is where it ought to be—inside the bit. I don't feel quite sure that the 18.75 watts in the heater will make the bit quite as hot as I like to have it. One feature of the design, though, is that the heater is so easily replaced. Thus it is simple to experiment. The first of my modifications will be to provide the flex with a good anchorage by fitting a screw cap to the chisel handle and putting a knob in the flex just inside it. The second will be to earth the core of the transformer—possiby my correspondent did this, though he doesn't mention it. I shall put my transformer into a perforated and earthed metal box.

□ □ □

Bombing by Instruments

It was with no little surprise that I read in *The Times* just before writing these notes what to technical folk will be a fairly complete disclosure of the methods by which bombing by instruments, of which we hear so much, is accomplished. The account states that a small apparatus known as the "gen box," fitted to the fuselage of the bomber, sends out a succession of electrical impulses, which bounce back from the ground and form on a glass screen a kind of contour map of the ground below. If that sort of apparatus can be described, even in such general terms, why should there still be a ban on giving any sort of account of plain, straightforward radar—such an account, I mean, as would tell the enemy nothing that he doesn't know already. Does not the article already quoted go on to say "The attackers then [in thick weather] have to contend only with flak and, as has already been disclosed, metal strips and other devices have long been used to render the enemy's fire inaccurate?"

□ □ □

No Overcrowding Here

If, as I believe will be the case, broadcasting is going to make more and more use of low-powered, high-fidelity transmissions on the ultra-short waves, we are never likely to be faced with the appalling overcrowding that has occurred in the medium- and long-wave bands hitherto allotted to this service. It isn't so much that there is room for immense numbers of channels without mutual interference on wavelengths between, say, two and ten metres; demands on that space are already great. On the medium waves a station may interfere with another not just at close quarters but at a range of thousands of miles. I have many records of heterodynes on European transmissions between 9 p.m. and midnight in winter caused by American stations. One of the merits of the ultra-short waves is that transmitters using them keep themselves to themselves, or rather to their own service areas.

□ □ □

Memory Test

In the course of a recent Brains Trust one of the "trustees" (Commander Gould, I think it was) offered to give the value of π to 30 places as a memory test—and did so. I don't want to cast aspersions, but I think that readers of these notes will know how *that* one can be done! Perhaps the Commander is a reader. If he isn't I'm willing to bet that he knows the mnemonic rhyme by Edouard Lucas. By the way I was made to commit one error in French of which I really wasn't guilty in quoting the said rhyme. I wrote "*Jugement*" (without a *d*) in the third line. The number of letters, however, was correctly given as eight.

□ □ □

Tap Water and Accumulators

Apropos of my recent note on the use of tap water (boiled and allowed to settle, if hard) for topping-up accumulators, I have had an interesting correspondence with a North-country water engineer, from whom I have had much useful information. He pointed out, to begin with, the hardness of water and the nature of the salts that cause it depend upon where and how it is collected. For instance, in one place, water from underground sources proves on analysis to contain 98 parts in 100,000 of dissolved solid matter, whilst in another, not far away, where the produce of upland gathering grounds is stored in large reservoirs, the figure is only 9.96 per 100,000. The main solid constituents of the water from underground are sodium sulphate (45 parts per 100,000), sodium chloride (40 parts), and sodium bicarbonate (8 parts). In the upland water, calcium sulphate (4.60 parts), sodium sulphate (2.15 parts) and sodium chloride (1.166) are the chief dissolved solids. By boiling water and allowing it to settle, one gets rid of calcium and magnesium carbonates (both of these appear in the harder water as bicarbonates, and in the softer there is 0.25 part per 100,000 of calcium bicarbonate), but leaves the sulphates and chlorides. My correspondent suggests that boiled tap water whose hardness is due to chalky constituents (mine is of that kind) would probably be harmless. Most of the dissolved solid matter is calcium bicarbonate and calcium sulphate. But he thinks that if water containing chlorides were used, some of the sulphuric acid would waste its energy in turning these into sulphates. His view is that, as tap waters differ so much writers play for safety by condemning all. Will some accumulator maker please give us the benefit of his experience?

□ □ □

Improvement Needed

ONE thing that will have to receive attention when this war is over and done with is the broadcast services of many of our colonies, protectorates, and what not. The dominions manage their own affairs and most of them have excellent services already in being. But it's a very different story in the colonies, many—if not most—of which are far from being well off in this way. The problems are often difficult. The problem is a big one, but it will have to be tackled as soon as possible. Broadcasting is a mighty power in the life of humanity to-day, and we can't afford to neglect it in our colonies.

ELECTRONIC MARVELS!

EX-GOVERNOR CHARLES EDISON, of New Jersey, has his father's love of a joke. The inventor's distinguished son is an M.I.T. graduate and knows his way around in electrical and electronic matters, as might be surmised. Recently, after listening to an amateur electronics enthusiast become eloquent about post-war electronic marvels, Gov. Edison asked whether the spellbinder had yet witnessed a demonstration of "the electromagnetic ray that can stop an automobile." "No, I've heard about such a ray," replied the electronic prophet, "but I didn't know it was yet practical." "Well, jump into my car and come down to our laboratory and I'll show you."

As the car approached the main street of Orange, N.J., the traffic signal turned red, and the Governor's chauffeur put on the brakes, bringing the car to a grinding stop. Pointing through the windshield at the red traffic light, Gov. Edison chuckled: "See, just as I told you; there's the ray that stops automobiles—and it *is* thoroughly practical, too!"—*From "Electronic Industries," New York.*

RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

CRYSTAL OSCILLATORS

WITHIN limits, the frequency of a piezo-electric crystal can be varied by regulating the thickness of the air gap between the free face of the crystal and its adjacent electrode. A smooth and accurate adjustment is, however, essential to avoid sudden jumps in frequency, and to ensure stability of oscillation after each setting.

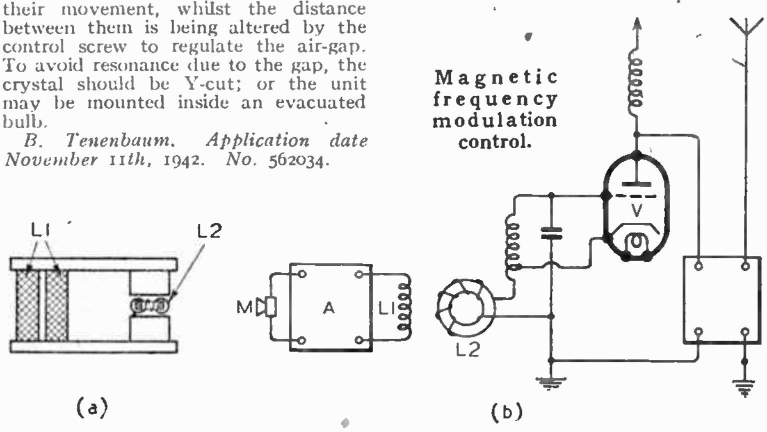
To meet this requirement, the crystal and its base electrode are mounted on the inclined surface of a stationary wedge-shaped holder, whilst the opposite electrode is set on the inclined surface of a second similarly shaped holder. Both holders are arranged in an outer casing so that the second holder can be moved transversely, in a straight line, relatively to the first, say by a screw under spring control. Both the inclined surfaces are thus kept parallel to each other in the course of their movement, whilst the distance between them is being altered by the control screw to regulate the air-gap. To avoid resonance due to the gap, the crystal should be Y-cut; or the unit may be mounted inside an evacuated bulb.

B. Tenenbaum. Application date November 11th, 1942. No. 562034.

FREQUENCY MODULATION

THE carrier-wave frequency is controlled by the inductance unit shown in diagram (a). Signal currents fed to one coil L1 vary the impedance of a second coil L2, which is included in the tuned grid circuit of the valve oscillator. The second coil is wound on a ring-shaped core, which is set across the gap between the pole pieces of the first, so that the two magnetic fields are at right angles to each other.

As shown in diagram (b), the coil L1 is fed from a microphone M through an amplifier A, whilst the coil L2 forms



Magnetic frequency modulation control.

part of the grid tuning inductance of the carrier-wave oscillator V. To avoid any frequency doubling, a steady biasing current is fed to the coil L1; or a part of its core may be permanently magnetised. Stress is laid on the fact that the inductance of the aerial circuit is not affected by this method of frequency control.

Aga-Baltic Akt. Convention date (Sweden) June 3rd, 1941. No. 561993.

TELEVISION IN COLOUR

IN a cathode-ray receiver three fluorescent surfaces are provided, each selected to give a distinctive primary colour response. All three surfaces are so applied to a common semi-transparent screen that the different colour effects can be seen simultaneously from the same viewpoint.

The back face of the common screen is a plane surface, and is coated to give a predominantly green picture. The front face of the screen is ridged or serrated, one sloping side of each ridge being coated to give a blue response, whilst the oppositely sloping sides are differently coated to produce a red picture. The two sides of each ridge are separately scanned by two widely spaced "gun" assemblies, generating electron beams which are set at an angle to each other; a third "gun" is suitably placed to scan the back face of the common screen. Because of its semi-transparency, the effects of all three colours are combined when the picture is viewed either from the back or front of the screen. A similar arrangement of colour-selective mosaic screens is used for transmission.

J. L. Baird. Application date July 25th, 1942. No. 562168.

HETERODYNE INTERFERENCE

A METHOD of reducing heterodyne interference is based upon the following observations: (a) that the continuous whistle produced by the interfering carrier wave waxes and wanes in amplitude; and (b) that the instantaneous phase of the heterodyne also changes, thus indicating the presence of a frequency-modulated component.

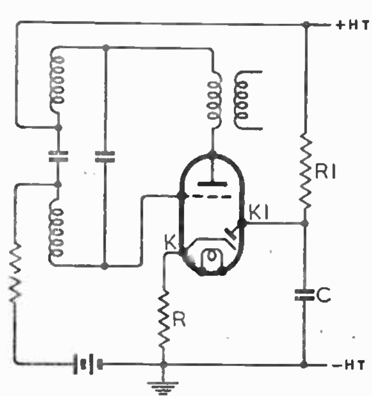
The receiver is provided with a frequency-discriminating circuit which separately delivers (a) a rectified voltage representing the sum of the amplitude-modulated signal and the interference, and (b) a voltage corresponding to the FM component of the heterodyne interference. These two voltages are applied to the different grids of a twin triode tube in opposition, so that the original interference is cancelled out from the final output, a reversing switch being provided to allow this to be done whether the offending whistle is located above or below the signal carrier frequency.

Marconi's Wireless Telegraph Co., Ltd. (assignees of M. G. Crosby). Convention date (U.S.A.) November 25th, 1941. No. 562553.

OSCILLATION GENERATORS

THE amplitude of the output from a Hartley oscillator is automatically regulated as the valve reaches equilibrium by the bias derived from the flow of grid-current. The action is not, however, sufficiently sensitive to maintain an absolutely steady state; nor is it easy to set up an oscillator to work at a predetermined amplitude, owing to the difficulty of accurately calculating the grid-current conditions.

The diagram shows a Hartley type of oscillator in which negative reaction is applied to secure stable operation at a desired amplitude. Included in the cathode lead is a resistance R, which is normally shunted by a circuit formed by an auxiliary anode K1 and a condenser C of low impedance to the generated frequency. The electrode K1 is positively biased through a resistance R1 from the HT supply; but as the oscillations build up, the cathode K will develop a "peak" potential which momentarily exceeds that of the



Oscillation amplitude limiter.

auxiliary anode K1. During these instants the low-impedance shunt path through the condenser C is disconnected, and negative reaction is applied through the cathode resistance R to curb any further build-up.

A. D. Blumlein. Application date June 17th, 1940. No. 563464.

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.

Rate 6/- for 2 lines or less and 3/- for every additional line or part thereof, average lines 5-6 words. Box Numbers 2 words, plus 1/-. Press day February, 1945 issue, first post Wednesday, January 10th. No responsibility accepted for errors.

Under Defence Regulations 1939, Statutory Rules and Orders 1940, Number 1689, a permit (T99G) 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

12-watt a.c./d.c. amplifier outfit; £36.—R. K. Wilson, Narrowgate, Alnwick.

H.P. RADIO SERVICES guarantee prompt despatch of the following goods:—
ROTHERMEL crystal gramophone pick-ups, £3/18/9; loud speakers, Rola 8in P.M., no transformer, 22/-; Celestions, with transformer, 6in 33/-, 8in 30/-, 10in 45/-; mains energised, 8in, 2,000 ohms, 36/-.
MEASURING bridges, temporary offer without priority of Mullard Universal measuring bridge, 10mmF-10mF, 0.1-10 megohms, a.c. operated, high sensitivity, 15gns.
MULLARD cathode ray tube unit, type B100, complete with 3in tube, 12gns.
MULLARD ECR30 3in cathode ray tube, complete with holder, 4gns.; GT1C Argon filled relay, 25/-.
MEICO moving coil microphone, 5gns; Meico stands, 52/6; Meico mike transformer, 13/-.
VIBRATORS, Mallory 6v 4-pin, 12/6; Bulgin 6v 6-pin self rectifying, 20/-; bases, 1/-; 12v vibrators in small square case, 3 leads, 10/-.
CAR radio plug and distributor suppressors, 2/3 each; dynamo condensers, 2/6 each; telescopic aerials, 21/-; chassis (ex television), containing approx. 100 modern parts, 29/6.
MAINS transformers, 120ma, all connections on terminal panel 350-0350, specify 4v or 6v heaters, each 39/6; line cord, 0.3amp 70ohms per ft, 5/- yd.
BOOKS, Modern Radio Test Gear, 1/6; Amplifier Manual, 2/-; Radio Valve Manual, 3/6; Radio Inside Out, 4/6; Radio Circuits, 2/-; Manual Disc Recording.
H.P. RADIO SERVICES, Ltd., 55, County Rd., Walton, Liverpool, 4. Tel. Aintree 1445.

COMMUNICATION receivers. — Remember "Dale" after the war.—Dale Electronics, Ltd., 152-6, Gt. Portland St., W.1. Mus. 1023.

HENRY'S offer t.r.f. 4, valve a.c./d.c. kit set, med wave, complete with all components and drilled chassis, 10×4×2½, easy to build, circuit supplied 5in speaker, no other extras; £8/10; cabinets for same, 22/6, 7 days' delivery.—Henry's, 5, Harrow Rd., Edgware Rd., W.2 (Pad. 2194). [3339

£24/10 only.—New 7-valve "Wireless World" Quality amplifier with tone control stage, 8watts push-pull triode output, price includes super Quality triple cone, 12in permanent magnet speaker with large matched output transformer and all valves; as above but with 15watt tetrode output, £25/10; ideal for realistic reproduction for public address, limited number available.—Bakers Selhurst Radio, 75, Sussex Rd., S. Croydon. Tel. Croydon 4226 for demonstration. [2772

QUALITY amplifiers, 200-250v ac, 5w, 8½gns; 12w, £14; output impedance to requirements, both types; s.a.e. for leaflet and copy "Design for Quality."—John Brierley, 1, St. Paul's Ave., Lytham St. Annes. [3195

AMPLIFIERS.—Complete equipment for P.A. industrial, dance and stage installations and portable apparatus from 15 to 150w; early deliveries; illustrations and spec. on request.—Broadcast and Acoustic Equipment Co., Ltd., Broadcast House, Tombland. Norwich 26970. [2963

RECEIVERS, AMPLIFIERS—SECOND-HAND

HAYNES radiogram, perf. cond.; offers.—20, Rutland Ave., Southend-on-Sea. [3305

PHILCO car radio, K728T, 12v, used one week, telescopic aerial; £18.—Box 3298.

GENUINE B.T.H., R.K. speaker, amplifier, cheap.—Blott, 31, Kingsway, Wembley.

W.W. QA super receiver, £12; W.W. Quality ampli, £15.—29, Poulton Rd., Blackpool.

28w amplifier, a.c. mains, 2 inputs, bass & treble tone controls, 2 speakers; £25.—Box 3290. [3285

MURPHY 9v ac mains console, a.f.c., quality reproduction, cost £35, perfect, £27; also Gambrell Novotone type M, 25/-.—Denny, 37, Pulteney St., Bath. [3354

PYE Empire 10-valve walnut console, semi-communication, 4 bands, var. selec., P.P., PX4s, R.G.D. exten. L.S., modern curved cabinet, Martin Colleti guitar, separate offers; wanted, Voigt and/or Q.A.—Box 3299. [3310

POST-WAR PLANNING

Why not let us handle your transformer problems ?

If transformers are employed in the equipment you manufacture, we shall be glad to give you the advantage of our experience and to offer the same efficient service that has won the confidence of the Government Experimental Establishments and of the Leading Industrial Organisations.

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These charts give full theory data and wiring plan for these three kits of components. Price 2/- each, 5/- set.

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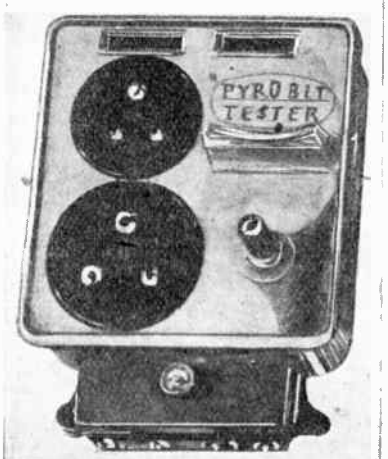

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SPEAKERS. Rola P.M., 5in., 21/-; 6½in., 21/6; 8in., 23/6 each. Goodmans 3½in. P.M., 27/6; 10in., 39/6 each. Celestion 10in. P.M., with Transformer, 45/6. In stock, over 5,000 new boxed English and U.S.A. mains and battery valves at list prices.

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COILS for Hartley and Brierley circuits, transformers and chokes for all W.W. circuits.—R. Clark, 30, Langland Crescent, South Stanmore. Tel. Wordsworth 5321. [3351

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POTENTIOMETERS, 1 and 2 meg., less switch, 2/9 ea., 30/- doz.; condensers, 2mfd, 400v wkg., 3/- ea.; selenium rectifiers, 200v 40mA, 5/- each.—Heathcote, 24, Durnford Ave., Urmston, Manchester. [3356

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RADIO spares.—Line cord, 0.3amp, approx. 60ohms per ft. 3-way 4/11 per yd, 2-way 4/- per yd; 2-gang condensers, midget coils, 6/6 per pair; v. controls (all values), with switch 4/9 each, less switch 3/9 each; Solon soldering irons (pencil bit), 13/6 each; biggest stock of radio valves in England at list prices, plus purchase tax, let us have your enquiries; Rothermel (crystal) pick-ups, £3/14 and £3/18/9; Celestion p.m. speakers, 6½in multi ratio trans, £1/8/6, 8in w/trans, £1/7/6; condensers, 8mfd, 4mfd, 0.01, etc., etc.; mains transformers, 4v and 6v, £1/7/6; valve holders, all types in stock; portable accumulators, celluloid, 2volt, 17/6 and 18/6; glass accumulators, 45amp, 14/6; resistances and condensers, all types in stock; strictly cash with order.—Matt Radio Service, 152, Richmond Rd., Kingston-on-Thames. (Kin. 4881.)

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Undrilled.

10 × 8 × 2½" .... price 7/- each
16 × 8 × 2½" .... price 8/6 each
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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
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2 Push-Pull Switches to suit above, 9d. each.

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All-brass construction, easily ganged.

15 mmfd. .... 2/11 100 mmfd. 3/11
25 mmfd. .... 3/3 160 mmfd. 4/8
40 mmfd. .... 3/3 250 mmfd. 5/8

Bakelite Dielectric Reaction Condensers and Condensers.

0001 mf. 1/3, 0003 mf. 2/11, 0005 mf. 3/3 each
0003 mf. Differential .... 3/3 each
S.W. H.F. Choke, 10-100 m. 1/3
Pie wound S.W. Choke, 5-200 m. ..... 2/6 each
Brass Shaft Couplers, ¼in. bore ...... 7½d. each
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SPECIAL OFFER. Premier Midget Coils. Set of three A.HF. and Osc. 200-557 metres. Intermediate frequency 465 Kcs. Price, A.HF. or Osc. coil, 2/3 each. Tuning capacity 0005 mfd. 60 mmfd. trimmers, 1/- each. Padder for Osc. coil, 750 mmfd., 1/9.

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Above speakers are less output transformer.
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30 amps. charge, discharge, bakelite case, **19/6** each.

Send for details of other Accessories. New list available.

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G. R. RYALL, 36, Huron Rd., S.W.17.—Mail order only; no c.o.d. under 20/-. TWO-WAY screened flexible, good quality, 1/3 yard, 3 yds 2/9; twin screened, high insulation & cotton outer cover 1/9 yd, 4-way 2/3 yd. TEN-WAY cable, good conductors, 1/3 yd, 3 yds 2/9. OCTAL 8-pin plugs with base, complete with insul. metal cap, 1/3 each, 3 for 2/9. Ditto with solder tags to take heavy gauge wire, 1/4 ea., 3 for 3/3. MORGANITE long spindle 10,000 vol. con. less switch, 3/9. DIAL plates, oblong, 5½×2½ approx., Burndept, Varley, with station names, 4 assorted for 1/6. BURNDEPT 4-band dial, 8×5½, s.w. on lower half of scale, 1/6 each. MICROPHONE capsules by Standard Telephones, 3/9 ea.; Centralab vc, less switch, long spindles, 5,000ohms, ½meg, 3/9 ea. INPUT strips, 2in×¾in, 2-way, 2/6 dozen; with terminal screws, 3/3 dozen; anchor or mounting strips, 2/3 dozen, 5-way. SPECIAL offer T.C.C. double mica cond. 0.0001×0.0001 five (ten condensers) for 1/3; Hunts 0.01 mica cond., 1/- ea.; hf chokes on ebonite bobbins, 5,000ohms, 1/3 ea. ERIE colour coded resistances, 2-watt type, 680, 6,800, 140,000, 150,000, 220,000, 470,0000, 820,000, 2 1/3; Erie 3w, 680, 1/3 ea. YAXLEY type low loss switches, single pole dt, 2 bank, 2/9, single bank, 2/3. CLYDON and Plessey trimmers, 2,000mm, 2, 1/-; low value oddments, 2, 1/-. TWIN rubber flexible cable, new, for mains leads, etc. (one cover), 1/3 yd, 3yds 2/9; push-back connecting wire, stranded, 2 colours, cotton-covered, 12yds 2/3. [3237

CHARLES BRITAIN RADIO (K. H. Ede) offers good quality radio spares. SERVICE kits.—No. 1, one 8mfd 400v tubular and 1 doz. asst'd. conds., 11/6; No. 2, two 16mfd 200v cans, 1 mains dropper, 1 choke and 12 asst'd conds., £1/10/6; midget t.r.f. coils, P type, and 465kc osc. coils, m.w., 3/- ea.; larger ones, t.r.f. only, 5/- pr.; 40-50 i.f. trimmers, 4/6 doz.; 0.0003 reac. conds., 2/3 ea.; i.f. trans., Litz wound in ali. cans with trims., 465kc, 21/- pair. TUBULAR condensers.—Prices per doz.; 0.1, 600v wkg., 10/-; 0.1, 500v, 8/6; 0.1, 400v (small), 7/-; 0.01-0.05, 1,000v test, 6/6; 0.001-0.005, 5/-; flat mica conds.: 0.01, 12/-; 0.001-0.002, 6/6; 0.0001-0.0005, 5/-; Philips ceramic 3.6pf to 470pf, 3/- doz.; sample parcel of 120 conds. for £2. KNOBS.—Best quality with brass inserts, 1½in, 8/- per doz.; 1¼in, 7/6 doz.; pointer knobs, 8/6 doz. (all ¼in spindle); screened cable, 2ft lengths twin, 9d. ea.; ex H.M.V. smoothing chokes, 120ma, 500ohms, 12/-; multi-ratio spkr. trans., 6/6; Marconi glass dials, 3 band, 7¼×4¼, 1/6 ea.; vertical, 2/- ea.; ivorine m.w. dials, marked Home, Forces, etc., 2/- ea.; paper dials for midgets, 3×4, 8/- doz. RESISTANCES. 50ohm to 1meg, Erie and Dubilier, ½w, 5/6 doz.; 1w, 7/- doz.; push-back wire per doz. yds., 2/6; tinned, copper wire, 16, 18, 20, 22 s.w.g., 2/6 per ½lb reel; Multicore solder, 5/3 per lb reel; valveholders (every type in stock except side contact), all at 7/6 doz.; screened grid caps, 9/- doz.; grid clips, 1/- doz. VOLUME controls.—Morganite and Centralab with switch, ¼, ½, 1 and 2meg, 5/6 ea.; Dubilier less switch, 5,000, 25,000, 100,000, ¼, ½, 1 & 2meg. 3/- ea.; bias conds., 25mfd, 25v & 50mfd, 12v, 2/6 ea.; mains droppers with feet & sliders, 0.3, 850ohms, 5/6; 0.2, 1,000ohms, 4/6; Little Maestro type (no feet), 5/-. THIS month's special offer.—Side cutters, ideal for radio work, 4/6 pair; terms: cash or c.o.d. over £1.—Charles Britain Radio (temp. address), Eureka, Surrey Gdns., Effingham, Sy.

VOLUME controls, various valves with switch 5/6, less switch, 4/6; mains droppers, wire wound on porcelain, with sliders and feet, 0.3amp 750ohms 5/6, 0.2amp 950ohms 4/6.—For other lines and many smalls, see full list 1d. from Radiosales, BCM/SALES, London, W.C.1.

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SERVICE kits. See November issue. C.o.d., but cash with order preferred.—London Sound Labs., Ltd., 40, South Molton Lane, Bond St., London, W.1. Look out for combined valve tester and circuit analyser. [3253

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THE Simplex Four, theoretical circuit diagram of 4-valve, m. wave, ac/dc, t.r.f. Midget, with all component values, 1/6; complete kit of parts, valves, speaker, chassis, etc., etc., for this most successful midget receiver, £9; Midget aerial and h.f.m. wave, t.r.f. high gain coils, 9/- pr.; m. and l. wave ditto coils, 11/- pr.; midget, short wave, aerial and oscillator coils, i.f. at 465 kc, 5/6 pr.; Midget 2-gang variable 0.0005mfd condenser, 15/-; ditto 3-gang, 14/-; Tiny Mite ultra midget 2-gang ditto condenser, slow motion drive, and trimmers, 17/6; midget chassis, sprayed grey, de luxe, 10½×6×2in, drilled four valves, 9/6; standard ditto chassis, 10×4½×2in, 5/6; midget dials, m. wave, 4×3½in, 2/-; s.m.l. wave, 7×4in, 1/6; midget chokes, 7/6; heavy duty, 80 mA, 12/6; 120 mA, 115/-; midget speaker trans. (pen), 7/6; Celestion 8in speaker, with trans., 30/-; line cord, 3-way, 60 ohms foot, 6/6; 2-way ditto, 5/- yard; mains droppers, 0.2 amp, 1,000 ohms, 4/6; 0.3 amp, 800 ohms 5/6; vitreous 10 watt, wire-wound resistances, 100, 60, 30 and 24 ohms, 1/6 each; nuts and screws, 4BA brass, 7/- gross; 6BA ditto, 6/- gross; trimmers, single, 30 pfds, 9d.; double ceramic, 80 pfds, 2/-; triple, 60 pfds, 1/6; iron cored i.f. transformers, screened, 125 kcs, 10/- pair; comprehensive list 2½d., s.a.e. enquiries, postage all orders.—O. Greenlick, 34, Bancroft Rd., Cambridge Heath Rd., London, E.1. Ste. 1334.

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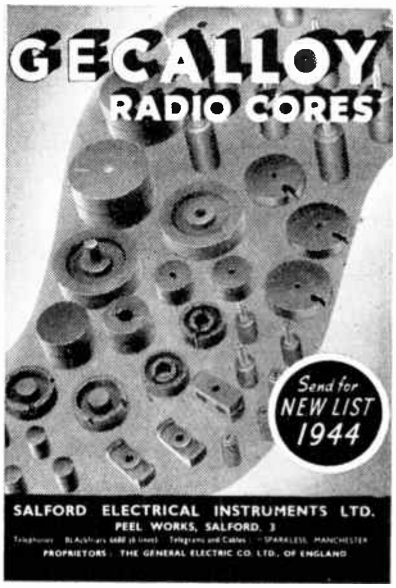

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WTD., Avo 40, good condition.—L. Smith, 21, Ash Rd., Aldershot, Hants. [3318

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WANTED, "Wireless World" for 1935 and 1936.—J. Everett, c/o J. Beattie's, Ltd., Victoria St., Wolverhampton. [3364

WANTED, Ferranti chokes, B1, 2 and 5, condenser type C3C, also wire wound resistances, condition as new.—Box 3309. [3347

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24-HOUR service, 6 months' guarantee, any transformer rewind; mains 15/6, outputs, 4/-; i.f. transformer, 3/-; all types of new equipment supplied to specification.—Majestic Winding Co., 180, Windham Rd., Bournemouth. [2764

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TRANSFORMER rewinds and replacement coils, machine layer wound on bakelite formers, interleaved, impregnated and clearly marked, rewinds £1, post paid, standard types to 70 watts; replacement coils, 15/6; larger types and additional secondaries pro rata; discount to trade; delivery by return post most types in common use; state model and iron size when ordering coils; cash with order or c.o.d.; fully guaranteed.—Radio Services, Field St. Works, Blackpool. R.T.R.A. Service members. Tel. 1774. [3328

MISCELLANEOUS

RUBBER stamps.—V. E. S., Radio House, Ruislip. [3209

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