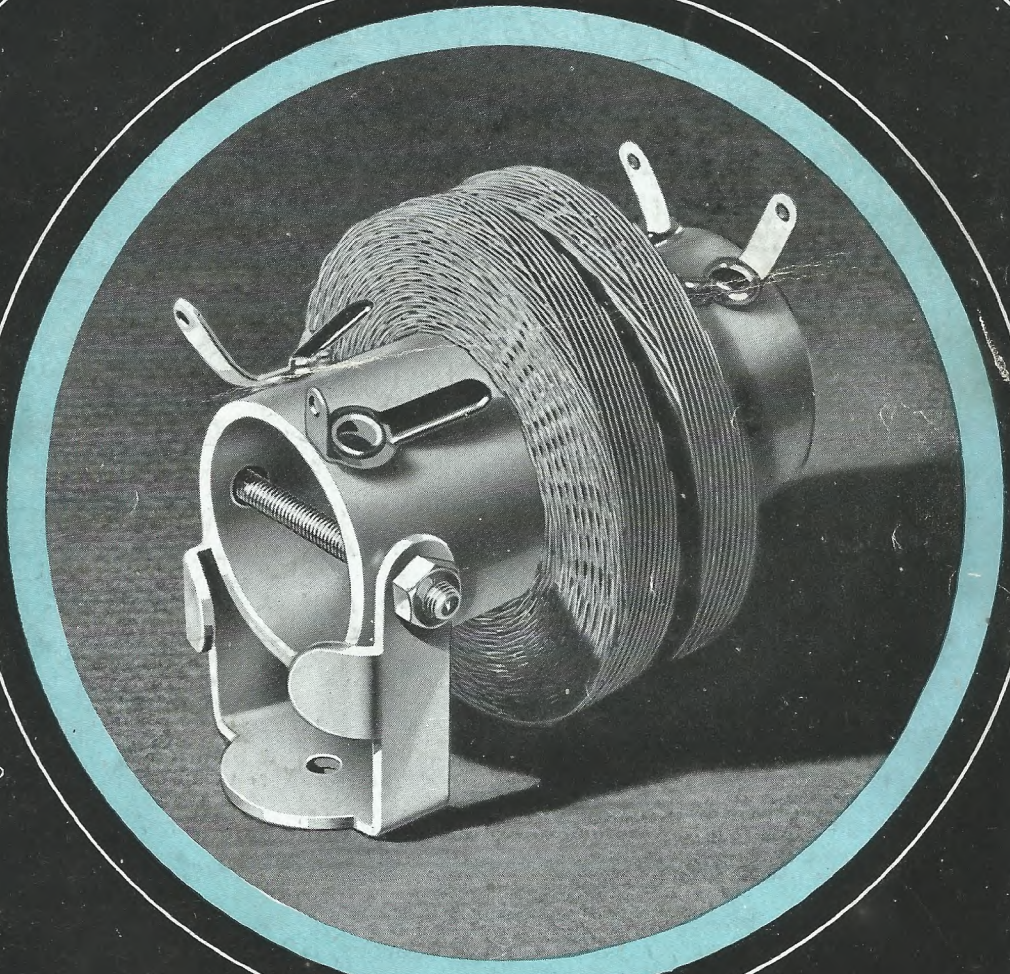
Wireless World

RADIO ✦ ELECTRONICS ✦ ELECTRO-ACOUSTICS



SEPT. 1942

1/3

Vol. XLVIII No. 9

VARIABLE SELECTIVITY ✧ MODULATION SYSTEMS

Sorry U.S.A - but

ERSIN MULTICORE

will not be with you again until after Victory

It sounds like "coals to Newcastle"—but U.S.A., the home of cored solder, found it worth while to import British made Ersin Multicore—the A.I.D. approved solder wire with three cores of non-corrosive Ersin flux, although Ersin Multicore, after paying freight and duty, cost American manufacturers fifty per cent. more than American made solders.

Why? With the correct, rapid soldering technique, H.R. or "dry" joints are impossible with Ersin Multicore, and production is speeded up.

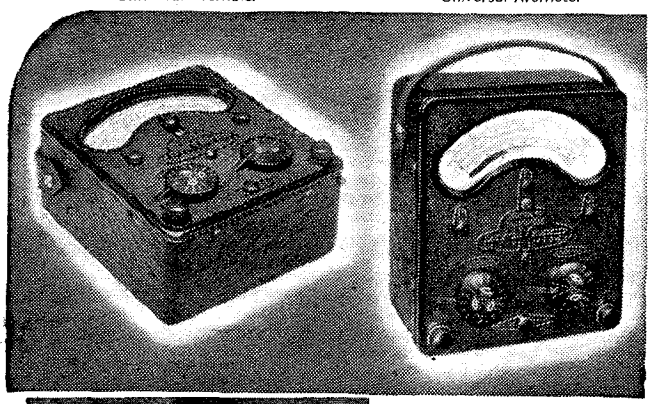
Present conditions do not permit the export of Multicore to U.S.A., but after Victory, U.S.A. manufacturers will once again be able to use "the finest cored solder in the world."

MULTICORE SOLDERS LIMITED, BUSH HOUSE, W.C.2. 'Phone Temp. Bar 5583/4

Pollard

46-range Model 7
Universal AvoMeter

40-range Model 40
Universal AvoMeter



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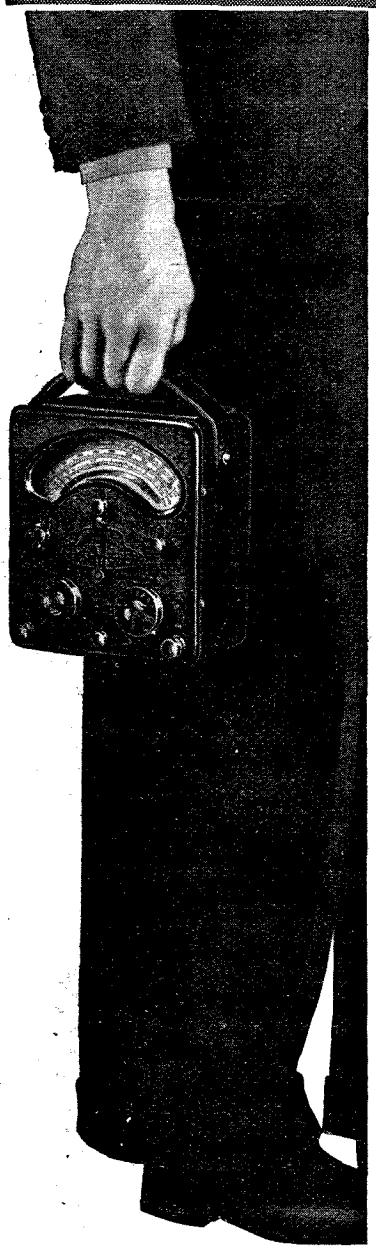
Regd. Trade Mark

Meters that Matter



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

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

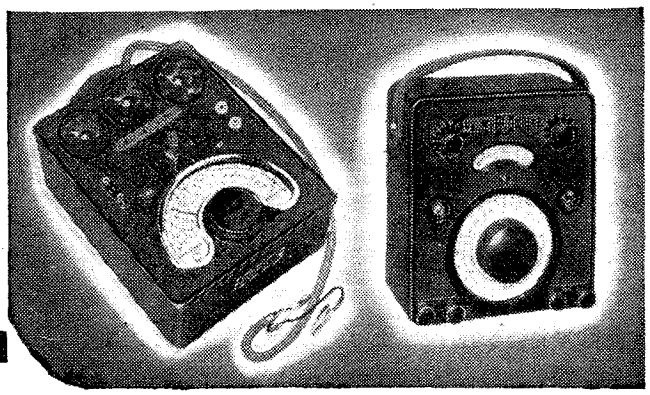
Write for literature fully descriptive of any "AVO" Instrument in which you are interested.

Sole Proprietors and Manufacturers:
THE AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT Co. Ltd.
Winder House, Douglas Street, London, S.W.1. *Phone: VICtoria 3404-7.*

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

All-Wave "Avo" Oscillator

"Avo" Test Bridge



ADVERTISEMENT OF THE TELEGRAPH CONDENSER CO., LTD.
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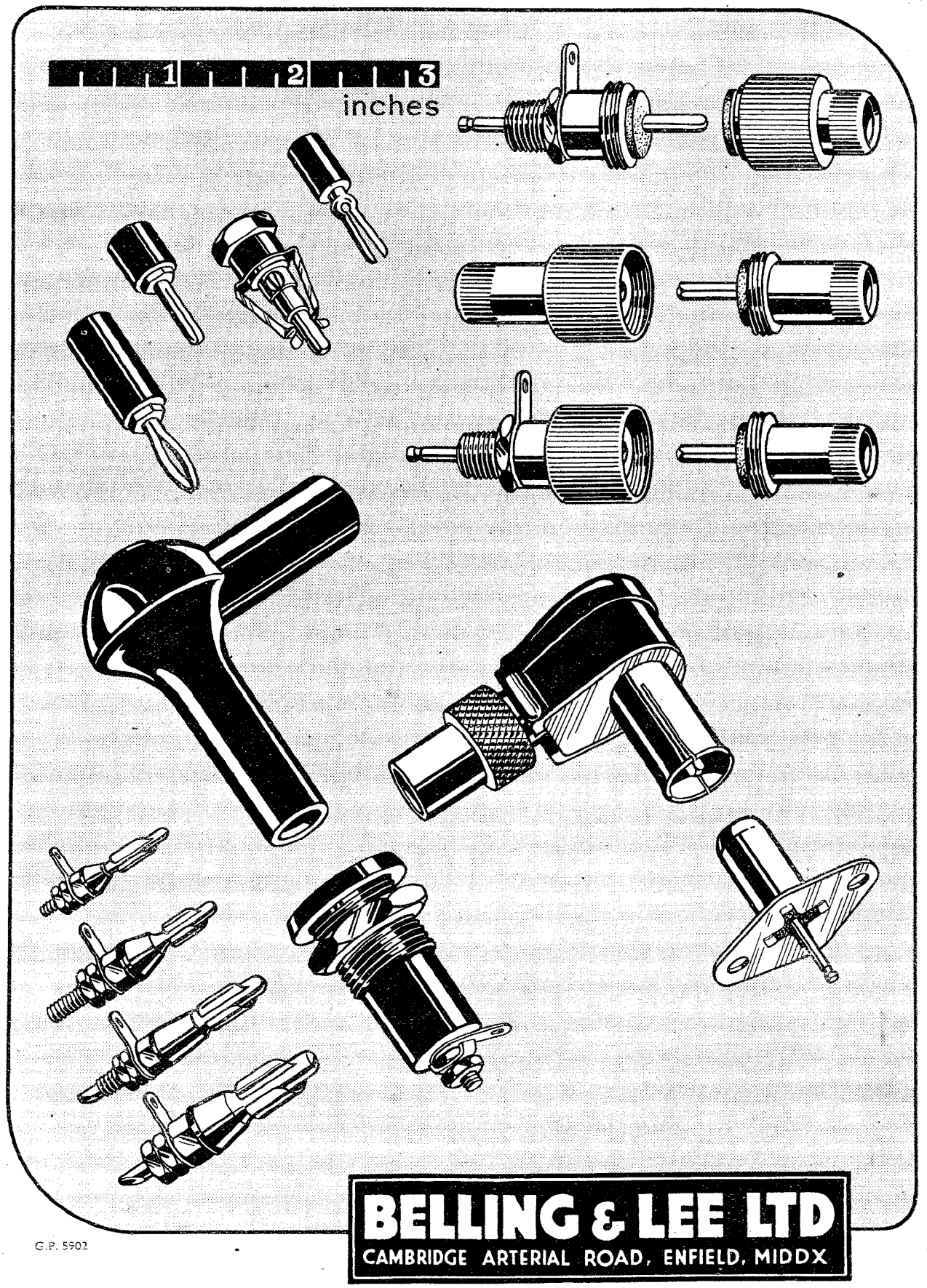

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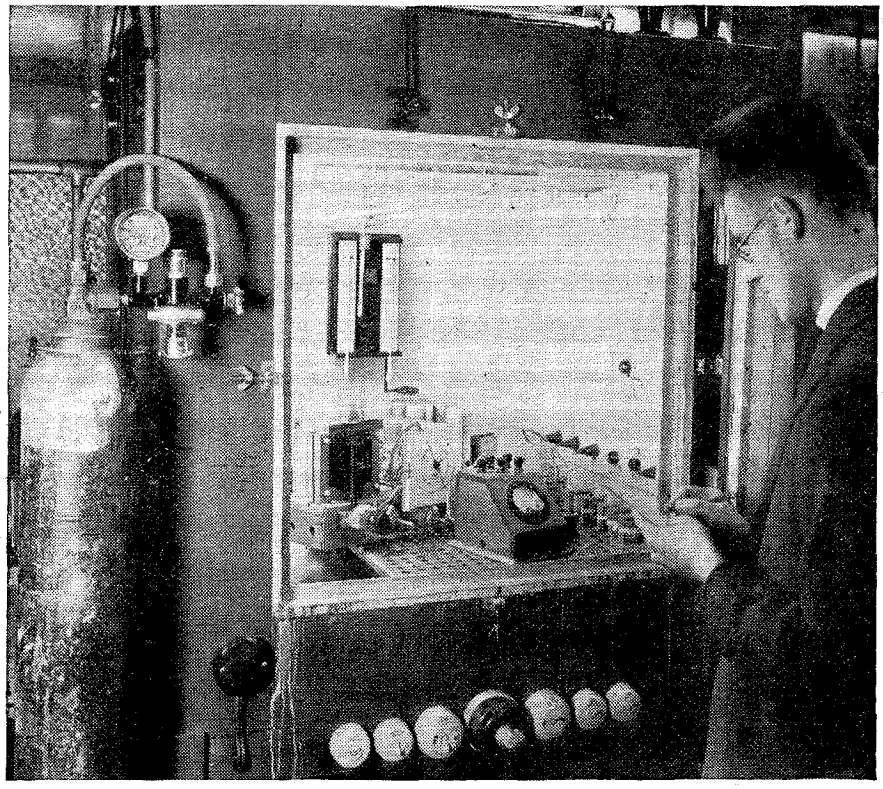

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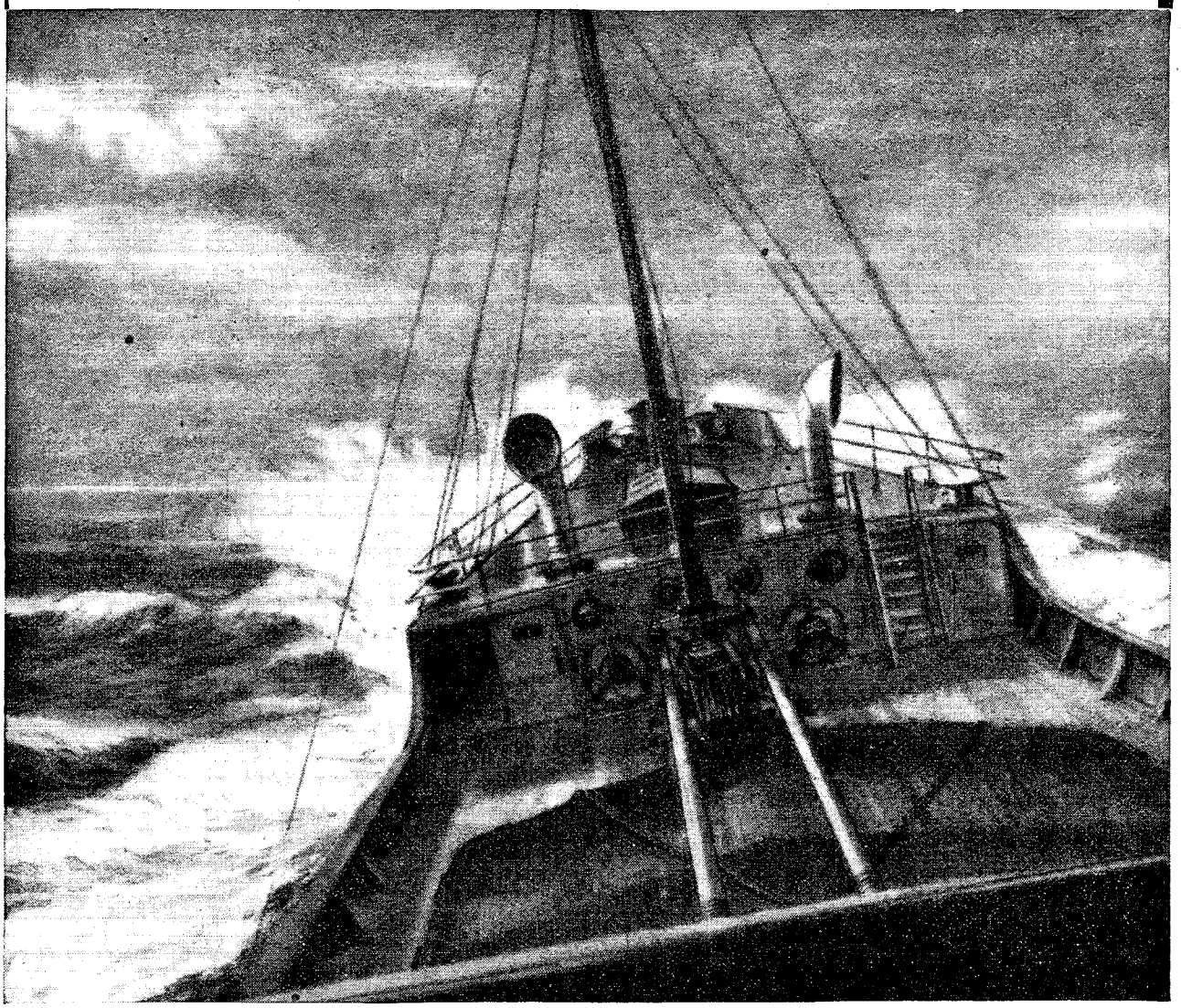
MADE IN ENGLAND

Ever since the advent of radio Osram Valves have been closely connected with all the progressive stages of development in radio science. Intensive research still goes on by improvements in design and technique to keep pace with the advancing times, and which will ultimately be of benefit to all.

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

With all the Ocean for a Road . . . .

. . . . a ship ploughs its way to port. Often contact with the world seems all but lost through fog or gale. But thanks to radio, contact is *never* lost. Each ship, great or small, can receive whatever warnings, whatever orders, whatever news or encouragement its guardians afloat and ashore may send forth.
Dubilier are proud to know that they are helping this great work, helping in the equipment which is bringing the ships home.



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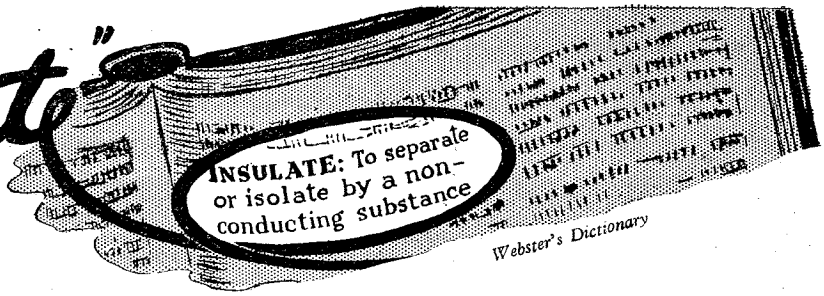
CONDENSER CO. (1925) LTD.

C.R.C. 160

"to Insulate"



Practically all waxes are used to "separate or isolate," but the degree of insulation provided by the different types of waxes varies enormously.

There is obviously no higher degree of insulation required than that of electrical components and apparatus in intense electrical fields, especially in the extremes of conditions to which they are subjected to-day.

We specialise in the supply of

WAXES *for all*

purposes — under all conditions

Our technical advice is at your disposal. If you have any problem of

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we, as consultants to the industry, shall be glad to offer you a solution.

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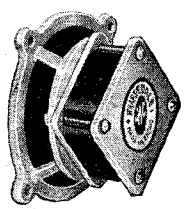
MIDGET 3½-inch UNIT



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Flux Density 8,000 lines.

Speech Coil 15 ohms or 2/3 ohms. The first Wharfedale Unit using the new ALCOMAX magnet steel which gives extremely high flux density with small size. Designed for use as Microphone or Midget Speaker. Very sensitive.

Supplies are available for PRIORITY ORDERS ONLY

PRICE **28/6** (list)

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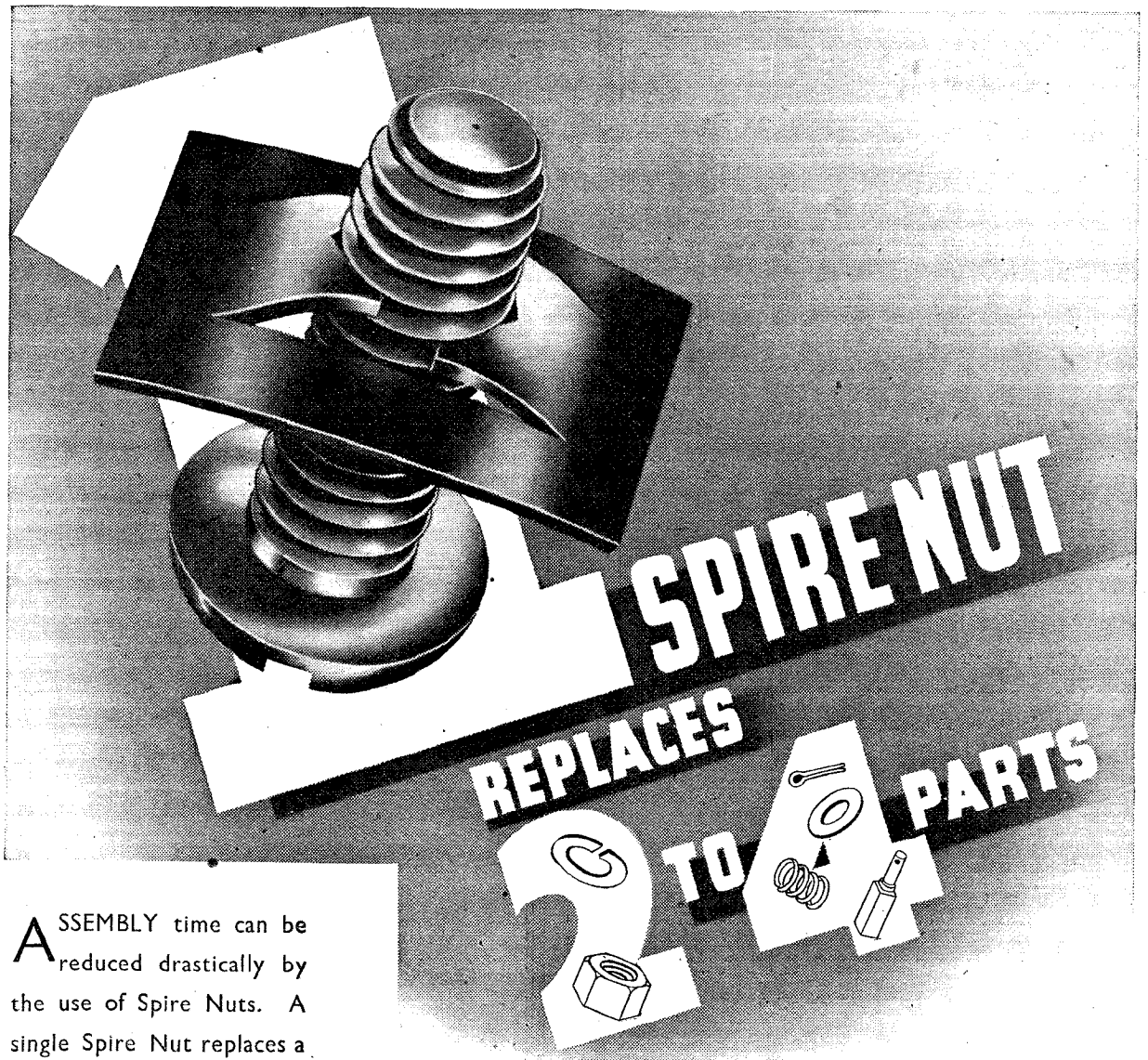

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Offer from stock the following brand new **INDUSTRIAL** and **ELECTRO-TECHNICAL EQUIPMENT**, for which early application is essential. All prices strictly nett cash.

INDUSTRIAL LOUDSPEAKERS. New 6-watt P.M. moving coil model, by G.E.C. Housed in 9in. grey enamelled metal drum, with front and rear grille and mounting bracket. Fitted multi transformer, **45/-.**

INDUSTRIAL ELECTRIC SOLDERING IRONS, best makes from stock. All for continuous use on 220/240v. **Stanelco**, 75-watt, 4in. pointed bit, **21/-**; 150-watt, massive flat bit, **32/6.** Also Electrode-heated model, 1,000 watts, operating from 4 volts, complete equipment with Transformer Power Unit, **£15** (carr. forward). **Aeru**, with 2½in. pointed bit, 100-watt, **28/6.**

GEARED HIGH TORQUE MOTORS, constant speed induction, 200/250v. A.C., final speed 3 r.p.m. in metal housing 4½in. dia., 3in. high, silent running and precision made, with flex and plug, **39/6.** Very useful in research depts., etc., for recording instruments and switching. Also low-torque model, 200/250v. A.C., final speed adjustable from 1 to 6 r.p.m. (infinitely), same style as above, **29/6.**

RELAYS, new compact model in 2in. by 1in. metal housing. Operating from 6 volts D.C. and breaking 6 amps., **10/6.** Also large range of Londex Relays, with 200/250v. shaded pole A.C. coils and mercury switches for various duties. Details on request. Also Londex, operating from 12v. D.C. (or 50v. A.C.) 10-amp. break, 2-pole silver contact switch, **35/-.** Executives should make a point of inspecting our present fine range of relays.

SLIDING RHEOSTATS, 100 watt capacity. Fully enclosed, with smooth positive action. Full range still in stock; 4 ohms 5 amps., 10 ohms 3 amps., 50 ohms 1.5 amp., 100 ohms 1 amp., and 400 ohms 0.5 amp., any one, **21/-.** Others made up to order in shortest time only against Government contracts.

HEAYBERD BATTERY CHARGERS, 200/250v. A.C., for 8 cells (16v.) at 0.5 amp., in strong metal case 8in. by 5½in. by 5in. for bench or wall, metal rectified, **39/6.** Very few of these.

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MAINS TRANSFORMERS for radio or amplifiers. Good makes. Prim. 200/250v., Sec. 350/350, 75m/a., 4v. 4a., 4v. 2a., **29/6.** Also 400/400, 200 m/a., 6.3v. 4a., 5v. 3a., **59/6.**

G.E.C. INTERVALVE TRANSFORMERS, "Hiflux," ratio 3 : 1, **6/9.**

HEADPHONES, here in stock—no waiting. G.E.C., 4,000 ohms, **22/6** pair.

L.T. SMOOTHING CONDENSERS, T.C.C. 1,000 mf., 12v. wkg., **5/6.**

ROTHERMEL-BRUSH PIEZO-CRYSTAL MICROPHONES, well-housed with knuckle joint for angle adjustment. Response level to 8,000 c/s. Output level—60 db. Mounting thread ¼in. (26), complete with 6ft. screened lead **72/6.** (To-day's best microphone opportunity.) Extending **TABLE STANDS**, with appropriate thread for above mike, heavy base, **22/6.**

HAND MICROPHONES, much in demand for factory and field use—can be used in ordinary telephone circuit without amplifier, **22/6.**

RESIN-CORED SOLDER (by prominent cable firm), 13 s.w.g., highest tin content available to-day. On 1 lb. reels, 40 per cent. tin, **4/6** per reel, post paid. 65 per cent. tin, **5/11** per reel, post paid. Final opportunity.

ROLA MIDGET P.M. SPEAKERS, 5in. overall, high-flux alni magnet, 3-ohm voice coil, **21/-.**

TOGGLE PRESSES, hand-operated senior model, for stamping out small parts. Height 32in. overall, weight 130 lb. Supplied immediately from present small stock, details on request, **£30** (carr. forward). Early application essential.

Please include sufficient for packing and postage—any excess will be refunded. Staff shortage—priority given to orders with remittance, excepting our ledger customers.

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RAYMART

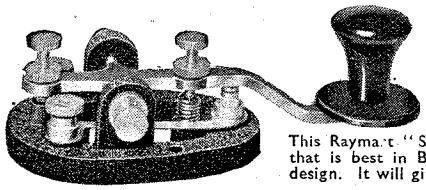
CRAFT-A CREED

"SPEED" KEY

8/6 Post Paid

- **Rigid in construction.**
- **Extremely light in action.**
- **Fitted with heavy silver contacts.**
- **Suitable for serious work.**

The above four phrases were chosen from a "test" report which appeared in the May issue of the "WIRELESS WORLD."



Read the full "test" report on page 116 "Wireless World."

This Raymart "Speed" Key combines all that is best in British and American key design. It will give years of useful service. Practically effortless high-speed sending can be achieved with this key, because in designing it special consideration was given to the important point of scientific weight distribution.

Build your own G.P.O. Type MORSE KEY.

Specification includes: Contacts of ¼-in. solid sterling silver. A high-grade spring is fitted. Gap adjustment is easily and accurately made. The high-grade bakelite knob is British standard size. Metal parts are instrument lacquer finished.

The Raymart KIT OF PARTS for building this Morse Key includes:

Solid brass bar ½-in. by 5/16-in. Set of pivot bushes. Pair of solid sterling silver contacts. Brass screw with adjusting collar for varying tension on spring. Spring for above. Brass stop screw with locking collar. Bakelite knob, highly polished, fitted with fixing screw. Washer for fitting below knob. Combined template and "erinofort" base for covering a wood base. In addition you will need as a base a two-way switch block (cost only a few pence) and two terminals. Obtain these from local electricians. Only tools needed are a gimlet and pliers. Anyone can assemble this Kit in 10 to 15 minutes.

THE KIT **7/6** Post Free.

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FOR RADIO, CARS MOTOR CYCLES COMMERCIAL VEHICLES ETC.

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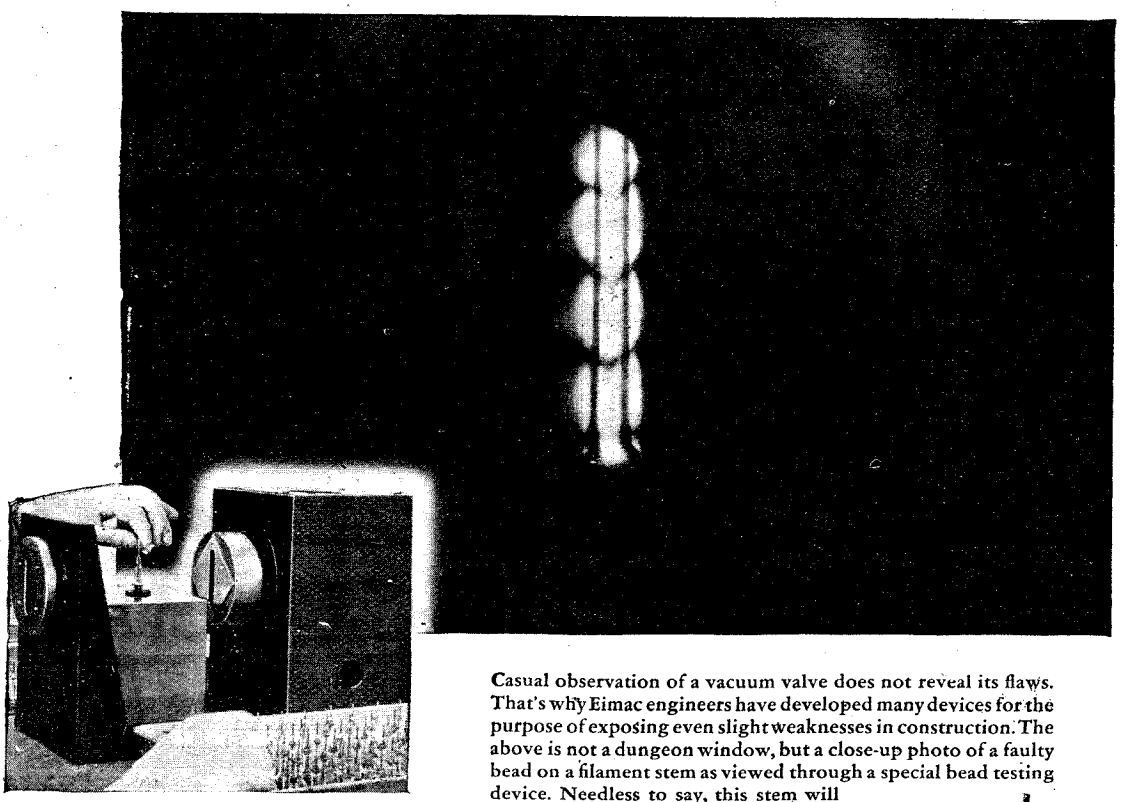
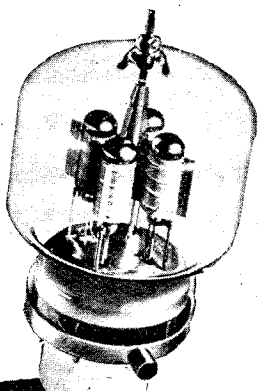
DEATH *before* DISHONOR!



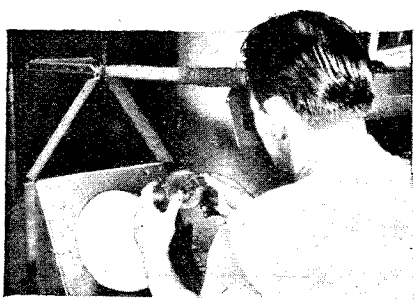
Observation of the stress points on glass bead seals around vacuum valves leads is made with this device. Close-up photo above shows the actual view of a faulty lead. Note the change in polarized light creating distorted shadows which show up stress and strain in beads. Such strain sometimes occurs where metal and glass are sealed together.

Casual observation of a vacuum valve does not reveal its flaws. That's why Eimac engineers have developed many devices for the purpose of exposing even slight weaknesses in construction. The above is not a dungeon window, but a close-up photo of a faulty bead on a filament stem as viewed through a special bead testing device. Needless to say, this stem will never reach final assembly... better "death before dishonor" to the Eimac tradition of dependability.

Such care in production plus constant research into the phenomenon of the electron valve assures you of the utmost in performance from every Eimac valve ... provides the answer to why Eimac valves are first choice by most of the leading engineers throughout the world.



Export Agents:
FRAZAR & CO., LTD., 301 Clay St.
San Francisco, California, U. S. A.



Inspecting the entire glass bulb with the help of a polarized light. This device shows up stress and strain on the glass which might be created during the shaping operations.

Follow the leaders to

Eimac VALVES

Mfg. by Eitel-McCullough, Inc., San Bruno, California, U.S.A.

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LOUD SPEAKERS

THE WORLD'S FINEST REPRODUCERS

TRANSFORMER LAMINATIONS

Core Widths 9/16" to 1 1/2" (E's and I's.)

EIGHT STOCK SIZES

A Comprehensive Bulletin together with details of Associated Covers and Clamps with design data will be sent to manufacturers on request.

BRITISH ROLA LIMITED

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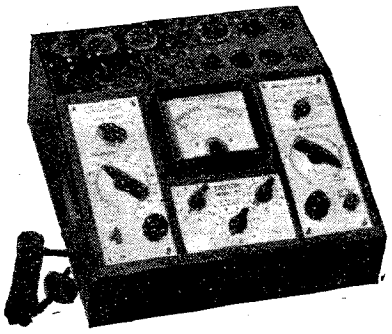
OUTSTANDING RELIABILITY

Many Westinghouse Metal Rectifiers are still in service after 16 years constant use, without any replacement; they are undoubtedly the most reliable rectifier for H.T. and L.T. supply, detection and A.V.C.

At the moment Westinghouse Metal Rectifiers are in short supply, but, with the return to normal conditions, the benefits of the many improvements which are at present being made, will be available to all.

Westinghouse METAL RECTIFIERS

Westinghouse Brake & Signal Co., Ltd., Pew Hill House, Chippenham, Wilts.



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MUTUAL CONDUCTANCE

VALVE TESTER

MODEL 45

A robust, compact and accurate test instrument essential to all radio manufacturers, servicemen and dealers.

Operates on A.C. 200/250 volts, 40/100 cycles.

SPECIFICATION

Mutual Conductance. Accurate and quick measurements are available for practically all British, American and Continental valves, from 0.25 to 24 mA/V.

Valveholders. 17 holders cover all modern types and include Loktal, Octal, Mazda Octal and side contact types.

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PRICE

£15.15.0

Portable Model 45P, with compartment for tools, **£17/6/6.**

Taylor Valve Testers are supplied with a book of instructions, including wiring diagram, a valve chart covering over 1,000 types of valves, and a grid connecting lead.

Further details on request.

BRITISH MADE AND GUARANTEED 6 MONTHS

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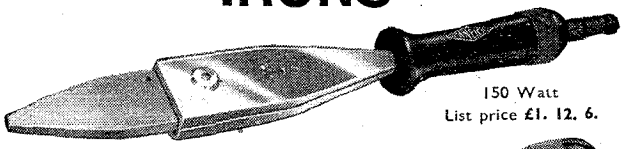
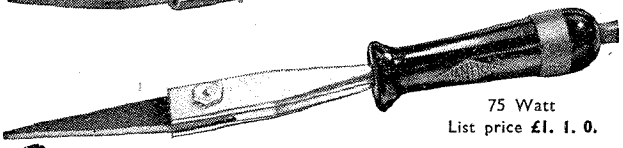
STANELCO

ELECTRIC SOLDERING IRONS



150 Watt
List price **£1. 12. 6.**



75 Watt
List price **£1. 1. 0.**

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Each Iron, fitted with 5½ feet of 3-core flexible cable, is available for 100/110, 200/220, 230/250 voltages.

When ordering, the voltage and type of bit required should be specified.

RESIN CORED SOLDER, SOLDER WIRE, Etc.

Stanelco Products

PROPRIETORS: STANDARD TELEPHONES AND CABLES LIMITED
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Communication Receiver

RADIO PRODUCTS EDDYSTONE TRADE MARK

WITH BANDPASS CRYSTAL FILTER

Special models of the Eddystone "358" and Medium Frequency Model "400" are available with Bandpass Crystal Filters. The advantage crystal control gives in improved rejection of interference outside the band and correspondingly better signal-to-noise ratio has been fully exploited by Eddystone designers. Both these receivers, at the moment, can only be supplied to holders of priority orders.

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The Short-Wave Specialists

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HOURS OF BUSINESS: 9 A.M.–5 P.M SATS. 9 A.M.–12 NOON

14 SOHO STREET, OXFORD STREET, LONDON, W.C.1

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LONDON CENTRAL RADIO STORES

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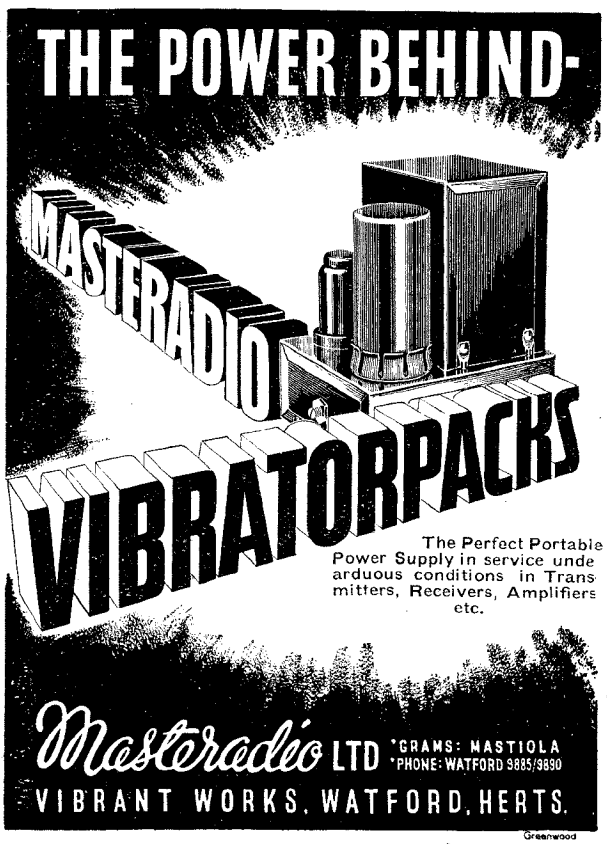

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for metallising CERAMIC, MICA, QUARTZ or GLASS.

Low melting-point **SOLDER** from 70°C. or to specification. Non-corrosive Liquid **FLUX** for all electrical or Radio purposes.

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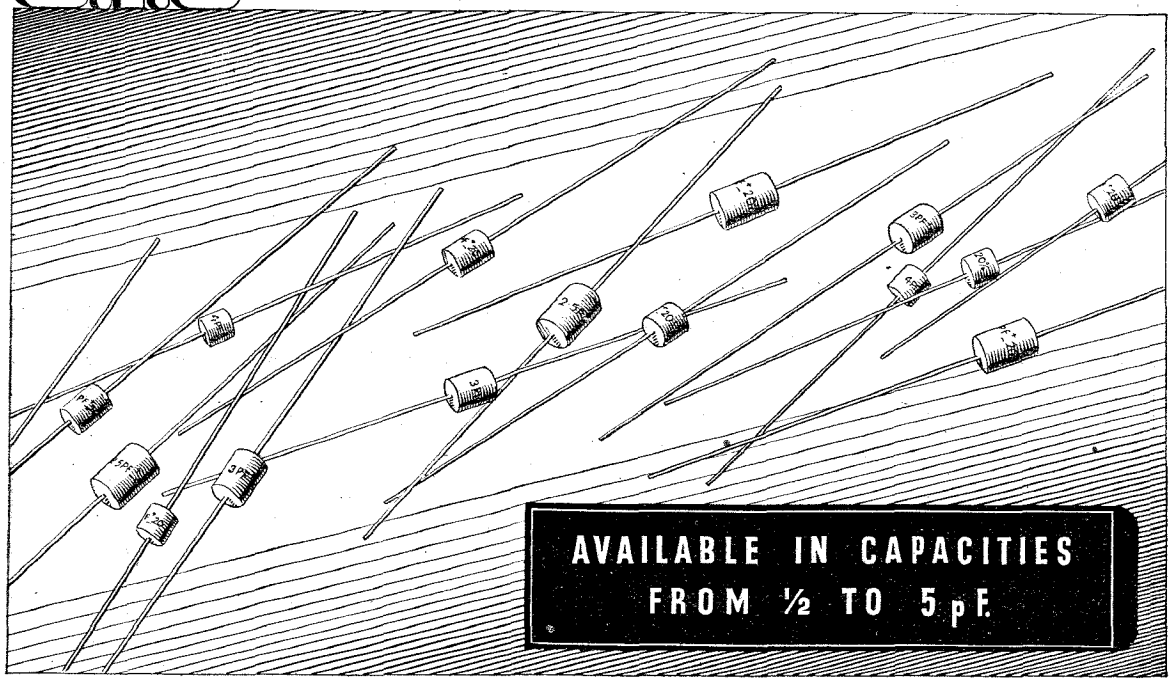
U.I.C

Silvered Ceramic Condensers

PEARL TYPE



Fixed Condensers with Ceramic Dielectric. The smallest condensers on the market. Mechanically and electrically stable.

Test Voltage -	1,500 Volts D.C.
Capacity - Tolerance	±20%
Finish - - -	Normal—Double lacquered.
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	Type approved.

Full details and advice gladly given.

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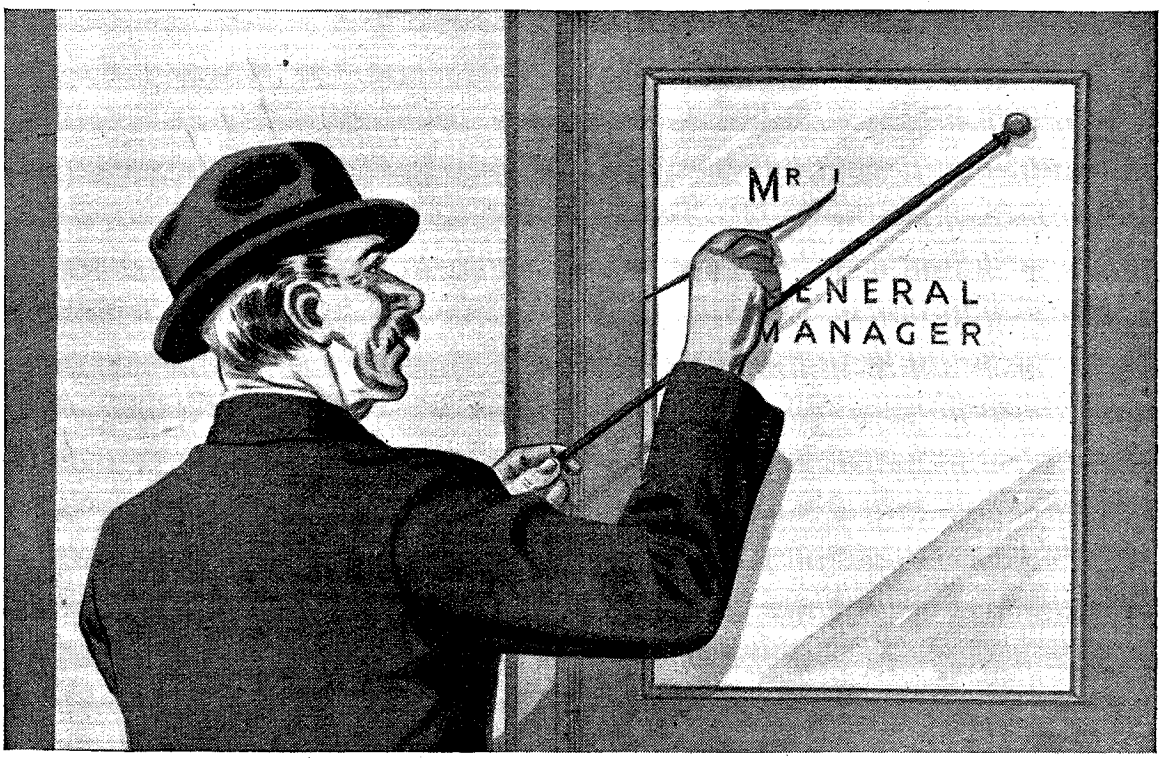

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EDITORIAL 201
VARIABLE SELECTIVITY I.F. AMPLIFIER.
By J. E. Varrall 202
PHYSICAL FOUNDATIONS OF RADIO.
By Martin Johnson, D.Sc. 206
"WIRELESS WORLD" BRAINS TRUST.—No. 4 .. 208
MIDDLE EAST TRAINING 209
PHASE AND FREQUENCY MODULATION.
By Christopher Tibbs, Grad.I.E.E. 210
UNBIASED. By Free Grid 214
SUNSPOTS AND SHORT WAVES 215
THE WORLD OF WIRELESS 216
NEWS IN ENGLISH FROM ABROAD 218
RANDOM RADIATIONS. By "Diallist" 220
LETTERS TO THE EDITOR 222
RECENT INVENTIONS 224

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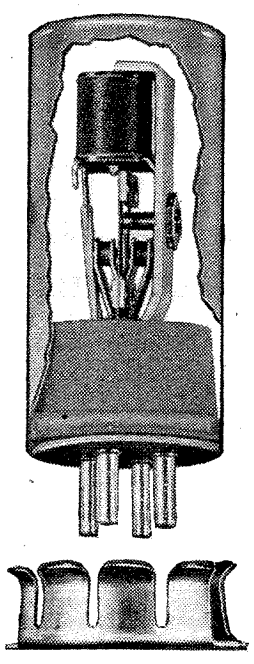

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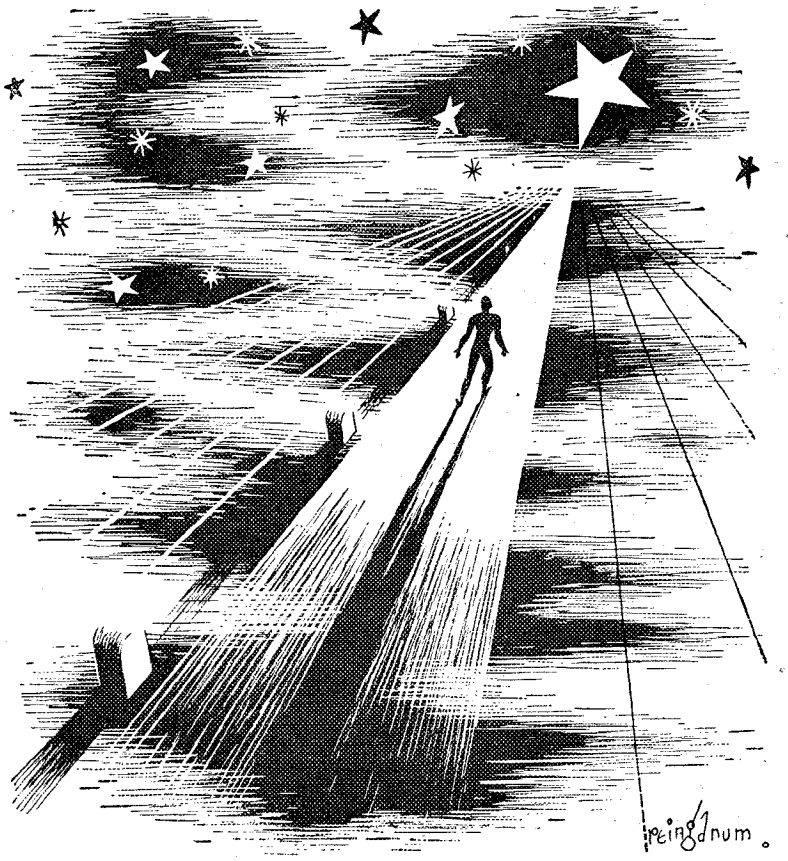

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Wireless World

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Hearing Aids: The Medical Aspect

A Case for Co-operation

A GREAT deal of interest is still being shown in an article published in our May issue in which it was suggested that, after the war, hearing aids should by manufactured by the wireless industry by mass-production methods, thus bringing alleviation to sufferers from deafness at much lower cost than at present. To that basic proposal there has been relatively little opposition, but few of our correspondents are in agreement with the author's implied suggestion that the standardised hearing aids produced on this plan should be distributed to deaf users through wireless dealers. All that has been written on this aspect confirms us in the belief, expressed when we first commented editorially on the matter, that co-operation with the medical profession is essential for the success of any scheme designed to lighten the burden of the deaf.

That such co-operation is necessary in the design of hearing aids is self-evident, and the matter need not be argued here. The wireless engineer has a flying start, so far as the electro-acoustic side of the problem is concerned, but, before he can use his knowledge to full advantage, he must know something of the medical problem he is to help in solving. But it is perhaps not so obvious that in the distribution of hearing aids, and particularly in everything connected with the "fitting" of the deaf with suitable apparatus, medical co-operation is equally necessary. There is, for example, one form of deafness, due to impairment of the nerve system connecting the ear with the brain, where no hearing aid can be of any use. The ear mechanism may be functioning perfectly, but the sufferer cannot interpret sounds, or does so haltingly and with difficulty. Clearly, the seller of hearing aids should be able to recognise this form of deafness; otherwise a sufferer from it may purchase an instrument that can be of no possible use to him.

Then there is nerve deafness, affecting the inner ear, which results in a falling-off in acuity of hearing at low sound levels, but, when sound intensity is increased (e.g., by an amplifier) beyond a certain point, a sound level is reached where the defective ear may be more sensitive than a normal ear, thus causing its owner to arrive at what is known as the "threshold of pain" at a lower acoustic level than persons of normal hearing. It is this effect that is responsible for the suggestion made by some correspondents that there is an actual danger in allowing hearing aids to be sold by persons completely unversed in the medical aspects. Whether or not "danger" is too strong a word to use here need hardly be debated, but it seems evident that some form of limiter, probably with facilities for adjusting the level at which it comes into operation, is needed in hearing aids for this form of deafness, and in any case it is evident that some skill and knowledge are needed for dealing with such cases.

All this gives support to the suggestion, made by several correspondents, that the sellers of hearing aids should have training in the physiological aspects of deafness and in diagnosing the various forms. We agree that this is necessary. To remove the taint of quackery there should be a recognised qualification, issued with the approval of the medical profession, and, perhaps equally important as a safeguard to the public, with the active support and collaboration of a recognised body in the electro-acoustic field. Collaboration is equally necessary in devising and standardising test apparatus and methods of testing for deficiencies of hearing.

Comparisons with the Optician

We see a very close parallel between the supply of aids to sight and aids to hearing. The optician sells spectacles, in many cases to his own prescription, but more serious cases are diagnosed and prescribed for by the medically qualified oculist, with whom the optician seemingly works quite harmoniously. A comparable system of selling hearing aids could be worked out, and, as we see it, the most efficient channel of retail distribution should be through the wireless dealer, provided he or his assistant has undergone suitable training. He has —or should have—the necessary background of electro-acoustic knowledge that is half the battle, and so it would be more efficient to train him than a beginner with no knowledge of either the electrical or medical aspects of the matter. We lay stress on efficiency, because wasteful methods of distribution are bound in the long run to be reflected in unnecessarily high costs of hearing aids.

VARIABLE SELECTIVITY IF AMPLIFIERS

Preserving Symmetry in the Response Curves of Switched Circuits

This article gives a brief survey of possible methods of obtaining variable bandwidth by means of switched circuits and of their shortcomings. A detailed description is put forward of a new system which preserves symmetrical response at all settings

By J. E. VARRALL

ONE of the main advantages of the superheterodyne method of reception is the concentration of nearly all the selectivity characteristic into the IF amplifier. Since this concerns only a fixed band of frequencies the response curve may be accurately adjusted and holds for any incoming signal with but a small modification, due to the RF circuits.

The RF tuned circuits are primarily to prevent second channel interference, and the selectivity requirements are not very stringent, particularly for IF frequencies above 450 kc/s. To prevent loss of gain due to tracking errors they should be comparatively flat, in which case the modification of the IF response curve is still further reduced.

In a receiver designed to give the highest possible quality from any desired signal, the provision of variable selectivity to enable the best compromise between sideband cutting and adjacent channel interference is desirable. An IF amplifier with variable bandwidth filters enables this to be achieved, because the receiver selectivity is sensibly that due to the IF characteristic in use. There are several methods by which variable selectivity in an IF amplifier may be obtained, but there are difficulties in the application of each method, and these will be indicated.

In order to provide a flat-topped selectivity curve, double hump tuning is always employed, the humps occurring at the two ends of the required band and the trough either being filled by another peak-tuned circuit or made small by limiting the peaks with resistive damping. The double hump may be produced by two peak-tuned circuits, tuned to different frequencies; or, preferably, two coupled circuits, tuned to the same frequency, and coupled with greater than critical coupling.

In this the tuned circuits are coupled either inductively or by means of a common reactive element. The double peak occurs if the coupling between the circuits is very much greater than critical, and is due to the change of sign of the second tuned circuit impedance when reflected back into the first tuned circuit. When the second tuned circuit is at resonance it effectively adds a small resistance in series with the primary tuned circuit, limiting the current in this circuit. At frequencies above resonance the second tuned circuit has an inductive reactance, and below a capacitative. These appear as capacity and inductance respectively in the first tuned circuit, and form a series tuned circuit with the primary circuit impedance (inductive above resonance and capacitative below) to produce the two peaks on either side of the resonant frequency.

It can be shown that if the coupling is considerably higher than critical, i.e. neglecting losses, the peaks occur at $f_r \cdot \sqrt{1 \pm k}$, where f_r is the resonant frequency of the tuned circuits, and k the coefficient of coupling. Critical coupling is exceeded when k is greater than $\frac{1}{\sqrt{Q_1 Q_2}}$, where Q_1 and Q_2 are the values of $\frac{\omega L}{R}$ of the two tuned circuits, and under these conditions the width of band separating the peaks is approximately $f_r \cdot (\sqrt{1+k} - \sqrt{1-k})$ or $f_r \cdot k$, if $k << 1$. For values of k a little in excess of $\frac{1}{\sqrt{Q_1 Q_2}}$ the rise in the response at $f_r \cdot \sqrt{1 \pm k}$ does not show up a peak. Its effect, however, flattens the selectivity curve between these frequencies, and the bandwidth of $f_r \cdot k$ can be assumed for all values of k greater than $\frac{1 \cdot 5}{\sqrt{Q_1 Q_2}}$.

The resonant frequency of the first tuned circuit is its resonant frequency with the second tuned circuit open, and that of the second tuned circuit, its resonant frequency with the first tuned circuit open. For variable selectivity it is obviously necessary to vary k, either continuously or in steps, to give the required values.

Methods of coupling are shown in Fig. 1. The capacity coupling system of Fig. 1 (a) provides reactive coupling between the two circuits across the common capacity C3. The coefficient of coupling is given by

$$k = \sqrt{\frac{C_1 C_2}{(C_1 + C_3)(C_2 + C_3)}}$$

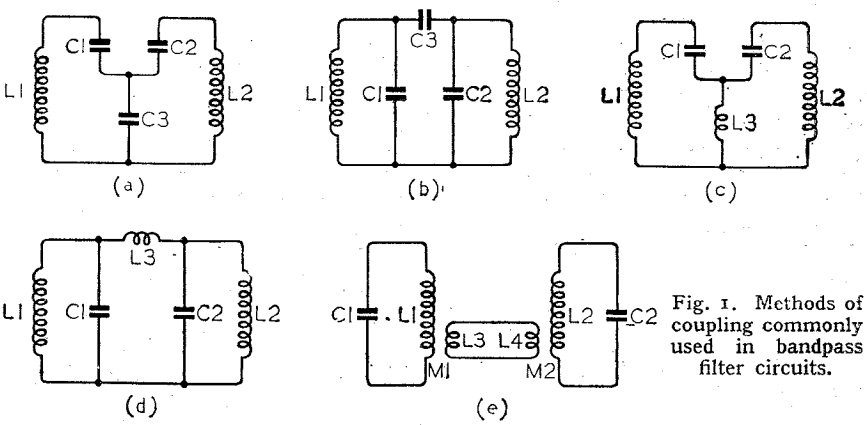


Fig. 1. Methods of coupling commonly used in bandpass filter circuits.

and to vary the coupling, different values of C_3 must be switched into circuit. The resonant frequency of the first tuned circuit is that obtained by removing L2, i.e. L1 tuned with

C_1 and C_3 in series, similarly the resonant frequency of the second tuned circuit is L_2 tuned with C_2 and C_3 in series. Since the peaks occur symmetrically about the resonant frequency, change of C_3 will change the resonant frequency, and hence the mid-band frequency, and if C_1 and C_2 are not the same value the resonant frequencies of the two tuned circuits will change by different degrees. Assuming C_1 and C_2, and L_1 and L_2 are equal, as is usually the case, then

$$f_r = \frac{1}{2\pi\sqrt{L_1\frac{C_1 C_3}{C_1 + C_3}}},$$

and $k = \frac{C_1}{C_1 + C_3}$. Combining these results in $f_r \cdot \sqrt{1 \pm k}$ the positions of the two peaks are found to be at frequencies of

$$\frac{1}{2\pi\sqrt{L_1 C_3}}, \text{ and } \frac{1}{2\pi\sqrt{L\frac{2C_1 C_3}{2C_1 + C_3}}},$$

i.e. if C_3 is changed the lower peak remains at its original frequency and bandwidth change is effected by moving the upper peak alone.

The top-end capacity coupling of Fig. 1 (b) has a value of k equal to $\frac{C_3}{\sqrt{(C_1 + C_3)(C_2 + C_3)}}$. If $L_1 = L_2$ and $C_1 = C_2$ the nominal resonant frequency of each tuned circuit is that of L_1, with C_1 in parallel with C_1 and C_3 in series. Here again variation of C_2 changes the mid-band frequency, and similar reasoning to the above shows that variation of C_2 moves only the lower peak. Coupling through a common inductance in the shunt by Fig. 1 (c), or high inductance top-end coupling, Fig. 1 (d), can be shown to produce similar results, in the former case $k = \frac{L_3}{\sqrt{(L_1+L_3)(L_2+L_3)}}$ and f_r is determined by L_1, L_3 and C_1; and L_2, L_3 and C_2 in series, i.e. if $L_1 = L_2$ the top frequency remains fixed; and in the latter

$$k = \sqrt{\frac{L_1 L_2}{(L_1 + L_3)(L_2 + L_3)}},$$

and f_r is determined by C_1, and L_1 in parallel with $L_3 + L_2$. Here, if $L_1 = L_2$ and $C_1 = C_2$, the bottom frequency does not change when L_3 is varied.

With link coupling, Fig. 1(e), the coefficient of coupling is given by

$$k = \frac{k_1 k_2}{\sqrt{(1 - k_1^2)(1 - k_2^2)}}$$

where k_1 and k_2 are the couplings between L_1 and L_3, and L_2 and L_4 respectively, i.e.

$$\frac{M_1}{\sqrt{L_1 L_3}}, \text{ and } \frac{M_2}{\sqrt{L_2 L_4}}$$

where M_1 and M_2 are the mutual inductances involved. The link changes the effective values of L_1 and L_2 for the computation of f_r, to

$$L_1 \cdot \left(1 - \frac{M_1^2}{L_1 L_4}\right), \text{ and } L_2 \cdot \left(1 - \frac{M_2^2}{L_2 L_3}\right)$$

respectively. If k is small and the coils and condensers identical, $k = \frac{M_1^2}{L_1 L_3}$, and substitution in $f_r \cdot \sqrt{1 \pm k}$ shows that here again variation of the coupling moves only the top peak.

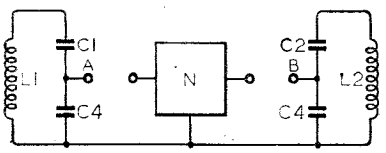


Fig. 2. Basic circuit of improved bandpass circuit suitable for switched bandwidth and constant mid-band frequency.

All these simple methods of varying the coupling suffer from lack of symmetry in the response curves. Methods can be developed for switching in separate trimmers for each coupling value, but these are clumsy and usually entail high HF potentials on the switch leads. The two methods generally adopted are the tertiary winding and mechanical variation of mutual inductive coupling.

The tertiary winding consists of a few turns, tightly coupled to the first tuning coil, which can be switched in series with the second tuning coil and assists the inductive coupling already existing. For a simple two-bandwidth system this method is satisfactory, detuning being present to a lesser extent than in any of the previously discussed methods. It does not, however, lend itself to the design of an efficient multi-bandwidth system.

The mechanical variation of mutual inductance is the only system that does not result in some degree of detuning, but only if the mutual inductance alone is changed. The changing of the position of one coil relative to the other usually results in small changes in capacity between the two coil, and also change in the damping loads on the moved coil due to the proximity of screening cans. These troubles can be largely overcome by electrostatic screens between the two coils, and careful arrangement of the cans, and the most satisfactory results have been obtained by this method. It has the disadvantages of employing mechanical links and requiring considerable care in its design. A third alternative was used in the *Wireless World* Communication Receiver,[1] and utilises separate IF transformers for the various degrees of selectivity. Although theoretically sound this method becomes unwieldy when more than three degrees of selectivity are required. Clearly, a simple method of varying coupling to any desired extent without tendency to detuning is required, and it is now proposed to describe such a system.

[1] *Wireless World*, June 30th, 1938.

In any system employing switching it is preferable to switch points of low HF potential, and of all the methods that of Fig. 1 (a), (bottom end capacity coupling) is the most convenient. Large variations of k can be obtained very simply, condensers being selected to give any required value, and the switching point is at low HF potential.

An examination of the causes of detuning when C3 is changed showed that the effective tuning capacity of the primary circuit is C1 in series with C3; and of the second tuned circuit, C2 in series with C3. Variation of C3 changes these resonant frequencies. Thus in order to prevent alteration of these frequencies a method of changing the coupling while preserving a constant effective tuning capacity for L1 with L2 disconnected, and for L2 with L1 disconnected, is required.

In Fig. 2 the capacity C3 is shown split into two equal sections, C4. When these two condensers are connected in parallel, the effective value of coupling condenser is 2C4, the tuning capacity for L_1 is C1 in series with 2C4, and for L2, C2 in series with 2C4. If now a network N be connected between A and B, of such

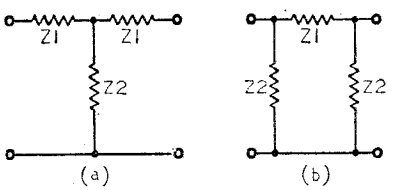


Fig. 3. "T" and "π" networks of the form required in the coupling N of Fig. 2.

character that the impedance presented at A when the other end is terminated with C_4 is equal to the impedance of C_4, and the impedance presented at B by the network when its far end is terminated by C_4 is also equal to the impedance of C_4, the tuning capacity for L_1 remains at C_1 in series with 2C4, and for L_2, C_2 in series with 2C4 when N is connected in circuit. Thus if N is designed to fulfil this condition and at the same time to attenuate the voltage coupled from the first tuned circuit into the second to any desired extent, the value of k will have been decreased while the effective tuning capacities

Variable Selectivity IF Amplifier—

for L_1 and L_2 have remained unaltered, i.e. the bandwidth will be decreased without change in the position of the mid-band frequency.

The parallel between the network N and the well-known "T" and "π" networks is obvious. In Fig. 3 these networks are shown: when either end is terminated with Z_0, the impedance looking into the other end is also Z_0. If the ratio of input to output volts when properly terminated is N, then for the "T" network the required values are, $Z_1 = Z_0 \cdot \frac{N-1}{N+1}$; $Z_2 = Z_0 \frac{2N}{N^2-1}$, and for the "$\pi$," $Z_1 = Z_0 \cdot \frac{N^2-1}{2N}$; $Z_2 = Z_0 \cdot \frac{N+1}{N-1}$. In the case of the required network, $Z_0 = \frac{1}{j\omega C_4}$, and the required elements are all condensers. For a "T" network, Z_1 will be a condenser of $C_4 \cdot \frac{N+1}{N-1}$, and Z_2 a condenser of $C_4 \cdot \frac{N^2-1}{2N}$. In the case of the "$\pi$," Z_1 will be a capacity of $C_4 \cdot \frac{2N}{N^2-1}$, and Z_2 a capacity of $C_4 \cdot \frac{N-1}{N+1}$. The coefficient of coupling when A and B are connected is $k = \sqrt{\frac{C_1 \cdot C_2}{(C_1+2C_4)(C_2+2C_4)}}$, and when the network is connected between A and B this must be multiplied by the factor $\frac{1}{N}$, where N is the voltage attenuation of the network.

From the above it will be seen that any required reduction in coupling can be obtained by means of a simple "π" or "T" capacity network with no alteration of the symmetry of the response curves. A more detailed design will be considered.

Four suitably selected bandwidths will be found sufficient for most purposes, and for the present design these will be taken as approximately 23, 15, 9, and 7 kc/s. For a 465 kc/s IF filter the required values of k are then $\frac{1}{20}$, $\frac{1}{31}$, $\frac{1}{51.5}$ and $\frac{1}{66}$. In order to limit the trough in the 23 kc/s condition, the "Q's" of the tuned circuits should be approximately 130, and critical coupling is exceeded in each case. The 7 kc/s bandwidth, however, will not show any marked two-peak effect, and a slightly lower coupling can be used with advantage to give high selectivity for bad reception conditions. Values of k of $\frac{1}{20}$, $\frac{1}{30}$, $\frac{1}{50}$, $\frac{1}{75}$ will be used. The effective tuning capacity for the coils depends largely on whether one or two IF stages are used, but a higher value than is usually adopted is advantageous since it prevents interaction between anode and grid circuits, which tends to modify the response curves long before unstable conditions are reached. The effects of valve capacities are reduced and the decrease of gain is justified by these advantages.

A value of 200 $\mu\mu$F will be assumed, and C_1 and C_2 will be made equal, thus L_1 and L_2 are both equal to 585 μH. For the maximum coupling A and B (Fig. 2) may be connected directly, thus eliminating one link. $2C_4$ should therefore be 200 × 20, i.e. $C_4 = 2{,}000$ $\mu\mu$F. The value of C_1 and C_2 is then 210 $\mu\mu$F, and making allowance for valve capacities these can be 175 $\mu\mu$F fixed and 5 to 50 $\mu\mu$F trimmers. The values of N for the three networks required are $\frac{3}{2}$, $\frac{5}{2}$ and $\frac{15}{4}$. If "T" networks are adopted the capacities for Z_1 are 10,000 $\mu\mu$F, 4,660 $\mu\mu$F and 3,450 $\mu\mu$F, and for Z_2, 835 $\mu\mu$F, 2,100 $\mu\mu$F and 3,500 $\mu\mu$F respectively. If "π" networks are used the capacities required are 4,800 $\mu\mu$F, 1,900 $\mu\mu$F, and 1,142 $\mu\mu$F for Z_1, and 400 $\mu\mu$F, 860 $\mu\mu$F, and 1,160 $\mu\mu$F for Z_2. From these figures it will be seen that the condensers required for the "π" pads are smaller and therefore more convenient than those required for the corresponding "T."

The complete variable bandwidth filter using these "π" networks is shown in Fig. 4. The trough will be too large when the two largest bandwidths are used, and a peak tuned circuit should be used as the second anode coupling. It has been shown[2] that a peak tuned circuit of "Q" equal to half the "Q's" of the band pass filter circuits provide the necessary correction and is far more efficient than adding dissipative elements to the coupling circuits. If two variable couplings are used the necessary correction can be obtained by a third coupled circuit of correct "Q's" but less than critical coupling,

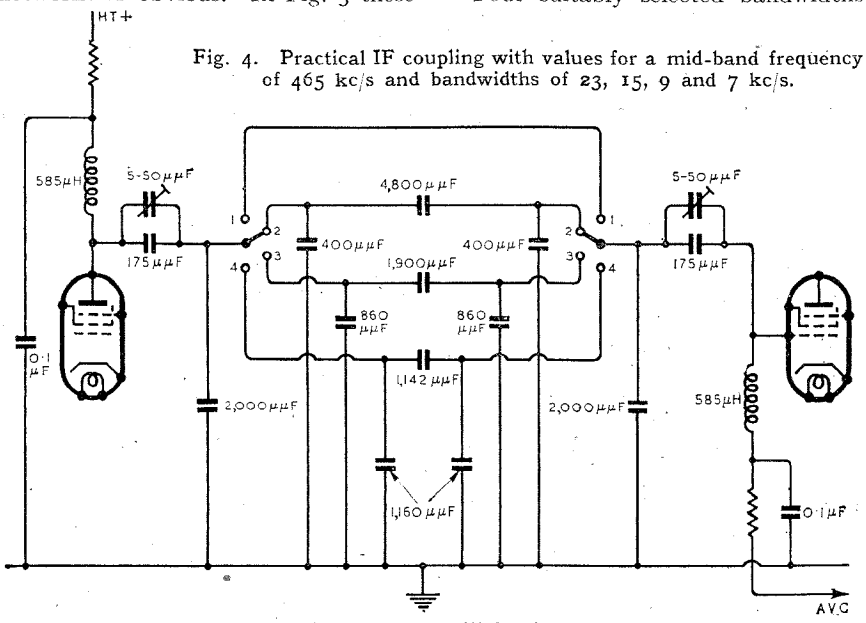


Fig. 4. Practical IF coupling with values for a mid-band frequency of 465 kc/s and bandwidths of 23, 15, 9 and 7 kc/s.

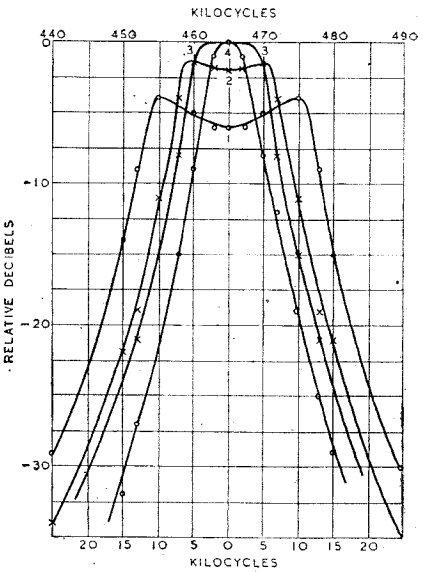


Fig. 5. Measured response curves of the filter circuit shown in Fig. 4 when used in conjunction with a peak tuned circuit of approximately half the Q of the filter circuits.

[2] "High-Fidelity Receivers with Expanding Selectors," by Harold A. Wheeler and J. Kelly Johnson. *Proc. I.R.E.*, Vol. 23, p. 594, June, 1935.

giving the effect of two peak tuned circuits and two double hump filters.

Using such a system an IF amplifier with any desired range of bandwidths can be produced and adjusted with no technical difficulties and having results at least equal to the most elaborate methods at present in use, with the exception of crystal gate filters. The coils L_1 and L_2 should of course have no inductive coupling between them, and the condensers should be within 5 per cent. of their calculated value.

The measured characteristics of the filter of Fig. 4, used in conjunction with a peak tuned circuit of a little less than half the "Q" of the filter circuits to provide correction for the RF tuned circuit selectivity, are shown in Fig. 5, and the symmetry of the response curves is clearly shown.

The use of "T" and "π" networks is not limited to bottom end capacity coupling, suitable networks for any of the couplings shown in Fig. 1 can be determined from the general pad formulae and the information given above on these couplings. If inductances are required for the elements they should have reasonably good "Q's" and there should be no interaction between them. The condenser arrangement adopted is the most convenient for normal requirements and is therefore the only method described in detail. However, in a circuit where neither end of one tuned circuit is at zero HF potential the link circuit of Fig. 1 (e) may be useful, and for this, inductance pads would be required.

Book Review

Short-wave Wireless Communication. By A. W. Ladner, A.M.Inst.C.E., and C. R. Stoner, B.Sc., A.M.I.E.E. 4th Edition. Pp. 573+iv. Chapman & Hall, Ltd., 11, Henrietta St., London, W.C.2. Price 35s.

Following a brief description of the requirements of a communication system, the book commences with a chapter on the history of short-wave development. The theory of modulation is then dealt with, and in a most satisfactory manner. The modulated wave is analysed into its component carrier and sideband frequencies in the usual way, and the distribution of power among these frequencies is discussed. The merit of this chapter, however, lies in the frequent use of both vectors and waveform pictures to illustrate important points, and it results in the presentation of an unusually clear picture of modulation. In addition to amplitude modulation, frequency and phase modulation are treated.

No fewer than 75 pages are devoted to propagation. The treatment here is largely non-mathematical, and the authors clearly explain the various effects which play an important part in short-wave communication. The layers in the upper atmosphere are discussed together with their effect upon the path of a wave.

To many, the most valuable part of the book will be the section dealing with aerials and feeders. The latter is extremely well done and not only includes a large amount of very useful information, but contains notes on methods of measurement. It is of a somewhat mathematical nature, but not unduly so. A minor misprint occurs on page 139; the length of a feeder is given as "I" instead of "*l*" the latter symbol being used throughout the equations.

The aerial section is very comprehensive and occupies 84 pages. It is an excellent chapter, but its value to the reader will depend on his point of view. It treats aerials largely from the transmitting aspect, and from the point of view of commercial transmission at that.

The remaining half of the book deals with power amplifiers, oscillators, modulating circuits and commercial equipment. The treatment of quartz crystals is unusually comprehensive, and there is a wealth of information about the performance of different "cuts."

Many will find the authors' use of the term "push-pull" puzzling, in spite of the fact that they define it most carefully. They use it in an unusual sense and so apply it to a single valve Class A stage. Their definition is quite a logical one, but it seems a pity that in this they have departed from accepted practice.

The book includes a comprehensive bibliography and is well printed and bound. It is remarkably free from errors, and it can be recommended to all whose business it is to deal with short waves. W. T. C.

Resistances in Parallel—Capacitances in Series

Abac for Calculating the Effective Value of Two or More Elements

THE chart is easily prepared—any two lines on a piece of graph paper or drawn with a rule will do. No figures other than those given are required provided it is realised that all measurements are to the same scale. The distance AB separating the scales is immaterial.

The following examples will show the use of the chart:—

1. *To find the resistance equivalent to two or more resistances in parallel (e.g. 2,000 ohms and 5,000 ohms .*

On scale A mark off 2,000 ohms (C), join CB.

On scale B mark off 5,000 ohms (D), join DA, cutting CB at E.

The distance of E above AB gives the equivalent resistance (about 1,430 ohms).

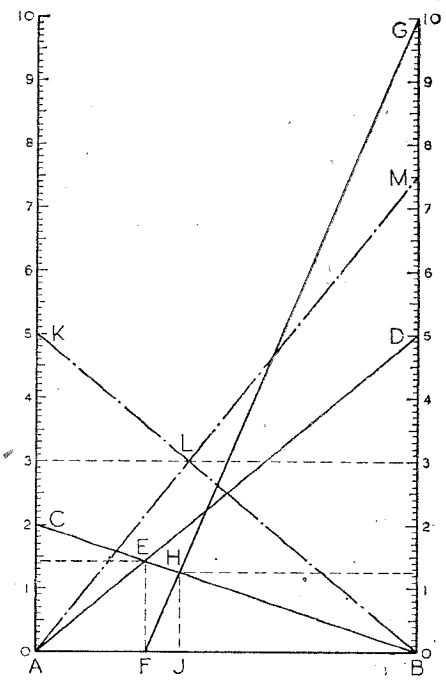
If we had a third resistance (say, 10,000 ohms) also in parallel, we should repeat the above process using 1,430 and 10,000, or, alternatively, join F to G (10,000), cutting EB in H. HJ gives the required answer (1,250 ohms).

2. *To find the resistance which should be placed in parallel with a given resistance to bring the final resistance to a required value (say 500,000 ohms and 300,000 ohms respectively).*

On scale A mark off 500,000 ohms (K), and join KB.

On KB mark the point (L) where it cuts the 300,000 ohms line.

Join AL and produce to cut scale B (in M). BM gives the value of the resistance to be inserted in parallel. (750,000 ohms.)



Naturally the treatment for capacitances in series is the same as that outlined above for resistances in parallel.

P. B. B.

PHYSICAL FOUNDATIONS OF RADIO

I.—Electrons in Simple Conductors

By
MARTIN JOHNSON,
D.Sc.

WHENEVER industrial progress alters the fashions among the materials of valve cathodes, some radio enthusiasts feel the curiosity to ask themselves questions which begin with, "Why does a dimly red-hot oxide emit more electrons than a white-hot pure metal?" Temperature is evidently not the only consideration, and we recollect that to overheat different filaments may damage one kind but improve another. Faced with the notion that the electrons emitted from the cathode surface might be those which conferred conductivity on the material, we ask why the better conductor is not the better emitter. Thinking over what must be happening inside the surface, we are immediately involved not only in the causes of metallic conductivity, but in the theory of potential barriers: the latter has a direct bearing on practical design in valves and photocells, but has hardly proved itself a readable text-book subject.

We propose, therefore, in this and some following articles, to look at the way in which such questions arise, and to give some idea of how they can be handled, pointing out the more intriguing gaps in contemporary answers for the sake of those who are not content to accept unquestioned any mystery in the materials which they use.

Conducting Processes

We shall begin with the reasons for free electrons being available at all in conductors, and why electrical conductivity is connected with heat conduction. It will later be of interest to see where semi-conductors fit into the scheme; for instance, the rectifying oxide of the so-called metal rectifier. At the other extreme, we might widen our view of conduction by a brief glance at the nightmare habits of "superconductivity," which develops at the lowest temperatures. A later article may then follow out the same mechanics of electrons in metals to see why certain compounds, though poor conductors, become useful material for coating the surfaces of the cathodes of valves and photocells when subjected to a carefully graded sequence of chemical and heat treatment.

As soon as Ohm's law is accepted as experimental fact, and proportionality of current to driving potential found reliable down to the smallest fractions of a volt, the most obvious but primitive attempt at explanation is any "fluid" theory of something transported through the apparently impenetrable solid.

A second stage is marked by discovering that similar electrons can be made to emerge from all metals, and this enforces a "free" electron theory: the fluid becomes a swarm of separate particles threading their way between fixed atoms of a crystalline metal. But when the electron is seen as a constituent of the outer structure of all atoms, metallic and otherwise, "free" has to become a relative term; we are driven to ask why the outlying electrons of a copper atom are so detachable as to migrate along a wire under the smallest potential, while those of a sulphur, selenium or other atom may migrate only under a potential gradient of thousands of volts per centimetre or under the stimulus of illumination. A still later stage consists in realising that "freedom" and "binding" of an electron involves its passage past barriers of potential.

The behaviour of electrons confronted with these electrical obstacles can only be understood if the electron acts as a system of waves and not merely as a sub-atomic entity with properties of a material particle. Thus some of the most fundamental properties of radiation and of matter seem to have recently become mingled or even interchanged in modern physics, and nowhere more strikingly than in the study of conductors, semi-conductors, and emitters used in radio.

Model of a Simple Metal

For the simplest way of picturing the "free" and "bound" conditions of an electron, consider (Fig. 1) a section cut along the length of an idealised monatomic metal where the atoms form a cubic lattice or network of fixed points. The electrical structure of each atom may be considered as giving rise to a symmetrical distribution of potential, represented by concentric spheres over the surface of each of which the potential is constant. In our sectional diagram these spheres appear as circles, and to migrate from an inner to an outer circle energy must be supplied to an electron, whereas for migration along any one of the circles no work is done. In an actual metal, solid or liquid, but not vaporised, the atoms are so packed that the outer of these equipotential lines touch those of neighbouring lattice points.

If an electron from the structure around any one point acquires enough energy to reach an equipotential which thus overlaps the similar curve of a neighbouring atom, no more work is needed for it to swing across to that neighbour's system, and then to the

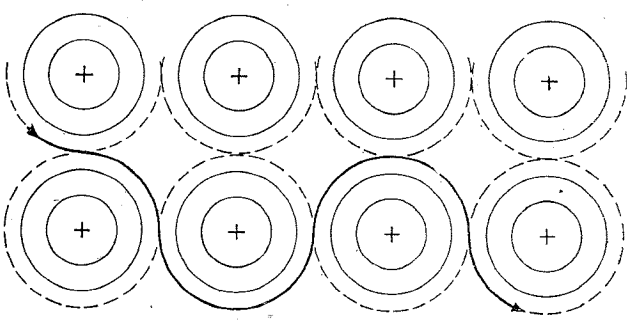


Fig. 1. Section through atomic lattice in a simple metal, showing equipotential lines surrounding each lattice atom and continuous path of possible migration for an electron due to the proximity of equipotentials. It is assumed in this simple model that the outer equipotentials of separate atoms touch each other; in a less idealised model they would separate and there would be a slight potential barrier between each.

next beyond, and so on. Such an electron acts as "free," since at any instant it belongs impartially to any of the nearest atoms. Its drift along the lattice under an externally applied potential constitutes a current obeying Ohm's law.

This drift would be completely fluid at any temperature so low that the atoms were nearly vibrationless, but resistance will develop and increase with rising temperature, as vibrations of the lattice points tend to break across the long chains of equipotential travel and to throw the migrating electrons into a random agitation upon which their drift is superposed. A conductivity by free electron migration, diminishing with temperature rise, will thus originate in any material conforming to this picture.

"Particle" or "Wave" Electrons?

Two main problems at once arise before this simplified view of metallic conduction can be convincing. What enables an electron from the structure

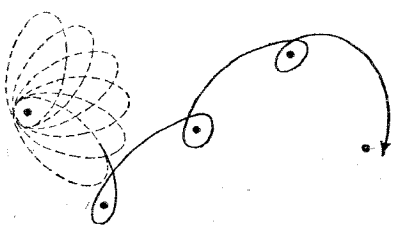


Fig. 2. Orbital model of electron migration. The older view of electrons as particles in elongated orbits allowed transfer from atom to atom.

of an atom to reach an outermost equipotential and so begin a career of migration? How far will it travel before recapture by a foster-parent atom or before any other encounter may be considered as terminating its freedom? The latter problem has been the most troublesome obstacle to a real understanding of electronic conduction: it is the problem of giving quantitative meaning to "mean free path." We have emphasised that even the most mobile electron is only intermittently free, between successive instants of being under the influence of one atom after another along the conductor. Little is known of just what constitutes these successive encounters, but the distance travelled between them has been called "mean free path," a term originally denoting the distance a gas molecule travels between its collisions with neighbouring gas molecules. If the free electrons which flow in the interstices of a solid metal behave as do the molecules of a gas, this free path might be many thousand atom diameters.

The older view of electrons as particles was quite usefully suggestive in the first of these two problems. If they were merely small-scale planets in orbital revolution around a central nucleus as the earth goes round the sun, many facts could be fitted by suggesting that some had grossly elongated elliptical orbits like comets (Fig. 2). At the maximum distance from the parent nucleus, such an electron sweeps as near or nearer to the nucleus of neighbours, and is very liable to be handed on along the lattice by switching allegiance at each revolution.

"Free path," however, came no nearer to consistent explanation until electrons were recognised to possess some properties of a system of waves as well as some properties of a swarm of particles. This was first made necessary by experiments showing that a beam of electrons is diffracted just as a beam of light is: it is a view also demanded by facts in photo-emission with which we deal later.

We see nowadays that it is meaningless to ask, "Is an electron a material particle or a wave carrying energy in some unknown medium?" or to demand that it must be wholly one or the other. For "electron" is only the name given to a mental construction which provisionally embodies certain items of experimental behaviour. That behaviour is now found not to be exclusively "particle-like," but in many ways "wave-like."

Barrier Penetration

Now among the wave-like properties are those of "leaking through" the barrier presented to its progress by a "potential step." Consider (Fig. 3) a region A separated from a region B by a discontinuity in the magnitude of electrical potential represented by the step in the height of the ordinate. Then a *particle* moving from A towards B can only surmount the hill if it has a kinetic energy at least equal to the potential energy represented by the step. But a *wave* similarly advancing can also exhibit a slight but very important leakage from A to B if the hill is thin; that is in Fig. 3 (b) but not in Fig. 3 (a). The physical picture of this leakage is based on the fact that a wave amplitude diminishes gradually from its central maximum, whereas a particle has a definite edge or boundary. Hence, when an electron stands against a high potential barrier, in so far as it is a particle nothing of it penetrates, but in so far as it is a wave some trace appears beyond if the barrier is thin. Statistically, some fraction of an electron stream gets through. In a later article we shall use this conception to show how the wave-like electron can take advantage of the modern doping of

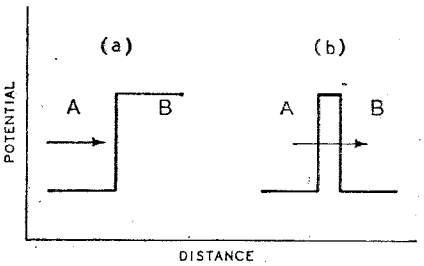


Fig. 3. Potential barriers. The electron as a particle cannot go from A to B without sufficient kinetic energy to mount the hill. The electron as a wave has a small but finite probability of leaking through if the hill is thin.

valve filaments. In the present discussion of conductivity, the wave property offers explanation of how an outer electron in the metal atom penetrates any small and thin potential barrier separating it from the corresponding equipotential of a neighbour, enabling it to travel freely along the lattice and contribute to the electric current.

The advantage of the wave point of view of liberation through penetrating a barrier is that it explains the whole range of lessening conductivity right down to insulators; the mathematician can also utilise the highly developed methods of calculation familiar in optics, sound, flow of liquids and other branches of physics and engineering where wave motion had long ago been commonplace. In the hands of A. H. Wilson and of N. F. Mott in this country, the wave treatment of electrons has shown that alloys and semi-conductors, such as the oxides of rectifiers and photo-sensitive materials, can be correlated with the chemist's periodic table of elements and its electronic explanation, and conductivity connected with many accompanying physical and chemical properties. This relation to chemical structure we shall discuss in a later article.

Thermal and Electrical Conduction

Let us now take the simplest metal (capable, therefore, of an unperturbed flow of easily liberated electrons) and notice what other phenomena will accompany electrical conductivity. It is well known that good electrical conductors are also good heat conductors (for instance, copper and silver), and a moment's consideration along the

Physical Foundations of Radio—

lines we have been developing will show why. If the free electrons act as a gas streaming between the fixed metal atoms of the solid, thermal vibration of the lattice points will not only set up resistance but will give an energy of random motion to the stream which the electrons can, in turn, hand over to the more distant fixed atoms; the far end of a good conducting wire heats up when the near end is put in a flame. From a very simple mechanics of charged masses accelerated in an applied field, and at the same time exchanging energy of thermal agitation, it is quite convincing to work out that the specific electrical conductivity of an ideal metal may be given by the formula:—

$$\sigma = \frac{e^2 N l u}{4aT}$$

The thermal conductivity, on a similar basis of free electron motions, is:—

$$K = \tfrac{1}{3} u l a N.$$

Here N is the number or free electrons per unit volume, u the average velocity of their thermal agitation, e their charge, l the mean free path, or distance between collisions, T the temperature on the absolute scale, and a the Boltzmann constant or ratio of any particle's energy to the gas temperature. The method of calculation differs only from that successfully applied to gas molecules, in that the particles, being electrons, are charged.

Unknown Quantities

The weakness in these equations, which were deduced in the very early days of electronics, is the unknowable l and the uncertain N, towards which only the wave-mechanical view has made much progress. But notice that the *ratio* of thermal to electrical conductivity eliminates the uncertainty, since these awkward quantities drop out of the quotient, leaving:—

$$\frac{K}{\sigma} = \frac{4}{3}\left(\frac{a}{e}\right)^2 T$$

a is known from many lines of work to be 2.06×10^{-16} in cm. gm. sec. units, e is 4.77×10^{-10} in electrostatic units, so that at an ordinary temperature of, say, 18 deg. C., the numerical value of this ratio comes out to 0.715×10^{-10}. The proportionality with T agrees with the experimental law found by Wiedemann and Franz, which holds true for most pure metals from silver to bismuth—a range of two hundred to one in conductivities. Even the numerical value of the ratio found in experiment agrees remarkably well with the calculated figure we quoted; for instance, measurements have yielded the following figures for K/σ:—

Aluminium ..	0.706×10^{-10}
Copper ..	0.738×10^{-10}
Silver ..	0.760×10^{-10}
Nickel ..	0.776×10^{-10}

The fit must be considered too lucky in view of the uncertainty as to whether the eliminated quantity "free path" means quite the same thing under differing conditions of experiment.

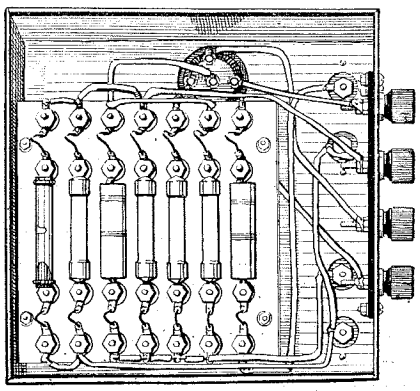
Apart from this uncomfortable feeling that the satisfactory verification of theory conceals our ignorance of electronic free paths, it is based on a picture too simplified to account for (a) specific heats, (b) conductors in magnetic fields, (c) "superconductivity," and (d) alloys. We will later briefly mention the problems raised by these, so far as they contribute to the radio experimenter's curiosity as to what must be going on inside the materials of his circuits. But without the relation to atomic structure and lattice structure, which we develop in the next article, we cannot carry farther the very idealised model of a conducting metal which we have so far used. For the present we leave the picture as a migration of electrons from the equipotentials of each atom to those of neighbouring atoms; the transfer does not involve any net loss or gain of work with respect to these atoms, except in so far as the latter obstruct the flow by thermal agitations. It must, however, be remembered that superposed on this equipotential flow is the slow drift due to the potential gradient along the wire controlled by an external source such as a battery or mains supply.

Sets for Training

Provision for Introducing Faults

By E. WILKINSON, Ph.D.

TO give experience in fault-finding to students undergoing training at Loughborough College, a series of special sets has been developed. The sets have been designed to overcome difficulties in the organisation of group training.



An underneath view of the chassis of one of the sets (a cathode-follower amplifier). The 4-in. square sub-panel mounts seven components, two of which are replacements for faulty ones. A broken connection, hidden by the insulating sleeving, is the third fault. The terminals on the right are for anode and heater supplies.

The sets are small and compact and a sub-panel fills most of the space under the chassis. This sub-panel is the important part of the apparatus, since all the faults may be corrected by cross-connections between soldering tags mounted on it. Some circuit components, as well as some spares, are fixed between the inner tags on this panel. Others may be situated elsewhere above or below the chassis, but all faulty components are connected directly to the sub-panel. Thus a faulty component may be replaced in the circuit by a spare by simply cross-connecting on the panel, and without disturbing the fault.

When the set is in its normal faulty condition, all the small links are connected straight across, as shown in the sketch view. Only these links and the tags to which they are immediately secured need be touched by trainees, so that the circuit can suffer no disarrangement. One advantage of the method is that the set may be returned to its original condition in a few moments by replacement of the connectors. Another advantage is in the possibility of checking a serviced set against a key diagram showing the correct cross-connections on the sub-panel to eliminate the faults.

It is recommended that a reasonably large number of different chassis be employed—say a score or more.

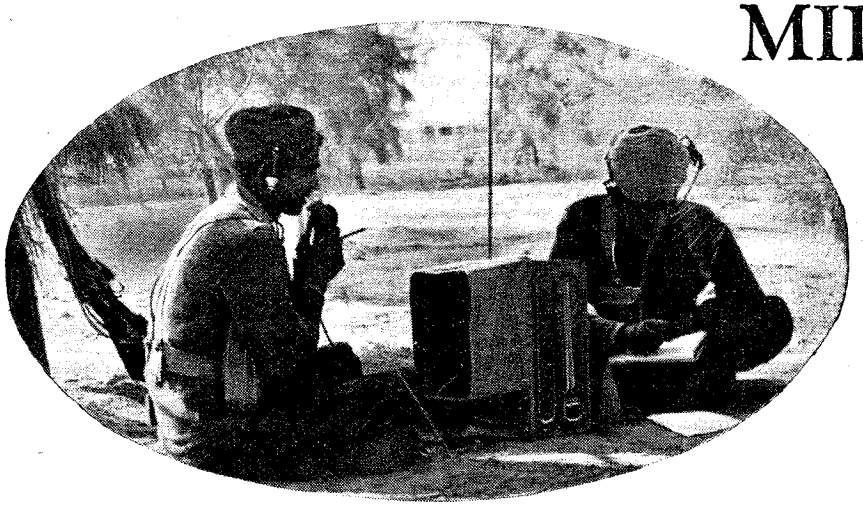
Wireless World Brains Trust

Question No. 4

IS it possible to modulate a transmitter without varying either its frequency or amplitude of output? (*Answer on page 219.*)

MIDDLE EAST TRAINING

Royal Corps of Signals School



IT may come as a surprise to readers to learn that the Royal Corps of Signals has a training school in the Middle East. It might be argued that one would expect the men to be trained before going oversea. In actual fact they are fully trained, but such factors as difference of climate, the long voyage during which little practical work is possible and the difference in communication technique for desert fighting made it essential that a signal school should be formed. Furthermore, Imperial and Dominion troops frequently need training in the use of apparatus which may be quite different from that with which they have been accustomed.

The Middle East Royal Corps of Signals Training School, which provides communication training for all sections of the Army, is concerned with all methods of communication and not only wireless. The methods of providing communication between different parts of a force vary according to such factors as the distance to be covered; whether the headquarters to be contacted are moving or stationary; the degree of secrecy necessary, etc. We will, however, confine ourselves to a few brief notes about one or two pieces of wireless apparatus widely employed in the Middle East.

A typical piece of radio apparatus in use in this theatre of war is the pack transmitter-receiver No. 18, which has a frequency coverage of from 6 to 9 megacycles. Although mainly employed for communication between company and platoon it is also used successfully between gunners and infantry. It has been found extremely useful for the mobile type of warfare experienced in the Middle East, for in open country it has a range of some three miles.

The aerial, which comprises twelve 12in. tubular duralumin sections, plugs into a socket on the side of the case. This socket is rotatable through 90 deg. to allow the aerial to be vertical when the infantryman is lying down. Twenty-five feet of wire is also provided for a ground aerial. Power for the transmitter and receiver is provided by self-contained dry cells. The LT current taken by the transmitter is 0.4 A, and that of the receiver 0.2 A. An economy switch is incorporated in the HT circuit of the receiver, which, when in use, reduces the HT consumption from 13 to 8 mA. The HT consumption of the transmitter is 23 mA.

A double-diode-triode is employed as the master oscillator in the 2-valve transmitter, which operates on 'phone and CW. A pentode is used for the power amplifier, which has a rated output of 0.5 watt. The four-valve receiver employs a pentode for the RF, FC and IF stages and a double-diode-triode as detector, AVC, AF amplifier and BFO.

An interesting point in the design of the set is that it incorporates a multi-range meter, with which it is possible by the turn of a switch to read the aerial current and HT current and to obtain an indication of the HT and LT voltages.

The No. 11 set, which is a transmitter-receiver of greater range designed mainly for use in trucks, derives its power from a 12-volt accumulator which heats the filaments and supplies HT through a rotary converter.

TRAINING infantrymen of the 8th Army in the use of the No. 18 set. The case beside each set is the heavy-duty "static" battery which is used for non-mobile purposes.

PHASE AND FREQUENCY MODULATION

Two Systems of Transmission Compared

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

In this article the two systems are defined and it is shown how each produces the other as a "by product." Professor Howe's classical example is examined. Possible circuits for phase modulation and demodulation are given.

MOST radio engineers are conversant with at least the broad outline of the frequency modulation system which is being so successfully exploited in America. When discussing the advantages and details of the new system the question sometimes arises as to whether frequency modulation is not the same thing as phase modulation. Some such remark as "frequency or as it is sometimes called phase modulation," is often the cause of a heated technical argument. If the opposing parties are mathematically inclined the question may be settled with the aid of Bessel functions and a weighty proof. If the contestants do not speak the language of mathematics fluently it is quite possible the discussion may have to be abandoned unsettled.

It is hoped that this article will help clear the air on a very interesting topic. Definitions are given, which set out the conditions for true phase modulation and true frequency modulation. The way in which one type of modulation must produce the other as a "by product" is dealt with, while the classical method, due to Professor Howe, of showing the difference between true phase modulation and true frequency modulation is treated in a non-mathematical and detailed manner. In addition, a short review is made of the nature of phase modulation and remarks made on its likely commercial value.

Definitions

The difference between phase modulation as a by-product of frequency modulation and a phase-modulated transmission is that while the first is unlikely to be a true phase reproduction of the modulating wave the second must faithfully follow it.

A phase-modulated transmission may be defined as one in which:—

1. The phase deviation (the amount by which it is advanced and retarded with respect to the phase of the unmodulated carrier) is in direct ratio to the amplitude of the modulating signal.
2. The phase variation between the modulated and the unmodulated carrier must, when plotted in degrees against time, be a faithful portrayal of the modulating signal.

If the above conditions are not complied with the carrier will be phase modulated but not in a manner which would make it correct to refer to it as a phase-modulated transmission.

The definition of a frequency modulated transmission can be given as one which satisfies the following two conditions:—

1. The frequency deviation above and below the unmodulated carrier is in direct ratio to the amplitude of the modulating signal.
2. The frequency variations (plotted in cycles per sec. against time) between the modulated and unmodulated carrier must faithfully portray the modulating signal.

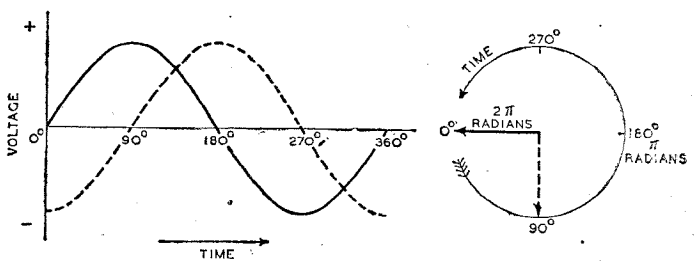


Fig. 1. Sine waves developed by vectors of constant voltage (length). The dotted lines represent a wave 90 degrees in advance of the full-line wave.

For comparison purposes an amplitude-modulated transmission can be stated as one which satisfies the following conditions:—

1. The amplitude deviation above and below the level of the unmodulated carrier is in direct ratio to the amplitude of the modulating signal.
2. The amplitude variation (plotted in volts against time) between the modulated and unmodulated carrier must faithfully portray the modulating waveform.

If there is doubt as to whether a given transmission is phase or frequency modulated, a comparison of the phase and frequency deviation curves with the original modulating wave, should decide the type of modulation taking place.

The strong point of those who join in a discussion as to whether phase modulation is the same as frequency modulation is very often the way in which phase modulation is, of necessity, produced every time frequency modulation takes place.

A simple example will be investigated. The voltage vector (see Fig. 1) turns through 2π radians (360 deg.) once every complete cycle. No phase modulation is present when this vector is rotating at the same speed as that of the unmodulated carrier. While in this condition it is said to be in phase with the unmodulated carrier.

Consider the case of a 1 Mc/s wave, the voltage vector of which is rotating at 1,000,000 × 360 deg. per second. If this vector is caused to rotate at a different speed, say 1,000,100 × 360 deg. per second, then phase modulation at the rate of 100 × 360 deg. per second is taking place. It should be noted that in producing this phase modulation a change in carrier frequency of 100 cycles per second has also occurred. This change is actually a frequency modulation of 100 cycles per second, and without it the phase modulation could not have take place.

In the same way when a carrier is frequency modulated there must of necessity be a "by-product" of phase modulation. It is a fundamental principle that there can be no frequency modulation without phase modulation and vice-versa.

Having run over the way in which frequency and phase modulation are produced by each other, the way in which a true phase modulated and a true frequency modulated transmis-

sion differ from each other will be shown. The method of treatment which follows has by now become almost classical. In spite of this it is usually given only in diagrammatic form; and sometimes it is supported

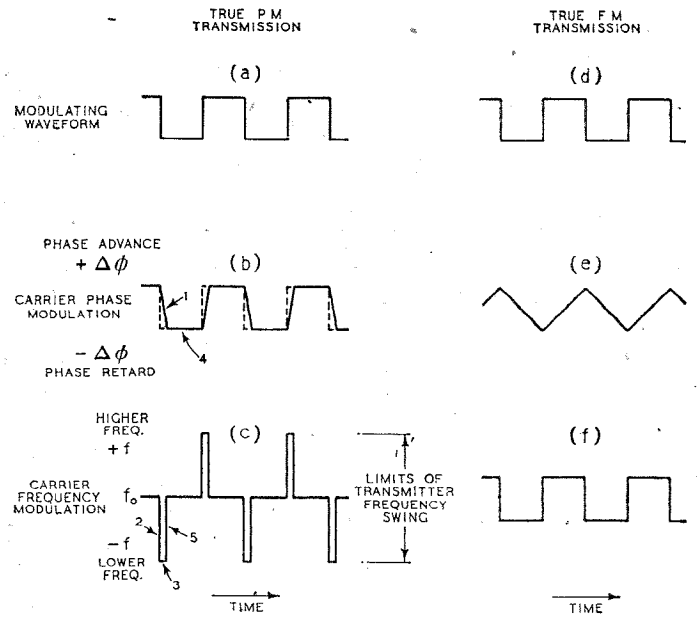


Fig. 2. Showing the effect on the carrier of a rectangular modulating waveform impressed, first by true phase modulation and then by true frequency modulation. In waveform (b) the dotted line shows the perfect waveform. This is not obtained due to the finite frequency band.

with a complex mathematical proof well above the heads of most radio engineers.

According to the definitions just given, true phase modulation takes place when the carrier phase modulation, plotted in degrees difference against time, portrays the modulating signal. The waveform shown in Fig. 2 (b) must, therefore, be the same, or very nearly the same, as the rectangular modulating wave shown in Fig. 2 (a). As an infinitely large frequency swing would be required to reproduce perfectly a rectangular phase-modulated wave, the limited transmitter pass-band results in slightly tapered sides. The dotted lines represent the case of an unlimited frequency swing.

The curve shown in Fig. 2 (c) for frequency modulation is of importance, and will, therefore, be examined section by section. The phase retarding which takes place at 1 (Fig. 2 (b)) must be preceded by modulation to a lower frequency; this takes place at 2. This "by-product" modulation is limited in amplitude by the frequency limits fixed for the transmitter swing, and the frequency at 3, therefore, remains constant at its maximum swing until the phase has arrived at its full modulation depth.

The period (4) during which there is zero phase change with respect to the unmodulated carrier can occur only if the phase vector is neither gaining nor losing when compared with the speed of the unmodulated carrier vector rotation. The only way this can be effected is by the return of the carrier to its unmodulated frequency. This return takes place the instant that the full phase modulation depth is reached, and results in the wave-face labelled as 5 in Fig. 2 (c). The second half-cycle of the rectangular modulation is formed in exactly the same way as the first, with the exception that the phase is advanced and the frequency modulated to its upper limit.

The important point to notice in connection with the phase modulation of a square wave is that, once the "by-product" frequency modulation has returned to its unmodulated value, no further change in the phase modulation takes place. To take a practical case, if due to the negative half cycle, phase modulation to a depth of -100×360 deg. occurs, the carrier will actually lose 100 cycles with reference to its unmodulated frequency. Until the frequency swings up again and the carrier starts gaining, this loss cannot be made good, and later replaced by a gain of, say, 100 cycles (i.e., a phase modulation of $+100 \times 360$ deg.). Fig. 3 makes this point clear.

Returning once again to Fig. 2, the effect of a rectangular frequency-modulated wave on a carrier will next be examined. The frequency-modulated carrier wave, which by definition must be a faithful portrayal of the modulating signal is shown in Fig. 2(f).

The resultant "by-product" phase modulation is shown in Fig. 2 (e). This curve is produced in the same way as the sloping sides of the waveform shown in Fig. 2 (b). All the time the flat top of the modulating wave causes the carrier to remain constant at a higher frequency; the phase vector is rotating at a faster speed than normal. This has the effect of producing a linear increase in the depth of the "by-product" phase modulation.

Upon the carrier again being frequency-modulated to a lower value, the same linear progressive phase shift takes place, but this time in the reverse direction.

Shallow Phase Modulation

Having shown with the aid of definitions and a practical example that phase modulation is an independent system of transmission, its nature will now be examined. The first point of interest is the extremely shallow phase modulation which is possible in any practical transmission. Fig. 4 shows the case of a transmitter with a bandwidth of 200 kc/s and a 10,000-cycle modulating waveform; the maximum phase modulation possible is only $\pm 2\frac{1}{2}$ cycles. It will be seen that when the carrier is modulated to -100 kc/s, the phase vector is losing on its unmodulated speed at the rate of $10^4 \times 360$ deg. per second. With the wave form shown, one complete cycle occurs every $\frac{1}{10000}$ second, and a quarter cycle every $\frac{1}{40000}$ second. During this period the phase vector will lose

$$100{,}000 \text{ cycles} \times \tfrac{1}{40000} \text{ second} = 2\tfrac{1}{2} \text{ cycles}$$

If it is assumed that 10,000 cycles is the maximum signal frequency, then

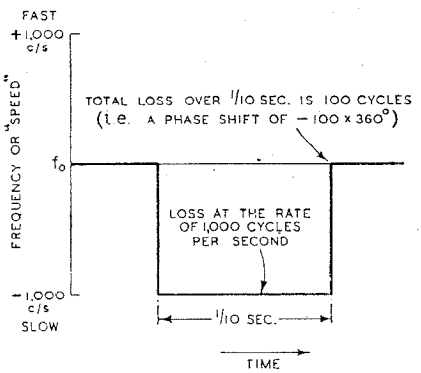


Fig. 3. This figure shows the way in which phase modulation to a depth of -100×360 degrees takes place. Directly the carrier frequency returns to its unmodulated value, the phase loss ceases. It will remain unchanged at the value shown, until a further change in frequency occurs.

$\pm 2\frac{1}{2}$ cycles (i.e., $\pm 2.5 \times 360$ deg.) must be taken as 100 per cent. phase modulation; otherwise the ± 100 kc/s frequency swing will be exceeded. In

Phrase and Frequency Modulation—passing, it may be noted that the phase shift produced by 10 per cent. modulation will only be

$2\frac{1}{2}$ cycles $\times \frac{1}{10} = \pm\frac{1}{4}$ cycles or 90 deg.

The band width necessary (i.e., 200 kc/s) in order to allow a modulation of even $\pm 2\frac{1}{2}$ cycles would force a PM transmitter to operate on the ultra-short waveband. At the present state of radio technique the task of accurately and efficiently demodulating phase fluctuations of less than one cycle in 40 or 50 Mc/s makes any practical phase-modulated system practically impossible to operate.

If a "DC level" is important, as it is, for instance, in a television picture, it is essential that the reference level at both the transmitter and the receiver should be held constant. On an amplitude-modulated receiver this means that the signal must not fade or the receiver sensitivity fluctuate. With an FM receiver working on, say, 50 Mc/s, and with a band of 200 kc/s, the reference frequency (in effect, the oscillator) must be held within ± 2 or 3 kc/s. Although this is difficult, it is not impossible. However, in the case of a phase-modulated system, the reference frequency (against which gain or loss of phase will be measured) must be held within a few per cent. of one cycle in many megacycles. Even the best frequency standard equipment does not attain this level of accuracy!

Once again, difficulties which are almost insurmountable seem to bar the way to any practical PM transmission. This is especially the case when considering the transmission of television pictures where a DC level is of very great importance.

It has been shown that 100 per cent. modulation of any true phase-modulated system will be of the order of ± 1 or 2 cycles. These very small fluctuations cannot be satisfactorily produced or detected by any of the conventional FM circuits. In order to explain the method by which the task might be tackled, a practical example will be taken. Assume that the carrier frequency is 40 Mc/s and 100 per cent. modulation is to be ± 2 c/s. A block schematic of a transmitter layout which could be used is shown in Fig. 5. On the left is a crystal oscillator which has had every possible precaution taken to produce a stable frequency output. For the case in question the oscillator frequency will be 5 Mc/s. The oscillator output is fed into a phase modulator stage.

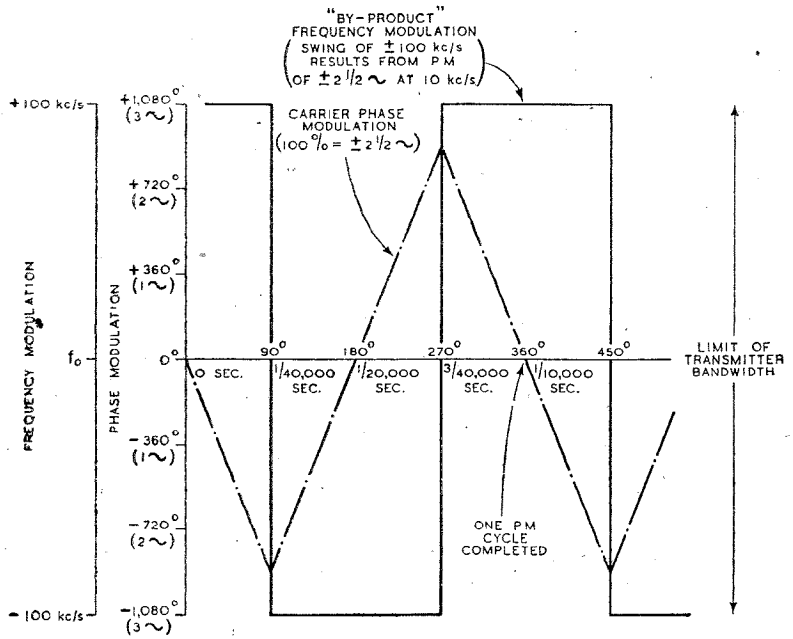


Fig. 4. Showing the extremely shallow phase modulation which is possible in practice. The case taken is of a 10,000 cycle modulating waveform and shows that with a bandwidth of 200 kc/s the maximum phase modulation is only $\pm 2\frac{1}{2}$ cycles.

A basic lattice type circuit for this stage, from which true PM is obtained, is shown in Fig. 6. All four arms are smoothly variable in such a way that when arms B and C are at zero impedance, arms A and D are at infinity. Under these conditions the input terminal 1 is connected to the output terminal 2 and the input terminal 2 to the output terminal 1. This results in the leads being reversed as they pass through the phase modulator (i.e., a 180-deg. phase shift). When the cross-arms B and C are infinity and the arms A and D are zero, then there is no phase shift through the lattice section (i.e., there is zero phase shift). If these variable-resistance arms are replaced by valves we have a practical form of phase modulator. When all the arms are equal there will be a constant 90-deg. shift through the phase modulator; as the modulation is applied this will vary between zero and 180 deg. (i.e., ±90 deg.) phase shift.

This circuit will produce a true phase modulation of the carrier and fully satisfies the definitions given earlier. It should also be noted that the frequency modulation produced will be in the form of a true "by-product"; it depends solely on the depth and rate of the phase modulation and may run into many kc/s. If the action of this circuit is clearly understood, and then compared with those used to produce FM, there can be no further doubts as to the difference between the two systems.

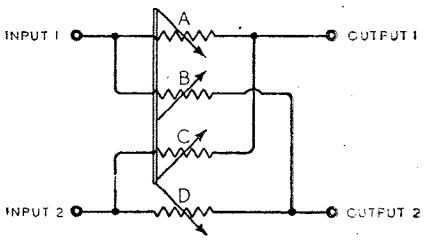


Fig. 6. Basic lattice-type circuit from which true PM is obtained. All four arms are smoothly variable in such a way that when arms B and C are at zero impedance, arms A and D are at infinity. In practice valves would take the place of variable resistances.

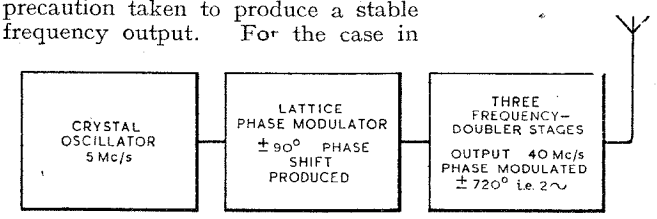


Fig. 5. Block schematic diagram of a PM transmitter. The output from the crystal oscillator is fed into a phase modulator stage (see Fig. 6). After being phase modulated it is fed via three frequency doubler stages to the aerial.

Returning again to Fig. 5, it will be seen that the phase modulator is followed by three frequency-doubler stages which step the frequency up from 5 Mc/s to 40 Mc/s and automatically increase the phase modulation from ±90 deg. to ±720 deg. (i.e., ±2 cycles).

True phase demodulation can be effected if, once again, an oscillator of mythically perfect stability is assumed for both the transmitter and the receiver. The incoming 40 Mc/s phase-modulated carrier is converted in the receiver to an intermediate frequency of 5 Mc/s, which will automatically have a phase swing of only ±90 deg. The phase demodulation is produced by the direct phase addition or subtraction of the incoming carrier and a signal produced in the receiver by a local oscillator. The action of this demodulation method is shown graphically in Fig. 7. Once either a phase or a frequency-modulated carrier has been converted into an amplitude-modulated waveform it can be demodulated, or rather rectified, with a diode in the normal way. This is the basis of all FM demodulator circuits.

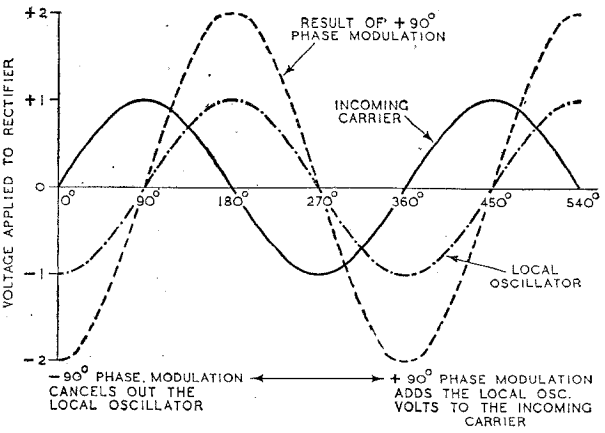


Fig. 7. Showing graphically the functioning of the "phase addition and subtraction" type of demodulator. It converts the phase modulated carrier into amplitude modulation which can be rectified in the normal way.

The method of demodulation indicated above works entirely on the phase shift, and any transient frequency-modulation "by-product" has no effect whatsoever on the functioning of the circuit. A phase demodulator of the type described could not possibly be operated without the aid of some sort of delayed automatic frequency control which would lock both the superhet oscillator and the demodulating oscillator to the mean frequency of the incoming carrier.

True phase and frequency modulation have been defined. It has been shown that they are produced by each other, and that it is impossible for one to take place without the other as a "by-product." The classical method of demonstrating the difference between the two systems has been examined. The circuits and functioning of a true phase modulator and demodulator have proved that a phase-modulated transmission is not a figment of the imagination. Every one of these points has helped to demonstrate the existence of three completely independent systems of carrier-wave transmission, namely, amplitude, frequency and phase modulation.

The writer is at present unable to see that phase modulation offers any advantages over frequency modulation, but it is possible that when a PM transmitter and the necessary receivers are put on test there may be some surprising results.

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"Frequency Modulation," K. R. Sturley, *Electronic Engineering*, November, 1941, p. 489.

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Books Received

Wave Guides, by R. L. Lamont.—The fact that electromagnetic energy can be guided along hollow conductors has been long known, but it is only in recent years that the subject has been of any but academic interest. This book deals with the theory of the use of hollow conductors as transmitting lines, resonators and radiators. Pp. 102. 32 diagrams. Published by Methuen and Co., Ltd., 36, Essex Street, London, W.2. Price 4s.

Short Wave Radio, by J. H. Reyner.—This book deals with its subject in a straightforward and practical manner, and does not resort to mathematics except in the simplest possible form. The author emphasises that he has to a large extent assumed that the reader is already familiar with radio technique on "ordinary" wavelengths. A chapter on frequency modulation is included. Pp. 186. 97 diagrams. Published by Sir Isaac Pitman and Sons, Ltd., Parker Street, London, W.C.2. Price 10s. 6d.

Reference Data for Radio Engineers.—Compiled originally for the use of radio engineers on the staff of Standard Telephones and Cables, this compact booklet is now available to others outside that organisation. A very wide field is covered and there are such unusual items as curves for propagation calculations, water cooling data, etc., for transmitting engineers, formulæ for attenuator design with a useful set of curves giving hyperbolic functions in terms of power ratio in db., comparisons between the European and American noise level scales, in addition to the formulæ commonly found in radio reference books. Pp. 60. Published by Standard Telephones and Cables, Ltd, Connaught House, Aldwych, London, W.C.2. Price 2s.

Radio Simplified, by John Clarricoats.—The main purpose of the author is to provide amplified explanations of fundamental radio principles dealt with in an earlier and more elementary book by him. In preparing it, the needs of members of the services to gain a good basic knowledge in a minimum of time has been specially kept in mind and the information it contains has been compressed as far as is consistent with clarity. Pp. 92. 51 diagrams. Published by Sir Isaac Pitman and Sons, Ltd. Price 4s. 6d.

Russian Morse Code

IT is regretted that in the Russian morse table published in last month's issue a number of errors occurred in the column showing English phonetic equivalents of the Russian letters. These have been corrected in the accompanying table; for some of the letters there is no simple English equivalent, but the information given should be sufficient for the purpose for which the table was originally published.

RUSSIAN LETTER	ENGLISH EQUIVALENT	MORSE SYMBOL
А	A	▬
Б	B	▬ ▪ ▪ ▪
В	V	▪ ▬ ▬
Г	G	▬ ▬ ▪
Д	D	▬ ▪ ▪
Е, Э	E	▪
Ж	ZH (1)	▪ ▪ ▪ ▬
З	Z	▬ ▬ ▪ ▪
И	I	▪ ▪
Й	Y (2)	▪ ▬ ▬ ▬
К	K	▬ ▪ ▬
Л	L	▪ ▬ ▪ ▪
М	M	▬ ▬
Н	N	▬ ▪
О	O	▬ ▬ ▬
П	P	▪ ▬ ▬ ▪
Р	R	▪ ▬ ▪
С	S	▪ ▪ ▪
Т	T	▬
У	U (3)	▪ ▪ ▬
Ф	F	▪ ▪ ▬ ▪
Х	KH (4)	▪ ▪ ▪ ▪
Ц	TS	▬ ▪ ▬ ▪
Ч	CH	▬ ▬ ▬ ▪
Ш	SH	▬ ▬ ▬ ▬
Щ	SH–CH	▬ ▬ ▪ ▬
Ъ, ъ	— (5)	▬ ▪ ▪ ▬
Ы	Y (6)	▬ ▪ ▬ ▬
Ю	U (7)	▪ ▪ ▬ ▬
Я	YA	▪ ▬ ▪ ▬

1, Like *s* in measure. 2 As in *yet*. 3, Like *oo* in *school*. 4, Like *ch* in Scottish *loch*. 5, Hard and soft mute signs, influencing preceding consonant. 6, Hard, like *i* as in *hit*. 7, As in *fume*.

UNBIASED

By

FREE GRID

J'Accuse

THE causes of the unfortunate set-back in North Africa which we suffered during June were well-ventilated in the House of Commons. Unfortunately, nobody seemed to hit upon the right cause, and although scapegoats were found in plenty, the real culprits were not.

The arch-culprit, if I may be permitted to use this horrible Greek and Latin hybrid, seems to me to be the Editor of this journal, although the whole of the radio industry must shoulder its share of the blame. I have searched in vain through the Editor's words of wisdom for years

The industry's *vade-mecum.*

back, but nowhere can I find one single instance of the military authorities being urged to adopt radio-telearchic control of tanks in climates where it might be expected that the temperature would be oppressive.

It is true that it might be urged by many that the science of radio-telearchics is not sufficiently advanced for this purpose, although I strongly doubt this after reading the article in this journal last December in which were detailed the remarkable developments that have taken place. In any case, if it be true that telearchics is still not sufficiently advanced, then this fact forms a still further indictment, for nowhere do I find in the Editorial pronouncements any lead given to the radio industry in this matter; nowhere is there any hint given to the big radio manufacturers concerning what their research departments should be doing.

True, the radio manufacturers are themselves largely to blame, as they cannot expect to be spoon-fed all the time in the matter of advice, as was the case with set design in years gone by. Yet, all the same, *Wireless World* is, after all, the bible and *vade-mecum* of the radio industry, as *Wireless Engineer,* of course, dwells too much in the clouds of philosophical philandering to be of much use to it.

It could almost appear, therefore, that in addition to the honours list, which appears twice yearly, there ought to be a dishonours list for those who merit it. Just as a person may be disqualified from obtaining a driving licence for a period even though he does not possess one, so also an appearance in the dishonours list might be made to disqualify a person for a period from appearance in the honours list.

The Universality of Infinity

ASTONISHING statements are made sometimes not only by advertisers of patent medicines and such-like nostra from whom, perhaps, one might expect them, but also by men of science who ought to know better.

One of the most astonishing I have read occurs in a recently published text book of radio engineering. The learned author—and he *is* learned, unless the particular university degrees and other qualifications after his name were obtained by "under the counter" methods, which is well-nigh impossible, as I can personally vouch for—starts off by a cheap jibe at our respected grandparents who regarded the atom as the ultimate subdivision of matter, "beyond which," says our learned friend, "their limited imagination and narrow-minded scientific orthodoxy did not allow them to go."

Having rid his system of this particularly nasty piece of narcissism, this erudite engineer proceeds to tell his readers quite rightly that we now know the atom to be a complete solar system in miniature with a centralised "sun" which, like the sun which we all know and of which we see so little, is very nebulous in character, consisting of a central core surrounded by rings of satellite electrons.

"The electron," continues the author portentiously and pompously, "consisting as it does of a single electric charge, is not really matter as we know the term, but is really only a strain in the ether. Thus," he continues, "we have reached finality in subdividing matter, since we have arrived at the point where matter ceases to exist."

I am sorely tempted to make reply to this astonishing piece of pig-headed dogma by giving utterance to the vulgar "sez-you" so beloved of the masses nowadays. Needless to say, the learned scribe is quite wrong. The electron is no more the ultimate than is a ten-ton bomb. It is, in fact, no *nearer* the ultimate than a bomb for the simple reason that there *is* no ultimate. I am prepared to deposit in the strong room of *Wireless World* a cheque for 100 gns. payable to bearer 100 years hence, in August, 2042, the cheque to be handed over to this particular engineer's heir-at-law if by that date it has not been proved that the electron itself is nothing but a solar system made up of neo-electrons. I will go even further and deposit yet another cheque for the same amount to be paid if in a further century science has not delved far beyond even these neo-electrons, finding each to be a solar system in itself.

The truth is, of course, that just as there is neither beginning or ending to time or space, so also there is no limit either to magnitude or micritude, if I may be permitted to coin a word. Even in the realm of temperature, the absolute zero of science is merely a myth. Although all molecular motion may have stopped at -273 deg., yet electron motion certainly has not, and even when the day dawns wherein man is able to reduce temperature to such a degree that electron motion ceases, so changing the very nature of matter, there will still be the motion of the neo-electrons to beckon on the

"Big bugs have little bugs
Upon their backs to bite 'em;
Little bugs have lesser bugs
and so *ad infinitum.*"

temperature-reducing research worker.

This essential fact of the universality of infinity is strikingly brought home in the old jingle which I would commend to the learned author's attention. It may cure his narrow-mindedness and stir his apparently dormant thinking faculties.

Sunspots and Short Waves

A Note on the Progress of the Cycle

AS is well known, the frequencies used for long-distance short-wave communication must be related to the ionic density existing in the refracting layers of the ionosphere, i.e., the frequencies must be increased or decreased in conformity with the increase and decrease in layer ionisation. The ionisation is produced by the action of the sun upon the outer atmosphere, and the ultra-violet radiations from the sun increase and decrease in a periodic manner over the 11.3 year solar cycle. A useful criterion as to the sun's activity, and hence as to the ionisation prevailing, and the highest frequencies which can be used, is the "relative sunspot numbers." Fig. 1 is a graph giving the annual averages of sunspot numbers and of non-critical frequencies for the F_2 layer for the period

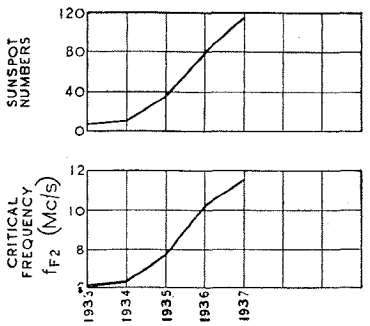

Fig. 1. Comparison of annual averages of sunspot numbers and non-critical frequencies of F_2 layer, 1933-1937 (after N. Smith, T. R. Gilliland and S. S. Kirby.)

1933-1937, during which period the sunspot cycle was progressing towards a maximum. It is seen that the correlation between the two curves is relatively good, and this indicates that the maximum usable frequencies for use in practical short-wave communication did, in fact, follow the sunspot numbers during this period.

Since 1937 the sunspot cycle has been progressing towards a minimum, with the result that the highest frequencies usable have been decreasing more or less regularly each year. It does not necessarily follow, however, that the sun's activity will show a constant annual decrease until the minimum is reached. On the other hand, a suspension in the downward trend of the curve of sunspot numbers—or even a rise—would not necessarily mean that the minimum phase of the cycle had prematurely been reached.

Fig. 2 shows the progress of the sunspot cycle during the period 1860-1867. It will be seen that the annual mean of the sunspot relative number was greater during the year 1864 than it was during 1863, and had our grandparents known the

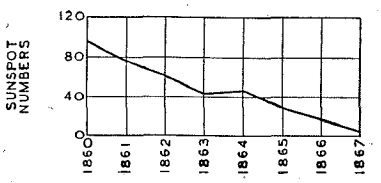

Fig. 2. Annual average of sunspot numbers, 1860-1867.

use of short-waves they would almost certainly have had to have used higher frequencies during 1864 than in 1863, for the reasons already indicated. After 1864, however, there was a further decrease in the sun's activity, as is seen by the downward progress of the curve until the minimum was reached in 1867.

The downward phase of the present sunspot cycle, i.e., from the year 1937 to 1941, is shown in Fig. 3. As is seen, the fall in the sunspot numbers to the end of 1941 was remarkably regular and consistent. There was some indication for a month or two around the vernal equinox this year—both from the relatively high frequency which it was possible to use and from the activity of the sun as evidenced by its spottedness—that the downward progress of the cycle might have been arrested. It is, however, quite wrong to jump to conclusions on this matter, as it has been well proven that short period fluctuations in the sunspot numbers—such as are shown by daily values or by monthly means—are not closely connected with the

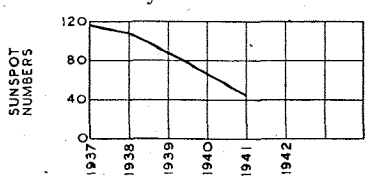

Fig. 3. Annual average of sunspot numbers, 1937-1941.

frequencies of use for radio communication. We must, therefore, await further evidence—such as provided by an annual mean of sunspot numbers—before we can say that such an occurrence as is shown in Fig. 2 has taken place. In estimating the utility of various frequencies on a forward basis it is most useful to have available the latest sunspot data, and to consider the mean of sunspot numbers over the last twelve months for which the numbers are available.

T. W. B.

ASTATIC

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THE WORLD OF WIRELESS

U.S. BAN ON NEW STATIONS

IN order to avoid the use of essential materials required for the war effort, the United States Federal Communications Commission has rejected applications for twenty-two new medium-wave broadcasting stations and seventeen applications for commercial frequency-modulation transmitters. Requests from nine stations for permission to increase their power to 500 kW have also been refused.

The F.C.C. has stated that it will not grant permits for new stations except where there is a definite need.

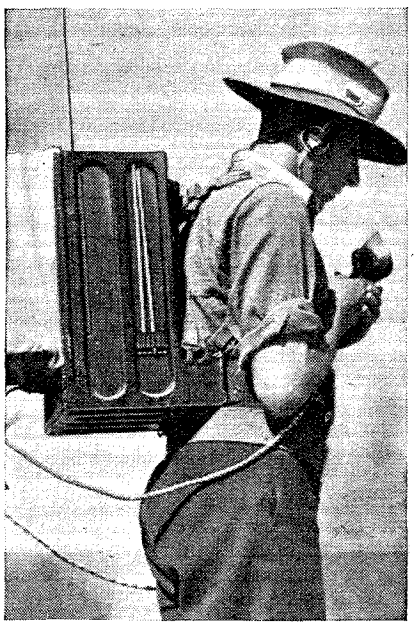
Two applicants who have already received their permits for commercial television and FM stations have decided to abandon the projects owing to their inability to obtain the necessary materials.

E. J. SIMMONDS, G2OD

THE passing of E. J. Simmonds, whose recent death we regret to record, brings back memories of the great days of British amateur radio. October 17th, 1924, is a notable date; on that day the honour of first transmitting signals to New Zealand, and thus covering virtually the greatest range attainable on this planet, went to Mr. Simmonds. His station, G2OD, at Gerrard's Cross, was then working on a wavelength of 95 metres—a "short" wavelength for those times. On the following day two-way communication with New Zealand was carried out by C. W. Goyder, G2SZ, now chief engineer of All-India Radio.

The late E. J. Simmonds

Though Mr. Simmonds' interest in radio was entirely that of an amateur (by profession he was a bank manager), the importance of his wireless work was widely recognised. His versatility was remarkable, and among other things he was a talented organist and pianist. The equipment used even in his early experiments was, considering the period, very highly developed. He must have been among the first to adapt the superheterodyne receiver for long-distance short-wave work.



THE WALKEE TALKEE, as the Americans call transmitter-receivers of the type described on page 209. A frame support, as used for rucksacks, is employed. The total weight is 30 lb.

RECORD SALVAGE

TO ensure the continuance of the supply of gramophone records, the manufacture of which has been severely restricted by the shortage of shellac—an essential material—the Government has agreed to the salvaging of old or unwanted records. The re-use of old records has always been part of the manufacturing process.

Provided that the discs are not cracked or broken—those with chipped edges are acceptable—any 10 or 12in. discs of the nine brands controlled by E.M.I. and Decca are urgently needed toward the ten million required.

The scheme, which commenced on Saturday, August 15th, and continues until September 30th, is being operated through the British Legion. The proceeds from the sale of these records to the manufacturers will be shared between the British Legion and the Hospital for Sick Children, Great Ormond Street, London, W.C.1.

RADIO AND NEWSPAPERS

"A MAJORITY of Americans have come to rely upon the radio, rather than upon newspapers, as the primary source of their news about the war; they express greater confidence in broadcast than in printed news on the grounds that it is swifter, more condensed, more accurate, and gives a greater sense of personal contact with personalities and events."

This statement is included in the summary of an official survey on the American attitude towards war news.

The question asked during the survey was: "Do you have more confidence in the war news on the radio or the war news in the newspapers?" Wireless was chosen by 46 per cent. and newspapers by 18 per cent. Of the remaining 36 per cent., "many of them were without preference between the two media."

Of those who expressed a preference for radio the majority gave as a reason that it has a better reputation for accuracy than the newspapers. Summarising this preference the survey records: "One factor which contributes significantly to radio's reputation for accuracy is its freedom from headlines. Newspapers, dependent in part for their sales on capturing the interest of potential readers, are prone to bedeck their front pages with capsule versions of events which magnify and distort their significance."

BRIT. I.R.E.

THE question of awarding a national certificate in radio servicing is being discussed by representatives of the British Institution of Radio Engineers, the Radio and Television Retailers' Association and the Scottish Radio Retailers' Association. The proposed examination would replace the existing one for the Brit. I.R.E. Radio Servicing Certificate, but the Institution would continue to be responsible for holding the examinations. Another matter under consideration is the question of the desirability of forming a separate association for radio service-men.

Sir Louis Sterling has been elected president of the Brit. I.R.E. in succession to Dr. C. C. Garrard. The presidential address, which it is expected will deal with the registration of engineers, will be given at the meeting on September 25th, which will be held at 6 o'clock at 21, Tothill Street, London, S.W.1. Dr. James Robinson, the new vice-president will speak on "Modulation" at this meeting.

CONTROL OF H.F. APPARATUS

THE Home Office announced on July 31st that a relaxation had been made in the Control of High Frequency Apparatus Order made in 1940, which prohibited the possession or use by any person in the United Kingdom of high-frequency apparatus having a HF output of over ten watts except under permit from the Postmaster General. Under that Order permits were only issued to hospitals, clinics and other authorised institutions, or to certain manufacturers and persons in charge of laboratories.

This restriction has now been removed, and any person (including enemy aliens) may apply for a permit which, however, will not be issued until the applicant has installed a screen and mains filter in accordance with Post Office specifications. Applications for permits or for particulars of screening should be addressed to the Engineer-in-Chief, Radio Branch (W.2/8), General Post Office, Harrogate, Yorkshire.

The principal types of apparatus to which the original Order applied are:—(i) Diathermy and electro-medical apparatus using valves or spark coils; (ii) high-frequency furnaces; (iii) eddy current heating apparatus such as is used by valve and electric lamp manufacturers; and (iv) testing oscillators with a high-frequency output exceeding 10 watts.

I.E.E. WIRELESS SECTION CHAIRMAN

DR. R. L. SMITH-ROSE, who will be taking up his appointment as chairman of the Wireless Section of the Institution of Electrical Engineers on October 1st, received his technical education at the Imperial College, studying physics at the Royal College of Science and then taking an

Dr. R. L. Smith-Rose, D.Sc., Ph.D., M.I.E.E., D.I.C., A.R.C.S.

advanced course in electrical engineering at the City and Guilds College.

In 1919 he joined the staff of the National Physical Laboratory as a member of the electricity department, and later formed the nucleus of the wireless division of that department. He has been associated with the work of the Radio Research Board since its formation in 1920, and has been responsible for conducting extensive investigations in radio direction finding and the electrical constants of soil and sea water and their influence on the propagation of electric waves. The results of these investigations have been described in numerous papers.

Following the formation of the radio department in 1933, Dr. Smith-Rose became principal scientific officer. He was appointed superintendent of the radio department in 1939.

THE LATE E. H. SHAUGHNESSY

THE death of E. H. Shaughnessy, O.B.E., M.I.E.E., at the age of 71, on July 29th, which we record with regret, removes one who played a large part in the development of national and international radio communication.

After obtaining a wide experience in most branches of telecommunications engineering—he entered the Post Office in 1887 as a telegraphist—he became in 1913 head of the Wireless Section of the Post Office Engineering Department. In 1925 he became assistant engineer-in-chief and retired from the service in 1931.

Mr. Shaughnessy will, perhaps, be best remembered for his part in the construction of the Rugby wireless station. The design was entrusted to a technical commission of which the late Lord Milner was chairman and Dr. W. H. Eccles, Mr. Shaughnessy and Mr. L. B. Turner were members. The commission recommended the construction of a valve station, although at that time no high-power station of this type was in existence or contemplated, and Mr. Shaughnessy, as executive member of the commission, was responsible for its construction.

Mr. Shaughnessy took a prominent part in radio activities outside the Post Office. He served on the Radio Research Board and on many national and international committees.

IN BRIEF

Radiophoto Service between New York and Cairo

THE first direct radiophoto service between America and Egypt was recently opened by R.C.A. Communications. Pictures are handled in both directions between New York and Cairo, a distance of 5,639 miles. Previously news pictures from Cairo had to be forwarded by radio to London, and thence across the Atlantic. The Egyptian end

KURZ-KASCH

RADIO KNOBS—DIALS
INSTRUMENT KNOBS

Circumstances to-day are such that unless you have the necessary Import Licences and Priorities we cannot continue to serve you. We look forward to the time when these conditions will no longer exist.

In the meantime we are busily engaged on essential war work and it is quite possible that you may still be using Kurz-Kasch mouldings on Lease-Lend instruments and other equipment.

We always appreciated your business prior to the introduction of restrictions and we shall be ready once again to satisfy your most exacting needs as soon as circumstances permit.

Kurz-Kasch will always offer you the finest quality and latest fashions in plastics.

Register your name with our Representative now. He will forward you information on our products as soon as they become available.

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"SILVERCAP" CONDENSERS
COIL FORMS, etc.

and all that is best where parts of this nature are concerned.

Present day restrictions applying to both exporting and importing are in the interests of our combined war efforts.

We are extensively engaged on Defence work, but when Victory comes and restrictions withdrawn, our parts will be ready to use in your receivers and our Engineering Laboratories will be at your service.

Register your name with our Representative now. He will forward you information on our products as soon as they become available.

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Th World of Wireless—

of the circuit is operated by the Marconi Radiotelegraph Company of Egypt. The rate is forty cents a square centimetre, with a minimum charge of $60.

New Brazzaville Station

ENGINEERS of the Canadian Broadcasting Corporation have designed a short-wave broadcasting station for the Fighting French and two C.B.C. engineers are supervising its erection at Brazzaville, French Equatorial Africa. The station is stated to be equipped with two 50-kW transmitters and an elaborate aerial system.

B.B.C. Short-wave News

THE B.B.C. morse transmissions of news in English, French and German are now broadcast at 0130, 0200, and 0230 (BST), respectively, on 261.1 and 49.59 meters. The B.B.C. oversea transmissions of news in English are radiated at the following times (BST) in the wavebands given.

0200, 0345 } 31, 25
0530 41, 31, 25
0715 49, 41, 31, 25, 19
0900 49, 41, 31, 25, 19, 16
1200, 1400 } 25, 19, 16, 13
1700 31, 25, 19, 16, 13
1900 25, 19, 16
2115 49, 41.
2145 31, 25, 19, 16
2245 (weekdays) 31, 25, 19
2345 31, 25

Servicing Charges

THE standardisation of charges for servicing and repairs has been considered by the Central Price Regulation Committee and the Scottish Radio Retailers' Association. It has, however, been decided that owing to the wide variation in the amount of work necessary due to the differences in set construction it was not practicable to apply any approved scale of charges.

Friendship Bridge

THE close liaison existing between the British and American wireless industries was exemplified by the receipt of the following telegram during the recent luncheon of the Radio Industries Club:

UNITED WITH RADIO INDUSTRIES CLUB IN ALL OUT EFFORT FOR VICTORY STOP AMERICAN RADIO INDUSTRY IS GEARED FOR RESEARCH TO PRODUCTION AND COMMUNICATIONS TO DO UTMOST TO WIN THE WAR STOP BEST WISHES TO DONISTHORPE (Chairman) AND CLUB MEMBERSHIP STOP COLONEL DAVID SARNOFF PRESIDENT RADIO CORPORATION OF AMERICA.

Following the luncheon Mr. S. Rostovsky, Editor of the *Soviet War News* and a member of the Soviet Embassy, spoke on "Radio Propaganda in the Front Line on the Eastern Front."

Broadcasting and Fuel Economy

THE Minister of Information, when asked in the House of Commons what decision had been reached on the question of the curtailment of hours for broadcasting in order to effect economy in light and power, said that the suggestion raised some very important issues and that it had been decided that the economy in fuel which would be secured was not large enough to justify reducing broadcasting hours.

Paper Salvage Campaign

THE radio industry has been asked to find 5,000 tons of waste paper. Although the country requires 30,000 tons a week, only 18,000 tons of the paper used is being recovered each week. A committee has been formed to conduct the campaign, and it asks manufacturers and retailers to send a postcard to the Radio Industry Waste Paper Salvage Appeal, c/o R.M.A., 59, Russell Square, London, W.C.1, giving details of their collection.

Ban on Radio-telegraphy

PUBLIC point-to-point radio-telegraph circuits in the United States have been closed in pursuance of an order by the Defence Communications Board. It is stated in *Broadcasting* that the reason for the cessation was that transmissions over domestic radio circuits can be received outside the States.

G.E.C. Research

THE appointment to the board of the General Electric Co. of Dr. C. C. Paterson, O.B.E., D.Sc., M.I.E.E., director of the Research Laboratories of the G.E.C. since their inception in 1919, was announced by Lord Hirst at the annual general meeting.

Appeal for Gear

A WIRELESS club recently formed by a group of airmen at an R.A.F. station is in need of equipment and tools. The club appeals to readers for the gift of any apparatus that is likely to be useful. Tools are specially required; even unserviceable articles, provided they are not past repair. Gifts should be sent to Sgt. E. Bromley, c/o The Editor.

Thermionic Emission

A LECTURE on "Thermionic Emission, with special reference to Oxide Coated Cathodes" will be given by Dr. Hilary Moss, of A. C. Cossor, at a meeting of the Institution of Electronics at 3 o'clock on Saturday, August 22nd, at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.

"Transformer Distortion"

IN the second footnote to this article (August *Wireless World*) G. A. V. Sowter should have been described as M.I.E.E., *not* A.M.I.E.E.

NEWS IN ENGLISH FROM ABROAD

REGULAR SHORT-WAVE TRANSMISSIONS

Country : Station	Mc/s	Metres	Daily Bulletins (BST)
America			
WNBI (Bound Brook)	11.890	25.23	4.0.
WNBI	17.780	16.87	2.0†, 2.45‡, 4.0§‡, 6.0.
WRCA (Bound Brook)	9.670	31.02	4.0.
WRCA	15.150	19.80	2.0†, 2.45‡, 4.0§‡, 6.0.
WGEO (Schenectady)	9.530	31.48	9.45 a.m., 9.0†, 10.55§‡.
WGEA (Schenectady)	15.330	19.57	2.0, 3.0, 7.45§‡, 9.55§‡.
WBOS (Hull)	11.870	25.27	Noon, 12.45, 4.0.
WBOS	15.210	19.72	2.0†, 2.45‡, 4.0§‡, 6.0.
WCAB (Philadelphia)	6.060	49.50	6.0 a.m.
WCBX (Wayne)	15.270	19.65	11.30 a.m., 3.30, 7.30‡, 9.30.
WCRC (Wayne)	11.860	25.30	11.30 a.m., 3.30, 7.30‡, 9.30.
WCW (New York)	15.870	18.90	3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0.
WRUL (Boston)	11.790	25.45	9.30‡, 11.45§‡.
WRUL	17.750	16.90	3.0‡, 3.45‡.
WLWO (Cincinnati)	6.080	49.34	6.0 a.m., 7.0 a.m.
WLWO	11.710	25.62	7.0, 8.0, 9.0, 10.0.
WLWO	15.250	19.67	3.0, 4.0, 5.0.
Australia			
VLQ6 (Sydney)	9.580	31.32	8.0 a.m.
VLG6 (Melbourne)	15.230	19.69	8.0 a.m.
China			
Chungking	9.410	31.88	3.0.
	11.900	25.21	9.0a.m., 10.30a.m., 11.15a.m., 12.30, 1.0, 3.0, 5.0, 8.15.
French Equatorial Africa			
FZI (Brazzaville)	11.970	25.06	4.45 a.m., 8.45.
India			
VUD4 (Delhi)	9.590	31.28	9.0 a.m., 1.30, 4.50.
VUD3	11.830	25.36	1.30.
VUD3	15.290	19.62	9.0 a.m.
Sweden			
SBU (Motala)	9.535	31.46	10.20.
SBT	15.150	19.80	4.0.
Turkey			
TAP (Ankara)	9.465	31.70	8.15.
U.S.S.R.			
Moscow	5.890	50.93	11.0.
	6.970	43.04	11.45.
	7.300	41.10	8.0, 9.15, 11.0.
	7.560	39.68	11.0.
	10.445	28.72	Noon.
	15.410	19.47	1.0.
Kuibyshev	8.050	37.27	8.0.
	13.010	23.06	6.0 a.m.
Vatican City			
HVJ	5.970	50.25	8.15.

MEDIUM-WAVE TRANSMISSIONS

	kc/s	Metres	
Ireland			
Radio Eireann	565	531	1.40‡, 6.45, 9.0.

It should be noted that the times are BST—**one hour** ahead of GMT—and are p.m. unless otherwise stated. Owing to the change from BDST to BST the times of some transmissions may subsequently be altered. The times of the transmission of news in English in the B.B.C. Short-wave Service are given at the top of the page. * Saturdays only. § Saturdays excepted. † Sundays only. ‡ Sundays excepted.

Wireless World

Brains Trust

Solution to Question No. 4

(See page 208)

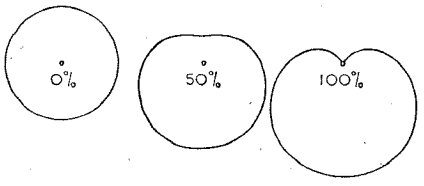
AS Joad would say, it all depends on what you mean by "varying the frequency" and "varying the amplitude of output."

In amplitude modulation, as used by the great majority of broadcasting stations, obviously the amplitude is varied, and we learn that an inevitable result of this is that extra frequencies (sidebands) are introduced, but ideally the frequency of the carrier wave itself remains constant.

In the more recently introduced frequency modulation, used by a growing number of American broadcasting stations, the frequency of the carrier wave is varied over a range proportional to the depth of modulation, at a frequency equal to the modulation frequency, but ideally the amplitude remains constant. At first it was supposed that by restricting the depth of modulation to, say, a total swing of 1,000 cycles per second, it would be possible to modulate the carrier by speech and music frequencies up to 5,000 or more cycles per second, and yet receive it without distortion on a receiver selective enough to cut out everything outside the 1,000-c/s band covered by the transmitter, and so operate more transmitters within a given frequency band. It was proved, however, that this was a fallacy, and that the range of frequencies produced was at least as great as in amplitude modulation, however small the depth of modulation when considered in terms of frequency swing.

Then there is phase modulation, in which the depth of modulation is indicated by the phase shift of a constant-amplitude carrier wave. To shift the phase it is necessary to alter the frequency. But it is not quite the same thing as frequency modulation, because a steadily increasing phase shift (corresponding to a steadily changing amplitude or frequency in the two previous types of modulation) is brought about by a sudden change of frequency which thereafter remains steady at its new value.

There is a fourth and even less well-known method of modulation, in which the total output from the transmitter is kept constant but the way in which the radiation is distributed varies, so that the amplitude of reception at any point varies according to the modulation. The system is



"LIGHTHOUSE" MODULATION. The diagrams show the distribution of radiation in a horizontal plane of (1) an unmodulated carrier wave, (2) carrier wave plus sidebands at 50 per cent. modulation, and (3) 100 per cent. modulation. The diagrams must be imagined to be rotating around their centres at the modulation frequency.

rather like a lighthouse, from which the output of light is uniform, but when viewed from any point it is seen to flash on and off. If the modulation is sinusoidal and 100 per cent., the horizontal radiation pattern is heart-shaped and rotates at the modulation frequency. So although the output remains constant, at any receiver it will appear to fluctuate from zero to double the average, just as in the conventional system of amplitude modulation.

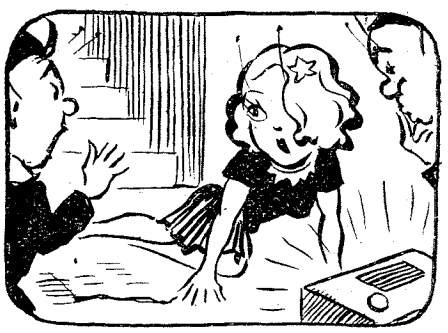
This result is obtained by feeding a central aerial with a steady carrier wave, and four outer aerials with the sidebands, the phases of the latter being adjusted so that they add and subtract from the carrier radiation, converting a circular distribution into a heart-shaped or some intermediate form, depending on the depth of modulation.

Here, then, we have a modulated transmitter from which the total output need not vary (although in any one direction it must), and in which the frequency need not vary (although extra frequencies must be introduced).

"CATHODE RAY."

GOODS FOR EXPORT

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



The "Fluxite Quins" at work

When moving the wireless one day,
OO tripped down the stairs, sad to say.
"Are you hurt?" hollered OI.
"Not a bit, darling boy!"
"But that set'll need FLUXITE," growled EH.

See that FLUXITE is always by you—in the house—garage—workshop—wherever speedy soldering is needed. Used for 30 years in Government works and by leading engineers and manufacturers. Of Ironmongers—in tins, 4d., 8d., 1/4 and 2/8.

Ask to see the FLUXITE SMALL-SPACE SOLDERING SET—compact but substantial—complete with full instructions, 7/6.

Write for Free Book on the art of "soft" soldering and ask for Leaflet on CASE-HARDENING STEEL and TEMPERING TOOLS with FLUXITE.

TO CYCLISTS! Your wheels will NOT keep round and true unless the spokes are tied with fine wire at the crossings AND SOLDERED. This makes a much stronger wheel. It's simple—with FLUXITE—but IMPORTANT.

THE FLUXITE GUN

puts Fluxite where you want it by a simple pressure. *Price 1/6, or filled 2/6.*

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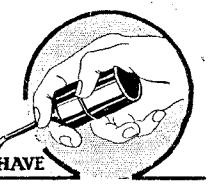

ALL MECHANICS *WILL* HAVE

FLUXITE

IT SIMPLIFIES *ALL* SOLDERING

RANDOM RADIATIONS

By "DIALLIST"

Accumulator Shortage

IT is reported, I notice, that numbers of battery-operated sets are going out of use in parts of Scotland owing to the impossibility of obtaining batteries. Accumulators seem to be the chief trouble; dry HT batteries are not so hard to come by. So great is the shortage of filament accumulators that battery sets are being disposed of at any old price. A curious state of affairs, for not so very long ago almost any kind of receiver was worth quite a bit. I wonder whether it as occurred to set users and to service-men in those parts that the secondary cell is by no means the only one that can be used for dull-emitter filament heating; it's undoubtedly the best kind of cell for the purpose, but in an emergency there are always primary cells—wet or dry—which, if not so economical to operate, will at any rate do the job and avert the necessity for putting battery receivers out of action. To the confirmed non-stop listener, who keeps his set switched on during every waking hour, primary cells would be prohibitive in cost, but they will undoubtedly help those who prefer a little news and entertainment by wireless to none at all.

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Outdoor Radio

WHILE I was at home the other day for a precious 24 hours' leave my ears were assailed by a horrid din coming from a house some 200 yards away. The loudspeaker of a wireless set was blaring away full bore—and you know the frightful distortion that results when a small set in full blast is heard at a distance. I waited for a bit, hoping that the noise would presently cease. It didn't, so I walked along to see what on earth was happening. I found an evacuee guest of my neighbour's busily engaged in mowing the lawn. To lighten his labours he had taken a portable set out of doors with him and had turned up the wick to make the sounds from the loudspeaker override those from the lawn-mower. Though my soul was full of pent-up fury, I remembered how much can often be done by gentle methods. He had earned, I suggested, a glass of beer, and I begged him to come to my house and have one. Making sure that the set was left blowing its head off, I led him to my home and gave him his cooling draught in the garden, which was filled with the welter of hideous sounds from his speaker. "I'd no idea," said he at length, "that my set was kicking up such a row." "Well, you know now," I returned, "and I'm sure I can rely on you not to inflict such suffering again."

Draw It Mild

That did the trick. There's no way of convincing a fellow that his set's causing a nuisance like getting him to come and hear for himself. Equally, there is no better way of making sure that your loudspeaker doesn't offend than by taking a stroll outside your domain when its working. It's surprising sometimes to find how far the sounds of a loudspeaker will carry through open windows even when the volume doesn't seem unduly great inside the house. In these days, when most folk are working long hours and many have night duty to do and must rest in the daytime, it behoves us to be specially careful not to disturb our friends and neighbours by letting our loudspeakers flood their homes with noise. So remember the old proverb and don't let your radio meat be the other fellow's poison!

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A Backslider

THE issue of *Wireless World* containing "Free Grid's" counter-attack on me unfortunately followed me from address to address on a tour of inspection that I was then making, and didn't catch me up until it was too late to deal well and truly with it, for by that time Press day had come and gone. The kind of fellow who apparently believes that the Greek language was the offspring of Hebrew is capable of writing or saying almost anything. And the man appears to be either without memory or without morals. Has he forgotten how during our last sojourn together at Princetown (which, we agreed, should always be spoken of as our post-graduate course at Princetown) we resolved to turn over each his new leaf? Does nothing remain in his memory of the great oath we swore never to disclose each other's murky past—unless it were made really worth our while to do so? I grieve for him. He may misquote Plato for his own ends, but I fear that unless he mends his ways the gentleman who is the arch-misquoter for similar purposes may be preparing, hot and free, his largest grid for F. G.'s reception.

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Smaller Lights

IN the lay papers suggestions have been made that more 200-volt and 230-volt 5-watt and 10-watt lamps should be made available so that people might economise in their consumption of electric current by using

BOOKS ON WIRELESS

issued in conjunction with "Wireless World"

	Net Price	By Post
"FOUNDATIONS OF WIRELESS," by A. L. M. Sowerby, M.Sc. Third Edition revised by M. G. Scroggie, B.Sc., A.M.I.E.E.	6/-	6/4
"RADIO LABORATORY HANDBOOK," by M. G. Scroggie, B.Sc., A.M.I.E.E. Second Edition Revised and Enlarged	12/6	12/11
"WIRELESS SERVICING MANUAL," by W. T. Cocking, A.M.I.E.E. Sixth Edition Revised and Enlarged	7/6	7/10
"HANDBOOK OF TECHNICAL INSTRUCTION FOR WIRELESS TELEGRAPHISTS," by H. M. Dowsett, M.I.E.E., F.Inst.P., M.Inst.R.E., and L. E. Q. Walker, A.R.C.S. Seventh Edition	27/6	28/3
"WIRELESS DIRECTION FINDING," by R. Keen, B.Eng. Hons. Sheffield, A.M.I.E.E. Third Edition	27/6	28/3
"RADIO DATA CHARTS," by R. T. Beatty, M.A., B.E., D.Sc. Second Edition Revised	6/-	6/3
"TELEVISION RECEIVING EQUIPMENT," by W. T. Cocking, A.M.I.E.E.	8/6	9/-
"RADIO INTERFERENCE SUPPRESSION," by Gordon W. Ingram, B.Sc.	5/-	5/4
"LEARNING MORSE." Tenth Edition. 285th thousand	6d.	7½d.
"RADIO DESIGNER'S HANDBOOK," Edited by F. Langford Smith, B.Sc., B.E.	10/6	11/1
"INTRODUCTION TO VALVES," by F. E. Henderson, A.M.I.E.E.	4/6	4/9
"WIRELESS WORLD" GREAT CIRCLE PROJECTION MAP	2/-	2/3
B.V.A. LIST OF EQUIVALENT AND PREFERRED ALTERNATIVE VALVES	1/-	1/1

Obtainable from Leading Booksellers and Railway Bookstalls or by post (remittance with order) from

ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1

them in passages and other places where only a dim light is needed. I don't know whether anything will be done to increase supplies of these, though I much doubt it. But anyone who has an old mains transformer with 4-volt or 6-volt windings can easily rig up small lights for himself, using 6-volt car sidelight bulbs or 4-volt flashlamp bulbs as the case may be. The HT windings should be made safe by sealing up their ends, or, better still, the transformer may be completely enclosed in a perforated box. Again, if a 200/230-50-volt or 200/230-25-volt transformer is available it may be pressed into service, for low-wattage bulbs for both 50 and 25 volts are, I believe, available. Actually it's surprising to find what a small wattage will give light enough to guide one's footsteps and save one from barging into obstructions. I have several tiny lamps in my own home, and a friend has a corridor some 40 feet long, with two steps in the middle of it, in which ample illumination for safety is given by two miniature bulbs suitably spaced.

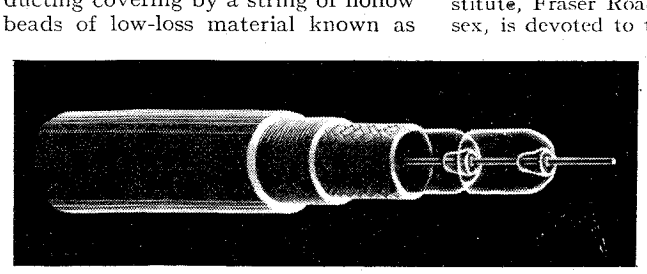
Low-capacity Cables

Flexible Types for Laboratory Equipment and UHF Experimental Work

THERE is always a steady demand for screened low-capacity cables for laboratory equipment and experimental work at high frequencies, and requirements cover a wide range of dimensions—electrical and physical. Having recently had the opportunity of examining some representative samples of concentric cables made by the Telequipment Co., 16, The Highway, Beaconsfield, Bucks, we would hazard a guess that there are few requirements in this particular line that they are unable to meet.

The most popular type made by this firm is the "Co-Ax" flexible cable consisting of a central conductor separated from an outer braided conducting covering by a string of hollow beads of low-loss material known as "Megastyrene." The beads give a remarkably high degree of flexibility, and are formed in such a way that there is the minimum surface touching the inner conductor.

Capacities as low as 15.7 $\mu\mu$F per yard are available, and characteristic impedances available range from 70 to 214 ohms. Exterior coverings and finishes can be supplied to individual requirements.



Specimen section of "Co-Ax" cable showing internal construction.

"Introduction to Valves"

THIS book, of which a preliminary announcement appeared last month, is now ready. It is a manual for those who, with little or no previous experience, are called upon to handle valves, cathode-ray tubes, and associated devices. It is thus an extremely useful book for actual or prospective members of the wireless branches of the Services.

After a preliminary chapter on the nature of electricity and thermionic emission, the author, F. E. Henderson, A.M.I.E.E., goes on to describe electron currents and the functions of the various electrodes in a simple valve. Succeeding chapters deal with practical applications of these principles to more complex valve types; with the uses of the valves and their functioning in typical circuits.

Finally, cathode-ray tubes and stabilisers are treated. "Introduction to Valves," which contains 112 pages, is liberally illustrated with diagrams. It is published and distributed from the offices of *Wireless World* on behalf of the General Electric Company of England, and costs 4s. 6d., or by post from our publishers, 4s. 9d.

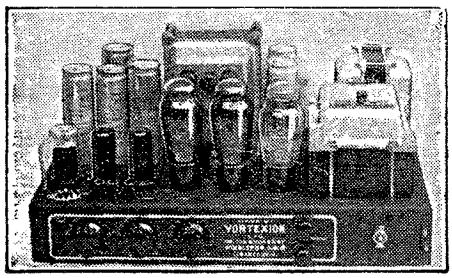
The Wireless Industry

THE difficulties which some manufacturers are experiencing in using the new lead-rich solders have been met by instructional literature from well-informed sources. This shows that the trouble disappears when the temperature of the soldering bit is adequately controlled. Facts and figures are provided in Reference Sheet 2 issued by Multicore Solders Ltd., Bush House, London, W.C.2.

The July number of "Tin and Its Uses," issued by the Tin Research Institute, Fraser Road, Greenford, Middlesex, is devoted to the need for economy and points out that 30,000 tons are normally absorbed annually in making solders.

VORTEXION

50w. AMPLIFIER CHASSIS



A pair of matched 6L6's with 10 per cent. negative feed-back is fitted in the output stage, and the separate HT supplies to the anode and screen have better than 4 per cent. regulation, while a separate rectifier provides bias.

The 6L6's are driven by a 6F6 triode connected through a driver transformer incorporating feed-back. This is preceded by a 6N7, electronic mixing for pick-up and microphone. The additional 6F5 operating as first stage on microphone only is suitable for any microphone. A tone control is fitted and the large eight-section output transformer is available in three types:—2-8-15-30 ohms; 4-15-30-60 ohms or 15-60-125-250 ohms. These output lines can be matched using all sections of windings and will deliver the full response (40-18,000 c/s) to the loud speakers, with extremely low overall harmonic distortion.

CHASSIS with valves and plugs £17 10 0
Moving Coil Microphones £5 5 0
Chromium Microphone Stands, from £1 5 0

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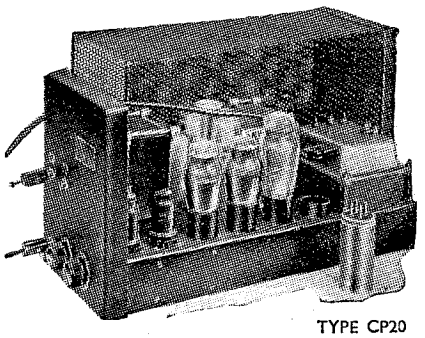

TYPE CP20

This small Portable Amplifier operating either from AC mains or 12-volt battery, was tested by the "WIRELESS WORLD," October 1st, 1937, and has proved so popular that at customers' demand it remains unaltered except that the output has been increased to 17.2 watts and the battery consumption lowered to 6 amperes. Read what the "Wireless World" said :—

"During tests an output of 14.7 watts was obtained without any trace of distortion so that the rating of 15 watts is quite justified. The measured response shows an upper limit to 18,000 c/s and a lower of 30 c/s. Its performance is exceptionally good. Another outstanding feature is its exceptionally low hum level when AC operated even without an earth connection. In order to obtain the maximum undistorted output an input to the microphone jack of 0.037 volt was required. The two independent volume controls enable one to adjust the gain of the amplifier for the same power output from both sources, as well as superimpose one on the other or fade out one and bring the other up to full volume. The secondary of the output transformer is tapped for loud speakers or fine impedances of 4, 7.5 and 15 ohms. Price:

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Letters to the Editor

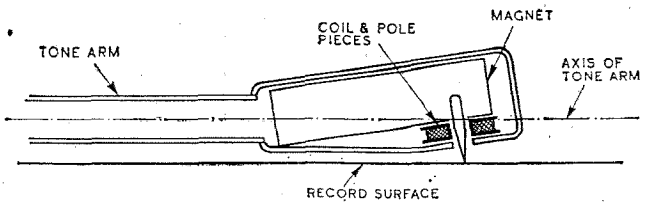
Pick-up Construction : Testing for Deafness : The Compensated Diode

Home-made Pick-ups

I SHOULD like to add a few remarks to the information given in the article "Making a Moving Coil Pick-up" in your July issue. There is much scope for this sort of thing, particularly as the constructional work is not beyond the powers of amateur mechanics, given a sound design.

Since February of this year I have been working along very similar lines, and have evolved a pick-up—strangely enough using an "Eclipse" magnet and Silent Stylus needle—with a similar response curve but much lower voltage output.

It is not generally realised that there exist three possible modes of vibration which might provoke irregularities in the response curve; these were enumerated by P. G. A. H. Voigt in *Wireless World*, March, 1940, and of these I have found the torsional resonance of the tone-arm to be most troublesome. This is probably the type of resonance referred to in the last page of Mr. Brierley's article, and in my experience it always exists with a tone arm having a symmetrical cross section, e.g., a hollow tube. It can, however, be made vanishingly small by arranging so that the axis of rotation of the moving system is coincident with the tone-arm axis. The diagram illustrates this roughly in the case of my own pick-up. The general effect is to reduce the moment of any torsional forces set up by the elasticity of the arm about the moving system to zero.



Sketch showing coincidence of axes of tone arm and moving system.

The arrangements for changing needles of such small size are important, and, in my opinion, something more solid than a mere push fit is necessary in a material like celluloid. The insertion and withdrawal of many needles is sure to enlarge the hole provided, with consequent increase of "buzz," top cut-off and other similar troubles. In my own pick-up this has been taken care of by the use of interchangeable rubber blocks (made from old pencil erasers), each of which has a needle embedded in it. The change can thus be made with suitable tools in the seclusion of the workshop.

In conclusion, might I congratulate Mr. Brierley on opening up this new field of constructional work?

GEORGE A. HAY.

Riding Mill, Northumberland.

"Hearing Aids for the Million"

IN the event of the British Medical Association agreeing with Mr. J. Stanley Jowitt's provocative views (August *Wireless World*) on the desirability of restricting the handling of deaf aids to persons instructed in both medical and electrical aspects, it is doubtful what prospect they would have of displacing those already in the hearing-aid trade. Mr. Balbi's graph gave the magnitude of the trade already built up by selling agencies. Perhaps he could tell us what proportion of these sales were effected through medical recommendation..

In the meantime, could Mr. Jowitt suggest a course of medical reading suited to those of your readers who are sufficiently interested to apply themselves to the subject? If all existing literature is so highly technical as to be only understandable by those with a specialised training, would not the British Medical Association do well to sponsor diffusion of a few guiding principles, preferably in a book for the benefit of all concerned? Perhaps Mr. Jowitt would do this himself.

C. B.'s "predictor" is an excellent idea. I do not think, however, that it should be developed at the expense of audiometer tests, but rather in supplement of them. Deaf people are prone to choose an instrument of "mellow tone" and lowest intelligible volume rather than one which restores the widest frequency range with a reserve of power. This is simply because they have forgotten the true loudness of sounds, if they ever knew them.

Testing instruments and hearing aids must be improved until the choice of a hearing aid is removed from the patient to the aurist. A patient choosing a deaf aid gives undue weight to size, appearance and price. A test with nonsense syllables as often as not reverses a decision.

JOHN A. HAMILTON.

Murtle, Aberdeenshire.

"Improving the Diode Detector"

THE suggestion made by G. A. Hay is certainly ingenious, but the improvements are not likely to be so marked as at first sight appears. In my article in *Wireless Engineer*, January, 1937, page 24, it is shown there that the distortion due to a ratio less than unity of AC to DC load in the non-delayed AVC valve can produce appreciable distortion in the detector valve, and I feel that the author is unwise to assume that distortion produced by the resistance R_3 in his Fig. 2 will be so much less than if that resistance were included as the AC load of R_1, the detector diode load resistance. Incidentally, if C_3 and R_3 formed the AC load of the main detector, the permissible modulation percentage would be 90 per cent., so that the practical advantage of the circuit is not so obvious.

Another point which seems to have been forgotten is that the condenser C_3 provides a long time constant in the diode V_2 circuit, so that when the signal fades the voltage across C_3 will fall at a very much slower rate than that across C_1, i.e., the DC back-balancing voltage will still remain when the DC voltage on the main detector has dropped to quite a low value. There is therefore every possibility of producing considerable distortion due to over-biasing V_3 during fading. Added to this will be the fact that for satisfactory volume control R_1 and R_2 will need to be ganged.

K. R. STURLEY.

Marconi School of Wireless Communication.

[The author writes: Dr. Sturley's criticisms are apparently based on a partial misapprehension of the intended uses of the compensated diode detector. He is obviously thinking of its application to the general-purpose superheterodyne. The standard of performance of the orthodox diode detector can be made so good that the

distortion which it introduces goes unnoticed in the much greater distortion caused by such factors as non-linear IF amplifiers, fading, etc. It is only in the field of high-quality local station reception where fading is zero or at most very slow and of small magnitude that the compensated form of detector would confer any material advantage. Under these conditions most of Dr. Sturley's remarks do not apply, though, of course, they are true of the general-purpose set.

In the first place the connection of a second diode rectifier with unequal AC and DC loads to the output of an RF amplifier will only cause distortion of the modulation envelope if the amplifier is a constant current generator, i.e., a conventional RF pentode. The degree of fidelity attainable with the compensated diode is so high that some more linear form of RF amplifier is necessary ; in practice we are limited to one such as the Colebrook double triode amplifier (*J.I.E.E.*, Vol. 74, p. 187) as used in my own receiver, in which the last valve acts substantially as a constant voltage source, thus ensuring complete absence of distortion of the modulation envelope by the presence of C_3 and R_3 in the circuit of V_2. In addition, Dr. Sturley has not mentioned the fact that, in the work quoted in his letter, the results were worked out for direct capacitive coupling between RF valve and AVC diode, whereas in my own arrangement the coupling is inductive through a step-down transformer.

While it is true that fading of the rapid kind would cause excessive bias to appear on the AF amplifier, this detector would never be used under such conditions, and hence the problem would not arise. Slow fading would cause only slight changes in bias which would be of no importance. Again, the use of R_1 and R_2 for volume control would not be contemplated, as they are carrying direct current, and this fact would give rise to noisy operation. Volume control in the AF amplifier is much better.

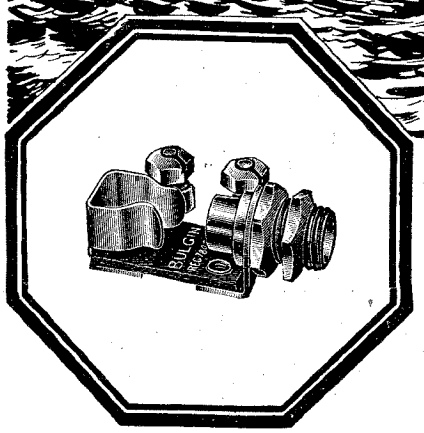
In conclusion, might I point out for the benefit of those who have shown interest, that the compensated detector, while resembling outwardly a push-pull arrangement, has no connection with the latter and works in an entirely different manner.—ED.]

A Correction.

IN a letter from Dr. John H. Mole in the August *Wireless World* the figure for suspension stiffness should be 190 grams per mm., and not 19 grams.

The Editor does not necessarily endorse the opinions of his correspondents

COMMUNICATIONS DEPEND....



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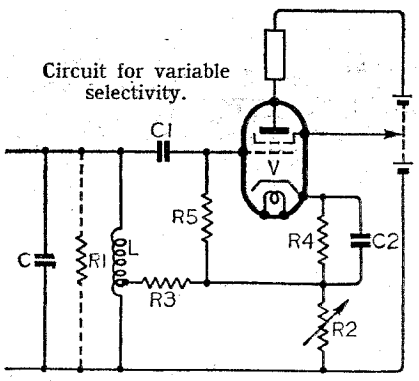
VARYING BANDWIDTH

ONE way of varying the bandwidth of a tuned amplifier is to widen the response of a normally highly resonant circuit by means of a shunt resistance. Another is to use positive reaction to sharpen the response of a circuit which is normally of medium selectivity. Both methods involve complications which the method shown in the figure avoids.

The circuit L, C is of medium selectivity as indicated by the resistance R1, and is assumed to be fed by a high-impedance valve (not shown). The



Circuit for variable selectivity.

cathode of the amplifier V is tapped through a resistance R3 to the inductance L, whilst a further resistance R2 is included in the anode circuit.

In operation the resistances R2, R3 apply positive reaction to the tuned circuit L, C, thereby increasing its selectivity, whilst at the same time they apply negative feedback to the amplifier, so as to keep the amplitude of the output constant.

E. L. C. White and E. W. Bull. Application date June 8th, 1940. *No.* 542469.

BAND-SPREAD TUNING

THE use of capacity trimmers for this purpose is usually unsatisfactory because the degree of "spread" to be obtained varies from point to point of the tuning range. A more uniform band-pass effect can be secured by varying the inductance of the tuned circuit, but this leads to mechanical difficulties in a multi-wave receiver.

The invention discloses an arrangement which is intended to remove the last mentioned difficulty by using an inductive trimming device which does not form part of the tuned circuit proper but is coupled to it. For instance, the trimmer may consist of two inductances in parallel, one being variable and the other of fixed value and coupled to the inductance of the tuned circuit. The current in the variable limb of the auxiliary circuit, and therefore its effect on the tuned circuit, will naturally decrease as the signal frequency rises, but this can be offset by inserting a suitable fixed condenser between the two limbs. One such trimming circuit can be provided for each wave-band and conveniently brought into operation by a control ganged to the wave-band switch.

The Mullard Radio Valve Co., Ltd., F. Caplin, and C. E. Payne. Application dates July 9th, 1940, *and February 18th,* 1941. *No.* 542611.

A DF INDICATOR

A RADIO compass for giving a steady reading both of direction and sense, from a constantly rotating frame aerial, is characterised by the use of a comparatively rugged type of indicator. The current from the rotating frame is combined with that from an associated vertical aerial to give a cardioid response. The resulting current is rectified and fed to the coil of an electromagnet which is rotated below a copper disc at the same speed as the aerial. As a result magnetic poles are produced in the copper disc along a line that coincides with the critical line of the cardioid curve. A permanent magnet pivoted on the same rotating shaft will then swing into this line, carrying with it a needle, which indicates both the direction and sense of the distant beam. A similar result, free from sense ambiguity, can be derived from a rotating frame aerial used alone, provided the electromagnet is rotated at twice the speed of the aerial.

Standard Telephones and Cables, Ltd. (assignees of N. E. Klein). Convention date (U.S.A.) October 25th, 1939. *No.* 542564.

AF AMPLIFIER WITH NEGATIVE FEEDBACK

IT is common practice to apply degenerative back coupling to an AF amplifier, both to improve its frequency response and to diminish the effect of any residual mains hum. There is, however, a tendency, owing to the phase shift produced by the circuit capacities, for the feedback to become regenerative at the higher frequencies.

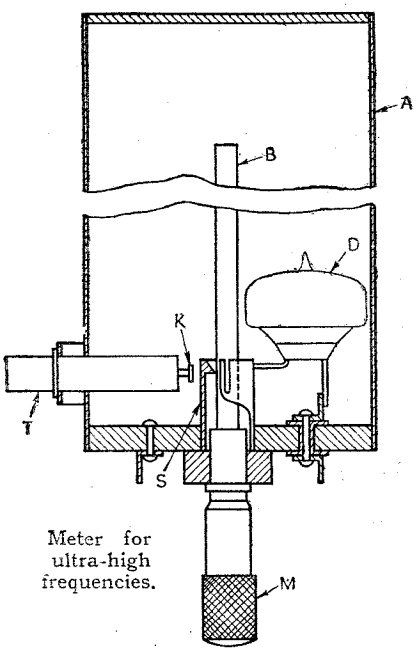
In order to prevent this an auxiliary voltage is fed back from the output transformer to the input through a lead including a resistance and a capacity having a sufficiently low impedance at the higher audio frequencies to ensure that the resultant of the two feedback voltages remains degenerative at the highest frequencies to be amplified.

The British Thomson-Houston Co., Ltd. Convention date (U.S.A.) August 17th, 1939. *No.* 543035.

RESONATOR FOR FREQUENCY MEASURING

THE drawing shows a compact combination for measuring very high frequencies. It includes a closed resonator AB of the concentric line type, the inner conductor or rod B being provided with a micrometer head M for adjusting the length extending inside the resonator for tuning purposes. The anode of a diode rectifier D is connected to a slotted spring member S which makes firm contact with the rod B about one-tenth of the way up and is connected at its lower end to the base of the resonator. The cathode lead of the diode is brought out to an external metering circuit through insulating "studs," the leads from the heater element being similarly arranged.

The frequency to be measured is introduced into the resonator by capacity coupling through a small flat terminal K on the inner conductor of a trans-

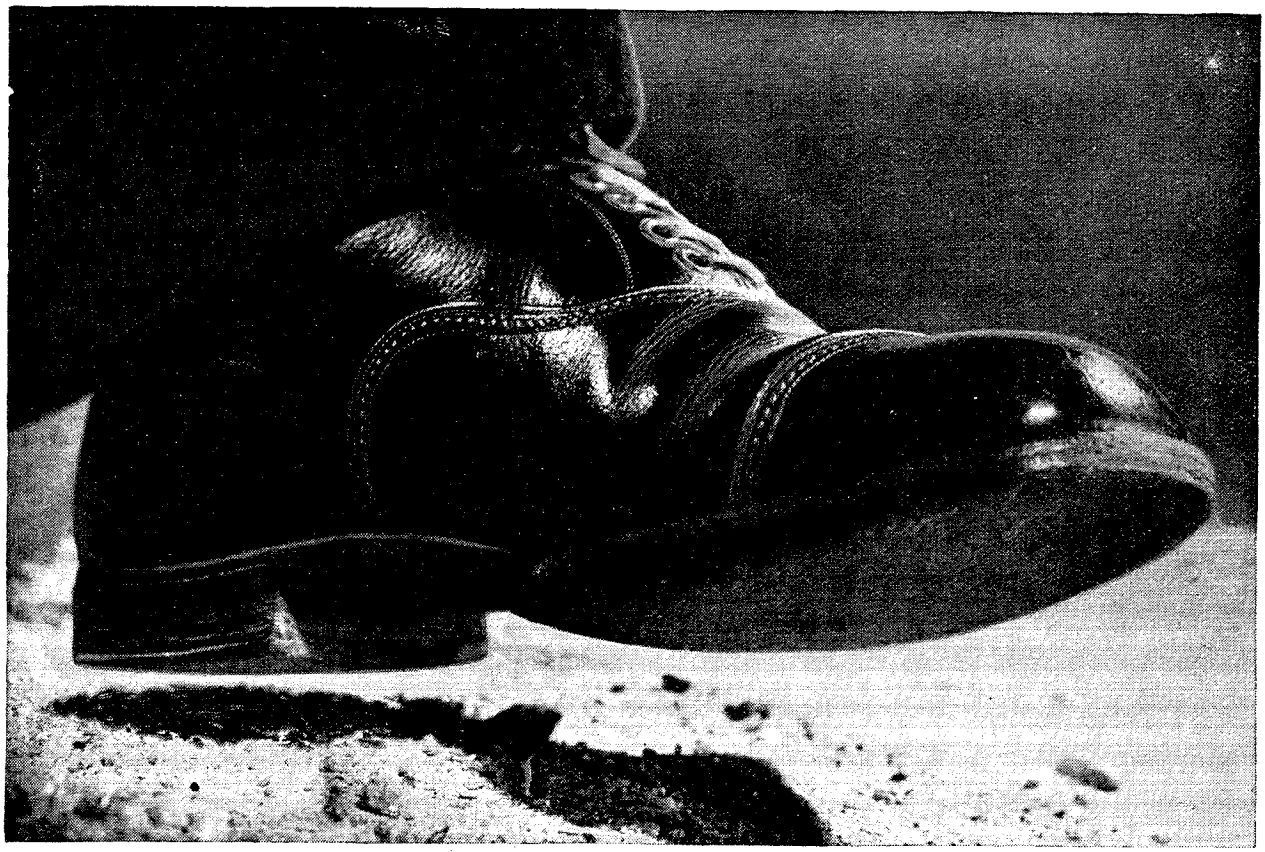


Meter for ultra-high frequencies.

mission line T. The length of the rod B is adjusted until the rectified current delivered to a meter connected in series with the cathode of the diode rises to a maximum. By placing the diode D at the lower or short-circuited end of the concentric-line resonator, it is kept out of the voltage node of the standing wave set up inside the system.

Electrical Research Products Inc. Convention date (U.S.A.), 26th July, 1939. *No.* 543052.

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.



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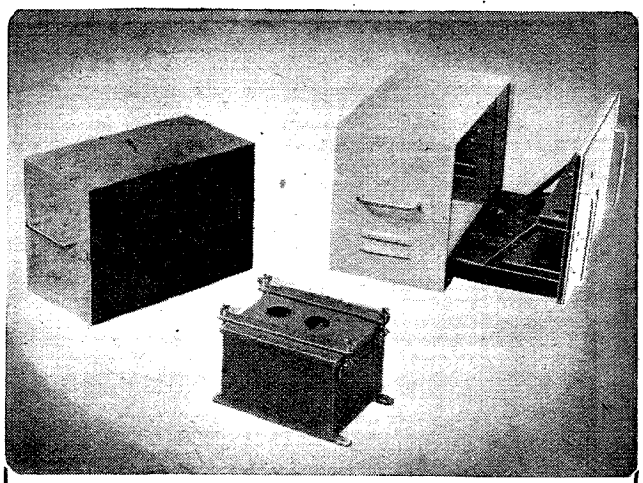

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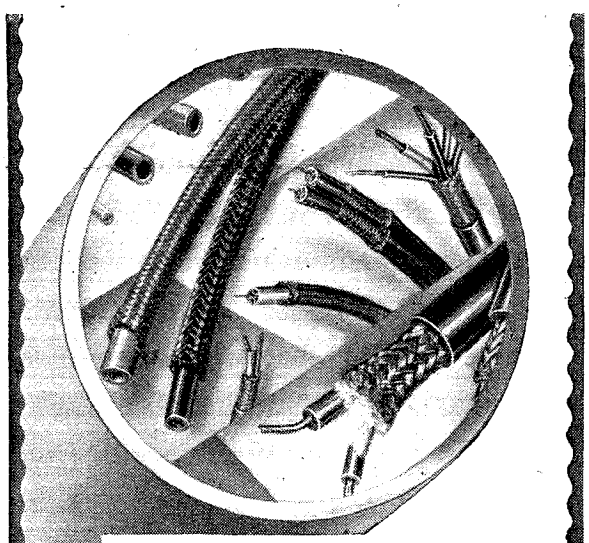

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N. Partridge

Ph.D., B.Sc., M.Brit.I.R.E., A.M.I.E.E.

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VALVES.—Europa AC/L 4v. 1 amp., makes good detector or L.F. amplifier, 3/3 each; Europa AC/HP, 5 pin base, 3/3 each (metallising of the AC/HP may be rather soiled, but all O.K.)

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Type	Range	Price	Type	Range	Price
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04D	76–170 m.	2/6	06D	76–170 m.	2/6
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Rotary Wave Change Switch, to suit above, **1/6.**

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2,000 ohms 25-watt Res., with 5 Tapping Clips, **2/- each.**

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Westinghouse Rectification, complete and ready for use. To charge 6 volts at 1 amp. (also tapped for 2 and 4 v.), **29/6.**

12 v., 1 a. (also tapped for 2 and 6 v.), **37/6.**

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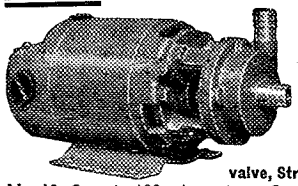

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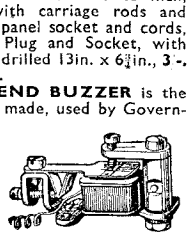

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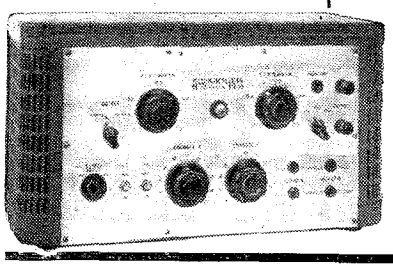

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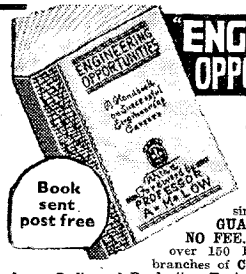

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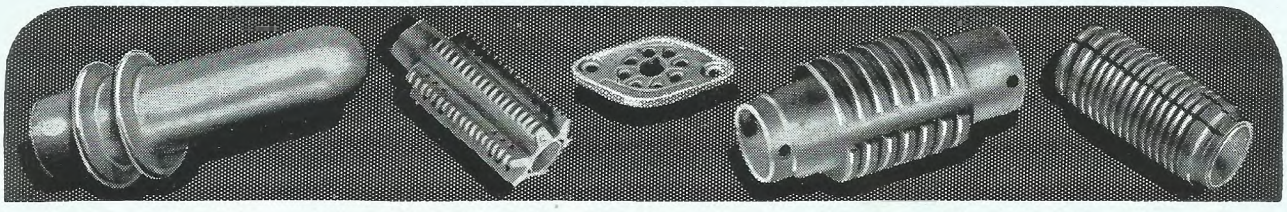

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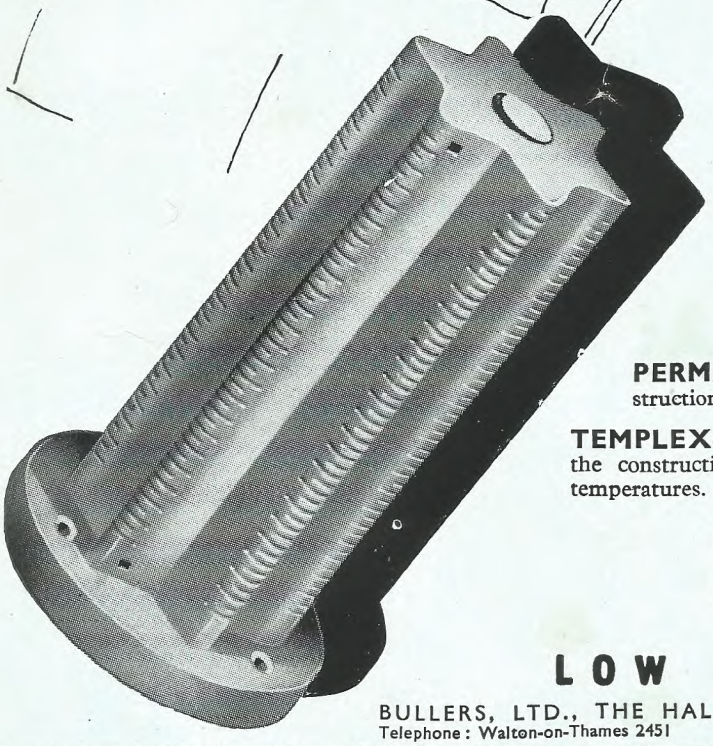

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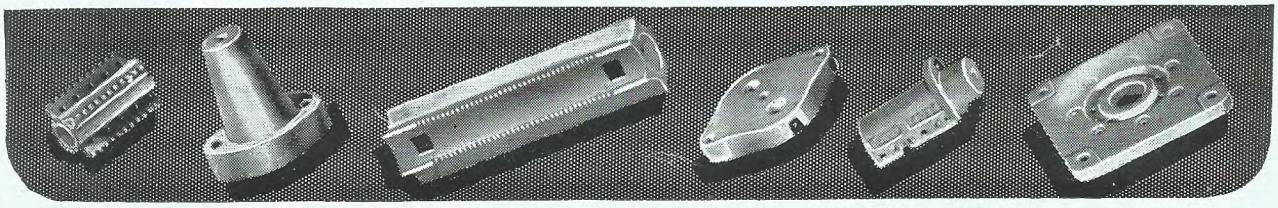

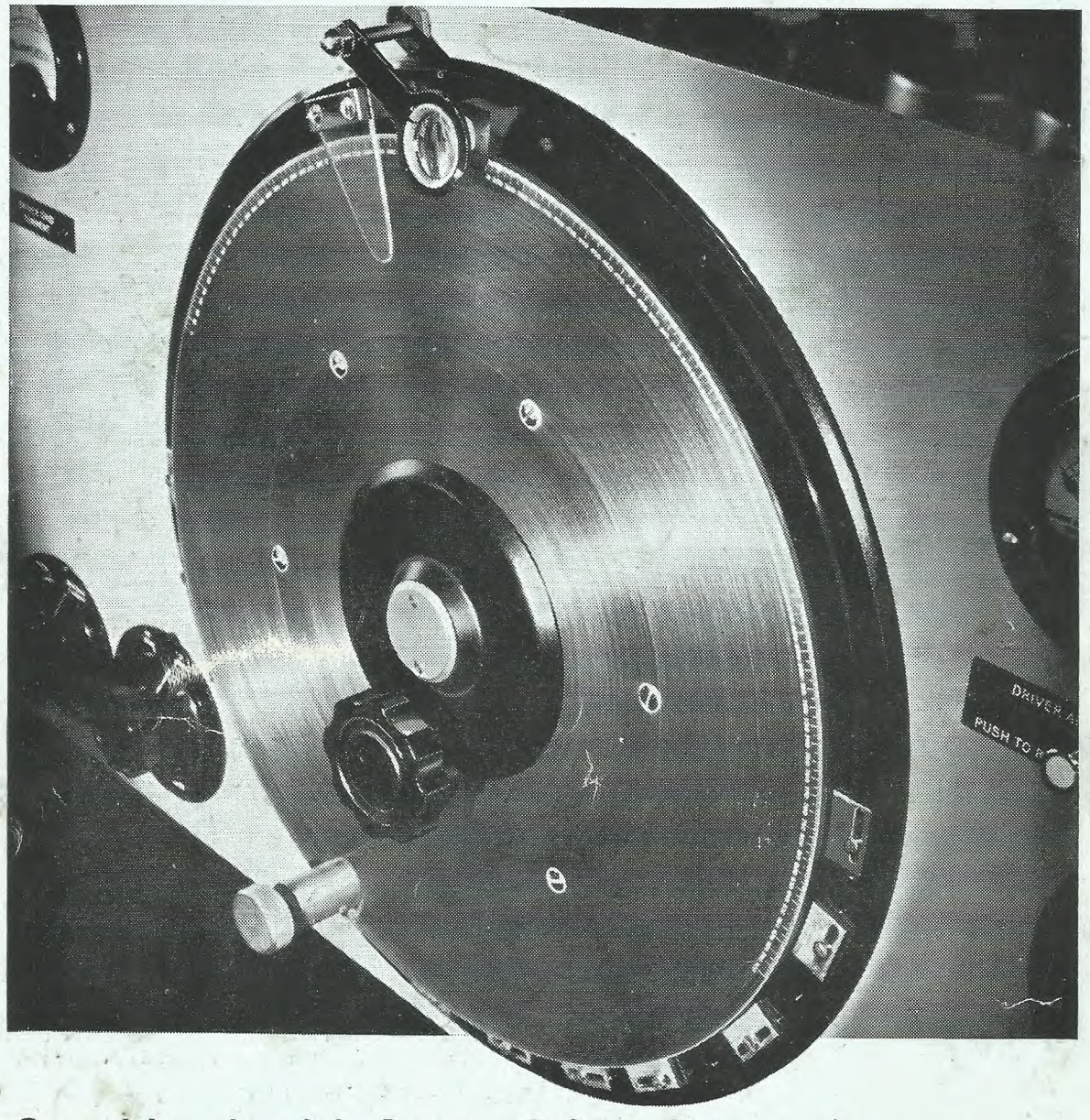

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