Wireless World

RADIO • ELECTRONICS • ELECTRO-ACOUSTICS

AUGUST 1942

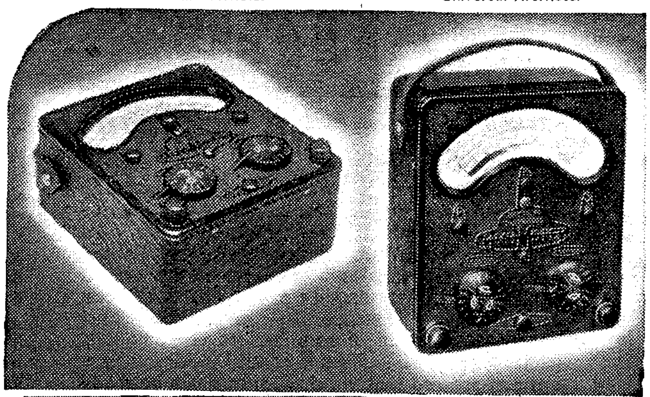
1/3

Vol. XLVIII No. 8

TRANSFORMER DISTORTION ✧ IMPROVING THE DIODE

Pollard.

46-range Model 7 Universal AvoMeter — 40-range Model 40 Universal AvoMeter



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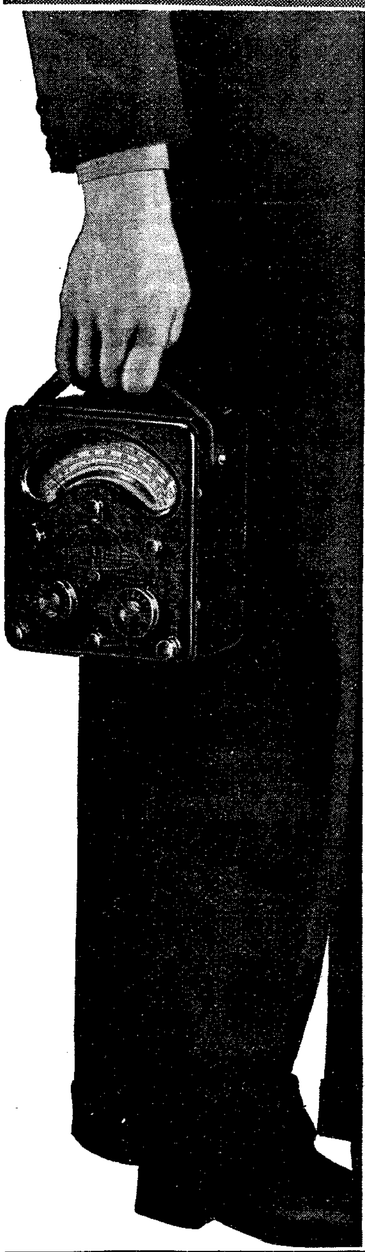
Regd. Trade Mark

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.

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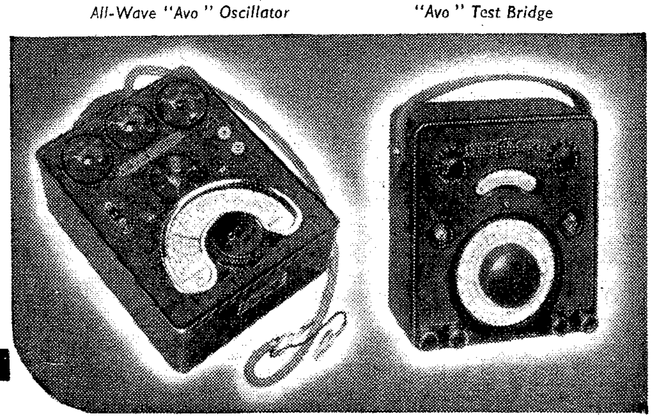
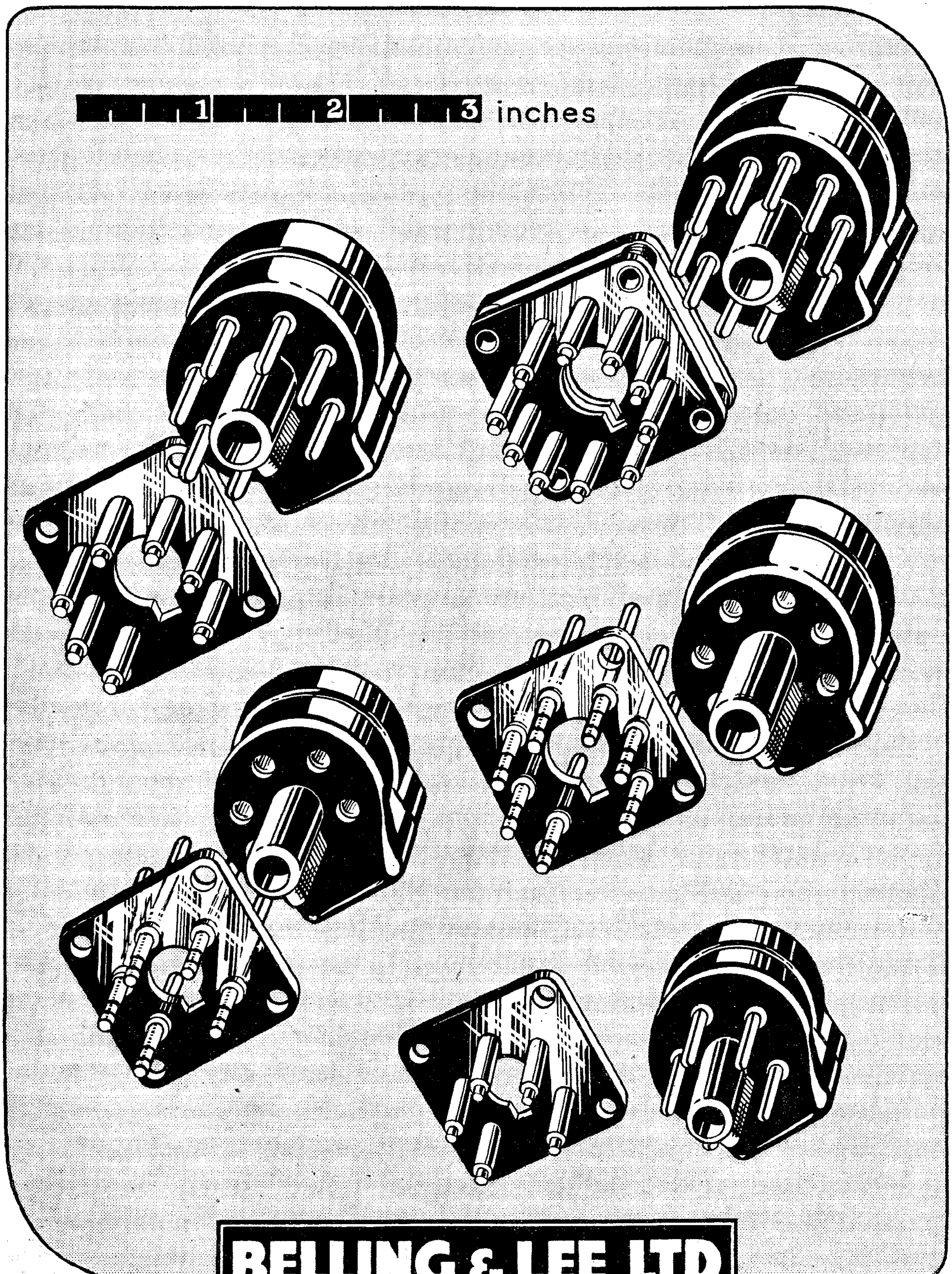
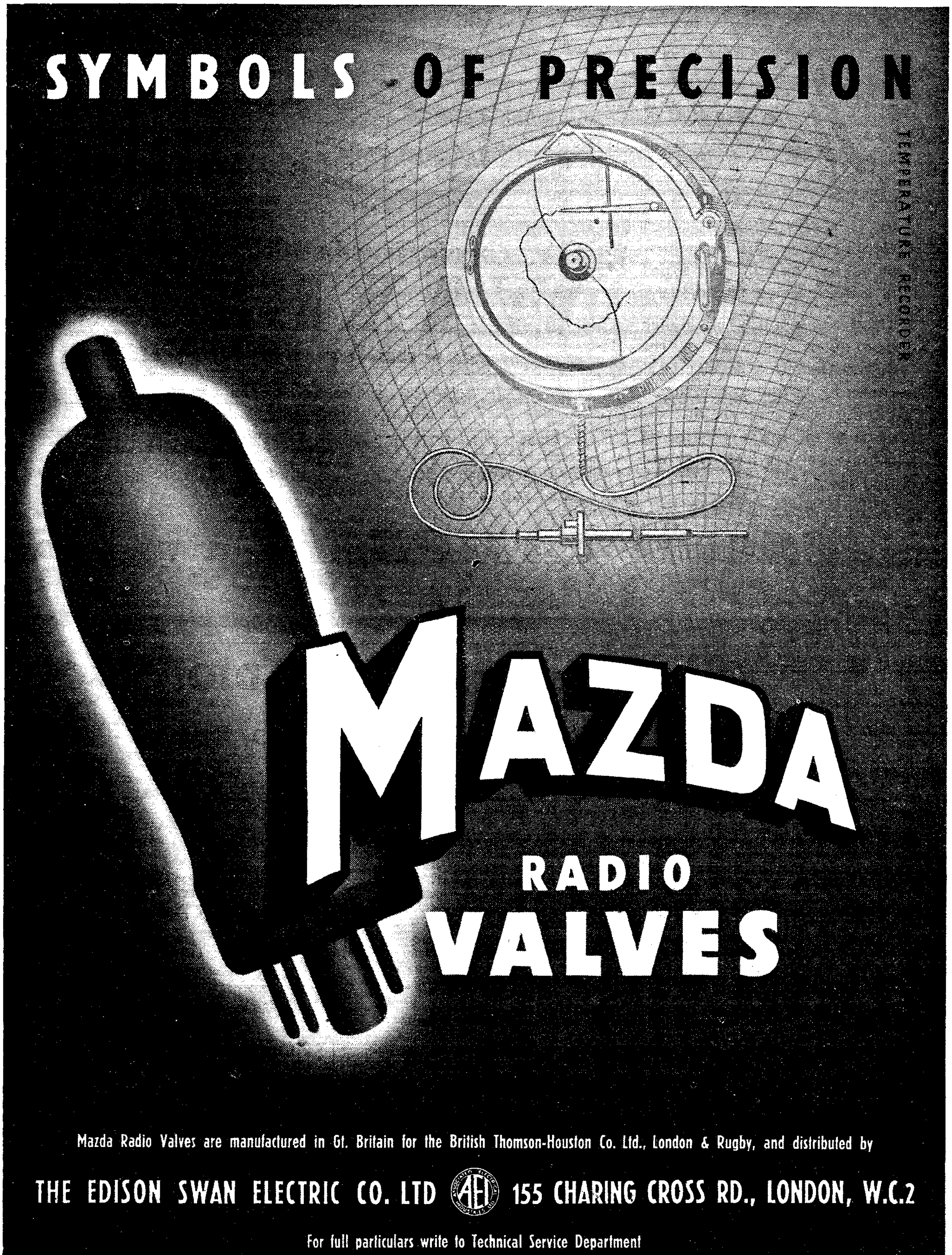



1 2 3 inches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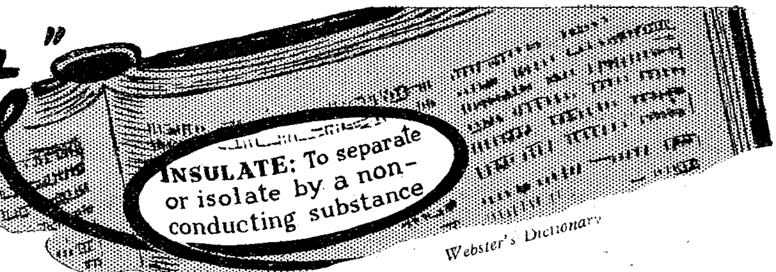

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RADIO RECEIVER CIRCUITS HANDBOOK

By E. M. Squire. This book is a useful guide to circuits for members of the radio industry and radio amateurs, containing practical notes on the operation of basic modern circuits. The text is liberally illustrated with circuit drawings and other diagrams. Second edition. 5s. net.

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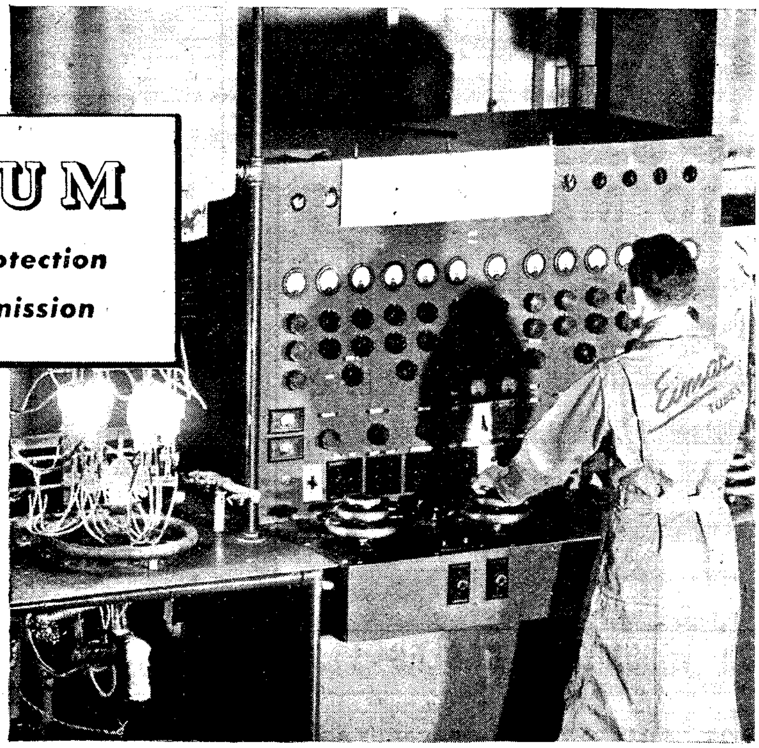

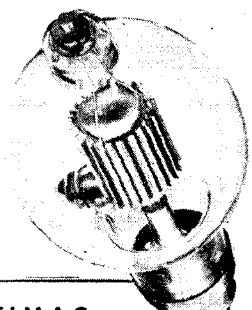

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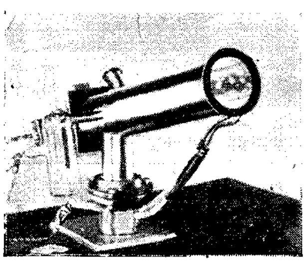
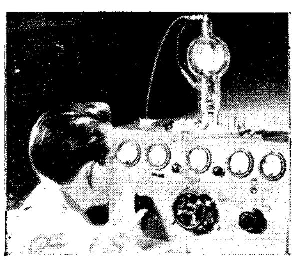
Filament Voltage	10 volts
Plate Voltage	up to 6000 volts
Plate Dissipation	2000 watts
Power Output (75% eff.)	6000 watts

Like a solid coat of armor-plate, hard, high vacuum protects filament emission in every Eimac valve. Extremely efficient evacuating pumps developed and built in the Eimac laboratories for the precise purpose of producing the highest possible degree of vacuum are shown in action above. It is this excellent vacuum that proved the idea fallacious that plate temperature destroyed emission...caused premature failures. Chiefly because of this processing, Eimac valves today, and in past years, have provided longer life, greater stamina and vastly superior performance.



ELECTRON MICROSCOPE virtually gives a moving picture projection of the action of electrons being emitted from a heated filament. Such observations enable Eimac engineers to constantly produce better filaments.



PEAK EMISSION TESTER measures the flow of electrons from the filaments of completed Eimac valves. Of the long series of gruelling tests made to insure more efficient filament emission in every Eimac valve, this is the final test.

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In Peacetime or Wartime... wherever you look...in the air, on land and at sea... you'll find Eimac valves doing their bit. Right now the Armed Forces get first call on our facilities and Eimac valves are receiving enthusiastic acceptance from all quarters.

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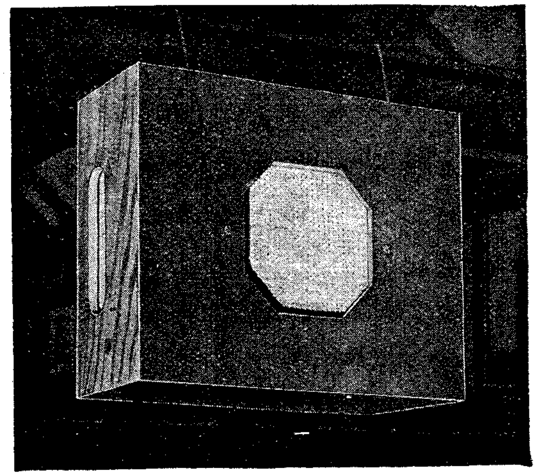

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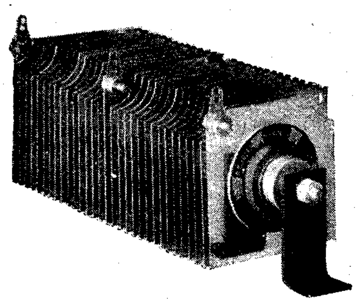

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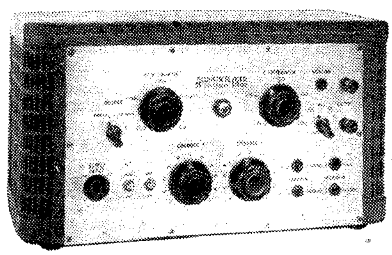

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C.40. Mains- and battery-driven 30-watt amplifier—Twin channels, independently controlled, employing nine standard service valves—Four inputs—Output stage operated as Triodes or Tetrodes—Bass and treble controls—Variable output impedance—etc. (as illustrated).

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M.30. As type C.30, but operated from 200/250-volt 40-100 c.p.s. mains.

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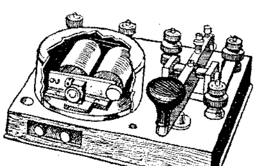
MANUFACTURING COMPANY LTD

HUNTINGDON *'TEL: 361*

G.P.O. MORSE KEY & BUZZER UNIT



We have only a small number of these instruments left. Made for professional use. All parts of heavy solid brass mounted on mahogany base. The Key is fitted with platinum contacts. An excellent opportunity for those requiring a robust unit which will give years of service .... Price **45/-**

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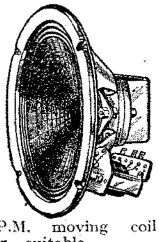
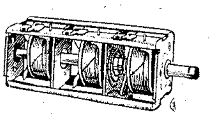


ROLA. Brand new 8in. P.M. moving coil, with transformer for super power or pentode valve. Fine cadmium plated chassis **27/6**

CELESTION 8in. P.M. moving coil, pentode output. New... **25/6**

GOODMANS 8in. P.M. moving coil Universal transformer, suitable for all output valves **27/6**

PHILIPS 3-GANG CONCENTRIC SPIRAL VANE VARIABLE CONDENSERS



.0005 mfd. without trimmers. As used in Philips well-known Push Button receivers. Price **4/6**

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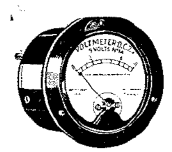

A good quality panel mounting meter with clear-reading 2¼in. dial. Voltage measurement 0-9 v. Fitted with terminals at back. Brand new. Price **20/-**

★ ONLY A FEW LEFT! ★

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Model T.26. Brand New. Offered at the cost of parts only

See June advertisement for full details

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● **MAINS TRANSFORMERS.** Originally made for Television Power Packs where accuracy and robustness are essential. Weight 12 lb. Size 5⅞in. × 4¼in. overall. 350-0-350 v. 120 m.a. Tapped. 4 v. 2 a.; 4 v. 8 a.; 3 v. 3 a.; 20 v. 1 a. Diagram free. Post and packing 1/6 .... **25/-**

● **G.E.C. MOTORS,** 1/100th H.P., A.C. 225 v. 50 ~.............................. **47/6**

● **HEAVY DUTY MAINS TRANSFORMERS.** Input 240 v. A.C. One tapping at approx. 5,000 v. max. 3 m.a., and one for supplying filament of Mullard H.V.R. 2 (6.3 v. at .65 amp.). Shrouded in metal box. Car. fwd. **10/6**

Also input 200-250 v. A.C., approx. 6,500 volts. Shrouded in metal box. Car. fwd. **20/-**

● **B.I. CONDENSERS.** .1 × .1 mfd. 7,000 volts D.C. test, with porcelain insulators **30/-**

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Includes heavy mains transformer 350-0-350, 120 m.a., with 4 tappings. High voltage transformer for supplying C.R. tube. Various condensers including 16 × 16 mfd. 550 v. working, 1-16 mfd. 450 v. working, 50 × 50 × 2 mfd. B.I. Electrolytics, etc. Pentode output transformer; chokes; resistors; trimmers; bias electrolytics; mica and tubular condensers; short-wave coils, etc. Workmanship and components are of the highest quality. Valve diagram free. Carriage forward. Add 2/6 for packing. **£3.17.6**

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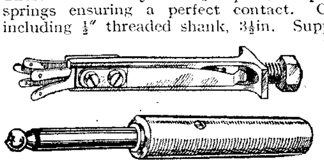
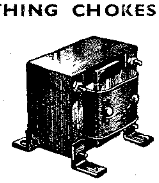
These ex-Govt. Jacks have powerful phosphor-bronze springs ensuring a perfect contact. Overall length, including ½" threaded shank, 3¼in. Supplied with nut for panel mounting. Price complete with best quality Plug (as illustrated) Plugs only, 2/-. **5/6**

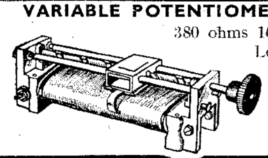


PHILIPS SMOOTHING CHOKES



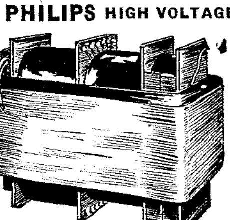
Brand new well-built chokes, 60 ohms D.C. resistance 400/120 m.a. Core size: 2¼in. by 2¼in. by 1⅛in., **5/6** each. Also 400 ohms D.C. resistance 60 m.a. Core size: 1½in. by 1¼in. by ⅝in., **3/6** each.

VARIABLE POTENTIOMETERS



380 ohms 10 watts. Low price to clear. **7/6** Each.

PHILIPS HIGH VOLTAGE TRANSFORMERS



Robust in construction; weight approx. 13 lb. Dimensions: 5⅞ × 5¼ × 4¼in. Specification: 350-0-350 v., 70 m.a. Four tappings giving 4 v. 3 amps., 6.3 v. 4 amps., 4 v. .65 amp. and 4,000 v. at 3 m.a. Input 100/250. Free wiring diagram. Carriage fwd. .... Price **32/6**

● **PLEASE NOTE. Write your name and address in Block Capitals.** You should order only from current advertisement, as many lines soon go out of stock. No orders can be sent C.O.D. Orders cannot be accepted from Eire or Northern Ireland. Postage must be included with all orders.

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SCREENED WIRE, 7/026 SWG, rubber covered **1/9** per yard.

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REACTION CONDENSERS. Mica spaced. 0.0003 mfd, 2in. spindles. **2/-** each.

VALVES are in short supply; stock of Mullard T.S.P. 4's and H.V.R. 2's to be cleared at **15/-** each; first come, first served.

CONDENSERS.—Special offer of metal-cased paper condensers, 300 v. working, all brand new and unused 2 mfd. **2/-**, 1 mfd. × 1 mfd. **1/9**, 1 mfd. **1/9**.

VARIABLE CONDENSERS, well made heavy 3-gang superhet condensers, die cast frames in first class condition. **5/6** each.

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PHILIPS HIGH VOLTAGE CONDENSERS. .1 mfd. 5,000 v. D.C. working. **10/6** each.

TRIMMERS.—Twin trimmers on ceramic base, brand new; to clear, **6d.** each; **5/-** doz. Also Bakelite Strip containing 5 Postage Stamp Trimmers, **2/6.**

TUBULAR WIRE-END CONDENSERS, brand new first quality components, 0.0003 mfd., **8d.**; 0.005 mfd **9d.**; 0.01 mfd., **10d.**; 0.1 mfd., **1/-** each.

— FOR CALLERS ONLY —

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MANUFACTURERS PLEASE NOTE!

Special prices quoted for large quantities of the above. Enquiries are invited.

ELECTROLYTIC TUBULAR CONDENSERS, 25 mfd., 12 v.; 25 mfd., 25 v.; 50 mfd., 25 v.; 50 mfd., 12 v., **2/6** each. .5 mfd., 350 v. D.C. working, **2/-** each.

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CHASSIS.—Beautifully finished, highly polished, new cadmium-plated Chassis. Superbly made. 12in. × 8½in. × 3in. Drilled for 5 valves, transformer, etc. **4/-** each. Also heavy gauge metal Chassis, plated as above. 12in. × 5½in. × 2½in., **1/3** each. All drilled for valves, etc.

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PUSH-PULL INPUT TRANSFORMERS, by well-known maker, nickel iron core, in metal case, size 2in. × 1⅝in. × 1½in. high, ratio 6 : 1. Price **6/6.**

OUTPUT TRANSFORMERS, primary 300 ohms D.C., secondary 0.5 ohm D.C., brand new, manufacturer's type, **5/6**; also new chokes, 30 henrys, 150 ohms, **5/-** each.

ELECTRO-MAGNETIC COUNTERS, resistance 500 ohms, from 1-12,999, size 4¼in. × 2in. × 1½in., ex-G.P.O., invaluable for countless purposes, **9/6** each; a smaller type, 1-1,999, size 4¼in. × 1½in. × 1¼in., **5/6.**

RELAYS.—Small relays for operation on 2 v. D.C. with 6-way make and break switches, brand new. **5/-** each.

FLEXIBLE DRIVES, well made, shielded cable drives for remote control, ideal for radiogramophones, approx. 2ft. long; to clear, **4/-** each.

MOVING COIL METERS.—A large selection of Ferranti and other well-known makes are offered to CALLERS ONLY.

MIDGET VOLUME CONTROLS, 5,000 ohms, **3/6** each.

VOLUME CONTROLS.—Without switch, 1 meg., 1½in. spindle; ½ meg., ⅝in. spindle; ¼ meg., 3in. spindle, **4/6** each.

WIREWOUND POTENTIOMETERS.—Without switch, 800 and 2,000 ohms, **3/6** each.

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Wireless World

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32nd YEAR OF PUBLICATION

Proprietors :
ILIFFE & SONS LTD.

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

Editor :
H. F. SMITH.

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

Telephone:
Waterloo 3333 (35 lines).
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PUBLISHED MONTHLY

Price: 1/3

(Publication date 20th of preceding month)

Subscription Rate Home and Abroad 17/- per annum.

AUGUST 1942

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

Wireless World

Radio • Electronics • Electro-Acoustics

Vol. XLVIII. No. 8 AUGUST 1942 Price 1s. 3d.

A British "Austerity" Set ?

Ensuring Continuance of Broadcast Reception

WRITING only a month or two after the outbreak of the present war, we discussed its retarding effect on various branches of wireless development and suggested that, before peace returned, we might be forced to receive the B.B.C. transmissions on apparatus that savoured more of 1922 than of 1939. The time has now come to face that unpleasant possibility squarely.

Broadly speaking, there seems to be two ways of ensuring that the majority of the population may still have facilities for receiving British broadcasting. The first is to devote a sufficient proportion of our wireless productive power to the manufacture of the replacement valves and components necessary to maintain existing receivers. The second is to embark on the large-scale production of a standard receiver of extreme simplicity which will be used to replace existing sets as they go out of commission through breakdown.

Of these alternatives, the policy of providing replacement components is probably the more economical in materials, but more wasteful in everything else, not excluding man-power. The strongest objection that can be urged against it is that the replacement of a defective part calls for a skilled service-man, who in many cases is not available nowadays. Again, the manufacture and distribution of the wide diversity of valves and components needed for the upkeep of old sets is far from being an efficient process. But, while facilities for the maintenance of these old receivers still exist, they should, of course, be used.

The introduction of an ultra-simple and strictly standardised receiver would appear to offer many advantages, in spite of the relatively larger consumption of raw materials involved in such a plan. Given a suitable design, servicing difficulties should be almost non-existent, and any troubles that might develop could be put right by almost any intelligent person after a few weeks of well-planned intensive and specialised training. The kind of receiver we have in mind would be designed and manufactured as a united effort of the radio industry as a whole, and production on a scale sufficient to meet the need for replacements of inoperative receivers would account for a very small proportion of our total wireless productive capacity. To ensure maximum economy, the work would probably be distributed among a number of firms, each one making those components for the producton of which they are best fitted. Similarly, assembly of the receivers could be allocated with a view to efficiency of distribution. Of course, both battery and mains models would be needed, but everything possible should be done to avoid a multiplicity of types.

Limitations of Crude Sets

One objection to a relatively crude, unselective and insensitive set is that it may prove inadequate over wide areas of the country so long as broadcasting is carried out on the present system. That, however, does not seem to be an insuperable objection ; it has already been suggested in these columns that the original reasons for adopting our wartime system of broadcasting may no longer apply, and that a change might be made without giving help to the enemy.

The circuit arrangement of a British " austerity " receiver would naturally be chosen after the most careful consideration of all the factors involved. The subject is one on which it is interesting to speculate, but perhaps it may be found that the case is best met by something technically no more exciting than a simple detector—AF combination. But, as we said in 1939, when first discussing the possibility of being compelled to revive out-of-date devices, there is no harm in applying to their improvement the knowledge gained during the intervening years.

TRANSFORMER DISTORTION

Why It Occurs and How to Calculate It

By N. PARTRIDGE,
Ph.D., B.Sc.(Eng.), A.M.I.E.E.

SEVERAL years ago the writer contributed to *Wireless World* a series of articles dealing with harmonic distortion in audio frequency transformers. These articles were based upon an original method of attacking the problem, and, at the time of publication, constituted the most complete and constructive review of the subject then available. But much remained to be done before the suggestions presented could be regarded as a definite contribution to knowledge in the scientific sense.

Therefore a rather ambitious research was set in motion. The original plan was developed, modified and expanded, finally to emerge in the form of a new technique to which academic recognition has been accorded.

Those who may wish to study the development of the new method in detail are referred to a recent Brit.I.R.E. paper,[1] and to a further article shortly to be published in *Wireless Engineer*. Here an attempt will be made to show in simple terms how iron distortion comes about, and to indicate how in practice its magnitude may be calculated.

Current and Voltage Distortion

A transformer does not ordinarily produce harmonic distortion within itself. For example, suppose the primary of a transformer to be directly connected to a low impedance sine-wave source such as the 50 c/s. lighting mains. An oscilloscope will readily show that the wave-form of the voltage appearing across the secondary is exactly the same as that applied to the primary.

Nevertheless, we know that transformers *do* cause harmonic distortion in spite of the above demonstration to the contrary. How ?

Two factors have to be considered. Returning to our experiment, if instead of examining the secondary voltage we examine the current flowing through the primary, as is shown in Fig. 1 (a) an ample degree of distortion will be revealed. But it is important to appreciate that this distortion of the current, by itself, is of no consequence whatever in the circuit of Fig. 1 (a). A sine-wave voltage is applied directly to the primary winding, hence the magnetic flux within the core behaves in such a way as to induce a back EMF of sine wave-form. This being so, it follows that the voltage induced in the secondary winding will also be of sine wave-form. Our present interest is strictly limited to this comparison between the applied primary voltage and the resultant secondary voltage. So long as no distortion occurs between these two points the primary current can adopt whatever wave-form it chooses.

The second factor necessary to produce the phenomenon of voltage distortion has nothing to do with the transformer. It arises from the unhappy fact that audio frequency transformers are not usually connected directly across a low impedance source, but generally have a series impedance between the source of voltage and the primary winding. In the case of an intervalve or output transformer, there is the AC resistance of the associated valve ; in the case of a microphone transformer there is the impedance of the microphone, and so on.

In Fig. 1 (b) a resistance R has been introduced to represent this series impedance. The shape of the current wave-form at once assumes importance. A distorted current will obviously produce a distorted voltage drop across the resistance, and therefore will cause the voltage across the primary of the transformer to be distorted. Thus the distorted primary current and the series resistance conspire to produce voltage distortion on the primary side of the transformer. No further distortion occurs within the transformer between the primary and secondary terminals.

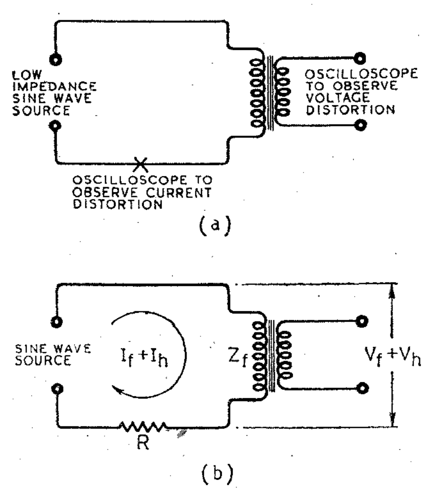

Fig. 1. Circuits employed to show that a series impedance (R) is essential for the production of voltage distortion. A transformer alone does not distort the voltage.

The magnitude of the voltage distortion can be expressed as the ratio of the harmonic voltage across the primary (or secondary) to the fundamental voltage across the primary (or secondary). Let us suppose that in Fig. 1 (b) the impedance of the transformer is Z_f, and let the current through the primary be I_f at the fundamental frequency, plus a harmonic component I_h. The voltage across the primary can be represented by V_f ($= I_f Z_f$) at the fundamental frequency and V_h at the harmonic frequency. The fractional voltage distortion is clearly V_h/V_f.

The harmonic voltage appearing across R will be (by Ohms Law) I_hR. We started with the clear understanding that the source was of pure sine wave-form, and therefore contained no harmonic voltage. Hence the harmonic voltage across R and that across the transformer primary must cancel out. In other words, these two voltages must be equal and opposite. Therefore $V_h = -I_hR$. Also we know that $V_f = I_fZ_f$, and dividing one by the other we find that :—

$$\frac{V_h}{V_f} = -\frac{I_h}{I_f} \cdot \frac{R}{Z_f}$$

Thus we arrive at an expression for the fractional voltage distortion (V_h/V_f) in terms of the current distortion (I_h/I_f), the series resistance (R), and the impedance of the transformer (Z_f).

Variables

Apart from throwing a certain light upon the mechanism of transformer distortion, the equation does not get us very far on account of the elusive nature of the ratio I_h/I_f. This ratio varies with the flux density within the core material, becoming greater the higher the flux density ; also, at any constant flux density it varies with R, becoming zero when R is infinite.

The papers already referred to will show the reader how the problem was solved, and in the present article it is proposed to jump in one leap from the present introductory stage straight

[1] "An Introduction to the Study of Harmonic Distortion in Audio Frequency Transformers;" *Journal of the British Institution of Radio Engineers*, Vol. 3, No. 1, July, 1942.

to the application of the solution in practical cases.

Two formulae have been evolved for the calculation of the total RMS harmonic distortion produced by a transformer. They both arrive at precisely the same result, but each

l is the length of the magnetic circuit in centimetres.

A is the cross sectional area of the magnetic circuit in square centimetres.

f is the frequency being considered in cycles per sec.

(2) It is accurate only providing that the ratio R/Z_f falls between 0 and 1. This restriction is not a serious one. The bass attenuation of a transformer depends upon the ratio of R to Z_f. If R/Z_f exceeds 1 the attenuation will exceed 3 db. Hence another way of

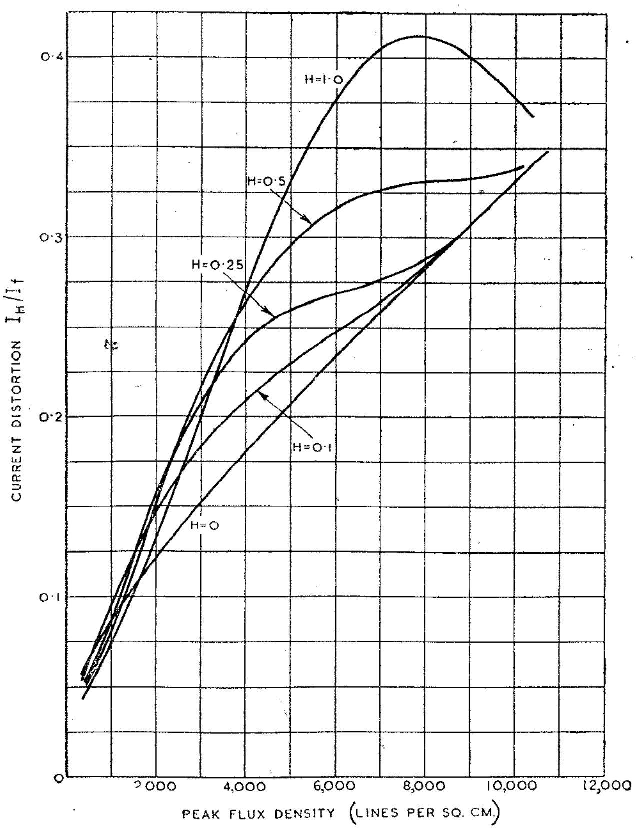

Fig. 2. Values of the factor I_H/I_f for Silcor 2 in the normal cyclic condition (H = O) and in the presence of various polarizing fields (H = 0.1, 0.25, 0.5 and 1.0 gilbert per cm.). The tests were conducted at 50 c/s upon laminations 0.014" thick.

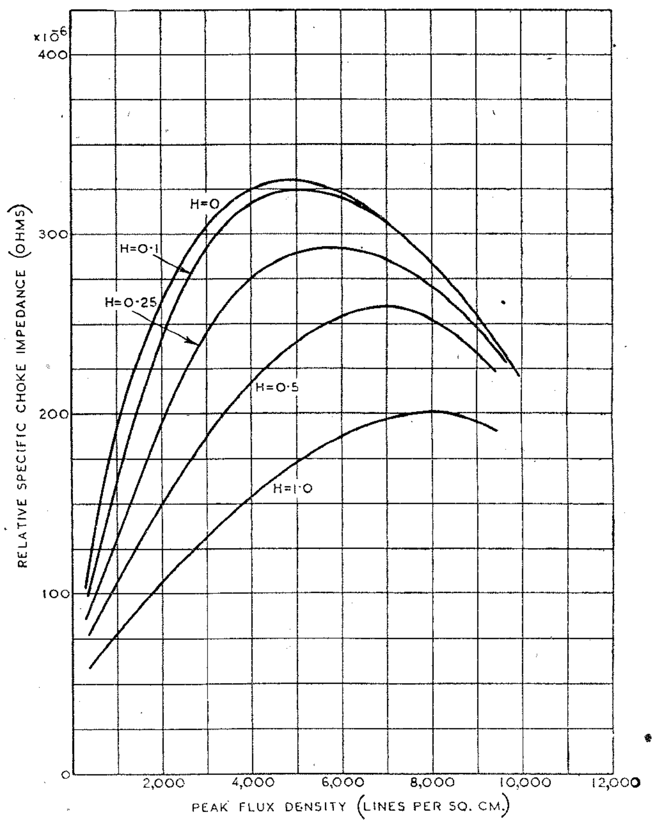

Fig. 3. Values of Z_{sp} relative to the values of I_H/I_f given in Fig. 2, i.e. the present curves were determined under the same conditions of test as those of Fig. 2.

has its own particular sphere of usefulness. We will deal with these one at a time, first stating the formula, then describing the factors appearing therein, and finally illustrating its employment.

$$\frac{V_h}{V_f} = \frac{I_H}{I_f} \cdot \frac{1}{Z_{sp}} \cdot \frac{l}{N^2A} \cdot \frac{R}{f} \left(1 - \frac{R}{4Z_f}\right) \quad (1)$$

I_H/I_f and Z_{sp} are two quantities relating to the core material. Both vary with flux density and measured values obtained from samples of silicon steels in common use are given in Table 1. Table 2 gives further information about the particular silicon steels studied. The effect of a polarising field upon Silcor 2 is indicated in Figs. 2 and 3.

N is the number of turns upon the primary winding of the transformer.

R is the combined resistance of the secondary load transferred to the primary in parallel with the resistance in series with the primary.

Z_f is the impedance of the primary as before.

It will be noted that the data concerning the core material is contained in the first two factors, i.e. I_H/I_f and $1/Z_{sp}$. The third factor (l/N^2A) relates entirely to the physical design of the transformer. The fourth factor (R/f) deals with the conditions in the circuit external to the transformer. The final part of the equation contained within the brackets is an empirical correction factor.

There are three limitations that must be observed when using the formula. (1) It has been proved to be accurate only in the case of the silicon steels.[2]

[2] Preliminary experiments by G. A. V. Sowter, B.Sc., A.M.I.E.E., the authority on the nickel irons and their applications, suggest that the formula holds for these alloys also.

expressing this limitation would be to say that the formula holds good providing the attenuation of the transformer at the considered frequency is not greater than 3 db. (3) The formula is applicable only when R is resistive. Again the restriction is not serious. The AC resistance of a valve or valves usually forms the major component of R, and this is, of course, purely resistive. The secondary load is often substantially resistive in practice, and in any case specifications of performance are usually framed with reference to a purely resistive load.

A little more must be said about I_H/I_f and Z_{sp}. Possibly the easiest way of understanding what these factors signify is to consider how they are measured. Take any stack of laminations of the material to be examined, such that the magnetic circuit is a closed one of constant cross-

Transformer Distortion—
sectional area. Suppose the length of the magnetic circuit to be l_1 cms. and the cross-sectional area A_1 sq. cms. Wind a primary coil of any convenient number of turns, say N_1. Dividing the latter by the former we obtain the value of I_H/I_f.

It should be noted that I_H is not the same as I_h mentioned earlier in connection with Fig. 1 (b). I_h is the I_H/I_f obtained under identical conditions of test. If a sample be tested at a number of different frequencies, the values of I_H/I_f and Z_{sp} so obtained will differ slightly in each case. But

TABLE 1

B_m Lines per sq. cm.	$\frac{I_H}{I_f}$	Z_{sp}	S_H	$\frac{I_H}{I_f}$	Z_{sp}	S_H	$\frac{I_H}{I_f}$	Z_{sp}	S_H	$\frac{I_H}{I_f}$	Z_{sp}	S_H	B_m Lines per sq. cm.
	Silcor 1			Silcor 2			Silcor 3			Silcor 4			
		$\times 10^{-6}$	$\times 10^{-6}$		$\times 10^{-6}$	$\times 10^{-6}$		$\times 10^{-6}$	$\times 10^{-6}$		$\times 10^{-6}$	$\times 10^{-6}$	
45	0.036	80	35.5	0.030	60	39.5	0.020	56	28	0.029	33	69	45
90	0.0385	108	28	0.0365	72	40	0.0285	70	32	0.038	36.5	82	90
180	0.041	130	25	0.0445	89	39.5	0.042	92	36	0.058	54	85	180
360	0.052	173	23.5	0.057	112	40	0.050	112	35	0.066	69	75	360
675	0.065	225	22.5	0.073	155	37	0.065	144	35.5	0.075	96	62	675
1,125	0.080	280	22.5	0.093	200	36.5	0.085	182	37	0.091	123	58	1,125
1,575	0.094	315	23.5	0.111	240	36.5	0.105	220	37.5	0.104	146	56	1,575
2,250	0.115	355	25.5	0.130	275	37	0.122	255	37.5	0.116	172	53	2,250
3,600	0.150	385	30.5	0.170	320	42	0.161	315	40	0.143	215	52	3,600
5,400	0.191	370	40.5	0.220	330	53	0.20	330	47.5	0.173	245	56	5,400
7,200	0.23	320	57	0.265	305	69	0.24	320	59	0.21	240	69	7,200
9,000	0.27	255	84	0.315	260	96	0.28	285	78	0.235	215	86	9,000
10,800	0.305	180	133	0.36	200	142	0.33	230	113	0.27	180	118	10,800

The above figures were deduced from tests at 50 c/s and the sheet thicknesses were as stated in Table 2.

The next requirement is a source of sinusoidal voltage having negligible impedance and capable of adjustment at will. The frequency is not important so long as it is low; let it be f_1 c/s.

The quantities to be measured are variable with flux density. It must therefore be decided at what peak flux density the test is to be performed. Call the chosen peak flux density B_m. Then the voltage to be applied to the winding to produce this flux density is given by the well-known formula

$$V_f = \frac{4.44\, B_m N_1 A_1 f_1}{10^8} \quad .. \quad (2)$$

Having adjusted the source to this voltage the test sample is connected directly across it, as in Fig. 1 (a). By employing an electrical wave analyser in place of the oscilloscope, the current can be measured at the fundamental frequency, giving I_f, and at the harmonic frequencies, giving I_H.

value of the harmonic current when a series resistance (R) is included in the circuit. I_H is the particular value of I_h when R is zero.

Z_{sp} remains to be evaluated. This is given by the formula :—

$$Z_{sp} = \frac{V_f}{I_f} \cdot \frac{l_1}{N_1^2 A_1 f_1}$$
$$= Z_f \cdot \frac{l_1}{N_1^2 A_1 f_1}$$

A little consideration will show that, at low frequencies, multiplying Z_f by $l_1/N_1^2A_1f_1$ gives (very nearly) the impedance at 1 c/s of a choke in which $N = 1$, $A = 1$ and $l = 1$.[3] This follows from the fact that at constant peak flux density the impedance is inversely proportional to l and directly proportional to N^2, A and f (nearly). Z_{sp} has therefore been christened "the relative specific choke impedance," and it is "relative" to the value of

[3] The approximation arises as a result of eddy current effects. For a discussion of this point the reader is referred to the forthcoming article in *Wireless Engineer.*

the product $\frac{I_H}{I_f} \cdot \frac{1}{Z_{sp}}$ will always be constant, hence formula (1) is in no way influenced by these variations in the separate members of the relative pairs of values.

Z_{sp} is a useful quantity to know about. It enables a rapid estimate to be made of the impedance at any low frequency of any choke. For example, let a new choke have the parameters N_2, l_2 and A_2, and let the frequency be f_2. A good idea of its impedance is given by :—

$$Z_f' \simeq Z_{sp} \cdot \frac{N_2^2 A_2 f_2}{l_2} \quad .. \quad (3)$$

A practical example will clear up any obscure points. Suppose a transformer to be made up of No. 56 stampings (M. & E.A. Ltd., see Fig. 5) in Silcor 2, the number of stampings being such that the centre limb has a square cross-section. Let the primary have 4,000 turns wound in two sections of 2,000 turns each. Next let us

TABLE 2

Silicon Steels to which Table 1 refers

Manufactured by Magnetic & Electrical Alloys, Ltd., of Wembley

Trade Name	Silicon Content* (per cent.)	Sheet Thickness (ins.)	Max. Loss $f = 50$, $B_m = 10{,}000$ (watts/kilo)	Specific Resistance	Specific Gravity	Equivalent Material by	
						Sankey	Armco
Silcor 1	4	0.014	1.30	56	7.5	Super Stalloy	Tran-Cor 2
Silcor 2	3½	0.014	1.40	56	7.5	Stalloy	Tran-Cor 1
Silcor 3	2¾	0.018	2.14	41	7.5	42 Quality	Special Elec.
Silcor 4	1	0.018	3.17	18	7.7	Lohys	Armature

* The figures quoted for the silicon content were supplied by Magnetic & Electrical Alloys, Ltd.

imagine that the transformer is to be used in connection with two valves in push-pull, the AC resistance of each valve being 1,500 ohms and the optimum load 3,000 ohms, i.e. 6,000 ohms anode to anode. Assume that the secondary is resistively loaded so that the optimum load for the valves is reflected to the primary, and also that the anode currents of the two valves are exactly balanced. Let us now estimate the attenuation and the harmonic distortion to be expected at 20 c/s when the transformer is delivering (a) 10 watts and (b) 0.1 watt.

First, it is necessary to discover what peak flux densities are involved in the two cases (a) and (b). This can be done in two steps. The voltage across the primary is calculated as follows :—

$$V_f' = \sqrt{\text{Watts} \times \text{load resistance}}$$
$$= \sqrt{10 \times 6{,}000}$$
$$= 245 \text{ volts RMS (case a)}$$
$$V_f'' = \sqrt{0.1 \times 6{,}000}$$
$$= 24.5 \text{ volts RMS (case b).}$$

Re-arranging formula (2) and substituting appropriate values, we find :

$$B_m' = \frac{245 \times 10^8}{4.44 \times 4{,}000 \times 14.5 \times 20}$$
$$= 4{,}750 \text{ lines per sq. cm. (case a).}$$

It will be noted that the area (A) must be in sq. cms. while the dimensions in Fig. 5 are in inches. The area is therefore $(1.5 \times 1.5 \times 2.54^2)$ sq. cms. Case (b) can be treated in exactly the same way, substituting 24.5 volts in place of 245 volts. B_m'' is thus found to be 475 lines per sq. cm.

Formula (3) enables us to calculate the impedance of the transformer. N, A and f are known. l is the mean length of the magnetic circuit (shown dotted in Fig. 2) expressed in cms., and is approximately 22 cms. Z_{sp} is found from Table 1 under the heading of Silcor 2. These figures have been plotted in Fig. 3 (upper curve, H = O), from which can be taken the values at (a) 4,750 lines per sq. cm. and (b) 475 lines per sq. cm. These values are roughly (a) 330×10^{-6} and (b) 120×10^{-6}. Substituting in formula (3) we have :—

$$Z_f' = \frac{330 \times 10^{-6} \times 4{,}000^2 \times 14.5 \times 20}{22}$$
$$= 69{,}500 \text{ ohms approx. (case a)}$$
$$Z_f'' = 25{,}300 \text{ ohms approx. (case b).}$$

The next step is to determine R. Neglecting the resistance of the transformer windings, this will be the resistance of the secondary load transferred to the primary, namely, 6,000 ohms, taken in parallel with the resistance in series with the primary, i.e. $1{,}500 \times 2 = 3{,}000$ ohms. R is therefore 2,000 ohms.

Since Z_f' and Z_f'' are so large by comparison with R, it follows that (a) the attenuation will be negligible, (b) formula (1) can be used with safety since R/Z_f is less than 1, and (c) the factor appearing within the brackets in equation (1) approximates to unity and can be neglected.

It now remains only to substitute the appropriate values in equation (1) and thus to determine the magnitude of the harmonic distortion. All the factors are known with the exception of I_H/I_f. By plotting the figures given in Table 1 (see Fig. 2, H = O)

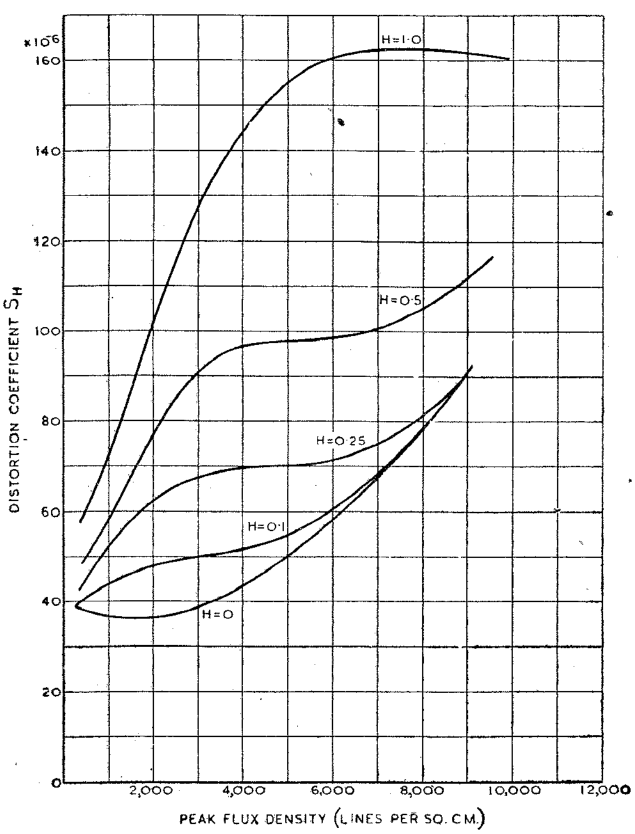

Fig. 4. Values of the distortion coefficient (S_H) for Silcon 2 in the normal and polarized states. These values are independent of the test frequency and lamination thickness.

it will be found that at 4,750 and 475 lines per sq. cm. $I_H/I_f = 0.2$ and 0.06 respectively. By substitution in equation (1) the fractional distortion in case (a) is 0.0057 (or 0.57 per cent.), and in case (b) 0.0047 (or 0.47 per cent.).

The example chosen for illustration happens to be a very favourable one, and it must not be assumed that the distortion is always so desirably small.

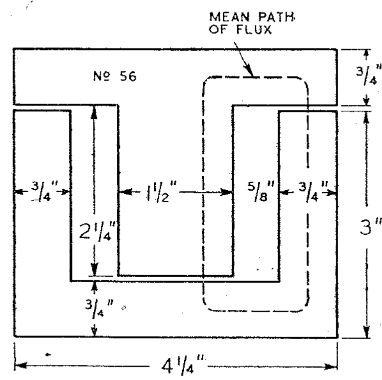

Fig. 5. Dimensions of the M. & E. A. Ltd. stamping No. 56 used in the numerical examples. The mean path of the magnetic flux in one half is indicated by the dotted line.

The second formula for calculating transformer distortion is :—

$$\frac{V_h}{V_f} = S_H \cdot \frac{10^9}{8\pi^2} \cdot \frac{l}{N^2A} \cdot \frac{R}{f}\left(1 - \frac{R}{4Z_f}\right) \quad (4)$$

This is little more than a variation of equation (1) in which $\frac{I_H}{I_f} \cdot \frac{1}{Z_{sp}}$ has been replaced by $S_H \cdot \frac{10^9}{8\pi^2}$. These two products are, in fact, equal. But special interest centres upon S_H, which is defined as the distortion coefficient of a magnetic material. It can be calculated from the data obtained when measuring I_H/I_f and Z_{sp}, and is given by :—

$$S_H = \frac{I_H N}{0.56\, B_m l}$$

It can be shown that this specific quantity is constant for any given material operating at any one value of B_m. It is dependent only upon the shape of the hysteresis loop and is independent of test frequency, lamination thickness, winding data, physical shape or size of the sample tested, etc., always providing the flux density is substantially constant throughout the magnetic circuit and the frequency is below that at which skin effect becomes appreciable.

Values of the distortion coefficient

Transformer Distortion—

(SH) are included in Table I, and the effect of a polarising current upon the coefficient in the case of Silcor 2 is shown in Fig. 4.

By way of illustrating the use of equation (4) we will answer the following question. Referring to the earlier numerical example, what would be the effect upon the distortion if the two anode currents differed by 6 mA. instead of being balanced?

We have already assigned values to N, l, A, R and f, and none of these will be influenced by the polarising field which results from the anode currents being unequal. Neither will the values of the alternating peak flux densities, B_m' and B_m'', be different. But Z_{sp} (which is wanted to calculate Z_f) and SH are both functions of the polarising field. The strength of this field is therefore the first thing to be decided. For a closed magnetic circuit, i.e. non-gapped, this is given by the well-known formula :—

$$H = \frac{0.4\,\pi NI}{l}$$

where N is the effective number of turns traversed by the polarising current I.

In the present instance one half of the primary winding carries 6 mA more than the other half. Therefore the polarising current is 6 mA and the effective turns are 2,000. Hence :—

$$H = \frac{0.4 \times \pi \times 2{,}000 \times 0.006}{22}$$

$$= 0.68 \text{ gilbert per centimetre.}$$

Referring to Fig. 3 and interpolating, it will be seen that the relevant values of Z_{sp} are 210×10^{-6} for case (a) and 70×10^{-6} for case (b). Substituting in equation (3) the values of Z_f are found to be 44,000 ohms and 15,000 ohms, respectively. The polarising field has caused the impedance to fall considerably, but in both cases it still remains very large by comparison with R (2,000 ohms), and therefore the attenuation will not be appreciable and the correction factor to the right of equation (4) can be neglected.

Turning now to Fig. 4 and again interpolating, the relevant values of SH are found to be of the order of 120×10^{-6} and 53×10^{-6}. Finally, substituting in equation (4) the two values of the distortion come out to be 0.0145 (or 1.45 per cent.) and 0.0064 (or 0.64 per cent.). Looking back at the original figures it will be seen that the lack of balance between the anode currents has caused the distortion to increase by no less than 155 per cent. at 10 watts output. In other words, the distortion is about $2\frac{1}{2}$ times as great as before. At 0.1 watt output the ill-effect is less marked, being an increase of only 36 per cent.

A very great deal more could be said about this matter of iron distortion in audio frequency transformers. Almost all preconceived ideas about it are now known to have been fundamentally wrong. But space is precious in a monthly journal and must be fairly divided amongst all interests. Perhaps an opportunity to return to the subject will occur later.

Russian Morse

CIRCUMSTANCES may arise where a knowledge of the morse code as used by our Russian Allies will be of value to British wireless operators. Accordingly we give below the symbols corresponding to the Cyrillic alphabet, which is used throughout the greater part of the U.S.S.R.

RUSSIAN LETTER	ENGLISH PHONETIC EQUIVALENT	MORSE SYMBOL
А	A	· —
Б	B	— · · ·
В	W	· — —
Г	G	— — ·
Д	D	— · ·
Е, Э	E	·
Ж	V	· · · —
З	Z	— — · ·
И	I	· ·
Й	J	· — — —
К	K	— · —
Л	L	· — · ·
М	M	— —
Н	N	— ·
О	O	— — —
П	P	· — — ·
Р	R	· — ·
С	S	· · ·
Т	T	—
У	U	· · —
Ф	F	· · — ·
Х	H	· · · ·
Ц	C	— · — ·
Ч	Öe, ö	— — — ·
Ш	CH	— — — —
Щ	Q	— — · —
Ъ, Ь	X	— · · —
Ы	Y	— · — —
Ю	Ue, ü	· · — —
Я	Ae, ä	· — · —

As will be seen from the table, transliteration from one alphabet to the other presents less difficulty than might be expected, as the morse symbols for each Russian letter are those allotted to the phonetic equivalent letter in the International Code.

Introduction to Valves

IN spite of the fact that the valve is the most important of all modern radio devices most textbooks deal with it as an auxiliary to the circuit in which it is used. In "Introduction to Valves," by F. E. Henderson, A.M.I.E.E., which is expected to be ready some time during the month of August, the normal process is reversed, and the valve comes into the foreground of the picture. As its title implies, the book deals with the subject from the point of view of those who have not previously studied it deeply. The book costs 4s. 6d. (by post 4s. 9d.), and is to be issued by our publishers on behalf of the General Electric Company.

INSTRUMENTS: *Test and Measuring Gear and Its Uses*

By W. H. CAZALY

V.—*Beat Frequency Oscillators*

IN testing the performance of audio amplifiers and receivers it is often necessary to make use of audio-frequency alternating voltage of which the frequency, the magnitude and the wave-form are precisely known. Moreover, it is very often necessary that the first two factors at least should be easily and accurately altered over wide ranges.

For instance, the response of an AF amplifier may be checked by applying a test input voltage and recording the resultant output on an output meter. In such a case the input voltage may need to be less than a volt in magnitude, but that magnitude must be known; the *frequency* of this voltage, however, must be variable from (for a first-class amplifier) about 20 c/s to 12,000 c/s, and in most cases it is very important that it should be of pure sine wave-form. A known voltage of this nature, but of much greater amplitude, may be needed to modulate some test RF carrier signal when measuring the performance of a receiver. There is, again, the testing of a loudspeaker for its efficiency and fidelity in converting electrical into acoustical energy, and for this quite considerable power as well as accurately known frequency and wave-form, may be needed. A little thought will show that a piece of apparatus capable of producing alternating potentials of such widely variable qualities with ease and certainty has to be a fairly complex device.

Sum and Difference Frequencies

Indeed, a good beat frequency oscillator, which is the most commonly used instrument for the purpose, is neither easy nor cheap to construct. Its principles, however, are simple enough. It is well known that if two sine-wave alternating voltages are developed simultaneously across some circuit that will record their resultant effect, that effect will contain not only the two original frequencies but also two more, one equal to the sum of the two originating frequencies and the other equal to their difference. Thus if $f1$ and $f2$ are the two originating frequencies, the mixing of them will give rise to $f3=f1+f2$ and $f4=f1-f2$.

To take some figures: if $f1=100$ kc/s and $f2=115$ kc/s, then the resultant of mixing them will contain also $f3=100+115$ kc/s $=215$ kc/s, and $f4=115-100$ kc/s $=15$ kc/s.

A glance at the circuit diagram shown in Fig. 1 will reveal two triode tuned-anode oscillators, V1 and V2, the frequencies of which are determined by the values of L1, C1,2,3, and L3, C4,5,6, respectively. The outputs of these two oscillators are mixed in a conventional triode-hexode, so that in the anode circuit of that valve there are present the four frequencies, two from the two oscillators, their sum, and their difference. The frequency of the oscillators themselves is approximately 100 kc/s, and the sum frequency is, therefore, approximately 200 kc/s. These three are of comparatively high frequency and are readily filtered out by chokes and by-pass condensers, leaving only the difference frequency, which is within the audible range. This difference frequency is now handled exactly like an ordinary AF input to the grid of V4, which acts as a buffer amplifier, and the signal passes to the output valve V5, and is conveyed to the output terminals through a massive and carefully designed iron-cored transformer.

This is a fairly typical and very commonly used form of circuit for a beat frequency oscillator. Before considering other forms of AF generator, it will be worth while to note a few

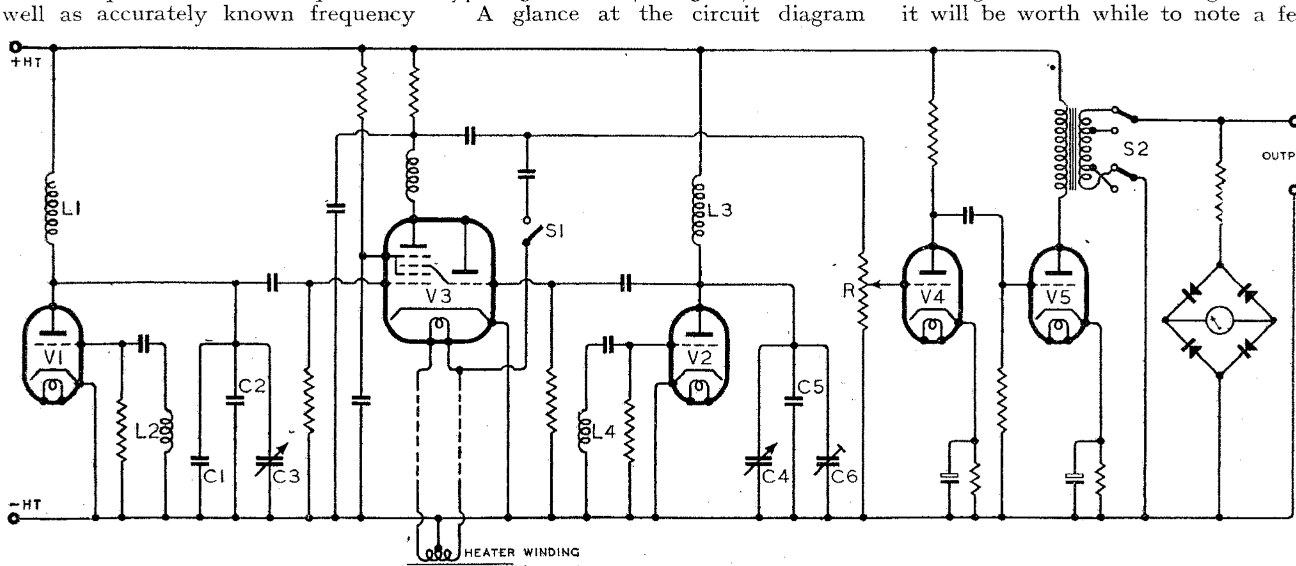

Fig. 1. Basic circuit of a typical beat frequency oscillator. V1 and V2 are tuned anode oscillators. $C3=0.00005\mu F$ (variable), and is used as the "Set Zero" control in adjustments preliminary to use. The output frequency is altered by $C4=0.0005\mu F$. $C6=0.00005\mu F$ and is a pre-set trimmer for scale calibration. $C2=C5=0.001\mu F$; these form the major part of the capacities tuning the circuits.

Instruments—

points about the circuit. In the first place, although it is not shown in the diagram, the screening of the two oscillators from each other has to be very complete. They are usually positioned as far away from each other as is practicable in the instrument and the coils at least are encased in cans. This is to avoid "pulling" between the two oscillators when they are on very nearly the same frequency. Those who have handled a "reaction" receiver close to a powerful transmitter will have noticed, perhaps, that when the receiver is oscillating the resulting whistle caused by the heterodyning of the incoming signal with the oscillation of the reacting valve cannot be brought progressively quite to zero. When it has dropped to a few score cycles per second it stops abruptly and a "dead spot" seems to extend over a degree or two of the tuning dial. This is because the powerful incoming signal is forcing the oscillatory currents in the receiver tuned circuits into resonance with itself. Plainly, when the two frequencies of the incoming signal and of the oscillatory currents in the receiver are exactly the same, there is no difference frequency—that is, no audible sound.

Hexode Mixer

The same sort of thing may happen if the two oscillators in the BFO pull into resonance, through stray coupling, at a common frequency; they produce in the anode of the mixer valve V3 no difference frequency, or a zero beat frequency. This would mean in practice that the BFO, instead of being able to produce alternating output voltage at frequencies covering even the lowest audio extreme (about, perhaps, 30 c/s), would give no output at all below about 100 c/s or so —which would render the BFO useless for quite a number of the more interesting performance tests.

Hence, the two oscillators are most carefully isolated from each other. The use of a triode-hexode mixer aids this—it is a type of valve noted for the small amount of coupling between the triode portion and the control grid circuit even in normal use in superheterodyne reception—and the very fact that the triode portion of this valve is not used save for the triode grid, but the two frequencies are generated by separate oscillators, enables them to be brought to within very small differences from each other before they tend to pull into resonance.

There is also a reason for picking on neither a very high nor a very low frequency for the two oscillators. Considering first what would happen if V1, say, were fixed at 40 kc/s and V2 had to be tuneable to produce difference frequencies covering the whole AF range. It is evident that to do so V2 would have to be tuneable from 40 kc/s to 25 kc/s. It would itself run nearly into the AF range, and an enormous tuning condenser would be required to cover this range of frequency variation. The oscillator frequencies are therefore made high enough to be well outside the AF range and easily tuneable over 15 kc/s, using the almost standard 0.0005 μF type of tuning condenser in conjunction with fixed condensers and trimmers.

Optimum Oscillator Frequency

Now, if we consider what would happen if, instead of about 100 kc/s, we were to use frequencies of the order of megacycles per second, it is found that the capacity changes to cover the 15 kc/s range of difference are so slight that they can be brought about by small alterations of stray capacities due to wiring, changes of valves, warping of the case, etc. So that with two high-frequency oscillators, tuning would certainly be easy, but the order or reliability and constancy would be remarkably low. Moreover, owing to the small percentage of difference between two such high frequencies, pulling between their circuits would become much more difficult to avoid. Hence, 100 kc/s seems to be a good working compromise.

In the diagram, V1 is the fixed oscillator, the trimmer C3 shown being used only for zero adjustments. V2 is tuned over a range from 100 kc/s to 115 kc/s by the 0.0005 μF variable condenser C5, across which there is also a fixed condenser C5, which corresponds to C1 in V1, and it, too, has a trimmer that may be adjusted to compensate for changes in strays. The difference frequency is determined by the setting of the condenser C4, the dial of which is calibrated in cycles per second.

Although the two voltages are combined, in this case, in a triode-hexode, another triode is often used. With careful design, one of the oscillators itself may function also as a mixer.

In the anode of the mixer, by-pass condensers and filters remove the supersonic components present, leaving the difference frequency, which is then fed to the grid of a buffer-amplifier valve stage and treated as an ordinary AF signal. There may be more than one of these stages.

A point worth noting is that connected to the grid of the buffer-amplifier there is not only the output control potential divider, but also a switch S1 that connects this grid at will to one side of the valve heaters. This is done in order that, when setting up the instrument for use, a quick check of accuracy of calibration may be made against the 50 c/s frequency of the AC mains supply that operates the instrument. Normally, "mains hum" is carefully avoided in amplifiers, one of the devices for this purpose being to centre-tap the heater supply windings as shown in Fig. 1 to chassis. However, by connecting the grid of V4 through a condenser to one side of these heater windings, a volt or two at 50 c/s is applied.

Now, if the difference beat frequency supplied from the anode of V3 is itself at 50 c/s, it will be exactly in step with this mains frequency and the pointer of the output meter of the instrument will merely indicate a steady output. But if the generated difference frequency is not exactly 50 c/s, the pointer will slowly rise and fall, and the "Set Zero" condenser (C3) must be adjusted until this wavering motion ceases and the generated and mains voltages applied to the grid of V4 are exactly in step. Admittedly this check can only be applied at the 50 c/s mark on the calibrated dial, or, if harmonics are sufficiently strong in the mains supply, at 100 and 150 c/s; but if the rest of the instrument is in good order, it can usually be assumed that the calibration is correct over the rest of the dial.

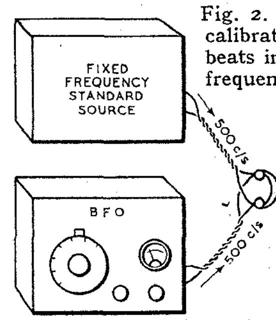

Fig. 2. A method of calibration by audible beats in which a fixed frequency standard and a BFO have their outputs applied simultaneously to a pair of headphones or a loudspeaker.

It will be noted that the only iron in the circuit is in the output transformer, which is usually of massive construction to avoid an approach to saturation, even on high outputs, with consequent distortion and the creation of harmonic frequencies in the output. Provision is shown for only two output impedances obtained by altering the ratio of secondary to primary in the output transformer; but, of course, the design can be adapted to the nature of the work to be done. A rectifier type of AC voltmeter is usually quite accurate enough to indicate the voltage developed across the output terminals.

The calibration of a BFO and of kindred sources of AF may be carried out either by means of comparison with standard fixed generators including tuning forks, or by visual means with a cathode ray oscillograph. Considering the first mentioned, all that is necessary is to combine the standard frequency output acoustically with that of the BFO under test. For instance, at frequencies over 100 c/s (above which the response of headphones is usually sufficient) the arrangement of Fig. 2 will be quite satisfactory. The output of the standard source and that of the BFO will combine as a complex sound output from the phones. The dial of the BFO may now be turned until the BFO output frequency approaches the standard frequency, say, 500 c/s. As coincidence is made closer, the combination of the BFO and the standard outputs will give rise to a beat note or flutter, falling in frequency until finally only a pure 500 c/s tone is heard. In this way, accuracy of the order of a fraction of a cycle per second can be obtained with ease, even at high frequencies of the order of 10 or 12 kc/s. Even with only one standard frequency, the BFO dial may be calibrated by the use of octaves and a good musical ear, with an accuracy quite sufficient for most purposes. If this method of calibration is adopted one should arrange to be at home when the piano-tuner calls!

Good public mains supplies preserve a considerable accuracy of frequency, even if their voltage varies somewhat, and therefore form a very handy standard 50 c/s frequency. With this source at 50 c/s, Lissajous figures obtained on the screen of a cathode ray oscillograph provide a very accurate and easy method of calibrating the dial of a BFO over the whole AF range. The method may be briefly outlined as follows: First, the saw-toothed time base for the "X" sweep is set up at exactly 50 c/s, by applying mains voltage (stepped down by a transformer) to the Y plate and adjusting the time base until a *single* sine-wave trace is obtained. Now the mains voltage is removed from the Y plate and the output of the BFO is applied in its place. The synchronising control should *not* be used to steady the picture; that must be done by exact control of the time base frequency and BFO output.

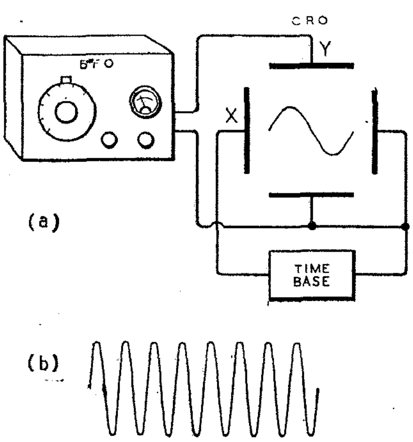

Fig. 3. (a) Shows the picture obtained when the frequency of the time base and the BFO output are the same. (b) Shows the picture obtained when the frequency of the BFO output is increased to 8 times that of the time base. There are 8 complete sine waves.

If the BFO output is now made 25 c/s, an elliptical figure will be obtained on the CRO screen. If desired, the time base can now be adjusted to run more slowly until the sine-wave is regained, showing the time base to be set at 25 c/s. With this time base, the application of BFO outputs at multiples of 25 c/s can be readily obtained by increasing the BFO frequency and noting the necessarily increasing number of sine-waves in the picture, up to some 200 or 250 c/s. Assuming that the last figure has been obtained with 250 c/s applied to the Y plate from the BFO—10 complete sine-waves on the screen—the time base is then adjusted, leaving the BFO dial untouched, to increase its speed until once more only one sine-wave is seen as the picture. The time base is now running at 250 c/s. Multiples of this can be obtained now, as before, by increasing the frequency of the BFO output so that in succession 2, 3, 4, 5, and up to 10 complete sine-waves are seen. This takes the BFO up to 2,500 c/s. The time base can now be again adjusted to regain a single-wave, showing that it is running at 2,500 c/s, and with that as a base, the BFO output can be taken in frequency right up to the limit of the AF band.

Having obtained a calibration point at, say, 1,000 c/s on the BFO dial, it can be used on similar principles to find a very large unmber of intermediate points. With care, this can be made an extremely accurate method of calibrating a frequency source up to radio frequencies, the limit being determined by the maximum speed of the time base and the characteristics of the cathode ray tube.

The uses of a good BFO are so many and varied that it is hard to select a few typical examples. There is, of course, the most obvious use, in checking over an AF amplifier for "frequency response." The arrangement is shown in Fig. 4, the BFO output, maintained at an unvarying level, being applied to the input terminals and the frequency altered to cover the whole AF range desired. The variations in the output of the amplifier as recorded on the output meter are noted and subsequently plotted against frequency. The effects of various speaker loadings can be observed and also the effects of long connecting leads.

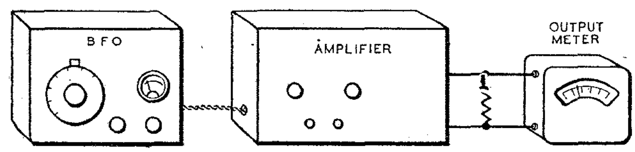

Fig. 4. An arrangement for taking a frequency response curve of an AF amplifier. R is a resistance equal to the normal load offered by the speaker.

With a signal generator it can be used, as was described in a previous article, for making overall acoustic response tests of a receiver, being then in operation as a modulator of variable frequency, or as a means of accurately tuning a RF carrier a few hundred or thousand cycles away from a mid-frequency for bandpass and adjacent channel tests.

The Wireless Industry

A HARD beryllium-copper alloy (Cu.Be.250) has been added to the range of "Telcon" alloys. Its high tensile and fatigue strength make it suitable for electrical spring contacts and it is easily worked in the soft condition. It is available in strip, wire and rod, and particulars are obtainable from The Telegraph Construction and Maintenance Co., Ltd., 22, Old Broad Street, London, E.C.2.

For delicate instrument work the average electric soldering iron is too heavy and clumsy and a special lightweight electric iron has been introduced by Runbaken Electrical Products, 71-73a, Oxford Road, Manchester, 1. It weighs 5oz., has a copper bit $\frac{3}{16}$in. × $\frac{3}{4}$in., and is fitted with radiating fins to keep the handle cool. The heater is rated at 30 watts and is supplied with current at 12 volts through a mains transformer, which is fitted with a pilot light and is available in sizes suitable for 1 to 50 irons.

Wireless World Brains Trust

Problem No. 3

WHAT is the difference between additive and multiplicative mixing? (*Solution on page* 194.)

Improving the DIODE DETECTOR

Design for Negligible Distortion at All Modulation Levels

By GEORGE A. HAY, B.Sc.

THE widespread use of the diode detector in modern receivers is due to its cheapness, low inherent distortion and ability to provide AVC. It is now realised, however, that it can contribute a large amount of distortion if not used correctly. This may be due either to curvature of the valve characteristic or to the arrangement of the diode in the circuit. The former is easily reduced to negligible proportions by working the diode with a sufficiently large carrier input, so that the curved part of the characteristic forms only a small proportion of the total used. Under normal conditions with a detector efficiency of 80 per cent. the total amplitude distortion in the output has been quoted[3] as 2 per cent., which is relatively harmless.

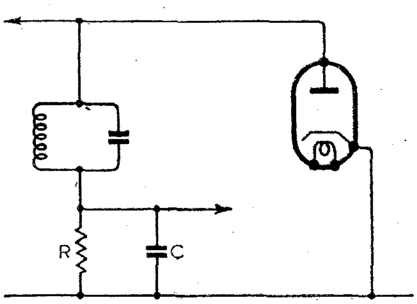

Fig. 1. Diode detector circuit.

Amplitude distortion is by far the more important, and apart from any non-linearity in the valve feeding the diode, is always due to the AC load being unequal to the DC load, causing clipping of the negative peaks at all levels beyond a certain critical modulation depth. The theory of this effect, has been amply treated elsewhere[1, 2, 3, 4], and it is sufficient to say that the maximum modulation depth handled by a diode detector without distortion is equal to the ratio of AC to DC loads. It will be apparent that if the DC load resistance be shunted by other components offering no DC path, the distortion present at 100 per cent. modulation will be greatly increased.[5]

Fig. 1 shows a conventional diode circuit. In this the DC and AC loads are equal for all low and medium modulation frequencies; at high frequencies, however, the AC load becomes less than the DC load because of the shunt reactance of C. This cannot easily be avoided, and is a possible source of amplitude distortion in receivers with a wide frequency response. The maximum modulation depth m is equal to the ratio $\frac{\text{AC load}}{\text{DC load}}$ i.e.

$$m=\frac{\frac{XR}{\sqrt{X^2+R^2}}}{R}=\frac{X}{\sqrt{X^2+R^2}}$$

If $R=0.25\ M\Omega$ and $C=300\mu\mu F$—common values in practice—X will be about $0.1\ M\Omega$ at 5,000 c/s, and m will be 0.37; any distortion will therefore result from the detection of any modulation beyond 37 per cent. Actually results are not quite so bad as this because of the demodulating effect of a diode used in this manner.[6] Evidently the choice of R and C is of some importance, and the deciding factor must be C, as this must be large enough not to reduce substantially the RF input to the diode. A reasonable value is ten times the anode-cathode capacitance of the diode, which, in the case of the Mazda V914, gives a value of $30\mu\mu F$, a value considerably lower than the usually quoted figure. R must now be chosen so that the AC load is nearly equal to the DC load. If we assume a maximum m of 0.9 at 5,000 c/s (i.e. the highest frequency whose second harmonic lies within the reproduced range) we have

$$m=\frac{X}{\sqrt{X^2+R^2}}=0.9 \text{ where } X\simeq 0.5\ M\Omega$$

$$\text{and hence } R=X\frac{\sqrt{1-m^2}}{m}\simeq 0.15\ M\Omega$$

A safe value to adopt will be $0.1\ M\Omega$.

So far we have not considered the connection of the detector to an AF amplifier. Such a connection in the normal way requires the interposition of a blocking condenser with accompanying grid resistance, in order that the DC component of the detector output will not alter the bias on the amplifier. This, however, forms another shunt circuit which reduces the load impedance to AC at all modulation frequencies. There exist several methods of overcoming this, such as operating the diode with positive bias[7], using a complex reactive load[2], or applying negative feed-back[8]. It seems to the writer, however, that the only really satisfactory solution lies in abolishing any reactive shunting, and thus removing the trouble at the source. This is done, of course, in the grid detector when used correctly, as the output of the diode, in this case the grid and cathode of the triode, is applied directly to the grid of the AF amplifier. The DC load is thus shunted only by stray capacitance. The great disadvantage of the grid detector is the fact that the working point of the amplifier depends on the value of the RF input, and thus we may find bottom-bend distortion taking place

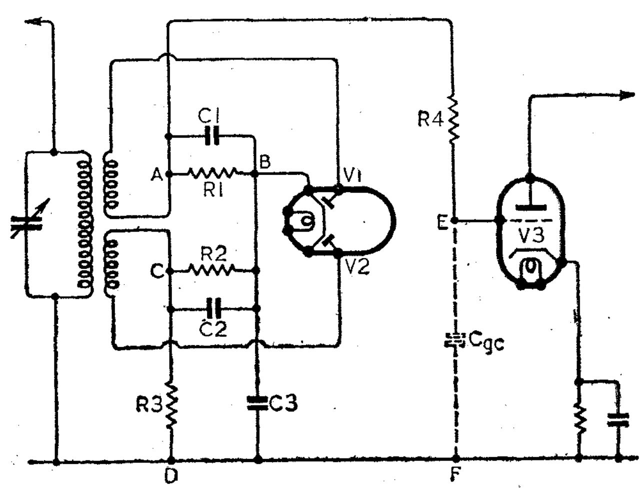

Fig. 2. Compensated diode detector with negligible amplitude distortion: values of components as given in the text.

[1, 2, 3, 4] etc.—These and subsequent references are to the Bibliography at the end of the article.

Even if we fix the value of the input by using an anode current meter and a manually adjusted pre-detector gain control, there still remains the difficulty that the RF input which will

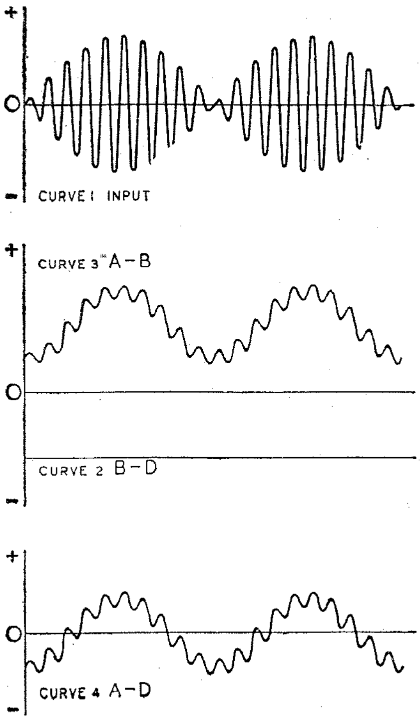

Fig. 3. Graphical illustration of working of Fig. 2.

bias a valve of the small triode class to its correct working point is too small for the avoidance of distortion due to diode curvature. On top of all this is the fact that it is impossible to obtain satisfactory AVC from a grid detector.

If we could connect in series with the detector output a source of direct potential difference which was always equal and opposite to the DC component of the output, the combination could then be connected directly to an AF amplifier without affecting the bias of the latter under any conditions. This has been done in the arrangement shown in Fig. 2. As can be seen, two diodes are used back to back, one, V1, connected normally, and the other, V2, arranged to supply only the DC compenent. The output of the detector proper is connected to the grid of V3 through an RF stopper R4. R1, R2, C1 and C2 may have the values worked out earlier in this article, while R3 and C3 have values of 1 MΩ and 1 μF. Assuming a modulated input, the voltages across A and B, and B and C, will contain DC, RF and AF components, such that A and C are negative with respect to B. R3 and C3 form a filter which removes the AF and RF components from the output across B and C, and hence across B and D we have only the steady DC component, D being negative. The results of this are shown graphically in Fig. 3, curve 1 being the input, curve 2 the potential of B relative to D and curve 3 the potential of A relative to B. Now the output is taken from points A and D, and hence the total output is the algebraic sum of curves 2 and 3, curve 4, which contains *only* AF *and* RF *components*. The latter is removed by R4 acting in conjunction with the input capacitance of V3, leaving only the audio frequency across E and F. It is important to realise that this occurs at any carrier input, and V3, being separately biased, is independent of the RF input for its working conditions. For this reason we can use any value of detector input, making this as large as necessary to reduce distortion due to diode curvature.

The DC and AC loads on V1 are substantially equal for all modulation frequencies, while V2, which we may call the compensator, is only supplying DC to the output, and hence the slight inequality of AC and DC loads does not matter, as it is insufficient to cause any appreciable distortion in the output of the valve feeding the detector.

If AVC is required, the circuit must be rearranged as shown in Fig. 4, when a negative potential is available from point B without further filtering. This circuit is not so good practically, as the double diode requires separate cathodes, and these are isolated from earth, and thus liable to give rise to hum. If the greatest freedom from background is required, it may be found necessary to use separate heater windings for the two diodes. In any case the AF gain will be low, as the RF input is large, and thus any hum will not be amplified greatly.

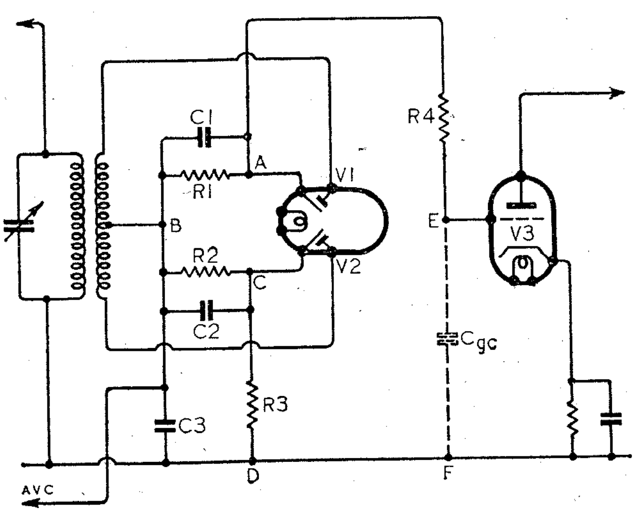

Fig. 4. Modification of Fig. 2 to give non-delayed AVC.

Delayed AVC is impossible with this arrangement, as the two diodes must always be working under identical conditions. This is perhaps just as well, as it has been shown that excessive distortion takes place when the carrier input is equal to the delay voltage.[9] The most promising arrangement appears to be some sort of DC amplified AVC using the positive output from point B in Fig. 2.

The coil design calls for some comment. Best results were obtained when each secondary section was given half the number of turns of the tuned primary. The voltage step-down is therefore 2 : 1, and if we require 5 volts input to each diode the pre-detector amplifier must give 10 volts RMS, which corresponds to about 28 volts peak for a fully modulated signal. This is relatively easy to arrange. The input resistance of each diode is $R/2\eta$ where R is the DC load and η the efficiency. Thus the load imposed by each diode on the secondary is about 50,000 ohms (taking η as unity) which, reflected into the primary, becomes $4 \times 50{,}000$ ohms or 0.2 MΩ. The total load on the tuned circuit is therefore 0.1 MΩ, which is not excessive. It is advisable to construct the coil to be as symmetrical as possible, in order that the stray capacitances and voltage outputs of each secondary should be equal. It may even be an improvement to earth the centre of the tuned primary where circuit arrangements will allow of this.

The circuit shown in Fig. 2 has been in use for some time in a pre-tuned local station receiver, and while critical judgment is difficult under war-time conditions, it is believed that the quality represents a distinct advance on any other detector so far tried.

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UNBIASED

By

FREE GRID

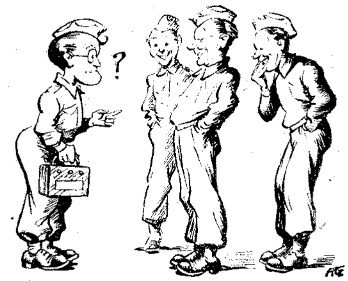
This Mechanisation

WE hear such a lot nowadays about the complete mechanisation of the Army that it leaves us old timers of the last war a little bewildered. When we remember the old days on the parade grounds of 1914 as we formed fours to the bellicose bellowings of the Sergeant-Major, it is hard for us to visualise a modern parade ground with its serried ranks of one-man tanks silently forming threes without any apparent command, for, of course, all orders are transmitted by USW wireless from the Sergeant-Major encased in his master-tank with the crown of his rank upon its tractors. Gone are the days when we were told to put soap or special marching powder in our socks. Nowadays, I suppose, it is some other portion of the anatomy that has to be protected against corns and callouses.

It was with such thoughts in my mind that the other day I gave a few words of fatherly advice to one of the little Grid Leaks on the eve of his departure to join one of these mechanised units. I bade him not to forget to let me have a full budget of news concerning his new life with its mechanised this and mechanised that, and I sternly admonished Mrs. Free Grid for her foolishness in insisting on his taking his all-electric portable, his electric blanket, electric shaver and various other electrical devices with which he had been endeavouring to mechanise himself during the past few weeks in readiness for his new life. As I explained to her, these things would be provided by an all-wise and fully mechanised army.

It was with no little indignation, therefore, that I learned from the first letter we received that such things had certainly *not* been provided, and that when he had blandly enquired at bed-time the whereabouts of the power point for his portable and his electric blanket "a mighty shout of laughter from all the troops arose," as Macaulay records in his graphic description of a war which bears a most astonishing resemblance to the present conflict in its record of unpreparedness and hasty improvisation.

Not only was there no issue of all-wave portables whereby each soldier might keep himself informed of the war's progress by ransacking the world for news, but there were no proper facilities for those who had been enterprising enough to provide their own sets. Electric light there certainly was, but if a set were plugged into a lamp socket it meant doing without the light, and this was frowned upon. The result was that those who did have portables possessed battery-driven ones, thereby wasting the country's supplies of zinc and lead in the construction of HT and LT bat-



"A mighty shout of laughter."

teries. As for the personal receivers by which each soldier will keep in touch with his unit when out on commando amid the lonely passes of the Black Forest, there has so far been no trace of these.

Nearly a "Yorker"

I HAD a distinctly nasty shock the other morning when I received a somewhat peremptory letter headed "*re* suppression," and signed by a man named Morrison. It took several minutes as well as two cups of coffee and cognac for me to realise that the letter was about electrical interference to broadcasting and that, in any case, the writer's name was not Herbert. It only goes to show how fatal it is to jump to conclusions, and reminds me of a secretary I once had, now married and safely out of the way, I am glad to say, who was singularly addicted to this habit of jumping to conclusions. Her crowning act concerned a letter which I had occasion to write to a correspondent rejoicing in the good old Anglo-Saxon name of Ebor. It was no thanks to her that I did not unwittingly commit a breach of good taste, as the terms used in the letter were, to say the least, very unrestrained, and it was only at the last moment that I noticed that she had addressed it to a very august member of the Upper Chamber.

Babel Confounded

ATTEMPTS have been made from time to time to bring into universal use an international language such as Volapük, Esperanto, Ido, Latinesco and basic English. These attempts have been based on the belief that the adoption of a universal language would abolish war, for according to Dr. Zamenoff, who invented Esperanto, it is ignorance of each others' language and therefore the inability to exchange ideas and aspirations which causes quarrels among individuals and, therefore, among nations which are, after all, merely collections of individuals.

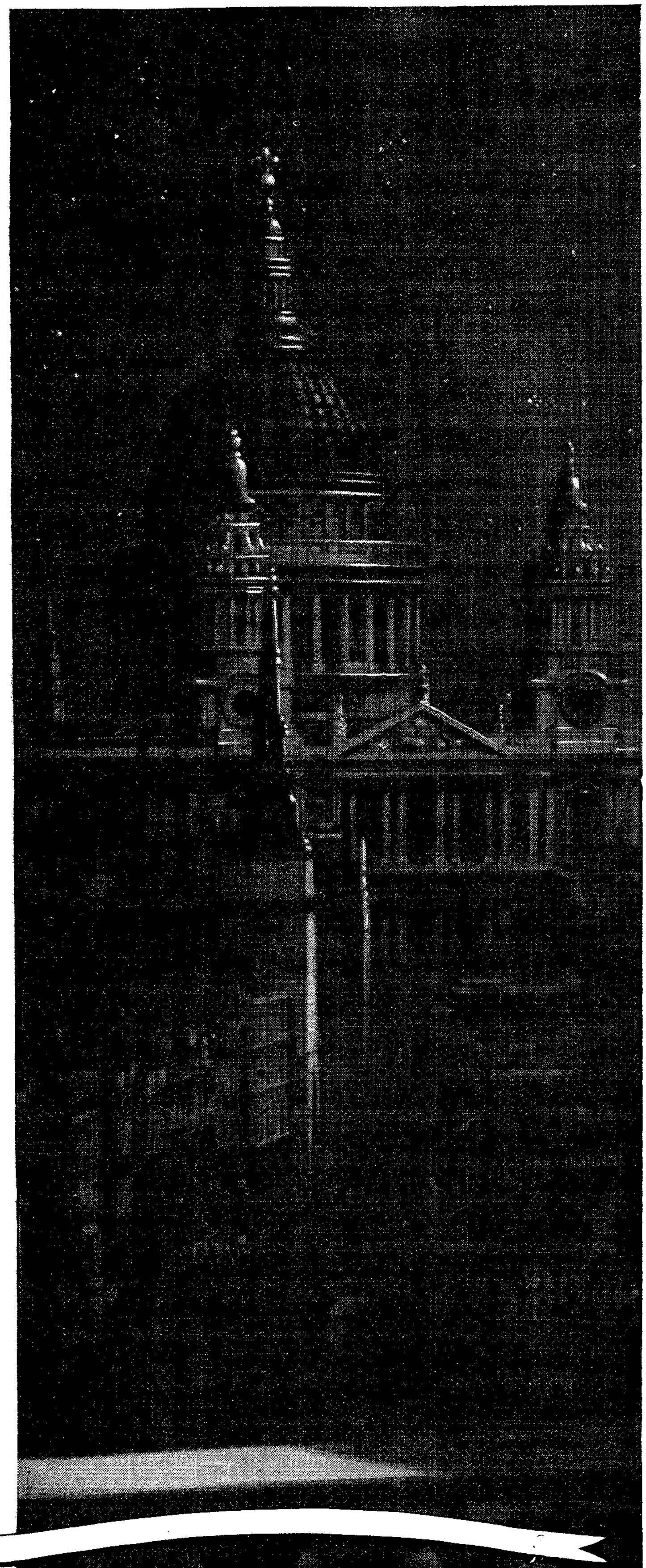
Of course absolutely the opposite is really true, for to quarrel with anybody you must make use of a language which he or she understands, and therefore it follows logically that if we all spoke a different language none of us could quarrel with the other and so all wars would be avoided. I once met with a striking instance of this when motoring in Wales. A native of those parts was walking in the roadway along which my car was coming and it was not altogether inappropriate, therefore, that, like the minstrel boy in the song, he had his harp slung behind him. Naturally I knocked him down, but as neither of us understood the other's language we could not quarrel, but with a polite raising of our hats we passed along on our respective ways.

Despite this I am all in favour of an international language, but to commend itself to me it must be founded on a sound scientific basis, and for this reason I am glad to see the *Wireless World* is tending more and more to follow the example of *Wireless Engineer* and other serious scientific journals in abandoning the use of the King's English in favour of the one international language which is worthy of serious support from men of science. I refer, of course, to mathematics, which, as "Cathode Ray" once told us, is nothing but a sort of shorthand. Thus $\sqrt{}$ is an instruction to do something, and it is understood by men of all nations. It is concise, it is definite and it cannot be twisted from its true meaning by artful luminaries of the law. I am considering the question of writing this page of notes henceforth in mathematics, but I would first like a few comments from the more scientific among you. Postcards only please, and only mathematical symbols to be used.

The stars look down . . .

. . . upon the sleeping villages and towns of England. Over the peaceful scene the moon mounts guard with watchful eye. Yet, at any given moment, should the necessity arise, the quietest country village can be in instant communication with the greatest city; can command its resources and enlist its help. Our products for many years have served in spreading human happiness and in forging links between men, and to-day we still proudly play our part in maintaining human fellowship.

DUBILIER
CONDENSER CO. (1925) LTD.



MORSE METHODS

Notes on Learning the Code and Operating Technique

OF late the morse code has been very much in the news. Some indication of the widespread interest in the subject is given by the fact that sales of the *Wireless World* booklet "Learning Morse" have now passed the quarter-million mark. Even the columns of *The Times* have carried a voluminous correspondence on the learning of the code.

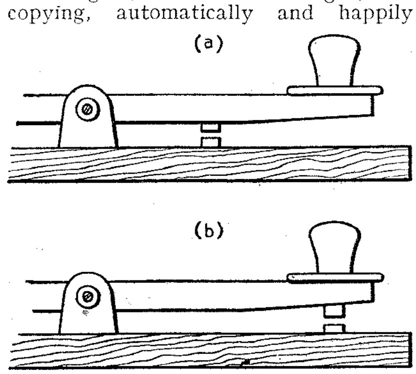
Far too much stress has been laid, both in *The Times* correspondence and elsewhere, on the relatively simple matter of learning the code; that is, of memorising the morse symbols corresponding to each letter and figure. Admittedly, the use of some of the ingenious aids to memory that have been suggested may save a few hours in a process that in any case should not take more than a day or two. But the point is that such aids involve an indirect line of thought that is far too slow even for the slowest reception or transmission of signals. It would hardly be an exaggeration to say that the memorising of morse symbols as such is a waste of time, if not worse. What the would-be wireless operator must memorise are, for reception, rhythmic sounds, and, for transmission, rhythmic wrist movements. Until these are firmly impressed on his subconscious mind, he is a long way from becoming competent.

What seems to be a more direct method, and one that is less wasteful of effort in the early stages of instruction, is described by T. R. McElroy, the American champion telegraphist, in the May *QST*. Writing under the title, "Good Morse is Easier," he claims to have succeeded in getting a class of average beginners, none of whom knew a dot from a dash, to copy simple words at 20 words per minute during their first evening's instruction. This is how he did it, in his own words:

"On the ordinary paper slip, in a Mac Recorder, made with an ordinary hand-key, I made about half a dozen dots spaced very widely apart. Then, after a minute or so, I made a half dozen series of two dots, the two dots being right together as they should be, but much space between each group of two dots. Then, after an interval, three dots, the same way. Then four dots. And then five dots. Then two dots again as originally. On the first night I ran that slip through my Mac Auto at 20 words per minute. A dot ran through, and I announced loudly 'That is a dot. One dot, or dit, is the letter E. Now here it is again; write it down with your pencil. Forget that it is dit—it is E.' And the slip meanwhile, running through at 20 words per minute, had come to the second dot. Each of the 16 persons in the group almost automatically wrote E when they heard it. . . . .

"Then we came to the two-dot group. I said 'Now we'll hear two dits. Listen.' And along came dit dit at 20 words per minute. I said 'That is I. Now here it is again. Write it down with your pencils when you hear it.' And the slip, running all the while, came to the two dots, and again automatically the group wrote I. After doing that a half dozen times, they would recognise I when they heard it. Mind you, they had never heard a dot or a dash before. But at 20 words per minute they automatically slapped down I. Then the letter S in the same way. Then we came to the letter H and the figure 5 in the same way. And then back over it again, excepting that this time I said 'Now, remember this is E,' and a single dot ran through. 'This is I,' and two dots ran through. 'This is S, etc. Now then, friends, here is a word. Write it down just as you did the letters. Don't let it fool you.' And then letter S ran through. All of this at 20 words per minute, you understand, but with a lot of space between the letters. Then the letter I and then the letter S again. 'And now, friends, you've copied the word SIS at 20 words per minute. Isn't it easy?' And by showing them how simple the code is, and how easy to copy at 20 words per minute, they had the job licked before they had hardly started. Then came the word HIS and the word SHE, etc.

"The second lesson, two nights later, I took them to the dash characters, and the third lesson, two nights later, to the combinations. Very easy ones, of course, but words just the same. The entire group, after the first week, or three nights, one hour each night, were copying, automatically and happily, easy words at 20 words per minute, and copying them correctly, too."



Courtesy T. and R. Bulletin

Sketch (exaggerated) to show how the contact gap is dependent on key design.

On the subject of operating technique, B. W. F. Mainprise makes some useful comments in the June *T and R Bulletin* on details that have seldom, if ever, been discussed in print. Writing on the proper tension of the manipulating key spring, he urges that it should be light, maintaining that the function of the spring is merely to prevent the contacts from closing under the weight of the lever; only slight resistance should be offered to downward pressure. This accords with the theory that the thumb and first finger should play an important part in opening the contacts, and that this operation should not be left almost entirely to the spring. Although some experts will maintain that the lightness of spring tension implied is excessive for regular work, it will probably be generally admitted that the use of a very light tension at the early stages of learning helps to encourage correct methods of manipulation, especially wrist action.

The same writer also advocates a wide gap for the key contacts, particularly in the beginner stage. He rightly points out, however, that it is useless to specify the actual gap unless the type of key is specified as well. Referring to the accompanying diagram, both keys are set to the same gap, but the finger rest of (a) will be depressed through twice the distance of (b). Depression is not only a matter of gap width; the dimensions between fulcrum and gap and fulcrum and finger-rest are also factors. Finger-rest depression is what really matters; from 1/16in. to 1/10in. is suggested for beginners.

Technical Progress Abroad

A SOLUTION to the problem of obtaining exact tracking between signal and oscillator circuits of a superheterodyne receiver at three arbitrary frequencies is given in the second part of an article reprinted from the Australian journal *A.W.A. Technical Review* in the July issue of *Wireless Engineer*. Occasional departures from our sister journal's practice of publishing only original matter are being made to assist those unable to obtain journals from abroad.

The translation of foreign papers of special interest and, occasionally, reprints from certain journals printed in English which are not readily available in this country, are, of course, additional to the many pages of each issue which are devoted to abstracts from the world's technical journals.

CONDENSER SMOOTHING

Performance in Conjunction with Rectifier Circuits

By

E. H. W. BANNER,

M.Sc., M.I.E.E., F.Inst.P.

Calculations for smoothing by condensers are given, with examples, although for low-voltage circuits where condensers are cheap the calculations are often neglected. The measurement of voltage on a rectified supply is not quite the simple matter often assumed, and various measurements are detailed. The uses of metal-rectifier units are included

CONDENSERS act as smoothing agents by virtue of their property of tending to prevent a change of voltage when they are connected directly across a circuit carrying unidirectional current, as in Fig. 1, but not when connected in series in an AC circuit as in Fig. 2. It may be noted here that the addition of a second condenser at B in Fig. 2 results in the Villard circuit used for some X-ray apparatus, where the voltage wave-form is sinusoidal.

The voltage curves for a full-wave rectifier circuit are shown in Fig. 3 where the full line *a* is the sine wave

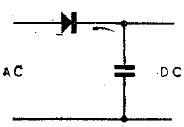


Fig. 1. Half-wave rectifier and condenser smoothing.

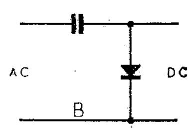


Fig. 2. Parallel rectifier, no smoothing.

for perfect rectification (not obtained in practice). Perfect smoothing maintains the voltage at the peak value for the whole cycle as at *b*. This is the case with almost any value of capacitance on no load, but load tends to discharge the condenser and so produce a falling wave-form as at *c*. Approximate calculations for the capacitance necessary for a given volt drop are as follows. With condenser smoothing the drop in voltage is inversely proportional to the resistance (which itself is inversely proportional to load), the frequency and the capacitance. Then

$$dV, \text{ the drop in voltage} = \frac{V}{2RfC}$$

where

V = load voltage (volts)
R = load resistance (ohms)
f = frequency (cycles per sec.)
C = capacitance (farads).

Alternatively the drop may be expressed in terms of current as $dV = \frac{I}{2fC}$, where I = load current, amperes.

Since $f = \frac{2}{t}$, where t = time of one-half cycle, the second expression may also be shown as $dV = \frac{Vt}{RC}$ and as $I = \frac{V}{R}$ a further expression is $dV = \frac{It}{C}$.

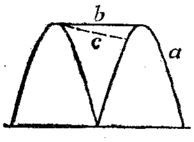


Fig. 3. Full-wave rectification. *a*, *b*, with smoothing on no load; *c*, smoothing on load.

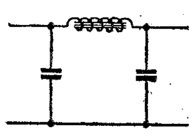


Fig. 4. Inductance and capacitance smoothing.

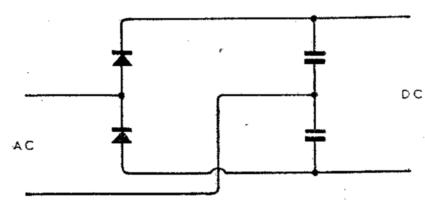


Fig. 5. Greinacher circuit.

Any of these alternative expressions may be used as convenient, with the reservation that they are approximate, the error increasing with the load. The error is partly due to the fact that no rectifier has a perfectly linear characteristic under all conditions.

As an example consider the case of a full-wave rectifier on 50 c/s mains, output voltage 1,000 V, peak; load current 100 mA and drop in voltage per half cycle to be 50 V.

Then $dV = \frac{I}{2fC}$ or $C = \frac{I}{2fdV} = \frac{0.1}{100 \times 50} = 20\ \mu F$.

But if the load current is only 10 mA, then for the same capacitance of condenser dV will be only 1/10, or 5V, or alternatively if dV may be 50V with this load current, then the capacitance may be reduced to 1/10, or 2 μF.

Whilst the calculations are necessary for high voltage circuits where condensers are expensive and a small known ripple immaterial, if the supply is required in a radio output circuit such as a directly heated filament, or for anode voltage in a receiving valve, any ripple becomes audible and objectionable as a mains hum and must be eliminated by further smoothing. Consequently for such low voltage circuits simple values of capacitance such as 2, 4 or 8 μF are generally used after trial.

Inductance smoothing alone is generally less satisfactory, as the inductance usually has appreciable resistance, and this causes a permanent power loss, not found with condenser smoothing. Also the voltage drop increases with load, so that "regulation" or $\frac{V(o.c.) - V(load)}{V(o.c.)}$ is bad, where V (o.c.) is voltage on open circuit and V (load) the voltage on load. A combination of condenser and inductance smoothing is generally the best arrangement, the common case being as in Fig. 4, or with more units similarly connected.

Where a voltage doubling circuit such as the Greinacher in Fig. 5 is used, the wave-form comprises two symmetrical halves about the AC base line as in Fig. 6. In this case let V be the RMS input voltage, then the smoothing will ensure the voltage being maintained at the peak value of the wave, or $\sqrt{2}$ V. But because

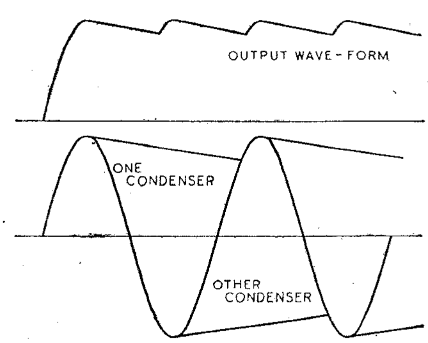


Fig. 6. Wave-forms in the Greinacher circuit.

of the voltage doubling the total line voltage will be $2\sqrt{2}$ V, or about 2.8 times the RMS input voltage. Here there are two condensers in series, each subjected to $\sqrt{2}$ V. The calculation for capacitance should be made by assuming there to be one condenser only, then splitting it into two series condensers each of *double* the capacitance. The condensers will only have to withstand half the total voltage so that the energy involved in both condensers is the same as one for the full voltage. A full analysis of this circuit has been given by the author[1]. Fig. 7 shows a voltage doubling circuit with a common line, very useful for retaining a common earth point if specially required. Here the capacitance of the condenser is calculable as before.

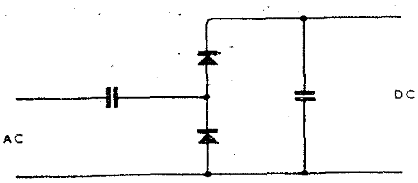


Fig. 7. Voltage doubler with common AC—DC terminal.

From the original expressions for smoothing it will be seen that the frequency is involved. For half-wave rectification the effective frequency is halved and so the condenser voltage drop is approximately doubled. For this reason some circuits, such as radio transmitters, use a frequency higher than 50 c/s. for more economic smoothing. Figs. 8 and 9 show the factors of half- and a full-wave rectifier circuits respectively, and the peak, RMS and mean values are marked. For a fully-smoothed circuit as Fig. 3 *b* all three values will be equal, and will be read on any suitable voltmeter. The half-wave circuit has a lower RMS and mean value for the same peak value and the resulting values of peak factor (peak/RMS) and form factor (RMS/mean) will differ, as follows :

	Half-wave	Full-wave
Peak factor	2	1.414 ($\sqrt{2}$)
Form factor	1.57	1.11

The peak voltage is not shown directly by any voltmeter, but the addition of a rectifier and condenser to an electrostatic voltmeter forms a suitable peak voltmeter[2]. A spark gap will spark over at a voltage proportional to the peak value. The electrostatic, moving iron, thermal and induction types all read RMS voltage, more or less accurately, but the rectifier instrument reads the mean value, although it is calibrated in RMS units, on the assumption of a sine wave-form, which may lead to considerable error.

A recent article[3] shows various rectifier and condenser circuits to which much of the foregoing may be applied. Rectifiers may in all cases be either valves or metal rectifiers, as convenient. Each has merits and demerits. When metal rectifier units are used (4 elements bridge-connected with two AC and two DC terminals) these may be used for many of the circuits by paralleling two sections and using the resulting two elements in series with up to double the load capacity. The bridge rectifier of Fig. 10 may be connected in the circuits of Figs. 5 and 7 by connecting the AC terminals together as a centre point, the two DC terminals forming the outer terminals for the two rectifiers in series.

Finally, it should be noted that where there is no transformer there is a direct electrical connection between the mains and the output side, which is usually to be avoided for low and medium voltages. A double-wound transformer removes most of the shock risk from live output terminals to earth.

[1] *Brit. Journ. Radiology*, 6, 1933, p. 360.
[2] *J. Sci. Instr.*, XI, 7, 1934, p. 218.
[3] *Wireless World*, March, 1942, p. 60.

Book Received

Radio Trouble Shooter's Handbook, by Alfred A. Ghirardi.—This book is essentially one for the serviceman; it contains carefully tabulated data of receivers upon the American market, together with notes concerning clearing faults in them. In this part of the book, over four thousand sets are dealt with. Information is given concerning the suppression of various types of electrical interference most commonly encountered. Special attention is paid to car radio, and full wiring diagrams of the electrical gear are given in a large number of cases. Pp. 710. Published by Radio and Technical Publishing Co., 45, Aston Place, New York, U.S.A. It may be obtained from A. F. Bird, 66, Chandos Street, London, Sherratt and Hughes, 34, Cross Street, Manchester, and Cornish Bros., 39, New Street, Birmingham. Price 3.50 dollars.

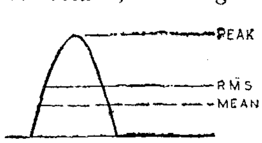


Fig. 8. Half-wave factors.

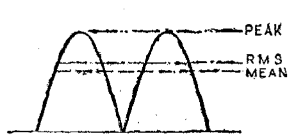


Fig. 9. Full-wave factors.

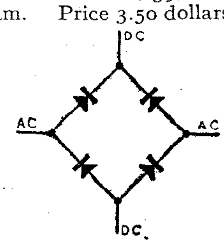


Fig. 10. Bridge rectifier (full-wave).

Letters to the Editor

Pick-up Design : Mass-produced Hearing Aids : Training Operators

Making a Moving Coil Pick-up

I SHOULD like to congratulate Mr. Brierley on the ingenuity of design and excellence of results of his pick-up, as described in the July issue. I have been working on similar lines, and the following remarks may be of interest.

First, I should like to ask Mr. Brierley whether he has tried any experiments to determine the best trailing angle for the needle. I note that he has made his nearly vertical (2 to 3 degrees), and that Mr. Voigt has made a similar recommendation. Most commercial pick-ups have about 30 degrees, and there is presumably some reason for this. So far as the reproduction of the groove waveform is concerned, this angle should be the same as that used in recording, viz., practically vertical. There is, also, however, the problem of ensuring that the point slides smoothly along the groove without chatter. If the case is at all analogous to that of a walking-stick dragged along a rough pavement, then there is no question but that some appreciable trail is necessary, and that the greater it is the better. In the pick-up which I have made the trailing angle is 10 degrees, and satisfactory results have been obtained.

I should also like to ask whether there is any difficulty in changing the needle from the points of view of inserting it the correct distance and of the hole in the celluloid coil former becoming enlarged. What is the order of the needle life obtained?

Mr. Brierley does not mention that to ensure correct tracking the pick-up head must be set on the carrying arm at an angle. I agree that, provided the carrying arm is made fairly rigid, there is little difficulty due to its resonances. Vertical and torsional rigidity are of more importance than the lateral stiffness. I have used a piece of H-section brass curtain rail with a square bar of hardwood screwed along it.

In my experience extreme lightness of arm and head and a spring counterbalance, as opposed to a counterweight, are not essential. The head of my pick-up weighs 105 grams, and the balance weight is nearly 400 grams, yet I have been able to play satisfactorily a markedly warped record with a vertical pressure of only 15 grams (½ oz.). The warp at the outside of this record is 1 mm., peak to trough. For the simplest kind of warp of this magnitude, the maximum vertical accelerating force is 0.45 gm., which is quite negligible in comparison with the steady weight of 15 gms. Eccentricity of the record ("a swinger") has a similar effect.

The counterweight only adds a small fraction of its mass to the effective mass of the head. The fraction is the square of the ratio of the distances of head and balance from the fulcrum. Thus, in the above example the balance only adds effectively some 25 grams to the head mass. The use of a spring instead would only save this amount. Of more importance, in my opinion, is the freedom of movement of the carrying arm in the vertical and horizontal directions. This depends on the workmanship and design of the pivots, on the total load and on the stiffness of the wires used to carry the pick-up output. The horizontal movement is the more difficult to arrange satisfactorily. The use of a spring counterbalance reduces the total vertical load which the bearing has to carry, but only at the expense of a considerable side thrust. The ball bearings fitted on some commercial pick-ups are very poor. After a very little use, they move in a series of small jerks because the races are made of soft metal, and wear very rapidly. Such a bearing is temporarily in use in my pick-up. A force of 4-5 grams at the needle tip is needed to produce horizontal movement. The vertical pressure for proper tracking may, therefore, need to be increased by about this amount.

The vertical pressure required depends on the mechanical impedance of the needle tip to lateral movement. At low frequencies this depends on the stiffness of the suspension and the bass resonance. The latter occurs where the head mass resonates with the suspension stiffness, and the impedance is then greatly increased. It is sufficient to have this resonance as low as 20 c/s. In my pick-up the suspension stiffness is 19 grams per mm. movement of the needle tip. This gives a bass resonance of 21 c/s with a head of 105 grams. A vertical pressure of 15 grams is then adequate at all frequencies on the H.M.V. test records except 25 c/s, where 22 grams is necessary.

This pick-up is of the moving iron type, and the "Silent Stylus" needle is held without any clamping screw. Oil damping in the form of a drop of vaseline is applied to the tip of the armature. The construction is more complicated than Mr. Brierley's model, and the frequency response trails off above 5 kc/s. The voltage output is slightly more than his, but no transformer is necessary. This is, I think, the principal advantage of the moving iron type. The magnet I have used is not nearly so good as his, and I estimate that with redesign an output of between two and three times the present value could be obtained. J. H. MOLE.

Dewsbury, Yorks.

The Editor does not necessarily endorse the opinions of his correspondents

"Hearing Aids for the Million"

THE articles and correspondence columns of your excellent paper have rightly expressed a desire for improved hearing-aids for the deaf.

Your Editorial stresses this and chides my profession for lack of ardour in this matter. May I plead on their behalf that the experts are probably too busy to read anything outside their medical journals.

The cause you are sponsoring is one of the most worthy of attention. There is, in my experience, no affliction of the senses that produces the same moroseness, irritability and generally hopeless outlook on life that deafness engenders in its victims. The deaf patient, unlike, say, the blind, frequently treads a path that becomes increasingly miserable, both to himself and to his immediate social contacts.

As regards the apparatus itself, this should be as nearly perfect as possible for the deaf and often suspicious individual (suspicious of the world as a result of his infirmity) can usually be persuaded to try an expensive piece of apparatus on "sale or return" terms, but will be very disappointed if he cannot hear fairly well at once.

A tone corrector with a great deal of emphasis, at maximum, on the higher frequencies should be included, and this should be manually variable by the patient if space, size and weight considerations permit. Alternatively, the frequency characteristics might be adjusted by the service man.

As regards distribution, the apparatus might be distributed through the National Health Insurance Scheme with some supervision by Ministry of Health doctors in addition to the usual recommendation from the insurance practitioner, and for the remainder of the population a Government subsidy might well pay for itself in the resulting increased efficiency.

As a medical man my point of view is probably my own, but at least I hope I have removed your charge of 100 per cent. indifference on the part of my profession.

ROBERT F. E. HARRINGTON,
M.R.C.S. (Eng.), L.R.C.P. (Lond.)
Rochdale, Lancs.

As a free-lance research worker I am in entire agreement with Mr. R. W. Lowden's views as expressed in the July issue of *Wireless World*.

Deaf-aids cannot be handled by salesmen as an ordinary retail commodity, and it is definitely dangerous to a person suffering from some forms of deafness to attempt to do so.

Not only must the design and operation of an instrument be very accurately understood by the person carrying out tests with a deaf subject, but he must also have a very clear idea and knowledge of the medical side. The human ear, like the eye, is a very delicate and complicated piece of mechanism, and a person showing signs of deafness may easily have what hearing capacity there is destroyed by non-recognition of the factors causing it. It may arise from an acute condition of rheumatoid arthritis in other parts of the anatomy or from an advanced state of catarrh. If a patient has excessive blood pressure it must be known and every precaution taken. A valve aid is liable to do serious injury in a case of this kind, due to the volume irritating the auditory and associated nerves.

In every instance where I am approached regarding a hearing aid I invariably endeavour to first discuss the matter with the medical man in charge of the person concerned. I would strongly recommend that before any attempt is made to mass-produce the equipment, the British Medical Association should be asked to consider the matter.

I would even go so far as to say that no one should be allowed to handle deaf-aids until they have passed some form of examination set by the British Medical Association in collaboration with the Institution of Electrical Engineers.

J. STANLEY JOWITT.
Lytham St. Annes.

THE fears raised by Mr. Lowden in connection with the sale and servicing of hearing-aids by the wireless trade are worthy of consideration.

It is appreciated that the trade at present does not know what is involved, and it is therefore suggested that the policy best suited to the industry is for the companies taking up this matter to appoint only certain dealers in different districts who have the necessary standing and who have agreed to have some training.

It is not essential for an agent to carry any stock, but he should be equipped with what can be termed a predictor. This consists of a small microphone, amplifier and switches, which by easy manipulation can be made to present a number of combinations of different response characteristics required by deaf people. The test would conclusively inform the client what benefit could be obtained from the use of a deaf-aid and an order could be placed for an instrument to give the same performance. I believe that no deaf person would object to paying a small fixed charge for the test.

For maintenance, I suggest an exchange system for defective parts.

C. B.

"Operators in the Making"

I AGREE with all except one of the statements made by "Raw-C.W." in the July issue.

When a learner of telegraphy gets past the morse memorising stage, practice gradually brings up his speed, but it is my experience, having done telegraphy instructional work since 1937, that different speed stages are reached in jumps, i.e., 8's, 10's, 12's, 14's, 16's, 18's, 20's, and so on.

The stale period he mentions—15's—does not require his remedy to counteract it. The only remedy is a rest. This has been proved over and over again in a very practical manner.

At the end of a session of work prior to a holiday, a stale 16's-18's student who could not do 20's, no matter how he strove, found it easy after the holiday period of a week or so. The student returns "fresh" to the job, and sits down to the key, and—there it is.

My remarks above apply to manipulation. Receiving comes more easily.

As a civilian technical instructor to the Air Ministry, I have seen students prior to, and at the beginning of hostilities, driven in some cases nearly frantic, and afraid to touch the key. One particular case had to go into hospital. A rest was the solution.

H. ARMSTRONG.
The North-Eastern School of Wireless, Newcastle-upon-Tyne.

Wireless World

Brains Trust

Solution to Problem No. 3

TO answer your question, it is necessary to go back a little and ask what "mixing" really is. It will then become apparent that you are not so much putting a problem before us as revealing a certain confusion caused by the unscientific use of the terms "additive" and "multiplicative"; it is unfortunately difficult to find the original sinners in this connection.

Fundamentally, mixing for superheterodyne reception is the same as amplitude modulation. In practice, of course, the electrical raw material fed into a mixer consists of two radio frequency waves, whose frequencies f_1 and f_2 differ by a fairly low radio frequency, the "intermediate frequency" (approximately 460 kc/s in modern receivers for domestic use). The modulating stage of a signal generator or transmitter is supplied with an RF wave and an audio-frequency wave.

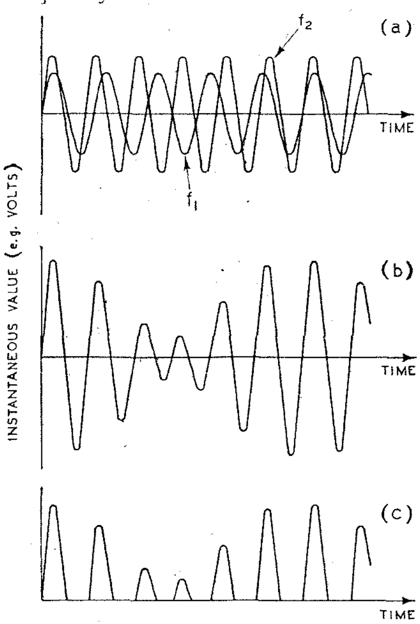


Fig. 1. (a) Two sine waves of frequencies f_1 and f_2 with separate existence. (b) Wave whose value at any instant is the sum of the original waves f_1 and f_2. (c) Result of rectifying wave-forms of either (a) or (b).

Now, consider what happens when two sine waves co-exist. Fig. 1 (*a*) deals with the case where this happens: the two waves are shown as being of different frequencies f_1 and f_2 respectively, and their resultant is

(*See page 185*)

obtained as the sum of the individual values at any instant of time, as shown in Fig. 1 (*b*). It can be shown that the resultant is a wave of frequency $(f_1 + f_2)/2$ and amplitude changing at frequency $f_2 - f_1$, assuming f_2 to be the higher frequency.

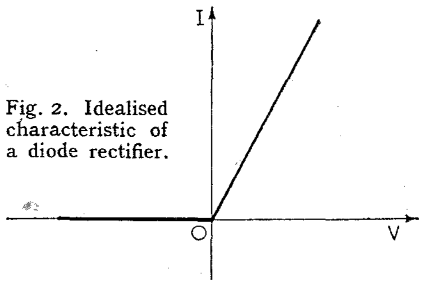


Fig. 2. Idealised characteristic of a diode rectifier.

Where this difference frequency is small compared with f_1, one speaks of "beat motion." Yet whether the resultant could be described as beat motion or not, it would be incorrect to say that it contained a difference frequency component: it is merely the sum of two sine waves, and no matter how much maths. we applied to it, its average value over a few complete cycles of f_1 or f_2 is zero. Physically, a simple check may be obtained with the aid of two audio oscillators (one of which should be variable), a cathode-ray oscilloscope, and a pair of headphones or loudspeakers. On connecting the oscillators to the X-deflector plates and suitably adjusting their frequencies and the time base, a picture of the Fig. 1 (*b*) type will obtain. Connecting the oscillators to the headphones, the observation will depend on the value of $f_2 - f_1$. If the notes radiated from the sound reproducers be 800 c/s and 1,000 c/s respectively, this is exactly what one will hear, barring outside noises; i.e., there will be no 200 c/s note. On making the difference in pitch smaller, i.e., setting the frequencies to 998 and 1,000 c/s respectively, matters would appear to becomes slightly different, for a distinct thud-thud uoise would become noticeable, a vibration of $1{,}000 - 998 = 2$ c/s which appears to be almost independent of the carrying note of $\frac{1{,}000 + 998}{2} = 999$ c/s. Yet there can be but little doubt that the ear is cheating in telling the brain that an independent difference frequency component is present in the last instance, for it is not possible to hear a note below 20 c/s or so in the normal course of events. The hearing expert would call the difference note heard "subjective," and blame either the nervous system or its inadequate discriminating powers or the mechanism of the ear for non-linear behaviour.

The latter point is the key to the whole problem. To obtain genuine—i.e., sinusoidal—components at the "combination" frequencies, such as $(f_2 - f_1)$, $(f_2 + f_1)$, etc., the original waves may be applied to a non-linear device, i.e., an instrument whose output is not directly proportional to the input. This is the simplest type of modulator, and its simplest and perhaps most useful representative is the diode valve: idealised, the characteristic between voltage and current is the "kinked, straight line" characteristic of Fig. 2. Hence, on applying the voltages of Fig. 1 (*a*) to the diode, a current of the wave-form of Fig. 1 (*c*) would result: this may be described as a unidirectional, pulsating current, and contains a DC component and alternating components of frequencies f_1, f_2, $(f_2 - f_1)$, $(f_2 + f_1)$, and

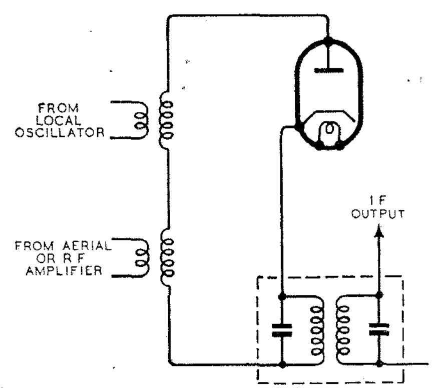


Fig. 3. Circuit of a possible diode mixer stage.

many others of smaller amplitude. These various combination frequencies occur because the output current is proportional to the *product* of the original waves, among other terms.

While a rigid proof of these last statements requires a certain knowledge of trigonometry, the less mathematical reader may convince himself of their truth by inspecting Fig. 1 (*c*): this "rectified" wave is evidently not zero over any significant time interval—its average value clearly varies at the frequencies above mentioned, as may be verified by considering suitable intervals.

In what is usually termed amplitude modulation, the terms f_2, (f_2-f_1), (f_2+f_1) are the carrier and its upper and lower sidebands, and

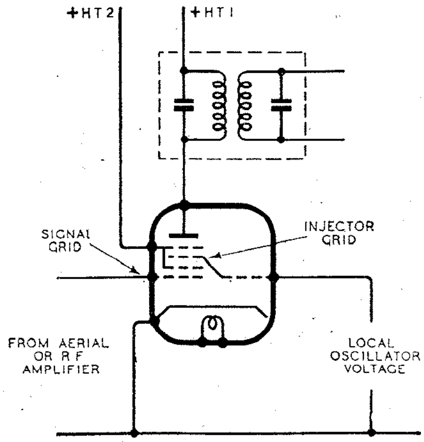


Fig. 4. Schematic diagram of the more efficient hexode mixing stage.

constitute the modulated wave. However, in mixing interest centres on the component (f_2-f_1), while (f_2+f_1) represents the unwanted image frequency.

The diode frequency changer is outlined in Fig. 3, including the tuned transformer for developing the output voltage at IF. While used quite a lot for very high frequency work, it suffers from low conversion gain (defined as the ratio IF output voltage signal-frequency input voltage), and interaction between the signal and local oscillator circuits.

Multi-grid valves are frequently used in the hope of overcoming these difficulties, and their fittest survivor seems to be the hexode or heptode, its glass envelope often containing a separate triode for the local oscillator circuit. Mixing takes place through simultaneous application of the signal at the grid nearest the cathode, and the local oscillator voltage to the third or "injector" grid. The IF transformer is, of course, connected in the anode lead. The important point about this mixer is illustrated by Fig. 5, which shows how the ratio "change in anode current/change in bias of first grid" (the mutual conductance of the first grid relative to the anode), varies with the voltage at the third grid. Hence, with alternating voltages applied to the first and third grids, some of the anode current at least will be proportional to the product "signal volts × oscillator volts," and hence contain the desired IF component.

You will see, therefore, that all types of modulators or mixers depend on "multiplicative" action, inasmuch the generation of combination frequencies requires (at least part) of the output current to be proportional to the original p.d.'s. While inspection of Figs. 3 and 4 might label one mixing circuit as being additive, because the two input p.d.'s are in series between two electrodes (anode and cathode in Fig. 3), this conclusion is rather meaningless, for the difference between various types of mixer systems depends not on their basic action, but on such finer details as interaction between circuits, input impedances, etc., arising from valve

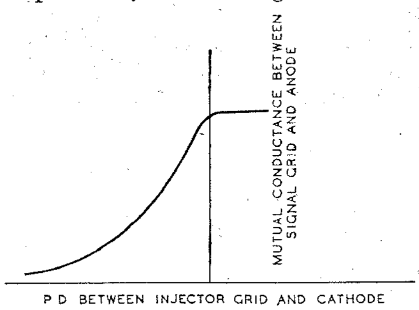


Fig. 5. Indicating the effect of injector grid bias on the mutual conductance from signal grid to anode in a hexode mixer.

structure, as well as circuit design and operating conditions.

These points have been admirably cleared up by E. W. Herold in an excellent descriptive paper entitled, "Frequency Converters for Superheterodyne Reception," appearing in the *Proc. I.R.E.* for February, 1942.

T. J. R.

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

Salvage and Economy

WITH the increasing demands upon the shipping space of the allied nations the need for the salvaging of every scrap of waste paper and rubber becomes greater. It is, however, not only the salvaging of waste paper that is necessary, but the conserving of supplies by economical use. One method of economy is the re-use of envelopes. Statistics, however, show that a large percentage of communications are still enclosed in new envelopes; and we are reminded that care in opening is essential to their re-use.

RANDOM RADIATIONS By "DIALLIST"

Wartime Pruning

THE Americans, I see, have ruthlessly cut down the number of kinds of radio valves that may be manufactured so long as the war lasts. We have done something of the kind, too; and now that this step has been taken on both sides of the Atlantic, is it too much to hope that the two great valve-making industries, our own and that of the U.S.A., will take steps to see that we have no return to a bewildering and unnecessary multiplicity of valve types when peace is with us again? Everyone was agreed, I think, that the pre-war state of affairs was ridiculous. On our own market here were hundreds and hundreds of different types, only a small proportion of which was really needed. The multiplication of types, many with a comparatively small sale, means greatly increased overhead manufacturing costs, and, therefore, high prices all round. It is the nightmare of the wireless shop owner, whose shelves must be packed with a vast number of types.

Too Many Types

The shopkeeper can't very well help himself. Unless he keeps a huge number of types in stock he can't be sure of supplying people readily with what they want. And customers are easily disgruntled if the men behind the counter can't produce what they ask for then and there. One hopes that the bigwigs of the valve industry are already planning a sane, far-sighted policy. There will be a terrific boom in wireless set sales when the war is over, for so many receivers are already long overdue for the scrap-heap or the salvage bin. Set makers would have no difficulty in educating the public up to bigger and better radio receivers if only the bugbear of the excessive cost of valve replacements were removed. And it could be removed were valve manufacturers to come to an agreement to confine their main energies to the production of a limited range of essential types.

Cut Out the Out-of-date

Don't think that I'm trying to suggest a brake on progress. Far from it. New and really useful types will be evolved from time to time, and as they are produced there should be a ruthless pruning of the dead wood. Give set owners a reasonable run for their money in the way of valve replacements, but don't keep obsolete valves in production years and years after they have ceased to be used in new receivers. In any event the pruning suggested wouldn't entail severe hardship, even if out-of-date valves were struck off the list early. Experience of war conditions has taught servicemen to be very clever in adapting existing circuits for valves for which their designers never intended them. And we need more than just cessation of production of obsolete types. We require the early and complete cutting out of the types which have no particularly good reason for existing. At present we have large numbers of, for example, RF pentodes, most of them good, few head and shoulders above the rest in performance, and all differing just a little from each other in their characteristics. For receiving sets two types of RF pentode should suffice. 'Tis much the same story with valves of other classes.

Valve Bases, Too

What I should like to see very much is the adoption of one standard base and one alone for all valves used in receiving sets—everything from diodes to triode-hexodes—and a standard arrangement of the connections. Were the valve industry to announce at the end of the war that as from a certain date no valves would be made with any but one particular base, the thing could be done quite painlessly. When stocks of existing valves with obsolete bases were sold out it would be a matter of small difficulty and small expense to fit new sockets to any receiver that needed re-valving.

Silent Sets

IT is stated that at least one receiving set in ten is out of action nowadays because it has developed a fault and its owner cannot get this put right. From what I see of friends' sets when I go on leave, I should say that this estimate is by no means too high. There are two main reasons for this state of affairs. One is the shortage of skilled servicemen, of whom so many have been called to the Colours; the other is that valves and components for many of the older receiving sets are not now obtainable. Comparatively few of the very old sets that one sees would still be in service in normal times; the need for war saving and the dearth of new receivers have meant that many have been kept in harness long after senile decay had set in. Good servicemen can often contrive to give a decrepit receiver new life even if they can't get the proper parts to replace those that have failed: I've seen one or two ex-superhets working quite happily as "straights." But to do jobs of that kind servicemen must be good—and have the necessary time. Wireless now plays so important a part in national life that the authorities should pause before they call more trained radio men to the Colours. If they don't, the proportion of sets temporarily or permanently out of action is likely to increase rapidly.

Leave Them to It

Actually it's rather surprising to find how very few fellows who were radio servicemen in civil life one comes across, in branches of the Army at any rate, that are concerned with wireless. I've mentioned before the diversity of civil-life occupations that one finds amongst "other ranks" now skilled in radio and electrical matters. One of the best trouble-spotters in complicated apparatus that I know was a waterworks hand, and he is run close by an ex-bookkeeper. Neither of them knew anything about electricity before enlistment or could have done the simplest of jobs on a radio set. Myself, I'd say leave the remaining wireless servicemen where they are in civil life, except where it can be shown that they aren't really needed—and that, I feel, would not occur very often!

An Improvement

IT'S good to notice that the campaign waged by *Wireless World* against the affected and exaggerated pronunciation of foreign personal and place names by our radio announcers is at last beginning to bear fruit. One of them still offends at times, though he's not so bad as he was. The rest do seem to have seen reason, and it was high time that they did. With the war zones now covering such a large part of the world's surface and embracing so many nations, fresh foreign proper names are always cropping up in the news, and it's a poor business if an announcer overlays them with so thick a coating of would-be correct accent that they become entirely incomprehensible to the listener. I still have a liking for the habit of some U.S.A. announcers, who not only pronounce unfamiliar foreign names carefully and distinctly, but also spell them out.

THE WORLD OF WIRELESS

BRITISH AND AMERICAN BROADCASTS

"BRITISH short-wave broadcasting is as superior to American short-wave efforts as American home broadcasting is to its British counterpart."

In this way Wells Church, who is serving in London as American adviser to the B.B.C. for its North American service, summaries his observations of the two countries' short-wave services in an article in our American contemporary *Broadcasting*.

He states that the difference so far as short-wave work is concerned, is "that the B.B.C. thinks internationally and speaks with one voice whereas American short-wave radio speaks with half-a-dozen voices and these in terms, largely, of the holding of a (transmitting) licence."

He urges the need for a plan under which all American short-wave stations will operate as a single voice with a unification of programmes. It is inferred that the primary cause of the ineffectiveness of American international transmissions is an inherent insularity.

VALVE PRICES

THE attention of the British Radio Valve Manufacturers' Association has been drawn to the excessive prices being charged for B.V.A. valves, which prices purport to include carriage and packing. To clarify the Association's policy with regard to valve prices we are asked to state that the B.V.A. prices for valves include carriage and packing. Thus valves reach the consignee free of the expense of carriage or packing.

It is, however, accepted that postage actually incurred by the retailer in forwarding a valve to his customer may be charged, but it will be appreciated that the expenses of such postage can only be from the retailer to his customer.

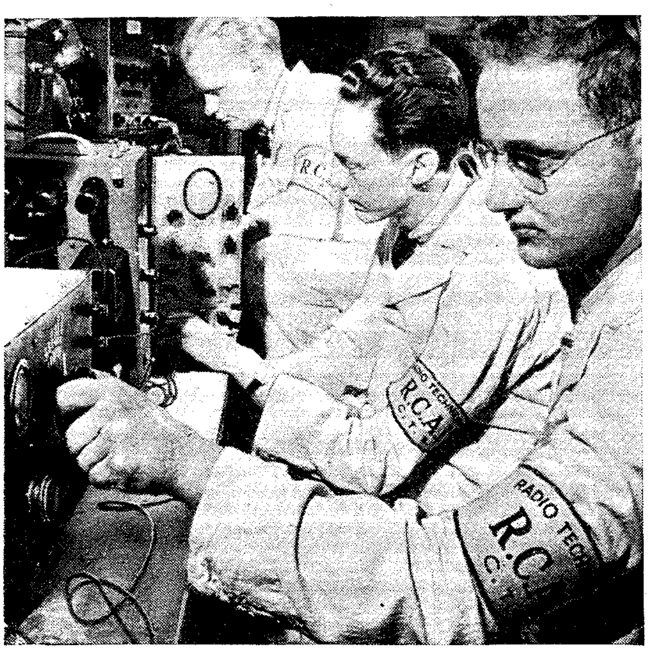
VALVE SHORTAGE

ASKED in the House of Commons whether he was aware that there was no improvement in the supply of wireless valves (chiefly rectifiers) the President of the Board of Trade said that he was well aware of the importance of securing an increase in the supply of valves for civilian receivers. He stated that short of interfering with the needs of the Services everything possible was being done to release valves of British manufacture and to obtain supplies from the United States.

W.R.N.S. WIRELESS MECHANICS

MEMBERS of the Women's Royal Naval Service can now qualify as wireless mechanics at Fleet Air Arm stations. Their job includes the fitting and repair of radio apparatus in aircraft. Incidentally, they test the apparatus during flight. The training period for these girls is from four to six months. They must have had a secondary school education, have attained

(*Continued on next page*)



PRE-ENLISTMENT classes are now arranged by the Royal Canadian Air Force for prospective radio mechanics, who are given a trade test before entering the Force.

The World of Wireless—matriculation standard in mathematics and physics and have a mechanical aptitude.

B.B.C. NEWS

EACH word is now repeated in the B.B.C. morse transmissions of news in English, French and German which are broadcast at 0230, 0300 and 0330 (BDST), respectively, on 261.1 and 49.59 metres.

The news in English broadcast in the overseas services of the B.B.C. is radiated at the following times and on the wavelengths given. The wavelengths used for the two bulletins in the European service at 1000 and 2215 (BDST) are marked with an asterisk.

0045: 31.32, 30.53, 25.68, 25.53.
0300: 31.32, 30.53, 25.68, 25.53.
0445: 31.32, 30.53, 25.68, 25.53.
0630: 40.98, 31.32, 30.53, 25.68, 25.53.
0815: 49.10, 42.46, 31.55, 31.25, 25.53, 19.82, 19.60, 19.49.
1000: 49.59*, 42.46, 41.96*, 41.49*, 31.75*, 31.55, 30.96*, 25.53, 24.92*, 24.80*, 19.82, 19.60, 19.49, 19.42, 16.84.
1300: 25.53, 19.82, 19.49, 19.42, 16.84, 16.77, 13.97.
1500: 25.53, 19.82, 19.49, 19.42, 16.84, 16.77, 13.97,
1800: 31.75, 25.53, 19.82, 19.66, 19.49, 16.84, 16.77.
2000: 31.55, 31.25, 25.53, 19.82, 19.66, 16.77.
2215: 49.59*, 49.10*, 48.43*, 41.96*, 41.49*.
2245: 31.25, 25.68, 25.53, 19.82, 16.77.
2315: 31.32, 31.25, 30.53, 25.68, 25.53, 19.82.
2345 (ex. Sundays): 31.32, 31.25, 30.53, 25.68, 25.53, 19.82.

IN BRIEF

German Television

IT is learned that Germany's television transmissions, which emanate from the station known as "Paul Nipkow," are entirely for the troops. Special theatres are provided with large screens for the reception of the transmissions which, it is believed, are "piped" by low-loss cable from the television studio.

A Westinghouse Promotion

MAJOR L. H. PETER, M.C., A.F.C., M.I.E.E., formerly chief electrical engineer of Westinghouse Brake and Signal Company, has been appointed chief engineer of that company. Major Peter, a one-time chairman of the Radio Manufacturers' Association, is prominent in wireless circles, being specially interested in the training of technicians.

Major L. H. Peter.

N.B.C. International Division

THE appointment of Fred Bate, who has been director of the National Broadcasting Company's staff in Western Europe since 1932, as head of the N.B.C.'s international division is announced from New York. His experience in Europe, where he has been resident for some 30 years, should be of considerable help to him in his onerous task. He opened the N.B.C. London office in 1932, and, it will be remembered, was injured when the office was bombed in 1940.

Polar Diagram Ready Reckoner

AN award by the American Institute of Electrical Engineering is to be given to Carl E. Smith, chief engineer of stations WHK and WCLE, Cleveland, for his paper on "An Electro-mechanical Antenna Pattern Calculator." In this he gives details of the construction and operation of his invention which mechanically calculates the distances at which a transmission is receivable in any given direction.

New WRUL Beam

THE engineers of the powerful American international short-wave station WRUL, operated by the World Wide Broadcasting Foundation in Boston, Mass., have hurriedly completed a new aerial array which completely covers Madagascar, French Equatorial Africa and the North Coast of Africa.

R.T.R.A.

THE address of the Radio and Television Retailers' Association, which is the combined association merging N.A.R.R. and W.R.A., is Avenue Chambers, 4, Vernon Place, Southampton Row, London, W.C.1 (Tel.: Holborn 8075). J. H. S. Smith, who was president of the W.R.A., has been elected chairman and H. A. Curtis, who has been assistant secretary of N.A.R.R. since 1937, is secretary.

Canadian Spare Parts

ALTHOUGH the production of civilian receivers has been discontinued in Canada, it is hoped that there will not be a shortage of replacement parts for some time at least. So far no restriction has been placed on the manufacture of components. The Radio Manuturing Association of Canada has stated that manufacturers of components and valves are working on an understanding

NEWS IN ENGLISH FROM ABROAD

REGULAR SHORT-WAVE TRANSMISSIONS

Country : Station	Mc/s	Metres	Daily Bulletins (BDST)
America			
WNBI (Bound Brook)	11.890	25.23	5.0.
WNBI	17.780	16.87	3.0†, 3.45‡, 5.0§‡, 7.0.
WRCA (Bound Brook)	9.670	31.02	5.0.
WRCA..	15.150	19.80	3.0†, 3.45‡, 5.0§‡, 7.0.
WGEO (Schenectady)	9.530	31.48	10.45 a.m., 10.0†, 11.55§‡.
WGEA (Schenectady)	15.330	19.57	3.0, 4.0, 8.45§‡, 10.55§‡.
WBOS (Hull)	11.870	25.27	1.0, 1.45, 5.0.
WBOS..	15.210	19.72	3.0†, 3.45‡, 5.0§‡, 7.0.
WCAB (Philadelphia)	6.060	49.50	7.0 a.m.
WCBX (Wayne) ..	15.270	19.65	12.30, 4.30, 8.30‡, 10.30.
WCRC (Wayne) ..	11.860	25.30	12.30, 4.30, 8.30‡, 10.30.
WCW (New York) ..	15.870	18.90	
WRUL (Boston) ..	11.790	25.45	12.45 a.m.§‡, 10.30‡.
WRUL..	17.750	16.90	4.0‡, 4.45‡.
WLWO (Cincinnati) ..	6.080	49.34	7.0 a.m., 8.0 a.m.
WLWO	11.710	25.62	4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0.
Australia			
VLQ6 (Sydney) ..	9.580	31.32	9.0 a.m.
VLG6 (Melbourne) ..	15.230	19.69	9.0 a.m.

Country : Station	Mc/s	Metres	Daily Bulletins (BDST)
China			
Chungking	9.410	31.88	4.0.
	11.900	25.21	10 a.m., 11.30 a.m., 12.15, 1.30, 2.0, 4.0, 6.0, 9.15.
French Equatorial Africa			
FZI (Brazzaville) ..	11.970	25.06	5.45 a.m., 9.45.
India			
VUD4 (Delhi).. ..	9.590	31.28	10.0 a.m., 2.30, 5.50.
VUD3	11.830	25.36	2.30.
VUD3	15.290	19.62	10.0 a.m.
Sweden			
SBU (Motala) ..	9.535	31.46	11.20.
Turkey			
TAP (Ankara) ..	9.465	31.70	9.15.
U.S.S.R.			
Moscow ..	6.977	43.01	6.15 a.m., 12.45, 7.0, 8.30, 10.0, 11.0, 11.45.
Moscow	7.770	38.61	6.15 a.m., 11.0, 11.45.
Kuibyshev	10.040	29.88	7.0 a.m., 2.45, 5.30.
Vatican City			
HVJ	5.970	50.25	9.15.

MEDIUM-WAVE TRANSMISSIONS

Ireland	kc/s	Metres	
Radio Eireann ..	565	531	2.40‡, 7.45, 10.0.

It should be noted that the times are Double Summer Time—**two hours** ahead of GMT—and are p.m. unless otherwise stated. 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.

with the Controller of Supplies that they will manufacture a normal quantity of replacements and have undertaken to see that this work does not in any way interfere with their war production.

Canadian Gramophone Records

An Order recently issued by Canada's Wartime Prices and Trade Board limits the manufacture and distribution of gramophone records and all other products containing natural varnish resin.

Receivers in Canada

Canadian manufacturers sold a total of 399,556 receivers in 1941 compared with 438,976 in 1940 and 370,568 in 1939. The number of sets imported by the Dominion was only 4,022, as against 36,062 the year before.

"A Rose by Any Other Name . . ."

With the publication of the July issue of the official journal of the Radio Society of Great Britain the familiar title for the past seventeen years of *T & R Bulletin* gives place to *R.S.G.B. Bulletin*. In future the membership badge of the society will include the initials R.S.G.B. instead of T. & R. (which incidentally stood for "Transmitter and Relay" section).

Trans-Pacific Radio Circuit

The sixth direct radio-telegraph link between the United States and the Far East and the South-western Pacific to be established by R.C.A. Communications since America entered the war was recently opened between San Francisco and Noumea, New Caledonia. The new circuit removes the previous necessity of contacting Noumea *via* Australia.

New Chairman for B.V.A.

The Board of Management of the British Radio Valve Manufacturers' Association has elected J. W. Ridgeway, manager of the radio division of the Edison Swan Electric Co., to be chairman of the Association. Mr. Ridgeway retains the chairmanship of the B.V.A. Committee on Production, which office he has held since its creation. In 1924, Mr. Ridgeway joined Metropolitan Vickers Supplies as a radio engineer. In 1930 he was appointed assistant manager of the radio division of Ediswan into which department the radio sales sections of Metropolitan Vickers and the B.T.H. Companies were merged. He became acting manager in 1941, and was this year promoted to manager.

Obituary

We regret to record the death in America a few months ago of J. C. Wilson, who was formerly with the Baird Company. Mr. Wilson was employed by the Hazeltine Service Corporation, and was the author of "Television Engineering" (1937), one of the first comprehensive textbooks on the subject.

Marconi Instruments

It was revealed by the Chairman of Marconi's Wireless Telegraph Company at the annual meeting recently that the company had purchased the share holding of E. K. Cole, Ltd., in Marconi-Ekco Instruments, which is now known as Marconi Instruments, Limited.

RECENT INVENTIONS

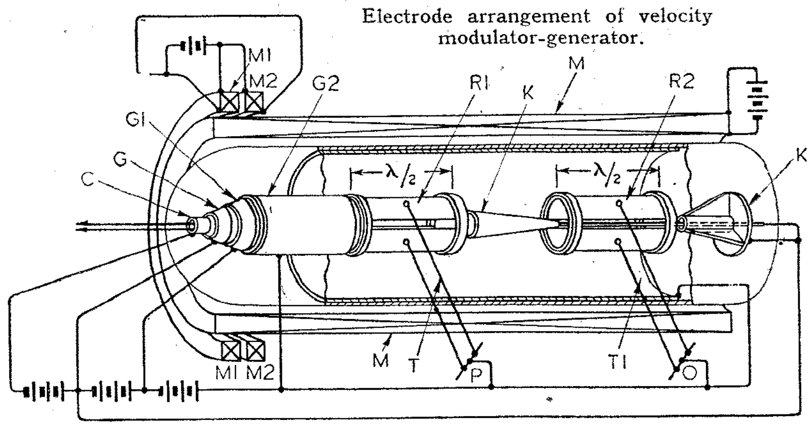
A Selection of the More Interesting Radio Developments

MICRO-WAVE OSCILLATION GENERATORS

THE figure shows the electrode arrangement of a "velocity modulator" for amplifying or generating very high frequencies. The cathode C is followed by two conical control elements and a cylindrical electrode G2, all carrying increasingly positive potentials. These are followed in turn by two "split" half-wave resonators R1, R2, with an intervening conical collector K. At the far end of the tube is a terminal collector K1 consisting of a disc with radial conical vanes. The tube is surrounded by a main magnetising coil M, with two auxiliary coils M1, M2 placed near the gun or cathode.

In the ordinary way the electron stream from the cathode would pass through the tube as a straight beam. The external magnetic field, however, imparts a spiral motion to the electrons so that they "fan out" and enter the electrode G2 as a hollow rotating cylindrical stream. Input current is applied across the two halves of the resonator R1 from P through a transmission line T. If the applied currents are of the same frequency as the periodicity of the rotating stream, some of the electrons will be accelerated and others will be retarded. Certain of the latter will follow a path of diminishing radius and are collected by the conical electrode K. The rest will form a "bunched" stream of varying density, and will deliver power to the resonator R2, which is coupled through a transmission line T1 to the output O. If the latter is back-coupled to P, persistent oscillations will be generated. The residue of the stream is collected at K1, any undesirable secondary emission being trapped between the vanes.

Electrode arrangement of velocity modulator-generator.



Marconi's Wireless Telegraph Co., Ltd. (assignees of I. Wolff). Convention date (U.S.A.) July 21st, 1939. No. 542182.

PRODUCING INTENSE ELECTRON BEAMS

IN certain discharge devices such as the Klystron tube for generating ultra-short waves, it is desirable to produce an electron stream of high density. Difficulty arises in doing so because of the space-charge created by the electrons, which tends not only to disperse, but also to decelerate the individual electrons, and may actually arrest them, so that they form a virtual cathode at a point along the path of the stream.

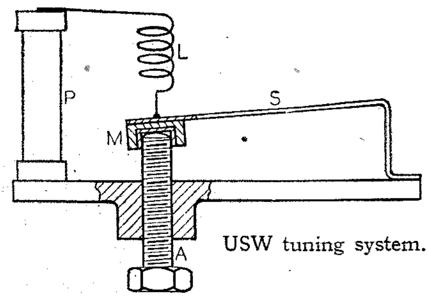
To overcome this tendency, a beam of positive ions is formed at the far end of the pipe and is directed against the stream of electrons towards the cathode. The positive ions are preferably liberated from a heated layer of some barium compound which is surrounded by a focusing "gun." Barium is preferred, if a barium-heated cathode is used, because the barium ions help to replenish wastage from the cathode. Also, any barium ions that are neutralised and deposited on the surface of the tube act as a "getter." Finally, the barium ions tend to neutralise the primary space-charge formed near the cathode, and so allow certain advantageous shapes of cathode to be more easily used. The same applies, of course, to the use of a cæsium-coated surface as the source of the ions when the electron-emitting cathode is of the cæsium type.

Standard Telephones and Cables, Ltd., and H. Motz. Application date July 5th, 1940. No. 542389.

HIGH-FREQUENCY TUNING

FOR very short wavelengths there are certain advantages to be gained by using a tuning coil in which the whole of the wire is constantly kept in circuit, and the effective inductance is varied by changing the spacing between the turns. This is particularly so when it is essential to maintain a uniform band-width.

The figure shows a method of mounting such a coil and of tuning it by varying the spacing between each of the turns uniformly. One end of the coil L is fixed to a pillar P, and the other end is soldered to the upper surface of a blade spring S. The under surface of the same end of the spring is fitted with a cup-shaped member M which bears against the end of a tuning screw A. The inside surface of the cup is preferably fitted



USW tuning system.

with an insulation to avoid the injection of "noise" owing to possible bad contact between the rotating end of the screw and the blade, the latter being electrically connected to the baseplate.

The Mullard Radio Valve Co., Ltd., and C. C. Eaglesfield. Application date August 14th, 1940. No. 542395.

DC VOLTAGE-CONVERTERS

RELATES to circuits for deriving a high-tension voltage from an accumulator or other LT source by using a make-and-break contact to feed a step-up transformer, and rectifying the output from the latter.

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The whole of the secondary coil is thus coupled to the rectifier load during each half-cycle, so that a much smaller coil can be used, as compared with known arrangements in which a centre-tapped secondary is employed for full-wave rectification.

Philco Radio and Television Corpn. (assignees of J. H. Pressley). Convention date (U.S.A.) September 8th, 1939. No. 543032.

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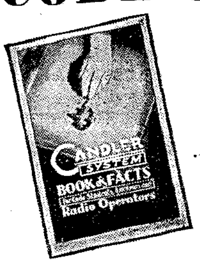

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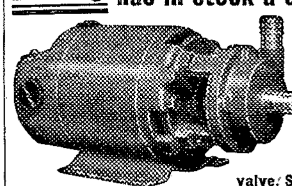

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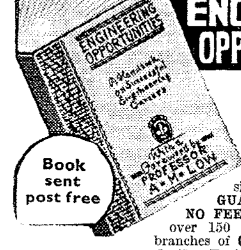

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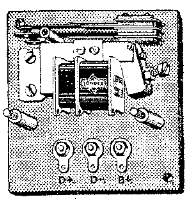

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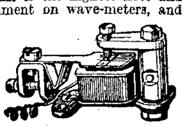

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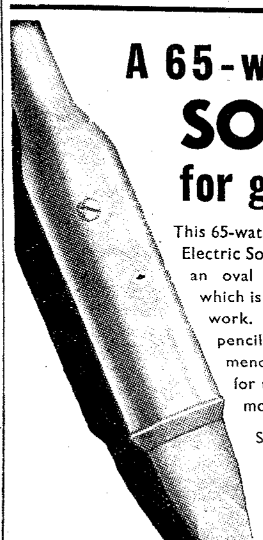

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04E	150–350 m.	3/-		CHASSIS	
04F	255–550 m.	3/-		MOUNTING	
04G	490–1,000 m.	4/-		OCTAL HOLDERS	
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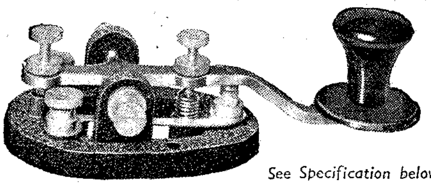

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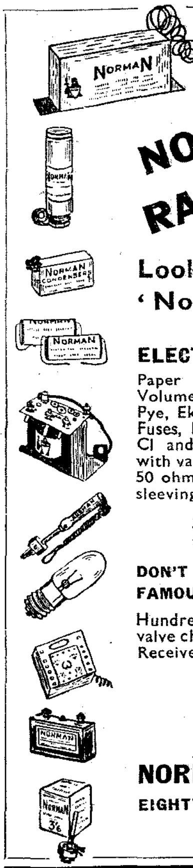

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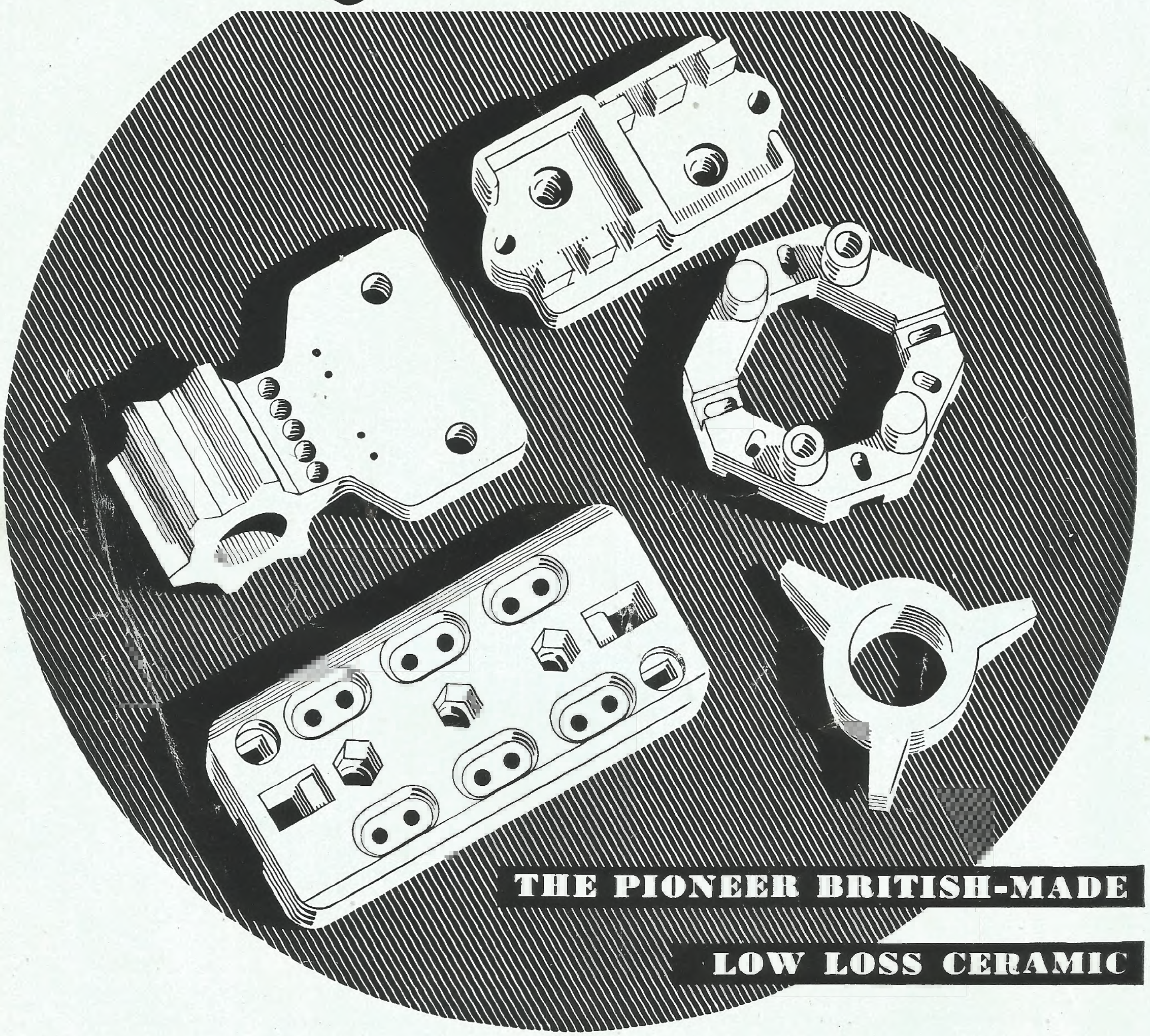

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