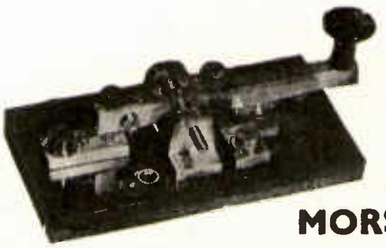
Electronic Engineering

INCORPORATING ELECTRONICS, TELEVISION AND SHORT WAVE WORLD

PRINCIPAL CONTENTS

1/6D JULY 1941

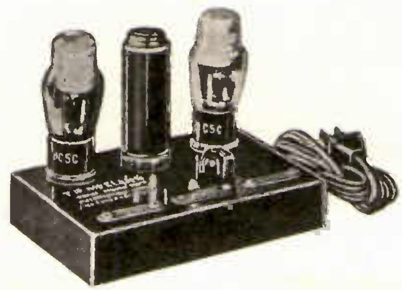
For H.M. Services



There is a great interest in equipment for training operators, particularly for Service requirements. Although supplies are limited, Webb's are making every endeavour to reserve supplies for members of the Forces, Schools, etc. Below are details of some of the lines which can be delivered speedily but numerous other lines are generally available.

MORSE KEYS

Model A. A bar type key of the popular "Post Office" type specially designed for initial training. Finish, nickel-plate on wood base with heavy terminals at 8/-.
Model B. Heavy-duty bar type key as illustrated. Lacquered brass, heavy contacts on polished wood base at 10/6.
Model C. Post Office type bar key with micrometer adjustments capable of withstanding hard work at 17/6.
McElroy Semi-automatic "Bug" key Standard heavy-duty model at 43/-.



AUDIO OSCILLATOR

Audio Oscillator suitable for feeding one to two pairs of headphones complete with line cord for 230-volt A.C. mains giving 1,000 cycle note, complete with valves, 45/-.

HEAVY-DUTY "SCHOOLS" MODEL AUDIO OSCILLATOR, giving outputs to feed 20 or 50 pairs of telephones or alternatively several loudspeakers, is now available at £7 10s. 0d.

McELROY AUTOMATIC TRANSMITTER

This is a machine consisting of photocell, the ray to which is broken by printed tape. The output from the cell is amplified and triggers a sensitive relay, making the instrument capable of keying at any speed from 5 to 50 words per minute. It should be used in conjunction with an audio oscillator as illustrated. Price of Mac Auto complete with one tape (approximately 2,000 words), £9 4s. Tape Puller for feeding the above, £3 17s. 6d.

HEADPHONES

Webb's have available a special lightweight headphone manufactured for training purposes by S. G. Brown solely for Webb's at 17/6 a pair. All other popular headphones are available from stock including the FAMOUS BROWN'S "A" ADJUSTABLE REED at 57/6.

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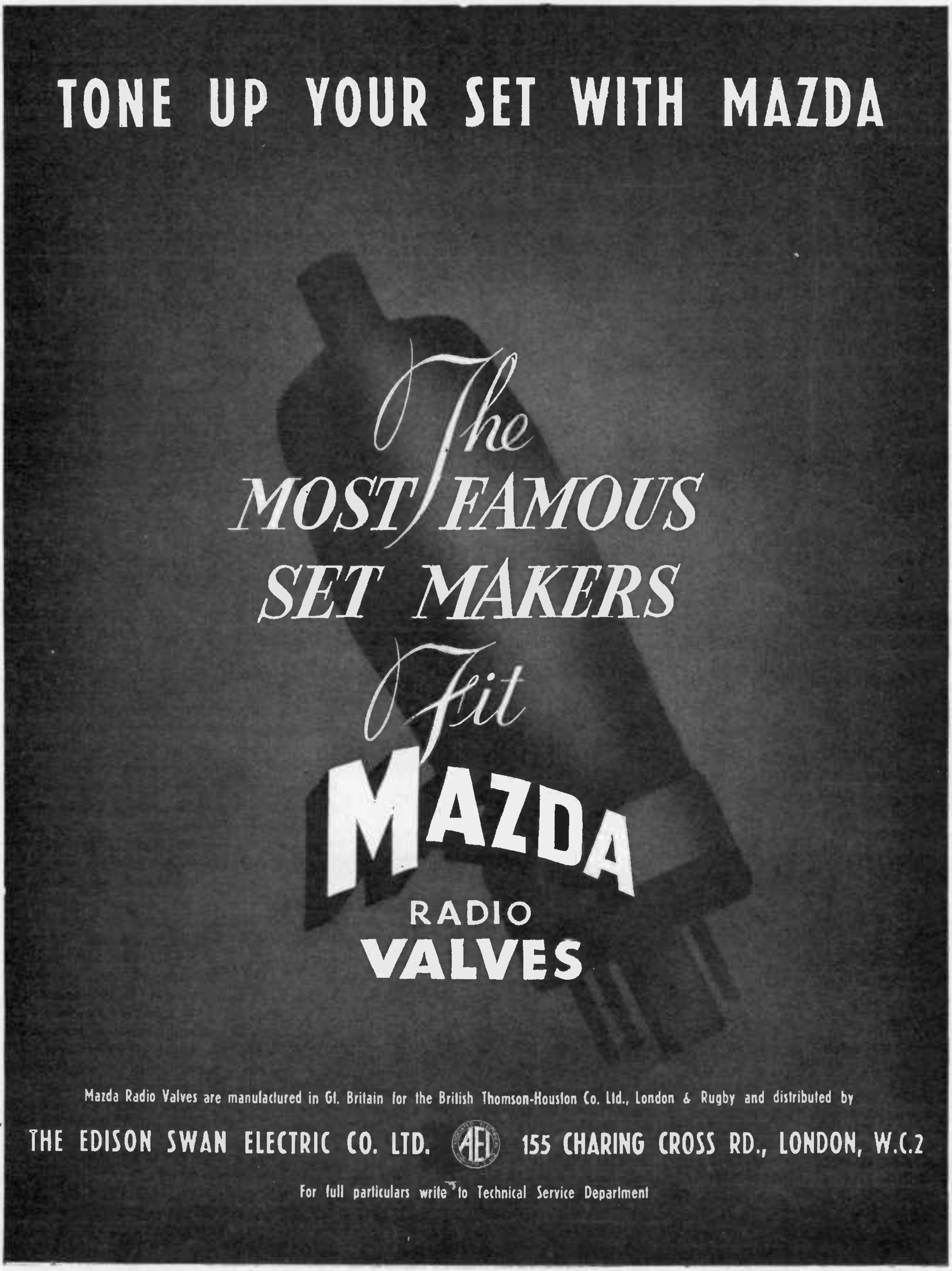
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Electronic Engineering

Radiolocation

A SHORT time ago the "best kept secret of the war" was revealed in the columns of the daily press, and the general public became aware for the first time that something more than acute hearing was employed to detect the approach of aircraft.

Unfortunately, a tendency to make the most of the news item in certain quarters produced such vivid headlines that the public were almost convinced that secret details had really been given away.

They need have no anxiety, as any radio engineer can inform them. The principles on which radiolocation works are well known and a number of references to them have appeared in the technical papers from 1935 onwards.

The credit for the initial experiments in detection by radio has been rightly given to Mr. Watson Watt, whose name is familiar to all workers in electronics. He would be the first to pass on a generous share of the credit to his colleagues of the old days and to the many "back-room" engineers and scientists who have later collaborated so successfully in its development.

The release of this information does, however, serve the purpose of directing attention to the urgent need of skilled radio workers in National Service.

It is one of the drawbacks of complex apparatus (and the modern radio receiver might also come into this category) that a correspondingly high level of intelligence is required to maintain it and obtain consistent results.

The R.M.A. and other responsible bodies in the radio world have for years been advocating a definite standard of competence for the service engineer. and those who have taken their advice are now in a position to render a service to the country. It is not too late for the younger radio enthusiasts or amateurs to help in the work and train as operators or repair mechanics, as the Air Ministry announcement on another page shows.

One thing is certain: the training and experience which so many radio men are obtaining through the war will have the greatest benefit in improving the status of the industry afterwards, provided that the later arrivals do not assume that a year or two's work on Service apparatus will entitle them to a well-paid service job in peace time.

The radio student cannot reasonably expect to receive a thorough training in electrical and radio engineering at the country's expense, and will have to supplement the scope of the training by extra study and reading.

After the last war there was no radio industry, and the problem of re-absorbing hundreds of skilled and semi-skilled workers did not arise. This time, radio, as an established industry, will share the difficulties of post-war reconstruction with the other engineering industries and only those who are thoroughly trained will be able to hold their own in the competition which is bound to occur.

It would be well if those responsible for the training of radio operators to work these new devices pointed this out in order to remove any false impression that students may have that they are being turned into fully-fledged radio engineers in a few months, and to anticipate their disappointment when they are not accepted later as fully qualified professional men.

Contributions

Original contributions to this journal are invited and will receive prompt consideration.

News items should reach the offices not later than the 15th day of the month for inclusion in the succeeding issue.

Manufacturers are invited to submit apparatus and components for review, which will be returned as soon as possible.

Drawings accompanying MS. need not be finished. Curves should be pencilled.

The recommendations of the British Standards Institution for symbols and graphical symbols should be followed as far as possible. Particulars of these can be obtained from the Institution at 28 Victoria Street, S.W.1.

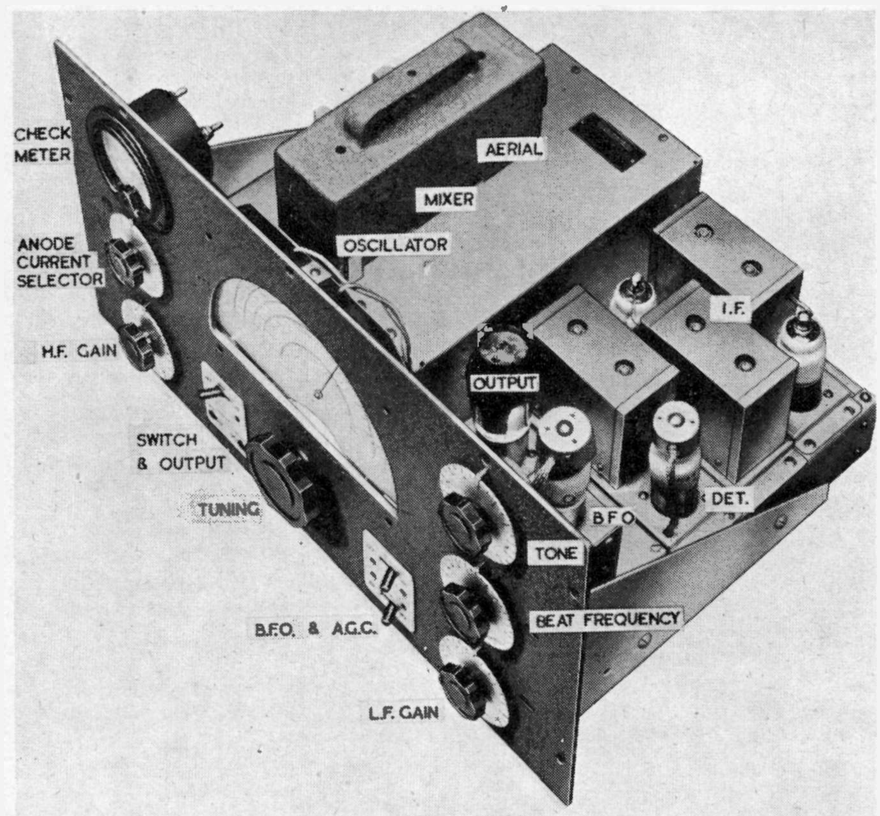
The 'Eddystone' 358

A New Communications Receiver

THE 358 Receiver is specially designed for reception of telegraphy and telephony signals. It has a tuning range of 31,000 kc/sec. to 1,250 kc/sec. by the use of interchangeable plug-in coil units. (Additional units will shortly be available to extend the range to 100 kc/sec.)

The Receiver operates from an input of 6 volts 1.4 amperes, and 175/180 volts 65 milliamperes high tension which is supplied by a separate power unit when operating the set from A.C. Mains.

The aerial input is arranged for a doublet or single wire aerial system. The output circuit incorporates twin jacks for the use of either high or 120 ohm low-impedance type telephones. To simplify maintenance, a meter and test switch is fitted by which the emission of each valve can be checked while in position. The meter when switched in position "V1" will act as a resonant dip tuning indicator.



View of chassis with principal controls and units.

Selectivity. — Adjacent channel: (two kilocycles at 2.5 dB. down). (Five kilocycles at 35 dB. down).

Sensitivity.—Approximately 3 microvolts above 1,500 kilocycles. 8 microvolts for lower frequencies. 30 per cent. modulation for 50 milliwatts output on all ranges.

Audio Output.—1.5 watts.

Intermediate Frequency.—450 kilocycles.

Dial Calibration.—Ranges B.C.D. and E are directly calibrated. Graphs are supplied for other ranges calibrated against 0-100 degree scale. The frequency ranges of the coil units are as follows :—

Range B	9,000—22,000	kilocycles.
C	4,500— 9,000	,,
D	2,100— 4,500	,,
E	1,250— 2,100	,,

Additional ranges are as follows :—

Range A	22,000—31,000	kilocycles.
F	600— 1,250	,,
G	300— 600	,,
H	150— 300	,,
I	90— 150	,,

Cabinet.—Steel, finished in an attractive durable grey crackle, provided with spring loaded lid, and substantial carrying handles. All brass fittings are chromium plated. Dimensions.—20½ in. by 12 in. by 13½ in. deep. The panel is of steel measuring 19 in. by 10½ in. by ⅛" (Standard rack mounting size). Weight of receiver: 50½ lb.

Power Unit.

A separate power unit is provided, built on a cadmium plated steel chassis with steel cover. The finish is grey to match the receiver and the case weighs 16 lb. Dimensions: 6½ in. by 9 in. by 4½ in. deep. The unit will operate on A.C. mains of 200-250 v. 40-60 c.p.s. and supplies 6 v. 1.4 a. A.C. and 175-180 v. 65 mA. The smoothing is effective to allow reception of weak stations on headphones without hum interference.

Loudspeaker.

A separate loudspeaker is supplied in a grey cabinet. This contains a 7 in. cone unit with dust-proof protection, fitted with a dual ratio transformer of 600 ohms (for extension use) and 7,000 ohms for matching the receiver. The handling capacity of the speaker is 3-5 watts and special attention has been given to the middle register response to ensure clear speech.

Dimensions: 9 in. by 9 in. by 4½ in. deep. Weight, 8½ lb.

Operating Data.

The receiver is fitted with flywheel drive tuning control having a ratio of approximately 70:1. Delayed A.G.C. working on three stages can be cut in or out at will. The beat frequency oscillator is variable in frequency and can also be cut off by means of a switch on the front panel. The stages are: R.F., F.C., two I.F., Det. and L.F., Output, B.F.O., employing either octal base Marconi-Osram or Mullard 6.3 volt valves.

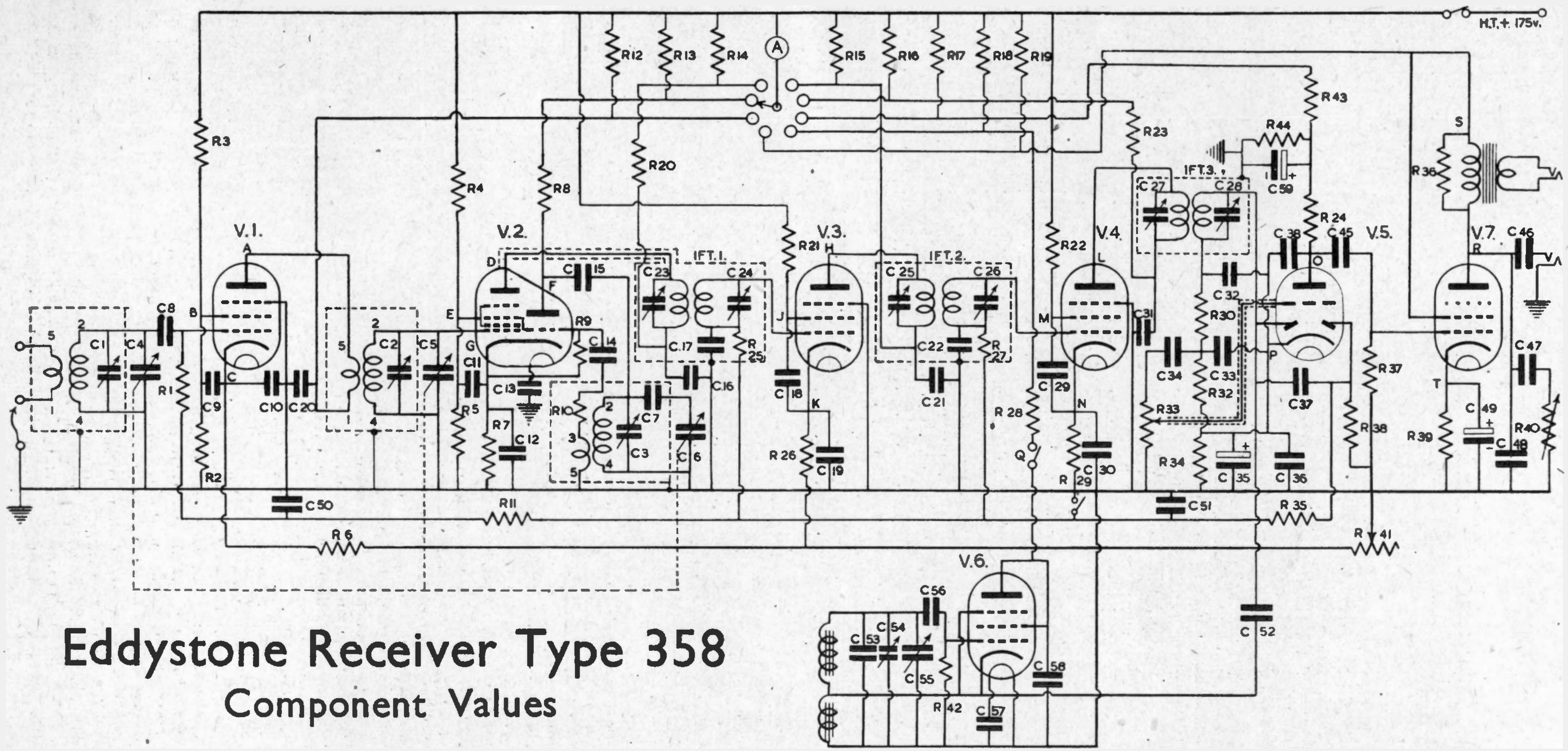
Image Ratio:

At 20 Megacycles	...	33/1
12 ,,	...	100/1
9 ,,	...	210/1
4.5 ,,	...	400/1
3 ,,	...	500/1
2 ,,	...	1,500/1
1.6 ,,	...	8,000/1
1.2 ,,	...	10,000/1

Operation.

Two output impedances are provided on the receiver. Telephones or speaker may be used in either jack, provided their resistances are reasonably close to the values engraved on the plate.

It should be noted that the output jacks of the receiver are engraved 120 ohms and 2,000 ohms. These values actually refer to the D.C. resistance of the telephones likely to be used under the operating conditions. The actual impedance of these two output jacks are 600 ohms and 6,000 ohms for the 120 ohms and 2,000 ohms positions respectively. As a matter of interest the impedance of 120 ohms and 2,000 ohms



Eddystone Receiver Type 358

Component Values

R.1	1 megohm	C.1	
R.2	30,000 ohms	C.2	In Coil Unit.
R.3	20,000 ohms	C.3	
R.4	20,000 ohms		
R.5	30,000 ohms	C.4	
R.6	300 ohms	C.5	3 Gang 271.5 mmfd. per section.
R.7	250 ohms	C.6	
R.8	30,000 ohms		
R.9	30,000 ohms	C.7	In Coil Unit.
R.10	In Coil Unit	C.8	100 pf.
R.11	.1 megohm	C.9	.1 mfd.
R.12	6 ohms	C.10	.1 mfd.
R.13	1,000 ohms	C.11	.1 mfd.
R.14	6 ohms	C.12	.1 mfd.
R.15	1,000 ohms	C.13	500 pf.
R.16	6 ohms	C.14	75 pf.
R.17	1,000 ohms	C.15	75 pf.
R.18	6 ohms	C.16	.1 mfd.
R.19	.33 ohms	C.17	.01 mfd.

R.20	5,000 ohms	C.18	.1 mfd.
R.21	.1 megohm	C.19	.1 mfd.
R.22	.1 megohm	C.20	.01 mfd.
R.23	5,000 ohms	C.21	.1 mfd.
R.24	.1 megohm	C.22	.01 mfd.
R.25	1 megohm		
R.26	1,000 ohms	C.23	
R.27	1 megohm	C.24	
R.28	10,000 ohms	C.25	5 0 mmfd. var.+500 pf.
R.29	500 ohms	C.26	
R.30	50,000 ohms	C.27	
R.31	In Coil Unit	C.28	
R.32	.5 megohms		
R.33	.5 megohms pot.	C.29	.1 mfd.
R.34	1,000 ohms	C.30	.1 mfd.
R.35	.5 megohms	C.31	.1 mfd.
R.36	.25 megohms	C.32	100 pf.
R.37	1 megohm	C.33	100 pf.
R.38	.5 megohms	C.34	.01 mfd.

R.39	200 ohms	C.35	10 mfd. Elect.
R.40	50,000 ohms var.	C.36	.01 mfd.
R.41	10,000 ohms	C.37	100 pf.
R.42	50,000 ohms	C.38	300 pf.
R.43	20,000 ohms	C.39	
R.44	.1 megohm	C.40	In Coil Unit.
		C.41	
		C.42	
C.45	.1 mfd.	C.52	3 pf.
C.46	.5 mfd.	C.53	75 pf.
C.47	.01 mfd.	C.54	15–45 pf.
C.48	.002 mfd.	C.55	7 pf.
C.49	10 mfd. Elect.	C.56	100 pf.
C.50	0.01 mfd.	C.57	.01 mfd.
C.51	.01 mfd.	C.58	.1 mfd.
		C.59	4 mfd. 350 v. wkg. elect.

For values of C1, C7, C39, etc., R10 & R31, (*see text*) telephones at 400 cycles approximates to 600 ohms and 6,000 ohms respectively.

If twin wire feeder from the aerial is used, this is connected one wire to each aerial terminal (marked "A1" and "A2") the earth being joined to the terminal adjacent to these. If a single wire aerial is used the aerial terminal "A2" is joined to the earth terminal together with the earth wire.

The functions of the controls on the panel are indicated by engraving on the dials.

The moving-coil meter provides an indication of valve emission and also operates as a tuning indicator of the resonant dip type when the associated switch is in position "V1." Valve emission is shown by switching the meter into each H.T. feed line by means of the eight position switch located below the meter. It should be noted that "V2" has two positions since the particular valve, the mixer, has two separate anodes. The meter scale is arbitrary and is only intended as a guide to the emission of each valve. Readings obtained on the test bench at the factory are supplied with the receiver and any wide variation from these readings should be regarded with suspicion, the appropriate valve or valves being replaced if performance is affected. When checking valves for emission the H.F. gain control must be at the maximum position, the A.G.C. switch "on" and the aerial disconnected. The B.F.O. V6 will only register when the B.F.O. switch is "on"; this switch should be "off" when checking any other valves.

In the case of weak signals, or when rapidly searching for signals it will be found easier to locate these by having the B.F.O. switched "on" and tuning to the silent point of the beat note caused by the heterodyne, switching the B.F.O. off when so tuned, to get clear reception of the modulated carrier.

The calibrations on the tuning scale are marked in kc/s. and the particular coil to which they refer is indicated at each end of the calibrations. Ranges B.C.D. & E. only are calibrated directly, and any extra ranges to these are separately calibrated on graphs supplied with the receiver, their readings being referred to the 0 to 100 degree inner engraving on the scale.

Ranges covered by the coil units, valve positions, and other technical information will be found in the service instructions issued with each receiver.

Service Notes.

The full circuit diagram of the receiver is shown in Fig. 2 together with a list of the component values. The following service notes are not intended to be comprehensive and the instruction book issued by the manufacturers should be referred to if the receiver is to be overhauled.

I.F. Amplifier Alignment.

The following apparatus will be required for the successful alignment of the I.F. amplifier stages of this receiver:—

Signal generator with calibrated attenuator to generate at 450 kc/s. (modulated 30 per cent.).

Output meter (power) giving loads of 600 ohms and/or 6,000 ohms.

For aligning the I.F. amplifier stages, the lead from the generator should be direct, *i.e.*, no dummy aerial in circuit, and must show continuity between the high and low potential leads.

If the amplifier is only slightly misaligned, connect the generator leads between the grid of V2 (after removing the cap) and chassis. Set H.F. gain and L.F. gain controls to maximum position. Switch off the A.G.C. and B.F.O.

Set the generator to give a suitable deflection on the output meter, and adjust all six I.F. trimmers, C28, C27, C26, C25, C24 and C23, to give maximum deflection. If no signal is obtained in this manner, proceed as follows:—

Connect the generator leads between grid of V4 (after removing clip) and chassis, and trim I.F.T.3. Transfer lead to grid of V3 trimming I.F.T.2, then repeat on V2 as already described.

A.G.C. and B.F.O. may be checked at this point. Adjust for zero beat by means of the trimmer C54 located near valveholder of V6. To check A.G.C. switch off B.F.O., switch on A.G.C. and increase input from the generator to 100 microvolts, reducing the output of the receiver if the output meter is overloaded by means of the L.F. gain control (not H.F. gain). Switch off A.G.C. Output meter deflection should now show a sharp rise.

Coil Alignment.

The plug-in coil units are very carefully adjusted before leaving the factory, and the tracking and padding condensers set to give the greatest possible efficiency. If after consideration, it is decided these units required re-adjustment, the following procedure should be carried out systematically:—

The tracking condensers in Ranges A B and C are of the fixed capacity type, whilst those of Ranges D E F G H and I are variable, adjustments being made through the holes in the top of the covers by means of a non-metallic trimming tool, which is insulated to avoid short circuits from high potential trimmers to the chassis. Approximate value of tracking condensers are given in the list of component values.

For this procedure a signal generator giving output between 32 Mc/s and 1,250 kc/s. is required if Ranges A B C D and E are used. If Ranges F G H and I are used, the frequency range must be extended to 85 kc/s.

On Ranges A B C and D use a dummy aerial consisting of a non-inductive 400 ohms resistor. For other ranges a standard dummy aerial consisting of a 200 mmfd. condenser, 20 ohms non-inductive resistor and a 40μH inductance in series with the high potential lead from the generator. (This dummy aerial is usually supplied with a generator).

Great care should be taken to avoid any overloading of the output meter, as may be caused by leaving the H.F. gain control full on, and injecting a signal from the generator of sufficient output to cause the needle to go hard over against the stop and possibly become bent. The controls should be adjusted so that the signal is enough to give deflection on the meter to about 50 per cent. of the total scale of reading.

Valve Positions.

No.	Function	Mullard	Marconi-Osram
V 1	Radio Frequency Amplifier ..	EF39	KTW73M
V 2	Mixer	ECH35	—
V 3	1st I.F. Amplifier	EF39	KTW73M
V 4	2nd I.F. Amplifier	EF39	KTW73M
V 5	Detector ..	EBC33	DH73M
V 6	Beat Frequency Oscillator ..	EF39	KTW73M
V 7	Output.. ..	EL32	KT63

It should be noted that the Mullard EL32 is not a replacement type valve for the Marconi-Osram KT63, since it utilises a top-grid form of connexion. Sets supplied with the Mullard EL32 are modified accordingly.

The Mullard ECH35 Mixer valve is used in receivers supplied with either type of valve, and apart from the exception mentioned above the valves are interchangeable.

Voltages.

Referring to circuit diagram, voltages are measured between the points indicated by the letters and chassis, using a high resistance type meter on 1,000 volt range. Range B coil unit should be in use, and the receiver tuned to 22.5 Mc/s with A.G.C. switched off and aerial disconnected.

Mullard Valves	Contact Point	Marconi-Osram Valves
167 volts ..	A	165 volts
67 ,, ..	B	70 ,,
1.5 ,, ..	C	1.8 ,,
155 ,, ..	D	150 ,,
75 ,, ..	E	70 ,,
50 ,, ..	F	50 ,,
1.7 ,, ..	G	1.6 ,,
165 ,, ..	H	160 ,,
75 ,, ..	J	85 ,,
3.2 ,, ..	K	4.4 ,,
150 ,, ..	L	140 ,,
65 ,, ..	M	70 ,,
1.8 ,, ..	N	2.4 ,,
45 ,, ..	O	55 ,,
0.9 ,, ..	P	0.8 ,,
167 ,, ..	Q	165 ,,
155 ,, ..	R	150 ,,
167 ,, ..	S	165 ,,
6 ,, ..	T	6 ,,

A variation of 5 per cent. in H.T. supply voltage is permissible.

Alternative Models

Type 358/1

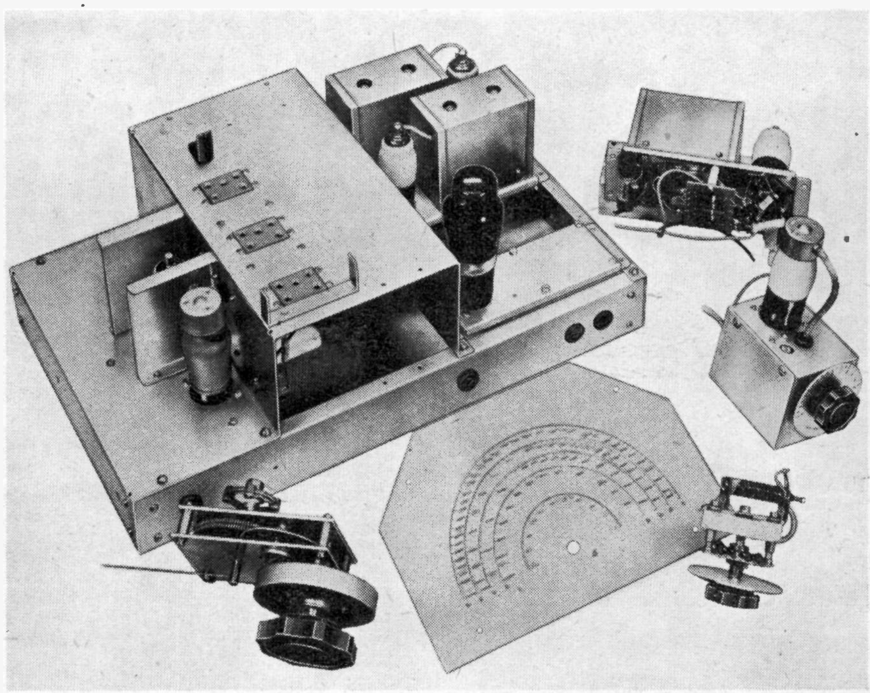
This received is a modified version of the Standard 358 Receiver, and is intended primarily for headphone reception and battery operation if necessary. The normal output valve has been replaced by one drawing less anode current, and giving as a result a lower audio output. To accommodate the new type valve, the auto-bias resistor R.39 has been increased to a value of 1,000 ohms, and R.26 in the second I.F. amplifier stage has been reduced to 500 ohms. By means of the above modifications the total anode current consumption has been reduced to approximately 33 milliamperes at 180 volts.

To stabilise the voltage from the power unit at the new load, a bleeder resistance of 15,000 ohms 3 watt rating has been placed across the rectified output.

It will be noted that the "on-off" high tension switch referred to in the operating instructions has been replaced with a similar type switch controlling the dial illumination.

The power unit has been provided with an "on-off" switch on the opposite side to the output socket, this switch being in the mains supply circuit. It is advisable to place this in the "off" position when changing coil units. In the case of battery operation the H.T. switch, located in the switch-box unit should be put in a similar position, the L.T. switch being left "on," while the new coil unit is being inserted.

A special battery lead is supplied when the receiver has to be operated from batteries. This lead incorporates a small switch-box unit. It is essential that both switches be in the "off" position when the receiver is left inoperative, as should the H.T. switch be left on there will be a small drain, even though the filament supply has been switched off, due to the potential divider circuits incorporated in the receiver itself.



The photograph shows the unit type of assembly adopted whereby each I.F., B.F.O., Audio Unit, etc., is build on a separate complete chassis. This considerably simplifies both construction and maintenance. Also shown is the fly wheel drive and Tufnol gearing mechanism for dial indicator.

For battery operation the following will be required:—A 6-volt accumulator of a sufficient capacity to give a reasonable number of operating hours, and a high-tension supply which may consist of four 45-volt block units of the super-capacity type, connected in series to give 180 volts.

Type 400

The Eddystone Type 400 has been designed for Service requirements and covers the medium frequency band only.

It is similar to the "358" but the four coils cover a range of 130 kc/s. to 2,200 kc/s. The dial is calibrated in frequency and a separate logging scale, as in the "358" is supplied.

Separate models of both the "358" and the "400," incorporating band-pass crystal filter units are available.

Coil Unit Component Values for Type 358.

C.1	Range A	15–45 pf.	Type C.V.S.11	
	B	,, ,,	,, ,,	
	C	,, ,,	,, ,,	
	C	,, ,,	,, ,,	
	D	,, ,,	,, ,,	
	E	,, ,,	,, ,,	+40 pf.
	F	,, ,,	,, ,,	
	G	,, ,,	,, ,,	+40 pf.
	H	,, ,,	,, ,,	+10 pf.
	I	,, ,,	,, ,,	+40 pf.
C.2	Range A	15-45 pf.	Type C.V.S.11	
	B	,, ,,	,, ,,	
	C	,, ,,	,, ,,	
	D	,, ,,	,, ,,	
	E	,, ,,	,, ,,	+40 pf.
	F	,, ,,	,, ,,	+40 pf.
	G	,, ,,	,, ,,	+40 pf.
	H	,, ,,	,, ,,	+10 pf.
	I	,, ,,	,, ,,	+20 pf.
C.3	Range A	15–45 pf.	Type C.V.S.11	
	B	3.5–20 pf.	,, ,,	
	C	15–45 pf.	,, ,,	
	D	,, ,,	,, ,,	
	E	,, ,,	,, ,,	+40 pf.
	F	,, ,,	,, ,,	
	G	,, ,,	,, ,,	+75 pf.
	H	,, ,,	,, ,,	+100 pf.
	I	,, ,,	,, ,,	+290 pf.
C.7	Range A	100 pf.		
	B	.0046 mfd.		
	C	.002 mfd.		
	D	1,000 pf. max.	Cyldon type St14.	+0005 mfd.
	E	,, ,, ,,	,, ,,	,,
	F	,, ,, ,,	,, ,,	
	G	,, ,, ,,	,, ,,	
	H	250 pf. ,, ,,	,, ,,	
	I	,, ,, ,,	,, ,,	+100 pf.
C.39	Range A only	75 pf.		+20 pf.
C.40	Range A only	75 pf.		+10 pf.
C.41	Range G only	15–45 pf.	Type CVS.11	+100 pf.
C.42	Range G only	15–45 pf.	,, ,,	+100 pf.
R.10	Range A	Nil.		
	B	25 ohms ½ W.		
	C	50 ohms ½ W.		
	D	500 ohms ½ W.		
	E	1,000 ohms ½ W.		
	F	1,500 ohms ½ W.		
	G	3,000 ohms ½ W.		
	H	3,000 ohms ½ W.		
	I	3,000 ohms ½ W.		
R.31	Range A only,	1 megohm ½ W.		

Review of Progress in Electronics

IV.—Photo-Voltaic Effects

By G. WINDRED, A.M.I.E.E.

" A new kind of photocell has been described in which the photo-electrons liberated by the light do not pass through a vacuum or gas space, but filter through an interface of unidirectional conductivity between two conductors. The name barrier layer photocell has been proposed for such an arrangement. Up to the present the combination copper-cuprous oxide has been employed. Recently Duhme and Schottky have succeeded in depositing thin metal films on cuprous oxide in such a way that the action occurs between the surfaces. There is now in addition the so-called selenium metal rectifier. . ." L. Bergmann, in an article on the selenium barrier-layer photocell published in the Physikalische Zeitschrift, 1931.

INVESTIGATION of the phenomena with which we are concerned in the present article has resulted in the development of some important and interesting types of photocell, known generally as rectifier or barrier layer cells. Although the practical and theoretical aspects of the subject have received a considerable amount of attention, the basic principles are by no means fully established, and many different theories have been put forward from time to time to account for the observed effects, which may be briefly described as the appearance of a spontaneous e.m.f. when the cell is illuminated. In this respect the action is similar to that of a Becquerel cell, but the rectifier type does not make use of an electrolyte and has a dry construction. Some investigators are of the opinion that the action of the electrolytic, photo-conductive and rectifier type cells can be ascribed to the same basic cause, represented by the action of light in liberating electrons inside certain semi-conducting materials.

Early Researches

The production of a spontaneous e.m.f. upon illumination of crystalline selenium was reported by Adams and Day[1] in 1877. These investigators put forward the unsatisfactory theory that the e.m.f. was due to a change in the crystalline structure of the selenium under the action of the light. They were able to show by experiment that the response to illumination was very rapid.

The subject was next taken up by C. E. Fritts[2] in America, apparently without knowledge of the work of Adams and Day. In his British Patent No. 3,249 of 1884 he mentions the self-generating properties of his cells, tests on which were carried out by Werner Siemens and showed results comparing very favourably with modern types of cell. Fritts appears to have been about the first experimenter to use a rotating perforated disc for commutating the light applied to a cell and to observe the changes of tone caused by the resulting intermittent current in a telephone when the speed of the disc was varied. Much of the development of manufacturing technique to obtain the best results in practice must also be ascribed to Fritts.

A considerable amount of work on the subject was also carried out by Uljanin,[3] who confirmed the idea that the e.m.f. appeared almost immediately upon illumination. He also experimented with light of different wavelengths, and was probably the first to determine with any accuracy the distribution of spectral sensitivity. The experiments of Uljanin were mainly academical, as compared with those of Fritts, and served the important purpose of adding to exact knowledge of the phenomena as well as indicating the technical difficulties associated with the production of cells. Similar experiments were carried out at about the same time by Righi,[4] who measured the potential from a cell consisting of a selenium plate with an insulated wire electrode in front of it.

It was not until 1901 that further work of importance on the subject was carried out. The U.S. Patent No. 755,840 of that year by J. C. Bose relates to a cell in which the photo-voltaic effect in a single crystal is utilized. The crystal photocell of Bose was a very realistic forerunner of the " electric eye " of modern times, being made actually in the form of a human eye. A small lens in front focused the light on to a crystal in an adjustable holder, very much on the lines of an ordinary crystal detector. The arrangement had little or no practical application, but the underlying idea of utilizing the photo-sensitive properties of certain crystals, such as lead sulphide (galena), tellurium, etc., was representative of a new branch of physical science which has become very much the domain of the specialist.[5]

A detailed study of the change of resistance of cuprous oxide under the effects of illumination was carried out by Pfund[6] in 1916. This investigator observed the effects of light of different wavelengths, but owing partly to the method of using his cells he did not detect the appearance of an e.m.f. upon illumination. His most important contributions to the subject are, firstly, his use of cuprous oxide, and, secondly, his novel method of attaching gold electrodes by cathodic sputtering. Both these features are characteristic of some modern types of cell, to the discovery of which Pfund came very close.

The practical aspect of the subject was extended considerably by Grondahl and Geiger[7] in a series of researches covering a period of several years. In addition to establishing the principles of the now-famous copper-oxide dry rectifier, they observed the photo-voltaic effect in a cuprous-oxide cell. It was left for Lange[8] to develop the modern type of cell using cuprous oxide, while Bergmann[9] described a similar cell using selenium. These are substantially of the same construction as the cells extensively employed in present-day practice.

General Theory

The properties of crystalline semiconductors such as selenium and cuprous oxide, as used in photo-voltaic cells, are by no means rigidly fixed, and for this reason great caution is necessary in formulating theories and arriving at conclusions. The results of experimental research indicate that electronic conduction in such materials is determined by the physical arrangement of the crystal structure rather than the material itself. It has been found, for example, that differences in thermal treatment of cuprous oxide which did not cause any physical change in the material could produce changes in conductivity represented by a factor of more than a thousand. Thermal treatment of the same substance might likewise result in a pronounced photo-voltaic effect or none at all. Even pure cuprous-oxide crystals do not exhibit uniform characteristics; some artificially produced ones being quite inactive. A vast amount of experimental and theoretical research has been directed to these problems, but as yet there is by no means any complete and coherent theory to account for all the observed phenomena.

Some of the most valuable research is due to W. Schottky, who visualized the interface or boundary between the materials comprising the cell as consisting of minute points of contact corresponding to the corners of individual crystals. The nature of this "sieve contact" was considered to be responsible for the rectifying property of the arrangement. After careful measurements, Schottky concluded that the actual aggregate contact surface amounted to only one-hundredth or even one-thousandth part of the nominal area. This conception led to the idea of a "barrier layer," which was regarded as the seat of the photo-voltaic effect.

The happenings inside a typical cuprous-oxide cell according to the principles formulated by Schottky can be represented as in Fig. 1. The light entering the cuprous-oxide face loosens electrons, which have two possible paths—an external path resulting in a flow of current through an external circuit, and an internal path closed upon itself through the interface between copper and cuprous oxide. It can be seen that if this is a true picture of the conditions, the light falling nearest the front electrode will result in the greatest flow of current in the external circuit, since the resistance of the corresponding path will be less in relation to the

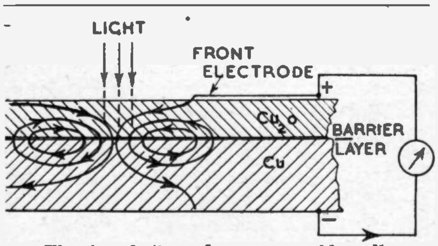


Fig. 1. Action of cuprous-oxide cell.

short-circuit path. This fact has been confirmed experimentally by Schottky and others. Extensive research based on these ideas led to the development of the so-called "front wall" cell, in which electrons are released in the *outermost* surface of cuprous oxide and flow to a translucent front electrode instead of originating in the interface and flowing in the opposite direction as in Fig. 1, corresponding to a "back wall" cell.

Several attempts have been made to develop a satisfactory theory to explain the exact mechanism governing the liberation and subsequent motion of electrons in the barrier-layer types of cell, but it cannot be said that any particular theory is definitely established. The best accounts of research in this complicated but important subject are to be found in the treatises by Lange,[10] Hughes and Du Bridge,[11] and Gudden[12], especially the first-named.

Types of Cell

In dealing with the photo-voltaic cell we have to discriminate between cuprous-oxide and selenium types, as well as front-wall and back-wall construction. The alternative types of construction are shown in Fig. 2, from which it is seen that the barrier layer is differently situated in the two cases and that the direction of the current flow is also different. It should be carefully noted that the arrows in the Figures represent the direction of the electron flow, which is, of course, in opposition to the conventional direction of current flow corresponding to the polarity of the cell.

The selenium-iron cell described by Bergmann[9] consists of an iron plate on which a layer of selenium is deposited, being then converted into the high conductivity metallic state by special processes. A thin layer of lead alloy is

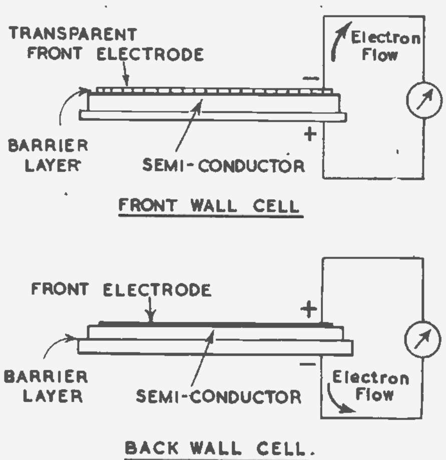


Fig. 2. "Front Wall" and "Back Wall" cells.

sprayed on to the selenium surface so as to form the second electrode. Bergmann states that up to 14 volts such an arrangement shows an appreciable barrier action in the direction metal film-selenium-iron, whereas the conductivity in the other direction is high. At 5 volts the resistance relationship was 2,500 to 1.

According to the manufacturers of modern British cells, the selenium used must be of the utmost purity, and no commercial kind is suitable. It is also stated that all stages in the application and annealing of the selenium are critical, and that minute variations have a marked effect upon the results. Protection against atmospheric effects is secured by a film of chemically neutral lacquer over the sensitive surface. Artificial ageing of the finished cells is carried out in order to obtain stable characteristics. A typical procedure is to expose each cell to a light intensity of from 500 to 1,000 foot-candles for at least forty-eight hours, followed by a short-circuit test. Any cell showing a tendency to an irreversible characteristic after this process is rejected. The cells are then kept for a month or two for natural ageing under dark conditions and again tested before use.

The construction of an American cell described recently[13] is shown in Fig. 3. The element in this case consists of a layer of selenium deposited on one side of a steel plate 1.7 in. by 0.9 in. and 0.065 in. thick. The transparent layer of conducting metal and the protective layer of lacquer are applied in the usual way, and the complete cell is mounted in a case with connecting terminals and a front window for admitting the light. The arrangement of this cell is seen to correspond to the front-wall construction, as shown in Fig. 2, and under illumina-

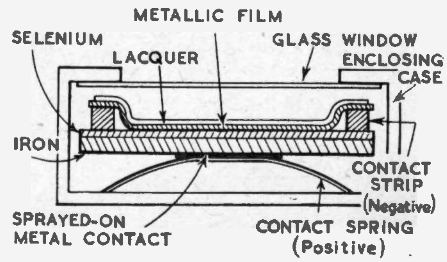


Fig. 3. Construction of typical selenium-iron cell.

tion the rear contact disc accordingly becomes positive.

With regard to cuprous-oxide cells, which have been extensively developed in America, a great deal has been written.[14, 15] One of the greatest spheres of application has been in connexion with illumination meters[16] and photographic exposure meters.[17] The general construction of these cells is similar to that of the selenium type already described.

Characteristics

The properties of a photo-voltaic cell of chief interest from the viewpoint of practical application are the current output in relation to the illumination for loads of different resistance, the power output under these conditions, the sensitivity, both spectral and electrical, the effects of temperature and the temperature coefficient, the frequency response and fatigue effects.

Bergmann[9] has given figures which

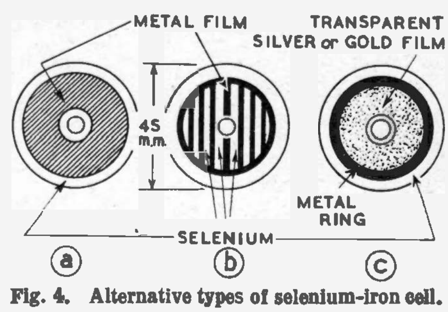


Fig. 4. Alternative types of selenium-iron cell.

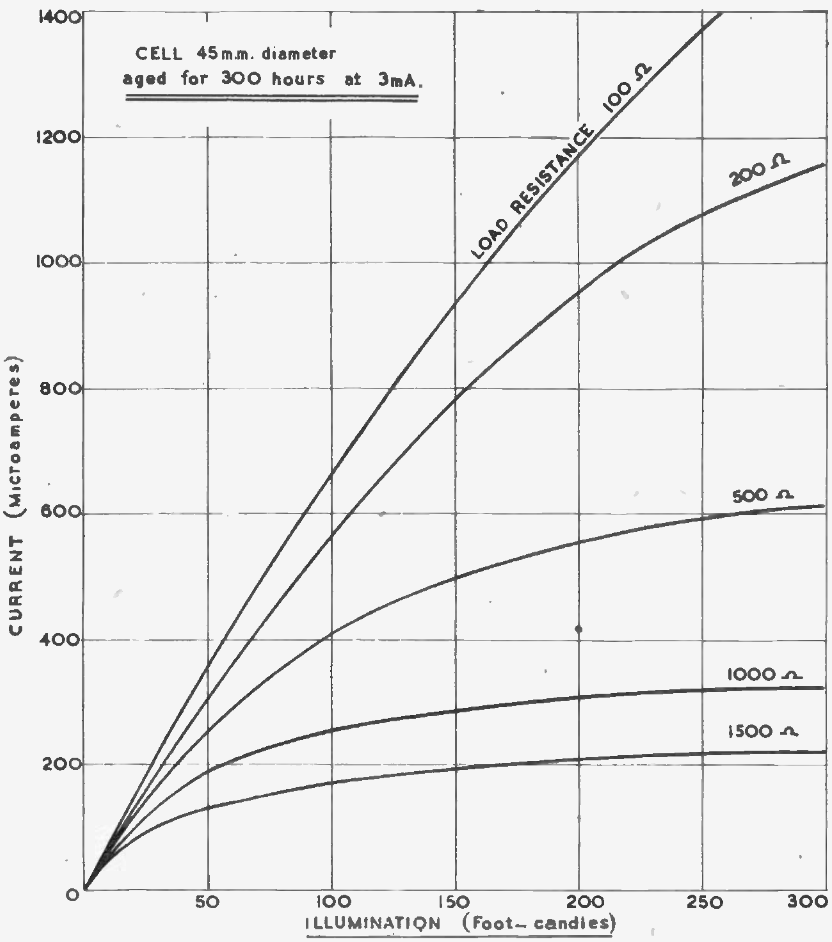


Fig. 5. Characteristics of modern selenium-iron cell (Courtesy Arthur E. Evans and Co., Ltd.)

show the pronounced effect of cell construction in so far as output is concerned. The alternative arrangements tested by him are shown in Fig. 4, and the relative outputs were as follows when illuminated by a 40-watt metal-filament lamp at a distance of 20 cm.:—

(c) 92×10^{-6} amp.
(b) 14×10^{-6} amp.
(a) 4.5×10^{-6} amp.

The increase of sensitivity in the case of cell (b) arises from the effect mentioned in connexion with Fig. 1 concerning the increased sensitivity in regions near the front electrode edges. The output figure of cell (c) cannot be compared directly with the others, since in this case the cell area was approximately 10 cm^2. Bergmann mentions that in the case of cell (c) illumination from a 40-ampere projector lamp produced a current of about 75 mA in a meter having 1-ohm resistance. With illumination from a 5-ampere arc lamp it was easily possible to drive a small electric motor.

The current output in relation to load resistance for a front-wall selenium cell of British manufacture is shown by the curves in Fig. 5. It will be seen that linearity of response is more nearly obtained with low external resistances—a factor of some importance when cells are used in illumination meters.

The power output resulting from a given illumination depends upon the external load resistance, and is a maximum when this resistance is equal to the internal resistance of the cell. For each size of cell it is possible to plot curves showing output power in relation to load resistance for given intensities of illumination, and from these curves to select the cell best suited to the conditions of illumination and the power required.

The spectral or colour sensitivity of the cuprous-oxide and selenium-iron types of cell in relation to the sensitivity of the eye is shown in Fig. 6. Too much reliance should not be placed on such curves, owing to variations in manufacture which affect the sensitivity. Closer approximation to eye response may be obtained by the use of suitable filters.[18, 19]

The frequency response of photo-voltaic cells is fairly good, and depends upon the self-capacitance, so that small cells have a better response. In the case of a selenium-iron cell 10-mm. diameter of the type already mentioned the response at 1,000 cycles is about 90 per cent. and at 5,000 cycles about 60 per cent. These figures show that when sufficiently small cells are used there is no difficulty in the use of audio frequencies.

The effect of temperature on performance is not very marked, especially in the case of low external resistance. In the case of the cuprous-oxide cell the internal resistance is considerably affected by temperature, and causes appreciable changes in current output when high external resistances are used. The average change, which depends upon the illumination, varies from zero under short-circuit conditions to about 0.6 per cent. with 500-ohms external resistance. According to manufacturers' information for the type of selenium-iron cell described by Bergmann, the change of current with temperature in the region of 20° C. is very small. With increasing temperature the current falls, more rapidly for high values of external resistance. The coefficient amounts to about 0.14 per cent. with 100-ohms and to 0.4 per cent. with 350-ohms external resistance.

With regard to fatigue, it is difficult

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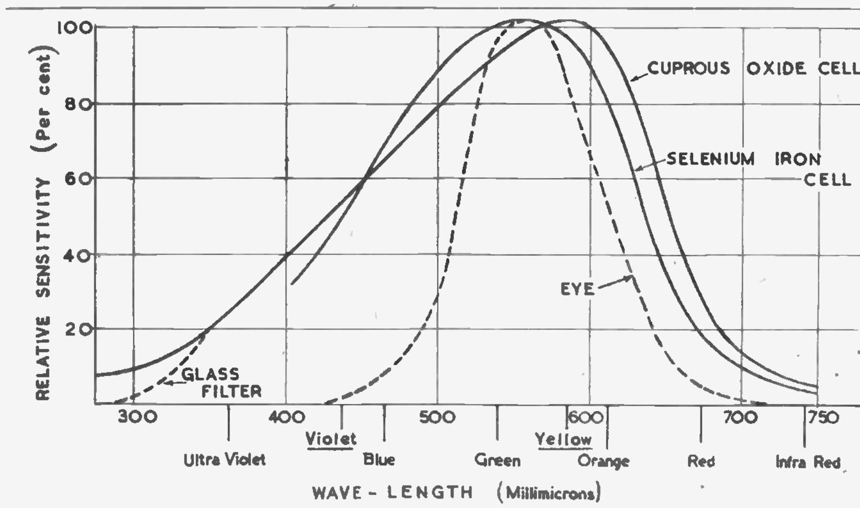

Fig. 6. Curves of spectral sensitivity.

Low-Loss Ceramics for Radio-Frequency Use

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The concluding article of the series which commenced in "Electronics and Television and Short Wave World," March, 1941

PREVIOUS articles have dealt with the composition and properties of low loss ceramics, and the methods by which they are manufactured. It remains to give brief consideration to the application of these materials to radio frequency engineering. At the outset, it may be remarked that, while great stress has always been laid on the extremely good electrical properties of these special ceramics, it is by no means this feature only which has caused them to be used so extensively. Certain of the organic materials compare quite favourably, so far as losses are concerned, but the ceramics are outstanding by virtue of their combination of excellent electrical and mechanical characteristics.

In broadcast receiver development, cost is a major limiting factor, and ceramic parts have therefore only come into general use where their cost compares reasonably with that of equivalent plastic mouldings. Bases for trimmer and padder condensers of the mica dielectric compression type form one of the main uses in this field. Though porcelain was used quite successfully in early trimmers of this type, preference was soon given to the steatite ceramics, more on account of superior mechanical strength than because of lower dielectric losses; it was found that reduced breakages in assembly more than offset the higher price of the superior material. Most modern gang condenser types utilise ceramic supports for their stator assemblies, usually in the form of short rods. As compared with earlier types, with laminated synthetic resin insulation, they show a marked improvement in power factor, and more important, the capacity matching between sections is maintained over long periods.

In high-grade communication apparatus covering a wide frequency range, maintenance of performance and calibration demands careful attention to mechanical and electrical stability and ceramics are freely used. Not only for the main tuning components, but also for valve-holders, valve bases, wave-change switch parts, etc., which contribute substantially to circuit stray capacities. In addition to the advantages of reduced dielectric losses and freedom from long-period changes in circuit values due to ageing, substantial reductions are effected in frequency drift due to thermal changes. The temperature coefficient of effective dielectric constant of the steatite group ceramics is only of the order of + 100 to + 120 parts/million/°C, as compared with some + 1,000 to + 2,000 parts/million/° C. common for synthetic resins, and the importance of this property is well illustrated by the following simple measurements taken on the oscillator circuit of an "all-wave" commercial broadcast receiver. Curve A of Fig. 1 shows the frequency drift during the first hour of a day's use, when tuned to the high-frequency end of the short-wave band (approx. 20 Mc./s.). Curve B shows the effect of removing all components with synthetic resin insulation, and substituting equivalents with low loss ceramic insulation. Tuning condenser, coil former, wave-change switch, valve-holder and base were all changed, and the layout altered as little as possible. It is obvious that, not only would it be impossible to calibrate the receiver in its original form, but even after an hour's running, retuning is necessary every few minutes. Most of the drift shown in curve B occurs in the first few minutes, before any appreciable general rise in temperature has taken place, and is obviously due to capacity changes resulting from initial heating of the oscillator valve's electrode system. Thereafter, the drift—of the order of 2 kc/s only in the remainder of the hour, and due to the general warming up of all components, is small enough to be negligible for most classes of service; further substantial improvements can, however, be effected by the use of compensating ceramic condensers, as will be indicated later. This is feasible, as the circuit giving curve B will repeat regularly. In its original form, the oscillator circuit could not readily be compensated, as the high degree of compensation required calls for critical balancing. Moreover, the use of synthetic resin insulation leads to non-cyclic behaviour of the key components, and such compensation as may be realised initially will not hold for any length of time.

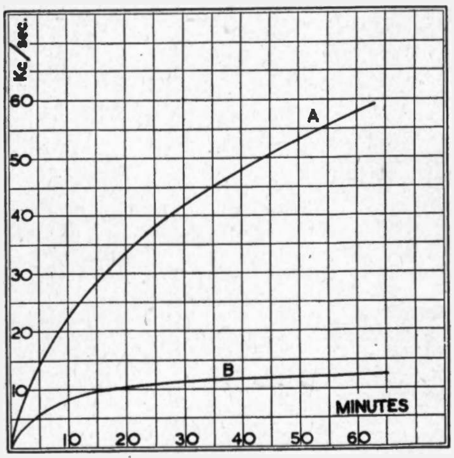


Fig. 1. The low frequency-drift of ceramics.

The above simple example indicates the very real advantages to be gained from the use of ceramics to secure stability of performance, and the conclusions are endorsed by the increasingly wide use of these materials in communication apparatus and precision measurement equipment. Little further comment on the mere substitution of ceramics for other established materials seems necessary, and we may therefore turn to consider applications in which they are unique.

The process of pottery decoration by firing on thin films of precious metals has been well-known for many years, and of late, similar methods have been applied extensively in the manufacture of ceramic condensers. A suspension of silver oxide in a suitable organic medium (*e.g.*, lavender oil), is sprayed or painted on to the ceramic, which is then fired to a temperature of 550° to 750° C., when the silver oxide is reduced to a firmly-adhering metallic coating, usually of the order of .0003 in. to .0005 in. in thickness. To electrodes formed in this way connecting leads are soldered directly, or the silver de-

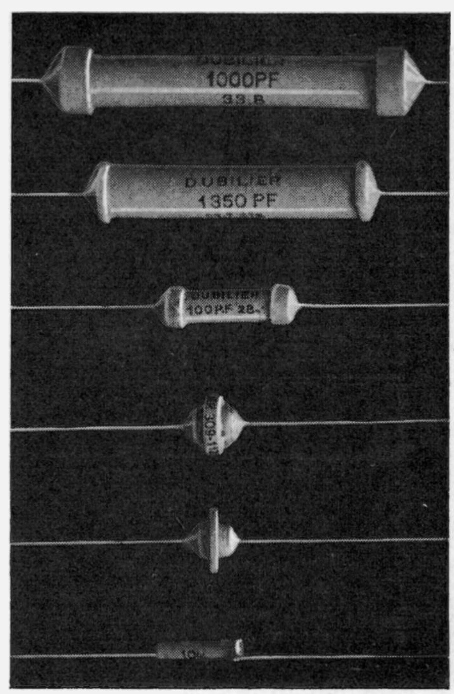


Fig. 2. Ceramic cup, disc and tube condensers.

posit may first be increased in thickness by electro-deposition. With proper firing relative movement between electrodes and dielectric is impossible, and this, coupled with the inherent stability of ceramic dielectrics themselves, leads to the production of condensers which remain perfectly stable indefinitely, and show a high degree of cyclicity when submitted to many cycles of temperature change. Moreover, as the properties of the ceramic dielectrics can be controlled very closely, it is possible to manufacture large quantities of any one type to close limits of temperature coefficient of capacity, which cannot be accomplished with mica dielectric except by selection. Capacity adjustment to close tolerances is also readily achieved, by starting with a slightly higher capacity value than desired, and reducing the silvered area by grinding. Fig. 2 shows a group of such condensers in the now well-known disk, cup, and tubular forms; values up to 1,000 p.f. are obtained, using thin-walled tubes of high titania material (S.I.C. 80), no more than 6 mm. diameter and 40 mm. long. Very low capacities, from 5 p.f. down to 0.5 p.f., difficult to produce by any other means, are made very simply by silvering the ends of little 5 mm. diameter rods, using different lengths for the various values required (Fig. 3). For high voltage, high power radio frequency use larger ceramic condensers —though still much more compact than their mica and foil counterparts—are made, usually in the form of thick-walled tubes closed at one end. Fired silver coatings on the outside surface form the earthy electrodes, and similar coatings on the inside form the high potential electrodes, insulated by means of substantial flanges at the open end to provide adequate flashover and creepage path. Due to the high electrical stresses at which these components work, the required capacity is secured by adjustment of the dimensions of the ceramic parts rather than by variation of the area of the silvered electrodes; a group of these condensers is shown in Fig. 4.

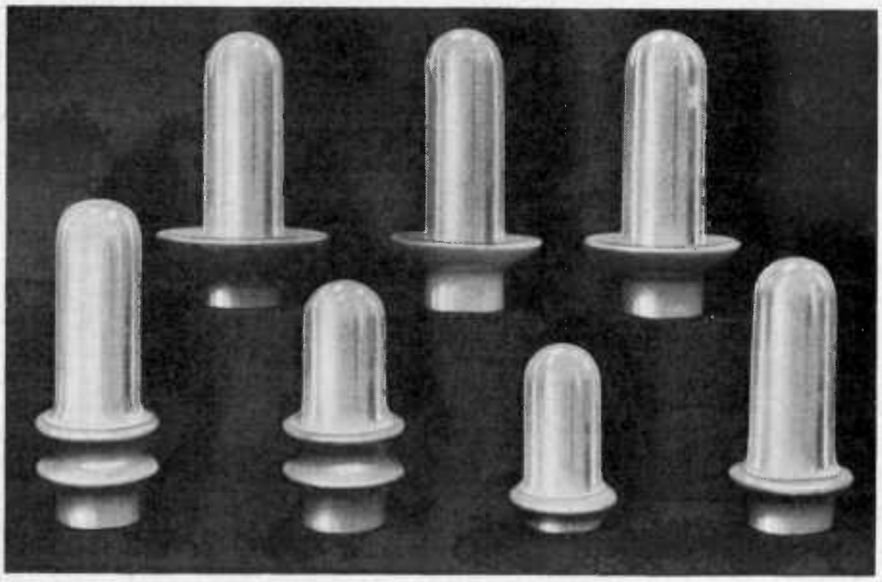


Fig. 4. Power condenser bodies.

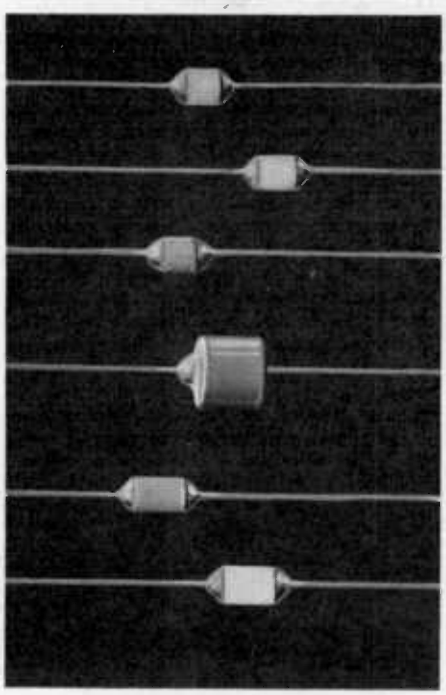


Fig. 3. Pearl or rod type condensers.

Ceramic trimmer condensers are widely used to-day. They consist of a base of steatite-type material, with a silvered area forming the stator plate. A thin disk of high titania or titania-magnesia material, forms the actual dielectric, the rotor " plate " being formed by a segmental area (usually 120°) of fired-on silver, connexion from which is made via the adjusting screw and spring which holds the two ceramic parts firmly in contact. A photograph of the disk and base is on page 318. Good electrical properties, particularly in respect of stability, can only be achieved by precision grinding of the meeting surfaces of the ceramic parts to quasi-optical standards. This type of trimmer was originally developed in Germany, but the British types now available show a number of detail improvements of considerable importance. Measurements on typical trimmers taken from bulk production show them to be highly satisfactory under mechanical vibration, and cyclic under temperature changes; in these respects they are superior to such air-dielectric types as the writer has had the opportunity to test.

The negative temperature coefficient of capacity of titania dielectric condensers makes them of great value for compensating the shift in resonant frequency of tuned circuits caused by temperature changes. Both coil and condenser of the simple circuit of (Fig. 7a) will in general have positive temperature coefficients of inductance and capacity. By reducing the value of C. and adding a ceramic condenser C1 of negative coefficient (Fig. 5b) and proportioning the two capacities such that the overall coefficient of the combined condensers is negative and equal to the positive coefficient of the inductance, frequency drift is eliminated. While very simple and exact for a single frequency, compensation of this simple nature will not hold if the condenser C is made variable to cover a range of frequencies. If, however, an additional large capacity condenser C2 of the high titania type is connected in series with the variable C, as in Fig. 6, exact compensation can be attained at two settings of C. For low values of C, the effect of changes in C2 is small, and the positive coefficient of C is balanced at one point by the use of a suitable value of C1—if this is of titania material with a high negative coefficient its capacity need not be large, and the frequency coverage therefore will not be unduly restricted. At a setting of C towards its maximum capacity, the influence of C1 will be small, but by suitable choice of the capacity of C2, the overall coefficient of capacity of C and C2 in series can again be made of the correct negative value to balance the positive coefficient of the inductance. At settings other than the two points at which balance is effected, the compensation

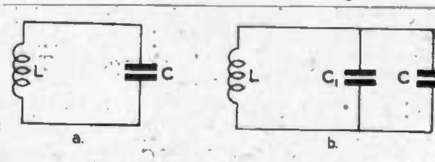


Fig. 5.

will not hold rigidly, and if a curve of residual temperature coefficient against frequency be plotted, something like the familiar superheterodyne "tracking" error curve will result. Computation of the values of C1 and C2, knowing the temperature coefficients of L and C, and the capacity swing of C, is simple though rather laborious; provided that the positive coefficients of L and C are initially of fairly low positive value, thermal frequency drift can be reduced to the order of ± 5 parts/million/° C for quite a large tuning range.

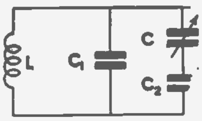


Fig. 6.

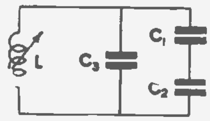


Fig. 7.

The above can obviously be applied to any conventional oscillator circuit of the Hartley or reaction coil type, but the Colpitts circuit of Fig. 7, using variable inductance tuning, is particularly attractive. Here C1 and C2 can with advantage be ceramic condensers of low temperature coefficient (*e.g.* titania-magnesia dielectric); then, provided the reasonable assumption is made that a variable inductance of sensibly constant temperature coefficient can be made, accurate compensation over a wide frequency band can be effected by adjusting the capacity value of a single negative coefficient condenser C3.

Where adjustment of the capacities of compensating condensers is not permissible on account of their effect on the tuning range and calibration of the circuit as a whole, or where the individual temperature coefficient of the main tuning components are not accurately known, adjustment of compensation can be carried out using two condensers in parallel for each compensating element, one of positive and one of negative coefficient; their total capacity may then be kept constant while varying the proportion of capacity of each, the overall temperature coefficient varying in similar proportion. Thus C3 of Fig. 6 may be replaced by two ceramic trimmer condensers, one with a rotor of high-titania material, the other with a rotor of titania magnesia material.

Earlier in this article, frequency drift due to heating of valve electrode structures was commented on; the capacity changes here also are generally of positive sign, and may therefore be compensated for by the use of a small ceramic condenser of high negative coefficient material in contact with a heater element energised from the same supply as the valve heater. This requires adjustment both of the heater wattage and thermal capacity of the assembly for correct operation, but when correct will also help to diminish the effects of slow heater voltage changes on frequency after the warming-up period.

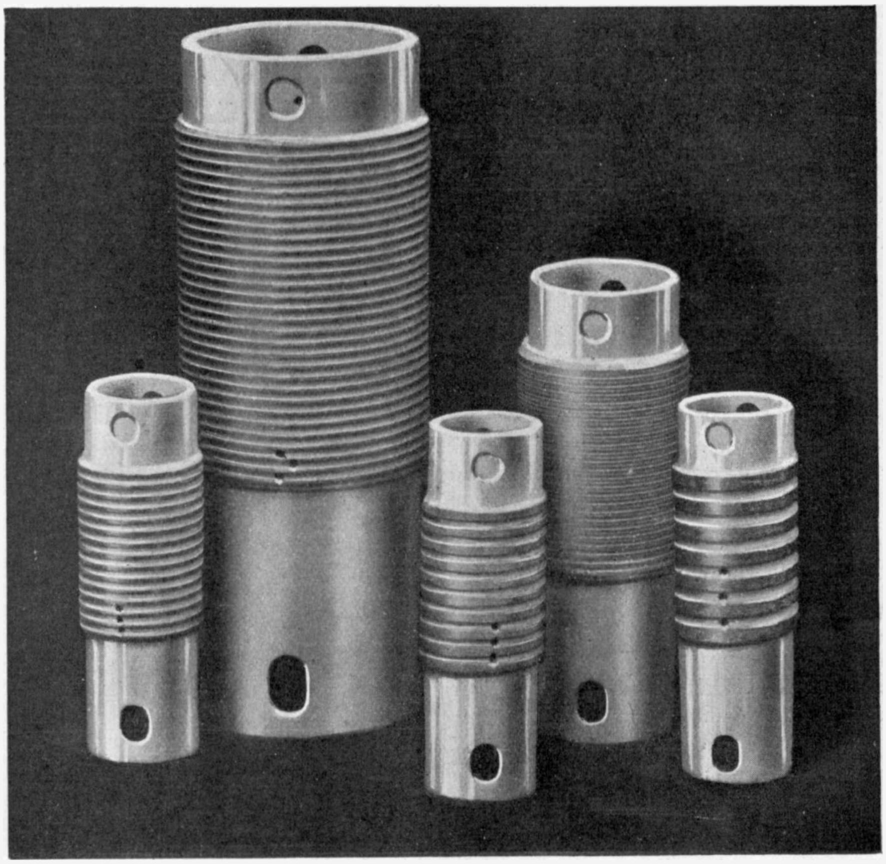


Fig. 8 Silvered coils.

The importance of reducing the temperature coefficients of all components as far as possible before attempting compensation has already been stressed, and in this connexion another important application of the silvering technique must be mentioned. An inductance of extremely high stability is produced by firing a spiral of silver on a low loss ceramic former, then electro-plating the thin fired silver deposit to give the required conductivity. As the "winding" adheres rigidly to the ceramic former, its expansion with temperature is limited by the latter's low coefficient of thermal expansion. Thus not only are permanent maintenance of inductance value and cyclicity attained, but also a low temperature coefficient of inductance. Fig. 8 shows examples taken from a range of such coils; a 25 μH coil recently tested had a temperature coefficient of the order of + 15 parts/million/° C., and was completely cyclic within the limits of measurement over several temperature cycles.

There seems every reason to believe that compensated oscillatory circuits can be produced to compare favourably with crystal drives. They certainly must show a considerable saving in bulk, weight and cost as compared with circuits using a multiplicity of crystals to provide alternative frequency channels for communication. Moreover, no difficulty arises when changes in each of several operating frequencies must be made quickly, whereas with crystal drive the complete set of crystals must be changed—by no means a light undertaking if many hundreds of oscillators have to be altered. It may be possible at a latter date to give data of the performance of experimental oscillators with varying types of compensation. A word of warning may not be out of place meantime; the most accurate of compensation can be ruined if care is not taken to ensure that all circuit components change in temperature at substantially equal rates. Also every precaution must be taken to reduce the effects of varying humidity—in this connexion the use is strongly recommended of ceramic condensers of the type in which the dielectric element is sealed into an outer protective tube. For most normal uses, a coating of good grade cellulose paint is adequate protection, but moisture films deposited on this paint can cause temporary capacity changes at least comparable with those due to temperature fluctuations; removal of the moisture films to a safe distance by means of an outer tube then proves to be the only adequate remedy where the highest attainable stability is desired.

There are many other possible applications of silvering technique which

(*Continued on page* 318)

The Pentode-Heptode

A New Method of overcoming Input Loss in H.F. Valves

THE object of providing an H.F. amplifying stage in a short-wave super-heterodyne receiver is (a) provision of greater preselection in order to remove spurious response, (b) reduction of radiation from the frequency changer and (c) provision of an improved signal/noise performance.

As the frequency is increased so the last requirement becomes more and more important. This is due to the fact that the signal-to-noise ratio of a receiver for a given voltage injected into the aerial depends upon the ratio of the signal volts developed across the input tuned circuit, to valve noise expressed as a voltage at the grid of the first valve. With increase of frequency a stage is soon reached where the obtainable voltage step-up of the aerial tuned circuit is limited by the low value of the input resistance of the H.F. amplifying valve.

As has been shown in a number of papers [1], [2], [3], [4], and more recently illustrated in this journal[5], the input resistance of a normal amplifying valve, shown in Fig. 1a, drops with increase in frequency both due to cathode lead degeneration and transit time loss.

The input conductance component, due to transit time is given by

$$\frac{1}{R_i'} = K_1 \, g_T \, \omega^2 \tau^2.$$

while the component of the input conductance due to cathode lead degeneration is given by

$$\frac{1}{R_i''} = g_T \, \omega^2 \, L_o C_{go}$$

where g_T = slope of cathode current-control grid volts characteristic

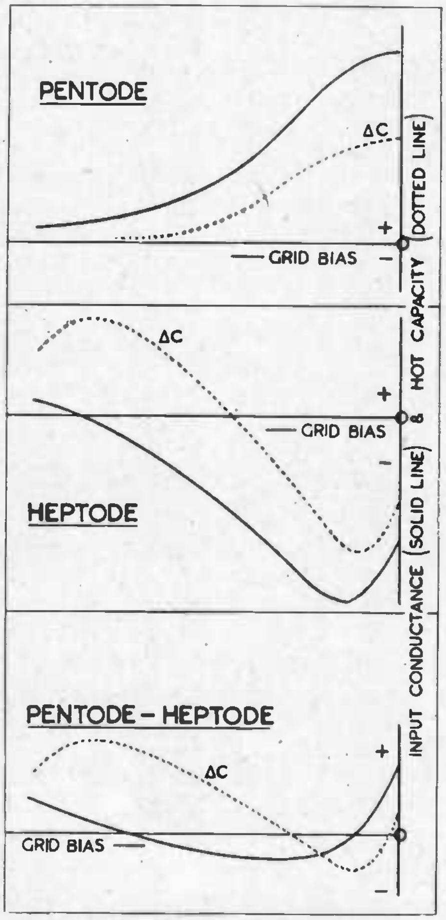


Fig. 2. Variation of input impedance and hot capacity for (a) Pentode (b) Heptode (c) combined Pentode-Heptode.

L_o = cathode lead inductance
C_{go} = grid-cathode capacity
ω = 2π (applied frequency)
τ = transit time between cathode and control grid
K_1 = factor depending on grid-cathode and grid-anode gap dimensions and applied voltages.

These two components of input circuit loss are difficult to separate as they are equally affected by changes in values of ω or g_T. In normal valves they usually have comparable magnitudes.

We can, therefore, lump the two effects and let

$$G = \frac{1}{R_i'} + \frac{1}{R_i''}$$
$$= \omega^2 g_T \left[L_o \, C_{go} + K_1 \, \tau^2\right]$$

a typical curve for this is shown by the full curve in Fig. 2a.

For simplicity the lead-self inductances and interelectrode capacities of the other electrodes have been omitted. Their effect will still mainly be a function of $\omega^2 g_T$ and can be expressed as either an increase or decrease of the product $L_o C_{go}$. For a detail analysis see reference[3].

If instead of employing a normal pentode amplifying valve Fig. 1a, in which the signal is applied to a grid between the cathode and a high potential electrode (screen grid), a heptode amplifying valve in which the signal is applied to a grid situated between two high potential electrodes (Fig. 1b) is used, cathode lead degeneration will be eliminated, as cathode current is practically unaffected by changes in the bias of the third grid. In addition, however, it can be shown that the G_3 to cathode space will now exhibit a negative conductance over the major portion of the I_a/V_{g3} characteristic and that this conductance will be theoretically a function of

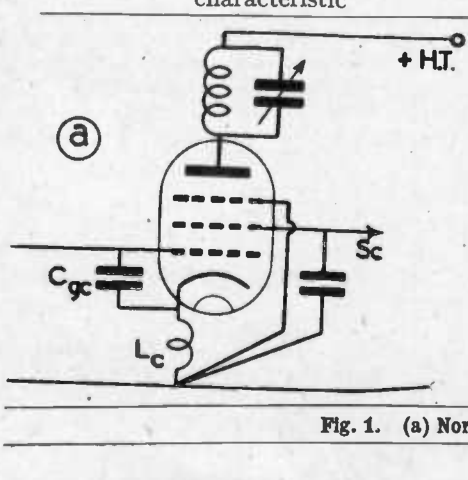
$$\frac{1}{R_i'''} = K_2 \, g_m \, \omega^2$$

where g_m = the slope of the anode current to V_{g3} characteristic

K_2 = a factor depending on the gaps between the electrodes, the applied voltages and the current collection of g_4 and includes the transit time.

Actual measurements carried out by different research laboratories have shown the exponent of ω to lie in the region from $1\frac{1}{2}$ to 2.

A typical input conductance characteristic plotted against V_{g3} volts is shown on Fig. 2b.



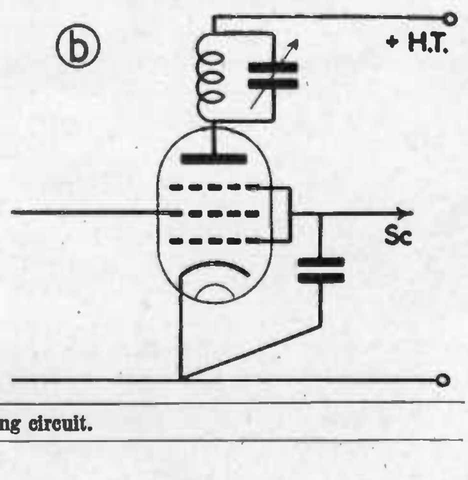


Fig. 1. (a) Normal Pentode and (b) Hexode or Heptode amplifying circuit.

R. L. Freeman and the Hazeltine Corporation have suggested (British Patent No. 535,969) the use of two such electrode structures in parallel in order to eliminate the input loss, the signal being applied to the first grid of one structure and to the third grid of the second structure. Under these conditions it will be seen that the negative conductance of one system may be made to neutralise the loading of the other system. The total conductance being given by

$$\frac{1}{R_1} = \omega^2 \left[g_T \left(L_0 C_{g0} + K_1 \tau_2 \right) - K_2 g_m \right]$$

this is shown in Fig. 2c which is a summation of the two full-line curves in Figs. 2a and 2b.

By suitably proportioning the individual characteristics of the two sections it is possible to make the input conductance have any desired value at a selected operating point. If, however, it is desired to A.V.C. the system, greater care has to be taken to match the shape of the two component conductance characteristics in order to prevent the negative conductance reaching excessive values within the working bias range.

Fig. 3 illustrates one of the suggested arrangements in which the two electrode structures have been combined into one system. The valve is provided with five grids. The first grid of the heptode section is connected to the cathode and included so as to enable a reasonably high positive voltage to be employed on the second grid without drawing excessive current. The third grid of the heptode section acts also as the first grid of the pentode section. The fourth grid is the screen grid and is joined to the second grid, and the sixth is the normal suppressor grid.

In order to obtain a sufficiently high slope in the pentode system, it might be necessary to subdivide the third grid into two sections so as to enable a small grid cathode to be provided in the pentode system.

While the system described suffers from the inherently reduced signal/noise ratio of the heptode section, due to the higher value of the current sharing noise, at a sufficiently high frequency, this might be more than compensated by the increased step up obtainable in the aerial tuned circuit as a result of the reduced input loss.

The dotted curves in Fig. 2a and 2b illustrate the general shape to be expected of the variation of the hot capacity with bias volts for the pentode and heptode, respectively. It will be seen that the hot capacity Δc of the heptode for low biases is negative; that is, the total working capacity of the valve is less than the measured cold capacity. As the bias is increased the hot capacity goes through zero and then becomes positive. The dotted curve in Fig. 2c shows the variation of the total hot capacity for the combined system.

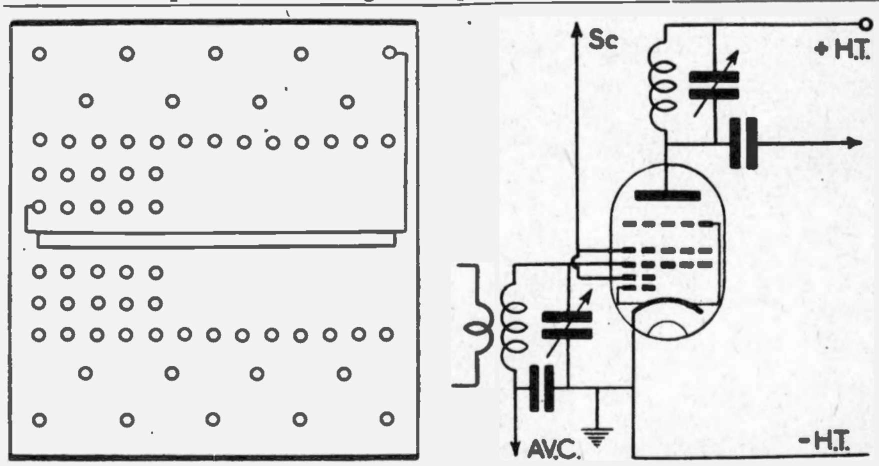


Fig 3 Construction of Pentode-Heptode valve (due to R. L. Freeman)

REFERENCES.

[1]. W. R. Ferris: "Input Resistance of Vacuum Tubes as U.H.F. Amplifiers." *Proc. I.R.E.*, Jan., 1936

[2]. D. O. North: "Analysis of the Effects of Space Charge on Grid Impedance." *Proc. I.R.E.*, Jan., 1936.

[3]. M. J. O. Strutt and A. van der Ziel: "The Causes for the Increase of the Admittance of Modern H.F. Amplifier Tubes on Short Waves." *Proc. I.R.E.*, Aug., 1938.

[4]. H. Rothe: "The Operation of Electron Tubes at High Frequencies." *Proc. I.R.E.*, July, 1940.

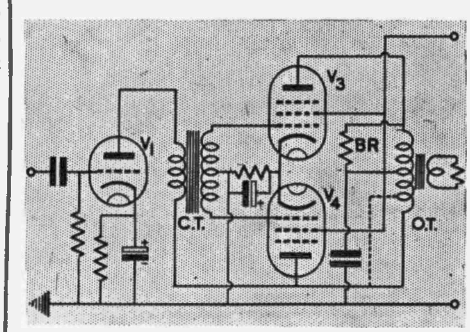
[5]. C. E. Lockhart: "Gain Control of R.F. Amplifiers—its Effect on the Input Admittance." *Electronics and Television & Short-Wave World*, Aug., 1940.

A New Negative Feed-back Amplifier

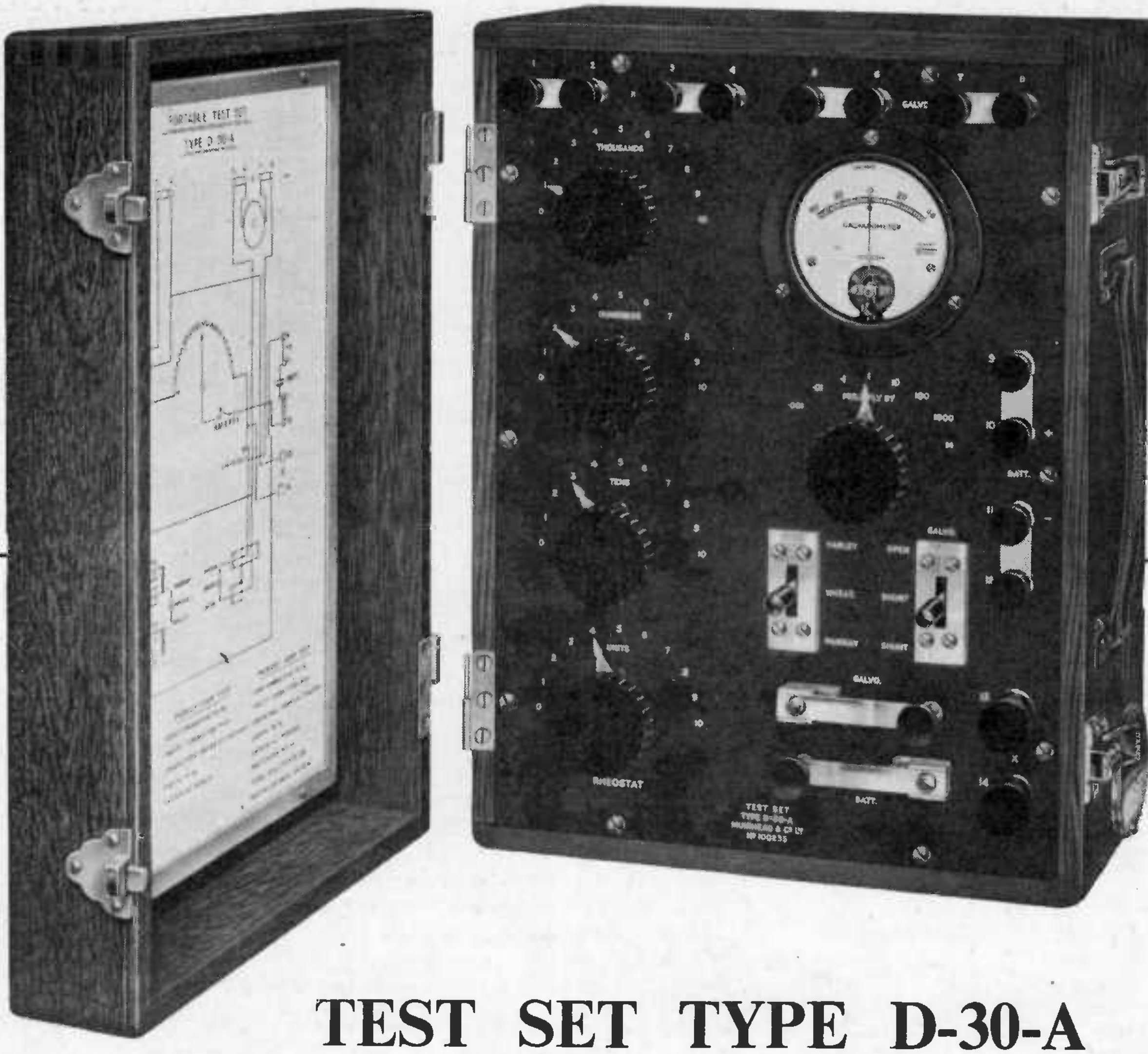
In amplifiers operating with negative feedback a separate path connecting the output and the input circuit is usually provided for the feedback, and this involves the use of a number of additional components.

In two amplifier circuits recently suggested by the Radio Corporation of America negative feedback is utilised without providing a separate path, so reducing the number of circuit elements.

A conventional amplifier having the first valve coupled to the output valve by a resistance capacity coupling with the difference that the anode resistance is connected to the anode of the output valve. With this arrangement a fraction of the anode voltage of the output valve is fed back negatively to the grid, the fraction being determined by the relation between the anode impedance of the first valve and the value of its anode resistance.



In the figure the same idea is applied to an amplifier in which a valve is transformer-coupled to a push-pull output stage. The primary winding of the intervalve transformer is connected to the anode of the valve of the push-pull pair which oscillates in the appropriate phase for the feedback via the coupling transformer to be negative. The amount of feedback can be reduced if desired by connecting the primary winding of the intervalve transformer to a tapping point in that portion of the primary of the output transformer which is in circuit with the valve from which feedback voltages are derived, the feedback decreasing as the tapping point approaches the centre tap on this winding. It is preferable, in order to avoid upsetting the balance of the push-pull stage, to connect a resistance across the whole or part of the other half of the primary winding of the output transformer so that the effect of the feedback connexion is balanced.



TEST SET TYPE D-30-A

RANGE - .001 ohm to 11.11 megohms

DIMENSIONS - - - 12½" x 9½" x 6"

WEIGHT - - - - - 12 lbs.

A descriptive bulletin will be supplied on request.

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DATA SHEETS IV and V

On the High-Frequency Characteristic Impedance of Transmission Lines

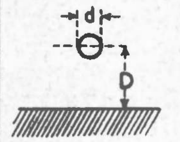
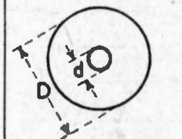
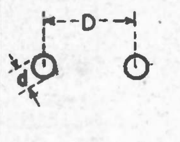
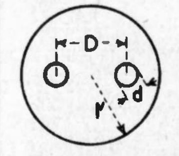
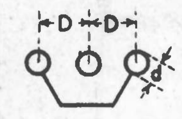
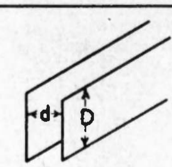
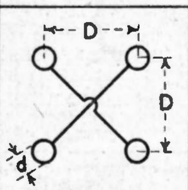
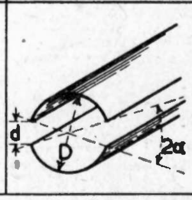
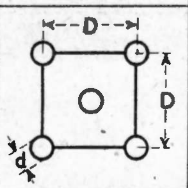
Line	No.	Diagram	Equation	Line	No.	Diagram	Equation
SINGLE WIRE LINE	I		$Z_0 = 60.\log_e 4\frac{D}{d}$	CONCENTRIC LINE	VI		$Z_0 = 60.\log_e \frac{D}{d}$
TWO WIRE LINE	II		$Z_0 = 120.\log_e 2\frac{D}{d}$	SHIELDED PAIR	VII		$Z_0 = 120.\log_e \frac{2D}{d}\left[\frac{1-\left(\frac{D}{2r}\right)^2}{1+\left(\frac{D}{2r}\right)^2}\right]$
THREE WIRE LINE	III		$Z_0 = 90.\log_e \sqrt[3]{4}\frac{D}{d}$	PARALLEL THIN STRIP LINE	VIII		$Z_0 = \frac{1190}{\frac{\pi D}{d}+1+\log_e\left[\frac{\pi D}{d}+1+\log_e\left(\frac{\pi D}{d}+1\right)\right]}$ for $D \gg d$
FOUR WIRE LINE	IV		$Z_0 = 60\log_e \sqrt{2}\frac{D}{d}$	SPLIT CYLINDER (THIN WALL)	IX		$Z_0 = \frac{296}{\log_e\left\{\cot\left(\frac{\alpha}{2}\right)+\sqrt{\cot^2\left(\frac{\alpha}{2}\right)-1}\right\}}$ $\approx 296 \div \log_e \frac{4D}{d}$ (for α small)
FIVE WIRE LINE	V		$Z_0 = 75\log_e \sqrt[5]{2}\frac{D}{d}$	Where more than one wire is present, all wires have the same diameter.			Z_0 in Ohms D, d & r are measured in the same units $\log_e X = 2{\cdot}303 \log_{10} X$

Table. Equations for Characteristic Impedance used in Calculating the Curves Overleaf.

THE characteristic impedance of a transmission line is one of the most important line constants and is equal to the input impedance of an infinitely long line. It is usually designated by Z_0 and $Z_0=$

$$\left(\frac{1}{\sqrt{k}}\right)\sqrt{\frac{R+j\omega L}{G+j\omega C}} \quad \ldots\ldots\ldots\ldots \quad (1)$$

where R = the resistance in ohms per unit length of line.

G = the leakage conductance in mhos per unit length of line.

L = the inductance in henries per unit length of line.

C = the capacity in farads per unit length of line.

K = the dielectric constant of the medium between line elements.

$\omega = 2\pi$ (applied frequency in c.p.s.).

At high frequencies with low-loss lines having air dielectric (k = 1) this may be simplified to

$$Z_0 = \sqrt{\frac{L}{C}} \text{ ohms} \quad (2)$$

As the velocity of propagation of electromagnetic waves in low-loss lines is equal to the velocity of light "c" and is also given by

$$v = \frac{1}{\sqrt{LC}} = c \quad \ldots\ldots \quad (3)$$

we can write

$$Z_0 \doteq \frac{1}{cC} \quad \ldots\ldots\ldots \quad (4)$$

which gives a more convenient method of computing Z_0.

It is the object of Data Sheets Nos. 4 and 5 to present the numerical solution of equations (2) and (4) in the form of a series of curves covering the majority of lines to be met in practice.

Table 1 gives the equations for Z_0 for nine types of lines in terms of their physical dimensions. The actual system of units used for D, d and r is immaterial provided the same system is used throughout.

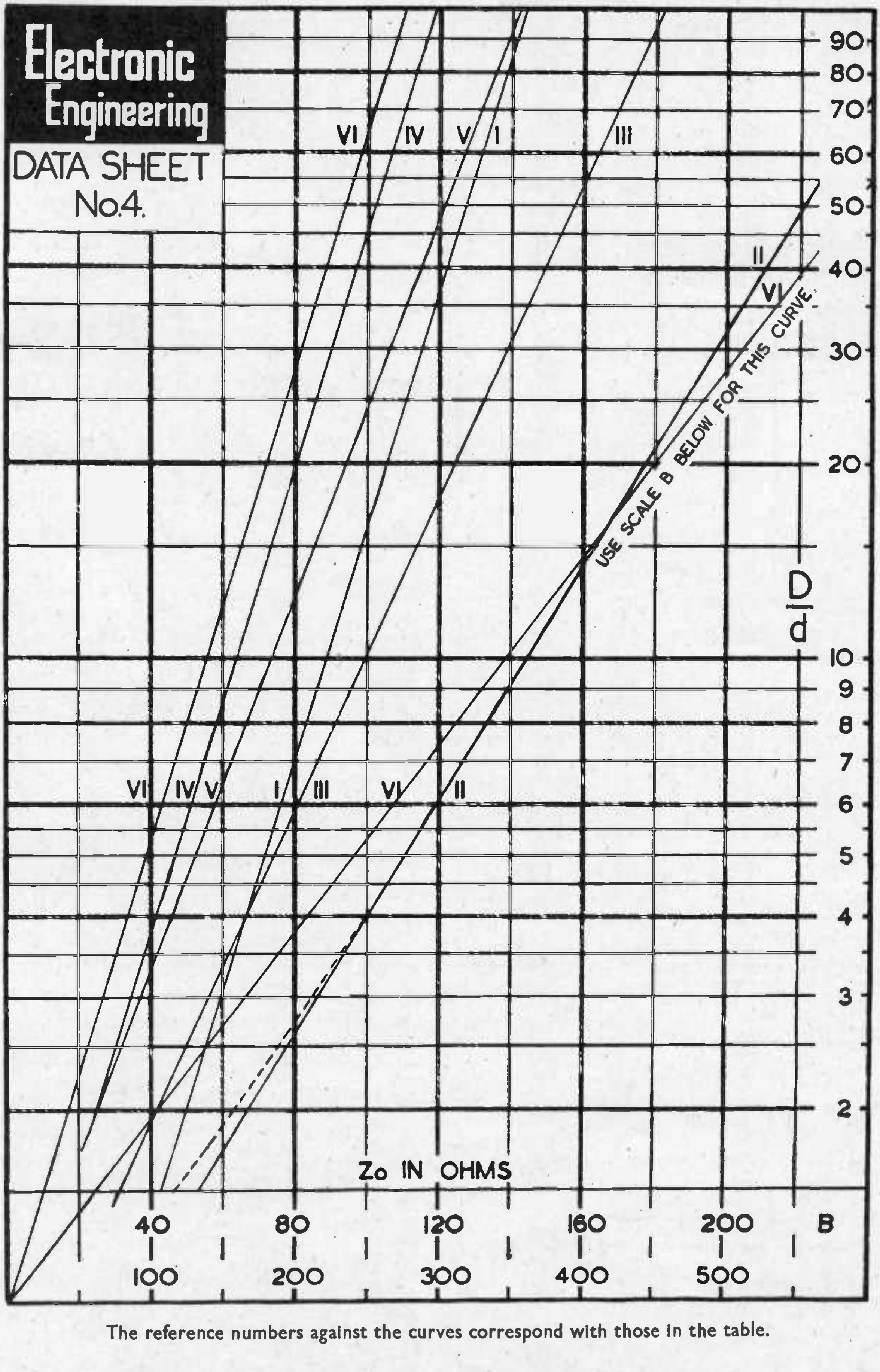
The first four lines in the table are open wire lines. Line I representing the case of a single feeder above earth or a connecting lead or wire above a chassis. It has half the characteristic impedance of a two-wire parallel line II of twice the spacing, but it gives an asymmetric circuit with much larger losses.

The equations given for Z_0 are only approximate for low values of D/d owing to the non-uniform distribution of current in the wires at close spacings. For example, the exact equation for the two-wire parallel line is

$$Z_0 = 120 \cosh^{-1}(D/d) \quad \ldots\ldots\ldots\ldots \quad (5)$$

$$= 120 \log_e \left[D/d + \sqrt{(D/d)^2 - 1}\right] \quad (6)$$

which is illustrated by the dotted line in Data Sheet 4. A similar correction



The reference numbers against the curves correspond with those in the table.

CURVES OF CHARACTERISTIC IMPEDANCE OF TYPICAL LINES

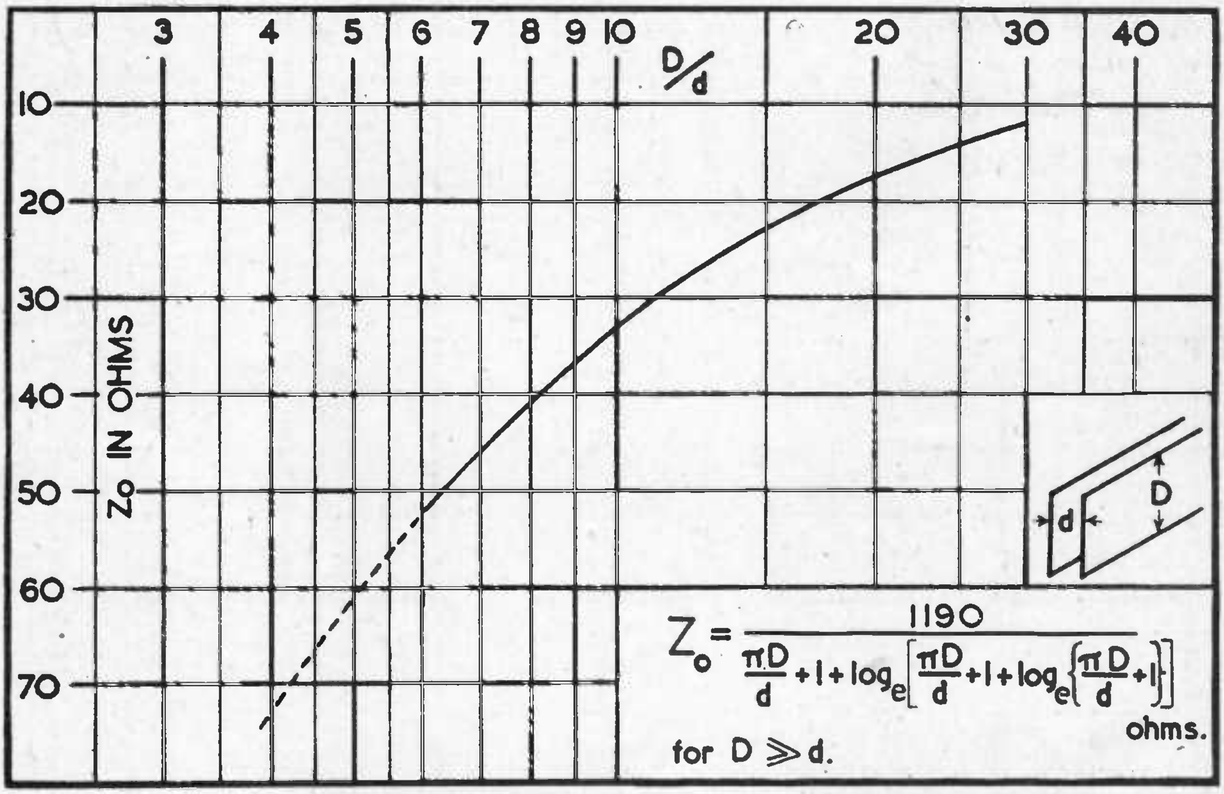
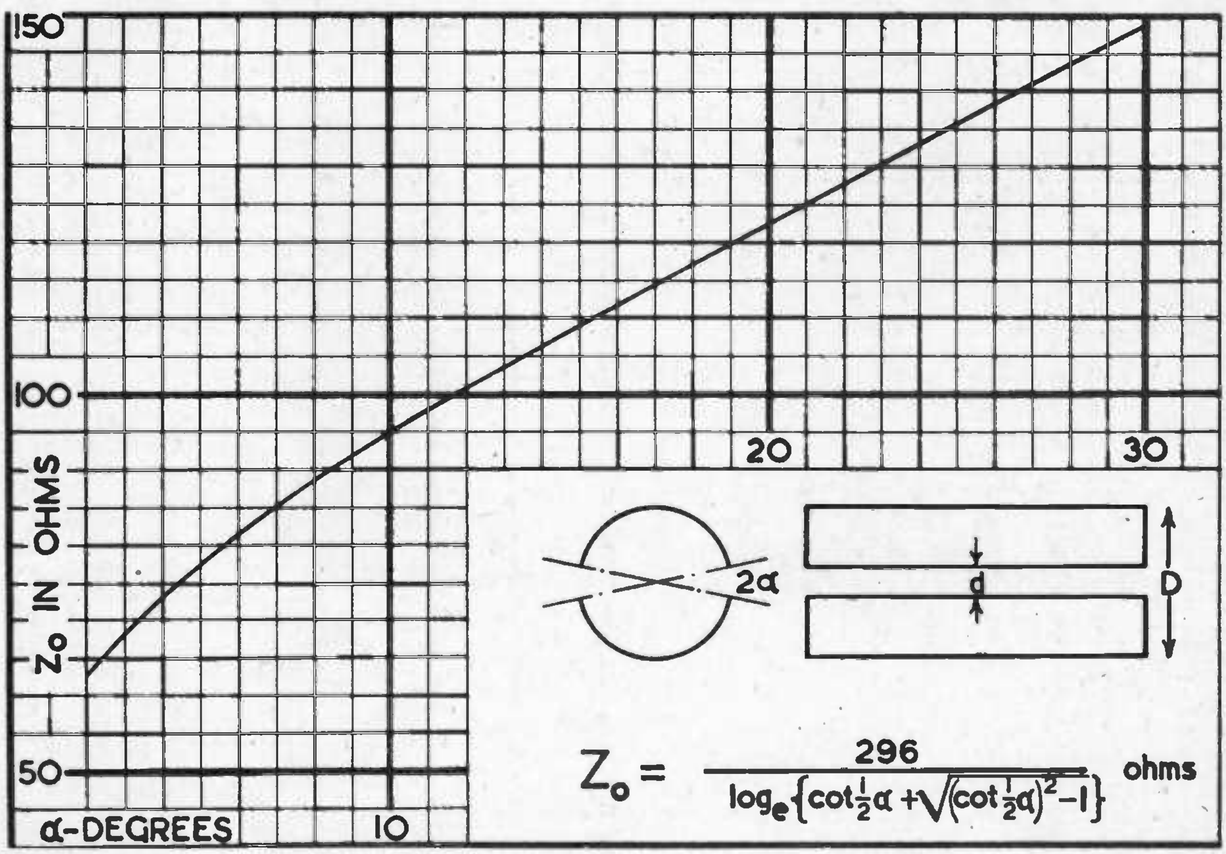
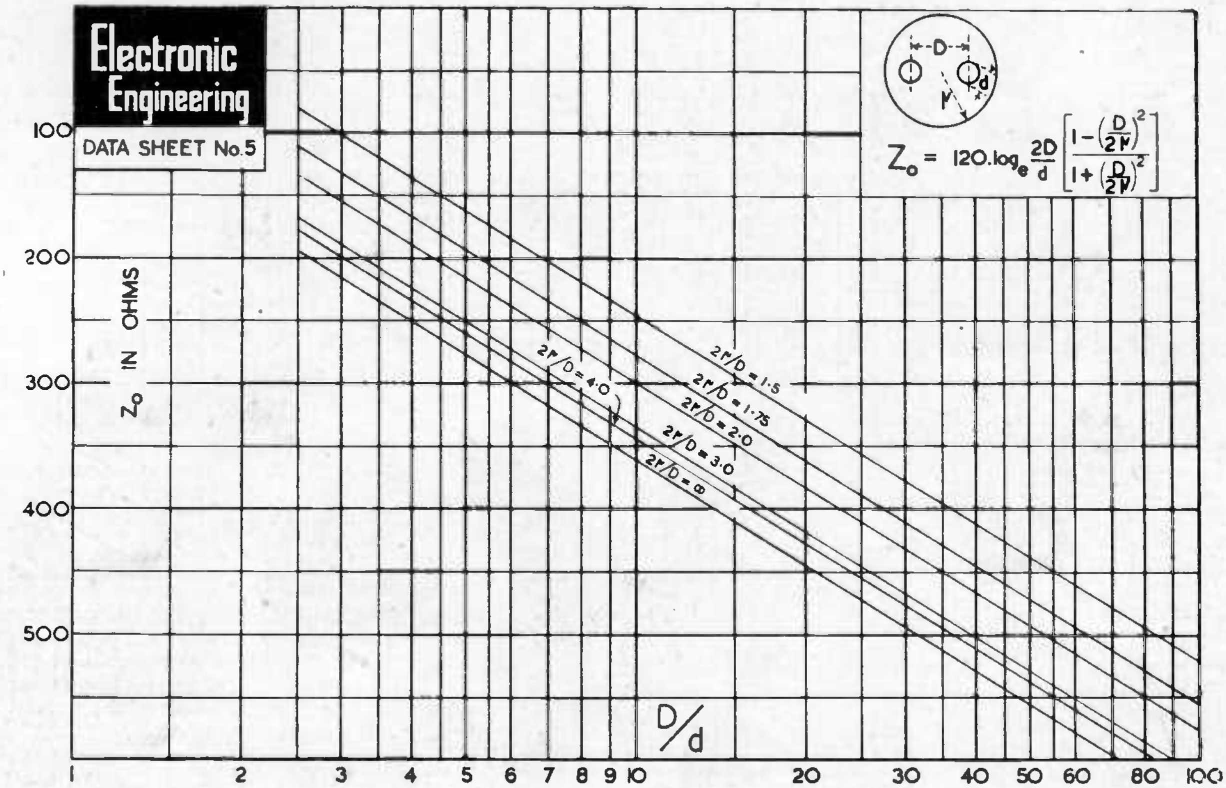


Chart 2 (above) Characteristic Impedance of Thin Parallel Strips.
Chart 3 (below) Characteristic Impedance of Thin Split Cylinder.





Characteristic Impedance of Shielded Pair Transmission Line.

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would be required for the single-wire line.

It will be seen that for the majority of practical cases the approximate relation given in the table is sufficiently accurate.

The three parallel-wire line III and the four parallel-wire line IV illustrate possible methods of reducing the characteristic impedance while preserving symmetry. The five-wire line V is a case approaching the normal concentric line; as the number of wires on the outer periphery is increased so Z_0 of the line approaches nearer and nearer the characteristic impedance of a normal concentric line VI.

As the range of Z_0 for usual concentric lines lies between, say, 50 and 150 ohms, the values for Z_0 are given on an expanded scale providing greater accuracy on Data Sheet 4. For comparative purposes, however, the values for Z_0 for the concentric line are also shown to a common scale with the open-wire lines by the left-hand curve VI.

Data Sheet 5 illustrates the case of a shielded pair VII which for large values of 2r/D becomes identical to II.

An expression for Z_0 in terms of line dimensions for the case of a line consisting of two thin parallel strips VIII (thickness of strip material $\ll$ d) is unfortunately only available when D $\gg$ d.

The value of Z_0 against D/d is plotted on chart 2 of Data Sheet 4. The curve, however, has been shown dotted for the lower values of D/d though the errors there may be appreciable.

The last case treated in Table I is the split cylinder line IX. This type of line has been used as the anode system of ultra-shortwave split anode magnetrons at wavelengths of the order of 8 cm. The approximate relation for Z_0 given in Table I, which can also be written as $Z_0 = \dfrac{296}{\log_e \dfrac{4}{\sin\alpha}}$ ohms, gives results within 1 per cent. of the full expression for values of $\alpha < 15^\circ$.

Earthing

With the exception of lines I, VI, VII, and to a lesser extent V, the expressions for Z_0 are accurate only provided neither conductor is connected to earth and that any earthed object is at a distance from the line large compared to the wire or plate separation.

In the case of lines VI and VII the outer sheath is assumed to be earthed and for VII the inner two-wire line to be symmetrically fed. Similarly the other wire and strip lines are assumed symmetrically fed and disposed with respect to earth.

C.E.L.

ERRATA

On Data Sheet II the formula for the Time Delay should read

$$\frac{\pm\phi^\circ}{360^\circ f} = \frac{\pm\phi\,(\text{radians})}{2\pi f}$$

The equation (6) on page 258 should agree with the equation on Data Sheet I.

Data Sheets in the August issue will cover Resonant Lengths of Lines.

Vibrators

By S. L. ROBINSON
(Masteradio Ltd.)

AFTER passing through various vicissitudes the vibrator has arrived at a stage where it is a completely reliable and efficient component, which is playing its part in many war-time applications where ability to stand up to hard work is of paramount importance.

The modern vibrator probably owes much of its development to car radio, the use of which in America has reached enormous proportions, and in which the vibrator is universally used as the means of obtaining the H.T. supply.

In appearance, the vibrator is a metal tube of approximately the size of a receiving valve, and the similarity is added to by the fact that usually the same form of connexion is employed—that is, pins on the base of the vibrator to plug into a valve-holder. It is usual for vibrators to have bases equivalent to American valves, four pins for the interrupter types, and five, six or seven pins for the self-rectifying types, although in one noteworthy case a special seven-pin base is employed for use with self-rectifying vibrators enabling the polarity of the output to be reversed by plugging the vibrator into one of two positions. This is a very necessary feature in car radio, where the car chassis (earth) may be used as either the negative or positive in the electrical wiring system.

If the outer metal can which serves as a screen is removed from a vibrator, the driving coil and contact assembly will be found; these are usually mounted on a stout metal bracket formed as an elongated " L " or " U," making a complete assembly. This assembly is fitted into a moulded sponge-rubber base through which are brought out the connecting leads to be soldered to the base pins. More sponge-rubber in the shape of a tube is slipped over the assembly and the whole is fitted into its screening can, the bottom end of the can being spun over the base plate. It is interesting to note that the sponge-rubber mentioned above, which plays the important part of damping-out the mechanical vibrations of the reed, is a special non-sulphorous rubber, and therefore cannot have any detrimental effect on the metals in the contact assembly. The foregoing mechanical details can be seen in Fig. 1.

In dealing with the electrical specifications of vibrators, they can be divided into two basic forms. Firstly, the " interrupter " type, variously called the " non-synchronous " or " valve " type, the latter name referring to the necessity of using a rectifying valve to obtain the D.C. output from the transformer. Secondly, there is the " synchronous "

Fig. 1. Sectioned vibrator unit showing driving magnet, reed and contacts.

or " self-rectifying " type, which possesses an extra pair of contacts for rectifying the output and thus obviating the use of a valve. The synchronous types can be sub-divided into two further classes, the one possessing a split reed enabling the input and output to be completely isolated from each other and thus coming in line in this respect with the interrupter types using a valve rectifier. The second type of synchronous vibrator not possessing the " split reed " feature must necessarily have the input and output negatives common. This on the face of things would appear to be a serious disadvantage, if the apparatus being operated requires the negative filament, and H.T. negative isolated for bias purposes, but this can easily be overcome by providing a separate winding on the transformer for this requirement.

In the writer's opinion the advantage of the split reed is completely overshadowed by the sounder mechanical construction of the types employing a reed which is made in one piece.

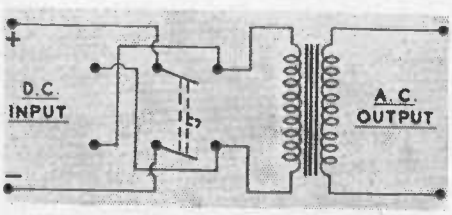


Fig. 2. The principle of the vibrator.

To come now to the functions of vibrators, let us make an analogy with A.C., which is probably the simplest method of explanation. If a D.C. voltage were applied to the primary of a transformer, there would be no flux change in the transformer core, except at the instant of application, and, therefore, no transformation of power from the primary to the secondary. If the same D.C. could be made to alternate first in one direction and then the other, through the primary there would be an " alternating current " flowing, and the transformer would operate in a similar manner as on A.C. (see Fig. 2). The double-pole double-throw switch used in Fig. 2 to alternate the current in the transformer primary could, if the primary were centre-tapped, be replaced by the simpler single-pole double-throw switch in Fig. 3. It will be seen that this switch connects the D.C. first through one half of the primary and then through the other half, which produces what is essentially an " alternating current " which can be transformed and rectified to high-voltage D.C. It is

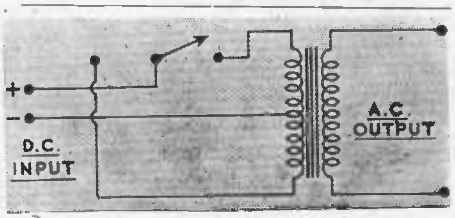


Fig. 3. Single pole switch replacing the double switch of Fig. 2.

possible to replace the simple switch in Fig. 3 with a vibrator. In Fig. 4 we have the simplified switching arrangement carried out by a magnetically driven switch or vibrator. This arrangement shows the vibrator reed being caused to vibrate by the driver coil shunted across the contacts, so that when current is applied to the vibrator the coil is energized, and pulls the reed towards the magnet.

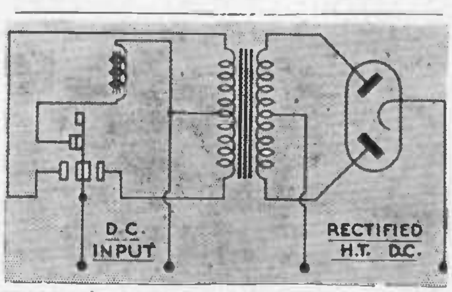


Fig. 4. Vibrator unit acting as switch of Fig. 3.

As the reed approaches the magnet, the contact points short the coal, destroying the magnetic force, and the reed springs back past its normal position to make contact with the opposite point. This operation is rapidly repeated at a frequency usually in the neighbourhood of 115 cycles per second. This method of causing the reed to vibrate is known as the "shunt type" driver coil system. Fig. 5 shows a different method of obtaining the magnetic force to energize the vibrator reed, and is known as the "series type" driver coil system. In this arrangement an extra pair of contacts are necessary.

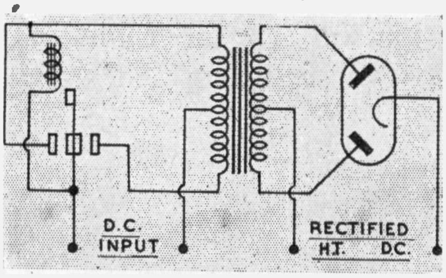


Fig. 5. Alternative method of energizing the reed.

These are opened when current is applied by the reed bearing one of the contacts being attracted towards the magnet. The breaking of this circuit having destroyed the magnetism in the coil, allows the reed which has gained sufficient momentum to travel somewhat farther and connect with the main contact, and from there it springs back to the opposite contact, thus completing the cycle. This latter method suffers from the obvious disadvantage of having an extra pair of contacts to wear out and also cause interference by the inevitable sparking which must take place every time the circuit is made or broken. The number of times at which the reeds complete the above cycle of operations per second is called the "vibrator's frequency," and in the better class of units this is remarkably stable, and varies very little between different vibrators. The frequency of different makes of vibrators, however, varies considerably, especially in units made before 1937-38. Prior to this date, full-wave vibrators were manufactured with frequencies of 85, 90, 100, 115, 135 and 165 cycles per second, but to-day the frequency of 115 cycles per second is generally adopted, having been found to give very satisfactory results.

Coming now to an examination of the self-rectifying types of vibrators, reference to Fig. 6 shows that the rectifying valve in Fig. 4 is replaced by a second single-pole double-throw switch, ganged to the first switch in the primary circuit (not electrically connected), and made to operate simultaneously. This would in effect reverse the operation of the primary switch and act substantially as a rectifier to the alternating output from the secondary of the transformer. In this arrangement the polarity of the switch rectified output would depend entirely on the polarity of the D.C. input. Reversal of polarity can be effected by changing over the outsides of the secondary, or, with certain Vibrators, where the special seven-pin base is used, by plugging the vibrator into the socket in the opposite position. In most receivers and other types of apparatus it is usual to have the L.T. and H.T. negatives grounded. Therefore both blades of the switch could be thus connected together both mechanically and electrically, or in the vibrator; the reed can be made in one piece with a consequent gain in mechanical strength and a simplification of manufacture (see Fig. 7). By using this method of construction, all the common interrupter and rectifying contacts can be mounted on the one reed, and thus operate synchronously. The synchronous types of vibrators possess one advantage over the simpler interrupter types in that the rectifying valve is not required, so that the watts employed in heating this valve's filament are saved and a consequent gain in overall efficiency obtained.

Two basic types of vibrators have been shown—Fig. 4 for interrupter types, and Fig. 7 for self-rectifying types—and with all the different variations of bases and connexions to the base pins, all modern vibrators can be classified into one of these two types. There is, however, a slight variation in the self-rectifying types, as previously mentioned. This is illustrated in Fig. 6.

The writer has personally carried out tests on American vibrators which well illustrate the reliability and efficiency of vibrators. In the first series of tests a synchronous vibrator (six-volt type), with a continuous primary current rating of 7.5 amps, was connected into a circuit with a transformer giving a D.C. output of 600 volts at 65 mA, and consuming 8 amps at 6 volts. By increasing the input volts the output was raised to 620 volts at 120 mA, while the input current rose to 12 amps, representing an overload of approximately 60 per cent. Under these conditions the vibrator was run for sixteen hours, and at the end of this period very careful checks were made, which showed that there had been absolutely no decrease in efficiency. The vibrator was then opened up and examined, and the contacts were found to be "as new." After reassembling the vibrator it was once more run, but by decreasing the load the output voltage was allowed to rise to find out where "flash over" took place, and it was not until the 900-volt mark had been passed that this occurred.

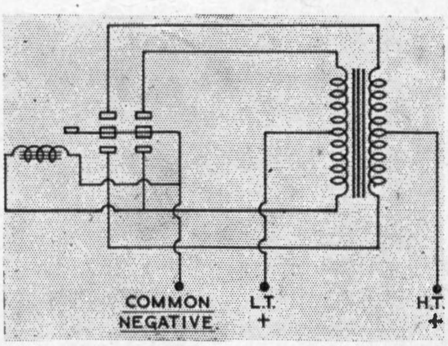


Fig. 6. Simplified self-rectifying vibrator.

The second test, which was intended as a life test, and which was never completed because the vibrator—a non-synchronous unit—after running continuously for 2,500 hours on load (not exceeding the maker's rating) with a falling off in efficiency of only 4 per cent., showed every sign of continuing to run indefinitely.

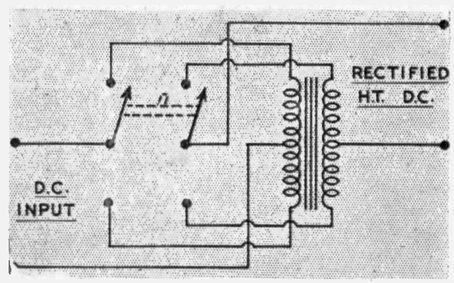


Fig. 7. Principle of self-rectifying vibrator.

Valve Circuits Utilising Inductive Output Currents

It is well known that when electrons flow through a grid in a valve currents are induced in the external circuit associated with the grid, even though the grid takes no current. The R.C.A. laboratories have recently developed some useful circuit arrangements based on this phenomenon. The general idea is to include a resonant circuit in the suppressor grid lead of a pentode and to make use of the signal frequency voltage set up across the circuit by the induced currents. Depending on various factors, such as the decrement of the coils, the impedance of the valve, and the bias on the control grid, the voltage thus obtained may be as high as 80 per cent. of the anode output voltage.

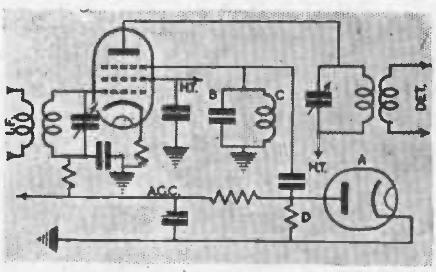


Figure 1 shows the principle supplied to A.G.C. in the I.F. stage of a superhet. The diode rectifier A is connected across the tuned circuit B,C, in the suppressor grid lead of the pentode, and develops across the resistor D a uni-directional voltage whose magnitude varies directly with the amplitude of the I.F. carrier; this is led back by the line marked A.V.C. to control the grid bias of the pentode or of previous valves, as is usual.

As the voltage developed across the circuit in the suppressor lead is effectively applied to the suppressor, if the voltage is large it exercises control upon the anode current, since the suppressor grid operates as a control grid having a small amplification factor. This effect is utilised in the following arrangements.

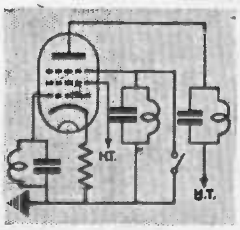
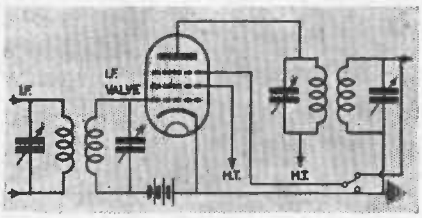


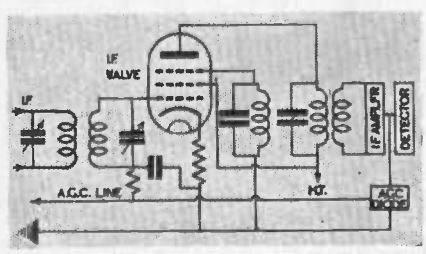
Figure 2 illustrates an arrangement for providing a simple band-width control by means of a switch connected across the tuned circuit in the suppressor grid lead: when this switch is closed, the resonance curve of the anode output circuit is a single sharp peak; when open, the curve is a broad double



peak. This same arrangement may also be used as a regenerative amplifier, or as an oscillator by suitable adjustment of control grid bias.

Figure 3 shows an alternative way of controlling band width, using the secondary circuit of the anode output transformer as the suppressor grid tuned circuit; this gives a broad resonance curve when the switch is connected to the upper contact, and a sharp curve when connected to the lower contact.

Figure 4 illustrates one way of providing automatic selectivity control in the I.F. stage of a superhet. In this case the suppressor circuit is tuned to a frequency just above the operating intermediate frequency, while the anode circuit is tuned accurately to the intermediate frequency. When the control-grid bias applied via the A.V.C. lead is small, the circuit is operating regeneratively,



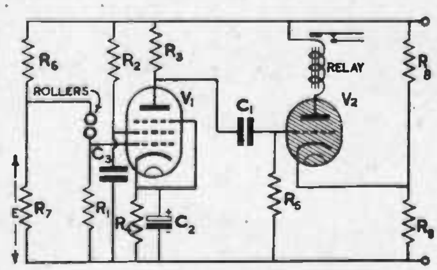
so that gain and selectivity are increased in the anode circuit; as the A.V.C. bias increases (due to increased signal carrier amplitude), regeneration ceases, reducing gain and selectivity. For very high amplitudes, such as occur with local reception, this effect is more marked, due to the slight detuning: thus a simple and economical automatic selectivity control is provided.

Detecting Pinholes in Rubberised Canvas

by A. W. Russell

Since rubberised canvas is used fairly extensively in A.R.P. work under conditions where is must be impervious to gas, it is of considerable importance to determine whether the layer of rubber has "taken" evenly over the whole area of the canvas, or whether minute pinholes have been left. The canvas itself is closely woven and pinholes in the rubber are very difficult to detect by eye, even when a very strong source of light is used behind the material.

If, however, the rubberised canvas is placed between two electrodes saturated in brine or some suitable conducting liquid, the resistance between the electrodes, which is normally of the order of tens of megohms, drops to a few thousand ohms if there is a pinhole in the rubber layer. A suitable method of testing consists in passing the material between a pair of insulated rollers saturated with the liquid chosen and using the circuit shown.

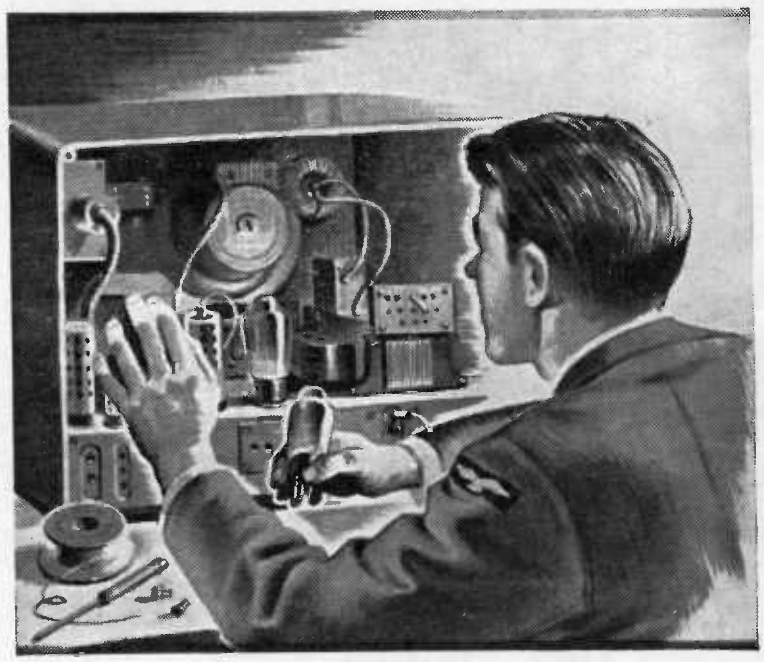


V1 has cathode bias as shown, while the grid receives further negative bias up to a maximum E1, the actual value being determined by the ratio of the resistance between the rollers and the value of R1. When there are no pinholes the resistance is very high and the bias on V1 is equal to the drop across R4. When, however, the resistance falls to a few thousand ohms indicating the presence of a pinhole, the negative bias is increased causing a positive impulse to be fed to the grid of the gas triode V2, which then fires, operating the relay in its anode circuit. This relay may be used to ring a bell or make a mark on the edge of the material to indicate roughly the position of the pinhole.

Suitable component values are given in the following table and using these values the relay will operate whenever the resistance between the rollers drops below 25,000 ohms. To change this limiting value it is only necessary to change the values of E1 and R1.

R1	5,000 ohms	C1	0.5 mfd.
R2	0.125 meg.	C2	50 mfd.
R3	5,000 ohms	C3	8 mfd.
R4	500 ohms	V1	Mullard EF36
R5	1.0 meg.	V2	Mullard EC 50
R6	32,000 ohms	Relay:	10 mA.
R7	1,000 ohms		17,500 ohms
R8	24,000 ohms		
R9	1,000 ohms		

Let the RAF make you a Radio/Wireless Mechanic



As Britain's air power grows, the need for Radio/Wireless Mechanics increases . . . . . . now, more than ever before, Radio/Wireless Mechanics are needed — and they are needed AT ONCE. Keen young men between 18 and 34, interested in the practical side of wireless, should volunteer immediately. They will be trained in the maintenance and repair of the most up-to-date radio and wireless equipment. Theirs will be a responsible job . . . . . a job upon which depends the safety of the air crews of the R.A.F. When peace returns their training and experience will stand them in good stead in civilian life. Go to-day to the R.A.F. Section of the nearest Combined Recruiting Centre (address from any Employment Exchange) and tell them you want to volunteer for immediate duty.

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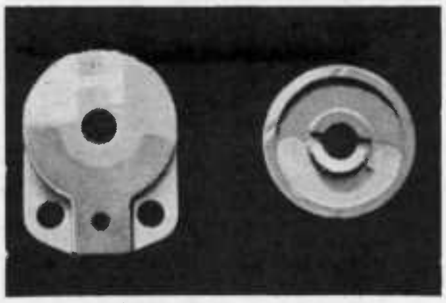
Low Loss Ceramics

(*Continued from page 303*)

will present themselves to an enterprising designer. A simple case is that of insulating bushes for the terminals or lead-out wires of apparatus to be sealed permanently against moisture. These can be silvered over appropriate areas and then soldered directly into position. Various insulating supports can be silvered and soldered directly to metal parts, thus simplifying assembly and producing components of great rigidity. Again, complete assemblies of valve holders, coil mountings, condenser and switch insulation can be arranged on a single piece of ceramic, with silvered areas replacing the function of metal parts normally attached by bolts or rivets—even the connecting leads can be formed in this way. While such extremes are unnecessary at normal frequencies, the possibilities are worth consideration in ultra-high frequency designs.

In valves of conventional design, use is now often made of ceramics for bases and the internal electrode supports, and in 1939 experimental valves were shown at the Berlin Radio Exhibition in which the electrode structure was carried directly on pins sealed to a ceramic disk base, the envelope being formed by a dome-shaped ceramic moulding sealed to the base by glazing. While the ceramic envelope seems an unnecessary complication, this use of a ceramic base should lead to an appreciable reduction in both losses and capacity change during warming-up, as compared with the all-glass base of the rather similar American Loctal construction.



Parts of Ceramic trimmer condenser.

Insufficient is yet generally known of the properties of ultra-high frequency circuits to enable any forecast to be made of the importance of ceramics in this field, nor are any methods of measurement yet established whereby the properties of insulating materials can be measured accurately at frequencies greatly in excess of 100 megacycles.

In conclusion of this present series of articles, I wish to acknowledge the help I have received from my colleagues in their preparation, and to express my thanks to the management of Steatite and Porcelain Products, Ltd., for permitting publication of the articles and of photographs of the Stourport factory.

New American Valves

R.C.A. 6SF7.—A combined single diode variable-mu H.F. pentode metal valve recommended for use as a combined I.F. amplifier and detector, but is also suitable for use as a resistance-coupled A.F. amplifier and will give the same high gain and voltage output as other similar pentodes. The heater rating is 6.3 volts 0.3 ampere.

R.C.A. 12SF7.—Identical to the 6SF7 except for the heater rating which is 12.6 volts 0.15 ampere.

R.C.A. 6SN7-G.T.—A glass valve comprised of two triode units. The cathodes of each triode are brought out to separate base pins. It is recommended for use in resistance-coupled circuits as a voltage amplifier or phase invertor.

R.C.A. 930.—A new photo-cell recommended for use in sound reproduction and relay applications. Electrically this is as the type 923 and physically as the type 929.

SYLVANIA 7V7.—A receiving pentode amplifier whose characteristics feature, it is claimed, the highest mutual conductance combined with the lowest anode-to-grid capacity possible for practical applications of a valve of this type.

Review of Progress in Electronics

(*Continued from p.* 300)

to form any definite rules, since this factor depends greatly upon manufacturing methods and the subsequent ageing process. If the ageing is thorough, any drift or change of sensitivity during normal use should be very small—not more than 2 or 3 per cent. In accurate measurements, however, the effect should always be looked for.

Applications

The order of magnitude of the current available in some types and sizes of photo-voltaic cell introduces the possibility of operating electro-magnetic relays and other devices directly, without intermediate amplification. In this case it is necessary to match the cell resistance carefully with the load, as already mentioned, so as to obtain maximum power, and if relays are used they must produce adequate contact pressure with an exciting current corresponding to the output of the cell.

In cases where amplification is necessary, the use of a D.C. amplifier may be avoided by interrupting the light at a steady rate, as by means of a rotating slotted disc, and using a conventional audio-frequency amplifier. Typical connexion diagrams for both arrangements are given in Fig. 7. It may be mentioned in conclusion that if voltage is applied to the cell there is in general a change of barrier-layer resistance and of the photo-voltaic effect. In the case of selenium cells the conditions are further modified by the photo-conductive effect. It was found by Bergmann[9] in the case of a front-wall selenium cell that, if the selenium was made negative by 12 volts with respect to the metal film and a small 2-volt, 0.25-ampere lamp connected in the circuit, the lamp lit up when the cell was illuminated by a 100-watt lamp at a distance of 20 cm. With only 4 volts, and illumination from an arc lamp, currents of the order of 150 mA were readily obtained. This arrangement offers distinct possibilities in connexion with the operation of relays.

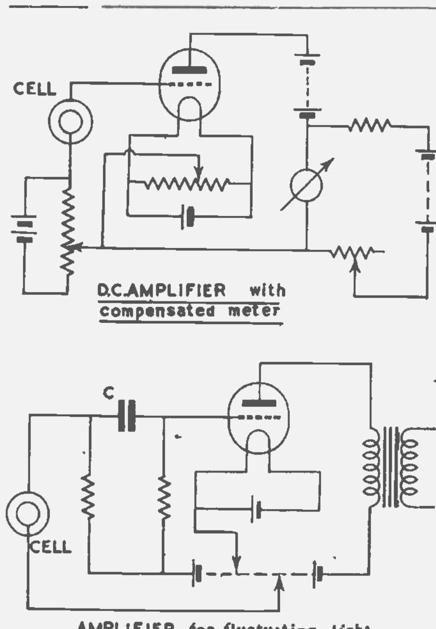


Fig. 7.

Bibliography

1 W. G. Adams and R. E. Day, Proc. Royal Soc., 25, 1877, p. 113.

2 C. E. Fritts, Amer. Journ. Sci., 26, 1883, p. 465; Lum. electr., 15, 1885, p. 226.

3 W. Uljanin, Ann. der Phys., 34, 1888, p. 242.

4 A. Righi, Wied, Ann., 36, 1889, p. 464.

5 N. F. Mott and R. W. Gurney, "Electronic Processes in Ionic Crystals," Oxford, 1940.

6 A. H. Pfund, Phys. Rev., 7, 1916, p. 289.

7 L. O. Grondahl, Phys. Rev., 27, 1926, p. 813; Science, 64, 1926, p. 306; (with P. H. Geiger) Trans. A.I.E.E., 46, 1927, p. 357; U.S. Patent No. 1,704,679 of 1929; Rev. Modern Phys., 5, 1933, p. 141.

8 B. Lange, Phys. Zeits., 31, 1930, pp. 139, 964.

9 L. Bergmann, Phys. Zeits., 32, 1931, p. 286.

10 B. Lange, "Photo-Elements," New York (Reinhold), 1938.

11 A. L. Hughes and L. A. Du Bridge, "Photo-Electric Phenomena," New York, 1932.

12 B. Gudden, "Lichtelektrische Erscheinungen," Berlin, 1928.

13 R. H. Mighell, G.E. Review, 40, 1937, p. 372.

14 C. H. Bartlett, Rev. Sci. Insts., 3, No. 10, Oct., 1932.

15 B. P. Romain, Rev. Sci. Insts., 4, 1933, p. 83.

16 W. N. Goodwin, Trans. Illum. Eng. Soc., 27, No. 9, Dec., 1932.

17 W. N. Goodwin, Journ. Soc. Motion Pict. Engrs., 20, 1933, p. 95.

18 L. Bergmann, Phys. Zeits., 34, 1933, p. 227.

19 A. Dressler, Licht u. Lampe, 22, 1933, p. 93.

Sinclair Speakers

Messrs. Sinclair Speakers whose head office is at Pulteney Terrace, Copenhagen Street, London, inform us that their works have suffered slight damage by enemy action, but production has not been affected in any way.

CHANGE OF ADDRESS

Messrs. Chas. F. Ward, of 46, Farringdon Street, London, E.C.4, manufacturers of rotary convertors for radio and other purposes, notify us that they have now moved to 37, Whitepost Lane, Hackney Wick, E.9.

PATENTS RECORD

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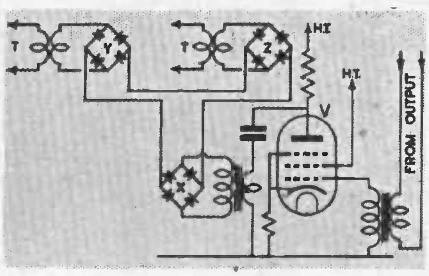
RADIO AND COMMUNICATIONS

Reception

Combined Compression and Expansion Circuit



A compressor circuit consisting of a three-stage amplifier has a control circuit bridged across the output valve by means of an additional valve V and a dry contact rectifier X. Negative feedback is applied to the first two stages of the amplifier by the rectifier bridges Y and Z acting as variable impedances in the negative voltage feedback circuit. The transformers T T isolate the control current from the feedback circuit and step up the impedance of the variable controlling bridge Y in the first stage.

In a form of expander circuit a similar control circuit is bridged across the input of a two-stage amplifier. Negative feedback is applied to both amplifier stages to an extent depending on the input to the control circuit. The gain of the amplifier is thus made to vary with the input level.

An experimental compandor set up according to these principles had a range of approx. 40 dB. and a ratio of 4½ : 1. The system gave an improvement of 30 dB. in signal-noise ratio.—*Standard Telephones and Cables, Ltd., and C. P. Rose. Pat. No.* 535906.

TELEVISION

Scanning System

The picture-signals, combined with both sets of synchronising impulses, are fed to the grid of the same valve. The cathode lead of the valve includes a choke coil which has a substantial impedance at the frequency of the line-scanning impulse, though practically none to the comparatively low " framing " frequency. Voltages at line frequency are accordingly developed across it and tapped off. The framing impulses are, in turn, developed across a resistance in the anode circuit, and are separately tapped off to their appropriate terminal. The valve is initially biased so that it reaches saturation point for any input voltage that is higher than the " black " datum line; this automatically filters out the picture signals.

The presence of the choke in the common cathode lead automatically produces a negative feed-back of the line impulses. It is found that this prevents phase-distortion and so keeps the desired saw-toothed shape, without, however, leading to any serious attenuation of their amplitude.—*Standard Telephones and Cables, Ltd., and D. N. Corfield. Patent No.* 532,718.

Periodic Wave Generators

A periodic wave generator is described comprising a high-mu value, preferably of the screen-grid type, having output electrodes coupled to the load circuit with one polarity and a low-mu valve having output electrodes coupled to the load circuit with opposite polarity. The output current of the high-mu valve varies continuously with time increasing during the trace intervals, and causes the low-mu valve to vary continuously with time in an opposite sense. The current of this valve decreases irrespective of the increasing voltage applied during the trace intervals.

The low-mu valve is so controlled and the output voltage across it so regulated that the rate of change of the saw-tooth current in the load circuit of the generator is substantially uniform and the wave form is thus substantially linear during the trace intervals.—*Hazeltine Corporation. Patent No.* 526,153.

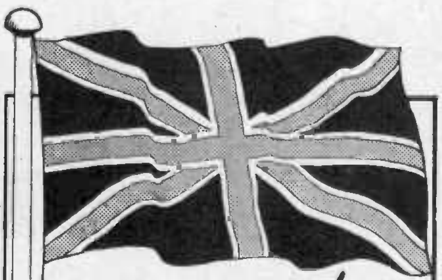
Pulse Sharpener

To provide a multi-vibrator or two valve relaxation oscillator circuits in which the flow of grid current is avoided, so that sharp substantially rectangular pulses from the oscillator can be obtained up to frequencies as high as 10 megacycles per second.—*E. L. C. White. Patent No.* 535,633.

MEASUREMENT

Electronic Frequency Meter

A frequency meter in which the multi-vibrator consists of two triodes, the anodes of each of which are connected through an impedance to a positive potential, and then through a further impedance to the grid of the other valve. Frequency is measured between the anode of one valve and the grid of the other on the grid side of the impedance. — *Marconi's Wireless Telegraph Co., Ltd., and H. Jefferson and P. E. Jellyman. Patent No.* 536,106.



CATHODE RAY TUBES

Fluorescent Screens

According to the invention a small decanting pipe is sealed into the C.R. tube just above the enlarged base. This allows the liquid to be poured out without applying much tilt. In addition, it allows the liquid to be removed without flowing over the metallic coating deposited to act as an anode higher up the tube. If fluorescent particles are allowed to attach themselves here, they are liable to produce an undesirable "haze."—*Marconi's Wireless Telegraph Co., Ltd. Patent No.* 532,886.

Improved Deflector Plate System for U.H.F

When the electron stream of a C.R. tube is deflected at increasingly high frequency, the time comes when the full deflection due to the applied control voltage is not secured, owing to the time taken by the electrons to pass from one end of the deflection plate to the other.

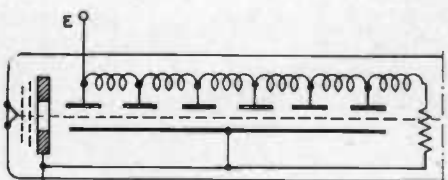


FIG I.

In order to overcome this difficulty, the deflection plates of a cathode-ray tube intended for handling very high frequencies are made to simulate a retardation line, so that the effect of the applied control voltage is, in practice, slowed down to keep pace with the passage of the electrons in the stream. This object is secured by splitting the deflection plate into a number of sections, as shown in Fig. 1, each section being connected to the other by an inductance. The series inductances, in combination with the shunt capacities to the opposite plate, can be arranged to produce any lag required to produce a correct deflection of the electron stream for a given working frequency. —*Standard Telephones and Cables, Ltd. Patent No.* 532,996.

Improvements in the construction of high vacuum cathode-ray tubes employing asymmetrical electrostatic deflection and having as an object the reduction of trapezium distortion, particularly in the case where the total angle of deflection is greater than 20 degrees. —*A. C. Cossor and E. E. Shelton, Patent No.* 529,523.

ABSTRACTS OF ELECTRONIC LITERATURE

Thermionic Tubes

Fluctuations Induced in Vacuum Tube Grids at High Frequencies

(D. O. North and W. R. Ferris)

A theoretical formula for the noise induced in the input circuit of vacuum-tube amplifiers by fluctuations in the electron stream is compared with measured values. The results are found to be in substantial agreement.—*Proc. I.R.E.*, Vol. 29, No. 2, Feb., 1941, p. 49.

A Simple Vacuum Tube Relay

(Serfass)

Details are given of a compact vacuum tube relay which is contained in a case measuring 4 × 4 × 2 inches. Many advantages are claimed for this relay, including simplicity of construction, low control current, high degree of sensitivity, large plate current, power line operation and alternating or direct current operation. The control current is limited to a maximum of about 5 micro-amps., whilst the plate current is stated to be as high as 45-50 mA. The high plate current eliminates the necessity for using a sensitive relay. *Ind. and Engg. Ch. Analytical Ed.*, April, 1941, p. 262.

Circuits

Distribution of Amplification with time in Fluctuation Noise.

(V. D. Landon)

The purpose of this paper is to show that fluctuation noise has a statistical distribution of amplitude versus time which follows the normal-error law. This fact is also correlated with the measurements of crest factor made on the noise output of band-pass amplifiers by various investigators.

It is shown that the distribution of noise amplitude has been passed through frequency-selective circuits. It is shown why the measurements of crest factor made by various experimenters group around the value 4, but it is pointed out that this is not a true wave crest-factor because the voltage occasionally goes considerably higher. The ratio of the effective voltage is shown to be 0.798. A discussion is given of the kinds of noise which do not follow the normal-error law.—*Proc. I.R.E.*, Vol. 29, No. 2, Feb., 1941, p. 50.

Vacuum Tube Scaling Circuit

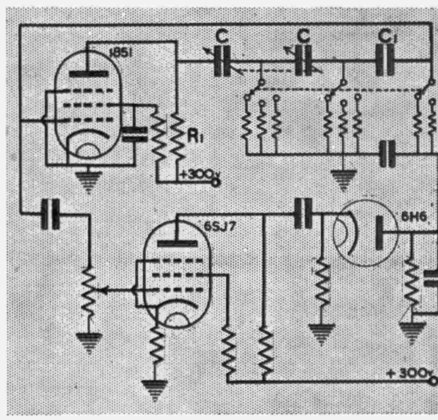
(Don De Vault)

A counting circuit is described in which certain desirable characteristics are obtained by applying the tripping impulses to the cathodes of the scaling tubes. The circuit is a scale-of-sixteen type employing hard valves with no interstage complications.—*Jour. Opt. Soc. America*, Vol. 31, No. 4, April, 1941.

Phase-Shift Oscillators

(E. L. Ginzton and L. M. Hollingsworth)

This paper describes a type of resistance capacitance tuned oscillator which operates with a single valve. A three or more mesh phase-shifting network is connected between the output and input of an amplifier. When the gain of the amplifier is adjusted either manually or by an A.G.C. circuit barely to maintain oscillation, almost pure sine-wave output is obtained. Variation in the basic circuit have been analysed and design formulæ are included in this paper. Experimental work varified theoretical expectations. A typical oscillator was found to have distortion of 0.1 per cent. at an output voltage of 20 volts.—*Proc. I.R.E.* Vol. 29, No. 2, Feb., 1941, p. 43.



Measurements

A Precision Thermionic A.C. Test Set

(K. A. Macfadyen and N. D. Hill)

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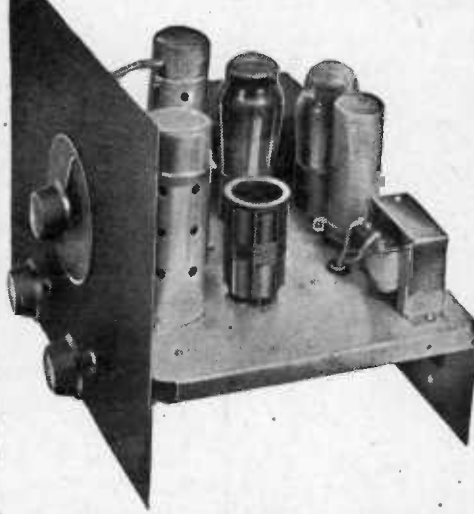

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Book Reviews

Electro-magnetic Theory

J. A Stratton (McGraw-Hill Book Co. 600pp. and dappendix. 116 figs. 42s. net).

This volume forms part of the "International Series of Physics" issued by the McGraw-Hill Co., and provides a thorough treatment of variable magnetic fields and theory of wave propagation. Some attention is given to the stationary state, but only for the purpose of introducing fundamental concepts under simple conditions.

The book is intended for the physicist and research worker rather than the engineer, and the reader must possess a really sound knowledge of electricity, magnetism and mathematics to appreciate it. Commencing with Maxwell's equations, the first two chapters are general in character. Stationary fields are treated as particular cases of dynamic field equations in Chaps. 3 and 4, and the propagation of plane cylindrical and spherical waves is followed by a chapter on radiation. Some boundary-value problems are considered in the final pages, which make interesting reading, but the main object is again a sound exposition of the principles involved rather than a detailed treatment. The majority of the chapters are followed by sets of problems with answers and references, and more of the latter would be welcome in the main text. An interestiug innovation is the use of the M.K.S. system of units throughout.

The author is to be thanked for such an excellent treatise, which is wholeheartedly recommended to all workers on radiation and wave propagation problems. The publishers are to be congratulated on providing a book which, however excellent, can have but a limited circulation, and the reviewer would suggest that they placed physicists even more in their debt by providing a companion volume dealing in greater detail with aerial radiation, cavity resonators, rhumbatrons, and other topics of engineering importance at the present time which the limitations of space have precluded from the present volume.

Plastics

V. E. Yarsley and E. G. Couzens, (Allan Lane 6d.)

One assumes by the fact that this book has been published in a "popular" series—it is a "Pelican"—that it is intended primarily for laymen. If this is so it can certainly be considered successful.

Normally, a popular treatise on a technical subject is viewed by the technician with a certain amount of scorn, but there is too much solid fact in this book to allow him to criticise it from this standpoint. For readers of this journal the obvious main interest is the application of plastics in the sphere of electrical and radio engineering, but the scope of the book is much wider than this. After a short historical survey a concise chapter follows on the chemical structure of plastic materials which sets the background for the remainder of the book. The few technical terms employed need not give the layman any undue concern, yet at the same time they give the technician the necessary clues to enable him to pursue the subject in more advanced treatises.

The astounding variety of materials and objects which is covered by the term "Plastics"—from shoe-lace tags to aeroplanes, from cellophane to coffins—justifies the comment in the short preface, that, "the possible applications being almost inexhaustible, it looks as though we were already in the throes of a second industrial revolution, the threshold of the Plastic Age." This view is very well presented in the two final chapters on the significance and future of plastics.

The value of the book would, perhaps, have been somewhat enhanced if at least a short bibliography could have been added, but to have included in such compact form so much information and in so readable a style is a notable achievement.

Tropical Receiver Design

AT the opening meeting of the Students' Section of the Institution of Electrical Engineers the new Chairman, Mr. M. J. H. Lemmon, presented an address on tropical receiver design of which the following is a summary :

Until about 1938 it was thought satisfactory to send out to India India or other tropical countries receivers which differed very little from those sold on the home market, with the result that sets of British make were not at all popular, mainly owing to their inability to stand up to tropical atmospheric conditions.

When designing a receiver for export use, a number of points not encountered in home-market design require consideration. These are mainly due to the necessity of ensuring that the receiver shall be capable of withstanding the most rigid climatic conditions. Other points arise out of sales requirements, and are therefore dependent upon the reaction of the purchasers. Novel features such as push-button station selection, motor tuning, etc., are not in demand for export receivers. The following are the main design requirements : (a) High sensitivity. (b) Good A.V.C. characteristics. (c) Frequency stability. (d) Effective "magic eye" indication on short waves. (e) Large audio power output. (f) Tropical proofed components. (g) Chassis finish. (h) Transport stability. (j) Reliability in service.

Where a high-frequency stage is employed the overall sensitivity of the short wave-bands is usually about 5 to 10μV for an output of 500mW across the speech coil of the loud-speaker. Where 13 m. band listening is widely used, its is often preferable to design the aerial circuit to give the highest sensitivity at this wavelength; this can most easily be done by using top capacitance aerial coupling. Owing to the use of a common capacitance to serve for all wavelengths between 13 m. and 90 m., the condenser, being of a low value (about 7.5 $\mu\mu$F), causes a greater slope in the sensitivity curve on the higher-wavelength band than on the 13 m. to 30 m. band, but as the overall sensitivity at any point is well under 10μV this effect is not at all serious.

In spite of present conditions, the London Students Section is endeavourto maintain its normal activities throughout the coming session. The following officers were elected for 1941-42: Chairman, M. J. H. Lemmon; Hon. Sec., J. D. McNeil, B.Sc.; Council's representative, F. Jervis Smith, A.M.I.E.E. The first social function of the session will take place on Sunday, June 22. Further details can be obtained from the Hon. Secretary, care of the Institution, Savoy Place, W.C.2.

ABSTRACTS (*contd.*)

The Interval Selector

(*Roberts*)

A description is given of a device for measuring the time distribution of pulses. It is stated that in conjunction with two scaling circuits the apparatus records the total number of pulses in a distribution, and also the number of intervals between pulses less than 0.0001 to 0.3 second. The application of the interval selector to the testing of particle-counting apparatus is described.—*Rev. Sci. Instr.*, February, 1941, p. 71.

An Electron Microscope for Practical Laboratory Service

(*Zworykin, Hillier, Vance*)

It is stated that the electron microscope has now been developed to a point where it is capable of a useful magnification nearly two orders of magnitude greater than the ordinary light microscope. The microscope described is claimed to be simple to adjust and operate, is self-contained and occupies only a small amount of space. The specimens are mounted on a cellulose film about 0.000001 cm. thick supported by a fine wire mesh.—*El. Engg.*, April, 1941, p. 157.

Video Output Systems

(*D. E. Foster and J. A. Rankin*)

The advantages and disadvantages of direct coupling, grid rectification, and diode rectification as a means of accomplishing d-c reinsertion are discussed. It is pointed out that d-c reinsertion tends to restore low frequencies.

The characteristics of circuits to obtain uniform high-frequency response are discussed. The circuits dealt with are shunt peaking, series peaking, series m-derived filter sections, shunt m-derived filter sections, and two-section constant-K filter sections. The performance of typical video output tubes with the several circuit types as to gain and voltage output is shown.—*R.C.A. Review*, Vol. 5, No. 4, p. 409.

Industry

The Spoiling of Tungsten Magnet Steels

(*C. Wainwright, M.Sc.*)

This paper describes an X-ray examination of the structural changes occurring in tungsten magnet steels during heat-treatment, with particular reference to the deterioration in magnetic properties caused by heating between certain temperature lines.—*Jour. Sci. Instr.*, May, 1941, p. 97.

A Ballistic Meter for Measuring Time and Speed

(*Reich, Toomin*)

This paper describes a speedmeter in which a ballistic galvanometer serves as the indicating and recording element. Current flow through the galvanometer is initiated and stopped by means of a thyratron controlled by two switches. It is stated that the instrument was designed primarily for the measurement of automobile speeds in traffic studies, but should have other applications.—*Rev. Sci. Instr.*, February, 1941, p. 96.

INDEX TO ADVERTISERS

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