EDDYSTONE

Ultra Short Wave

GUIDE

PRICE 1/-

Fully Illustrated articles on —

MANY wireless experimenters will be making their introduction to the wavelengths below 10-metres at the present time. The object of the Eddystone Ultra Short Wave Guide is to present a number of tested circuits which can be relied upon for performance, together with a résumé in simple everyday language of other allied matters.

Those who are interested in ultra short wave television will find several inexpensive pieces of apparatus described which will be most useful in the workshop. For those who will be outside the range of the first experimental transmissions, a useful acquaintance with the ultra short waves can be obtained by experimental work on the 5-metre amateur bands which are now full of activity in all parts of the country.

5-metre work has a great fascination and is a hobby that can be carried on out of doors as well as in the workshop. The apparatus described has, therefore, been designed for battery operation, but with the usual conventional alterations, conversion to A.C. working is easily accomplished.

<div align="right">

Stratton & Co. Ltd.,
Eddystone Works,
Bromsgrove Street,
BIRMINGHAM 5

</div>

EDDYSTONE
ULTRA SHORT WAVE GUIDE.

CONTENTS

THE ULTRA SHORT WAVELENGTHS

A SHORT CHAT.

The use and possibilities of ultra short waves are now engaging the serious interest of the radio experimenter. Possibly, the advent of television broadcasts on these high frequencies has been responsible for a quickening of interest. Yet, pioneer work on wavelengths between 18 cm. and 10 metres has been carried out extensively for several years and it is a curious fact that this now new field of radio development was used by Heinrich Hertz in his earliest experiments in 1886 and was abandoned in favour of wavelengths of several thousand metres.

In order to compare the ultra short waves, let us group the band of wavelengths in general use for comparison purposes. The grouping, of course, is purely arbitrary in nature.

	Frequency Kc/s.	Wavelength Metres
Long Waves ..	300—10	1,000—30,000
Medium Waves	1,500—300	200—1,000
Intermediate Waves ..	3,000—1,500	100—200
Short Waves	30,000—3,000	10—100
Ultra Short Waves..	Over 30,000	Under 10

Of these, the long waves are, perhaps, the most consistent with freedom from fading over long or short distances, but great power is needed for long distance work. They suffer severely from atmospheric disturbances, as do also the medium and intermediate waves. The medium waves serve their main purpose for local broadcasting and only under favourable conditions does their range exceed 1,000 miles. They suffer from fading when the range increases. The intermediate waves have a smaller local range comparatively free from fading and a longer range subject to extreme fading.

The short waves have a small local range and a skip-distance which increases, as does the frequency, and also varies according to ether conditions. They have a world-wide range on the higher frequencies with comparatively small power necessary due to the fact that they are continually reflected back by reflecting ether layers above the earth surface. Their long distance possibilities vary greatly according to frequency and the time of day and they suffer considerably due to changes in the reflecting layers, which cause fading. On the other hand, they show a considerable freedom from atmospherics, which becomes greater as the frequency increases and becomes almost negligible on wavelengths below 17 metres. With modern knowledge of their peculiarities, they are extensively and successfully used.

We now turn to our main interest, the ultra short waves, the possibilities of which are being developed and final exploitations may cover unthought of territories. At the moment, their earth wave only is used and it is generally thought that the sky wave pierces the reflecting layers so that their range is considered as quasi-optical or horizon range. It may be found, however, that they have extreme long distance uses with very simple apparatus. With the means of generating these waves at our disposal, the fact that practical and useful experimental work can be carried out with small power and that many types of efficient aerials and aerial arrays, with widely differing characteristics, can be constructed in limited space and cheaply, affords the enthusiastic radio amateur unlimited scope for their future development.

To appreciate fully how the ultra short waves differ fundamentally from the longer waves it is necessary to consider the frequency difference more than the wavelength aspect of the case. For example, on the medium waveband from 200-600 metres, the wavelength ratio is 3 : 1. The frequency difference

THE ULTRA SHORT WAVELENGTHS—continued

is, however, only 1,000 kc/s. On the ultra short waveband from 3-9 metres, still a wavelength ratio of 3 : 1, the frequency difference is 66,667 kc/s. or nearly 67 times as great !

Let us now review some of the present uses and results which are known concerning these ultra short waves. Television, needing a high definition service to be of value, has been forced down to their use. A transmission needing a band width round about 2,000 kc/s. can only be accommodated in a waveband where the frequency is high and range short. In the whole of our intermediate and medium wavebands, only one high power television transmission could be accommodated, free of interference. Between 5 and 10 metres, 60,000 to 30,000 kc/s. and with limited transmission range, a number of services are available.

For ordinary telephony purposes, the ultra short waves provide a practical and portable wireless telephone with simple apparatus and small power. The range is local, but there appears to be distinct possibilities for police, fire and ambulance work since inter-communication between moving motor cars or with headquarters can be easily accomplished. To cover longer distances, high efficiency beam transmissions can be utilised as a wireless telephone link. Sharply beamed transmissions are also being tried in connection with fog landing systems for aircraft and for direction of seacraft into harbour during fog. In other spheres, the use of ultra short waves for curing disease, for the surgical destruction of tissue and for the maintenance of body temperature is being tried. Plants exposed to ultra short wave rays also show signs of greatly increased and rapid growth and intensive cultivation of certain types of produce by their use may be a possibility.

The range of the ultra short waves, as before mentioned, is considered as quasi-optical but there are a number of factors which must be taken into account. (For a first class television broadcasting service, 25 miles range is probably a fairly accurate estimate for reliable results). In the first place, the height of the aerial is of great importance. The range of an ultra short wave transmitter is increased the higher the radiating aerial. Transmissions from aeroplanes flying at several thousand

feet high can be heard over much greater distances than the same transmitter at sea level. Quite recently, an English amateur, G.5CV, took a small power ultra short wave transmitter to the top of Mount Snowdon and his signals were picked up 207 miles away. Under more normal circumstances, our own experimental ultra short wave transmitter (G6SL), with an aerial 50 feet from earth, 390 feet above sea level, has been heard just over 90 miles away. Apart from pure height, aerial design is of great importance and by using special beam aerial systems, the range can be considerably increased as compared with an omni-directional radiator. For a first class television broadcasting service, an efficient service range would, however, be not more than 20 to 30 miles. The range of ultra short wave transmissions over sea is greater than that of land areas.

One of the great features of ultra short waves for local communication purposes is that they are little affected in general reliability by time of day or weather, and further, they are comparatively free from fading and quite free from atmospherics. Our own experiments show there is little trouble from shielding up to distances of 10 miles but that at longer range, hills and obstructions do cause loss of signal strength. The rays appear to penetrate porous buildings much as light passes through a window, and they close in behind a hill or mountain, much as water waves close in behind a rock or just as a searchlight a mile away heads around a halfway house in its path.

It will be appreciated, therefore, that the ultra short wave field is full of possibilities and affords excellent scope for the ingenuity and ability of the constructive radio experimenter. Although this book deals mainly with ultra short wave work on 5 metres, the wavelengths under this and below 1 metre also show great promise for development in the future.
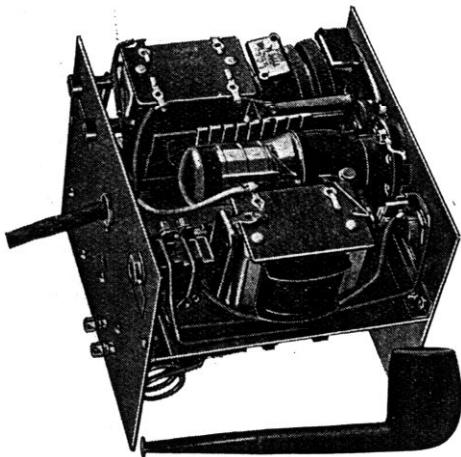
TWO VALVE TRANSCEIVER

COVERING THE 56 TO 60 Mc/s BAND.

One of the advantages of 5-metre work is the small power necessary to obtain results, and so practical apparatus which is quite portable can be built. Here, we describe a complete 5-metre band transmitter and receiver combined, built from standard parts into what is probably the smallest bulk possible, consistent with efficiency. A 120 volt H.T. battery, a 2 volt L.T. accumulator, microphone, 'phones and a telescopic aerial, form a complete equipment which can be carried anywhere by one person.

The transceiver has given good and consistent results over a prolonged test period and has achieved R9 2-way working over a distance of above 30 miles under favourable outdoor conditions. In the centre of a city, its range is reduced according to circumstances, but 5 mile working has been accomplished consistently under ordinary conditions and 2-way communication has been carried out between two travelling cars.
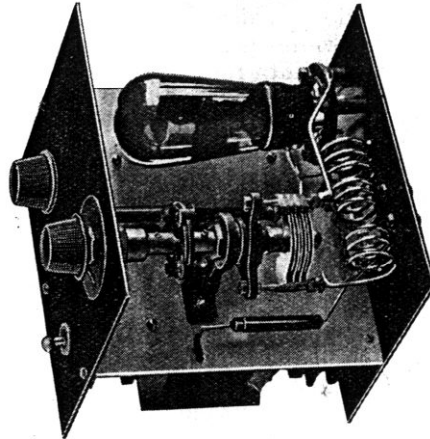
Top view of Transceiver showing oscillator valve, tuning control and condenser, and coils L1, L2 and L3, which are each 3 turns of 14g. copper wire, wound on a ¾″ core. The coils are supported in the wiring except the aerial coupling (centre) which is fastened on the paxolin panel to the feed out terminals.

Under side view of chassis compared with pipe to show small compact size. The modulation choke, modulator valve, send, receive switch, quench coil unit and microphone transformer are all clearly seen.

Most transceivers employ the squegging grid leak self-quench detector for reception, but in this model, the detector is not called upon to do both operations, the pentode modulator being utilised as a separate quench valve using quench coils. Change over to send or receive is made by a 3-pole shorting switch. An Osram LP2 small power valve is used as an oscillator for transmission and a detector for reception. The second valve is a Mullard PM22 pentode, used as a modulator for sending and as quench valve for receiving. The action of the switch is as follows. In the receive position, all points are open, the grid leak value being 3 megohms plus 10,000 ohms, 'phones in circuit, quench coils operative with drop resistance in H.T. feed. On send position, the grid leak value is 10,000 ohms, 'phones and quench coils short circuited, full H.T. in use. A microphone transformer is fitted, the microphone being plugged straight into back of set and the L.T. battery is used for energising it.

TWO VALVE TRANSCEIVER—continued

The construction of the receiver presents no great difficulty. A paxolin panel 6″×5″ is used at the back, a front panel 6″×5″ of 060″ aluminium and a sub-baseboard of the same, 8¼″×6″. The top and bottom views illustrated show the position of the component parts. An Eddystone Slow Motion Head with Flexible Coupler is used for tuning control. The

Adjustable Bracket must be cut down suitably in height.

The power output with 120 volts H.T. is about 1.5 watts. A half-wave aerial is recommended and this can be of the Zepp fed, Windom, Impedance matched or Johnson Q type as elsewhere described. The third named was the one used in our experiments.
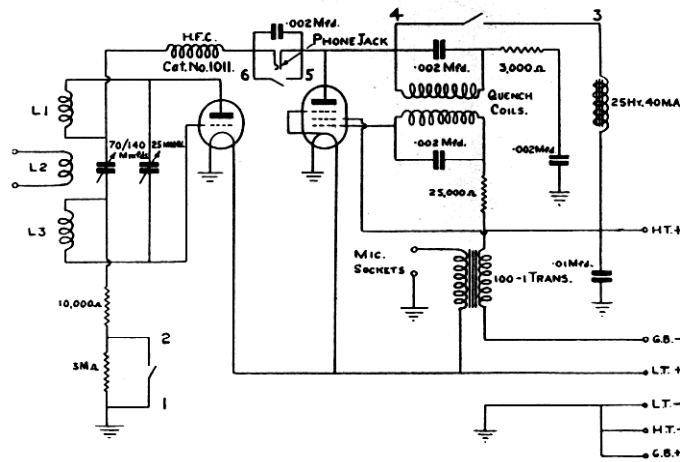

LIST OF PARTS

	Price
1 Eddystone Valveholder, No. 1015	1/3
1 Eddystone Microdenser, No. 900, 25 m.mfd.	4/-
1 Eddystone U.S.W. H.F. Choke, No. 1011	1/3
1 Eddystone Adjustable Bracket, No. 1007	1/6
1 Eddystone Flexible Coupler, No. 1009 ..	1/6
1 Eddystone S.M. Driving Head, No. 1012 ..	3/-
1 Eddystone Quench Coil Unit, No. 958 ..	4/6
1 Eddystone Knob, No. 903	6d.
1 each Erie 1-watt Resistors, 3,000, 10,000 25,000 ohms, 3 meg. .. .. ..each	1/-
1 Cyldon 70/140 m.mfd. Capacitor	2/-
1 Igranic Jack	1/3
2 Belling Lee Plugs and Sockets .. ..pair	4½d.
1 T.C.C. " M " type Condenser, .01 mfd. ..	2/-
3 T.C.C. " M " type Condensers, .002 mfd. ..each	1/-
1 Keston 25 hy. 40 m/a. Choke, No. 204a ..	6/6
1 Keston Mic. Transformer 100 : 1, No. W44	8/-
1 On-Off Switch	1/6
1 Utility Switch, No. W342/3	3/-
1 WB 5-pin Valveholder	10d.

Paxolin and Aluminium Panels, Wire, Leads, etc.

SWITCH CONNECTIONS.
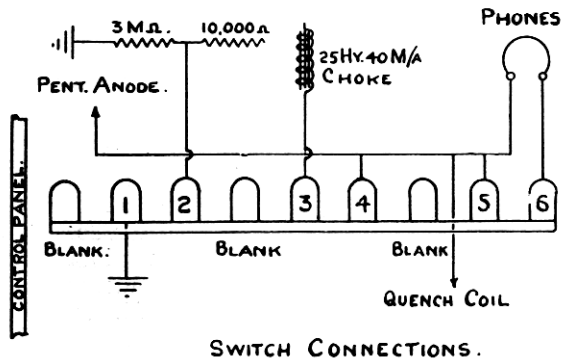
TWO VALVE QUENCH RECEIVER

4 METRES TO 6 METRES
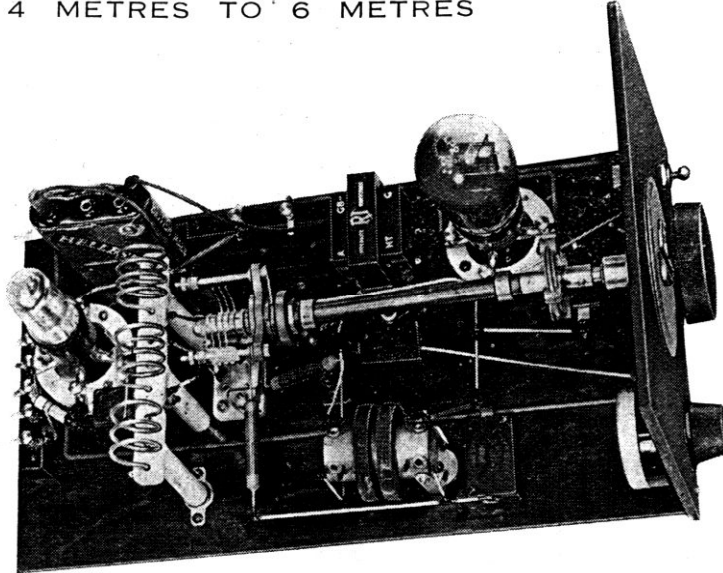
Illustrating the baseboard layout. This receiver is easily adapted to other waveranges if suitable coils are fitted.

This is an ideal set for those making their introduction to ultra short wave reception for the first time. The receiver gives a first class performance and has a real professional look. It is simple and inexpensive to build and does not need advanced knowledge to get working correctly. The circuit consists of two valves, the first of which combines the functions of oscillating detector and quench valve. This is followed by an ordinary steep slope triode output stage. The whole lay-out is based on true ultra short wave lines so that maximum efficiency is obtained. The oscillator circuit is a modification of a circuit originally designed by C. S. Franklin as a short wave self-oscillator to which the quenching arrangement has been added. The tuning inductance consists of two 4-turn silver plated coils which are raised on pillars to bring their connections to the level of the tuning condenser to obtain short leads. A 3-turn aerial coupling coil is used for the aerial connection. The valveholder is a low loss Frequentite type, also mounted on pillars for shortness of wiring. The tuning condenser has a maximum capacity of 25 m.mfd. and is operated by an Eddystone Slow Motion Head with special dial and cursor, the coupling being by means of a Flexible Coupler and Extension Spindle. The Extension Spindle is desirable since both sides of the condenser are at high potential and hand capacity

LIST OF PARTS.

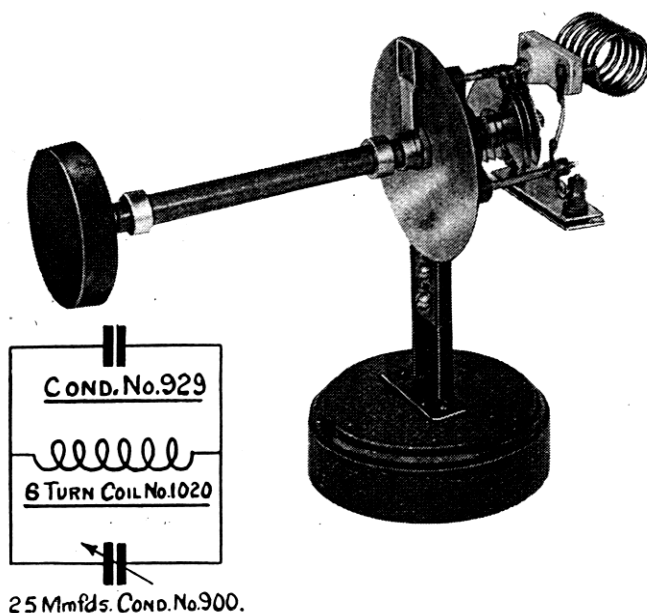|	Price
1 Eddystone 5-way Bakelite Terminal Saddle, No. 997	1/2
1 Eddystone 3-way Bakelite Terminal Saddle, No. 995	1/-
1 Eddystone S.M. Driving Head with Knob Dial and Cursor, No. 1036 ..	4/6
1 Eddystone Flexible Coupler, No. 1009 ..	1/6
1 Eddystone Extension Control Outfit, No. 1008	1/3
1 Eddystone Adjustable Bracket, No. 1007..	1/6
1 Eddystone Microdenser, 25 m.mfd., No. 900	4/-
2 Eddystone 4-pin Frequentite Valveholders, No. 949 .. ..each	1/5
1 Eddystone Quench Coil Unit, No. 958 ..	4/6
2 Eddystone Ultra S.W. Chokes, No. 1011 ..each	1/3
3 Eddystone 2½" Insulating Pillars, No. 1028 each	6d.
3 Eddystone 1½" Insulating Pillars, No. 1029 each	4½d.
2 Eddystone 4-turn Coils, No. 1020 ..each	1/6
1 Eddystone 3-turn Coil, No. 1020 ..	1/6
1 Eddystone No. 903 Knob, ¼" hole	6d.
1 Potentiometer, 50,000 ohms (Reliance) ..	4/6
1 2 pt. On-off Switch (B.A.T)	1/6
1 Fixed Condenser, .01 mfd. (Dubilier or T.C.C.)	2/-
1 each Fixed Condensers, .002 and .001 mfd. (Dubilier or T.C.C.) .. .. ..each	1/3
1 Fixed Condenser, .0001 mfd. (Dubilier or T.C.C.)	1/-
1 L.F. Transformer (R.I. Hypermite) ..	12/6
1 70-140 m.mfd. Trimmer (Cyldon)	2/-
1 3 meg. Grid Leak (Mullard, Erie or Dubilier)	1/-
1 4½v. G.B. Battery and Clip (Hellesen) ..	1/-
1 Baseboard, 7" × 11½" × ⅜"	
1 Panel, 7" × 6" × ¼" (wood or bakelite) ..	
Wire, Wood Screws, etc.	
1 Osram Valve, type HL2K, Clear.	
1 Osram Valve, type LP2.	

ABSORPTION WAVEMETER
4.5 METRES TO 7.7 METRES.

An absorption wavemeter for the ultra short wavelengths is a most useful accessory and can be quickly and cheaply built. The construction consists of a 6-turn silver plated coil mounted on a 25 m.mfd. condenser, which is variable and provided with an engraved scale and cursor. A small padding condenser is connected in parallel with the main capacity, to give a somewhat straighter wavelength curve.

The assembly in this case has been mounted on an Eddystone adjustable bracket fastened to an ordinary $3\frac{1}{4}''$ round plinth, as commonly used by electricians.

The instrument covers all the uses of a wavemeter for receiver or transmitter work and is easily portable. When once calibrated, however, it is essential that it should not be dropped or roughly handled since the calibrations may be upset. A full description of the method to be used to calibrate the wavemeter is given in the article on ultra short wave frequency measurements.

The frequency range, 67 to 39 megacycles, covers the 5-metre amateur band and the proposed television services with overlap on each side. For higher wavelengths, a larger coil can be substituted.

COND. No. 929

6 TURN COIL No. 1020

25 Mmfds. COND. No. 900.

LIST OF PARTS.	Price
1 Eddystone 6 turn Coil, No. 1020	1/8
1 Eddystone 10 m.mfd. Condenser, No. 929	1/-
1 Eddystone Microdenser, 25 m.mfd., No. 900	4/-
1 Eddystone Knob Dial and Cursor, No. 1026	2/-
1 Eddystone Extension Control Outfit, No. 1008	1/3
1 Eddystone Adjustable Bracket, No. 1007..	1/6
1 Round Wood Block	
Connecting Wire, Screws, etc.	

TWO VALVE QUENCH RECEIVER—continued

effects would occur if it was mounted close to the panel.

The lay-out of the components can be seen from the illustration and with the help of this and the circuit diagram, there should be no difficulty in construction. The method of adjustment for correct regeneration and quench oscillation is as follows : Set the Cyldon Trimmer Condenser with the plates well apart, connect 60v. high tension to H.T.+1 and turn the 50,000 ohm potentiometer to a point approaching half way. The Cyldon Trimmer Condenser should then be adjusted so that regeneration occurs over the whole band. Final control of regeneration and quench oscillation can then be obtained by the 50,000 ohm potentiometer. In practice, H.T.+1 should be between 50-70 volts and H.T.+2 100-120 volts. The grid bias adjustment will accordingly need to be $3-4\frac{1}{2}$v. negative.

The detector quench valve is an Osram HL2K and the output valve is a Mazda P220 or Osram LP2.
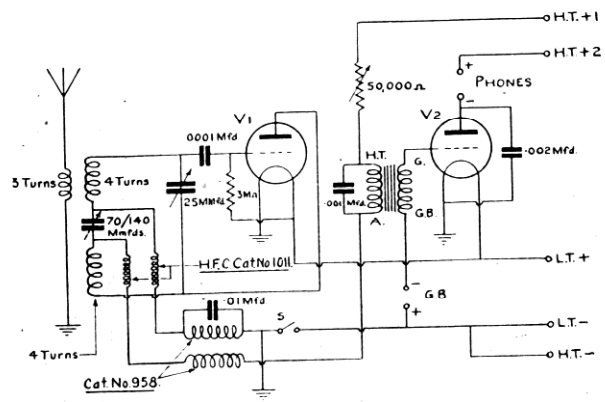

CIRCUIT DIAGRAM.

ELECTRON COUPLED OSCILLATOR

4,5 METRES TO 7.8 METRES,

This type of oscillator can be used for obtaining frequency measurements using the Lecher wire method. A full description of the use of the oscillator for this purpose is given in the article on Ultra Short Wave frequency measurements. The oscillator can be directly calibrated as a wavemeter itself if desired, but in this case must be rigidly constructed so that no variations can take place and the high tension voltage should be ad justed so that the same milliammeter reading is maintained. It is usually more convenient and accurate to use the oscillator in the way described for calibrating an absorption wavemeter.

The circuit comprises a screened grid valve, type Osram VS/24K, working as an electron coupled oscillator. The coil is a 5-turn silver plated unit which is tapped from 2-2½ turns from the earth end and the frequency range covered is from 66.7 to 38.5 megacycles. A grid leak and condenser is used as a self-adjusting bias arrangement. The greater the oscillation the greater the grid current, the more voltage developed across the grid leak, and so the greater the bias. When the oscillator is coupled to a circuit tuned to the same frequency, the load on the oscillator is increased, a smaller amount of grid current flows, so that less bias is developed and an increase of plate current is shown on the milliammeter. The function of the milliammeter, therefore, is to show at once by means of a sudden increase in current, when a coupled circuit is brought into resonance with the oscillator.
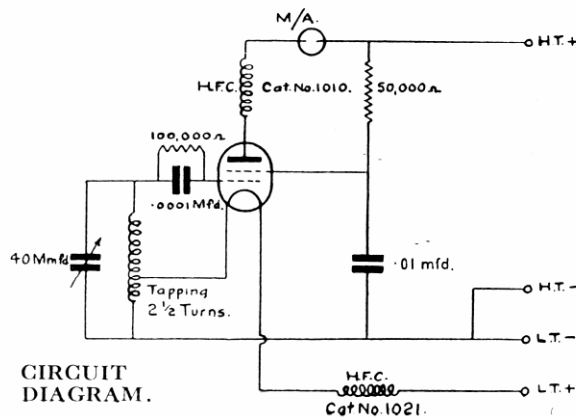
Here is shown the general layout of the various parts.
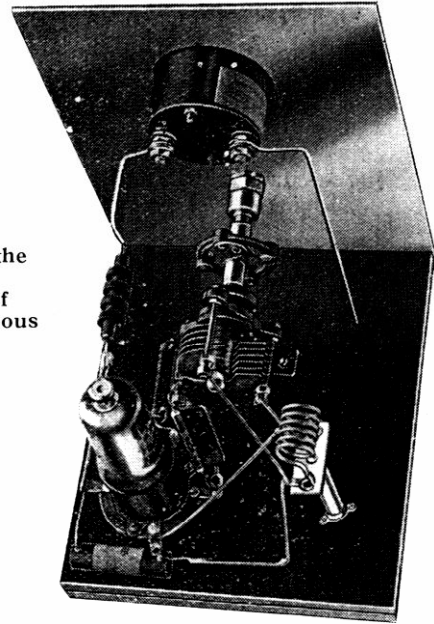
The apparatus is simple to construct and is built on a plain panel and baseboard assembly. The illustration shows the finished article and the general disposition of the components. A low resistance high frequency choke must be used as the choke is in series with the filament supply.

LIST OF PARTS.

		Price
1 Eddystone S.M. Driving Head with Knob Dial and Cursor, No. 1036	.. ..	4/6
1 Eddystone Flexible Coupler, No. 1009	..	1/6
1 Eddystone Adjustable Bracket, No. 1007..		1/6
1 Eddystone Microdenser, 40 m.mfd., No. 900		4/3
1 Eddystone Ultra S.W. Choke, No. 1021	..	1/3
1 Eddystone Universal S.W. Valveholder, No. 1015	.. ..	1/3
1 Eddystone 1½″ Insulating Pillar, No. 1029..		4½d.
1 Eddystone S.W. H.F. Choke, No. 1010	..	2/-
1 Central Millammeter, 0-5 m/amps...	..	25/-
1 Grid Leak, 100,000 ohms (Mullard, Erie or Dubilier)	.. .. ..	1/-
1 Grid Condenser, .0001 mfd. (Dubilier, No. 690)	.. ..	1/-
1 Tubular Condenser, .01 mfd. (T.C.C.)	..	1/-
1 Panel, 6″ × 8½″, aluminium or plywood	..	
1 Wood Baseboard, 7″ × 6″ × ⅜″	..	
1 Wood Strip, 6″ × ¼″ × ⅜″	.. .. ..	
1 4-way Battery Lead	.. .. ..	
Connecting Wire, Screws, etc.	.. ..	
1 Osram Valve, type VS24K ..	.. ..	

CIRCUIT DIAGRAM.

ULTRA SHORT WAVE FREQUENCY MEASUREMENTS WITH LECHER WIRES

How to use the Electron Coupled Oscillator to calibrate the Absorption Wavemeter.

One of the oldest formulae used by radio engineers is the one giving the relation between frequency and wavelength. It is given by :

Frequency × Wavelength = a constant.

This constant is the velocity of propagation of light waves and is equal to 300,000 metres per second (or 186,000 miles per second).

It is essential that the reader should be familiar with the relation between frequency and wavelength before trying out the experiments outlined below, for curiously enough Lecher wire are the only measurements made nowadays in wavelength, as the latter may be measured directly by a metre rule.

The Lecher wire method of measuring wavelength is not new, for as long ago as 1887 Sir Oliver Lodge succeeded in measuring the wavelengths of radio waves by expressing their lengths by the nodes and antinodes which

apparatus described on page 8 fulfils the requirements. This oscillator is coupled to the Lecher wires by closing the one end of the system with a 1-turn coil. This coil is coupled to the coil in the oscillator, and for accurate results, the coupling should be as loose as possible. The Absorption Wavemeter described on page 7 can then be calibrated.

The wires should be securely fastened at each end to prevent any variation in the system. One good method of erecting the parallel wire system is to fix an Eddystone Insulator (No. 999) at the end of each wire and secure the ends by means of coil springs to two ends of a room, in the manner shown below. The springs take up the stretch in the wire, which may consist of 18, 20 or 22 gauge bare copper wire, at least 25 feet long if wavelengths up to 7 metres are to be
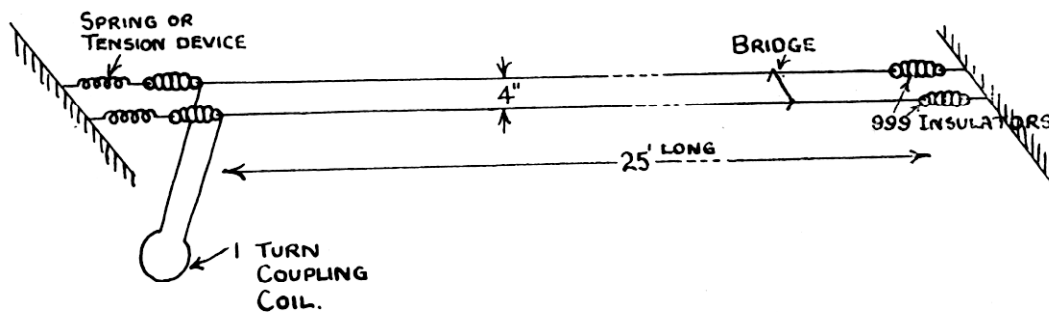
the waves set up by their reflection at the remote end of parallel wires. Excitation was obtained by the oscillatory discharge of a Leyden Jar, but it was left to Lecher himself to make the measurements later, with the aid of an oscillatory valve.

The waves travel along the wires at approximately the same speed as they do in free space, provided the wire is of small diameter and good conductivity. The wires simply guide the waves just as sound waves are guided in a speaking tube.

Lecher wires usually consist of two parallel feeders generally about two wavelengths long, separated over 2″ apart, so arranged that the wires may be short circuited by a sliding wire bridge at any point required. An oscillator is now necessary, and the simple

measured. Stranded wire should not be used and care must be taken to keep the feeder system well away from surrounding objects.

The wavemeter dial is then set at say 20° and loosely coupled to the oscillator coil, which is already coupled to the Lecher wires. The dial of the oscillator is then turned slowly until a sharp change of current is indicated by the milliameter in its anode circuit. This shows that the oscillator tuned circuit is resonating at the same frequency as the wavemeter. A piece of thick wire is then placed at the energised end of the feeder line and moved slowly along the Lecher wires until a point is reached where the current shown by the milliammeter again kicks. The position of the bridge is then marked and the shorting bar moved further towards the open end of

ULTRA SHORT WAVE FREQUENCY MEASUREMENTS WITH LECHER WIRES—continued

the wires until another point is located in a similar manner. These two positions are two points of the wave formation on the Lecher wires where current is at maximum and are one half-wavelength apart, twice this distance being the wavelength to which the oscillator is now tuned. This wavelength reading is the first calibration point for the wavemeter.

The oscillator circuit is now tuned to different wavelengths in 10° steps, the wavemeter brought into tune at each step and the wavelength measured off the Lecher wires for wavemeter calibration purposes.
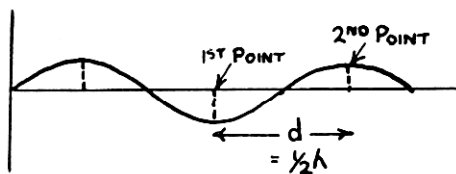
In taking measurements, if a metre rule is not available, the distance may be measured in inches and the result divided by 39.37, i.e.,

$$\frac{\text{Distance in inches}}{39.37} = \text{Half-wavelength in metres}$$

or

$$\frac{\text{Distance between maximum points in inches}}{19.69}$$

$$= \text{wavelength in metres}.$$

i.e., $\dfrac{d}{19.69} = \text{wavelength in metres}$ . . (2)

If it is desired to convert this to megacycles, we have from equation (1) :—

$$f \text{ (in megacycles)} = \frac{300}{\text{wavelength.}}$$

$$= \frac{300 \times 19.69}{d}$$

$$\text{or } f = \frac{5907}{d} \qquad \qquad \qquad \ldots \ldots (3)$$

where f=frequency in megacycles.
d=distance between points in inches.

If a smooth curve is drawn through the points obtained, all possible error in reading or locating exact distance along the wires will be eliminated. If the readings are taken carefully, the results obtained will be perfectly satisfactory to within .01—.5%, which is sufficiently accurate for most purposes.

In the above measurements the oscillator was used to calibrate the wavemeter for the following reason. If the oscillator itself was needed as a frequency wavemeter, it would have to be very rigidly and expensively built in order to maintain accurate calibration, whereas by calibrating an absorption wavemeter from the oscillator, accurate results should be obtained and further, unless the wavemeter is dropped it should maintain its accuracy for a long period of time as there are no valves or batteries to alter its calibration. A further advantage of the absorption wavemeter is that it is portable and may be used on field days.

When used with a straight set, the wavemeter will cause a click in the headphones when the oscillations are suppressed and in the case of a super-regenerative receiver, a fall in noise level will be indicated at the resonant frequency.

A small oscillator will not supply sufficient energy to light a fuse bulb and it is found that the points may be more accurately located by the current rise method used. It is extremely difficult to tell when a small bulb is glowing at its most brilliant intensity.

In the case of a relatively high power 5-metre transmitter, the Lecher wires may be coupled directly to the tank circuit and the frequency of operation immediately determined by a fuse bulb mounted on the shorting bar, or by means of a neon lamp.

Earlier in this article it was mentioned that radio waves travel along the wires at approximately the same speed as they do in free space. For the benefit of those wishing to obtain very accurate results, the correction necessary for the waves being led by the wires may be given :—

$$\lambda o = \frac{d}{19.69} \times (1+k) \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where λo is the true wavelength in free space expressed in metres.
d is the distance between points in inches.
k is a constant.
The true frequency f_o in megacycles is given by :—

$$f_o = \frac{5907}{d} \times (1-k) \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

In the above formulae,

$$k = \frac{\sqrt{r_o}}{8 \log_e B \sqrt{\omega} \left[1 - \left(\frac{a}{b}\right)^2\right]} \quad . \quad . \quad (6)$$

ULTRA H.F. TRANSMITTER
WITH PARALLEL INDUCTANCE LINES.
120—50 MC/S.

A transmitter similar to the one described here was first used in the United States, and with its use regular ultra short wave communication over 90 miles has been established. It was decided to build the same type of transmitter for our own experimental use, and although in its earlier forms it did not prove a success, after certain modifications it is now giving really splendid results, and the transmitter described here is now used for the experimental transmissions from G-6SL.

Compared with the usual form of oscillator which uses inductance coils and is tuned with a variable capacity, this oscillator has no variable condensers whatever and the inductance for both grid and plate circuits consists of lengths of tube which run parallel to each other with the grid lines and plate lines at right angles. Control of frequency is carried out by means of adjustable shorting bars on the inductance tubes. The efficiency of the arrangement is good because the inductance in use is large compared with the capacity present and since there are no coils and condensers which can vary or be misplaced, the frequency stabilisation is definite. Two valves are used in push pull and a large variety of types were tried. The pair finally used, however and found best were two of a new type, Ediswan E.S.W.501. These valves have carbon anodes. The filament leads are brought out in the base and the plate and grid leads are Tungsten steel rods brought out at the top. The valves also have filament centre tap connections brought out at the top, but in this case these were not used, as the top connection did not work in with the design and a 50 ohm potentiometer is used across the filaments to obtain an electrical centre tap leading away to H.T. negative. In Fig. 1 an illustration of the transmitter lay-out is shown. The plate lines are vertical and aerial coupling is obtained by means of a hairpin coupling device at the low potential end of the lines. The ends of this hairpin are taken out through series condensers to the aerial feeder lines. The hairpin used is 5″ long with 1″ centres.

An insulating strip carrying two aerial series Microdensers and two aerial current ammeters with the hairpin mounted directly on the supports of the condensers is fastened
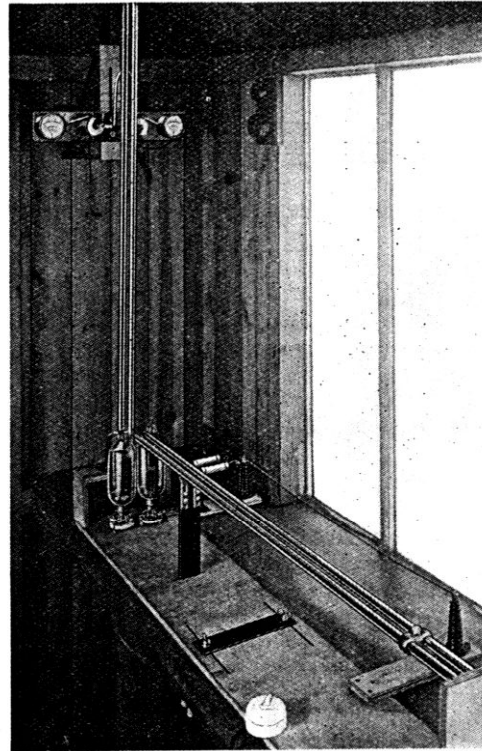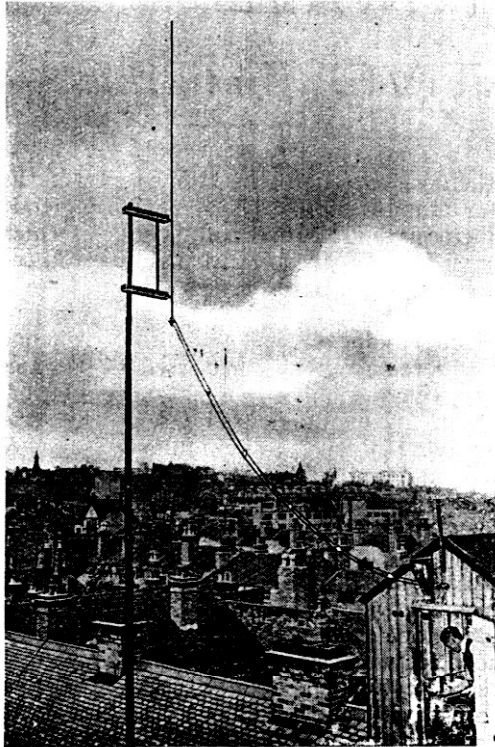

Fig. 1.   General layout of Transmitter.

to a slide on the wall, which gives an up and down adjustment for variation of coupling in this direction. The oscillator portion itself was built up on a long baseboard with the grid lines parallel to it and raised to the level of the top of the valves. A small strip extending out near the valves carries the filament and H.T. negative terminals, the filament potentiometer and the grid leak, which comprises two 30,000 ohm 5-watt resistors in parallel. H.T. negative is carried from the insulator on this strip to another strip also with an insulator, towards the end of the grid lines. From this insulator the lead is taken to the shorting bar of the grid lines, a high frequency choke being included as near to the shorting bar as possible. H.T. positive is taken from a high frequency choke attached to the shorting bar of the plate lines and is carried over the top and then down to the power pack, through a milli-ammeter.

ULTRA H.F. TRANSMITTER—continued

CIRCUIT DIAGRAM.

The whole transmitter is fastened to the bench with a slot adjustment so that the distance of the hairpin coupling from the plate lines could be adjusted laterally. Both grid and plate inductance lines consist of $\frac{1}{2}''$ copper tube spaced apart with $1''$ centres. The ends of the tubes are connected to the valves with heavy copper braiding. This braiding, the hairpin coupling and tubes are all heavily silver plated. The length of the grid lines is $40''$ and for operation of the transmitter on 58 Mc/s., the position of the shorting bar was $35\frac{1}{2}''$ away from the grid connections. The small section of tube remaining free was left open at the ends. The plate lines are $44\frac{1}{2}''$ long and the position of the shorting bar is approximately $39\frac{1}{4}''$ from the plate connections. The oscillator gives excellent results irrespective of the power used and the ratio of radio frequency output to power input is very good indeed.

The oscillator is modulated with a 3-stage amplifier with two valves in Class B as the final output.

Several types of aerials have been used for omni-directional work. Under the existing circumstances, a half-wave aerial which consisted of a $\frac{1}{2}''$ copper tube 8′ 0$\frac{1}{2}''$ long with Zepp feeders was found to give excellent results. The aerial was voltage fed and the feeders therefore had to be an odd number of quarter-wavelengths long. In this particular instance, three quarter-wavelengths plus about $12''$ was the length used. The feeders were brought in through two hot wire milliam-meters, through two 40 m.mfd. Microdensers to the hairpin coupling, so that the feeder system was series tuned. The spacing of the feeder lines is $2''$ apart and if carefully designed, this system can be made to have small losses and to be practically free of radiation.

Beam array as described in text.

ULTRA H.F. TRANSMITTER—continued

Showing Omni-Directional Aerial as described.

A directional aerial used is also illustrated. This consists of two half-wave radiators spaced a half-wave apart with two reflectors a quarter-wave behind each radiator. $\frac{3}{16}''$ copper tube was used for the radiators and reflectors and the whole was built up cage fashion, as shown, and suspended from an overhead wire. Incidentally, this aerial had to be erected over a V-shaped roof and broke many times before it was finally erected. The feeders for this aerial, again, were just over three-quarters of a wave long, which distance includes a quarter wavelength from the centre of the array on each side to the radiators. The same method of coupling and series tuning was used. This aerial gave a definite beam in the direction required and at a distance of 20 miles in the direction of the beam, the signal was twice as strong as compared with the omni-directional aerial.

Although this transmitter has been operated on 58 Mc/s. in the amateur waveband, it is also adaptable to use at lower frequencies and is very easily adjustable for this purpose.

ULTRA SHORT WAVE MEASUREMENTS WITH LECHER WIRES—(continued)

where r_o = d.c. resistance/cm. length of double line—expressed in CGS units. 10^9 CGS units = 1 ohms.

a = diameter of wire in cm.

b = distance between centre of wires in cm.

$$B = \frac{2b}{a}.$$

In a measurement taken, the following results were obtained :—

d = 98.45″.

b = 3.94″ (10 cm.).

a = .06″ (.15 cm.).

From equation (2), wavelength in metres

$$= \frac{98.45}{19.69} = 5.00 \text{ metres.}$$

From equation (3), frequency in megacycles

$$= \frac{5907}{98.45} = 60.00 \text{ megacycles.}$$

Using equation (6), the constant k is equal to $5.04 \times 10^{-4} = .000504$ for a 5-metre wavelength, and therefore the true wavelength is :—

5.00 (1 + .000504) = 5.0025 metres,

and the true frequency :—

60 (1 — .000504) = 59.968 megacycles.

AERIAL SYSTEMS—continued

of this array built with eight telescopic aerials on wood battens, $4'' \times 2'' \times 26'$ long, is illustrated in diagram 16a. This arrangement can be erected very quickly, in two sections of four if more convenient and is again easily faced in the required direction. The radiators are shown in front, reflectors behind with diagram 16b underneath giving the feeder connections necessary to keep all the aerials in phase. Another smaller array on the same lines is illustrated on page 12.

Lengths of aerials and reflectors for the systems described above are shown in the table below for the 5-metre amateur band frequencies :—

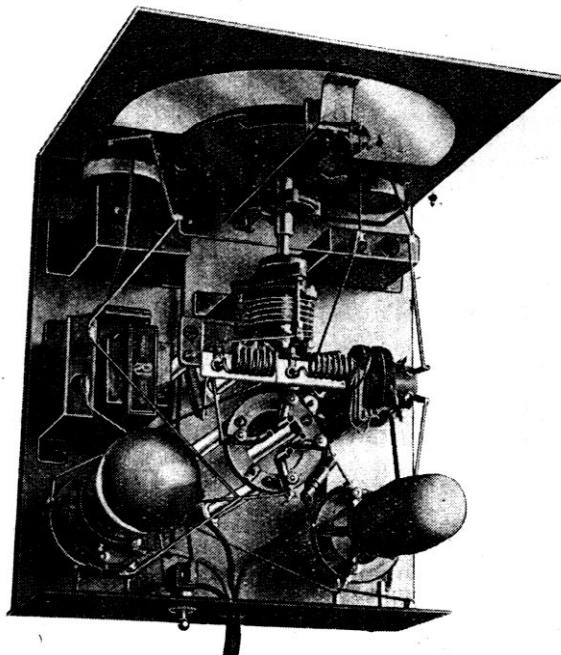| Freq. Mets.	W.L. Metres	Aerial Length A	Ref. Length R	Aerial Spacing, D.1	Aerial to Ref. D.2
56	5.36	8′ 4″	8′ 7″	8′ 9″	4′ 4½″
57	5.26	8′ 2⅜″	8′ 5½″	8′ 7½″	4′ 3¾″
58	5.17	8′ 0½″	8′ 3¾″	8′ 5¾″	4′ 2⅞″
59	5.09	7′ 10¾″	8′ 2″	8′ 4″	4′ 2″
60	5.00	7′ 9″	8′ 0½″	8′ 2½″	4′ 1¼″

SUPER-REGENERATIVE THREE—continued

Fig. 3. Showing general baseboard layout of Components. The input and output terminals which are on the Paxolin Back Strip are not shown in the illustration. The Aerial Coupling Coil is also not illustrated but should be mounted in line with the other Coils.

detector valves can be adjusted. The detector can then be operated at the point of maximum sensitivity with the minimum amount of quench necessary for reception purposes.

The circuit diagram is shown in Fig. 2, and the view of the general lay-out in Fig. 3. The tuning coils are Eddystone, Cat. No. 1020, which are wound with 14g. copper wire, silver plated. Tinned copper coils should not be used as they have a much greater high frequency resistance. The set is built into an Eddystone Welded Steel Cabinet and the baseboard is mounted to the front panel, leaving $\frac{3}{8}''$ space between the bottom of the baseboard and the bottom of the cabinet. A small supporting strip of wood is thus necessary at the back of the baseboard. A general view of the front of the set is shown in Fig. 1, with the quench control on the left and the detector oscillator control on the right. Two pairs of terminals are provided on the back for input to the aerial coupling coils and 'phones output. The switch and leads are also at the back on the same paxolin strip.

The quench and detector oscillator valves are Osram HL2K and the output valve is a steep slope triode type Osram LP2 or Mazda P220.

The frequency range of the set with the present coils is approximately 66-50 Mc/s. This range can easily be increased up to 30 Mc/s by substituting larger coils. The usual type of broadcast aerial can be used for reception but better results should be obtained with an aerial cut to a half-wavelength or a number of half-wavelengths of the middle frequency in the band in which it is desired to receive. An impedance matched aerial as described in the article on Aerials, using the two input terminals for the feeder lines, is an ideal arrangement.

LIST OF PARTS.

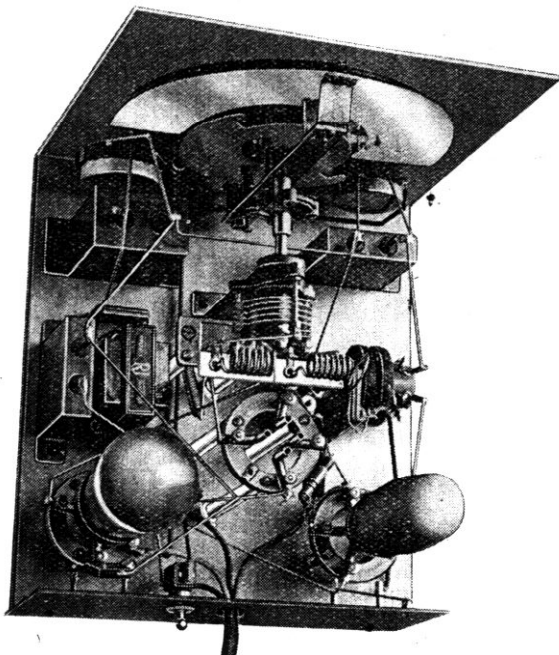|	Price
1 Eddystone Welded Steel Cabinet, No. 1033	16/6
2 Eddystone Knobs, $\frac{1}{4}''$ hole, No. 903 ..each	6d.
1 Eddystone Vernier Dial, No. 973	10/6
1 Eddystone Flexible Coupler, No. 1009 ..	1/6
1 Eddystone Adjustable Bracket, No. 1007..	1/6
1 Eddystone Quench Coil Unit, No. 958 ..	4/6
1 Eddystone Microdenser, 25 m.mfd., No. 900	4/-
3 Eddystone 4-pin Frequentite Valveholders, No. 949 .. ..each	1/5
6 Eddystone $2\frac{1}{2}''$ Insulating Pillars for mounting valveholder No. 1028, and coils ..each	6d.
1 Eddystone S.W., H.F. Choke, No. 1010 ..	2/-
2 Eddystone $1\frac{1}{2}''$ Insulating Pillars, No. 1029, for mounting Cyldon Condenser ..each $4\frac{1}{2}$d.	
1 Eddystone Ultra S.W. Choke, No. 1011 ..	1/3
2 Eddystone 4-turn Coils, No. 1020 ..each	1/6
1 Eddystone 3-turn Coil, No. 1020	1/6
1 Potentiometer, 250,000 ohms (Erie) ..	3/6
1 Potentiometer, 50,000 ohms (Reliance) ..	4/6
3 1 mfd. Condensers, 250 v. A.C. working (Helsby) .. ..each	2/6
1 L.F. Transformer (R.I. Hypermite) ..	12/6
1 each $\frac{1}{2}$-watt Resistors, 20,000, 40,000 ohms, 1 and 3 megohms .. .. ..each	1/-
1 1-watt Resistor, 500 ohms	1/-
1 Fixed Condenser, .01 mfd. (Dubilier or T.C.C.)	2/-
1 Fixed Condenser, .0001 mfd. (Dubilier or T.C.C.)	1/-
1 each Fixed Condensers, .002 and .001 mfd. (Dubilier or T.C.C.) .. .. ..each	1/3
1 Tubular Condenser, .1 mfd., 200 v., D.C. working (T.C.C.)	1/4
1 3 pt. On-Off Switch (B.A.T.)	1/6
1 Trimmer Condenser, 70-140 m.mfd. (Cyldon)	2/-
1 Wood Baseboard, $9\frac{1}{4}'' \times 7\frac{1}{2}'' \times \frac{3}{8}$.	
1 Wood Batten, $7\frac{1}{2}'' \times \frac{3}{8}'' \times \frac{3}{8}''$	
1 Paxolin Terminal Strip, $7\frac{7}{8}'' \times 2\frac{1}{2}''$ ..	
1 Piece $\frac{1}{4}''$ dia. Brass Rod, 1'' long ..	
1 Small Piece Wood, $1\frac{5}{8}'' \times \frac{5}{8}'' \times \frac{3}{4}''$, for mounting No. 1007 Bracket	
Connecting Wire, Screws, Lead Washers, 4 Terminals, etc.	
2 Osram Valves, type HL2K Clear ..	
1 Osram Valve, type LP2	

SUPER-REGENERATIVE THREE—continued

Fig. 3. Showing general baseboard layout of Components. The input and output terminals which are on the Paxolin Back Strip are not shown in the illustration. The Aerial Coupling Coil is also not illustrated but should be mounted in line with the other Coils.

detector valves can be adjusted. The detector can then be operated at the point of maximum sensitivity with the minimum amount of quench necessary for reception purposes.

The circuit diagram is shown in Fig. 2, and the view of the general lay-out in Fig. 3. The tuning coils are Eddystone, Cat. No. 1020, which are wound with 14g. copper wire, silver plated. Tinned copper coils should not be used as they have a much greater high frequency resistance. The set is built into an Eddystone Welded Steel Cabinet and the baseboard is mounted to the front panel, leaving $\frac{3}{8}''$ space between the bottom of the baseboard and the bottom of the cabinet. A small supporting strip of wood is thus necessary at the back of the baseboard. A general view of the front of the set is shown in Fig. 1, with the quench control on the left and the detector oscillator control on the right. Two pairs of terminals are provided on the back for input to the aerial coupling coils and 'phones output. The switch and leads are also at the back on the same paxolin strip.

The quench and detector oscillator valves are Osram HL2K and the output valve is a steep slope triode type Osram LP2 or Mazda P220.

The frequency range of the set with the present coils is approximately 66-50 Mc/s. This range can easily be increased up to 30 Mc/s by substituting larger coils. The usual type of broadcast aerial can be used for reception but better results should be obtained with an aerial cut to a half-wavelength or a number of half-wavelengths of the middle frequency in the band in which it is desired to receive. An impedance matched aerial as described in the article on Aerials, using the two input terminals for the feeder lines, is an ideal arrangement.

LIST OF PARTS.

		Price
1	Eddystone Welded Steel Cabinet, No. 1033	16/6
2	Eddystone Knobs, $\frac{1}{4}''$ hole, No. 903 ..each	6d.
1	Eddystone Vernier Dial, No. 973	10/6
1	Eddystone Flexible Coupler, No. 1009 ..	1/6
1	Eddystone Adjustable Bracket, No. 1007..	1/6
1	Eddystone Quench Coil Unit, No. 958 ..	4/6
1	Eddystone Microdenser, 25 m.mfd., No. 900	4/-
3	Eddystone 4-pin Frequentite Valveholders, No. 949 .. ..each	1/5
6	Eddystone $2\frac{1}{2}''$ Insulating Pillars for mounting valveholder No. 1028, and coils ..each	6d.
1	Eddystone S.W., H.F. Choke, No. 1010 ..	2/-
2	Eddystone $1\frac{1}{2}''$ Insulating Pillars, No. 1029, for mounting Cyldon Condenser ..each	4½d.
1	Eddystone Ultra S.W. Choke, No. 1011 ..	1/3
2	Eddystone 4-turn Coils, No. 1020 ..each	1/6
1	Eddystone 3-turn Coil, No. 1020	1/6
1	Potentiometer, 250,000 ohms (Erie) ..	3/6
1	Potentiometer, 50,000 ohms (Reliance) ..	4/6
3	1 mfd. Condensers, 250 v. A.C. working (Helsby) .. ..each	2/6
1	L.F. Transformer (R.I. Hypermite) ..	12/6
1	each ½-watt Resistors, 20,000, 40,000 ohms, 1 and 3 megohms .. .. ..each	1/-
1	1-watt Resistor, 500 ohms	1/-
1	Fixed Condenser, .01 mfd. (Dubilier or T.C.C.)	2/-
1	Fixed Condenser, .0001 mfd. (Dubilier or T.C.C.)	1/-
1	each Fixed Condensers, .002 and .001 mfd. (Dubilier or T.C.C.) .. .. ..each	1/3
1	Tubular Condenser, .1 mfd., 200 v., D.C. working (T.C.C.)	1/4
1	3 pt. On-Off Switch (B.A.T.)	1/6
1	Trimmer Condenser, 70-140 m.mfd. (Cyldon)	2/-
1	Wood Baseboard, $9\frac{1}{4}'' \times 7\frac{1}{2}'' \times \frac{3}{8}$. ..	
1	Wood Batten, $7\frac{1}{2}'' \times \frac{3}{8}'' \times \frac{3}{8}''$ ..	
1	Paxolin Terminal Strip, $7\frac{7}{8}'' \times 2\frac{1}{2}''$ ..	
1	Piece $\frac{1}{4}''$ dia. Brass Rod, 1″ long ..	
1	Small Piece Wood, $1\frac{5}{8}'' \times \frac{5}{8}'' \times \frac{3}{4}''$, for mounting No. 1007 Bracket	
Connecting Wire, Screws, Lead Washers, 4 Terminals, etc.	
2	Osram Valves, type HL2K Clear ..	
1	Osram Valve, type LP2	

ULTRA   SHORT   WAVE
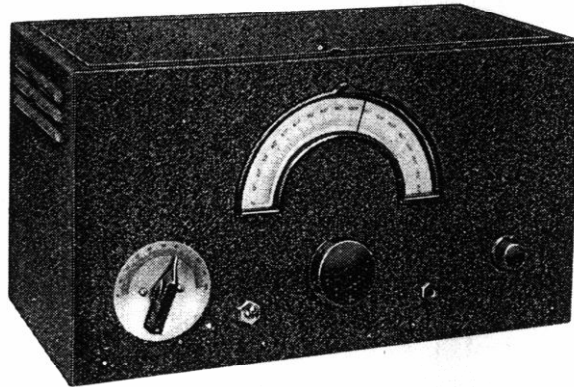# SIX VALVE SUPER-HETERODYNE
62 MC/S. TO 50 MC/S.

Fig. 1.

The completed receiver housed in welded steel cabinet showing panel layout.

This is a receiver for the more advanced amateur since although the circuit is one which has been thoroughly tried out and duplicated without difficulty, a general all round knowledge of the circuit and how it works is of great use in making small final adjustments so that the receiver is working at maximum efficiency. The set is one which is delightfully easy to handle, it has a low level of background noise and is sensitive to weak signals. At the same time it will not overload on strong signals which may be received from a nearby transmitter. The circuit is an extremely flexible and reliable one, and although the present frequency range with the existing coils specified is from 62 Mc/s. to 50 Mc/s., if the set is modified as far as coils and tuning capacity are concerned, it can be adapted to cover any wavelengths from 2.5 to 100 metres.

The circuit arrangement comprises a screened grid Osram V.S.24K valve as anode bend first detector, the same valve as a screened grid electron-coupled oscillator, followed by two intermediate frequency stages, again using V.S.24K valves. A double diode triode Mazda L.2/D.D. is used as second detector, the first diode being used for rectification purposes and the triode portion as a L.F. amplifier. One diode of this valve is not used and if desired, it could quite easily be connected up so that A.V.C. is obtained. Under present conditions we have not considered this to be necessary. A low frequency transformer follows the second detector and feeds into an Osram L.P.2 or Mazda P.220 as the output stage.

The coils to cover the frequency band above mentioned comprise a 3-turn aerial coupling coil coupled closely to a 4-turn grid coil with a 5-turn grid cathode oscillator coil, which has a tapping from one side of the filament, in the centre of the coil. Mutual or inductance coupling is arranged between the grid cathode coil of the electron-coupled oscillator and the detector grid coil, the high potential ends of each coil facing each other, with a distance of approximately $3\frac{1}{4}''$ between the two coils. The performance of the set depends upon this coupling, and so for best results the distance should be experimented with and it is suggested that the oscillator coil is not fastened down permanently until the best distance is found.

The main tuning control is the oscillator circuit. This is provided with a slow motion dial driving a 15 m.mfd. Microdenser. Tuning on this circuit is quite sharp without being difficult. The detector grid coil is also tuned with a 15 m.mfd. Microdenser, which is controlled by an ordinary pointer knob and dial, as shown on the left of the set in Fig. 1. This adjustment is not at all critical, but by making this control individual, maximum results are always obtainable. We find that the two controls do not affect the ease of tuning and they give the necessary adjustments to compensate for variation of aerials and valves, which would not be available if the condensers were ganged.

The frequency of the two I.F. stages is not critical. As long as the three units are all lined up to the same frequency, good

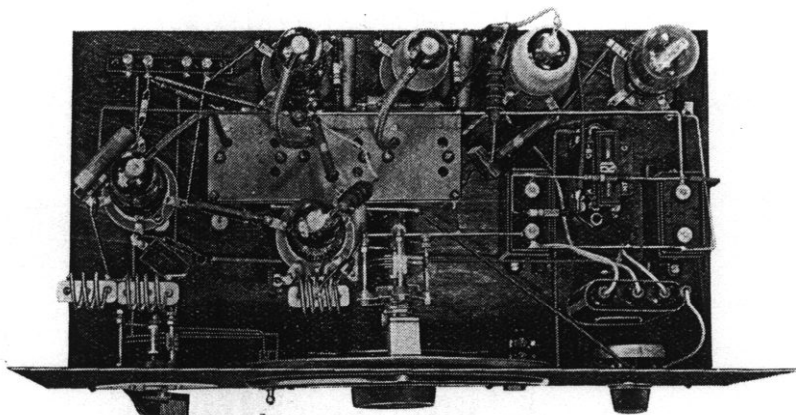## ULTRA SHORT WAVE SIX VALVE SUPER-HETERODYNE—continued

Fig. 2.   The Baseboard layout, showing disposition of components.

results will be obtained.   The tuning unit is so arranged that when the trimming condensers are set about half-way the intermediate frequency is approximately 2,000 Kc/s.   It was found necessary to damp the primary and secondary windings of the transformers with resistances in order to give a suitable working band-width and this has already been done in the construction of the unit. Without these resistances tuning is altogether too sharp.   This unit is the special "EDDY-STONE" Ultra Short Wave I.F. Unit, the three pairs of coils and condensers being built into one diecast aluminium container which is subdivided by integral screening partitions into three sections.

A volume control is fitted and adjustment obtained by applying bias to the control grids of both intermediate frequency valves.   The control is a potentiometer which is used across the 4.5 volt grid bias battery.   This potentiometer takes 1.25 milliamps when connected in circuit and this is done by using a 3-point on-off switch.   The volume control knob is shown on the right in Fig. 1, and the front panel also carries the on-off switch and jack for telephones or loud speaker.

The construction of the set is not difficult, and it is built into an "EDDYSTONE" Welded Steel Cabinet, No. 1034, and the front panel and baseboard slide out for the construction process.   The baseboard should be fastened to the panel leaving $\frac{3}{8}$" gap between the bottom of the baseboard and the bottom of the cabinet. The back of the baseboard therefore needs supporting by a $\frac{3}{8}$" wooden strip.   The coils are "EDDYSTONE," No. 1020, and they are
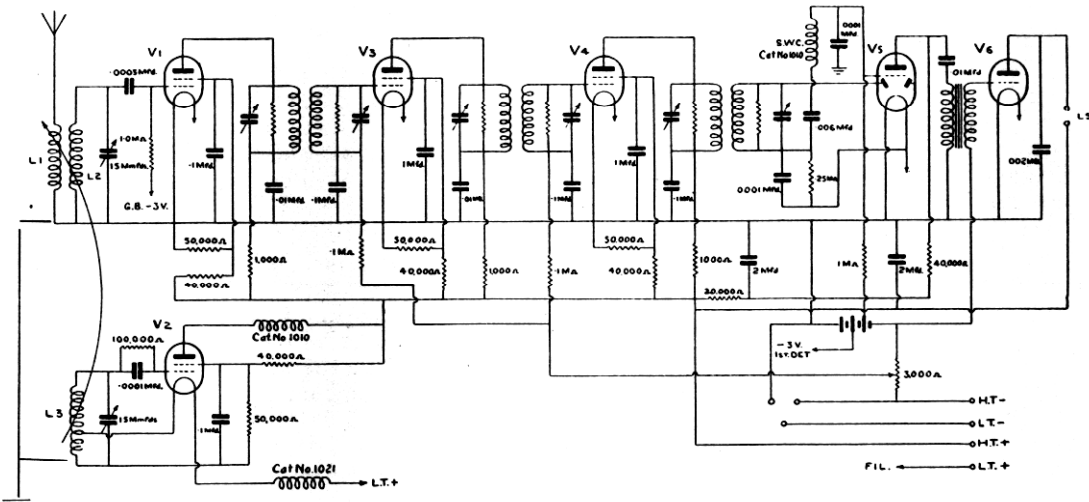
each mounted on supporting pillars, No. 1028. The first detector valveholder is mounted immediately behind the aerial coupling and grid coils and is raised up on three pillars, No. 1029.   The oscillator valve and coil are mounted to the left of the main tuning condenser and the valveholder is raised on three pillars, No. 1028.   The high frequency choke in the anode lead from the oscillator valve is mounted in the wiring of the lead itself and is placed at the extreme end of the lead near the clip which fits on to the top of the valve. The other components are mounted on the baseboard with the exception of the resistances and condensers, which are conveniently mounted in the wiring in a conventional manner.

The receiver will work on any type of aerial.   There is an advantage, however, in using an aerial cut to a resonant length and erected as high as possible and in an unscreened position.   An Eddystone Telescopic Aerial can be used for this purpose.   Since, when the aerial is erected in this manner, it may be some considerable distance away from the receiver, it is important to use a suitable feeder or lead-in system.   A matched impedance type of aerial with twin spaced line, as described in the section on aerials, or the single type line on the Windom principle, are recommended.   If a matched impedance line is used, the aerial coupling coil connection should be disconnected from earth and the feeders connected across the coil.   If the aerial is quite close to the receiver, it will usually be found quite satisfactory to take a lead from the bottom of the aerial.

## ULTRA SHORT WAVE SIX VALVE SUPER-HETERODYNE—continued

LIST OF PARTS.

	Price
1 Eddystone Welded Steel Cabinet, No. 1034	25/-
2 Eddystone Microdensers, 15 m.mfd., No. 900 .. ..each	3/9
1 Eddystone Pointer Knob and Dial, No. 1027	1/3
1 Eddystone Vernier Dial, No. 973	10/6
6 Eddystone 2½″ Insulating Pillars, No. 1028 each	6d.
3 Eddystone 1½″ Insulating Pillars, No. 1029 each	4½d.
6 Eddystone Universal S.W. Valveholders, No. 1015 .. ..each	1/3
2 Eddystone S.W. H.F. Chokes, No. 1010 ..each	2/-
1 Eddystone Ultra S.W. Choke, No. 1021 ..	1/3
1 Eddystone 4-way Bakelite Terminal Saddle, No. 996	1/1
1 Eddystone Ultra S.W. I.F. Unit, No. 1037	25/6
1 Eddystone Knob, ¼″ hole, No. 903.. ..	6d.
1 Eddystone 3-turn Coil, No. 1020	1/6
1 Eddystone 4-turn Coil, No. 1020	1/6
1 Eddystone 5-turn Coil, No. 1020	1/7
1 Fixed Condenser, .0003 mfd. (Dubilier or T.C.C.)	1/-
2 Fixed Condensers, .0001 mfd. (Dubilier or T.C.C.) .. ..each	1/-
1 Fixed Condenser, .002 mfd. (Dubilier or T.C.C.)	1/3
1 Fixed Condenser, .006 mfd. (Dubilier or T.C.C.)..	1/6
1 Fixed Condenser, .01 mfd. (Dubilier or T.C.C.)	2/-

	Price
6 Fixed Condensers, .1 mfd. (T.C.C., type 250) .. ..each	1/4
2 Fixed Condensers, .01 mfd. (T.C.C., type 300) .. ..each	1/3
2 Fixed Condensers, 2 mfd. (T.C.C., 200v. wkg.) .. ..each	3/6
4 1-watt Resistors, 40,000 ohms (Mullard, Erie or Dubilier) .. .. ..each	1/-
3 1-watt Resistors, 50,000 ohms (Mullard, Erie or Dubilier) .. .. ..each	1/-
3 1-watt Resistors, 1,000 ohms (Mullard, Erie or Dubilier) .. .. ..each	1/-
1 1-watt Resistor, 20,000 ohms (Mullard, Erie or Dubilier)	1/-
1 1-watt Resistor, 70,000 ohms (Mullard, Erie or Dubilier)	1/-
3 1-watt Resistors, 100,000 ohms (Mullard, Erie or Dubilier) .. .. ..each	1/-
2 1-watt Resistors, 1 megohm (Mullard, Erie or Dubilier) .. .. ..each	1/-
1 P.40 Plug and P.72 Jack (Igranic).. ..pair	2/6
1 Potentiometer, 3,000 ohms (Reliance) ..	4/6
1 Baseboard, 16¼″ × 9″ × ⅜″, Connecting Wire, Screws, etc.	

Valves :—2 Osram V.S.24K. Clear. .. ..
 2 Osram V.S.24K. Met. .. ..
 1 Mazda L.2/D.D. .. .. ..
 1 Mazda P.220. .. .. ..

CIRCUIT DIAGRAM—To prevent slight drain from the H.T. supply through the 3,000 ohm. Potentiometer an additional switch should be incorporated in the H.T. system, or one of the H.T. Plugs always removed.

A MODULATED OSCILLATOR
4.5 METRES. TO 8 METRES.
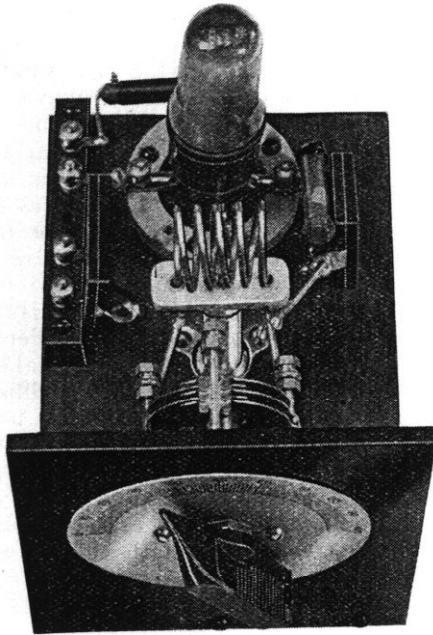
General layout showing disposition of Components.

This is a useful piece of laboratory equipment for the ultra short wave experimenter. It is practically a miniature transmitting station of very small power, radiating a continuous note at a constant level over a variable frequency band from 67-37.5 Mc/s., from 15° to 100° on the dial. For checking receivers after construction or after alterations, or for lining up ultra short wave superheterodyne sets, it is invaluable.

The oscillator valve functions in the usual way, an electron-coupled circuit being used. A time constant arrangement, consisting of a suitable value grid leak and condenser is, however, incorporated which breaks the oscillations up into groups of about 300 per second, thus giving an audible output. The high tension supply necessary is 60 volts, and it should be noted that a variation of high tension will slightly alter the pitch of the audible note. It is also interesting to note that in this case a triode valve has been successfully used as electron-coupled oscillator, although it is general practice to use a screened grid valve for this purpose. The present triode

arrangement works extremely well and there is a considerable saving in cost between the price of the two valves.

The frequency range, which gives a complete overlap each side of the 5-metre amateur band and the television wavebands, is covered by a 40 m.mfd. condenser tuning a 5-turn silver plated coil. A tapping from one side of the filament is taken into this coil at a point 2 to 2½ turns away from the earth end of the coil. The high frequency choke used in the filament lead must be of low resistance so that no appreciable drop of filament voltage occurs.

The unit is mounted on a small panel and baseboard, an illustration of the lay-out being given, and the assembly is one which can be completed without difficulty in a very short time.

LIST OF PARTS.
                                                        Price
1 Eddystone 4-pin Frequentite Valveholder,
   No. 949 ..   ..   1/5
1 Eddystone Ultra S.W. Choke, No. 1021 ..   1/3
1 Eddystone 4-way Bakelite Terminal Saddle,
   No. 996 ..   ..   1/1
1 Eddystone 1½″ Insulating Pillar, No. 1029   4½d.
1 Eddystone Microdenser, 40 m.mfd., No.
   900   ..   ..   4/3
1 Eddystone 5-turn Coil, No. 1020 ..   ..   1/7
1 Eddystone Pointer Knob and Dial, No.
   1027   ..   ..   1/3
2 Fixed Condensers, .006 mfd. (Dubilier or
   T.C.C.) ..   ..each 1/6
1 ½ watt Resistor, 70,000 ohms (Mullard,
   Erie or Dubilier) 1/-
1 Baseboard, 6″ × 4″ × ⅜″, plywood ..   ..
1 Panel, 5″ × 4″ × ¼″, wood or bakelite ..
Connecting Wire, Screws, etc.
1 Osram Valve, type HL2K Clear.
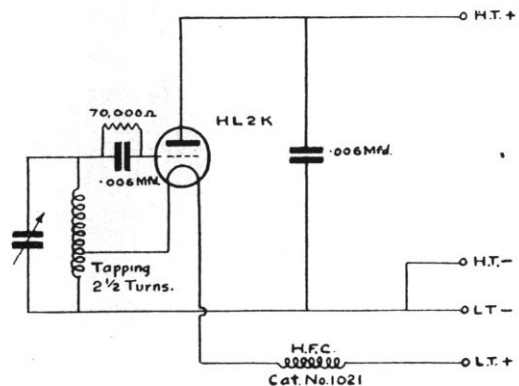
**CIRCUIT DIAGRAM.**

PUSH PULL
ULTRA S.W. TRANSMITTER

UNITY COUPLED WITH CLASS B MODULATOR UNIT.

This transmitter is designed for use on the 5-metre amateur band and has a frequency range of 56 to 60 Mc/s. As described, it is arranged for portable use and has an output of 3 watts. As is mentioned later, however, the power output can be increased to 6 watts if suitable power supply is available. The oscillator portion comprises two Osram L.P.2 valves in push pull, using what is known as a "Unity Coupled" circuit. This type of oscillator circuit has been found exceedingly good for ultra short wave use as it gives a very good radio frequency output per watts input. Further, it is very stable in operation and is simple in construction and tuning.

In order to make the complete transmitter portable and available for use on batteries, Class B amplification is used in the modulator section. Sufficient power output is available from the B21 Class B valve to fully modulate the oscillator section. If Class A modulation was used, the modulator section would need to be much larger and would take considerably

more current. A Mazda type L.2 valve was found to give sufficient gain as driver valve. The driver transformer is a Multitone type B.E.P.U., ratio 1 : 1, and the output transformer a Ferranti O.P.M.15C. This transformer is tapped but the 1 : 1 ratio was found to be best. The current taken by the modulator section is 7 milliamps, the L.2 valve takes 4 milliamps and the standing current of the Class B valve is 3 milliamps. This valve draws current in proportion to the depth of speech input and at maximum peaks, the current drain increases to 26 milliamps, making 30 milliamps in all, allowing for the driver valve. A standard single button carbon microphone is quite suitable for use with the L.2 valve.

The oscillator portion uses a grid leak value of 20,000 ohms. With this value the current taken by the valves is 20 milliamps and the power in use with 150 volts H.T. supply is therefore 3 watts. If the value of the grid leak is decreased to 5,000 ohms, the current taken by the valves will rise to 40 milliamps and the power will be 6 watts. This rather exceeds the makers' characteristics for these valves, but we have found in practice that for short periods they will stand up to it without trouble. When the oscillator output is increased as above mentioned, it may be advisable to increase the high tension voltage on the Class B valve if additional modulation is required.
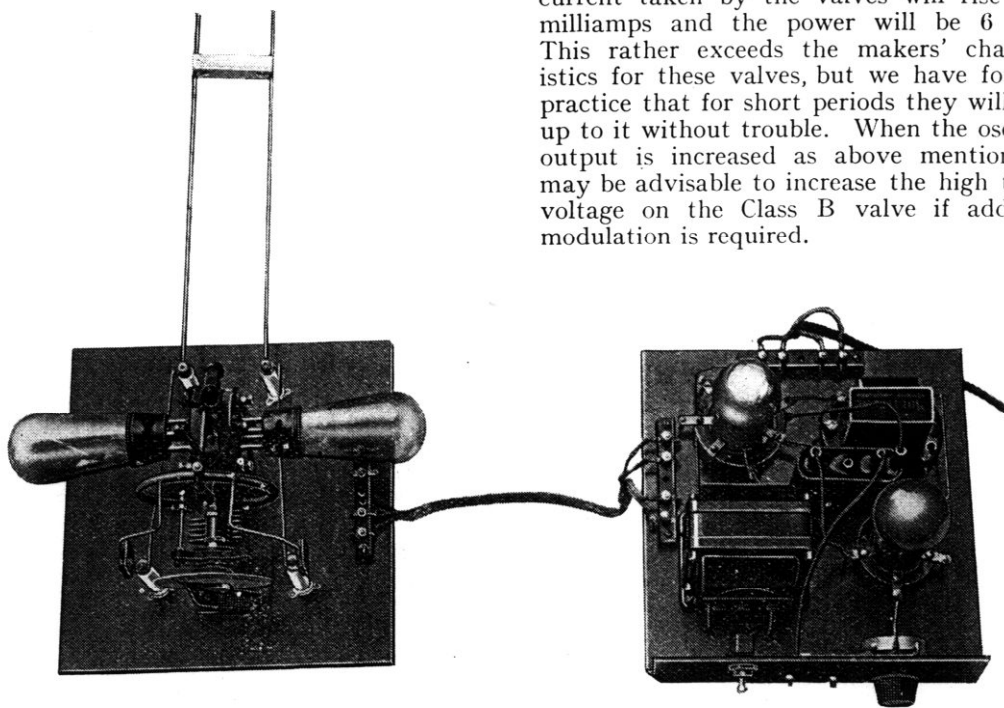

Layout illustration of the Oscillator and Modulator Units.

PUSH PULL ULTRA SHORT WAVE TRANSMITTER—continued

The construction of the Class B Unit is quite straightforward, the components being mounted on a small wooden baseboard. The lay-out is shown in the accompanying illustration. A 4-way terminal saddle at the back of this unit carries high and low tension terminals for both oscillator and modulator supply and similar 4-way terminal saddles link up oscillator and modulator sections. A small paxolin panel is fastened to the modulator baseboard and this carries a volume control, which is in parallel with the secondary of the microphone transformer, two terminals for the microphone transformer winding and an on-off switch, this switches both units at the same time. The baseboard is raised some $\frac{3}{8}$" by means of small wooden strips, which enables the supply leads to be carried in insulated wire under the baseboard and brought up to their respective connections. This is not essential but it improves the look of the finished unit.

The oscillator section is built on a similar wooden baseboard raised by small wooden strips. A 40 m.mfd. tuning condenser is fitted with pointer knob and dial and is mounted on an Eddystone Adjustable Insulated Bracket. The coil is mounted across one of the fixed vane pillars and the moving vane pillar of the Microdenser. This coil needs to be specially made and details of its construction are as follows : $\frac{1}{4}$" copper tube is used, 10" long, three holes about $\frac{5}{32}$" diameter being drilled in the side of the tube, one
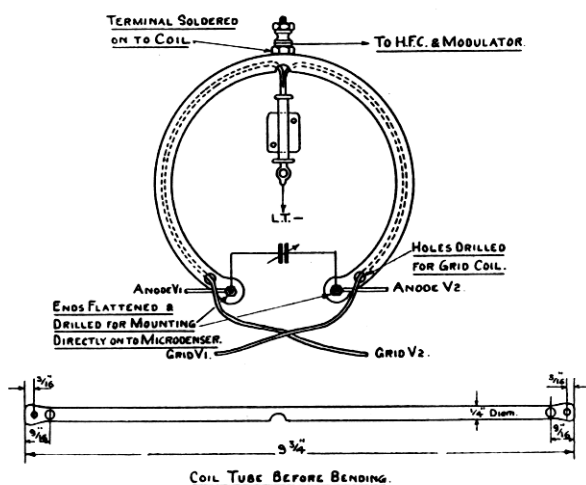
in the centre and the other two $\frac{9}{16}$" from each end. A length of stranded insulated slip-back wire is threaded through the tube into one of the small end holes and out of the other. The ends of the tube are then flattened and drilled out suitably to fit on to the Micro-denser. The flexible insulated wire is then pulled through the centre hole of the tube until a double length of wire about $2\frac{1}{2}$" long comes out from the centre of the tube. The coil can now be bent into shape and will form an almost closed circle with an inside diameter of $3\frac{1}{4}$". We now have the 1-turn copper tube coil with ends hammered out and holes for fixing to the Microdenser and coupled inside it, an insulated flexible wire protruding at each end through the small holes, the tapping pulled out at the centre of the coil from the side in a short double length. Two Eddystone No. 949 4-pin valveholders are now placed back to back and must be mounted with their centres in line with the condenser spindle. A U-shaped piece of brass strip is bent up for this purpose and the valveholders are supported by clamping the opposite filament legs of each valveholder by means of their fastening screws through the metal strip. The grids of the valveholders are on top in a vertical line with the plate sockets of the holders, which are at the bottom. The ends of the main tuning coil are connected directly to the two anode sockets and the ends of the interior insulated flexible coil are crossed and taken to the grid sockets. The two valve sockets which support the valveholders on the brass U piece are joined together with a piece of wire across the back and one end of the grid leak and condenser should be fastened to this wire. The other end of the grid leak and condenser should be fastened to the top tapping from the interior coupling coil.

A small terminal is soldered at the top centre of the main copper anode coil and an ultra short wave choke is connected directly to this terminal in a vertical position, the lead from the other end of the choke goes down between the Microdenser and valveholders through the baseboard to the front terminal of the 4-way terminal strip, crossing to the front terminal of the terminal strip on the modulator section and passing the secondary of the output transformer to H.T.+

A matched impedance aerial cut to length is recommended for use with the transmitter and the feeder lines are brought to two small

TERMINAL SOLDERED ON TO COIL

To H.F.C. & MODULATOR

L.T.—

HOLES DRILLED FOR GRID COIL.

ANODE V1.

ANODE V2

ENDS FLATTENED & DRILLED FOR MOUNTING DIRECTLY ON TO MICRODENSER.

GRID V1.

GRID V2.

COIL TUBE BEFORE BENDING.

PUSH PULL ULTRA SHORT WAVE TRANSMITTER—continued
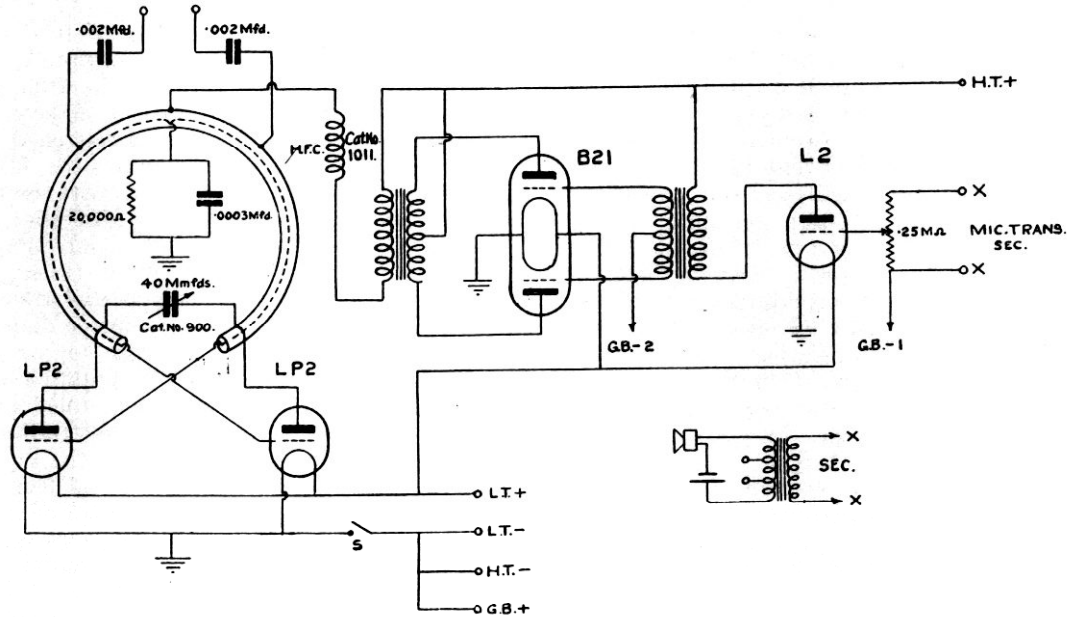
CIRCUIT DIAGRAM.

pillars at the back of the valveholders. Leads from these two pillars are taken up to two larger pillars at the side of the Microdenser, which support two .002 mfd. mica condensers. The other ends of these condensers are then taken to equidistant points from the centre of the main anode coil. The points at which these two leads are soldered on this coil gives the degree of aerial coupling, and experiments can be made to find out the best tapping points. In practice, these were found to be about 2″ from the top centre of the coil.

The transmitter will be found to have an excellent performance, with its range, of course, governed by the operating circumstances.

LIST OF PARTS.
Oscillator Unit.   Price

1 Eddystone Pointer Knob and Dial, No.
   1027 ..   ..   1/3
1 Eddystone Adjustable Insulated Bracket,
   No. 1007 ..   ..   1/6
1 Eddystone Microdenser, 40 m.mfd., No.
   900 ..   ..   4/3
2 Eddystone 2¼″ Insulating Pillars, No. 1028 each 6d.
2 Eddystone 1¼″ Insulating Pillars, No. 1029 each 4½d.
1 Eddystone Ultra S.W. H.F. Choke, No.
   1011 ..   ..   1/3
1 Eddystone 4-way Terminal Saddle, No. 996   1/1
2 Eddystone Frequentite Valveholders, No.
   949 ..   ..each 1/5
2 Fixed Condensers, .002 mfd. (Dubilier or
   T.C.C.) ..   ..
1 Length ¼″ Copper Tube, 12″   ..   ..
1 Fixed Condenser, .0003 mfd. (Dubilier or
   T.C.C.) 1/-
1 Resistor, 20,000 ohms, 1-watt   ..   ..
1 Length ¼″ × 1/16″ Brass Strip for mounting
   valveholders, 12″ long ..   ..   ..
1 Wood Baseboard, 8″ × 8″ × ¾″ ..   ..
2 Wood Strips, 8″ × ⅝″ × ¾″ ..   ..   ..
Connecting Wire, Screws, etc.   ..   ..
2 Valves, type Osram L.P.2 ..   ..   ..

LIST OF PARTS.

Modulator Unit.
                      Price

2 Eddystone 4-way Terminal Saddles, No.
   996 ..   ..each 1/1
1 Eddystone Universal Valveholder, No. 1015   1/3
1 Eddystone Universal Valveholder, No. 1024   1/8
1 2-point On-off Switch 1/6
1 Potentiometer, 250,000 ohms (Erie)   ..   3/6
1 Output Transformer (Ferranti O.P.M.15C.)   26/6
1 Grid Bias Battery, 4.5 volt, with clip
   (Hellesen) 1/-
1 Driver Transformer, ratio 1 : 1 (Multitone
   B.E.P.U.) 9/6
1 Wood Baseboard, 8″ × 8″ × ¾″ ..   ..
2 Wood Strips, 8″ × ⅝″ × ¾″ ..   ..   ..
1 Paxolin Terminal Strip, 8″ × 3″   ..   ..
Connecting Leads, Spades and Wander Plugs
Connecting Wire, Screws, etc.   ..   ..
1 Valve, type Mazda L.2   ..   ..   ..
1 Valve, type Osram B.21   ..   ..   ..

AERIAL SYSTEMS
FOR ULTRA SHORT WAVE USE.

Aerial systems for ultra short wave transmission and reception can form a most interesting subject for experiment. Apart from the numerous types already in existence, there is still much scope for originality. Due to the small physical proportions of U.S.W. aerial arrays, experiments with these can be carried out in limited space and without great expense. Since aerial lengths can be arranged to resonate to the frequencies in use, they operate efficiently and give a high percentage of radiation using small power. It should be noted that a good transmitting aerial will also prove a good receiving aerial. We have already mentioned in our chat on the ultra short waves that height plays an important part as far as reception and transmission range is concerned, and it is therefore desirable to erect the aerial in as high a position as possible and out of the way of nearby objects which may cause screening.

For transmission purposes, it is essential to bear in mind the distribution of voltage and current in the aerial, and for this purpose diagrams 1a, 1b, and 1c show this for $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ wave aerials. Radiation is greatest from those parts of an aerial where the change of current is most, and it will be noticed that whatever type of aerial is used the top of the radiator is always at maximum voltage.
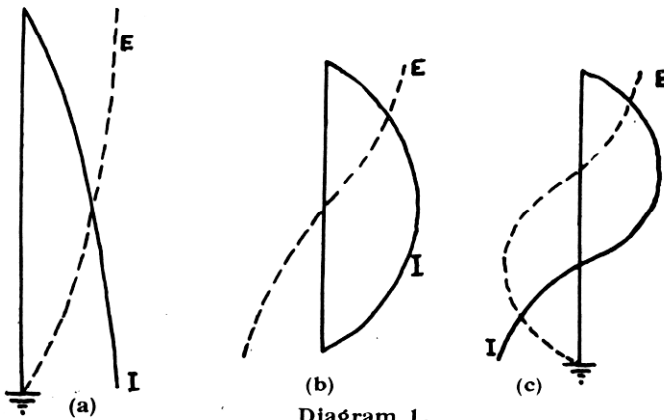
Diagram 1.

The exact length of a $\frac{1}{4}$ or a $\frac{1}{2}$ wave radiator is not exactly a $\frac{1}{4}$ or a $\frac{1}{2}$ the wavelength in use, but more nearly

$$\frac{\text{wavelength}}{4.3} \quad \text{or} \quad \frac{\text{wavelength}}{2.1} \quad \text{respectively.}$$

because the distribution of capacity and inductance is not uniform. The exact figure is dependent on diameter of the conductor and its proximity to surrounding objects.

The sky wave which on the lower short wave frequencies is reflected back to earth by the Ionised Appleton layers, is not able to be utilised for ultra short wave working. It is thought that either the ionization of the reflecting layers is not sufficiently great to reflect the rays back and penetration occurs, or that the angle of incidence is below that of the critical angle required for reflection.
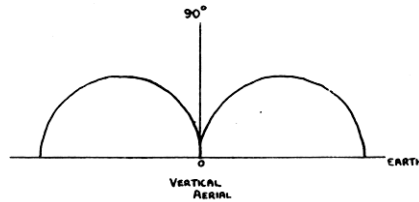
Diagram 2.

It is possible that under freak ether conditions, reflection may take place and also that extreme long distance working may at some future date be found possible. Our present aim, however, is to find aerial systems which enable us to make maximum use of the direct ray. We therefore need an aerial which will radiate most of the energy in a horizontal plane to the earth's surface, i.e., low angle radiation. To obtain this, a vertically polarized wave is known to be more effective than a horizontally polarized one, so that a vertical aerial is the first requirement. The length of aerial can next be considered, and in practice a length of radiator which is cut to resonate at half the wavelength in use gives the greatest radiation parallel to the earth and is therefore generally used in modified forms. Vertical polar diagrams for a half-wave vertical aerial, showing the radiation patterns for different heights above earth, are illustrated in diagrams 2 and 3.
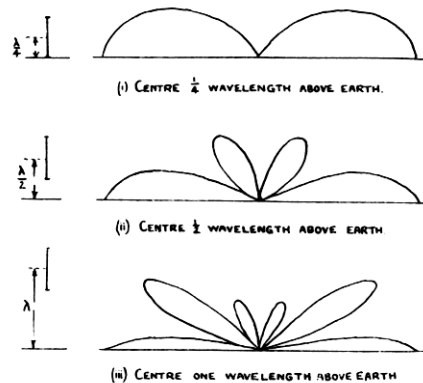

(i) CENTRE $\frac{1}{4}$ WAVELENGTH ABOVE EARTH.

(ii) CENTRE $\frac{1}{2}$ WAVELENGTH ABOVE EARTH

(iii) CENTRE ONE WAVELENGTH ABOVE EARTH

Diagram 3.

AERIAL SYSTEMS—continued

It will be seen that the effect of increasing the height of the aerial above earth is to concentrate the radiation into upward beams which increase in number as the aerial is raised. The radiation characteristics of an aerial are distorted by nearby objects, such as buildings, guy wires, telephone or power lines.

When more than one half-wave is present on the aerial, the aerial is said to be operating on a harmonic. The number of the harmonic is the same as the number of half-waves in use, so that with an aerial three half-waves long, we are said to be operating on the third harmonic with full-wave aerial on the second harmonic.

Diagram 4.

(i)   (ii)
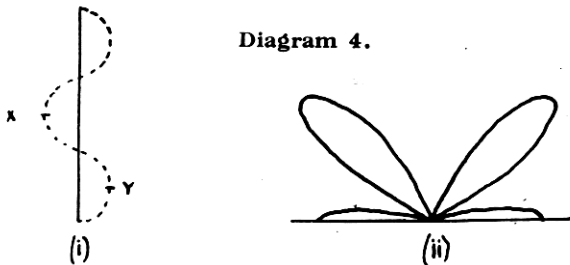
The radiation pattern using three half-waves on the aerial is shown in diagram 4 (i) and (ii). The currents at points X and Y are in antiphase, and the effect is to give maximum radiation in an upward direction, which is undesirable. If, however, the alternative half-waves can be arranged so that they can be prevented from radiating energy and the other radiating portions are operating in phase, a much better result can be obtained. This is done in the Franklin uniform current aerial where phasing coils, which are arranged to resonate at half the wavelength in use and have practically no radiation, are interposed between half-wave radiators. An example of this with the resultant radiation pattern is shown in diagram 5 (i) and (ii).

(ii)
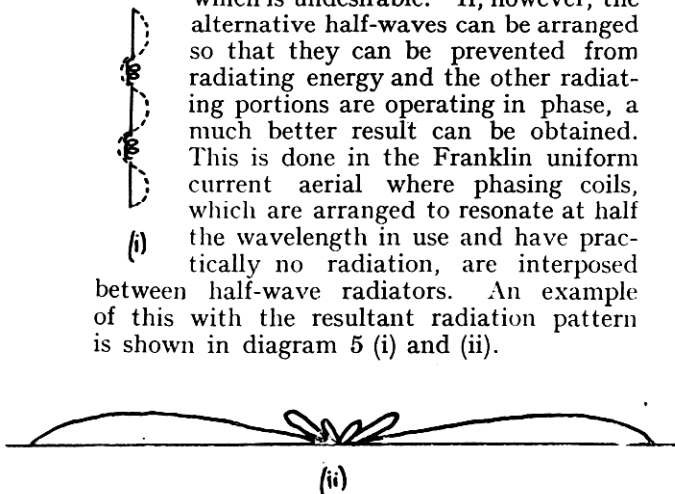
Diagram 5.

A number of aerials used for ultra short wave work are described in the following matter. In all cases a vertical half-wave aerial is used and the fundamental difference lies in the methods in which the feeder or lead down lines are connected to the transmitter or receiver. Maximum results are obtained when the impedance of the aerial is matched to the load impedance of the tuned receiver or transmitter circuit.
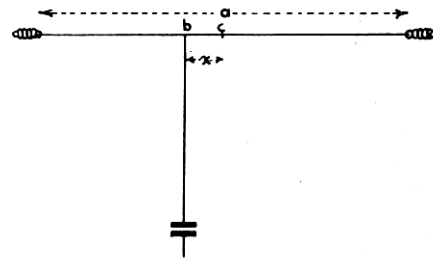
Diagram 6.

Diagram 6 illustrates the Windom aerial, sometimes known as the single wire matched impedance feed system. With this aerial correct matching is obtained by neutralising the standing waves on the feeder by tapping the aerial a short distance away from its exact centre. The length of aerial a and the tapping distance bc for different frequencies is calculated from the following formulae :

We have frequency in Mc/s. (f) by wavelength in metres (λ) is equal to **300,**

but wavelength is equal to **2.1a,**

therefore 2.1af = 300,

or $a = \dfrac{300}{2.1\,f}$ metres

$a = \left(\dfrac{300}{2.1} \times \dfrac{39.37}{12}\right)\dfrac{1}{f}$ feet

or length of aerial $a = \dfrac{468}{f}$ feet

The tapping distance b c is given by :—

$\dfrac{a \times \beta}{180}$ feet.

When β is a factor which depends largely on the diameter of the wire used.

For 16g. wire, $\beta = 25$.

Therefore b c $= \dfrac{a \times 25}{180}$ feet $= \dfrac{a}{7.2}$ feet

AERIAL SYSTEMS—continued

For the 5-metre amateur waveband, the values of a and b c are as follows :—

Freq.	λ	a (feet)	b c
50	6.00	9′ 4″	1′ 4″
52	5.77	9′ 0″	1′ 3″
54	5.56	8′ 8″	1′ 2¼″
56	5.37	8′ 4″	1′ 2″
58	5.17	8′ 0½″	1′ 1¼″
60	5.00	7′ 9″	1′ 1″

There are two points to remember in the erection of this aerial, firstly the feeder must be kept straight and at right angles for a quarter-wavelength, secondly when the aerial is erected vertically, the feeder should be tapped on the lower half-section of the aerial.
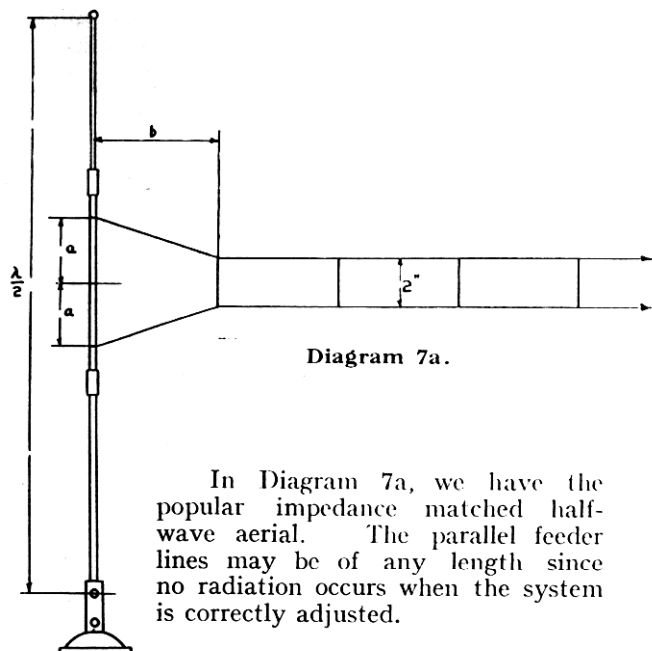
Diagram 7a.

In Diagram 7a, we have the popular impedance matched half-wave aerial. The parallel feeder lines may be of any length since no radiation occurs when the system is correctly adjusted.

Since an aerial, even though it is a straight length, has inductance and the two opposite ends have capacity to each other, the whole system can be compared to a tuned circuit with a definite impedance. For a half-wave aerial, this impedance will be in the order of 12,000 ohms across the ends. This impedance decreases as the centre is approached, when it is about 75 ohms. Therefore, with a two-wire feeder spaced 2″ apart with an impedance of about 440 ohms, to obtain a matched system each feeder must be tapped into the aerial at two points equidistant from the centre where the aerial impedance is approximately this figure.

The length of the vertical wire can be calculated as described for the Windom aerial. The distance (a) in inches of the tapping points from the centre is given by the formula :—

$$\frac{678}{\text{frequency in Mc/s.}}$$

The distance b is also important and is equal to :—

$$\frac{1771}{\text{frequency in Mc/s.}}$$

Diagram 7b shows five different types of coupling for use with this aerial.
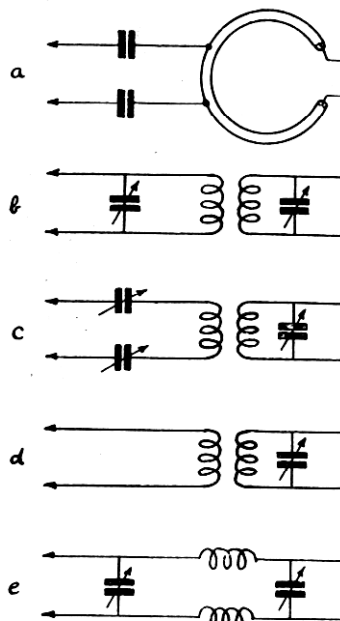
Diagram 7b.

In Diagram 8 a half-wave Hertz aerial with Zepp feeders is shown. The length of the aerial in feet can be directly calculated from the simplified formulae :—

Length in feet = wavelength in metres by 1.56

or Length in feet = $\dfrac{468}{\text{frequency in Mc/s.}}$

The feeder line consists of two parallel wires spaced 2″ apart. Eddystone Bar Insulators, No. 1017, can be used for this purpose. One side of the line is connected to the bottom of the aerial and the other connected to the other side of an insulator. This feeder line must be tuned and for lengths under a quarter-
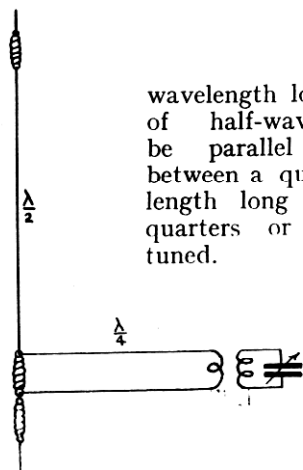
AERIAL SYSTEMS—continued

wavelength long and multiples of half-wave-lengths, should be parallel tuned, lengths between a quarter and $\frac{3}{8}$-wave-length long and multiples of quarters or just over, series tuned.

Diagram 8.

In Diagram 9 a doublet type of aerial is shown, the half-wave aerial being split in the centre by an insulator. The length of the quarter-wave sections at each side can be arrived at by using the formula given for the half-wave Hertz and cutting the length into two equal parts. When used for transmitting, the current antinode is at the centre and the feeders must be a half-wave or a multiple of half-wave long. They should be series tuned.
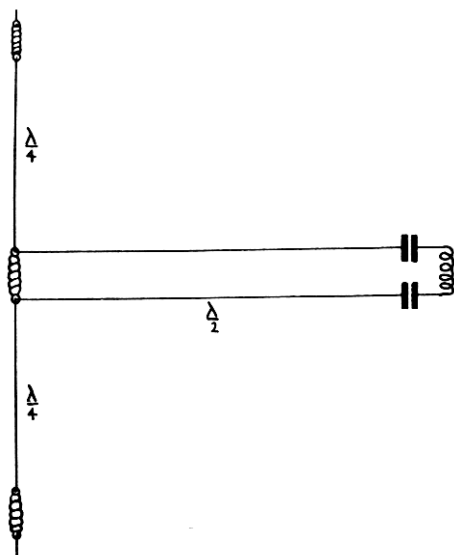
Diagram 9.
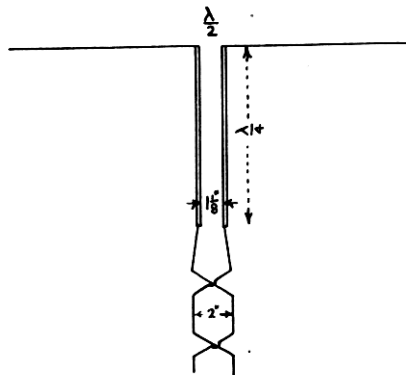
Diagram 10.

In Diagram 10, an aerial known as the Johnson " Q " is shown. This is similar in operation to the previous type of aerial with the exception that an untuned transposed transmission line is employed, and the matching of the tuned circuits to the half-wave doublet is accomplished by means of a quarter-wave section of parallel copper tube.

Now, a half-wave doublet aerial erected more than a quarter-wave above earth has an effective impedance of anything between 70 and 80 ohms. An average value would therefore be 75 ohms. A transposed 16g. feeder line using Eddystone Crossfeeder Blocks has an effective impedance of about 440 ohms, and to match this impedance to the doublet, we require the parallel copper tubes to form a series impedance of 182 ohms. This is computed from the formula :—

$$Z_O = \sqrt{Z_D \times Z_T}$$

where Z_O is the characteristic impedance of the quarter-wave section.
Z_D is the doublet impedance.
Z_T is the transposed feeder impedance.

We have, therefore,
$$Z_O = \sqrt{75 \times 440} = 182 \text{ ohms.}$$

Such an impedance is offered by two $\frac{1}{2}''$ copper tubes placed $1\frac{1}{8}''$ centres apart. These must be at right angles to the aerial and the transposed feeder line can be any length. The doublet length is calculated from the formula already given and the length in feet of the copper tubing is given by :—

$$l = \frac{246}{f \text{ (megacycles)}}.$$

For 56, 58 and 60 megacycle operation, the length of the copper tubes will be 4' $4\frac{1}{4}''$, 4' 3" and 4' $0\frac{1}{2}''$ respectively.

AERIAL SYSTEMS—continued
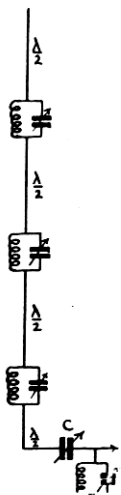
In Diagram 11, the Franklin uniform current aerial with phasing coils between each half-wave section, as already described, is shown. The length of the half-wave sections is calculated from the formula for the Hertz aerial. The phasing coils, which must resonate at 2.5 metres, can consist of 3 turns of 14g. copper wire wound with a $\frac{1}{4}''$ internal core and tuned with a 15 m.mfd. Microdenser. This type of aerial can be voltage fed as shown or current fed in the centre if three radiators are used. A twin 2″ spaced feeder line, as mentioned earlier, should be employed. For receiving, the single feeder arrangement as shown is ideal.

Diagram 11.

AERIAL ARRAYS.

It has already been mentioned that the range of an ultra short wave transmission can be considerably extended if the radiation is beamed in the desired direction. Fortunately, the construction of small arrays for ultra short wave working is by no means difficult and with the aid of telescopic aerials, they can even be made portable.

Diagrams 12, 13, 14 and 15 show the radiation diagrams for a selection of directional arrangements. Diagram 12 shows two-half wave radiators placed one quarter-wavelength apart giving maximum radiation directly in front and behind. If the aerials are spaced one half-wavelength apart, as in Fig. 13, the polar diagram will be in the form of a figure eight. The loops can be still more concentrated if four or eight aerials are arranged, each a half-wavelength apart. To obtain maximum radiation in one direction only reflectors can be used behind the aerials. These reflectors are entirely free with no connections to them, but must be placed an exact distance behind the aerial and cut to a slightly longer length as shown in the table, and the aerial must be placed centrally in respect to them.

Diagram 14 shows the pattern for a half-wave aerial with one reflector placed a quarter-wavelength behind it. This arrangement lends itself well for portable use. A piece of 4″ × 2″ wood, 4′ 6″ long, mounted on a pivot arrangement with two telescopic aerials fixed upon it, makes a directional arrangement which can be pointed in any direction.

Fig. 15 shows the greatly increased directional effect obtained using a larger number of radiators and reflectors. In this case, four half-wave aerials spaced a half-wavelength apart with four reflectors a quarter-wave behind, are used. A pictorial arrangement

Diagram 12.

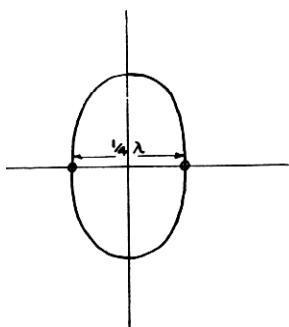**Diagram 13.**

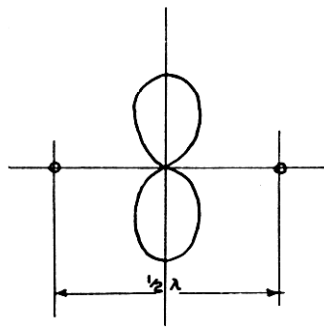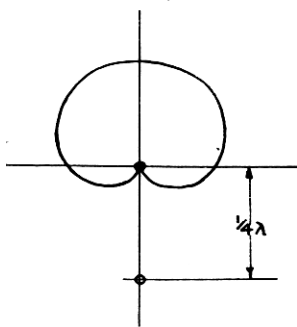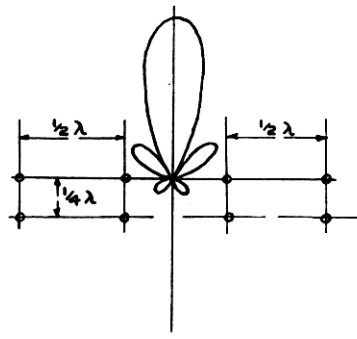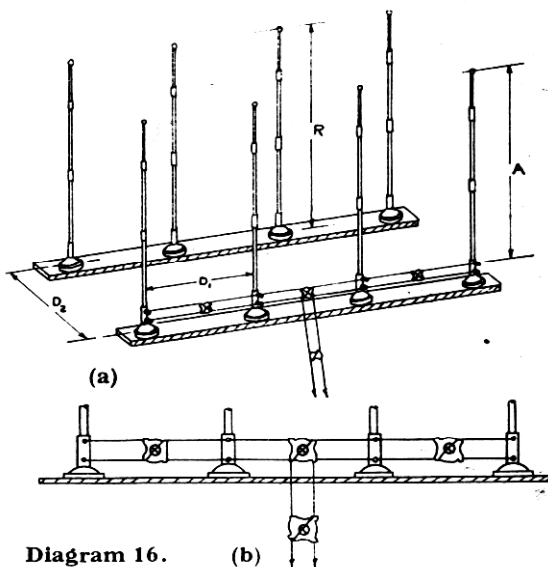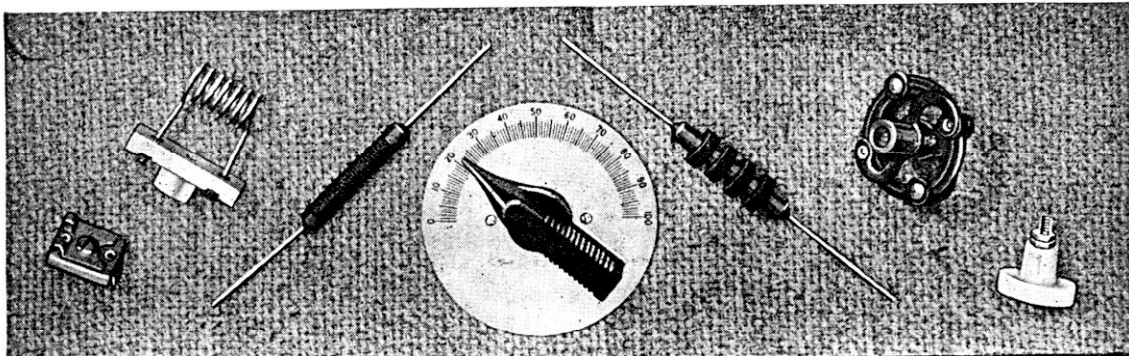**Diagram 14.**

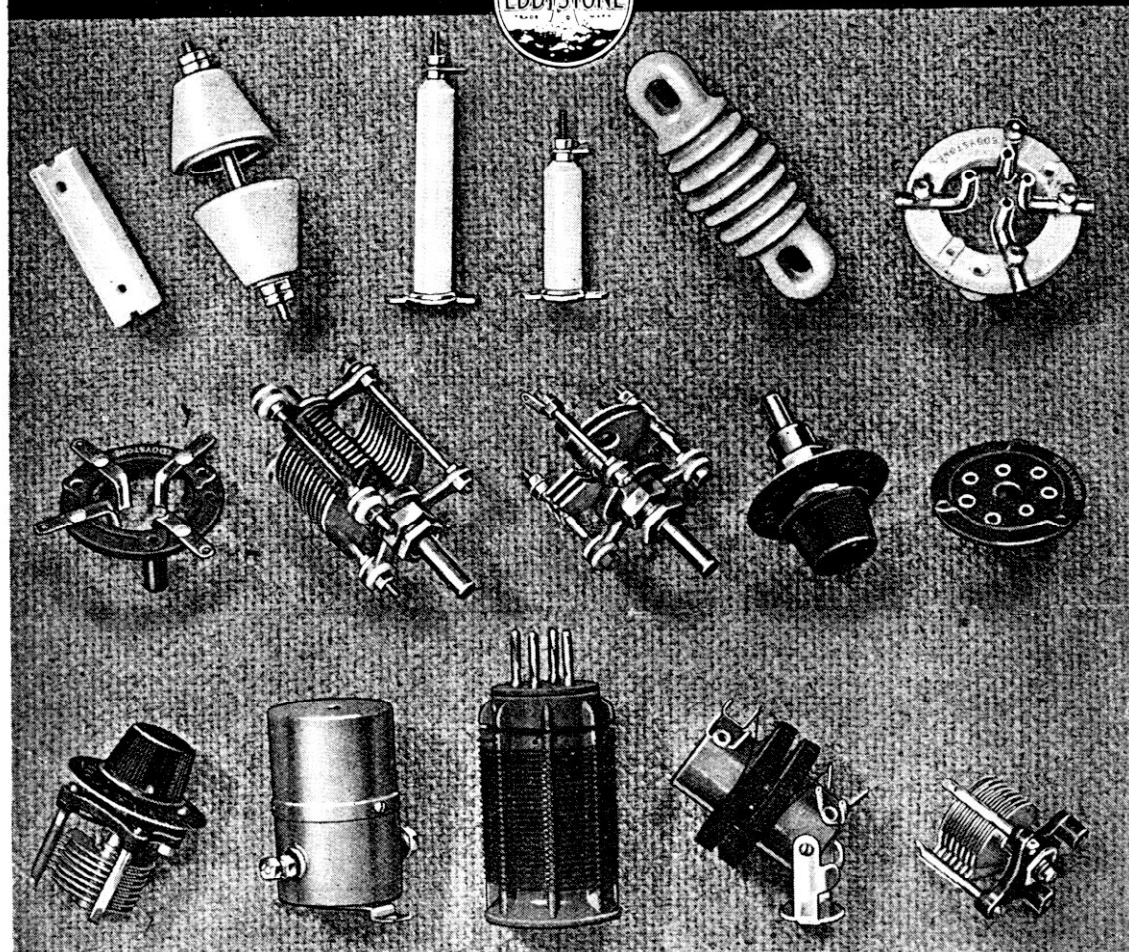**Diagram 15.**

(a)

Diagram 16.   (b)

EDDYSTONE

SHORT WAVE COMPONENTS

SEASON 1936

STRATTON & Co. Ltd. • EDDYSTONE WORKS • BROMSGROVE ST. • BIRMINGHAM 5.

COMPILER'S NOTE.

All the sets and apparatus described in this Manual have been subjected to thorough tests and trial before inclusion, with satisfying results. Much as we desire that they should give equal satisfaction to all who make use of the articles herein, we would point out that we cannot enter into long correspondence concerning difficulties which may arise through faulty construction or the substitution of different components. With the assurance that, if built exactly according to instructions without errors, they are capable of first class results, we would request that constructors who may have any troubles in the initial instances should check their apparatus over carefully before writing to us. Finding out the cause of one's own troubles is, moreover, not only a reason for self-satisfaction but is highly instructive.