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Index

The Three Electrode Valve
(Extracted from the "Wireless World" June 1917)

The three electrode valve receiver is a developement of the Fleming valve (two element)
To understand its action let us first take Fleming valve with a battery "B" connected between the filament and the plate as shown in fig. 1 and vary the voltage "V" measuring each time the corresponding current "A"

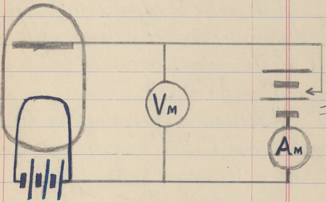
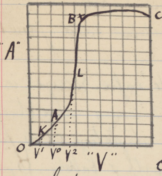


Fig. 1.

Having obtained a series of results plot a curve showing the functional relation between "V" and "A"

(see Fig 2)

Fig. 2.



We find that the curve may be roughly divided into three portions: The portion OA with $\frac{DV}{DA}$ small; the portion AB which is comparatively steep, $\frac{DV}{DA}$ large and the portion BC almost parallel to the V-axis ($\frac{DV}{DA}$ almost $= 0$)

The variation in ratio $\frac{DV}{DA}$ has a very important physical meaning.

Let the valve be adjusted to the point "A" If then we increase the voltage by the amount V^oV^2 the increase in current will be given by $LV^2 - AV^o = (SA)$

A decrease of the voltage by the same amount $V^oV' = V^oV^2$ will lead to a decrease in the current by $AV^o - KV' = (SA)_2$

Now obviously $(SA)_1 > (SA)_2$

therefore if a variable voltage is superimposed on the valve, the net result will be an increase in the average value of the current from A to $A + (SA)_1 - (SA)_2$. So the device is then a rectifier. In the same manner the valve adjusted to the point B will also rectify; only the average value of the current will be decreased instead of being increased as in the first instance.

Let us now consider the case when the valve is adjusted to the point (which may be coincident with L). Usually the portion AB is very nearly a straight line. Therefore if we apply an alternating voltage the increase in current during one half period will be compensated by the decrease during the second half period. In other words $(SA)_1 = (SA)_2$; the device does not rectify in this case, and the variable voltage produces an alternating current superimposed upon the direct current generated by the battery.

A question of the utmost importance is the value of the amplitude of the A.C.

Obviously this value will vary with the slope of the curve in the neighborhood of the chosen point "D" (the amplitude of the applied variable voltage is supposed not to exceed a certain value.) The steeper the curve, the larger will be the superimposed A.C.

With the portion AB almost vertical even a very small variation of the voltage will lead to a comparatively large variation of the current. It is clear now that the presence of portion AB with a large value of $\frac{DV}{DA}$ enables us to use the valve as a magnifier.

To get a large magnification it is necessary then to make the portion AB as steep as possible. It has been found (by De Forrest) that very steep characteristics can be got by providing the valve with a third electrode in the form of a grid.

The curve is essentially the same shape as that shown in Fig. 2 and whether the device will work as a rectifier or amplifier will depend on the point to which it has been adjusted, exactly in the same manner as in the case of the two electrode valve.

In conclusion we would like to draw the attention of the reader to the portion of the curve BC. Here the current is nearly independent of the voltage. When adjusted to that portion of the curve, the valve (either two or three electrode) can be worked as a current limiting device.

It should be borne in mind that the sensitiveness of a valve depends on the temperature of the filament, the degree of evacuation, and the general construction, i.e (the material of the electrodes their relative positions etc.)

PART I

The three element valve consists of an evacuated vessel containing a filament, a grid, and a plate. The elements are so disposed that the grid either entirely surrounds the filament or lies between it and the plate. A battery with a variable resistance is used to heat the filament.

Now suppose that by means of a battery and potentiometer we arrange that the grid shall be slightly positive with respect to the filament; and we take a ten volt battery and connect the positive pole to the plate of the valve and the negative pole to the + arm of the filament, a certain current will flow in the circuit comprising battery, filament, space and plate. This current will have a definite value depending on the EMF of the battery, the nature and brilliancy of the filament, the construction and degree of exhaustion of the valve.

Leaving all these factors constant, it is found that we can control the value of this current from plate to filament, by varying the potential of the grid with respect to the filament. If the grid be sufficiently negative with reference to the filament, no current can flow from plate to filament, even if the former is hundreds of volts positive.

Whereas, if the grid be a fraction of a volt less negative, then a comparatively large current will flow in the plate circuit.

In adapting this arrangement for use in Wireless receiving circuits, the incoming signal is applied in such a way as to cause variations in the potential of the grid.

The steady potential of the grid is adjusted to the critical point before mentioned; then when the A. C. potential is applied by the incoming signal in superposition upon this steady potential, the following conditions obtain:- 1st When the grid is slightly more negative than the critical value, no current will flow in the plate circuit; 2nd When the grid is slightly more positive than the critical value, a comparatively large current will flow in the plate circuit. Thus we have the valve giving the effect of a rectifier and magnifier.

This relay effect occurs with great rapidity. Variations of the grid potential at a frequency of millions per second are faithfully reproduced as variations of the plate current. This allows the valve to be used as a relay for actual oscillations in the receiver circuits, even on short wave lengths.

A receiving circuit employing the valve detector is shown in Fig. 3

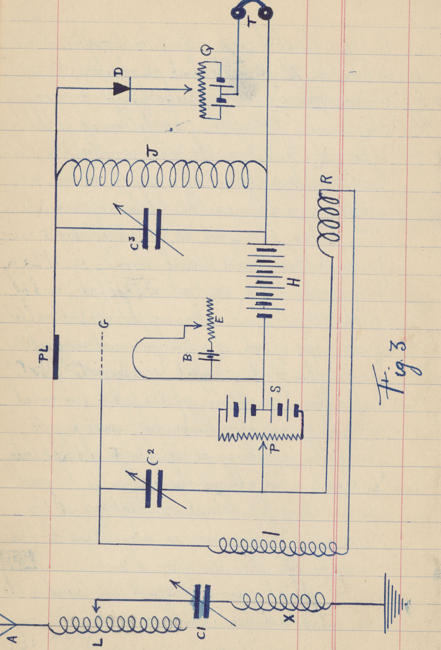


Fig 3

Fig. 3.

A is the aerial, tuned by means of the inductance L and condenser, C1. Coupled to this thru X, is circuit composed of the inductance l, the coil R and the condenser C^2, this condenser being for the purpose of tuning the secondary circuit. One side of C^2 is connected to the grid of the valve, G; the other, to the slider P of a battery & potentiometer S: the midpoint of this battery goes to the valve filament. B is a battery heating the filament, regulated by resistance E. This completes the first, or grid circuit of the valve.

The plate circuit is composed of the plate PL connected to one end of an inductance J, the other end of which connects to the positive end of the high voltage battery H, the negative pole connecting to the filament.

The inductance J is shunted by condenser C^3 : J & C^3 thus form a closed oscillating circuit, which is also tuned to the incoming wave. The carborundum crystal D & its potentiometer Q are in series with the 'phones T, and this combination placed across the inductance J.

The full potential difference of the battery H is applied across the space between the filament and the plate. The value of the current that flows as result of this E.M.F is dependent upon the potential of the grid with respect to the filament. The potentiometer S may be adjusted to a point where current is just beginning to flow thru J to the plate PL and across the space to the filament.

At this point a small increase in the potential of the grid will make a big change in the current between the plate and filament. With these conditions the incoming signal will clearly vary the potential of the grid alternately from a little less than the potential required for the steady current, to a little more.

These minute changes produce large current changes in the plate circuit, and oscillations will be excited in the J, C^3 circuit which will be received in the usual way by the crystal D, and 'phones T.

It will thus be seen that the functions of the valve is not to produce a current in a telephone as is done by a crystal receiver, but to open and close a circuit which is quite independent, and which can naturally be made to supply more energy than could be obtained from the received signal.

The action of the coil R is important: it is in the oscillating circuit I, R, C^2, and is inductively coupled to the J, C^3 circuit. Its function is to transfer to C^2, I, R, a portion of the large energy developed in the circuit C^3, J, and so help to increase the variations of potential across C^2 produced by the signal. There is a critical coupling for this coil: if it is too low, the

signals will not be magnified sufficiently.
If it is too tight, the circuits will maintain themselves in a state of continuous oscillation, thus producing a howling noise in the telephones.

This set of connections requires three distinct tuning arrangements. 1st. The aerial circuit 2nd. the grid circuit & 3rd. the plate circuit.

These may be reduced to two by employing the connections shown in Fig. 4. Here the grid potentiometer & slider are connected across the ATI instead of across the inductance of of a separate closed oscillatory circuit.
It has the advantage of being reduced to a simple crystal receiving circuit by cutting off the filament battery.
It will be observed that the valve potentiometer is not provided with a separate battery but is connected across the heating battery as shown. This arrangement answers the purpose equally and economises batteries.

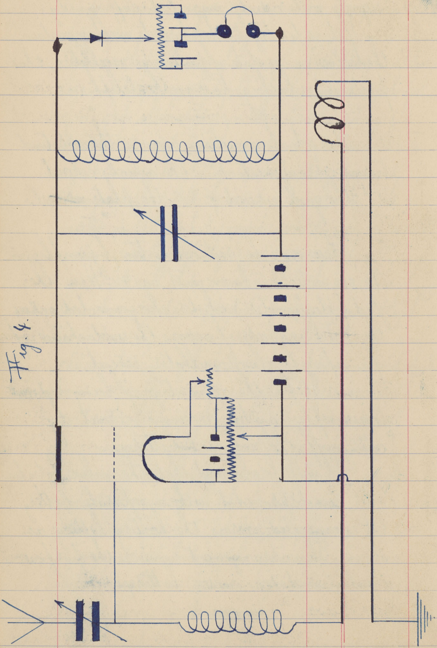


Fig. 4.

Part II

The three electrode valve, & continuous waves.

When the key of a spark transmitter is depressed, a series of wave trains is produced, one to each spark. Each train as it is received is rectified by the crystal, the result being a series of impulses in the telephones, a note being produced of audio-frequency corresponding to the spark-frequency of the transmitter.

A continuous wave transmitter, however, emits only one persistent wave train to each depression of key, and as the rectified current is of more than audio frequency, no sound will be produced in the 'phones.

It is clear therefore, that we must either, (1) break up the current in the telephones into a series of impulses: or (2) convert the oscillating current in the receiver circuits into a series of trains of oscillations.

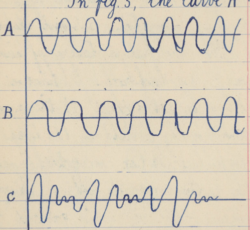
This latter result is best obtained by the "interference" method. The "interference" method is used almost universally at the present time, and we shall therefore confine our attention to the consideration of its application in practice.

The method consists of superimposing

upon the oscillating current produced by the incoming waves, an alternating current of slightly different frequency.

The two currents are then rectified together and operate the telephone in the usual way. The signal is heard as a note whose frequency depends on the difference of the frequencies of the incoming waves, and the superimposed oscillation.

In fig. 5, the curve A represents the



current produced in received circuit by the incoming signal. The curve is a uniform sine wave, the value of current at any instant being plotted as ordinate, the time as abscissae.

Since the amplitude of this curve is constant the current produced in the telephone after rectification will be a constant direct current of a given value. (It should be noted that although the current through the rectifier will be a pulsating one, each second half-wave producing a pulsation, the impedance of the telephone windings is much too high to allow the separate impulses to pass. The impulses are all "smoothed out" into a uniform current.)

Now suppose we induce in the receiver circuit another oscillatory current of persistent waves of slightly lower frequency, this current being represented by curve B. This current, taken by itself, would produce no sound in the telephones. If however both currents are existing in the circuit at the same time, the effective current, at any instant, is given by the sum or difference of the two according to whether they are flowing in the same, or different, directions.

The curve of the resultant current is shown as C. It is clear that the oscillations are no longer uniform, but are rising and falling in amplitude; after rectification, this current will produce a note in the telephones, just as the varying oscillation trains do, from a spark transmitter.

We can therefore adjust the note in the

telephones to any desired pitch by simply altering the frequency (or wavelength) of the local oscillations. Any receiver can be adapted by this means to C.W. reception

The most convenient way of generating the local oscillations, is by the use of the 3 electrode valve.

Taking the circuit illustrated in Fig 3, it was explained that any oscillatory current in the tuned circuit connected between the grid & filament of the valve is magnified and reproduced in the circuit between the filament & plate.

Fig 6 (a), shows this circuit with the aerial & crystal circuits omitted, but with a high frequency generator G inducing a persistent oscillation inthe circuit A. The circuits A & B are tuned to the wavelength that generator G is producing.

For the purpose of explanation, let us suppose that the current induced in A by G is 1 milli-ampere: then if the valve gives a magnification of 10, the current in B will be 10 m.amp.

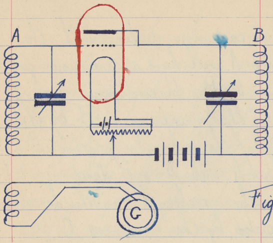


Fig. 6 (a)

Now since the energy in B is so much larger that in A, there is no reason why we should not use a small part of it to maintain the oscillations in A. This we can do by coupling the circuits together loosely, as shown in fig. 16 (b)

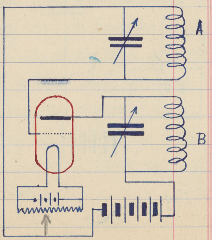


Fig. 6 (b)

It is clear that we can now dispense with the generator G, since A will have a continuous current induced in it by B. A continuous high frequency current is thus maintained in B by the magnifying action of the valve. In practice it is found best to have A untuned, & B tuned as shown in fig. 7. The wavelength can then be easily and conveniently adjusted by the condenser C.

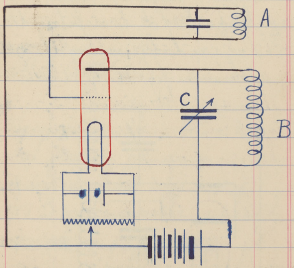


Fig. 7.

Now let us see how this oscillator is applied to a receiver. Fig. 8 shows a simple crystal receiver circuit at (a), such as is ordinarily used for spark signals; coupled to it loosely by means of R is the oscillator (b), the oscillator being tuned to a slightly different wave length from the incoming signals. The compound wave produced is rectified and heard in the usual manner.

The note heard, as explained before, is equal to the difference of frequency: so that if the signal has a frequency of 100,000 per second (3000 metre wave), and we wish to have a reading note of 1000, it will be necessary, to tune the oscillator either to 10100 (2970 metres) or 99000, (3030 metres).

Thus a very considerable advantage, as interfering stations produce entirely different notes and unless very strong does not stop communication.

It is best not to have the coupling too tight. It is often dispensed with, the oscillator merely being stood near the receiver, depending upon what chance coupling may happen to exist between them.

Hook-up for Honey-comb Coil (DeForest)

If a fixed grid condenser is used, the grid leak must be very carefully adjusted. Wavelength range is 7375 to 17,500 meters with average aerial of ·0007 mfds capacity. This circuit works equally well on short waves, regenerating sparksignals to a remarkable degree. For 600 meters plug in a No. L-100 Coil in place of the L-1500 Coil; wavelength range with this coil is 430, to, 1010 meters.

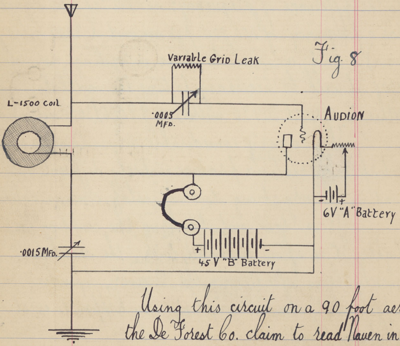


Fig. 8

Using this circuit on a 90 foot aerial the De Forest Co. claim to read Nauen in daytime.

Preferred Circuits for Marconi V.T.

The preferred circuit for the Marconi V.T. is shown in Figure 9, where an inductively coupled tuning transformer is indicated. The secondary coil of the tuner is shunted by a variable condenser of 0·0005 mfd. maximum capacity. The grid condenser is of 0·0001 mfd. capacity. It may be fixed or variable. A grid leak of two million ohms is connected between the grid and filament.

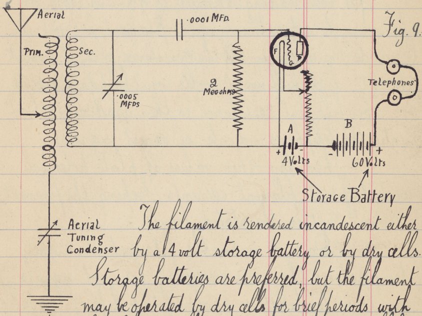


Fig. 9.

The filament is rendered incandescent either by a 4 volt storage battery or by dry cells. Storage batteries are preferred, but the filament may be operated by dry cells for brief periods with good results. If dry cells are used, a series-parallel connection of the cells will prolong their life. If a battery in excess of 4 volts is used, a 10-ohm rheostat should be used in the filament circuit.

The Plate voltage may be furnished by a bank of flashlight cells giving an E.M.F. of approximately 60 volts. The telephones should be of about 2000 ohms.

Precautions:

If a battery in excess of 4 volts is used, be careful not to exceed the stated filament current of 0.7 ampere.

If a low reading ammeter is not available, an approximate adjustment of the filament current can be made by inserting all the resistance of the filament rheostat and putting 60 volts on the plate circuit.

The filament resistance is then gradually cut out until the telephones indicate strongest signals.

Then try other values of plate potential and different filament currents, keeping the filament current within the stated limits.

Do not burn the filament at higher temperatures than are necessary for good signals as lower temperatures prolong the life of the valve

The V.T. may be used in either detecting or in amplifying circuits. Its average "life" is 1500 hours.

One step amplifier for C. W. & spark reception.

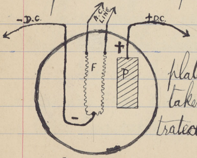
The diagram shows how a four pole switch may be used to throw in the audio-frequency amplifier.

Starting at the aerial: the primary of a loose coupler is shown, also a switch for putting the primary condenser in series with the aerial or in shunt to the primary inductance. The secondary of the coupler has the ordinary detector hook-up when the "tickler" coil is shortcircuited. When the "tickler" coil is in circuit you have a regenerative feed-back hook-up.

These two circuits obtain when the 4 pole switch is thrown to the left. When the switch is at the right, the audio-frequency amplifier is in circuit.

Lamp Rectifier for A. C. ("The Electrician" April 23, '20)

This rectifier was evolved by John Scott-Taggart. It was desired to design a rectifier which took the form of an electric lamp & which could be plugged into the ordinary A. C. supply. The required rectified current was in the neighborhood of 100 milliamperes. It was decided to employ the so-called "Edison effect."
Edison found that if a metal plate were inserted in an ordinary lamp, & connection were taken from this plate to the positive side of a filament heated by direct current, thru an ammeter, a current passed thru the meter. But if connection were made to the negative side of the filament, no current flowed. This phenomenon is the basic principle of the audion valve.
The current through the meter is due to electrons emitted by the filament, which pass to the plate when the latter is at a positive potential with respect to a portion of the filament.



The inventor enclosed a horse shoe filament with a cylindrical plate. Connections for the D. C. were taken from the middle of the illustrated filament & also from the plate.

Now let us assume that the potential across the filament is 240 volts. The potential of the plate will be almost the same as the potential of the middle point of the filament.

Consequently, at the peak of one half-cycle, the plate will be at a potential of +120 volts with respect to the negative end of the filament, & will therefore draw to itself electrons from that portion of the filament between the negative end & the middle point. Since the P.D. between the plate & the negative end of the filament will be the maximum value, the most electrons will come from that portion of the filament. Since the plate will be negative with respect to the other half of the filament, no electrons will pass from that half to the plate. When, however, the direction of the A.C. changes the reverse takes place. Thus, there will always be a flow of electrons to the plate from one half of the filament.

Consequently this device will act as a full-wave rectifier for A.C. & will supply D.C. suitable for use in audion receiving circuits and oscillators. By using filaments of greater diameter, considerable D.C. currents may be obtained, although currents of 1 ampere will not likely be exceeded.

This form of rectifier has been used with considerable success on audion receiver circuits by connecting a large condenser of about 10 mfds. capacity across the rectified supply terminals.

This condenser acts in the ordinary way as a reservoir from which the direct current is drawn.

"Annaka" Japanese Wireless Apparatus.

(From the Wireless Age, May 1920)

The set described is in use on the U.S.S. "Eastern Chief" formerly the "Yoshida Maru 3d". This set is of the Teishinsho quenched spark type, made by the "Annaka" company.

"The apparatus is mounted entirely on marble, all metal parts being nickel plated. Even the smaller instruments, such as starting boxes and field rheostats have individual marble panel mountings. The receiver is very elaborate and enclosed in a mahogany cabinet with hard rubber top, all controls and metal parts being silverplated.

The transmitter comprises a main set of 3 K.W. energy and an auxiliary generator and transformer of ½ K.W. rating which may be connected to the closed oscillating circuit of the main set. A separate power control panel is provided for each motor generator, and contains all the controlling devices except the starter & motor field rheostat, which are mounted individually, convenient to the operator's hand.

Power for the auxiliary motor-generator is provided by a fifty volt storage battery, contained in suitable housing near the radio cabin. Circuit breakers and the necessary controls for charging the battery are contained on the main power panel.

The motor-generators are of General Electric pattern and consist of the usual motor (D.C.) coupled to the generator by flexible couplings. The generators are of the solid rotor type. the main unit giving 600 cycles and the auxiliary, 500 cycles.

The transformers are of low secondary potential and closed core type, immersed in oil. Secondary potential is controlled by single pole, double-throw switches within the transformer casing. As these switches are also immersed in oil, they are operated by a wire fork, access being permitted by a removable plate in the top of the transformer casing.

The transformer leads are connected directly across the condenser, which is of the plate-and-foil type. It consists of two large units of glass plates and copper foil embedded in beeswax, and contained in a marble-topped case. On this marble top is mounted a heavy single pole, single throw switch permitting the change in capacity necessary for the 300 meter wave.

The quenched gap is at once the most unique and probably the most efficient of the present day spark dischargers both quenched & otherwise. It consists of sixteen plates mounted vertically in two rows, having a geared edge on one plate of each gap. A series of fibre gear wheels moving on a shaft which passes between the two sets of plates, engages the teeth in the gap plates. A small tube leads from the sparking surface of each gap to a feed pipe which is connected to an alcohol chamber by a rubber tube. A bellows, actuated by a small motor forces alcohol vapour onto the sparking surfaces, assisting in the quenching. The same motor also, by a system of chains and gears, causes the fibre gear wheels on the shaft to revolve. This revolves the gap plates slowly, thus exposing the whole sparking surface of each plate to the alcohol blast. The plates are held apart by the customary mica rings.

The jigger is an auto-transformer, the almost perfect quenching of the gap permitting the use of this type, while ensuring a pure wave. Its inductance is variable by means of a hand-wheel which is on the marble panel supporting the jigger. The hot-wire ammeter and wave length changer are also mounted on this panel. Wave is changed by means of taps taken off the jigger & ATI. The jigger taps are brought out to three sockets on the jigger panel, and a plug inserted in the socket corresponding to the wave length desired. A similar arrangement exists on the ATI panel for tuning the aerial circuit.

The jigger & ATI are of the spiral pancake type. For the 1700 metre wave, with which the Japs work their shore stations when qrm is heavy, several loading coils for the ATI are installed. A heavy single pole switch on the ATI panel enables the loading coils to be shorted for the shorter wavelength.

The antenna send-receive switch is single bladed, with a throw of 60°. The primary power circuits and the blower motor for the gap are controlled by this switch, as well as the high-frequency circuits. Two transmitting keys are provided, of the massive "pumphandle" type.

The receiver is a "marvel of intricacy". A birds eye view of it has the appearance of a letter E with the middle leg left out, thus C. A loose-coupler of about 3,000 metres holds the right "leg". The primary is varied by a slider moving on a rubber strip which carries thirty switch points. A similar slider, but working on a worm gear from the inside of the coil varies the secondary; this is controlled by a small crank projecting from the secondary head. An ATI is mounted within the cabinet, controlled by the usual dial switch on the panel.

A variable condenser can be inserted in series or parallel with the primary circuit, or may be shortcircuited by a plug switch. A variable condenser is in shunt to the secondary. These condensers are composed of paper

and tinfoil, as is the telephone condenser.
A fixed air condenser is controlled by a five plug switch on the panel. A dial switch controls a non-inductive potentiometer, which is used with either of three crystal detectors. A drawer is set in the narrow part of the cabinet for spare crystals etc.
Binding posts are provided for the wing, grid, and filament circuits of a valve detector. An extremely intricate switch within the cabinet and controlled by a handle on the outside, serves to change over from the valve to the crystal detector. Telephones are provided of very inferior design and manufacture, single pole, low resistance.

Many record transmissions have been made with this type of apparatus, one case (the Eastern Chief's) being 2000 miles in daylight in July, working with San Diego Cal.
Average night range is 1500 miles.

Marconi C. W. Apparatus. (fm "Electrical Review" March 12, 1920)

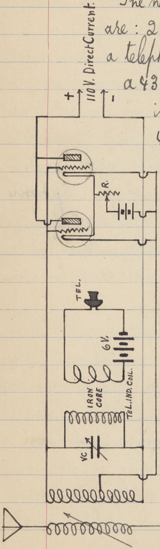
The complete ½ K. W. ship set is contained in a cabinet about 4 ft. high, 2 ft. deep, and 4 ft. wide.

The transmitter may be used as a continuous wave set, as an interrupted continuous wave ("tonic train") set, or as a wireless telephone.

The source of high frequency energy for transmission is the Marconi pliotron vacuum tube, which is maintained in oscillation with a reaction coupling; for telephony a similar valve is used to control the amplitude of the oscillations; and by means of a switch, a signalling key and buzzer may be inserted in place of the microphone, and change to "tonic train" effected.

The high-pressure for the anodes of the valves is provided by a step-up transformer through a two electrode rectifying valve, in circuit with smoothing out choking coils and condensers; and a step-down transformer with two secondaries supplies current to the filaments of all three valves. Energy is supplied by a rotary converter or motor generator at 85 volts 150 cycles. The minimum daylight range of this set is 100 n. miles for telephony, 130 n. miles for "tonic train" and for C. W. 300 n. miles, using aerials at least 100 ft. high and 220 ft. long.

Short range Radiophone transmitter (W/Age June 1920)

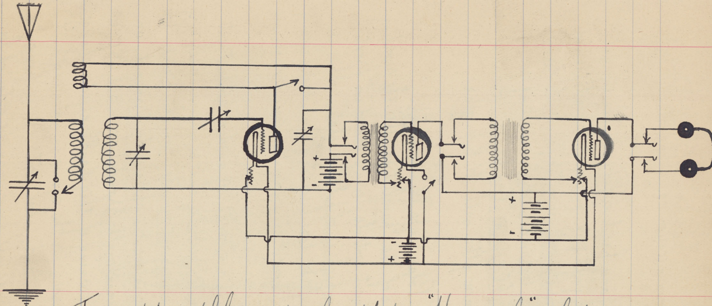


The necessary materials for this telephone are: 2 Marconi V.T. transmitting tubes; 2 socket. a telephone transmitter; a filament rheostat, a 43 plate variable condenser; a telephone induction coil; with a cardboard tube 4" in diameter & 8" high, & a another tube 3" in diameter & 2" high. Also ½ lb. of Nr. 20 D.C.C. magnet wire.

Wind 40 turns of the magnet wire tapping off every 10 turns.

Then wind 30 turns on the small tube, taking taps of each end & a long flexible lead from the centre.

Additional bulbs may be connected in parallel, which will add to the output. The VC serves to tune the closed circuit, while the tapped large coil tunes the open circuit.



Two step amplifier and valve detector. "Honeycomb" coil tuning system

Radio Communication Co. Apparatus.

This English Company has developed a highly efficient system of radio-telegraphy, & their gear has supplanted that of the Marconi Co. on many ships.

The "Bonheur", "Caronia", "Carmania", "Empress of Britain", "La Paz", "Oropesa", "Orontes", & "Yorkshire", are some of the ships now fitted with R.C.C. gear.

The $1\frac{1}{2}$ KW "Polar" type is illustrated.

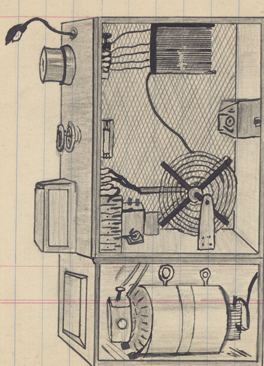
The transmitter is of the panel type. All the recording instruments, adjustment controls etc. are placed in front of the switchboard, which is of polished slate, while the various elements of the low-frequency and high frequency circuits, including those of the emergency gear, are arranged behind it.

Below the panel is a soundproof wooden compartment which encloses the motor-generator and synchronous discharger.

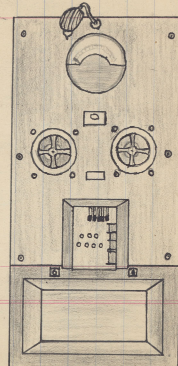
Two control wheels are mounted on the panel. The right-hand one enables the operator to transmit on any of the four wavelengths provided for:- 300, 450, 600 and 800 metres. Turning of this handle effects change in the circuits necessary for the change in wavelength.

The left-hand wheel controls the power. quarter, half, and full power may be obtained by

Radio
Communication Co.
"Polar" type
$1\frac{1}{2}$ K.W. Panel
Transmitter.



Side view.



Front view.

manipulation of this handle.
Signals radiated by both main and emergency transmitters are sharply tuned, and have high and distinctive spark frequencies. It is claimed that a combination of sharp tuning, and spark frequency in the neighborhood of 1000 is a feature which places the "Polar" installation in a very distinct class.

Details of transmitting gear.

The motor generator is designed to give an A.C. output of 1½ KW at 500 cycles and a pressure of 200 volts and is normally run from the 110 D.C. supply, although it may be necessary sometimes to vary this to suit the voltage of the particular ship's dynamo.
The D.C. armature and A.C. rotor are mounted on a common spindle between a single pair of ball bearings. The fields are separate. This construction has the advantages of compactness; and freedom from the mechanical trouble which is often involved in lining up two separate machines, and the employment of a coupling between them.
Brush gear for both A.C. and D.C. systems is placed at one end of the machine and is readily accessible.

The A.C. rotor has 20 poles, and the speed for 500 cycles is 3,000 R.P.M. The speed, and consequently the spark frequency, is capable of variation by adjustment of the motor field. This adjustment can be readily made by the operator, since the field resistance is placed on his right hand side, below the operating table.

The synchronous spark gap is mounted at the outer end of the machine, and is normally completely enclosed in a strong aluminum-alloy case.
A large inspection cover is provided which is held in position by wing nuts. The spark gap rotor is made of special aluminium alloy, and has 20 teeth giving two sparks per cycle or 1,000 sparks per second at normal speed. The fixed electrodes have been designed with great care. They are easily adjusted, are self-locking and self-cooling, while the spark points themselves are made of copper strips which last a long time, but are easily renewed.
The spark gap casing, which carries the fixed electrodes, can be rotated on the end plate of the machine through an angle just greater than that corresponding to the pitch of a tooth on the rotor. The timing of the

spark can, therefore, be arranged at the most suitable part of the A.C. cycle.

Control arrangements.

The motor generator is controlled by a push button switch, which is fitted to the operator's table. Two buttons are provided, one for starting, the other for stopping, the machine. The starter mechanism is entirely automatic, and is of the multiple finger type; resistance being cut out in four successive stages. The total time of starting is controlled by an adjustable air dashpot. In this way the machine is started quickly and smoothly, and the initial starting current is in no way dependent on the temper or mood of the operator, as the dashpot is normally adjusted to allow full speed to be reached in about 4 seconds. The field regulator is only altered if it is desired to change the spark frequency.

The operating key has a breaking-in system which dispenses with a separate change-over switch for the aerial from transmitter to receiver, and enables the operator whilst receiving, to call the attention of the transmitting operator for corrections and repeats etc, in the manner of ordinary line telegraphy.

Condensers & Inductances.

The primary condenser is of 0·01 mfd. capacity, and is rated to stand 15,000 volts safely. The condenser is built up of mica sheets, and consists of a number of large condensers in series. It is mounted in a metal box, containing special cooling and insulating oil, & possessing an oil-tight lid of ebonite. A safety spark gap is fitted. Care has been taken in designing the condenser, to ensure that there is no chance of mechanical movement of the plates taking place under the alternating forces imposed upon them; which, in badly designed condensers gives rise to heating, loss of efficiency, and ultimate breakdown.

The primary and secondary inductances are built up from copper strip in spiral form.

The wave-length selector switch is mounted behind the main slate panel and consists of a vertical bar of insulating material, which can be moved up or down by the control working through a rack & pinions. This bar carries two contact blades, each being arranged to engage successively with four fixed contacts.

One blade is fixed to the top end of the bar, and selects one of four A.T.I. tappings; while the other, fixed at the bottom end, selects a primary inductance tapping to correspond. Any of the four waves can therefore be brought into use, without any further adjustment, by the movement of one handle.

The A.T.I is mounted at the top of the transmitter. In series with it is the flat spiral jigger secondary, which is inductively coupled to the primary spiral. A graduated slide bar enables the coupling to be varied to obtain a pure radiation.

Above the two control wheels on the panel is mounted the aerial ammeter, fitted in lieu of the usual glow lamp.

The emergency transmitter

On the operator's table is mounted a change-over switch, enabling an emergency transmitter to be brought into action when required. This transmitter is rated at ½ KW, and has a spark frequency of 650 per second, giving a clear high note.

The set is fitted with motor-interrupter, and forms a single unit inside the switch board cubicle. The terminals of its high tension transformer are led to a special auxiliary spark-gap. A remote control switch automatically transfers the leads of the main oscillating circuit from the rotary spark gap to the emergency spark gap without interfering with the tuning of the primary circuit.

The emergency transmitter is operated by the same morse key as the main set.

Receiving Apparatus.

The receiving gear supplied with the $1\frac{1}{2}$ KW installation is illustrated.
All its component parts are mounted on a single ebonite panel with controls on the face.

The panel is recessed into a strong polished teak case, and is inclined at an angle to the operator's desk, thus enabling all controls to be easily manipulated while giving a clear view of the scales and indicators. The range of wavelengths obtainable with this apparatus is from 250 to 9,000 metres. An increased tuning range may be obtained up to 20,000 metres by the addition of a unit containing two inductances.

The aerial circuit is tuned by means of the right-hand adjusting handle, which varies the A.T.I. (at the top of panel) The lower right hand knob, varies the capacity of the aerial condenser, which may be connected in series or parallel with the A.T.I. by means of the lower switch in the centre of the panel.

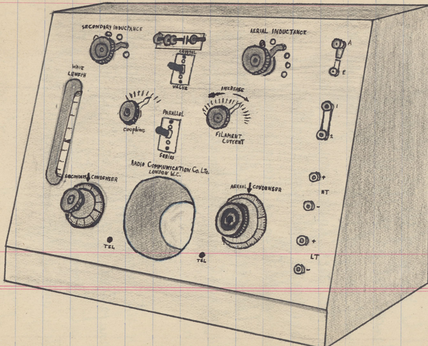
The closed circuit is tuned by the inductance-varying switch on the top left-hand corner of the panel, and a variable condenser whose controlling knob is at the lower left hand corner.

By means of an ingenious wave indicator the wave-length to which the closed circuit is tuned may be read off directly. The indicator can be seen through a window situated on the left hand side of the receiver; it consists of a rotary metal drum carrying a white scale, and a movable pointer. The drum is rotated by movement of the secondary tuning coil switch, which exposes at the window one of the six calibrated scales corresponding to each stud of the switch. The secondary tuning condenser operates a pointer which travels longitudinally over the exposed scale, indicating the wave length. The six scales are made to overlap one another, and, for any given position of the secondary switch and condenser, the wavelength to which the secondary circuit is tuned may be seen ~~at~~ by a glance at the pointer, without reference to chart or tables.

A switch above the "parallel-series" key enables either a crystal detector, or three-electrode valve to be used.

The valve detector is situated centrally between the tuning condensers, and is recessed into the instrument giving ample protection from mechanical injury.

The valve filament is heated by current from accumulators, and normally takes 0·75 amps., the filament life being approximately 1000 hours.



Radio Communication Co.
Standard Receiver.
Supplied with $1\frac{1}{2}$ KW "Polar"
Transmitter.

For C.W. reception, a "Kallirotron" oscillator unit is placed beside the receiver, for the production of local oscillations. This oscillator employs the same source of anode and filament voltage as the receiver. Its range of oscillation is from 600 to 20,000 metres.

The range of the set depends of course, on various circumstances; but, for the $1\frac{1}{2}$ KW, a day range of 800 miles and a night range of 1200 miles has been so frequently obtained, that such figures may be taken as indicating the average range under good conditions. A range of 500 miles may be taken as being normal.

The emergency set has frequently communicated 400 to 500 miles at night while its normal range may be taken as 200 miles.

A $\frac{1}{4}$ KW set running off a battery of 10 accumulators is also manufactured by the R.C. Co. It is a miniature of the $1\frac{1}{2}$ K.W. set, having a special type of charging board for its battery and a different transmitter panel arrangement.

(From the "Electrician" January 7th, 1921. Description of set exhibited at the Ship-building and Engineering exhibition at Glasgow.)

The Type P-8, 2 K.W. Amn. Marconi Set.

A set of this type is installed on the C.S. "Mackay-Bennett," replacing the former $1\frac{1}{2}$ K.W fixed gap English Marconi set.

It has a remarkable efficiency, and in addition to providing simple means of varying the power over a wide range, is connected so that either the 300, 450 or 600 metre wave may be used, through the manipulation of a switch.

The 2 kw. panel set is a compact transmitter, so designed as to carry all its component apparatus within its frame, having its necessary controls mounted on the front panel.

When set up, the whole transmitter is virtually one piece of apparatus, and apart from the obvious compactness of such an arrangement, the connecting leads are of minimum length, permitting maximum capacity in the condenser, and maximum turns in the jigger primary.

Motor control & generator control are obtained by variable resistances in the field circuits of motor and generator.

An automatic solenoid starter cuts out the starting resistances when the "send-receive" switch is put to "send", and on finishing transmission, the motor is brought to a quick stop by a dynamic brake which is automatically cut in by the solenoid switch as it drops from the starting resistance studs.

A low power switch for use with the quenched gap, when open, introduces a high resistance into the A.C. field, reducing power to $\frac{1}{10}$ or $\frac{1}{16}$ KW.

The main panel is divided into three portions. The lower of the three is devoted the motor & generator; the auto-starting solenoid switch is at the left side, and the D.C. Line, Generator Field (sp.) and A.C. line switches to the right of the solenoid. Above the A.C. switch is an overload circuit breaker, set at from 35 to 45 amps, which prevents excessive current when starting up.

The central panel is devoted to the quenched gap & is made on hinges, so that it may be swung out, giving access to the condenser rack which is immediately behind the quenched gap. The upper panel carries an aerial hot-wire ammeter, to show the current in the aerial; while on the opposite side is a wattmeter, calibrated in kilowatts, to show the energy flowing in the primary circuit of the transformer. A little below these meters and in the centre of the panel, is the handle controlling the variable ATI. On the left side of this handle is the motor field control rheostat, while on the right is the generator field control rheostat. Below the ATI handle & between the two rheostats, is the wavelength changing switch, while still further below is the coupling regulator handle. The leads to the quenched gap come through this part of the panel. Behind the right side of this panel is the two-way switch which connects either the rotary, or the quenched gap, to the high-frequency closed circuit, as desired. This panel also holds the lower power switch.

At the right side of the bottom panel is the handle controlling the position of the rotary gap muffler drum (and therefore also controlling the position of the fixed electrodes with respect to the rotating electrodes.

The motor generator is fastened to the floor with skids (to facilitate moving) immediately behind the lowest panel. Behind the motor generator is the starting (& braking) resistance box; also transformer, which is of the closed core type, immersed in non-liquid oil. It is provided with a protective spark gap which permits a discharge when potentials become excessive.

On the next "floor", behind the middle panel is a rack holding the main condenser bank, consisting of 6 Leyden jars.

On the "top floor", behind the upper panel, are found the oscillation transformer; wave-changing switchgear and ATI in succession.

The jigger & ATI consist of copper strip wound ~~spirs~~ in flat spirals, and mounted on bakelite bases.

The jigger primary & secondary are varied by means of ~~slip~~ contacts, which are set with screw when the set has been tuned. Variation of the ATI is accomplished by means of a sliding contact, on a revolving arm, connected by suitable gearing to the ATI handle.

These circuits may now be considered in detail. Starting from the + terminal of the D.C. switch, current flows through the D.C. rheostat to motor field, energising the windings, & returns to the negative pole. It is well to leave the D.C. switch open when not using the set, otherwise the motor field coils will be unnecessarily heated.

To start the motor, either a flush-type button switch on the operating table may be closed, or the handle of the send-receive switch placed in the "send" position.

Current then flows through the overload relay tongue to the solenoid starter, from the + to the − pole of the D.C. switch. The plunger of the starter immediately rises at a speed determined by the setting of its air-valve, successively engaging five contacts which start the motor at the proper speed. Should the solenoid act too quickly, or should the current flow rise above a pre-determined rate (to which the overload relay has been set), the overload armature is attracted vertically, & carries the relay tongue with it to an upper contact.

This closes the relay circuit and maintains a break in the solenoid circuit until the aerial switch or button switch is opened.

When the solenoid plunger drops, it makes contact with two springs, thus connecting a resistance across the motor armature. This forms an effective brake, bringing the motor to a stop in 15 seconds.

The generator field is not closed until the rising plunger has engaged the fifth contact. At the same time that this occurs, a resistance is inserted in the solenoid circuit; the reason being, that little current is required to hold the

plunger up, as compared to that required to move it up.
The A.C. field circuit is broken by the single pole "Gen. field" switch on the lower panel of the switchboard.
This is used when the operator has occasion to make adjustments while the motor is running: a very necessary provision, as the free voltage of the generator is about 350 volts. It is again broken at the aerial switch, from whence it continues to the A.C. field rheostat, low power switch and rheostat, and the generator windings.
The A.C. line current is also broken at the aerial switch, from whence passes through the morse key, wattmeter, and primary of the transformer.
A reactance to limit the energy to about 1 kw. is automatically connected into circuit when the wave-changing switch is placed in the 300 metres position: higher power would be too much for the 3 Leyden jars used for this wave.

The transformer charges a bank of Leyden jars: 3 jars for the 300 metre wave, and 6 jars for the 450 & 600 metre waves; all being connected in parallel. A switch (d.p.d.t.) cuts the rotary gap or quenched gap in at will; when the quenched gap is used an inductance is connected in series, (to compensate for the inductance of the rotary gap leads) by means of the d.p.d.t. switch.

The quenched gap leads must be short circuited when the rotary gap is used and the lowpower switch must be closed.

The Quenched Gap consists of 15 copper discs separated by "presspahn" gaskets and clamped airtight by means of an adjusting screw at the right end of the gap.

The two leads may be plugged on so that any number of gaps may be employed. Too many gaps result in a broken note: too few gaps results in a ragged, hissing note.

The right number may first be selected from experience, and then by variation of the motor speed & alternator output the note may be made clear. When the gap is not airtight the note will be variable & poor; the gaps should tested, one by one, and the leaking gap shorted by means of a bridge clip. When cleaning, be sure to get the sparking faces parallel. This is done by rubbing the whole disc on a piece of sandpaper laid on a flat surface.

If the gap has been taken apart, care should be taken when reassembling to have all the gaps airtight.

The gap should then be "seasoned" by sparking for an hour or two, to consume the enclosed air and render the note clear. Otherwise it will be "wobbly" and variable.

The Rotary Gap consists of a revolving disc keyed to the generator shaft and carrying 30 discharge points of heavy Λ-shaped copper as in Fig. 1. These electrodes (when the gap is correctly phased) approach the two stationary electrodes synchronously with the maximum charge of the condenser. The stationary electrodes are mounted in stoneware insulators on the muffling drum, which may be revolved through an arc of 25° by the handle and screw thread which projects at the right side of the lowest panel. This movement permits of the correct phasing of the spark for each value of power used, and practical adjustment is made by rotating the muffler drum during transmission until the note is pure and maximum reading on the aerial obtained.

Fig 1.

If the spark is very badly phased the transformer will discharge to earth over the safety spark gap. Care should be taken to avoid this, as the rotary gap throws heavy strain on the condenser and is liable to cause breakage under unfair treatment. (Should a jar break it may be renewed by swinging open the quenched gap panel and substituting a new one)

The rotary disc is earthed through the muffler drum. The electrodes on the disc should clear the fixed electrodes by $1/100$ of an inch.

The disc is fitted with a number of specially shaped vanes which suck air from the airholes in the drum and force it up a fibre tube to cool the quenched gap. Care should be taken to see that the redglass inspection door in the rotary gap muffler is kept tightly closed. Otherwise when using the quenched gap there will be no cooling airblast, resulting in unnecessary heating and probable failure of the gaskets.

The radiating circuit now engages our attention. The aerial is led to the cabin by the Bradfield (or other) insulator tube through the Send-Receive switch to short-wave condenser rack.

When using the 450 and 600 meter waves this condenser is shorted by means of flexible leads which are plugged across the four jars of which it is composed.

The circuit is completed through the continuously variable inductance, plug inductance, jigger secondary and to earth through the thermo-couple of the aerial ammeter. When the wavelength switch is placed at the 300 meter position, an eccentric collar attached to the switch drives forward a pin which opens a spring switch. This puts a resistance in the transformer primary circuit, limiting the power to about 1 kw.

All the framework, generator frame, transformer case etc are grounded with flexible copper braid to guard the operator from shock. Protecting condensers are contained in a box on the top of the generator.

Emergency power is obtained from a battery of 90 Edison cells. The Edison is alkaline. Instead of the usual lead plates, nickeled steel grids and tubes are used. The electrolyte is a solution of sodium hydrate and the whole cell is made up and welded together at the factory so that the plates cannot be withdrawn.

Care and repair of Storage Batteries.
(From the "Electrical Experimenter" April 1920.

W" First test the voltage of the cells. If they give 1 to 2V each, they probably need only charging. Next test the Specific Gravity, by means of a hydrometer or other device. The table below shows the relative strength of the battery for the various readings.

1·250	= 80%	strength of battery
1·225	= 60%	" "
1·200	= 40%	" " "
1·175	= 20%	" " "
1·150	exhausted.	

A fully charged battery should have a SP. GR. of 1·275 but it sometimes occurs that one shows a density of 1300, or even 1325. (Note: these figures do not apply to the ordinary chloride cells used in wireless work). The charging rate will be found on the nameplate tacked to each case. For example:-
"Start $13\frac{1}{2}$ amp. finish $4\frac{1}{2}$ amp"
In this case a current of $13\frac{1}{2}$ Amperes is allowed to flow until the cells gas freely, then continue the charge for 6 hours at the finish rate, i.e. $4\frac{1}{2}$ Amperes.

Never hold a match or any naked light near the vent holes of the cells, while charging; as the products of electrolysis explode.

Sometimes a cell lags behind during charging because the electrolyte leaks out of a cracked jar.

If acid is added to raise the Sp. Gr. it should be 1.210 (S.G.)

If a battery is standing idle for any length of time, it should be given a full charge before laying up, & at intervals of one or two months to keep the Sp. Gr. up.

If batteries are allowed to freeze, the active material of the plates becomes spongy and will fall off.

The table below gives freezing points of various dens

Specific Gravity of	1.150	freezes	20° above Zero Fahrt.
	1.180	"	0° "
	1.215	"	20° below Zero "
	1.250	"	60° " "

On a 110 Volt circuit, a 100 Watt lamp draws nearly 1 ampere & a 50 or 60 Watt draws ½ amp.

When these size lamps are used for the charging resistance the current flow is easily calculated.

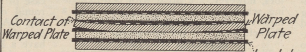
Sometimes a battery has one or more cells whose voltage will not rise after continuous charging.

This condition is usually caused by warped plates give a very exact reading. Most all motors, however, are fitted with belt-tightening screws on their base, so that quite a little variation is allowed for tightening up the belt, once it is put into place.

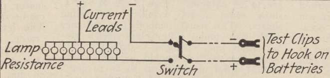
LEVELING SHAFTING.

The leveling of shafting, whether large or small, is an important affair, if the best efficiency and quietest running results are to be obtained. Figs. 2, A, B and C show some useful wrinkles in leveling shafts. The usual method for ordinary work is to employ a first-class steel level—preferably one having a V-shaped bottom—and the shafting should be turned into several different positions, so as to get a mean average on the level readings, and also the level should be placed on several points along the shaft while making the measurements, such as those indicated by X, X, X.

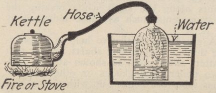
A unique suggestion to help in simplifying the leveling of long shafts, or, for that matter, short ones, is shown at Fig. 2-B. Two boiler gage glasses or other suitable glass tubes are hooked up with a length of rubber garden hose or rubber tubing; this is then filled with water, the water not quite reaching the tops of the gage glasses. The free ends of the gage glasses are fitted with hooks, which may pass over the shaft



BOTTOM VIEW OF SET OF PLATES. ONE IS WARPED

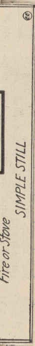


CHARGING CIRCUIT



SIMPLE STILL

which have worn through the insulators & are "shorting"
The faulty separators should be replaced.



As they increase in age, storage cells deteriorate. The active material falls from the grids. The more material they lose, the less charge they will hold.

It is usually the positive element which falls out first, and a new set of positive plates will often give new life to a battery.

A battery with plates "shorting" will show little or no voltage, while one with the active material gone will give normal E.M.F. but no amperage.

Any broken connections may be soldered with a blow-torch or an arc-welder. A D.C. arc welder can be made from a pointed battery-carbon, connecting the carbon to the negative pole of the source of E.M.F.

A simple still for making distilled water is illustrated.

Don't fill cells more than ½" above the plates.

Keep the vent-plugs out while charging.

If you file a soldered joint smooth, don't leave the filings on the top; it may cause a short circuit. Acid or water spilled thereon will also cause short-circuit.

The "Marcuson" Storage battery.

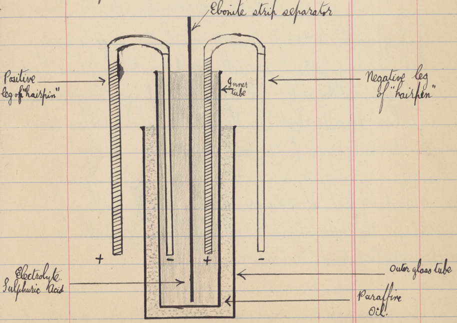
This storage battery has been patented by E. Marcuson, of New York. It is excellent for "audion" "B" battery work, giving high voltage; and what is more important, is very compact. It measures $11\frac{1}{2}$" x 6" x 7" overall dimensions.

The constructional details of the battery are as follows:-
1. A "pasted" element of hairpin form, one leg of which is a positive (brown) plate and the other a negative (grey) plate.
2. A thin ebonite strip separating the positive and negative plates in each cell.
3. An inner glass tube containing the plates, separator and electrolyte
4. An outer glass tube containing ordinary yellow paraffine oil, the object of which is to prevent electrical leakage from cell to cell.
5. An antimonial lead crate, provided with longitudinal and transverse strips of hard rubber, to form a nesting for the cells. The crate, together with the cells and switch may be lifted bodily out of the wooden container by means of special hooks supplied with the battery.
6. A commutating switch for the purpose of connecting the sections of the battery in series or parallel. The end wires of the sections are brought up into the body of terminals and switch posts, and clamped by small set screws.

7. Beneath the switch, "anti-creeping" oil traps on the ends of the sections of the battery. These are to prevent the acid from "creeping" up to the metal parts of the switch. The inner, as well as the outer tubes of these oil traps contain paraffine oil, and the end wires of the battery sections are led down into the oil, then up again through ebonite tubes to the switch.

8. A wooden box specially treated to render it acid proof.

The type "A" Marcuson battery is eminently suited to valve work. It is composed of 50 cells, divided into two sections of 25 cells each.



By means of the lugs on the terminals, the sections, of 25 cells each, may be connected in series or parallel, thus giving 100 or 50 for each connection respectively.

The capacity of the cells is, 0·40 ampere-hour and the normal discharge rate is, 0·05 amperes.

On 100 volt D.C. circuits, an ordinary 8 C.P. lamp in series with the battery (two sections in parallel) will pass approximately the correct current for charging in about 8 hours.

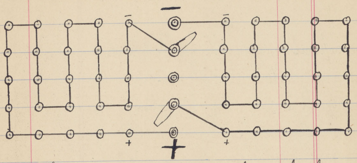
The battery when fully charged, and while still charging at the normal rate, should show at the terminals, 62·5 volts, i.e. 2·5 volts per cell, the two sections of cells being in parallel.

Sufficient electrolyte for a 100 volt battery may be made by slowly pouring ½ pint chemically pure Brimstone Sulphuric Acid into 2 pints of distilled water. (On no account pour the water into the acid but Pour The Acid Into The Water, Slowly). Allow the solution to cool before putting into the battery.

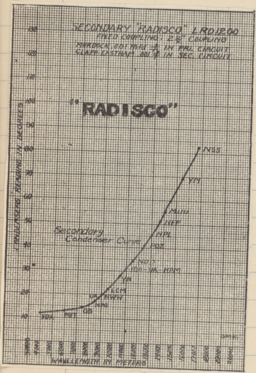
About 1½ pint of ordinary yellow paraffin oil will be required for the outer glass tubes, oil traps, and for putting on top of the electrolyte to retard evaporation.

The accompanying diagram indicates the two sections of

25 cells each, and their connections to the lugs.



The commutating lug switch on the battery is arranged so that when the switch arms are turned outwards on to the binding posts, the two sections are in parallel; when the arms are turned inwards on to the central contact stud, the two sections are in series.


SECONDARY "RADISCO" LRD1200
FIXED COUPLING: 2½" COUPLING
CLAPP-EASTHAM .001 IN SEC. CIRCUIT
"RADISCO"
Secondary
Condenser Curve
CONDENSERS' READING IN DEGREES
WAVELENGTH IN METERS
NSS
YN
MUU
NFF
NPL
POZ
NDD
120-UA-NPM
LCM
NWW
NPG
GB
MFT
XDA
10
20
30
40
50
60
70
80
90
100
110
120
130

Sparking distances in air.

Volts	Distance (inches)	Volts	Distance (inches)
5,000·0	·225	60,000·	4·65
10,000·	·47	70,000·	4·85
20,000·	1·00	80,000	7·1
30,000·	1·625	100,000	9·6
35,000·	2·00	130,000	12·95
45,000	2·95	150,000	15·00

Useful Constants.

1 Inch = 2·54 centimetres
1 gallon = ·1604 cubic foot = 10 lbs. of water at 62°F
1 Knot = 6080 feet
1 pound avoirdupois = 7000 grains = 453·6 grammes
1 cubic foot of water weighs = 62·3 lb.
1 foot-pound = 1·3562 × 10^7 ergs.
1 horse power = 33,000 ft.-lbs. per min. = 746 watts.
π = 3·1416
1 radian = 57·30 degrees
1 atmosphere = 14·7 lbs. per sq. in. = 760 mm. of mercury = 10^6 dynes per sq. cm
$pu^{1.0646}$ = 479
1 lb. at London weighs 445,000 dynes.
1 cubic foot of air at 0°C and 1 atmosphere = ·0807 lbs.
Absolute temp: $t = \theta°C. + 273°$ or $\theta°F. + 460°$
The base of Napierian logarithms is, $e = 2·7183$
To convert common in Napierian logs. multiply by 2·3026
Value of G (gravity) at London = 32·182 ft. per sec. per sec.
A column of water 2·3 ft. high = a pressure of 1 lb. per sq. inch.
1 metre = 3·28 ft.
Joule's equivalents = 774 ft-lbs = 1 Fah. unit; 1393 ft. lbs. = 1 Cent. unit.

Formulae. Electrical. Tables

Capacity of a condenser. Where T = distance between the plates and S = the dielectric constant (see table of dielectric constants page 138) & A = area of one plate. T measured in cms. and A in square cms.

$$K = \frac{A \times S}{4\pi \times T} \div 900,000.$$ Result is in micro-farads

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Wave length of an oscillating circuit.

$\lambda = 1{,}885\sqrt{(LC)}$ where L = inductance in microhenrys, C = capacity in mfd's & λ = wavlength in metres.

The energy of a charged condenser is obtained from the formula: $E = \frac{KV^2}{2}$. where E = energy, K = capacity and V = voltage to which condenser is charged.

The frequency of any alternator = $\frac{N \times S}{2}$ where N = number of field poles, S = speed of armature in r.p. second.

Reactive pressure occasioned by a circuit loaded with inductance (inductance reactance) is expressed.

Reactance (in ohms) = $6{\cdot}28 \times N \times L$, where N = frequency in cycles per second, L = inductance in henries.

i.e. Reactance in ohms = $2\pi \times N \times L$.

Specific Inductive Capacity Values.

Dielectric		Specific Inductivity
Flint glass (Double extra dense)		10·10
Flint glass (Very dense)		7·40
Flint glass (Light)		6·85
Porcelain		4·38
Common glass (radio-frequency)		4·21
Common glass (low frequency)	3·25	to 4·00
Mica sheet (pure)	4·00	to 8·00
Sulphur	2·24	to 3·84
Gutta Percha	2·46	to 4·20
Iddia rubber (pure)	2·22	to 2·49
Hard rubber ebonite	2·05	to 3·15
Celluloid		1·555
Manila Paper		1·50
Beeswax		1·86
Paraffine ~~paper~~ wax	1·9936	to 2·32
Paraffined Paper		3·65
Shellac	2·74	to 3·60
Castor Oil		4·80
Petroleum	2·03	to 2·42
Resin	1·77	to 2·55
Sperm Oil	3·02	to 3·09
Turpentine	2·15	to 2·43
Olive and Neats foot oils	3·00	to 3·16
Air at ordinary pressure. Unity.		1·0000

Dielectric	Specific Inductivity.
Pure water	81·07
Aniline	7·30
Bisulphide of carbon	1·81
Quartz	4·50
Flint glass (Very Light)	6·57

Using inductivity of vacuum as unity.

Air	1·000586
Ammonia	1·00718
Helium	1·000074
Hydrogen	1·000264
Nitrogen	1·000581
Sulphur dioxide	1·00905

Dielectric Strength of materials 1 (one) millimetre thick.

Dielectric	E.M.F. required to pierce.
Dry paper	1400 to 8000 volts
Varnished paper	10,000 to 28,000 volts
guttapercha	7,700 to 19,000 volts
indiarubber	16,000 to 21,000 volts
ebonite	28,000 to 31,000 volts
mica	60,000 to 200,000 volts
dry paraffin oil	30,000 to 100,000 volts

Resistance & Conductivity Data.

	Specific Resistance	Specific Conductivity
Silver	1·609	100·
Copper	1·642	96·
gold	2·154	74·
Iron (soft)	9·827	16·
Lead	19·847	8·
German silver	21·470	7·5
Mercury (liquid)	96·146	1·6.

Conductors in order. (most efficient conductor silver; next, copper)

Silver
copper
aluminium
zinc
brass
platinum
iron
nickel
tin
lead

column 2.
platinoid (German silver 49 parts tungsten 1 part)
antimony
mercury
bismuth

German silver (copper 2 parts, zinc 1, nickel 1)

Insulators in order (dry air = most efficient; marble = least efficient)

Column 1.	Column 2.
Dry air	wool
glass	dry paper
paraffin wax	dry leather
amber	porcelain
jet	oils
mica	slate
ebonite	marble.
shellac	
gutta percha	
resin	
sulphur	
sealing wax	
~~wax~~ silk	
~~sealing~~	

Capacity reactance in an A.C. circuit.

C reactance in ohms $= \dfrac{1}{2\pi \times N \times C}$ where N = frequency of the current in cycles per sec. and C = capacity of condenser in Farads.

thus C reactance $\omega = \dfrac{1}{6.28 \times N \times C}$

To find the value of the current in an A.C. circuit.

Current in amperes $= \dfrac{V}{\sqrt{\{R^2 + (2\pi NL - \frac{1}{2\pi NK})^2\}}} = \dfrac{V}{Z}$

V = voltage, R = resistance, K = capacity in Farads, L = inductance in Henries, N = frequency (cycles per sec). Z = total impedance

Received current in an aerial in the case of two stations working one another over open sea.

$$C = \frac{(6\pi LAH \times 10^{10})}{(\lambda D R)} = \frac{267 Ah^2}{\lambda DR}$$

Where C = rec'd. current (amps); A = current in transmitting aerial (amps); h = height from cabin to aerial (metres); D = distance between ships (metres); R = resistance of receiving aerial (ohms); λ = wave-length in metres.

Wind Symbols

No.		Force	
0	Calm	3	M.P.H.
1	Light Airs	8	"
2	Light Breeze	13	"
3	Gentle Breeze	18	"
4	Moderate Breeze	23	"
5	Stiff Breeze	28	"
6	Fresh Breeze	34	"
7	ditto.	40	"
8	Moderate Gale	48	"
9	Strong Gale	56	"
10	Gale	65	"
11	Heavy Gale	75	"
12	Hurricane	90 & over.	

Morse Code. Figures

1	· — — ·
2	·· — ··
3	··· — ·
4	···· —
5	— — —
6	······
7	— — ··
8	— ····
9	— ·· —
10	— or — · — —
Q.	·· — ·
X.	· — ··
J.	— · — ·

Long wave Stns 1919

Arlington, NAA, 2500 metres, press & weather forecasts at 0255 G.M.T. also time sigs at 1655 G.M.T.
New York, NAH, 1610 metres, press, at 0815 G.M.T. also 0200 G.M.T.
Bar Harbor, NBD, 1800 metres, press, at 0815 G.M.T.
Poldhu, MPD, 2800 metres, press at 0100 G.M.T.
Paris, FL, 2500 metres, press at 1500 G.M.T. and 2300 G.M.T. Time sigs from 2344 to 2349 and from 1044 to 1049, G.M.T.
St. Johns Nfld, BZM, 1600 metres, ice & navigation warnings at 0100 G.M.T.
Paris, FL, 2500 metres, weather reports at 2400 G.M.T.
Poldhu, MPD, 2800 metres, navigation warnings, weather reports, 0930 and 2130 G.M.T.
"ULIF", France, mine warnings (in French) 3500 metres at 2100 G.M.T.

Wave lengths of principal high-power stations.

			Metres	
XOA			4,000	
MFT	Clifden, Ireland.		6,500	+ Spk.
GB	Glace Bay, N. S.		7,500	Spk.
NPG	Mare Island (California)		8,500	
UA		11,000	8,750	
NWN	Wilmington (N. Carolina)		9,000	
LCM	(Norway)		9,500	
YN	Lyons (France)	15,500	10,500	C.W.
IDO	Rome (Italy)		11,000	C.W.
NPM	Honolulu (Hawaii)		11,000	
NDO			11,500	
POZ	Nauen (Germany)		12,500	C.W. & Spk.
NPL	San Diego (California)		13,000	
NFF			13,500	
MUU	Carnarvon (Wales)		14,500	
NSS	Annapolis, U.S. 4000 mls.		16,800	C.W.
BYB	Cleethorpes (nr Grimsby) Eng.		3,000	
MPD	Poldhu (extreme SW Eng.)		2,700	C.W. & Spk.
GSW	Stonehaven (nr Aberdeen)		600, 1800, 3,000, 5000	
WZO	Fort Bliss (Texas) 2000 miles		3,000 – 10,000	