POULSEN EXPERIMENTS.

Wireless Experiments carried out between Arlington (Washington) and the North Front Station at Gibraltar.

Considerable progress has been made in the Poulsen experiments during the last year, and it is probable that the system should prove suitable for use in the Fleet.

Arcs.—The unsteadiness and irregular burning of the arcs was found to be due principally to the following causes :—

(*a*) Leakage of air into the arc chamber.
(*b*) Flickering of the arc about the copper anode, and inefficient cooling of the anode.
(*c*) Inferior quality of carbons used.
(*d*) Drip feeds.

With regard to (*a*), the leakage usually occurred through the covers failing to make an air-tight joint with the arc chamber ; these covers are fitted with springs, so that in the event of a small explosion occurring when switching on the arc, due to the presence of air in the chamber, the cover would act as a safety valve.

This arrangement proved unsatisfactory, as the cover usually failed to remain air-tight after an explosion. Safety valves have now been fitted in the cover, and the latter is kept screwed hard down.

The area of the joint between the cover and the arc chamber has also been increased.

(*b*) The copper anodes, as supplied, were fitted with internally threaded copper ferrules to take the wear as the arc burned, the ferrules being replaced or turned on their threads when burnt away. This arrangement was unsatisfactory, since, although the anode is water cooled, the ferrules themselves were inclined to melt and run, also the arc had a tendency to flicker about the circumference of the ferrules.

To overcome this, the ends of the anodes were redesigned, and hollow wedge-shaped ends are now fitted. These are directly cooled internally by the water supply, and the wedge-shaped nose concentrates the arc, and keeps it steady in the centre of the magnetic field.

(*c*) Various qualities of carbon have been tried, those originally supplied were inclined to chip and flake away, causing the arc to flicker and become unsteady. A satisfactory carbon has now been obtained.

(*d*) The original arrangement whereby the spirit was dropped directly on to the copper anode was not satisfactory, as the supply of gas appeared to vary. Wick-feeds have been led from the drip-tubes into the arc chamber, and appear to produce a steadier and more regular supply of gas.

Range of Wave Lengths.—It has been found that long Waves can be radiated from Ship Aerials with a good degree of efficiency when using the Poulsen system, and it is anticipated that there will be no difficulty in radiating Waves from 1,800 to 18,000 feet from the ordinary Ship's Aerial.

The radiation will tend to decrease with the longer Waves, but not to nearly the same extent as when using spark systems.

Transmitting Inductances.—Experiments have been carried out with various types of inductances. For transmitting very long Waves, it has been found convenient to use three coils placed one inside the other ; this gives a very large step-up to the inductance of the individual coils, and appears to be quite efficient.

The longest Wave that has been obtained on the Horsea Aerial, using these inductances, is 80,000 L.S.

Transmitting Circuit.—It is of the utmost importance that all connections in the transmitting circuit should be extremely good. Any failure in this direction causes over-heating at the point of contact and a consequent drop in the Aerial current.

Shunting the Spacing Wave.—The presence of the spacing Wave, *i.e.*, the Wave radiated when the signalling Key is up, gives rise to "back signals." Thus when Signalling the letter "Q," it can be read on the spacing Wave as the letters E I T. To avoid the presence of these back signals, steps are being taken to shunt the arc, whenever the signalling key is up, by means of a closed oscillation circuit. The change over from Aerial to shunt circuit has to be so adjusted that the arc is never left without some circuit on which to oscillate, otherwise the arc goes out.

Insulation.—The strain on insulation with this system appears to be very great. It is not due to the voltage, which is comparatively low, but it is probably occasioned by fatigue caused by the continuous oscillation of the very high frequency current.

Reception of Continuous-Waves.—Important developments have taken place with regard to the reception of continuous-Waves, owing to the introduction of the Heterodyne receiving apparatus. Information concerning this method of reception was obtained during the visit of the U.S. Cruiser "Salem" to Gibraltar in March 1913.

Permission was given for the U.S. Cruiser "Salem" to use the North Front Aerial at Gibraltar, between the 8th and 11th of March, when carrying out certain experiments with Arlington, where a 30 k.w. arc is installed. The following description of the "Heterodyne" is taken from Captain Willis's report :—

The Heterodyne.

"This apparatus and method of receiving signals is being tested for the first time in the U.S. Navy, and has been patented by the National Electric Signalling Co., of Pittsburgh, Pa., U.S.A.

"The apparatus consists of an arrangement to produce undamped continuous oscillations by means of the electric arc in hydrocarbon atmosphere.

"The oscillating circuit is a closed one, and, except for the coupling inductance and the arc, it is entirely enclosed in a wooden box, measuring 23½ inches by 17 inches by 18¾ inches, with an ebonite front 22 inches by 15½ inches, carrying the necessary instruments and switches for tuning the circuit to Wave-lengths varying from 700 up to 11,000 *metres*.

"The Arlington (Washington) Station transmitted a prolonged letter 'D,' using a spark from 3.30 to 3.50 a.m. and p.m., and an arc from 4.10 to 4.30 a.m and p.m.

"The Wave-Lengths used during the tests were, in the case of the spark, 3,800 metres, and in the case of the arc, 4,100 metres, short circuited by the operating key to 3,900 metres.

"The method of employing the Heterodyne is as follows:—

"The box and arc are placed as far as possible from the usual crystallite receiving circuit, and a loop of the aerial lead is placed near the Heterodyne mutual inductance (forming a very loose coupling with it).

"The Heterodyne is tuned to a Wave-Length either slightly over or under the Wave-Length which is being received—and should Washington be using the arc transmitter, then the combination effect of the frequencies of the two undamped oscillations due to Washington and the Heterodyne will produce periodic beats or impulses in the receiving circuits of an amplitude considerably in excess of that of either Wave, and the frequency of these beats will be the *difference* between the frequencies of the two undamped oscillations.

"It will be seen, therefore, that by a slight alteration in the tuning of the Hederodyne, a note of any desired pitch can be obtained in the telephone receivers, the receiving circuits having been adjusted for the mean of the two Wave-Lengths.

"To illustrate this effect, the Waves from the transmitting station might be represented as coming in at the rate of 20 cycles, in a period of time represented by a length of 6 inches, and as having an amplitude in the receiving circuits represented by $\frac{2}{10}$ths inch, thus:—

and the Waves received from the Heterodyne might be represented at the rate of 15 cycles for the same 6-inch time period, and as having an amplitude represented by $\frac{3}{10}$ths inch, thus:—

"These two oscillations superimposed would be as follows:—

"It will be seen that the number of resultant beats in the 6-inch time period is 5, *i.e.*, 20–15, and on this frequency depends the pitch of the note heard in the telephone receivers; the amplitude, moreover, varies from a maximum of about $\frac{5}{10}$ths to a minimum of about $\frac{1}{10}$th inch, so that the maximum is more than double that of the Wave received from the transmitting stations.

"The following claims were made for the Heterodyne when receiving continuous undamped Waves:—

"(1) Pure musical notes of any desired pitch can easily be obtained, the pitch being under the control of the operator receiving the message.

"(2) No tikker is required to make the undamped continuous oscillation audible (tikkers not giving pure notes).

"(3) Strength of signals are considerably increased in comparison to the tikker (signals quite inaudible with the tikker can be read with the Heterodyne).

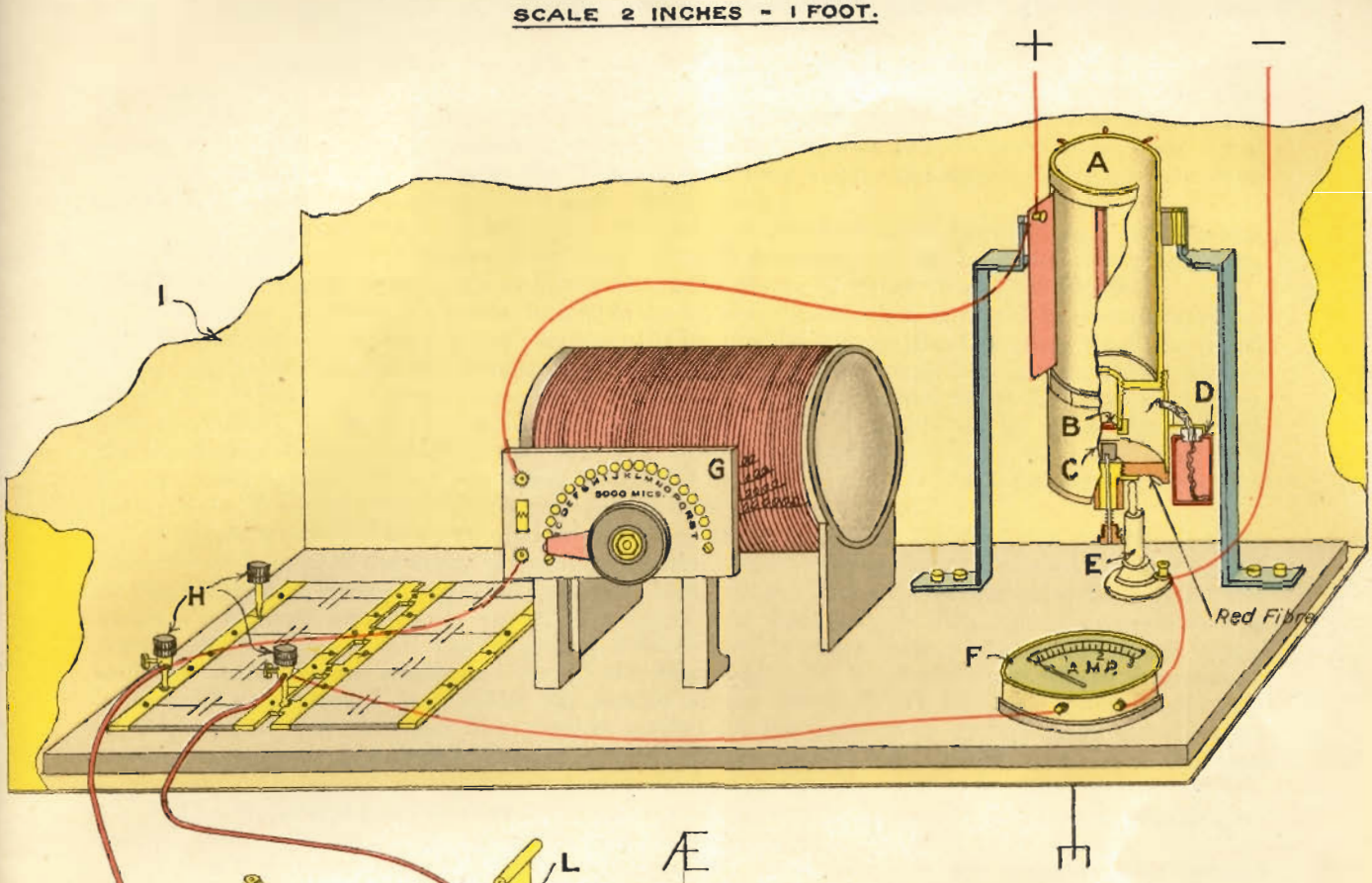
"(4) Atmospherics considerably decreased.

"(5) Means of getting away from interference.

"(6) Not upset by the rolling or vibration of the Ship.

HETERODYNE RECEIVER.

SCALE 2 INCHES = 1 FOOT.



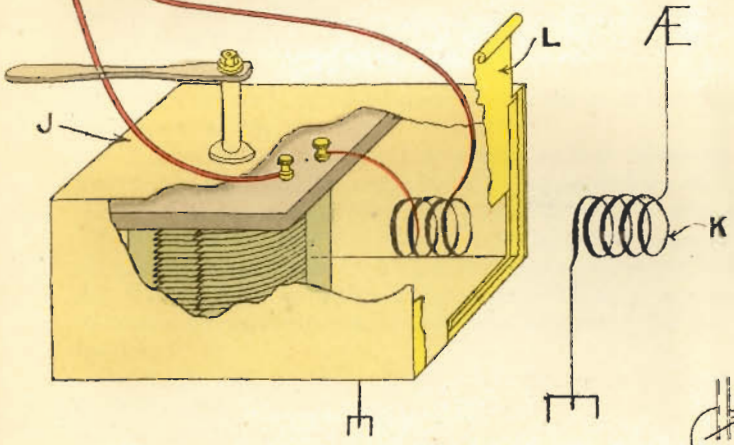
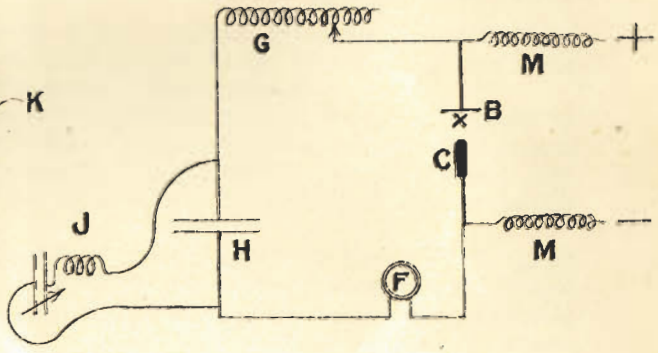


DIAGRAM OF CIRCUIT.



REFERENCE.

A	Water Cooling Vessel for Arc.
B	Copper Electrode for Arc.
C	Carbon " " "
D	Spirit Evaporator.
E	Spring Terminal Plunger.
F	Ammeter.
G	Variable Inductance.
H	Plugs for inserting Fixed Condensers.
I	Brass Box for enclosing Arc, etc.
J	" " " " Variable Condenser, & Coupling Coil.
K	Aerial Coupling Coil.
L	Sliding Screen to control Coupling.
M	Protecting Coils.

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"It was stated that signals from Washington were heard on the 'Salem's' ordinary aerial during daylight up to 2,600 nautical miles with the Heterodyne, and only up to 1,600 miles with the Tikker.

"With regard to claim No. (4), atmospherics are certainly reduced, but by no means eliminated; there were, however, no very severe atmospherics at Gibraltar during the time that the experiments were in progress, but it was reported that the Arlington Station at Washington suffers a great deal from atmospherics, and that when signals are completely drowned by a continuous rattle, then switching in the Heterodyne at once lessens the atmospherics and brings in the signals, which can be adjusted to a high piping note.

"With regard to claim No. (5), if the frequency of the undamped Wave is, say, 100,000, and should it be required to obtain a musical note of 1,000 beats per second in the telephone receivers, the Heterodyne must be adjusted to give a Wave frequency of either 101,000 or 99,000.

"If, however, there is an interfering Wave of, say, 99,300, then it would be better to adjust the Heterodyne to the lower of the two frequencies, viz., 99,000, so that two notes would be heard in the telephones, namely, the signals required at a pitch of 1,000 beats and the interfering signals at one of 300 beats, but as the former is at the higher pitch there would be no difficulty in reading over the latter; or, as an alternative, the Heterodyne could be tuned to the same frequency as the interfering Wave, viz., 99,300, so that the interfering signals would not be heard at all, and the required signals read at the lower note of 700 beats to a mean Wave-Length between the Heterodyne Wave and the Wave whose signals it is required to read.

"Again it is well known than when using the arc transmitter, it is the usual practice to short circuit 2 or 3 turns of the aerial inductance coil when the operating key is pressed (or *vice versâ*), so that either one Wave-Length or another is being transmitted without cessation throughout the message; if these two Waves are of very nearly the same length then, receiving instruments working with a Tikker will not be able to differentiate between them, and one continuous 'long' will be heard in the telephone; but if the Heterodyne be employed, the Wave transmitted when the key is pressed (*i.e.*, either the shorter or the longer Wave-Length) can be made into the higher note, and the other Wave either made into the lower note or left inaudible—in other words, a message could be purposely sent in such a manner as to be only readable with the Heterodyne apparatus.

"The Heterodyne arc was very silent and gave no trouble, but the 30 k.w. arc at Washington was very unsteady during one out of the four night programmes.

"It will be noted that the voltage generated for the Heterodyne arc at the dynamo brushes in 550 volts, which is cut down through resistances to a working voltage of 60 at the arc terminals; this was reported to be necessary in order to maintain a steady arc, the reserve of pressure giving a flywheel effect.

"The D.C. supply is 1·8 amps., so that although 1 k.w. was taken from the generator only about one-ninth of this was actually expended on the arc. It was stated that this policy was *not* followed in the case of the high power arcs at Washington and San Francisco.

"There is no doubt that the Heterodyne apparatus should have been completely enclosed in an earthed metal case. At present the operator with the telephone receivers is unable to approach the Heterodyne to make adjustments without increasing the coupling far beyond the necessary looseness—therefore under present conditions he has to signal to an additional man to do this for him."

On receipt of this report, three Heterodyne arcs were constructed in "Vernon," and after some experiments, satisfactory results were obtained. It is considered that the claims put forward in Captain Willis's report are fully borne out. Plate XI. shows the Heterodyne arc and adjustable oscillation circuit; it will be seen that the design of the arc is extremely simple. The arc-chamber is supplied with hydrocarbon gas by means of the spirit flash and wick-feed. The block condensers are built up of mica and copper foil, and have an average value of 0·6 jars each, the adjustable inductance has a maximum value of 3,800 mics.

The adjustable condenser is placed inside the Silent Cabinet in a copper screening box, the arc and oscillating circuit are also enclosed in a copper screening box, the boxes themselves being earthed. The Heterodyne is coupled to the receiving circuit as shown on Plate XI.

Coil "A" is placed inside the screening box containing the adjustable condenser.

Coil "B" is placed immediately outside the box, a sliding door on the side of the box allows the operator to adjust the coupling by closing and opening the door.

This method of coupling the Heterodyne to the receiving circuit has not proved satisfactory since a certain considerable coupling occurs between the adjustable condenser and the receiving instruments, in spite of the former being contained in an earthed metal box.

It appears probable that the adjustable condenser will have to be mounted outside the cabinet and operated by means of a rod connection passing through the side of the cabinet.

Experiments are in progress to determine the best method of coupling the Heterodyne to the receiving gear when the adjustable condenser is mounted outside the cabinet.

Reception with Heterodyne.—Day Signals from the Poulsen arc installed at Wick War Signal Station are received strength 8 at Horsea as opposed to strength 4 on the rotary tikker. In many cases, where atmospherics or local interference have entirely prevented signals being read on the tikker, reception by Heterodyne has been quite easy and reliable. The note on Wave-lengths below 1200 L.S. is liable to be rather warbly and uncertain, due to the fact that any unsteadiness of the arcs, and consequently variation in L.S. when transmitting on a wave-length of 1,000 L.S., will cause a considerable variation in the frequency, and since the note depends on the difference in frequency between the Wave received and that produced by the Heterodyne, it is obvious that alterations in this difference will affect the note, and that the effect is more pronounced on the shorter Waves.