APPENDIX C.

WIRELESS TELEGRAPHY.

EXTRACTS FROM A REPORT BY LIEUTENANT SALWEY ON THE INSTRUMENTS FITTED IN H.M.S. "EUROPA"; A SIMILAR INSTALLATION BEING ALSO SET UP IN H.M. SHIPS "JUNO" AND "ALEXANDRA." (Peace Manœuvres, 1899.)

Apparatus.

Mr. Marconi sent two of his assistants on board with the necessary instruments, which included a 10-inch coil, two specially screened relays and tappers, printer, and cells; a battery of 98 Siemens' dry cells (arranged 14 in series and 7 abreast) being used with the coil.

Relays.

One relay was adjusted to work up to 15 miles, the other (sensitive) for distances above 15. They were adjusted by Mr. Marconi himself, and remained in perfect adjustment during the entire manœuvres.

Connections.

The connections were similar to those shown in Annual Report of Torpedo School, 1897, except that a "jigger" was used in series with each "coherer."

The induction coil was thickly coated with paraffin wax, and two separate good "earths" used, one for the coil and one for the coherer, the use of two earths being advocated.

Adjustments.

The great success of the apparatus seemed to lie in the absolute similarity between the induction coils and the adjustment of the relays and tappers in the three ships, the instruments being thus tuned to exactly the same wave vibrations; and if signals were unintelligible, when well within the effective range of the instruments, it was generally quickly proved to be due to the method of sending, a great deal apparently depending on good sending. The delicate adjustment of the tapper and the efficient screening of the relays are also most important.

Masthead wire.

The masthead semaphore projected 2 feet above the truck, and as Mr. Marconi made a great point of raising the masthead wire as far above the iron of the semaphore, mast, and backstays as possible (every extra foot being of the greatest importance) a 38-foot spar was lashed, with stout hemp lashings, to the topmast, with a housing of 18 feet on the port side. This left the masthead semaphore free to work from right ahead to the starboard quarter.

The spar was further supported by two 3-inch hemp stays, and two 3-inch hemp backstays, fitted over a funnel 5 feet below the upper end of the spar, and set up by jiggers on deck.

Immediately above this funnel a 20-ft. yard was firmly parralled, with 15 feet abaft the mast and 5 feet before it, the 5-ft. heel being martingaled into the mast, so that it was sufficiently peaked to take the masthead wire well abaft the wire topmast backstays, and clear of the iron ensign gaff. This also gave it an increase of 2 feet in height.

Two pair of signal halliards, one well out and one (spare) half-way out, and guys, led through blocks at the topsail yardarm and into the top, completed the fittings.

Even at 18 or 19 knots the masthead did not vibrate dangerously, but no heavy rolling was experienced, the worst weather being encountered while steaming fast against a breeze of force "6."

Insulation.

Great care was taken to thoroughly insulate the masthead wire (which was somewhat similar to Patt. 600). At the masthead it was fitted into a 6-ft. bight made up in three coils, with the cores joined together at the bottom of the loop.

At masthead.

This bight was hung from the lower end of a long vertical ebonite rod, hanging from a similar rod, which was supported by the outer signal halliards. The connections in each case were made with cod line, which had previously been steeped in boiled oil for several hours.

Lower end.

The wire was led at its lower end to one of the after quarter-deck stanchions on one side of the ship, thus clearing the gaff and getting well abaft the iron backstays. At the stanchion it was guyed similarly to the masthead attachment, except that a porcelain ring was secured to the inboard end of the two ebonite rods and the wire rove through it, and led direct to the admiral's shelter-house on the after-bridge; here it was steadied by similar insulated attachments to stanchions, and then rove through a long ebonite tube fixed through the window shutter, led through a porcelain ring hanging by india-rubber bands from an overhead hook in the cabin, and connected to the induction coil

Cabin fittings.

The ebonite tube was supported by passing through a ¼-inch ebonite disc screwed to the sides of a hole cut in the window shutter, and also passed through an india-rubber pad outside, screwed to the steel bulkheads of the cabin, the tube being further insulated from the pad by india-rubber tape and solution.

As Marconi's sending and receiving key was not used, it was necessary to fork into the wire a lead for the coherer, so that it could be disconnected from the latter, and hung up to an insulated support overhead whilst sending. No failures due to weak insulation were obtained at any time.

Results obtained during Manœuvres.

1. On the first day of war, "Europa" reported to "Alexandra" (Flag) before sundown that no enemy was in sight. "Juno" received this signal and passed it to Flag, she being 30 miles ahead of Flag and 50 miles astern of "Europa," the latter steaming at 17 knots. Results.

2. When the convoy was sighted "Europa" rang "Juno's" call bell at 60 miles, the latter being 60 miles ahead of, and just out of touch with, Flag. An hour later "Juno" was able to call up Flag, a distance of 100 miles, approximately, being thus signalled over.

3. While making Milford Haven, where the Fleet was known to be, communication was established 50 miles off.

4. While picking up the Fleet in very hazy weather after target practice they were located by signal some hours before sighting them.

The "Europa's" vertical wire (174 feet) was somewhat higher than that of "Alexandra" or "Juno." In every case 50 miles proved the effective range of "Europa's" apparatus, and this gave a fairly reliable radius for obtaining signals from Flag or "Juno." Final observations.

The lead of the masthead wire requires consideration, being in this case foul of the stern fire. Gun fire.

It appeared to me that any average electrician and good telegraphist could manipulate the instruments *when once adjusted;* but that the initial adjustment, and also any readjustment, requires a very fully qualified expert, well acquainted with the intricacies of the whole system. A good plan for leading the masthead wire through the upper deck is to pass it up through hollow bitts, using ebonite insulators, and making the fitting watertight on top with sheet india-rubber, tape, and solution. Maintenance.

INVENTIONS FOR STEERING TORPEDOES AND VESSELS FROM A DISTANCE WITHOUT CONNECTING WIRES.

The Captain of the "Defiance" was ordered to proceed to Glasgow and Dublin to inspect and report on inventions for steering torpedoes or vessels from a distance without any wires being attached to them, by the means of Hertzian waves.

The Glasgow invention was one by Mr. Govan, and is covered by Provisional Specification No. 3032 of the 7th February 1898. It was in a purely experimental stage, and consisted in the main of an electrical escapement actuated by two electro-magnets that work alternately. By the model shown four operations could be performed successively, viz., Starboard, Port, Stop and Start, resting on the one it is wished to carry out. So crude was the model that it was impossible to make sure that even these first principles could be carried out with certainty, probably however, with much experiment they might. Mr. Govan's invention.

The Dublin invention was one by Professor C. P. Fitzgerald and Dr. Trouton and was not patented. Professor Fitzgerald's and Dr. Trouton's invention.

The principle was that of utilising instruments that are actuated by single pulsations of current, preferably those that recur at certain set intervals. This invention was also in a purely experimental stage; various methods were shown, but the most practical was an adaptation of the synchronous clock system of printing telegraphy, samples of which instrument can be seen in most clubs. The difficulty of the action being intermittent where a continuous action is required was ingeniously got over by a bellows switch, so arranged that it will make contact with a snap, but takes a fixed time, slightly longer than the recurrence of the signals, to break. This was far the most practical method of the two of solving the question of steering a vessel at a distance by means of Hertzian waves, and with very little further experiment it might no doubt be easily made to take the place of the "Vernon" pattern electrically steered steamboat.

As regards the use of either of these inventions, or of any of the many other similar ones which have appeared, supposing the difficulties of applying them to torpedoes were got over, which is quite possible at great trouble and expense, the question arises as to whether at their best they would be better than a gyroscope. To use a controlled torpedo from a moving base is most certainly a tactical mistake, and if used from a fixed base it would have no practical advantage over the Brennan torpedo, which, considering its range, speed, and charge, is far the cheapest automobile torpedo known. Use of the invention. No advantage over Brennan torpedo.

MEMORANDUM OF INSTRUCTIONS FOR INSTALLING A SET OF WIRELESS TELEGRAPH INSTRUMENTS, &c., ON BOARD ONE OF H.M. SHIPS AFTER THE NECESSARY FITTINGS HAVE BEEN MADE TO THE MASTS AND SHIP.

Issued by Authority of the Lords Commissioners of the Admiralty.

Admiralty,
1900.
N.S. 7267–99.

TO FIT THE AERIAL WIRE.

To fit the aerial wire.

To fit the aerial wire to the masthead gaff, cut off three lengths, each of 4 feet, from the wire supplied, reeve them through a short insulator, and make a neat junction, soldered, of the ends of each part, splicing in, with a **T** junction, 6 inches of wire. Carefully insulate each junction. Join the ends of the three tails of the **T**'s together, and join them with a soldered junction to the end of the aerial wire, carefully insulating the junction.

Secure the lanyard of the short insulator to a long insulator. Splice a toggle in the other end of the long insulator, to which attach the tricing line.

Trice up to the masthead, and measure approximately the length of wire required to reach the instrument. Cut the wire at this length.

Reeve it through as many fixed or short insulators as are necessary to stay it clear of rigging and fittings, reeve the wire through the deck or panel insulators to the instruments, and cover it with indiarubber tubing as high as the position from which it leads direct to the masthead. In the office, suspend the wire from a position directly over the front nipple of signal key by an insulator, and join the end of the conductor to the contact on the insulated arm of the signal key.

A good contact must be made to the contact on the key, one which will not shake loose, and sufficient slack must be left to allow the key to drop into place and make good contact on the receiving nipple. It must be clear of the bulkheads, &c., when the key is pressed for signalling.

Note.—The wire, if new, will stretch considerably, and the slack will occasionally have to be taken in and the end cut off.

TELEGRAPH OFFICE.

General arrangements.

A sheet of indiarubber must be spread over the bench for the instruments.

The signal key is to be secured firmly to the bench in a convenient position between the coil and receiver box, and the inker placed near the key, so that the operator can attend to both without moving from his position at the key.

Arrange the four accumulators so that the connections can be easily got at, and the batteries removed if necessary for recharging.

Two batteries are to be used for working the coil, the other two are spare, and the four batteries should be used in rotation, two being charged whilst the other two are in use.

The two batteries should be capable of signalling continuously for four hours, or, roughly, sending 2,000 words at a rate of 10 words per minute. The charging current should not exceed 6 ampères. The discharging current should not exceed 12 ampères, and the capacity at this rate of discharge is 25 ampère hours.

Eight cells are sufficient for working the coil: By the aid of the three terminals fitted, any number up to 10, except one, seven, and nine, can be joined up by making the connections as required with two batteries. Ten cells should be used for long-distance signalling.

TRANSMITTER.

Primary connections.

Primary Connections.—Join the + pole of the accumulators to the terminal marked + of the induction coil, which should be placed with the contact-breaker to the front.

Join the negative pole to one terminal of the signal key.

Join the other terminal of the signalling key to the — terminal of the induction coil through the safety contact on the receiver box, if supplied. Pattern 104 wire is supplied for these connections, and the leads should be as short and direct as possible, arranged neatly, led through holes in the bench, and stapled down where necessary.

Secondary connections.

Secondary Connections.—Connect the terminal on the movable standard of the coil to the nearest earth terminal in the office by a direct lead of Pattern –1480 wire, taking care that it does not pass within a foot of any of the wire connections from the fixed standard to the aerial wire.

Connect the fixed standard of the coil to the terminal on the upright guide of the signalling key by an open spiral of silk-covered wire.

See all connections free from points, that is, double the wire back on itself before making the connection.

To adjust the interrupter.

To Adjust the Interrupter.—Connect up the battery by the switch on the coil, also the aerial and earth wires to the secondary terminals as described. Fix the balls $1\frac{1}{4}$ inches apart.

Screw up the milled-headed contact screw till it just touches the platinum contact at the back of the hammer, there being no tension on the spring. Put very slight tension on the spring by means of the ebonite-headed adjusting screw. Press the signalling key and observe the spark between the balls whilst you are putting more tension on the spring. The sparks should be bluish and bright, not yellow with furred edges; they should crackle sharply and be thick or double and continuous. At the same time there should be little or no sparking at the hammer, nor should there be any tendency for the hammer to stick, and the rapidity of vibration should be great, *i.e.*, faster than can be counted. Ease up the key, fix the balls $\frac{3}{4}$ inch apart, the normal distance, see that a VERY short contact of the key will give a good thick spark, and that a long contact gives an equable spark during the time the key is pressed; if so, the instrument is in adjustment.

If there is much sparking at the hammer, or if the platinum contacts are rough, they should be filed square with the smooth file (supplied in the case) by an experienced artificer, and the interrupter readjusted.

Guard particularly against putting too much tension on the hammer spring, and also do not attempt to obtain sparks beyond the distance that the coil will easily give them, viz., $1\frac{1}{4}$ inches with the balls. The act of detaching the balls from the aerial and earth wires will entirely change the length and character of the spark obtained between them.

The balls are not to be burnished, but should be kept reasonably clean and perfectly dry, and not greased in any way. The ebonite casing of the coil must be kept free from dirt, dust, and especially moisture, and the coil should not be exposed to the direct rays of the sun; when not in use it should be kept covered by a dry flannel-lined cover, or stowed away in its packing case.

These coils are supplied solely for use with wireless telegraphy, and are not to be used for other work, such as X rays, except in an actual emergency for medical purposes, nor are they to be interfered with or worked by unskilled persons.

With proper care they will last for years, but an inexperienced person may damage them in a few minutes.

The coil, with the make and break as fitted, is never to be used without its condenser in circuit; that is, the two pairs of terminals marked C must be respectively connected by the copper strips supplied for the purpose.

If the coil, apparently in good adjustment, should suddenly or occasionally refuse to spark across the balls when they are less than 1 inch apart, it is probable that a leak to earth has developed in the aerial wire, and this should be sought for and remedied before trying to send any more signals.

Signalling key.

Much depends on the successful manipulation of this key, and this is only obtained by careful attention and practice.

The key must be worked differently to the ordinary telegraph key. The play must be greater so as to ensure the actual breaking of the current and prevent arcing between the nipples. The dots should be made very sharply, so that one spark only passes between the balls. The spaces must be *at least* that laid down for them, and the long should be of the proper duration also. Briefly, the dots as short and the spaces as long as possible.

For a signal made like this	▬ ▬ ▬ ▬▬▬	(i)
will generally appear -	▬▬▬▬▬▬	(ii)
and one made - -	▪ ▪ ▪ ▬▬	(iii)
appears - - -	▬ ▬ ▬ ▬▬▬	(iv)

which is very easily legible.

Any speed of signalling up to 15 words a minute may be used as long as these points are attended to.

Also, at long ranges, or with the instruments not well adjusted, longs MAY come in broken, thus:—T O may appear ▬ ▬ ▬ ▬ ▬▬▬ ▬ ▬. If a man is always signalling as in (i) the receiving operator is likely to read the signal as T A T N, whereas if he usually made his signal as in (iii), with good spaces, the receiver would see at once that the broken longs were not due to the sender making T A T N, but to the fault of the instrument, and read it T O. This point is of the greatest importance, and cannot be too strongly impressed on the operators, viz.:—"*shorten the dots and lengthen the spaces.*"

If an arc should form at the nipples of the key when sending a message, it is easily extinguished by a sharp puff of air from the mouth. Arcing is a sign that either there is not enough play of the key, or that the interrupter of the induction coil requires adjustment.

It is absolutely necessary, to prevent damage to the coherer, that the lid of the receiving **box be closed firmly before sending a message or passing** a spark between the balls of the **transmitter.**

To prevent this occurring it is proposed to fit a safety contact on the lid of the box (in the primary circuit of the coil and signal key).

If in sending a signal a spark, when, making a short is missed, that short will not be recorded at the distant receiver, and should therefore be instantly repeated.

The operator for this reason should watch the spark when signalling, and also note at once if any change in its character takes place.

The Receiver.

Before joining up the various parts of the receiver in the box each part should be tested as follows :—

The jigger.

(1.) *The Jigger.*—Test for insulation between the primary and secondary windings, *i.e.*, large from small terminals. Test for continuity the primary and each half of the secondary wires, *i.e.*, A to E, C_1 to R, C_2 to B.

Note.—The resistances of these wires should be taken before the instrument is mounted in its box, and the values written on the box for future guidance.

The batteries.

(2.) *The Batteries.*—E.M.F. 1·5 volts, I.R. ·75 ohms for each cell. The cell for actuating the relay should be insulated from the local battery cells by a thin sheet of indiarubber supplied for that purpose. The spare cells should be used in rotation with the others, as dry cells apparently last longer when working intermittently than when stored idle. They should be kept as cool as circumstances will allow.

The tapper.

(3.) *The Tapper.*—This should be adjusted so that it will vibrate rapidly (six per second) with a short ($\frac{1}{8}$-in.) path for the hammer to move through when six cells are joined up to the terminals. The final adjustment can only be made when the whole apparatus is mounted. The adjustment is a very important and rather difficult one; alterations to it are effected by the milled-headed adjusting screw, and by altering the stiffness and shape of the vibrating spring on the armature. Before fixing it in the box, it should pass the following tests.

Tests for Tapper.—Each tapper is to be tested as follows :—

Tests for tapper.

Using a battery with an E.M.F. of at least 15 volts, perfect insulation must be found between the winding of the bobbins and the frame of the magnet, and also between the insulated contact pillar and the frame of the magnet. The resistance of the windings of the bobbins, which are to be joined in series, is to be 500 ohms. ± 3 per cent. limit.

With the connexions made and shunts joined in place, the armature is to vibrate freely and rapidly when a battery of an E.M.F. of 8 volts is joined up to the terminals.

With a battery of 15 volts joined through an external resistance of 3,000 ohms, there is to be no vibration of the armature when connected up to the terminals.

There should be no sparking at the contact spring when the armature is vibrating.

The adjustable slider should work freely for the whole length of its travel, and be rigid, and free from play, when clamped lightly in position by the clamping screws.

The same remark applies equally to the standard of the coherer, and its position should be such that it can be easily adjusted for the hammer of the tapper to tap the centre of the coherer tube, when both are clamped in position for working, and the act of tapping should visibly displace the filings in the coherer.

The relay. Sullivan's pattern.

(4.) *The Relay. Sullivan's Pattern.*—Join up the tapper with six cells to the local terminals. Join up one cell through two boxes of resistance coils, or one box and the test coils, to the armature with a key in circuit. Screw up the coil by means of the key supplied till it is in its most sensitive position, *i.e*, close to the pole pieces.

Place the adjusting lever on the coiled spring so that the tongue rests against the ivory stop.

Press the key, the tapper should work. Unplug resistances till the tapper stops vibrating; this should be when 20,000 to 25,000 ohms are unplugged. Ease up the key.

The exact position of the lever can be found where it ceases to control the coil and the tapper will work without pressing the key.

This position will never be used, and care should be taken that the lever is never left in this position.

By a little manipulation the most sensitive working position can be found, and should be such that the coil will move over with one cell through at least 20,000 ohms, work the tapper, and return when the key is raised.

This fine adjustment can be used at shore stations or when there is no vibration.

A less sensitive position (15,000 to 20,000 ohms) is the one that should be used for ordinary work, when the relay should stand moderate vibration, on a table, and also heeling to any moderate angle, without affecting the coil. When the relay is triced up in the box it should be quite unaffected by heeling or vibration with this adjustment.

Screw the contact stops of the local circuit close up to the tongue of the relay. The thickness of a sheet of thick paper is ample play for the tongue of this relay.

No further adjustment (of the lever to the coiled spring) should ever be required, unless it is subject to excessive vibration, when it may be necessary to give it, temporarily, a less sensitive adjustment.

The glass cover should now be placed on, and the resistances through which the relay will work with one cell, with the suspended coil in various positions, should be noted for future guidance. It should work through 5,000 ohms in any position.

ELECTRICALLY, there should be no change *whatever* in its sensitiveness and no readjustment should ever be required.

The pivots may occasionally require readjustment.

There should be perfect insulation between the coil and local terminals. The key supplied for altering the position of the suspended coil should be kept in the box. This particular adjustment has been fitted with a view of judging approximately the distance between the two stations by observing the change of resistance in the coherer, and will not be required for the present for instructional or ordinary signalling purposes. It will be, however, useful for judging the value of the jigger and the tuning apparatus in experiments and in installing the apparatus in different ships. When actually joined up in the box the resistances through which the relay will work can be easily tested by inserting a box of P.O. coils in place of the coherer.

The contacts of local circuit are burnished and should be cleaned occasionally with paper and spirit of wine.

The Morse inker.

The Morse Inker.—See ink pot filled, paper in place, and that the clockwork will reel off the paper at about 2 feet per minute. Adjust the stops so that the ink wheel marks the paper when the lever of the armature is on the lower stop and does not mark the paper when it is against the upper stop; the play of the lever should not exceed $\frac{1}{8}$ inch, and the smaller the play the better for rapid signalling. See the 2,000 shunt joined up across the terminals. Screw up the magnets till they are just clear of the armature when it is on the lower stop.

Join up to a box of resistance coils and a battery of 15 volts, adjusting the spring and magnets so that the armature will not work through an added resistance of 3,000 ohms, but will work through 500 ohms and signal clearly with this adjustment. Switch on the bell and adjust it to the same resistances. No further adjustment should ever be required. Join up the actual lead of steel-braided wire to the printer terminals. This should be done before the connections are made in the receiver box, and it is most important never to short circuit the printer terminals or the leads to them, as the relay local connections may be fused thereby.

INSTRUCTIONS FOR SETTING UP THE INSTRUMENTS IN THE RECEIVER BOX.

Placing the cells.

Placing the Cells.—Place the Q cells in their compartment on a sheet of indiarubber, and see that the front left-hand cell is insulated from the others by indiarubber sheeting. Join the eight back cells in series, starting from the + of back left-hand cell and ending at — of right back cell. Place the relay on its bed of lagging, adjusting key to the rear.

Secure the tuner to the front inside of the box, the right-hand end in line with the right-hand hole for leading in the aerial wire. Graduate the edge of the box in inches to mark the number of turns in the tuner, which are 20 to 1 inch. Secure the tapper in the centre compartment, coherer stand to left, and edge of the tapper base about 1 inch from the back of the box. Secure the jigger between the tapper and front of the box.

COHERER CIRCUIT.—Using pattern 733 wire, join the + pole of the single insulated cell to + pole of the coil circuit of relay. Join the negative pole of this cell to the B terminal of jigger; join the R terminal of jigger to the — terminal of the relay.

Local Circuit.

Local Circuit.—Join the negative pole of the local battery to the most distant local terminal of the relay. Join the other local terminal of relay to the back terminal of tapper, join the other terminal of tapper to the + pole of the battery.

Printer.

Printer.—Using twin wire, pattern 1480, join them up to the printer first, then reeve the wires into the box, and connect one wire to the back terminal of the tapper, and the other to the + pole of local battery. Test the connection by short-circuiting the C terminals of the jigger, when the tapper and printer should work.

Coherer.

Coherer.—Fix the coherer in the standard, test its position by seeing that the tapper strikes it fairly, and connect the wires of coherer to the C terminals of the jigger.

It is important that all the wires are neatly laid in box and as short as possible, and where two wires carrying out and in-going currents are in proximity they should be stapled together. Loose straggling wires are detrimental to accurate signalling, as they are affected inductively by the working of the tapper.

Primary circuit.

Primary Circuit.—Connect the lead-cased wire from the front nipple of the signalling key to the right-hand fixed terminal of the tuner.

Connect the slider of the tuner to the A terminal of the jigger by a foot of No. 28 S.W.G. silk-covered wire.

Connect the distant earth by lead-cased wire to the E terminal of the jigger.

See the brass casing of the box and the lead or braided casings of the leading-in wires are connected to the lead casing of the earth wire, which lead casing also should make earth at the distant end.

If these latter details are carefully attended to it is almost impossible for the coherer to be affected by transmitting signals from the same office as long as the brass-cased box is closed.

The various parts of the apparatus having now been placed in the box and connected up according to the attached diagram and instructions above, it is necessary to test through.

To test the apparatus.

To Test the Apparatus.—Before connecting up the coherer and the aerial and earth wires, short-circuit the two CC terminals of the jigger, or join them up through a resistance, the tapper and printer should work correctly.

This tests the connections.

Join up the coherer, aerial and earth wires. Nothing should happen. If, however, the tapper vibrates the coherer is too sensitive. Short-circuit the two CC terminals of the jigger, the tapper should work, and on breaking the connection should at once stop vibrating. If this is the case, the instrument is in adjustment, but it may be possible that the coherer is not sufficiently sensitive.

It may now be tested by holding the gas-lighter near the coherer, with its axis parallel to the axis of the coherer. On pressing the thumb-patch on the gas-lighter, and thereby causing a spark to pass across its spark-gap, the coherer should excite, and the apparatus work.

The gas-lighter will also actuate the coherer if it be placed close to, and parallel to, any part of the aerial wire within the telegraph office.

It may be tested roughly by holding an ordinary trembling bell *close* to the coherer with the vibrating armature in line with the axis of the coherer. As a general rule this should excite the coherer and work the apparatus.

If in para. 3 the tapper should continue to work, either, (i) it is out of adjustment, or (ii) there is an abnormal induction in the local circuit. In this case proceed as follows:—

Tap the coherer with a pencil, knife, or other hard light body; if the tapper stops vibrating, the fault is in the tapper and it requires adjustment.

If it does not stop, hold the hammer with the finger and tap several times as before. If it now stops vibrating the fault is due to abnormal induction.

If it does not stop, the coherer is too sensitive.

In all cases the tapper must be adjusted so as to visibly displace the filings of the coherer when the hammer strikes the tube.

In the first case (i) proceed as follows:—

To adjust the tapper.

To Adjust the Tapper.—Fix the standard of the coherer so that the ball will strike the glass tube fair in the centre. Adjust the height of the ball by the milled-headed screw of the tapper slider so that the ball hits the tube nearly at the end of its stroke. Adjust the screw contact of make and break so that the break occurs before the hammer hits the tube.

The glass tube should, generally, be about $\frac{1}{8}$ inch (not more) from the ball when the latter is at rest and the tapper in good adjustment.

Speaking generally, the shorter the stroke and the lighter the tap, the better will be the adjustment of the instrument. If a hard tap is necessary there is something wrong with the coherer or circuit.

In the other case (ii) where the fault lies with the induction from local circuit, it is necessary to examine and test all shunts. See that none of the leads have been displaced, and that there are no bad contacts of wires and binding screws, and also observe carefully the relay, contacts, and make and break of tapper to see that there is no abnormal sparking.

The defect is not likely to be observed except with abnormally sensitive coherers and very fine adjustment of the relay.

The coherers are constructed so as to be more sensitive when the V formed by the angle of the plugs is down than when up. The sensitiveness varies according to the angle the point of the V makes with the vertical, thus allowing a large range of adjustment.

As a rule coherers get more stable but less sensitive after use, and a few minutes' steady tapping on a very sensitive one will often reduce its sensitiveness to practical working limits. The tubes being sealed, there is no method of altering the sensitiveness except by change of position of the V plugs from the vertical.

A coherer with the tips cracked (through which the platinum wire leads) may be resealed by a blow-pipe, but will not then be a vacuum tube, and if damp inside will be utterly unreliable.

Unfortunately, from the nature of their construction, with a number of different-shaped particles forming a bad electrical contact, even the best coherers are not always absolutely consistent in their behaviour, and the change of resistance under the same circumstances may vary greatly. This is especially the case with a very sensitive one. The use of one of this description is not therefore recommended, but by paying attention to the tuning of the instrument a coherer of moderate sensitiveness will be able to record intelligible signals at a greater distance than a very sensitive one in a badly-tuned instrument, and, in fact, many faults in signals due to imperfect tuning are often erroneously attributed to the coherer as the effect on the signals is almost identical, viz., some signals being recorded perfectly and others at the same distance being broken or not recorded at all. Accurate tuning is therefore essential, and though at first generally troublesome and apparently often unattainable, the exercise of patience and careful attention will generally result in success.

To enable tuning to be effected with facility the tuner is supplied, but it may be replaced by fixed coils in the connections when the results required have been finally attained.

Tuning.

The tune or fundamental note of each installation, *i.e.*, of both transmitter and receiver, independently varies with the capacity and self-induction of the circuits.

The tune of the transmitter will vary but little in different ships with the same height of aerial wires and the balls the same fixed distance, $\frac{3}{4}$ inch, apart; in fact, it will depend only on the length and lead of the wire. Ships with short aerial wires may well add, therefore, about 20 to 30 turns in a spiral of No. 28 S.W.G. copper wire, between the fixed sparking ball and the fixed guide of signalling key. A few trials with a ship with a receiver normally tuned will determine the best number of coils to be inserted. Thus the latest fitted ship tunes her transmitter to the receiver of the ship normally tuned.

It should be noted that inserting either inductively wound coils of wire, *i.e.*, self-induction, or condensers, *i.e.*, capacity, lowers the fundamental note of the circuit, which is termed "tuning down," and removing them is "tuning up."

Tuning the receiver to the fundamental note of another ship's receiver requires care and patience, but, as far as our experience has gone, is best obtained in the following manner, observing that the receiving aerial wire and the primary coils in the jigger are first to be tuned to the transmitter of the other ship, roughly, and then the secondary winding with the coherer are to be tuned to the primary circuit (already roughly tuned) of the jigger. To do this ships should be anchored at a moderate distance apart, preferably within signal distance, in case messages cannot be exchanged by the instruments.

The transmitting ship should send at fixed times, or by signal, V's slowly and steadily for about two minutes, during which time the slider of the tuner in the aerial circuit should be shifted along the tuner till the best results are obtained, the relay being adjusted to its least sensitive adjustment if the signals are clear enough to enable it to be so altered. If signals still come the aerial wire should be lowered till they become broken, and the slider worked till the best results are obtained. If a large number of turns are required in the tuner, it is probable that the secondary will not require many added, and *vice versâ.*

To Tune the Secondary to the Primary.—The signals should be made and the relay and aerial wire worked as before, whilst inductively wound turns made in a $\frac{1}{4}$ inch spill of 28 S.W.G. are added in coils of 10 on each side of the coherer between it and the CC terminals of the jigger, till the results are better or decidedly worse. When the best results are obtained, neat coils, if any are required, should be made and permanently placed in the secondary circuit.

The primary circuit should be returned as before, and a permanent coil may be placed in it in lieu of the tuner.

This procedure should be repeated with one ship under way near the extreme limit at which signals can be exchanged with these adjustments.

Limit of Distance.—With regard to the limit of distance, as it is neared, it will be noticed that the tapper works more lightly and the longs of the inker become broken, making it difficult to read the tape; and, when important, signals should be repeated back and sent again. Limit of distance.

As the distance further increases stray dots only will be received, and the signals become unintelligible. At a greater distance no indications will be received.

Experience tends to show that an increase of about 15 per cent. of the distance at which longs are broken will be the distance at which all signals are lost.

As this is approached an increase in battery power at the transmitter, a good adjustment of the interrupter of the coil, a change in the surface of the balls, and slight increase in their distance apart may possibly improve the signals, which should always at long distances be made slowly.

At the receiving end the relay and coherer should be placed in their most sensitive adjustment, and the coherer repeatedly excited by a *gas-lighter* or short circuiting the CC terminals of jigger.

An alteration in the course of one or both vessels may affect the distance at which signals can be exchanged, and the presence of hills, iron masts, shears, and buildings between the two ships necessarily decreases the distance at which signals can be exchanged between them.

To charge a 5-cell Battery, about 20 quarts of acid and distilled water should be mixed to a specific gravity of 1190°. and, when cool, poured into the cells through the holes on top until the liquid rises to about half an inch above the top of the plates in the cells. Charging the cells.

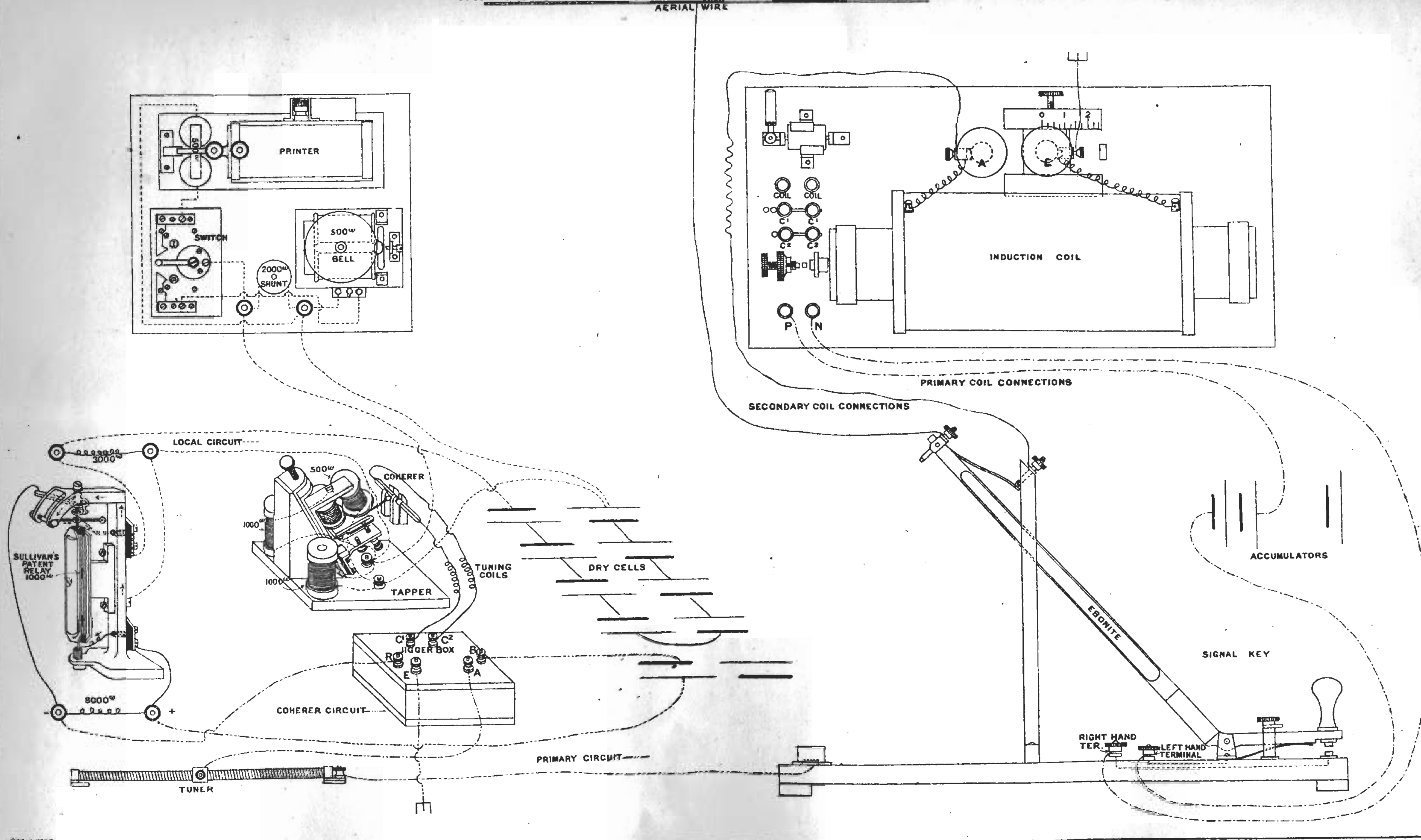
The cells should be *immediately* placed on charge on the ship's electric light circuit, with two 50 c.p. lamps in fork as a resistance, so as to give a charging current of five ampères, care being taken to connect up the + pole of dynamo to the terminal coloured RED.

The first charge should be continued from 24–36 hours, until voltage rises to 13, S.G. to 1215, and cells gas freely.

The voltage of each battery should be occassionally taken, and should never be permitted to fall below nine volts; when this limit is reached the battery should be recharged in the above manner.

Note.—In diagram, the tapper is shown, in error, with coherer stand to the right instead of to the left.

Wireless Telegraphy. Diagram of Circuit.



E. Weller & Grahams Ltd Litho. London