SUBMARINE INSTALLATION.

(REPORT FROM "DEFIANCE.")

The final design of this installation has now been settled, and B5 Submarine has been completely fitted.

The whole installation has been arranged to use instruments already designed and in use in the Service, as far as this is possible. (*See* Plate IV.)

The transmitting circuit is similar to destroyers, except that the H.D. impedance coil and transformer are used; the condenser has been altered in value, the primary has been made of larger size rod, both these changes have been made to allow a 600-foot wave to be sent.

The rotary converter is ½-K.W., exactly similar to destroyers. The safety points have been enclosed in an air-tight ebonite box to minimise the danger of sparking.

The H.O. key has been made air-tight, the two knobs are extended and brought through air locks to prevent the danger of sparking, and in lieu of silver contacts, platinum has been fitted.

The receiving circuit is similar to the usual tuned shunts circuit, using the H.D. instruments as far as possible.

The fine tuner and a No. 3 condenser have been fitted to enable longer or shorter waves to be received, as it is possible that the boats may require to receive from T.B.D.'s or from H.D. sets.

The rejector has been fitted so that interference from merchant ships, &c., may be cut out.

It is found that, given good tuning of the transmitting ship, no alteration of adjustments is necessary, and so the rather complicated circuit is not a drawback.

The silent cabinet follows the lines of those fitted in ships, and is made as large as the space will allow.

The aerial is of the 4-fold roof type supported on two masts, which can be lowered from the conning tower.

The deck tube is fitted with watertight glands top and bottom, and a ⅜ths-inch copper rod passes down the centre of the tube which is 4 inches in diameter. The tube has been filled with insulating oil to prevent any chance of brushing.

The feeder is attached to the copper rod by a butterfly nut, and the connection from the bottom of this rod to the oscillator is made by the high-tension cable supplied to the boat for ignition purposes.

In order to transmit a 600-foot wave efficiently from "Forth's" Mark I. star set, the spare element of the transmitting condenser has been fitted with insulated terminals and an ebonite top, and has been placed alongside the main condenser in such a position as to bring all the insulated terminals on the same level. The spare element is joined to the main condenser by a brass strip so that all four elements are in series.

With the whole of the first primary ring in the circuit and the short-circuiting clip as close to the spark-gap as possible, a wave of 615 feet is emitted. (*Note.*—This circuit was tuned with the old wavemeter, and has not been checked with the new one recently supplied owing to "Forths" absence from Devonport.)

Without the short-circuiting clip, a 600-foot wave can be obtained with ⅓rd of the primary first ring in the circuit.

The aerial circuit consists of five leyden jars all in series, joined in series with the aerial and connected between the aerial and mutual coils.

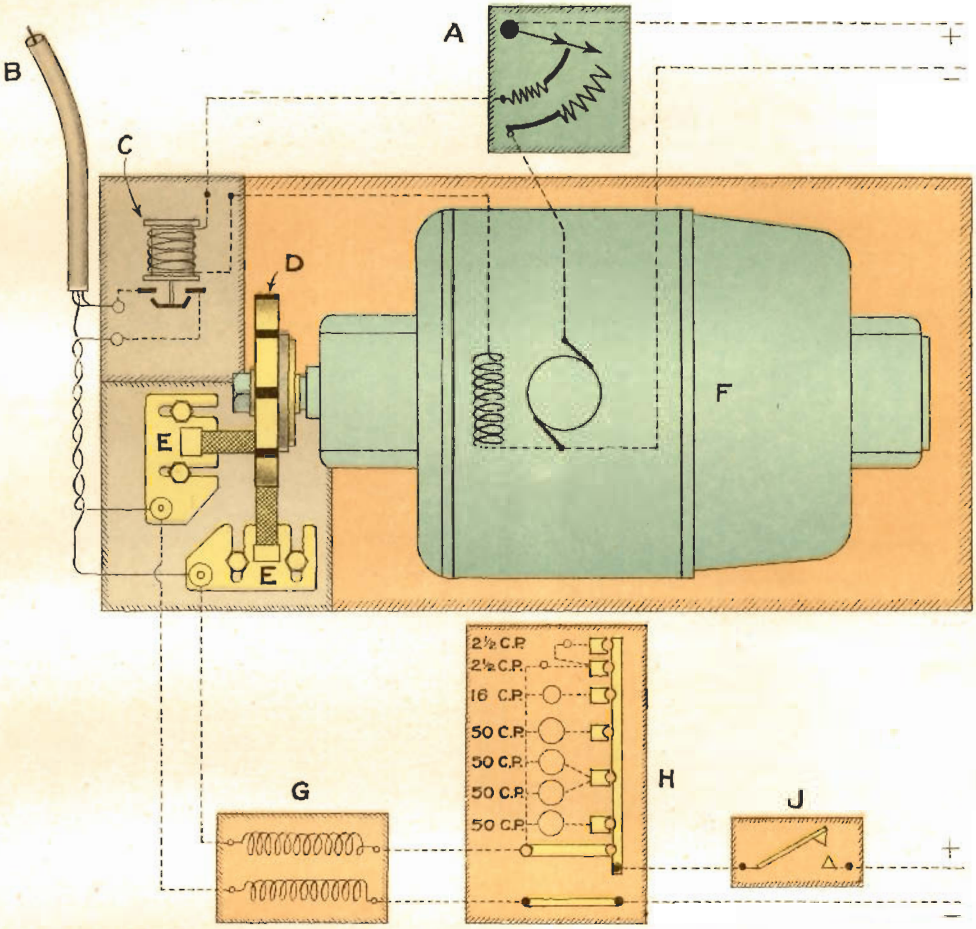
Very sharp tuning was thus obtained with first method for the primary, and good radiation was obtained.

COPY OF REPORT FROM C.O. "FORTH," RE SUBMARINE INSTALLATION.

In order that the gear should be given a more extended trial than the officers of the boat could spare time for in addition to their other duties whilst cruising, a Petty Officer Telegraphist and a Telegraphist were sent in the boat and signals were passed between submarine and "Fourth" for five minutes every half-hour, and on no occasion was there any failure to establish communication.

MOTOR BUZZER

SHOWING INSTRUMENTS AND CIRCUIT.



REFERENCE.

A	STARTER FOR MOTOR.
B	FLEXIBLE CONCENTRIC CABLE TO CONNECT UP WITH CONDENSER ETC.
C	SWITCH AUTOMATIC.
D	WHEEL FOR ¼ H.P. MOTOR.
E	BRUSH-HOLDERS FOR WHEEL.
F	MOTOR ¼ H.P.
G	INDUCTANCES.
H	RESISTANCE LAMPS.
J	MORSE KEY.

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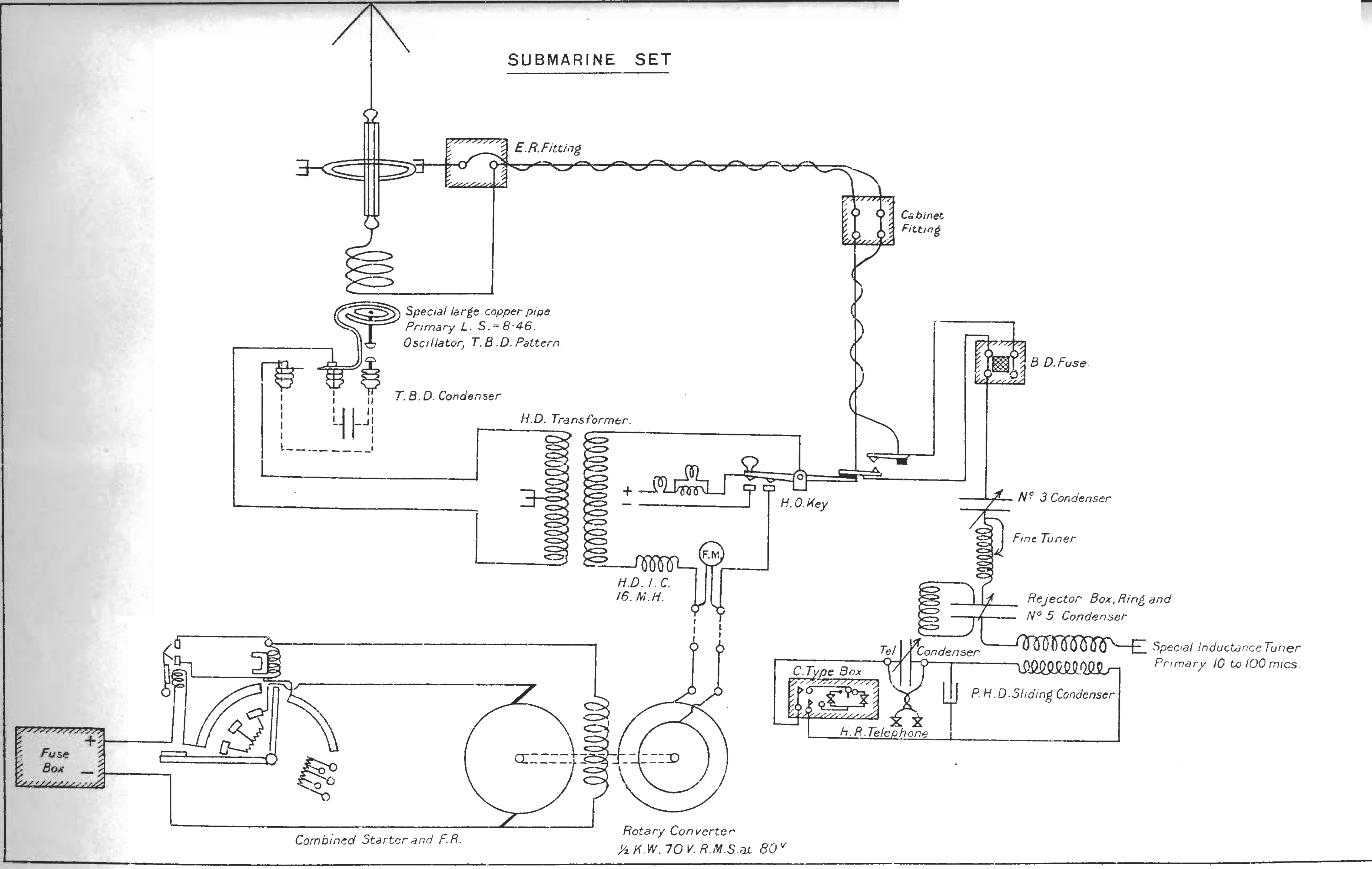
SUBMARINE SET



In most cases the distance was very short, between one and two miles, the greatest distance submarine was from "Forth" was 25 miles when signals were exchanged, strength 12 in submarine and "Forth."

The absence of any stays to the masts was much felt and necessitated their housing before going to sea in any bad weather. In later type submarines the masts should be stayed if practicable.

Great difficulty was experienced in keeping the condenser oil tight, especially when diving, through the oil overflowing from the top.

Considerable induction took place inside the cabinet when sending. This was partially cured by carefully earthing each lead separately, and it is hoped to obviate this by the use of concentric lead cased cable for the aerial sending circuit inside the cabinet.

The Service crystals were found to be more satisfactory than the tellurium detectors.

Brushing took place at either end of the deck-tube, particularly the top end, and it is proposed to make the ebonite tube a little longer and thicker.

Trouble was experienced from spray thrown up on the aerial, and it is proposed to fit an insulated feeder from the deck-tube to within a short distance of the roof.

The bridge extension fitted to support the deck-tube is unsatisfactory in a heavy sea, it was bent upwards, and it is hoped to devise a better method of staying the tube, in order to obtain the most efficient working of the W.T. gear.

It is considered that a trained operator is essential, as an officer who comes off the bridge or gas engine to the W.T. cabinet is not likely to be able to get good results until after he has been in the cabinet some minutes, and it is impracticable for the boats' officers to keep continuous watch owing to their other duties.

"Defiance" Comments on the above Report.

On 1.—Previous experiments have shown that a distance of 50 miles may be expected under fair conditions of sea, &c.

On 2.—The most efficient aerial is obtained with two masts, and, if stays are used, it will be difficult to lower the masts from the bridge in a hurry, which is at present possible.

If stays are necessary, it may be better to have only one mast. This must be settled by trial with a later class Submarine.

On 3.—The washer on the condenser will be examined, but if the leak is due to an overflow from the top, it may be necessary to sling the condenser.

On 4.—Concentric cable will be fitted.

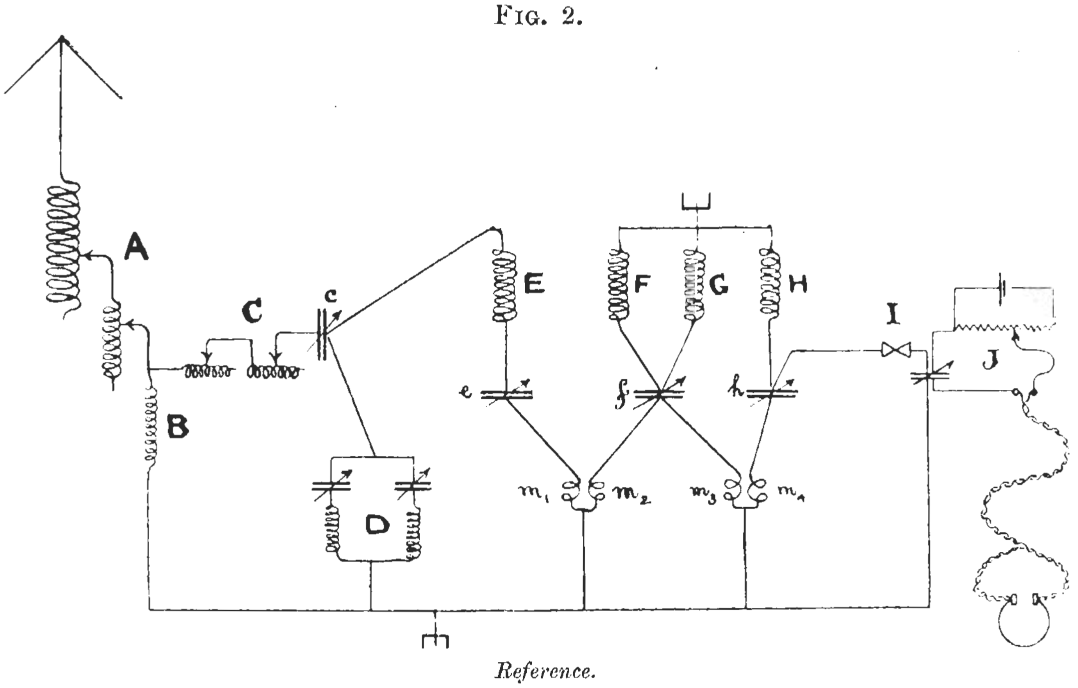
On 5, 6, *and* 7.—All these faults were to be expected.

On 9.—This remark is concurred in; it was found during experiments that even expert operators found some difficulty in hearing at first entry into the cabinet, owing to the other noises in the boat, even when not near the engines.

RECEIVING CIRCUITS AND DETECTORS.

New Experimental Receiving Circuit.

Fig. 2.



Reference.

A = Aerial tuner.
B = Atmospheric drain, 2,000 mics.
Cc = Aerial acceptor.
D = Shock absorber.
E, F, G, H = Each 1,000 mics, or 100 mics, or a short circuit by switches.
Ee, m_1 = Primary acceptor.
m_1, m_2, m_3, m_4 = Coupling coils each 30 mics, the coupling being varied by revolving one of the coils on top of and close to the other.
Fm_2, Gm_3, f = Secondary circuit.
Hm_4, h = Tertiary circuit.
I = Crystal detector
J = Telephone circuit.

A number of experiments have been carried out with circuits of the form mentioned in last year's Report, with the object of increasing selectivity as well as range. Special attention has been paid to the reception of undamped waves, accompanied by an initial shock, such as those received from a quenched spark transmitter, and it has been found that the Tuned Shunt Circuit is not very suitable for the reception of such waves so far as selectivity is concerned when compared with circuits of the form described last year. The range obtained with the Tuned Shunts Circuit could be increased by increasing the electrical efficiency of the instruments, but it is thought better to use the knowledge now available with regard to efficient instruments in designing a new circuit which will be specially suitable for undamped waves.

All inductances in the new circuit will be composed of stranded wire, each strand of equal length and insulated, with the object of reducing eddy current losses and resistance, the overall diameter of the wire being as large as the size of the instruments will allow.

Experiments with different forms of condensers are still in progress, but it seems probable that the dielectric for the variable condensers will be air or oil, and that for the fixed ones oil or mica.

The actual circuit now being made up for trial is shown in Fig. 2, and it will be seen that this circuit does not differ in principle from that described last year. The idea of using a number of acceptors, each tuned to the Service waves, which it may be necessary to cut out, did not fulfil theoretical expectations, and has therefore been abandoned, but it is possible that two variable acceptors will be used as a shock absorber instead of the series of fixed ones shown in the diagram last year.

In the experiments carried out it was found that with persistent waves a very loose coupling could be used without any diminution in the strength of signals, in fact a loose coupling is better both for strength and selectivity when receiving waves, such as those produced by a quenched spark transmitter, and it will be noticed that the present circuit is arranged so that very loose couplings are used. It was also found that the coupling for greatest selectivity is so close to that required for greatest strength that in practice it is unnecessary to readjust the condensers when the coupling is altered from that required for greatest strength to that required for greatest selectivity.

This requires confirmation on waves other than those used in the experiments, but if it holds good for all Service waves, the adjustment of the new circuit will be simpler than that of the Tuned Shunts Circuit.

The necessity of screening various parts of the receiving circuit so as to eliminate undesirable mutual effects between the instruments, &c. has been very apparent during the experiments, and in the new circuit all the inductances will be enclosed in metal boxes, and the circuits arranged in such a way as will prevent these effects from taking place.

Crystal Detectors.

The Dennis Detector, described in last year's Report, has been on trial in the Fleet during the year.

It would appear from the reports received that this detector is more stable and as sensitive as the crystallite.

With the Dennis, a potentiometer circuit is required and its adjustment is critical, but the objection of having this additional adjustment is counterbalanced by the fact that continual alteration of the points of contact of the stones is no longer necessary. The multiple holder shown in last year's Report has not proved suitable, but the reports from the Fleet suggest that a number of separate detectors arranged so that any one of them can be switched into the circuit, would be suitable for ship use.

A few detectors used by commercial companies, including the Telefunken Molybdenite—German silver couple, have been tried, but none, so far, have been found superior to the Service detectors.

An endeavour was made to initiate experiments in conjunction with the Geological Museum on the rectifying properties of crystals with the object of the investigation being further pursued by the museum staff. The museum authorities, however, after some preliminary experiments, came to the conclusion that they would not be able to afford sufficient time for this investigation, so the experiments have officially closed for the present.

A.L.N.S. 9567 of 25th December 1912 authorises the adoption of the Dennis Detector. A holder has been designed, and these detectors will be issued, as stocks of the crystallite detector become exhausted, to all ships with C type receiving circuits.

POULSEN TIKKER.

A Poulsen tikker, of the type which consists of a vibrating contact between two gold wires, has been tested in comparison with the Service crystallite, and the following results obtained :—

1. Receiving Quenched or Poulsen waves.

In the C type circuit, the tikker was more sensitive than the crystallite. Signals received on the tikker in the Poulsen circuit were stronger than those received on the tikker in the C type circuit, the best coupling for strength being used in each case.

For cutting out Quenched or Poulsen interference when receiving a similar type of wave, the tikker was not so efficient as the crystallite, as with the latter any difference of note can be detected, whereas with the former the note depends of course on the tikker itself, not on the transmitting circuit. When the interference was from an ordinary spark set, the tikker was more selective than the crystallite, as it is less sensitive to ordinary spark waves.

2. Receiving ordinary spark waves.

The tikker was not so sensitive as the crystallite, the signals on the tikker being broken and difficult to read.

C TYPE RECEIVING CIRCUIT.

During the year nearly all ships have been supplied with the C Type Receiver, and the results obtained have been very satisfactory.

Information with regard to the use of the A Stop on the primary for increasing the strength of signals, and the use of a wavemeter as an acceptor in the lead from the secondary to earth for increasing selectivity, was promulgated in G. and T. Order No. 139 of July 1912.

A method of rewiring the Protecting Switch so as to prevent the detector from being rendered insensitive when sending was promulgated in G. and T. Order No. 140, of July 1912. Reports have been received that the detector can be protected by earthing each side of the crystallite instead of breaking the circuit as at present, or by using the Protecting Switch to break the leads from the secondary winding to the crystallite and to the telephone condenser, the No. 7 and 8 condensers being connected directly across the crystallite.

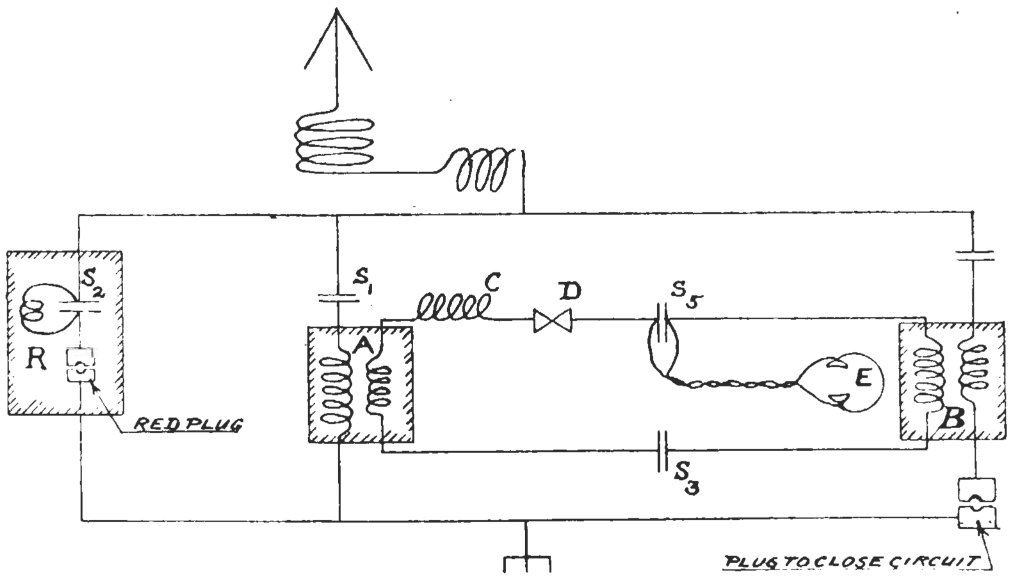
Tuning the Receiving Circuit.

A convenient method of tuning the receiving circuit to the waves for which the transmitting circuit is adjusted was promulgated in G. and T. Order No. 120, of June 1912. Instead of using short leads from the small Buzzer to the spark gap, as suggested in para. 2, it is more convenient, if transmitting adjustments for the various waves, using Buzzer Transmitter, are known, to disconnect the concentric lead from the Buzzer Transmitter, and use this lead for connecting the small Buzzer to the primary circuit.

INTERFERENCE PREVENTER.

P.O. Telegraphist, E. J. Hudson, of H.M.S. "Lancaster," has suggested and used the circuit shown in Fig. 3.

Fig 3.



Reference.

A = Oscillation transformer (tuned to signals).
B = Oscillation transformer (tuned to interference)
C = Strengthener.
D = Crystalite detector.
E = Telephone.
R = Service rejector.
S = Condensers (Service numbers as marked).

Petty Officer Hudson obtained some very promising results, and the arrangement is under trial in the Mediterranean Fleet.

The circuit is on the same lines as that used in the shore stations, *see* p. 3, and is somewhat similar to some Marconi and Fessenden Patents.

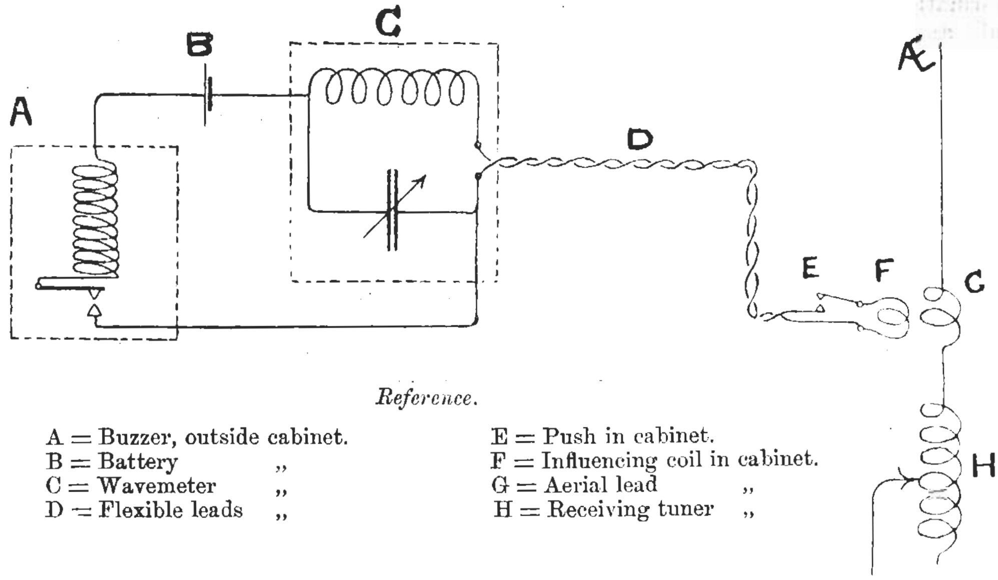
Rejector Tuners.

Lieutenant S. C. Wace, R.M.A., H.M.S. "Exmouth" devised an arrangement for increasing the efficiency of the Differential Interference Preventer. This circuit is under trial at St. Angelo Station.

The arrangement consists essentially of a Rejector placed in the auxiliary aerial. This Rejector is in tune with the wave length of the signal required, and at the same time tunes the auxiliary aerial to the wave length of the interfering signals.

Tuned Testing Set.

Fig. 4.



Reference.

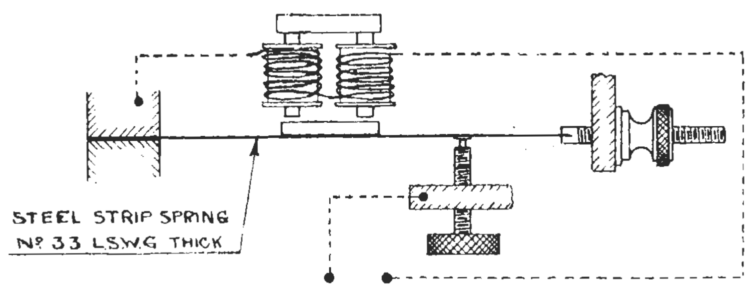
A = Buzzer, outside cabinet.
B = Battery ,,
C = Wavemeter ,,
D = Flexible leads ,,
E = Push in cabinet.
F = Influencing coil in cabinet.
G = Aerial lead ,,
H = Receiving tuner ,,

Experiments have been carried out with the object of devising some arrangement by which the operator can test not only the sensitiveness of the receiver, as at present, but also the tuning of his circuit.

The circuit shown in Fig. 4 appears to be fairly satisfactory, but as the influencing leads from the testing set to the receiving circuit add capacity and induction to the wavemeter, the necessity arises of specially calibrating the testing set before issue, or calibrating it afterwards in the ship by the known receiving adjustments for the various waves.

It is of advantage in a Testing Set to use a Buzzer with a clear high note, and for this purpose, a Buzzer designed on the lines shown in the Fig. 5 is much superior to the service form of Buzzer.

Fig. 5.



Dielectric Efficiency.

Experiments have been carried out with the object of obtaining information with regard to the comparative efficiency of various dielectrics and condensers when used in a receiving circuit.

The efficiencies were compared with that of air by noting the comparative deflections obtained on a thermo-galvanometer in a circuit in tune with, and very loosely coupled to, a quenched spark transmitter. The circuit was tuned by varying an air condenser, and the maximum deflection of the galvanometer noted. The condenser under test was then switched in in parallel with the air condenser which was again varied for a maximum deflection. The ratio of the latter deflection to the former was taken to represent the comparative efficiency of the two condensers if used in a receiving circuit. The brushing losses which might occur in this circuit, but would not occur in a receiving circuit, were probably so small as to be negligible.

These dielectric efficiencies may be considered as comparative only when the capacities, circuits, and conditions of test are the same.

The transmitter was that used for calibrating wavemeters, and was made up of ebonite condensers in oil, stranded wire coils, and leads of copper tubing.

The receiver was made up of stranded wire coils, leads of Patt. 611, and a copper eureka thermal junction of about half an ohm resistance.

The tables on pp. 16 and 17 show some of the results obtained.

In these tests, the plates used in the experimental condensers were of tin-foil unless otherwise stated. The dimensions of tin-foil were 2 inches by 3 inches, the dielectrics being $2\frac{3}{8}$ by $3\frac{1}{4}$ inches.

It will be noticed that the efficiency increases and the capacity decreases as the pressure of the plates on the dielectric is reduced. This is, no doubt, due to a layer of air being formed between the plates and the dielectric, so that the condenser becomes partially an air condenser with a consequent rise in efficiency and fall in capacity.

This variation according to pressure makes it very difficult to obtain any reliable comparative results.

In the results given, the plates were pressed down on the dielectric between two ebonite plates, which were secured together by screws round the edges.

The low efficiency of the ebonite and mica condensers used in the present Service Receiving Circuit as compared with air condensers is, of course, largely due to losses in connections, insulating and adhesive materials, &c.

Insulating oil seems to be particularly efficient, but the capacity obtained is only about 2·36 times greater than a similar air condenser, so that it would be an impracticable dielectrico, wing to size, for receiving condensers of very large capacity.

QUENCHED SPARK.

Experiments and Progress.

Much valuable information was obtained from the experiments and programmes carried out between "Vernon" and "Vindictive" during the cruise of the latter in June and July.

In the set erected in "Vindictive," gaps of ·008 inch clearance were first employed, but before sailing, gaps of 0·15 inch clearance were substituted, the larger gap being proved to be better.

In each ship the maximum number of gaps that could be used was 32, and the primary capacity (a Mark II. condenser tank) was arranged to have a value of 48 jars. The gap connections could be readily altered, so that the number of gaps employed could be reduced to 24, 20, 16, 12, or 8. The gaps were placed in oil tanks, and were constructed and arranged as shown in Plates VI. and VII. of the Annual Report for 1911 (20 gaps are equivalent to about 14·5 K.W.). Each ship was turned to two-wave lengths, L.S. values being 800 and 320. Different primary and secondary mutual coils were used for each wave.

The "Vindictive" sailed on June 12th, and proceeded to Queenstown, Madeira, and Gibraltar, returning to Portsmouth on July 10th. Such troubles as were experienced were due principally, not to the quenched spark mechanism, but to the present type of deck insulator.

Twelve gaps were replaced when at Madeira, the remainder were left to the end of the cruise, of these, the majority, when opened up, were found to be in good order and adjustment, but a general examination revealed the fact, that small modifications were required in design, and there is no doubt that when these have been made, the gaps will last for 6 or 12 months without being overhauled, although it may prove desirable in practice to examine them every three months.

The conditions of the trial were not favourable for obtaining extreme range, but a maximum day range of 700 miles was obtained both on the outward and homeward voyages, which is considerably greater than "Vernon" has obtained before, whilst night communication was obtained throughout the cruise, including the time at Madeira (approximately 1,400 miles). Comparison was also made with an ordinary Mark II. set, and it is considered that the quench spark system, applied to existing Mark II. sets, with average ships aerial, will give an increase in range of about 20 per cent.

During the cruise, each ship sent programmes amounting to $4\frac{1}{2}$ hours transmitting daily, in addition to considerable signalling for communication, so that the gear had to stand a fair amount of work.

The gaps were found to heat up considerably after continuous sending for any length of time; when using full power the oil in the gap tank would reach a temperature of about 200° Fah.

The primary, and primary mutual coils gave no trouble, nor did the condenser. The secondary mutual coils were found to get hot, and towards the end of the cruise trouble was experienced from heavy sparking at the top of the mutual, when using the long wave, the coil on several occasions catching fire.

The chief trouble, as mentioned above, was due to the deck insulator; several of these fittings broke down, and had to be replaced in both ships, and it was proved that the present type of insulator will not be suitable for quenched spark. The breakdowns were due chiefly to the greatly increased heating from the more persistent wave produced in the aerial, and partly from the increased tension in the aerial obtained by the much greater efficiency of the quenched spark system.

Anti-brushing aerials were fitted and found extremely satisfactory, no brushing being observed in dry weather, and very little in damp, in spite of the large power induced in the aerial (*see* page 5).

Dielectric.	Condenser.	Capacity.	Frequency of Alternator.	Transmitter L.S.	Receiver L.	Percentage of Deflection on Receiving Ammeter compared with that using Air Wavemeter Condenser.	Remarks.
Mica ·0025 in. thick -	Experimental, 1 sheet	·63	310	715	379	76	Flat German silver plates.
Mica ·0025 in. thick -	Experimental, 1 sheet	·27	310	Various	Various	94	German silver plates bossed so as that flat surface plate is separate from mica by ·002 on each side of the mica.
Mica ·0025 in. thick -	Experimental, 1 sheet	·47	310	715	379	91	Flat German silver plates separated from mica by thin silk net.
Mica ·0025 in. thick -	Experimental, 1 sheet	1·67	310	715	379	50	Mercury instead of plates in condenser.
Ebonite ·016 in. thick	Experimental, 1 sheet	·066	310	715	379	84	Mercury instead of plates in condenser.
Wakefield's insulating oil.	Wavemeter, Vane pattern.	2·11	310	246	379	100	Capacity with air for oil was ·895.
Mica - - -	Siemens' Service Rejector.	2	293	176	379	17	
Ebonite - - -	No. 1 receiving condenser.	1·5	293	176	100	14	
Glass - - -	Leyden jar - -	1·25	293	268	162	64	
Glass - - -	Moschichi - - -	·45	295	268	379	44	
Glass - - -	Plates as in Poldhu pots.	—	310	357	162	33	Condenser made up of two in series, two in parallel.
Glass - - -	Copper deposited on plates.	—	310	357	162	37	Condenser made up of two in series, two in parallel.

During the trials the existing "C" type receiving circuit was made use of, and there appears to be no doubt that with this circuit, although the system emits only one wave, the quenched spark system will cause more interference with ships in its immediate neighbourhood than the Mark II. system. This result was expected.

In order to gain more experience on the matter of the interference of the new system with fleet W.T. organisation the "Vindictive" was attached to the First Battle Squadron for one month, *i.e.*, September—October, 1912.

The report of the V.A. commanding, summarised, states that :—

(i) In close order with a fleet of ships with Mark II. installation and "C" type receiving gear, a ship with quenched-spark apparatus would interfere with reception on other waves to such an extent as to make it impossible to carry out the Service organisation of wave-lengths.

(ii) As a detached ship, even at 50 miles range, a ship fitted with a Q.S. transmitting apparatus, would interfere with reception on other waves to such an extent as to make it extremely difficult to carry out the service organisation of wave-length.

(iii) By placing a wave meter in the receiving circuit in series with the "acceptor," and tuning to the wave being received, interference was found to be reduced to such an extent, that (ii) could be modified as follows :—As a detached ship, at not less than 20 miles range, a ship fitted with Q.S. transmitting apparatus would not interfere with the present service organisation of wave-lengths.

A new form of receiving circuit, to overcome the above difficulties, is being experimented with in "Vernon," *see* page 11.

Progress during the Year—

As a result of the cruises mentioned above, and of the experiments continually carried out during the year in "Vernon," a reliable gap has now been obtained, it is shown on Plate V.

Referring to the difficrlties previously experienced, enumerated on page 22 of the W.T. Appendix to Annual Report for 1911.

Pimpling has now been overcome by making the gaps airtight and placing them under oil.

Hydrogen has been found to be unnecessary; with air-filled gaps, properly closed and placed under oil, it is found that the oxygen is burnt up quickly, and thereafter the gaps work in nitrogen.

The tiny pores in the gunmetal castings which would allow fresh air to enter the gaps are sealed by the oil, which does not enter the gap so long as the pressure is maintained fairly even. It was found that oil did penetrate into the gap after some time in many cases, and this was found to occur from the gaps becoming hot, and a pressure being formed inside. This pressure opened the gap out and allowed oil to enter, this sometimes caused an explosion.

This drawback has been overcome by fitting expansion chambers: each gap has its own expansion chamber, connected to it by woodite tubing which fits over the ends of small pipes in the gap (*see* Plate V.) and the chamber,

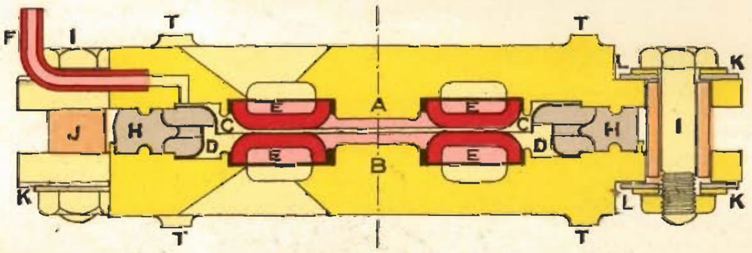
TYPICAL QUENCHED GAP.

PAIR OF PLATES FORMING A GAP.

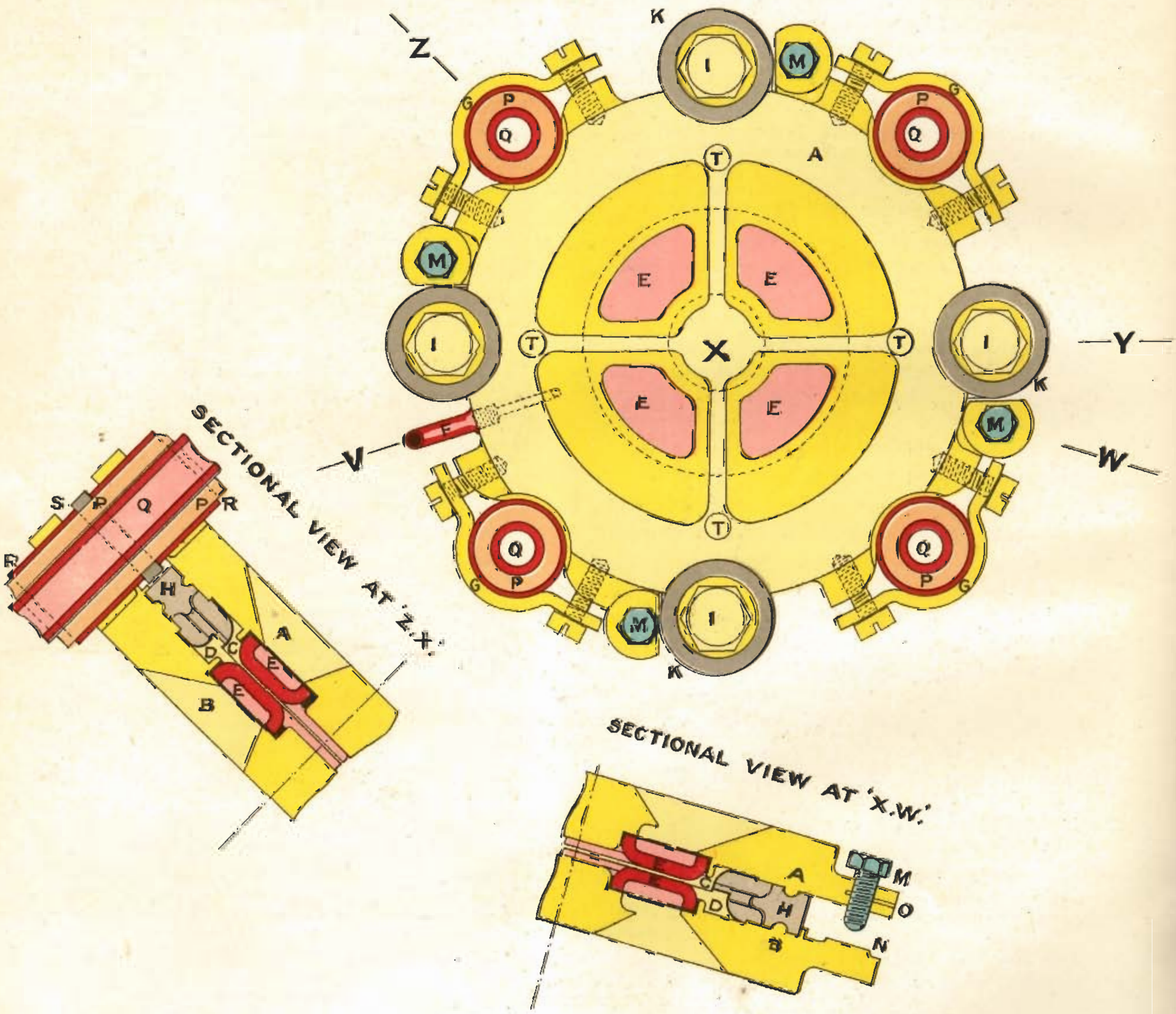
REFERENCE.

A	PLATE UPPER FOR ELEMENT.	K	MICA WASHERS.
B	„ LOWER „ „	L	BRASS „
C	GUARD RING FOR PLATE UPPER FOR ELEMENT.	M	MICROMETER SCREWS FOR GAUGING GAP.
D	„ „ „ „ LOWER „ „	N	RAISED TABLING „ „ „
E	DISC COPPER FOR ELEMENT.	O	SAW-CUT FOR TIGHTENING MICROMᴿ SCREWS.
F	PIPE „ „ EXPANSION.	P	TUBE PERTINAX.
G	SECURING AND CONTACT CLAMPS.	Q	„ COPPER.
H	WOODITE WASHER, UNDER COMPRESSION.	R	SLEEVES „
I	BOLT CLAMPING FOR ELEMENT.	S	RING EBONITE.
J	BUSHES PERTINAX „ „	T	SMALL RAISED TABLING.

SECTIONAL VIEW AT "V.X.Y."



PLAN OF ASSEMBLED GAP.



Dielectric.	Condenser.	Capacity.	Frequency of Alternator.	Transmitter L.S.	Receiver L.	Percentage of Deflection on Receiving Ammeter compared with that using Air Wavemeter Condenser.	Remarks.
Mica ·0025 in. thick -	Experimental, 1 sheet	1·6	310	357	163	92	Comparative results for same capacity.
Ebonite ·016 in. thick	Experimental, 6 sheets	1·6	310	357	163	54	
Ebonite ·016 in. thick	Experimental, 1 sheet	—	320	268	379	83	Tin-foil pressed hard down on mica.
Ebonite ·016 in. thick	Experimental, 2 sheets	—	310	357	163	80	
Ebonite ·016 in. thick	Experimental, 3 sheets	—	310	357	163	74	
Ebonite ·016 in. thick	Experimental, 5 sheets	—	310	357	163	62	
Ebonite ·016 in. thick	Experimental, 6 sheets	1·6	310	357	163	54	
Mica ·0025 in. thick -	Experimental, 1 sheet	1·67 about.	310	357	163	83	
Mica ·0025 in. thick -	Experimental, 1 sheet	·68 about.	310	357	163	97	Pressure removed.
Mica ·0025 in. thick -	Experimental, 1 sheet	1·35 about.	310	357	163	65	Full pressure, rubber between pressing surfaces.
Mica ·0025 in. thick -	Experimental, 1 sheet	·88 about.	310	357	160	77	Medium pressure, rubber between pressing surfaces.
Mica ·0025 in. thick -	Experimental, 1 sheet	·24 about.	310	357	160	94	Pressure removed, rubber between pressing surfaces.

Then, when a pressure is set up inside the gap it forces air out of the expansion chamber, on the pressure falling again the oil rises in the expansion chamber until the pressure inside the gap is again equal to that outside.

Another difficulty was due to the use of ebonite insulating bushes which were found to soften and contract and then harden again as the gaps varied in temperature, thus allowing the gaps to open out and get much out of adjustment.

There is no doubt that this opening out of the gaps was the cause of the high tension obtained towards the end of the "Vindictive's" cruise with consequent variation in results and increased strain on the coils and deck insulator. This difficulty has been obviated by the use of pertinax bushes and mica washers which do not soften.

On opening up gaps that have been working properly for a considerable time and have remained airtight, the copper sparking surfaces are found to be smooth and to have the appearance of newly electrically deposited copper. Most of the gaps that were untouched in the "Vindictive's" set during the first cruise of that vessel were found to have this appearance. Plain copper sparking surfaces have given better results than any other metal that has been tried so far.

Yet another fault in the working of the gaps was due to copper dust which was thrown off the working surfaces and collected on the insulation, thus lowering the efficiency of the gap.

This defect will be met in the new gaps by fitting guard rings which overlap one another (*see* Plate V.).

The adjustment of the gaps is a matter of some nicety and requires experience. It will not be, however, at all a difficult operation with the new gaps.

Mark II. sets converted to quenched spark will be known as Mark II*., and will be on the following lines.

The new gaps will be arranged in elements and held in frames similar to the old type, but each element will consist of six gaps only instead of eight, the space thus obtained at the end being filled by the expansion chambers.

The gap stands are placed in an oil tank and the gaps connected by wide copper strips to four concentric terminals on the lid. The primary circuit is connected to two terminals only, the other two being used for short circuiting gaps. In order to obtain the necessary tight couplings it is imperative that the self-induction of the primary connections shall be reduced as much as possible. To this end the connections between adjoining gaps is made by four concentric connections.

Concentric terminals will have to be fitted also to the top of the condenser tank.

A series parallel switch will be placed above these terminals. The adjustable primary coil will be in two parts joined in series, one influencing the mutual coil and the other well away from it: the coupling will be altered by increasing the number of turns in use in the one, and decreasing those in the other, and *vice versâ*.

One mutual coil will be used for long waves and another for short waves.

Condensers will be connected, two in series and two in parallel to give 50 jars when using full power. For shorter waves, they will be connected to give 25 or 12½ jars.

Mark II. transmitting condensers will be used.

It has been found that to get the best results the primary and secondary should be slightly out of tune with one another, in ship sets it is better to have the primary rather shorter than the secondary.

The coupling is a very important adjustment, there being certain best couplings, shown by curves of current in aerial, for every percentage out of tune and wave-length.

These curves, as a rule, give certain well-defined "peaks," the coupling adjustments for the "peak" being often very critical. Gaps with a clearance of ·015 inch appear to work best with a coupling of about 10 per cent.

When gaps with a smaller clearance are used it appears necessary to tighten the coupling to obtain best results. The 10 per cent. coupling, and therefore the ·015-inch gap, has been decided on from the following consideration :—

If very tight couplings are used the interference caused is increased, as up to the moment of quenching the two waves in the system are well separated on either side of the mean wave, also the system approximates to the plain aerial system in so far as it causes interference by giving shocks to other receiving circuits.

On the other hand if the coupling is made too loose the energy does not get into the aerial quickly enough, and a large proportion of it is wasted on the primary. Tuning of Q.S. transmitting apparatus for experimental purposes entails expenditure of much time and labour, but it is thought that, with a properly designed and adjusted primary, the tuning in practice will be very much simpler than that of Mark II. sets, especially as the tuning of the aerial is so sharp and definite on the wave meter, and it is not necessary to tune the aerial with a spark in it.

Air-Blast Gaps.—These gaps were given a lengthy trial but have been found to be unsatisfactory, except for very small powers as the sparking surfaces tend to burn or arc.

This type of gap was devised by Lieutenant Schreiber for use in the standard wave meter calibrating set where it has proved very successful.

The gaps were formed out of metal discs, which were rove one above the other on a central vertical rod : the centre of each disc was the bearing surface, circular mica washers being placed between these surfaces to obtain insulation and the correct sparking distances.

Outside the bearing surfaces was a ring of air holes and outside these again came the sparking surfaces. An air blast directed up from beneath travelled through these holes and found outlet between the sparking surfaces. These gaps work very efficiently and an excellent note can be obtained for a very short time after which, unless the power used is extremely small, arcing takes place.

Various metals were tried, copper and nickel being found most satisfactory, but the life of any was found too short for practical purposes and the trials of these gaps for signalling sets have been abandoned.

Horsea Experiments.—A small transmitting set has been erected at Horsea station for experiments with quenched spark when applied to long waves and a large aerial. For the first experiments air-blast gaps were used, but no reliable or satisfactory results could be obtained. Further experiment was delayed by pressure of work in "Vernon" and "Vindictive" but now an oil gap set is working with satisfactory and promising results.

The circuits are similar to those for the Mark II*., but 10 gaps only are used with a primary capacity of 150 jars. This set approximates to $\frac{1}{12}$th of the final Q.S. set for the station which would have 120 gaps.

Much tighter couplings can be obtained than in the experimental ship sets, and it is found that with the large primary capacity and a coupling of 20 per cent. the primary L.S. must be slightly *greater* than the Secondary L.S. to obtain the best results, *i.e.*, the maximum radiation.

Whether this will hold with the coupling reduced to 10 per cent. remains to be seen.

Advantages and Disadvantages.

The principal advantages of the Quenched-Spark System as compared with the ordinary coupled system that has been in use in the Service are :—Firstly, that it makes a more effective use of the power applied and would enable more power to be radiated from an aerial of a given size; secondly, that by generating one wave only and by giving more sustained trains of waves it will enable a more finely tuned and more selective receiving circuit to be made use of for its reception. Both these advantages are more pronounced when using long wave-lengths than when using short ones.

The principal disadvantage of the Quenched-Spark System is that it is more nearly related to the Plain-Aerial System than is the ordinary coupled circuit with a loose coupling, inasmuch as it tends to generate the waves more suddenly than the ordinary coupled circuit does and with a greater initial shock at the beginning of each train; if, however, a receiving circuit can be designed to deal with this, it can then, as stated above, be made more selective than existing service arrangements.

In the system therefore lies the possibility that it can be made selective to its friends and interfering to an enemy not fitted with the special receiving circuits.

If this possibility can be realised it need not be pointed out what an advantage would accrue to the Navy possessing such a system, with corresponding disadvantage to a Navy fitted with a system, however selective to its friends but also selective to the enemy. Under this latter head of course, come such systems as the Service Mark II., Poulsen, &c.

The advantages of the Quenched-Spark System should be more marked with the long waves than with the short ones. When long waves are used, in general the aerial radiates its energy slowly. The oscillations remain in the primary and secondary circuits for a relatively long time, and the losses in the primary circuit therefore represent a faily large proportion of the total energy applied to the circuits. In this case if the primary oscillations are quenched the aerial circuit will go on oscillating for a comparitively long time because the rate of radiation, and therefore the damping, is small.

When short waves are used, however, or when long waves are used with very large aerials, the radiation from the aerial takes place rapidly; the oscillations remain in the circuits for a relatively small time only, and the loss in the primary does not represent a large proportion of the energy applied to the circuits. In this case, if the oscillations in the primary were quenched, the oscillations in the aerial would not take the form of a long train of waves, because the damping in the aerial due to radiation would be great.

Policy.—It is anticipated that on the whole the conversion of Mark II. sets into Quenched Spark would be a decided improvement, but to overcome interference that would be caused by its introduction a more selective receiving circuit will be necessary. As stated previously, "Vernon" has for some time been experimenting with receiving circuits with very promising results. The design of a new circuit is being pressed on with, but until it is completed and quite satisfactory, Quenched Spark will not be introduced generally. It is proposed to purchase 12 sets of Quenched-Spark apparatus, or rather apparatus for converting 12 Service Mark II. sets into Quenched-Spark sets. The allocation of these sets has not yet been decided upon, but it is probable that the first set will be erected in "Vernon," and that the remainder will be installed, pending the provision of the new receiving circuits, in ships whose duties are largely in extended order, such as Cruiser Squadrons, and these ships will temporarily retain on board all the Mark II. fittings displaced in order that they may be quickly replaced, should it be considered desirable to do so at any time.