SECTION L
D/F

SUB-SECTION LA D/F OUTFITS ETC.

SUB-SECTION LB RADIOGONIOMETERS

SUB-SECTION LC SENSEFINDERS

SUB-SECTION LD SEMI-CIRCULAR CORRECTORS

D/F GENERAL

The theory of D/F and its service application is contained in Admiralty Handbook of W/T (1931) paragraphs 786 to 817 inclusive.

As stated on page AC4 the letter "S" prefixes all D/F apparatus (except D/F training units, see section F) and the following table shows the items in detail -

SA to SZ - Independent W/T Receiving Outfits for D/F termed "D/F Outfits" (In some cases where the primary use of the Outfit is for normal reception they are termed "Receiver Outfits")

S1 to S19 - Frame coils for D/F

S20 to S39 - Radiogoniometers for D/F

S40 to S59 - Sensefinders for D/F

S60 to S79 - Semi Circular Correctors for D/F

There are two main types of D/F installation fitted in H.M.Ships.-

(a) The Bellini-Tosi System (See Admiralty Handbook of W/T (1931) paragraph 792) employing two large crossed aerial loops. D/F Outfit SD is of this type and is described on page LA6.

(b) The Rotating Frame Coil System (see Admiralty Handbook of W/T (1931) paragraph 788). Receiver Outfit SF (see page LA13) and D/F Outfit SGX (see page LA14) are of this type

The relative advantages of the two systems are summarised below (see also Admiralty Handbook of W/T (1931) paragraphs 795 and 813).

Bellini-Tosi.
1. Higher speed of operation
2. Greater sensitivity

Rotating Frame.
1. Electrically more simple.
2. Free from risk of errors due to movement of loops or bad contacts.
3. If well situated, is unaffected by other aerials.
4. If well situated, can be used on the higher frequencies.

D/F ERRORS

All systems of D/F are liable to certain errors which can be considered under two headings:-

(a) Errors due to pecularities of the wave being received. These cannot be corrected, but their presence can sometimes be detected by the operator.

(b) Errors due to the gear being fitted in a warship. These may be to a large extent avoided or corrected.

ERRORS DUE TO THE WAVE.

Night Effect. At present (February 1932) Naval D/F gear is capable of indicating accurately the great circle bearing of a transmitting station provided that the wave being received has followed the earth's surface, i.e., provided it is the "direct wave". A wave which has travelled via the upper atmosphere will not be travelling horizontally when it passes the D/F gear, nor will its magnetic field be necessarily horizontal. The result of these facts is that bearings taken with either a rotating frame or Bellini-Tosi apparatus cease to be accurate whenever such a wave-i.e., the "indirect wave"- predominates. This effect may cause an error in the zero or a blurring or both. By day, on medium and low frequencies, the direct wave nearly always predominates sufficiently to remove all risk of this effect, but at night it is liable to occur on any frequency, except at fairly short ranges (about 30 miles). For this reason it is called "Night Effect" and is generally at its worst within an hour either side of sunrise and sunset, when the changes in the state of ionisation of the atmosphere are particularly violent. On high frequencies - except at short ranges - the indirect wave normally constitutes the greater part - if not all - of the signal, and so the effect is experienced by day as well as by night. As it is impossible for any correction to be applied for this error, it is essential that the risk of its presence should be understood. The fact that a very unusual setting of the semi-circular corrector is necessary to obtain a sharp zero, or that it is suddenly impossible to get any satisfactory setting, is an almost CERTAIN indication of the presence of "Night Effect".

Land Effect. If a wave crosses the coast line at an angle of 20° or less, its direction of travel is appreciably altered, and so the bearing obtained of the wave is no longer the bearing of the transmitting station. The effect is particularly pronounced when either station is near the coast, especially if high land intervenes. High land behind a transmitting station may also cause misleading reflections, for instance, bearings taken of ships transmitting in Gibraltar harbour are unreliable.

Convergency Error. As a W/T wave travels along a great circle, it may be necessary to apply a correction before laying off the bearing on a Mercator Chart. Particulars of this correction are given in the "Admiralty List of W/T Signals".

ERRORS DUE TO THE SHIP.

General Considerations. As the hull of a ship is a conductor, a passing wave will induce currents in it. The resulting field together with similar fields from superstructure, funnels, masts, stays, aerials etc., - will affect the D/F gear. The errors thus produced may be resolved into two components.

D/F ERRORS

(a) Quadrantal Error. This is due to the component of the ship field which is in phase with the wave. It produces a definite angular error which is called "Quadrantal" as it is normally zero ahead, astern and on the beams and maximum on the bows and quarters. The effect is always to seem to "pull" the bearing towards the fore and aft line. In Bellini-Tosi sets this error is corrected by reducing the effect of the fore and aft loop in the first place by making it smaller than the beam loop, and in the second place by adding impedance by means of correcting inductances. The determination of these corrections - known as "Balancing the Loops" - is carried out during calibration, and a final "curve of correction" is obtained by trial so that any remaining deviations on particular arcs may be allowed for. In Rotating Frame sets a curve of correction must be found by trial, and the necessary correction applied in each case by the operator, unless a cam corrector is fitted to the pointer to correct it automatically.

(b) Semi-Circular Effect. This is due to the component of the ship field which is 90° out of phase with the wave, and produces a "Rotating Field". This means that wherever the Rotating Frame or Goniometer search coil is placed there will be always some signal heard, i.e., the zero is "blurred". This effect is found to be worst on the beams and nil ahead and astern and is therefore called "Semi-Circular Effect".

It is corrected by introducing a correcting E.M.F. equal and opposite to that which produces it, by means of a "Semi-Circular Corrector", which, when, correctly adjusted, makes the zeros absolutely sharp.

Variation of "Ship Errors" with frequency. With L/F waves, the errors due to the ship do not vary with the frequency. When, however, the frequency increases until it corresponds to a wavelength equal to or shorter than about five times the length of the ship, the error becomes rapidly more pronounced. We therefore find that -

(a) Quadrantal Error is usually constant on frequencies below about 300 kc/s and increases on higher frequencies (the amount being determined during calibration).

(b) Semi-Circular Effect increases similarly with frequency and so the amount of correction necessary will also increase.

With still higher frequencies, the above become not only greater but more complex owing to various conductors approaching resonance at these frequencies. A limiting frequency is therefore reached with every ship installation, above which D/F bearings can no longer be taken, even at short ranges. A frame coil placed above the foretop, where it is above the main aerial and as far as possible from other conductors, is greatly superior to the other D/F outfits on the higher frequencies. The Bellini-Tosi loops cannot easily be so advantageously placed; moreover, trouble is experienced owing to the tendency of one or other loops suddenly to tune at these frequencies, and to the increasing effect of the capacity of the leads from the loops to the goniometer.

ERRORS DUE TO FAULTY GEAR.

Although "Ship Errors" can be corrected as described above, for accuracy to be obtained great care is necessary in the fitting-out, calibration and maintenance of the D/F gear. Otherwise, errors are liable to occur for the following reasons:-

(a) Unequal impedance in the two sides of one or both loops; hence the necessity for checking the insulation and ohmic resistances of the loops and their individual symmetry.

(b) Asymmetrical distribution of conductors near the frame or loops. The initial choice of site is most important; after calibration, any change in the position of neighbouring conductors must be avoided.

(c) Loops not at right angles to and not bisecting each other.

The above are liable to cause error in zero, blurring or both.

(d) Aerials wrongly connected to goniometer (the zero appears in the wrong quadrant).

(e) Pointer error, causing a constant all-round deviation.

(f) Repeater scale on goniometer being out of step with ship's master gyro. The operator should check this frequently and correct it if necessary; he should also know, and report, which of the master gyros is driving his repeater scale.

(g) Goniometer coils not being exactly at right angles to each other. This is the reason for zeros taken with each loop separately not being 90° apart. A new goniometer is required.

(h) Lay-out of instruments in the D/F office.

(i) It is essential that the E.M.F. produced in the amplifier should originate entirely from the search coil (or rotating frame). It follows that, not only must the whole office be effectively screened but there must be no direct induction from the aerial leads-in, owing to insufficient spacing of gear. Either of the above cause signals to be heard whatever the position of search coil (or frame) and so blur the zero.

(ii) Spacing must also be sufficient to prevent any mutual induction between aerial leads-in or between correcting inductances, as this may introduce an error in the zero.

(iii) Mutual induction between the goniometer primary and the tuned circuit would cause zeros to be not exactly 180° apart. With modern screened goniometers this should not occur provided the screen is earthed and the goniometer is at least 18 inches from other instruments.

D/F ERRORS

MAINTENANCE OF ACCURACY AFTER CALIBRATION.

The process of calibration eliminates errors due to faulty gear and determines the necessary corrections for quadrantal error on all frequencies. The following points must, however, continue to receive attention and "check calibrations" should be carried out periodically.-

(a) The pointer must not slip.
(b) The position of the loops must not be altered in the smallest degree. If the beam loop has to be slipped for boat hoisting, it must ALWAYS be correctly replaced.
(c) All switches, terminals, etc., must be kept scrupulously clean, so as to keep ohmic resistances down to their proper value.
(d) Steps should be taken to ascertain whether unavoidable changes such as the elevating and training of guns, movement of davits between sea and harbour positions, change of stowage of paraffin drums, etc., have any appreciable effect.
(e) The main aerial is so close to the D/F gear in most ships that it is almost certain to affect it. As it is insulated in the office just below the deck insulator (in Type 36S by removing the top link) during calibration, it MUST be in the same condition whenever bearings are taken. A receiving aerial tuned to the same frequency as the D/F set may also cause an error. A rotating frame coil fitted above the main aerial is generally free from these limitations in which case aerials need not be insulated.

RECEIVER OUTFIT S A

Date of design:- 1918.
Frequency range:- 60 - 667 kc/s.
Components:- S1, M9, Board F, M3B, S25, 8000 mic inductance, N9, K5.

Receiver Outfit SA is used in certain cases for D/F reception but its primary use is for other reception.

The aerial system consists of four frame coils (5)(6)(7)(8) S1 built into the bridge structure of the vessel and fitted at right angles to each other. They may be fore and aft and athwartships, in which case the fore and aft coils form one pair and the athwartship coils form a second pair; or they may be at 45° to the centre line, in which case the starboard forward and port after coils form one pair, and the port forward and starboard after coils the other pair. The coils of each pair are connected in parallel. For D/F reception both pairs must be used, but for other reception it is generally better to use one pair only. The direction of the transmitting station determines which pair should be used.

The leads from each pair of frame coils (5)(6) and (7)(8) are taken through copper tubes for screening purposes to change over switches (120)(121) each marked "S.A." and "D.F."

D/F Reception. From the "D.F." side of the switches (120)(121) leads go to a radiogoniometer S25 (see page LB2). The search coil (21) of the S25, an 8000 mic inductance (117) and three condensers in parallel, a number 7 (113), a number 13 (114) and a number 39 (115), form the tuned circuit whence the output is taken through a C.O.S. (109) to Amplifier M9. The reaction coil (116) of the M9 is coupled to the 8000 mic inductance (117).

From M9 the leads pass through:- two C.O.S. (105)(104), note magnifier N9, telephone condenser (101) and transformer (102) to the telephones.

C.O.S's (110)(109) are provided to enable amplifier M9 to be used instead of M3B with the normal receiving set, and C.O.S. (105) so that the output from M9 can be taken to telephones thus cutting out N9 and leaving it for use on the ship's normal reception line (see figure a.) when C.O.S. (104) is changed over.

Other Reception. For other reception the radiogoniometer is disconnected when the C.O.S.'s (120)(121)(118) are put to "S.A." and the frame coils connected to the 8000 mic inductance (117). The tuned circuit now consists of the frame coils (5)(6)(7)(8), the 8000 mic inductance (117) and the three condensers (113)(114)(115).

Calibration. No satisfactory calibration has been carried out with Receiver Outfit SA, and the set is no longer considered as suitable for D/F except to give very approximate bearings.

RECEIVER OUTFIT S A

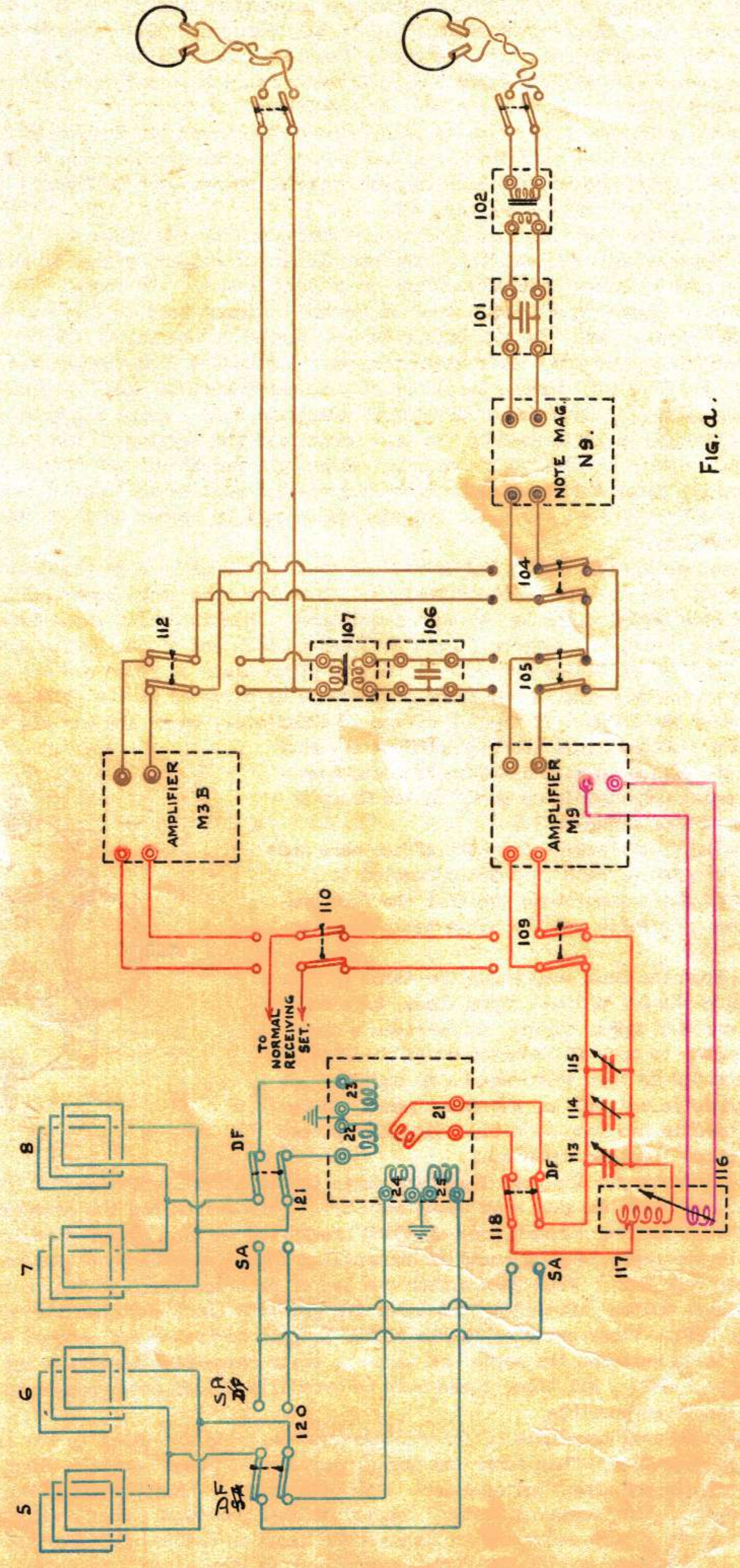

Fig. a.

D/F OUTFIT SD.

Date of design - 1920
Frequency range - 60 - 670 kc/s
Components - A41, M9, N9, S25, S41, K5

D/F Outfit SD employs the Bellini-Tosi system of direction finding and is fitted in most heavyships and cruisers (See Admiralty Handbook of W/T (1931, paragraph 792) Two vertical single wire loop aerials (1)(2) about 20 feet high are used. One loop (1) is fitted in the fore and aft line and is usually rectangular and the other (2) is fitted athwartships and is usually triangular. The loops are rigged at right angles to and bisecting each other.

In two funnel ships the D/F office is usually on deck between the funnels with the two loop aerials rigged directly above it. This is a good position since symmetry can be obtained both with regard to the aerials themselves and with respect to metal masses such as funnels, guns etc., (see Admiralty Handbook of W/T (1931) paragraph 806).

In one funnel ships there are two alternative positions for the loops -

(a) If the fore superstructure is suitable, the aerials can be rigged between it and the funnel, the D/F office being either in the auxiliary office or on deck beneath the loops.

(b) The loops may be rigged from a small spur on the main topmast head to fore and aft and athwartship yards on the main top. The D/F office is then placed in one bay of the C.R.R. This method suffers particularly from the disadvantage that very long leads from the aerials to the D/F office are necessary and they will have a large capacity to earth even if paper insulated cable is used (see page Z3 and Admiralty Handbook of W/T (1931) paragraph 813). Loops rigged around the mainmast are also particularly influenced by the main aerial and the rigging of the mast.

With aerials fitted between the funnels or between the funnel and the fore superstructure the beam loop is usually suspended from the triatic stay which should be at least 15 feet below the main aerial and if possible 30 feet above the funnels, and should be broken up in 60 foot lengths or less with rigging insulators.

The fore and aft aerial (1) is rigged between the funnels or between the funnel and the fore superstructure and must be kept absolutely rigid. To enable this to be done, bottle screws should be fitted in this aerial close to the deck insulators. When inserting these bottle screws the aerial lead must not be broken but must be firmly attached to each end of the bottle screw.

The beam loop (2) is hauled out on each beam to stump masts or booms and the ends of the aerial are taken in to the deck insulators which must always be situated at the point of intersection of the bases of the loops. If the D/F office is immediately under the aerials they are taken through Pattern 1719 deck insulators mounted on the roof of the office. If the office is at a distance from the base of the aerials a special deck insulator group called Group N deck insulator is used (see figure b).

In connecting up the cables from the office care must be taken that the two cores of each twin are connected to opposite and not to adjacent insulators, so that the fore and aft loop will use one twin cable and the athwartship loop the other.

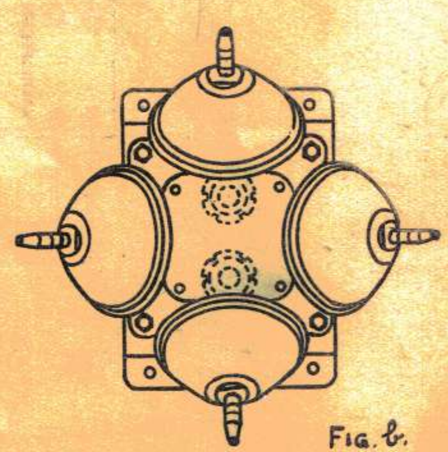

Fig. b.

The leads from the deck insulators are taken to four terminal blocks inside the D/F office. From these, bare copper leads are run over earthed copper strips, to maintain a constant capacity to earth, to four L3 inductances (125)(126)(127)(128) these being mounted so that there can be no coupling between the inductances in the legs of the same loop. Since inductance is only used in one loop at a time coupling between inductances in different loops is immaterial.

From these inductances the four leads are taken to the aerial safety switch (601) which is provided for earthing the loop aerials when using main W/T. This switch has two external contacts which are in the 20 volt warning circuit, one of which breaks the warning buzzer circuit, the other making the circuit to the reply lamp on board 2G controlling in the central receiving room when aerials are earthed (see page R42). From this switch one leg of each loop goes to the centre of a 2-pole, 2-way, change-over switch (123)(124), the other leg going to these switches through a buzzer tester G21 (see page GB2). These switches enable either loop to be broken and earthed separately when testing. From these switches the leads are taken to their respective terminals and the radiogoniometer S25 (see page LB2). All these leads must be carefully spaced and arranged to have them as nearly the same length as possible.

From the search coil terminals of the radiogoniometer leads are taken to the input terminals of tuner A41 (see page BB3). This tuner has three positions. Direct position which is used when searching for signals and when finding sense. Coupled position - this is used when the required signal is picked up to give selectivity. Coupled untuned position - when receiving very strong signals the quality of the zeros may be improved by using an untuned intermediate circuit this being obtained by short-circuiting the tuning condensers in this circuit by means of the intermediate condenser switch (50). Reaction is obtained from the amplifier M9.

D/F OUTFIT S D.

The outer terminals of tuner A41 are connected to grid and filament terminals of amplifier M9 (see page H13) and from this amplifier the output is taken through note magnifier N9(see page I3), telephone condenser and transformer to the telephones. When receiving C.W. signals amplifier M9 is generally used as an autodyne receiver to reduce the number of adjustments necessary, but for greater selectivity the heterodyne unit K5 which is fitted should be used as a separate heterodyne.

Sensefinder S41 is used (see page LC2) the centre point of each field coil of the radiogoniometer being connected to the sensefinder terminal marked "to mid point of goniometer" and a No. 1 inductance (38) is connected between terminals marked "to tuner" This inductance is used for detuning the aerials to ensure capacitive reactance when finding sense (see Admiralty Handbook of W/T (1931) paragraph 802). The terminals of the sensefinder marked "to amplifier" are connected to the input terminals of amplifier M9.

Semicircular Corrector S61(see page LD2) is sometimes fitted, particularly in ships where there are long leads between the aerials and the D/F office when the zeros will specially need sharpening. It is connected between the search coil (21) and tuner A41.

when using sensefinder tuner must be in the direct position

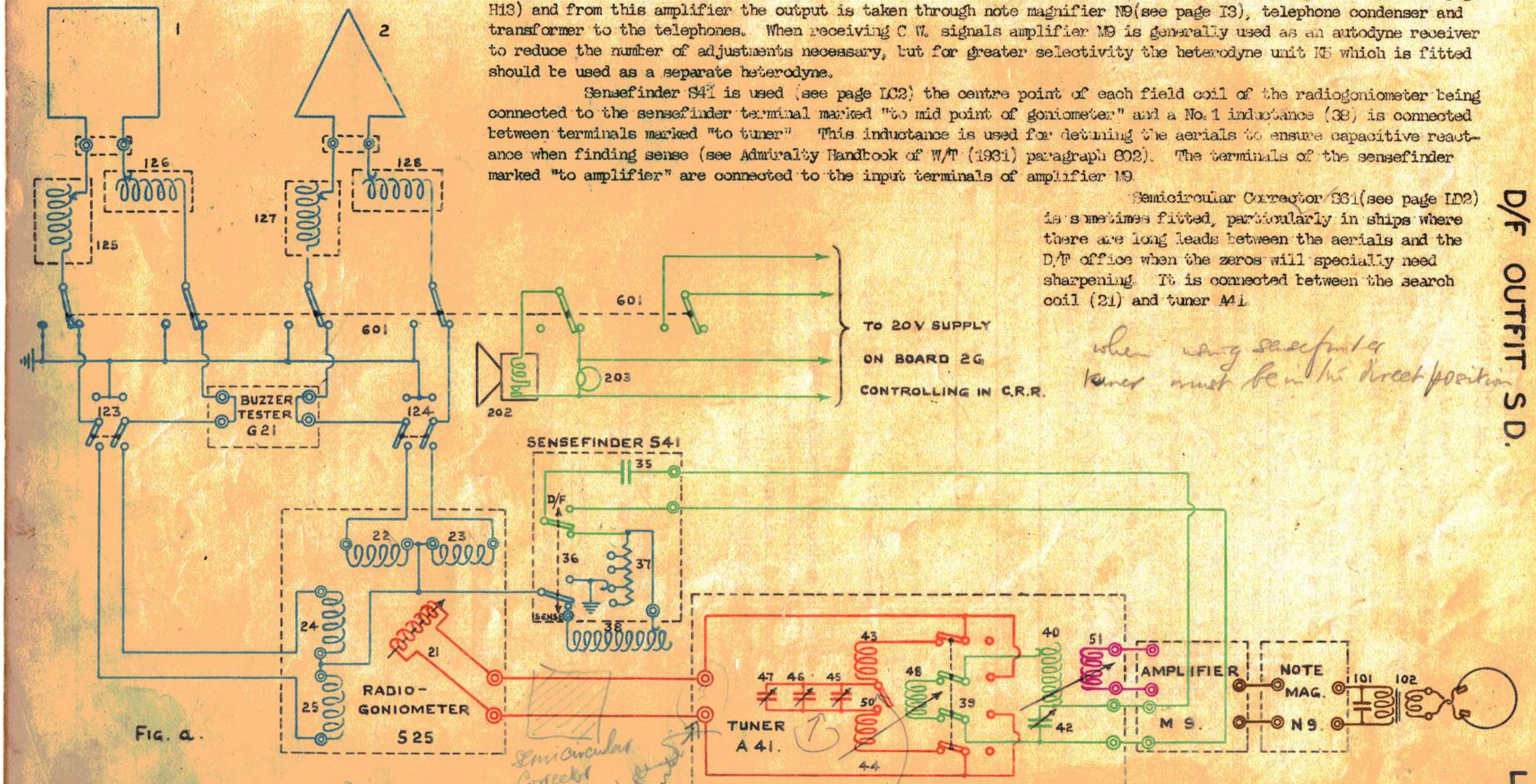

FIG. a.

D/F OUTFIT S D.
CALIBRATION

Reference.- Admiralty Handbook of W/T (1931) paragraph 811.

Calibration of D/F sets is necessary owing to a variety of errors which effect the bearing obtained. These calibrations may be divided into four parts:-

Tests to be carried out by ship's staff in harbour.
Balancing of Aerials.
Swing for curve of correction.
Determination of effect of change of frequency.

TESTS TO BE CARRIED OUT IN HARBOUR BY SHIP'S STAFF.

When calibration is being carried out by Signal School Officers, the ship is first supplied with Form 153 (see page LA11 and 12). This form gives details of tests, errors and remedies, and contains a column in which the result of each test is inserted by the Ship's Staff. Forms Nos. 150 and 151 (see figures c. and d.) are supplied at the same time giving the programme and instructions for the rest of the calibration. The completed form should be returned to Signal School one week before the calibration is to take place. If a calibration is being carried out by a W/T officer from the Fleet, the preliminary tests should be carried out in accordance with pages LA11 and 12 and the results tabulated for his information.

The remaining portions of the calibration are carried out with the ship at sea and under way, and a W/T officer from the Fleet or from Signal School is in charge.

PROPOSED PROGRAMME FOR CALIBRATION OF D/F OUTFIT SD IN

H.M.S. ____________

Position of Ship.

Ship to be approximately 5 miles off, and in sight of ....
W/T Station by ....

This distance should be maintained throughout the calibration. It may be reduced slightly if visibility is poor but a satisfactory calibration cannot be carried out if the distance is less than 3 miles. Intervening land should be reduced to a minimum.

Note. Satisfactory calibrations cannot be carried out within half an hour of sunrise or sunset.

Part I. Balancing Aerials.

Ship to be stopped, with station bearing Red (or Green) 45. This bearing to be held within 3 degrees on either side if possible. Time required:- about 1 hour.

Part II. Swing for Curve of Correction.

Ship to be turned slowly through 360° at about 6° per minute.
Time required:- about 1¼ hours.

Part III. Correction for Change of Wave Frequency.

Conditions as for Part I, preferably with the station on the same bow as in Part I. Time required:- about 1½ hours.

Bearings.

Throughout Parts I, II and III relative visual bearings of the station will be required. "Stand by —— stop" will be passed to the Bridge for each bearing, and the bearings should then be passed to the D/F office as soon as possible.

An interval of ½-hour is required between Parts I and II and Parts II and III.

Total time required for calibration, about 4 hours.

....

H.M. Signal School,
R.N. Barracks,
Portsmouth.

Form No. 151.

Fig. c.

D/F OUTFIT S D.
CALIBRATION.

INSTRUCTIONS FOR D/F CALIBRATION OF H. M. SHIPS.

Ship being calibrated.

It is essential that reliable and rapid communication should be maintained with W/T transmitting station. If possible, remote control of the second office transmitter should be arranged for in the D/F office.

This transmitter should remain on 170 kc/s or as ordered in (e) of the calibration signal. See Portsmouth General Orders article 549, and Plymouth Port Orders article 1068.

Communication between compass platform and D/F office, whether by telephone or voicepipe should be as direct as possible in order to reduce the "time lag" to a minimum. If necessary flexible voicepipe should be run to eliminate human links.

W/T Transmitting Station

In Parts I and III the transmission should be of 2 minutes duration and in Part II of 10 minutes duration. In each case there should be an interval of 30 seconds between transmissions to enable the ship being calibrated to establish communication if necessary.

H. M. Signal School,
R. N. Barracks, Portsmouth.

Form No. 150.

Fig. d.

PART I. BALANCING THE AERIALS.

The ship is turned so that the Transmitting Station is on a relative bearing 45°(bow or quarter) to balance the aerials.

The Transmitting Station transmits on a pre-arranged wave frequency and relative bearings are taken simultaneously by D/F and compass. If quadrantal error exists, it is then eliminated by adjusting the size of the fore and aft loop. The beam loop will have been rigged as large as possible, and it will normally be found that, when the error has been eliminated, the fore and aft loop will be considerably the smaller. If the error cannot be entirely eliminated by this method a small final adjustment can be made by inserting a small (and equal) amount of correcting inductance in each leg of one aerial.

PART II. SWING FOR CURVE OF CORRECTION.

When the aerials are balanced the ship is swung to obtain a curve of correction in a similar manner to a swing for adjustment of compasses. The ship should be steadied every few degrees (intervals should not exceed 10°) and simultaneous relative bearings by compass and D/F are taken. If time does not permit of this being done a slow swing should be carried out through 360° at a rate not exceeding 5° per minute. If possible the ship should be swung through 360° but if time does not permit of this being done a swing of 180° should be carried out. Errors of synchronisation between bridge and D/F office can be avoided if the gyro compass and repeater scale on the goniometer are used. Gyro bearings of the transmitting station are passed down from the bridge, and the officer in the D/F office notes the ship's head by gyro scale at the instant of taking each D/F bearing. Great care must be taken that gyro compass and repeater scales are correctly lined up.

From the two sets of relative bearings obtained a curve of errors can be plotted showing the correction necessary on any bearing (see figure e.).

PART III. CORRECTION FOR CHANGE OF WAVE FREQUENCY.

It is now necessary to determine the effects of various wave frequencies on D/F bearings. The ship is again turned so that the transmitting station bears on the bow (or quarter). Bearings are now taken on various frequencies, quadrantal error being eliminated by the insertion of more or less correcting inductance in the legs of one aerial. If part I was done on, say 170 kc/s, it should first be confirmed that the quadrantal error is the same on any lower frequency; higher frequencies are then tried and it will usually be found that, at some point round about 200-300 kc/s, the error increases. It will then be found necessary, gradually, to cut inductance out of the legs of the beam aerial, and, when this is all cut out, to add inductance in the legs of the fore and aft aerial. From these results a curve will be constructed showing the amount of L3 inductance necessary for any given frequency (see figure f.).

The sense arrow has now to be set. Bearings are taken and both zeros obtained. The sensefinder is then switched over to the sense position, and if using sensefinder S41 the tuning is adjusted so that the reactance of the aerial circuit shall be capacitive. (See page LC2). The search coil is then moved until the maximum position is found (half way between the two zeros). It is known which of the two zeros gives the actual direction of the transmitting station, and so the sense arrow on the goniometer handle can then be set to point in the direction of that zero. (See page LB2).

LA10 *Must have:- 1. Reactance of aerial circuit capacitive 2. A41 in direct position*

D/F OUTFIT SD.

CALIBRATION

This is done with the aerial de-tuned as described above. If too much inductance is inserted in the aerial circuit the aerial reactance will become inductive. This will change the phase of the antenna effect 180° relative to the loop effect and will thus cause a reversal of sense. It is therefore necessary on all occasions to de-tune with the No. 1 inductance so that the aerial impedance is capacitive. When finding sense, tuner A41 must be in the direct position to ensure correct phasing (see Admiralty Handbook of W/T (1931) paragraph 802).

During calibration it is customary to insulate the main aerial. Other conditions which affect the accuracy of D/F bearings after calibration are:-

Alterations in the loop aerials.

Alterations in the positions of instruments or wiring inside the office.

Positions of large moving masses of metal in the neighbourhood of the aerials, differing from their positions during calibration.

Although the calibration is carried out with the main aerial insulated it is advisable to take bearings with the main aerial connected when possible and to note the errors caused since it will not always be possible to insulate the main aerial before taking bearings in actual practice.

<u>Waves.</u> The balancing of aerials and swing should be carried out using the Reconnaissance wave of the fleet to which the particular ship is attached if possible.

When obtaining corrections for change of frequency the corrections necessary for the main waves in use in the fleet should be obtained and in addition, those for any other frequencies considered desirable.

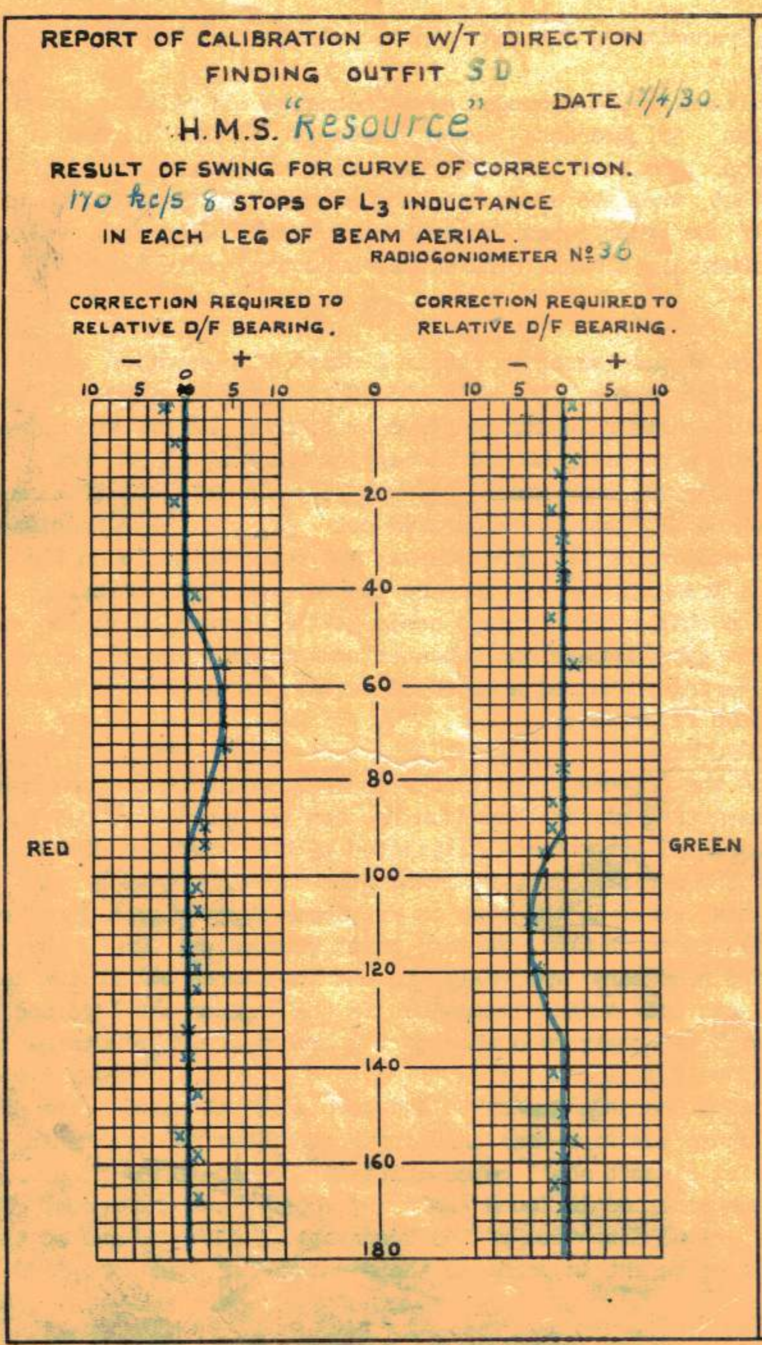

Fig. e.

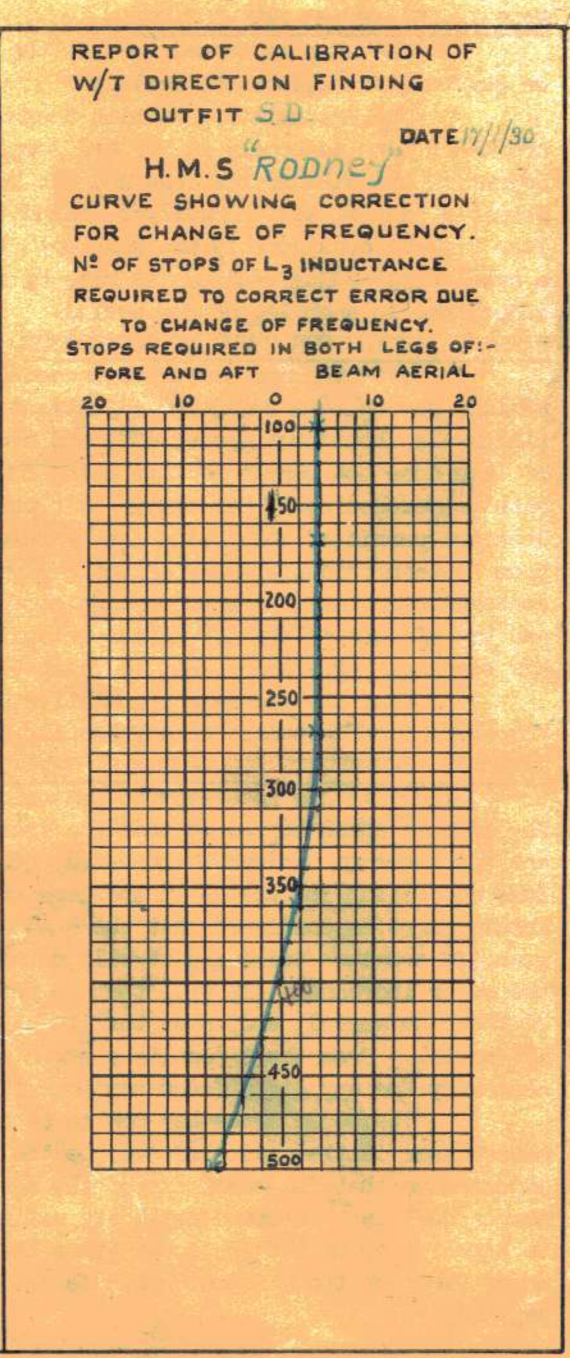

Fig. f

D/F OUTFIT SD

TESTS TO BE CARRIED OUT BY SHIP'S STAFF BEFORE D/F CALIBRATION

No.	Test.	Fault.	Cause.	Remedy.	Result of Test and Remarks.
1	Examine aerials and plan of ship to see that each aerial lies in a vertical plane, and that the two planes are strictly perpendicular	Planes not perpendicular	Booms, deck insulators, or point of attachment to triatic stay misplaced.	Correct, as far as possible and draw attention to what cannot be rectified.	
2	Test insulation resistance of each aerial to earth with a megger.	Insulation resistance less than 1-megohm.	Probably deck insulators	Wipe surfaces with cloth. If possible, wash with distilled water and leave to dry.	
3	Test insulation resistance between any point in one aerial and a point in the other. (Remove earths from goniometer).	Resistance less than 1-megohm	Leakage across switches or surface of goniometer.	Wash surfaces with very diluted ammonia followed by distilled water.	
4	Test insulation of amplifier and batteries to earth with filament disconnected.	Resistance less than 1-megohm.	Acid on battery supports.	Wipe clean all insulators, supports etc.	
5	Examine aerial rig, funnel guys, blocks, halyards, etc to see that they comply strictly with the specification	Items not in accordance with specification	Faulty installation.	Correct as far as possible, and call attention to points that cannot be rectified.	
6	Measure the ohmic* resistance of each aerial circuit, with switches and L3 inductances in the circuit	High resistance (More than 5 ohms) in ships fitted with P.I. cable and between deck offices. More than 2 ohms in ships fitted with Pattern 6895 cable and between deck offices. More than 1 ohm in ships fitted with upper deck offices)	Broken wire, or imperfect contacts in the circuit.	Examine all contacts, switches and connections, repairing or renewing where necessary.	
7.	Measure the ohmic * resistance of the windings of the goniometer and of the search coil	High resistance (greater than following figures.) S23 and 25, 20 mic. Pattern 6764 or 7450 "Beam" Field Coil 0.2 ohms "Fore & Aft" Coil 0.2 ohms. Search Coil 1.0 ohm	Break or imperfect contact in the circuit.	Examine all contacts, soldered connections, etc., and repair as necessary. N.B. Great care must be taken not to disturb or damage the fixed windings of the field coils in any way.	
8.	Measure resistances in the eliminator reciprocal bearing between terminal marked "To mid point of gonio" and earth. (a) In D/F position (b) In sense position	High resistance i.e., more than the following. (a) 0.1 ohm. (b) 30 ohms Stop 0 100 " " 1 200 " " 2 400 " " 3	Break in resistance or bad contact at switch.	Examine all contacts, soldered connections, etc. and repair as necessary.	
9.	Test amplifier and note magnifier stage by stage for satisfactory magnification. Rotate goniometer search coil while receiving signals.	Poor or noisy reception Noisy reception during movement of search coil	Defect in instrument, or batteries in bad conditions. Imperfect contact at search coil brush contacts.	Examine batteries for voltage and for acid density. Test instrument for broken winding of transformers, etc., Wipe plate of rubbing contact clean and smear lightly with pure vaseline oil.	

Fig. g.

D/F OUTFIT SD.

TESTS TO BE CARRIED OUT BY SHIP'S STAFF BEFORE D/F CALIBRATION (CONT.).

No	Test	Fault	Cause	Remedy	Result of Test and Remarks
10	Break both aerial circuits at the switches and try to receive signals on amplifier and tuned circuit alone	Signals heard	Imperfect screening of tuner, and amplifier, or direct radiation inside the office from aerial leads.	Increase distance between aerial wires and tuner. Run leads as non-inductively as possible, or use braided cable where little space is available	
11	Test heterodyne unit for C.W. and I.C.W. on each range.	Cannot be heard or tuned properly on amplifier and tuner.	Bad valve contact, or defective Coil, Coupling too tight.	Try new valve, and a coil from another heterodyne unit. Increase distance between heterodyne unit and amplifier.	
12	Trace leads from aerials to goniometer	Leads wrongly connected at goniometer terminals. (Zeros in wrong quadrant.)	Faulty installation.	Rewire to accord with markings on goniometer.	
13	Break beam aerial circuit and receive any strong signal on F. and A. aerial Set pointer so that one zero is at 0°.	Opposite zero not at 180°.	Direct coupling between goniometer and tuner or amplifier.	Rearrange leads and instruments, keeping goniometer as far from all other instruments as possible.	
14	Break F. and A. aerial circuit and receive any strong signal on beam aerial.	Zeros 180° apart but not at 90° and 270°	Primary windings of goniometer not perpendicular.	New goniometer.	
15	Take an approximate bearing of Daventry. (Lat. 52° 15' N. Long. 1° 08' W.) N.B. Daventry bears 359½° from Portsmouth, 309° from Chatham and 045° from Devonport.	Bearing greatly in error, or in wrong quadrant.	(a) Wrong value of ship's head (b) Defect in the connections of the aerials (c) Defect in goniometer windings.	(a) Check ship's head (b) Examine connections and repeat tests 6 and 12. (c) Repeat test 7 and compare connections with diagram in lid of goniometer.	
16.	Test gyro repeater motor by causing master gyro to be turned slowly through 360° first clock-wise and then anti-clockwise.	Lost motion between master and repeater, i.e. failure to keep in step.	Gears meshed too tightly Imperfect transmission from the master gyro.	Set gears so as to give a slight play (1/4°) to the rotating scale. Report other defects to department in charge of gyros.	

Form No. 153

*Tests Nos 2, 3, 4, 6, 13 and 14 should be carried out weekly, before going to sea, and before carrying out a D/F Exercise.

NOTE:- * When measuring ohmic resistance in tests 6 and 7 above with an insulation test set and bridge the resistance of the leads joining the test set and the circuit under test should be measured. This resistance should be deducted from the total resistance of the circuit as measured.

Fig. 9.

RECEIVER OUTFIT SF.

Date of design.-	1928.
Frequency range:-	60 - 670 kc/s. (D/F reception).
	15 - 170 kc/s. (Other reception).
Components:-	S4, S5, A7, A8, A42, M9, M13, N9, K5.

Receiver outfit SF is used for D/F reception on frequencies 60 - 670 kc/s using a vertical frame coil S4 (3), and for other reception on frequencies 15 - 170 kc/s using the vertical loop aerial (253) or horizontal frame coil S5 (4).

Aerials. Frame coils S4 and S5 are mounted together in wooden casings, S5 being above S4, on a hollow vertical tube (see page F3 figure b.). Raising and lowering by hydraulic power and training, by rod gearing, are controlled from the W/T office. Care should be taken not to lower the frame coil unless the vertical frame coil is in a fore and aft position or this coil will foul the casting which is specially recessed to hold it in the lowered position. A stop is fitted on the casing of the frame coil S4 to prevent the coils being turned too far in one direction which would twist the leads in the frame coils. These coils consist of 8 turns(S4) and 10 turns(S5), approximately, of rubber covered cable, the leads from which pass down the centre of the tube on which the frame coils are mounted and thence to watertight junction boxes. Screening between the leads is effected by the use of phosphor-bronze sheathing between the bottom of the tube and the junction boxes. From the junction boxes twin lead-cased cables are run to the W/T office. The vertical loop aerial consists of a loop of rubber covered cable and is arranged to be as large as possible between the bridge and the jack staff. The ends of the loop are connected to two contacts of the loop aerial safety switch (173)(see figure a.), a third contact of this switch, which is operated from board 2R controlling, closes the circuit to the main relay when the loop aerial is broken, ensuring the safety of the receiving gear.

The aerials and various instruments of the outfit are connected as shown in figure a. The reaction and input terminals of amplifier M9 can be connected by change-over switches(139)(140) to either of the tuners A7 or A42. Similarly, the input terminals of N9 can be connected to the output terminals of either of the amplifiers M9 or M13 via change over switch (138). Heterodyne unit K5 is provided and is used as a separate heterodyne for the reception of C.W. signals on all occasions, except D/F reception when amplifier M9 may be used as an autodyne receiver. For taking accurate bearings, however, the K5 should be used as a separate heterodyne. In this case also, the output from K5 can be connected to the heterodyne terminals on either of the amplifiers M9 or M13 via the quadrantal coupling coil (132) and a change-over switch (133).

D/F reception of 60 - 670 kc/s is carried out using vertical frame coil S4, A42, M9, N9 and K5. Range is limited by the smallness of the frame coil but bearings of ordinary commercial coast stations at 50 miles and of high power shore stations at 100 to 250 miles should not be more than 2°in error subject to the usual conditions (see page LA2). The bearing indicator may be either on the bulkhead or carried on the training handle itself, the pointer being mechanically driven (see page F2). The indicator consists of two scales, the inner, graduated from 0 - 180° Red and Green, being fixed, the outer graduated from 0 - 360°, being rotatable, driven from the master gyro compass, and a pointer fitted with angle dividing device similar to that fitted in radiogoniometer S25 (see page LB2).

Other reception. Signals can also be received either on 60 - 170 kc/s using horizontal frame coil S5 (4), A7, M9 and K5 or on 15 - 60 kc/s using the vertical loop (253), A8, M13 and K5.

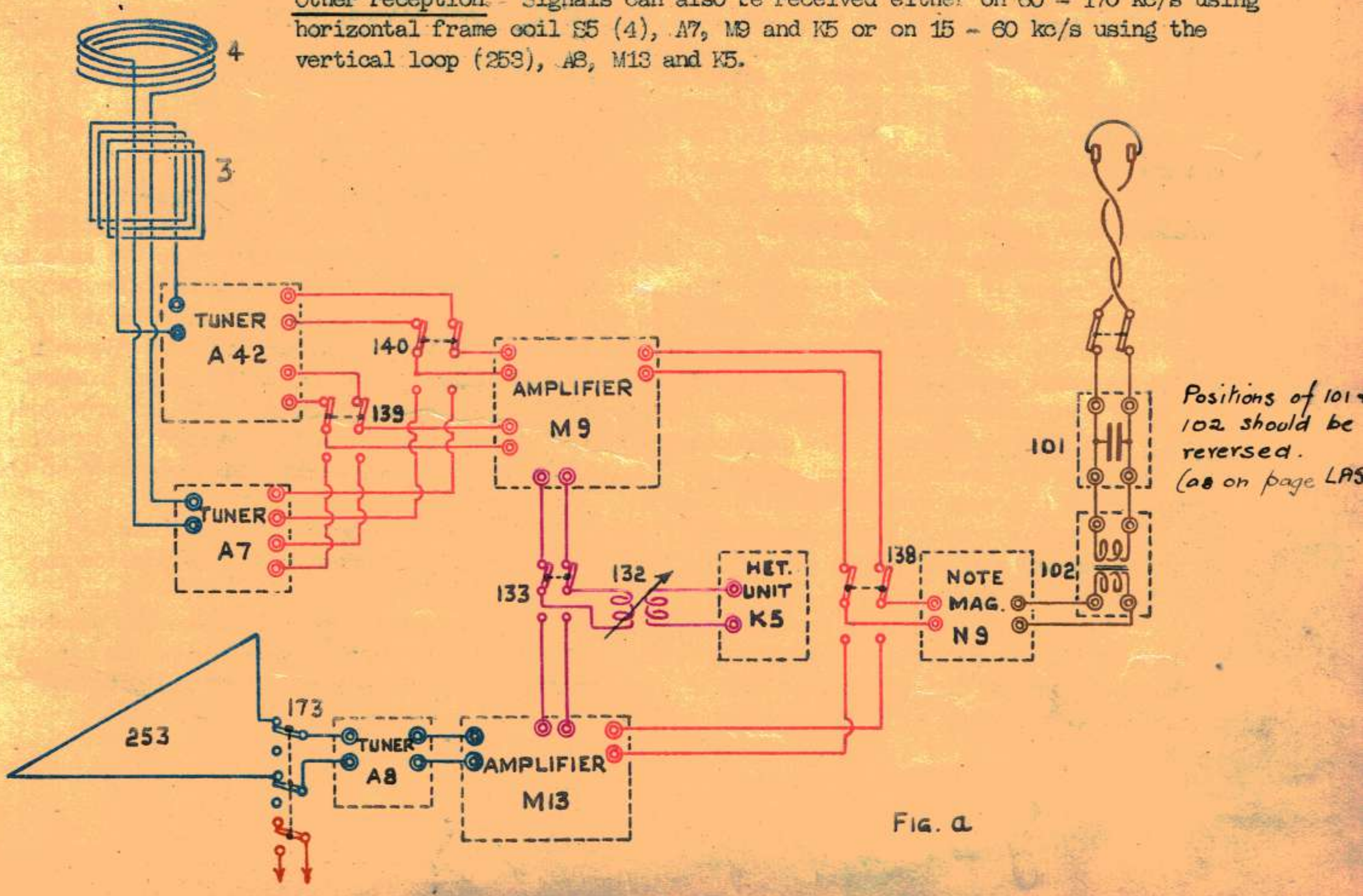

FIG. a

RECEIVER OUTFIT SF

CALIBRATION

The calibration of receiver outfit SF is almost exactly similar to that of D/F outfit SGX (see page LA16) and in consequence will not be given here. The few minor differences are:-

(a) It will usually be necessary to insulate the main aerial to obtain satisfactory results with this set.

(b) As a revolving drum scale is not fitted to training unit F21 Part I of the calibration will consist only of adjusting the pointer.

(c) In Part I of the calibration, when the pointer has been adjusted, the vertical frame coil should be trained fore and aft and the handwheel in the office locked. The reading of the pointer should then be noted and should be within about 1° of 90° Green or Red. On future occasions this reading will afford the operator a quick check on the adjustment of the pointer.

(d) A cam corrector is not fitted on the training unit F21 (see page F2) which is used for this set, and consequently the amount of correction for quadrantal error given by the curves of correction must always be applied to the bearing.

(e) In the earlier models sensefinding is not possible. The later outfits are however fitted with the sensefinder S42 and semi-circular corrector S61 in which case the main aerial is used with them.

D/F OUTFIT SGX

Date of design:- 1930.
Frequency range:- 60 kc/s and above.
Components:- A43, A44, E26X, M5, M9, N9, S42, S61, K5, F23.

D/F Outfit SGX uses a rotating frame coil S8 (see page F4) which is mounted in a clear position aloft preferably above all other aerials and metal work. It takes the place of D/F outfit SD where the Bellini Tosi aerials cannot conveniently be used. The coil is about 4 feet in diameter and is rotated, from the D/F office not more than 20 feet below the coil, by means of a handwheel so geared that eight revolutions of the wheel give one revolution of the coil. Due to the use of a screened frame coil bearings can be obtained on frequencies of a much higher order than with SD.

Figure a. shows the R/F circuits and lay out of SGX. From this it will be seen that the frame coil S8 (3) can be connected via a 2-pole 4-way distributing switch (144) to the following combinationsof receiving gear:-

For 60 to 670 kc/s	- A43 - M9 - N9
" 670 to 1200 kc/s	- A44 - M5 - N9
Above 1500 kc/s	- F26 - M9 - N9

In some SGX sets the combination of A44 and M5 is not fitted, in which case the switch (144) is 2-pole 2-way.

The connection between the amplifier in use and the N9 is made via a single, 4-way selector switch (141).

For receiving C.W. (except in the case of M5, which is used as an autodyne for C.W.) a separate heterodyne K5 should always be used when taking accurate bearings.

Sense can only be obtained below 670 kc/s and the sensefinder S42 (see page LC3) is therefore used in conjunction with Tuner A43. It is connected to a non-directional aerial (10).

Semi-circular corrector S61 (see page LD2) can be used on frequencies below 670 kc/s to sharpen the zeros if they are blurred. This corrector uses the same aerial as sensefinder S42. The switch (7) on S42 puts the aerial either to S61 (Corr) or S42 (Sense) or disconnects it altogether (D/F). In older models of S42 this switch has only two positions "D/F" and "Sense". In this case the non-directional aerial (10) is connected either to S42 or to S61 by an independent single pole change over switch. In either case an aerial earthing switch (150) is provided.

Aerial Earthing Arrangements. The connections from the frame coil (3) and sense-finding aerial (10) are taken via an aerial earthing switch (601). Two poles of this switch are connected to the 20 volt warning circuit from the main W/T office. (See page F42).

When the aerials are connected to D/F outfit SGX, the loud sounding buzzer can be operated from the main office to warn the D/F operator to earth his aerials as transmission on power is about to take place.

When the D/F operator moves the earthing switch (601) over, one pole makes the connection to a 20 volt reply lamp in the main office. At the same time another pole breaks the circuit to the loud sounding buzzer, but not to the indicating lamp, which remains alight while transmission is taking place on power.

D/F OUTFIT SGX.

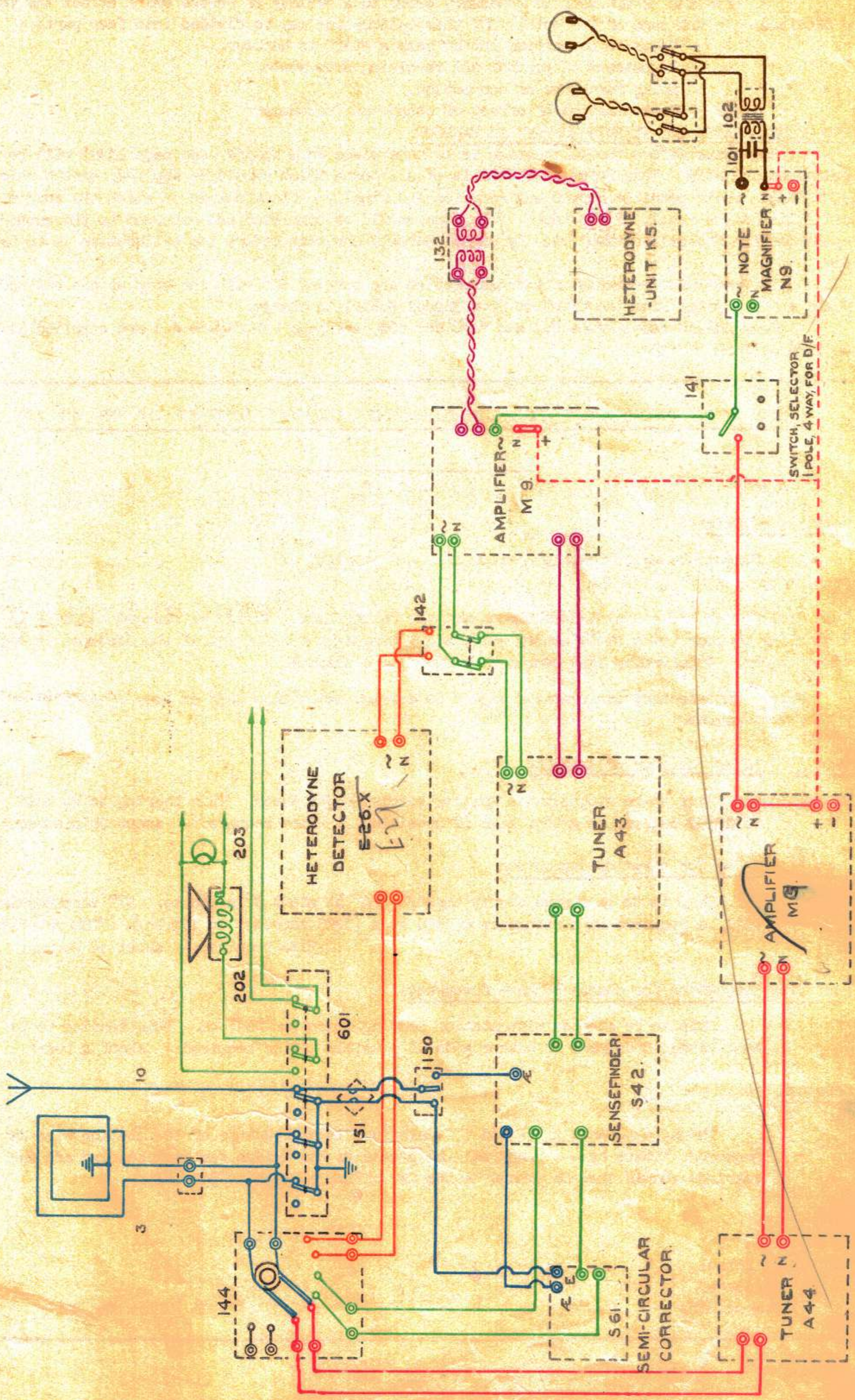

Fig. 2.

D/F OUTFIT SGX

CALIBRATION

Components in use:- A43, M9, N9, S42, S31.

Calibration of D/F sets is necessary owing to a variety of errors which affect the bearing obtained. In the case of D/F outfit SGX this calibration may be divided into four parts:-

Tests to be carried out by ship's staff in harbour.
Adjustment of pointer and revolving drum scale.
Swing for curve of correction.
Determination of effect of change of frequency.

TESTS TO BE CARRIED OUT BY SHIP'S STAFF IN HARBOUR.

Some time before the calibration is to take place Form No. 154 (see page LA18) will be supplied to the ship. This form gives details of all tests which should be applied, errors which may be found, their possible causes and remedies and finally a blank column in which the ship's staff fills in the result of the test. The form should be completed and returned to the authority responsible for the calibration (usually Signal School) one week before the calibration is to take place.

The remaining portions of the calibration are carried out with the ship at sea and under way and a W/T Officer from the fleet or from Signal School in charge.

Form No. 152 (see figure t.) and Form No. 150 (see page LA9 figure d.) are supplied at the same time as Form No. 154.

PROPOSED PROGRAMME FOR CALIBRATION OF D/F OUTFIT SF OR SG IN

H.M.S. ______

Position of Ship.

Ship to be approximately 5 miles off, and in sight of .... W/T Station by ....

This distance should be maintained throughout the calibration. It may be reduced slightly if visibility is poor but a satisfactory calibration cannot be carried out if the distance is less than 3 miles. Intervening land should be reduced to a minimum.

Note Satisfactory calibrations cannot be carried out within half an hour of sunrise or sunset.

Part I. Adjust pointer of training unit.

Ship to be stopped with station bearing right ahead. This bearing to be held within 3 degrees on either side if possible. Time required:- about 30 minutes.

Part II. Swing for curve of correction.

Ship is to be turned slowly through 360° at about 5° a minute. W/T transmissions will be required on a frequency of 170 kc/s (1765 metres), or 111 kc/s (2703 metres). Time required:- about 1½ hours.

Part III. Correction for change of wave frequency.

Ship to be stopped with station bearing Green (or Red) 45. This bearing to be held within 3 degrees on either side if possible. Time required:- about 1 hour.

Bearings.

Throughout Parts I, II and III relative visual bearings of the station will be required, "Stand by --- stop" will be passed to the Bridge for each bearing and the bearings should then be passed to the D/F office as soon as possible.

....

H.M. Signal School,
R.N. Barracks,
Portsmouth.

Form No. 152.

Fig. t.

D/F OUTFIT SGX

CALIBRATION

PART I. ADJUST POINTER OF TRAINING UNIT.

This part is carried out on a frequency of about 200 kc/s. The frequencies to which the main and other aerials in the ship are tuned are immaterial in so far as the frame coil is concerned but it has been found that the open aerial used with the semi-circular corrector may be affected by main aerial if the latter is tuned to a frequency which is near to that on which D/F bearings are being taken. The main aerial should therefore in these circumstances be isolated if possible, in order to ensure the correct functioning of the semi-circular corrector. The tuning of the other aerials in the ship is immaterial.

The ship is turned so that the transmitting station bears right ahead.

The cam corrector is set at 0° and the sensefinder to "D/F".

The transmitting station then transmits on the pre arranged frequency (about 200 kc/s) and the frame coil is revolved until the position of minimum signals is reached, which should be when the frame coil is athwartships. The pointer is now adjusted so that it reads 0°. (For method of adjusting the pointer see page F4)

The semi-circular corrector can be used for improving the zero but should not be necessary. The revolving drum scale is adjusted (see page F4) to read the same as the pointer.

PART II. SWING FOR CURVE OF CORRECTION.

With the cam corrector set at 0°, the ship is swung to obtain a curve of correction in a similar manner to a swing for adjustment of compasses. The ship should be steadied every few degrees (intervals not to exceed 10°) and simultaneous relative bearings by compass and D/F are taken. If time does not permit of this being done, a slow swing should be carried out through 360° at a rate not exceeding 5° per minute. If possible the ship should be swung through 360° but if time does not permit of this being done a swing of 180° should be carried out.

From the two sets of bearings obtained a curve of errors can be plotted showing the correction necessary on any bearing (see figure c.).

This correction will be maximum on the quadrantal points (see Admiralty Handbook of W/T (1931) paragraph 808(a) and this amount should be set on the cam corrector (see page F4). All bearings taken on this wave frequency will now automatically be corrected for quadrantal error.

PART III. CORRECTION FOR CHANGE OF WAVE-FREQUENCY.

It is now necessary to determine the effect of change of frequency on D/F bearings. With the cam corrector set at 0° the ship is again turned so that the transmitting station bears on the bow (or quarter). Bearings are now taken on various frequencies and the quadrantal error noted. It will probably be found that the curves already obtained in Part II on about 200 kc/s will also hold good for frequencies up to about 375 kc/s. For frequencies between 375 kc/s and 670 kc/s it will usually be necessary to carry out Part II again and obtain another set of curves.

In cases where great accuracy is essential (e.g. for navigation) the cam corrector should be set at 0° and the correction to be applied for quadrantal error obtained from the curves. In other cases where it is important that the bearing be taken quickly, and the type of transmission does not permit of the highest accuracy, the cam corrector should be used.

Testing for Sense. Any of the wave frequencies on which calibration has taken place can be used, the cam corrector being set accordingly.

The D/F bearing of the transmitting station is obtained, and "sense" found in the manner described on page LC3. This direction is then checked by the visual bearing.

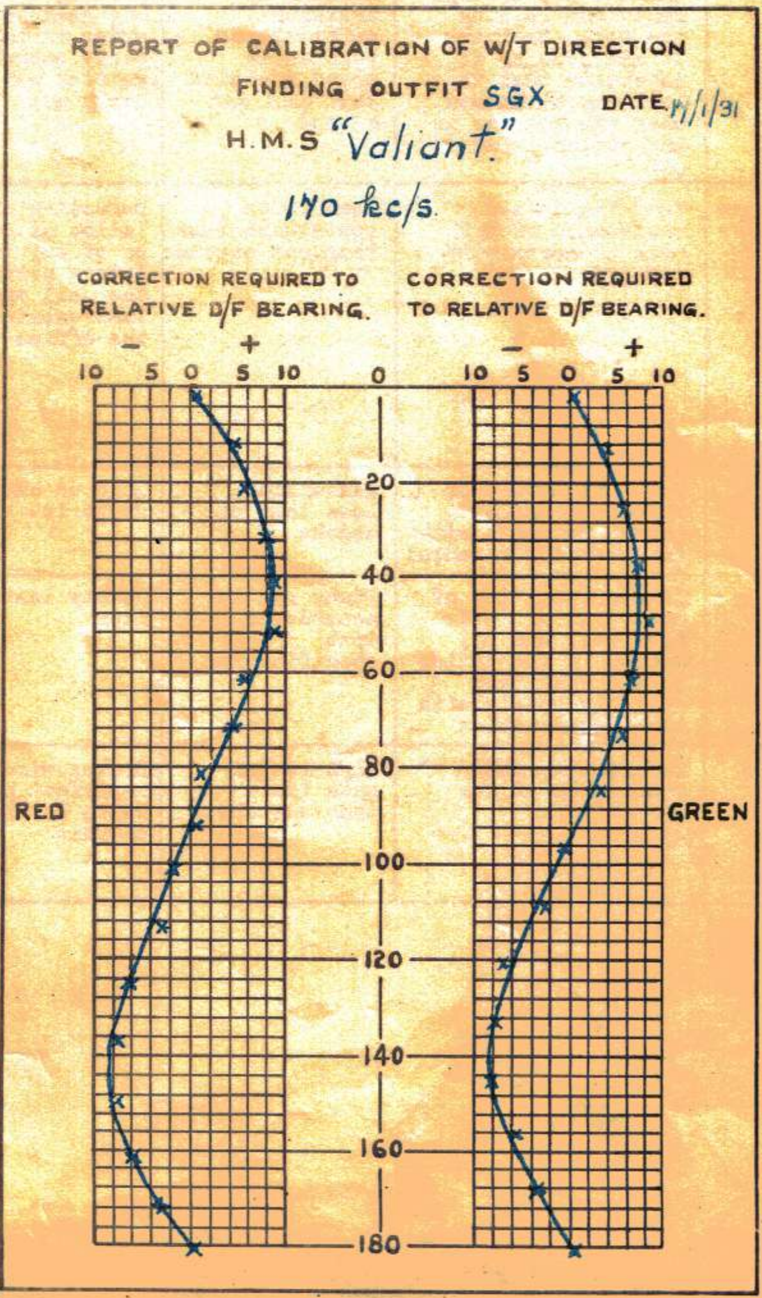

FIG. C.

D/F OUTFIT SGX

TESTS TO BE CARRIED OUT BEFORE D/F CALIBRATION.

No.	Test.	Fault	Cause.	Remedy.	Result of Test and Remarks.
1.	Examine all shafting and cable glands for watertightness. Ascertain that the trailing parts of cables from the framecoils are in good condition, and not likely to foul anything when the coil is being raised or lowered.	Glands leaking or loose Metal braiding or insulation of cables damaged	Glands require attention. Action of sea-water or mechanical damage.	Tighten glands as necessary. Repair where possible and call attention to serious defects.	
2.	The starting torque at the handwheel necessary to rotate the coil must not exceed 7.5 lbs. per foot. This can be measured with a spring balance and is equivalent to a pull of 16-1/2 lbs. applied to a point where the spokes join the rim.	Stiffness in training.	Mechanical defect in the training system, or want of proper lubrication of the gearing.	Make good when possible and report what cannot be made good. Clean and lubricate all gearing.	
3.	Remove glass face of training unit and ascertain that pointer is firmly clamped i.e., no movement of pointer possible with the coil at rest.	Slip between pointer and coil.	Defective clamping arrangements	Make good when possible and report what cannot be made good.	
4.	Examine the arrangements for raising the coil, training it and housing it. Ascertain that the coil can be housed when the pointer in the office is at 90°.	Raising or training difficult or pointer in wrong position when coil is housed.	Raising or training gear out of order or improperly assembled. Pointer not properly set.	Correct, as far as possible, and draw attention to what cannot be rectified.	
5.	Test insulation resistance of D/F coil to earth with a megger.	Insulation resistance less than one megohm.	Defective insulation of coil or of any insulators between the coil and instruments in the office.	If coil is defective a new one will probably be necessary. Wipe surfaces of insulators with cloth. If possible, wash with distilled water and leave to dry.	
6.	Test insulation of amplifier and batteries to earth with filament disconnected.	Resistance less than one megohm.	Acid on battery supports.	Wipe clean all insulators, supports, etc.	
7.	Examine position of coil, run of leads from coil and all wiring in the office to see that they strictly comply with the specification.	Items not in accordance with specification.	Faulty installation.	Correct, as far as possible, and call attention to points that cannot be remedied.	
8.	Measure the ohmic * resistance of the D/F coil.	High resistance (more than one ohm).	Broken wire or imperfect contacts in the circuit.	Examine all contacts, switches, and connections, repairing or renewing where necessary.	

Fig. d.

D/F OUTFIT SGX.

TESTS TO BE CARRIED OUT BEFORE D/F CALIBRATION (CONT.)

No.	Test	Fault.	Cause.	Remedy	Result of Test and Remarks.
9.	Test amplifier and note magnifier stage by stage for satisfactory amplification. Rotate D/F coil while receiving signals (coil must be in raised position). Test each range of both circuits in tuner.	Poor or noisy reception. Noisy reception during movement of D/F coil. Poor reception on any range of either tuner circuit.	Defect in instruments or batteries in bad condition. Imperfect contact at D/F coil brushes. Defective tuner.	Examine batteries for voltage and for acid density. Test instruments as far as possible. Wipe rubbing contacts clean and smear lightly with pure vaseline oil. Examine inside of tuner and locate and remedy fault if possible. Report unremedied defects.	
10	Break leads from D/F coil and try to receive signals on amplifier and tuned circuit alone.	Signals heard	Imperfect screening of tuner and amplifier, or direct radiation inside office from aerial leads.	Increase distance between coil leads and tuner. Run leads as non-inductively as possible or use braided cable where little space is available. Report any unremedied defect.	
11	Test heterodyne unit for C.W. and I.C.W. for each range.	Cannot be heard or tuned properly on amplifier and tuner.	Bad valve contact or defective coupling coil. Coupling too tight.	Try new valve and a coil from another heterodyne unit. Increase distance between heterodyne unit and amplifier.	
12	Rotate D/F coil and ascertain that good minima can be obtained.	Poor zeros and not at 180° apart.	Direct coupling between leads of D/F coil and tuner or amplifier.	Re-arrange leads and instruments, keeping all instruments as far as possible from coil leads	
13	Take an approximate bearing of Daventry (Lat. 52° 15N Long. 1° 08 W.) N.B. Daventry bears 359½° from Portsmouth, 309° from Chatham and 045° from Devonport.	Bearing greatly in error.	Probably wrong value of ship's head.	Check ship's head.	
14	Test gyro repeater motor by causing master gyro to be turned slowly through 360° first clockwise and then anti-clockwise.	Lost motion between master and repeater, i.e., failure to keep in step.	Gears meshed too tightly. Imperfect transmission from the master gyro.	Set gears so as to give a slight play (1/4 degree) to the rotating scale. Report other defects to department in charge of gyros.	

* N.B. When measuring ohmic resistance in Test 8 with an insulation test set and bridge the resistance of the leads joining the test set and the circuit under test should be measured. This resistance should be deducted from the total resistance of the circuit as measured.

S.G. Frame coil has 4 turns used for both M/F and L/F.

Form No. 154.

SH protection of a screened coil; for H/F use screen itself

Fig. d.

1. Frame coils/receiver
2. Method of rotating them } different from SHX.