Owner's Handbook for Hornet

ELECTRICALLY LIT INDICATORS

The indicators supplied with this instrument are fitted with internally mounted scale-illumination lamps. These are connected to terminals at the rear of the indicator which are clearly marked. THE LIGHTING CIRCUIT OPERATES AT 12V d.c.

If the ship's d.c. supply voltage is higher than this a voltage dropper must be connected. The Brookes & Gatehouse DIMMER unit, Part No. 162 - 0 - 3, is recommended for this purpose.

Brookes & Gatehouse Ltd. cannot accept responsibility under the terms of the guarantee for damage caused by the application of an excessive voltage to the lamp terminals.

BROOKES & GATEHOUSE LIMITED

Bath Road, Lymington, Hampshire, SO4 9YP, England
Telephone Lymington 74252 (STD 0590–74252)
Cables 'Homer' Lymington
Telex 477724

Printed in England by Printwise, Lymington, Hampshire

CONTENTS

5 OPERATION

6 MAINTENANCE

ILLUSTRATIONS

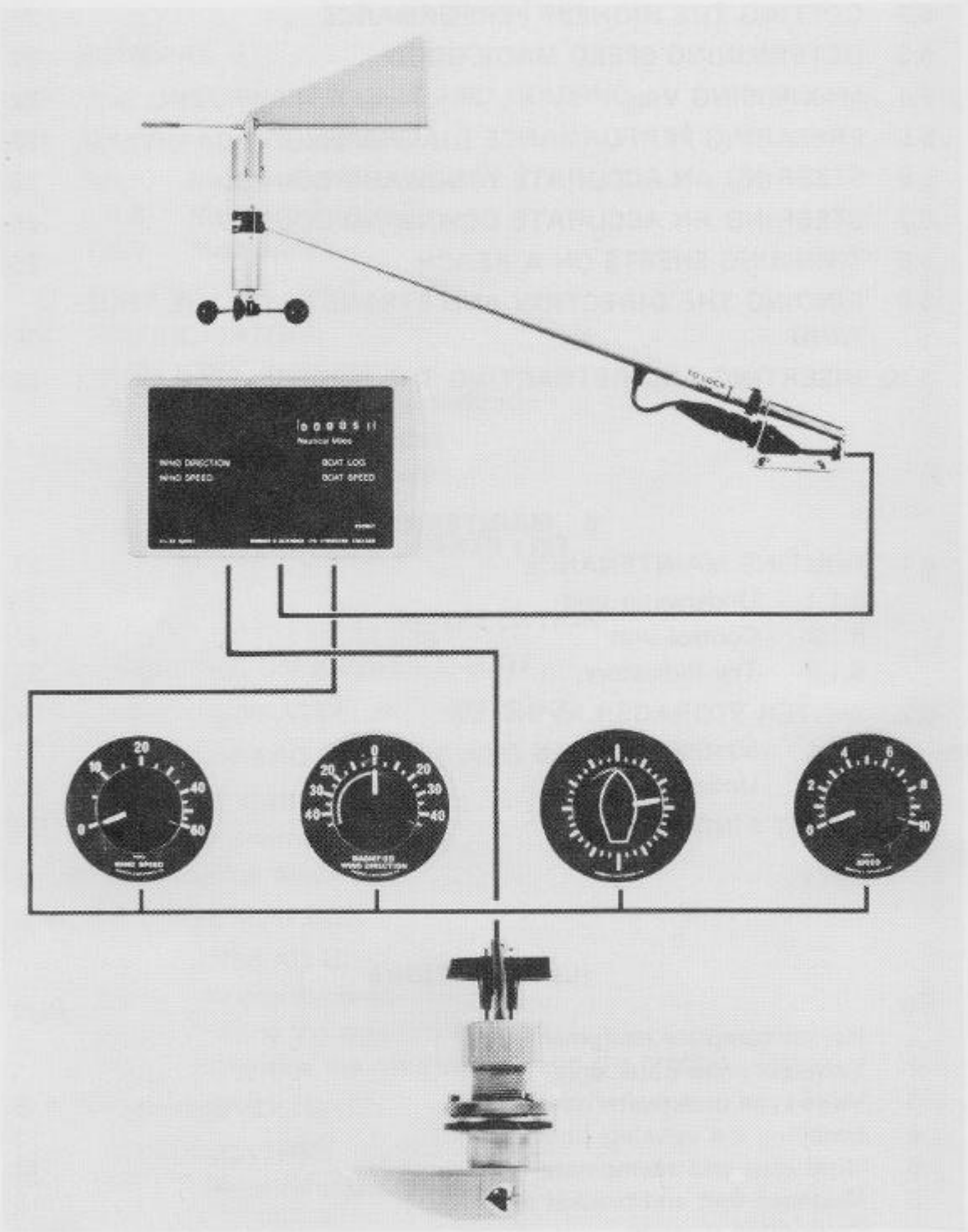


FIG. 1 – HORNET COMPLETE EQUIPMENT

PART 1 – DESCRIPTION

1.1 GENERAL

Hornet is a combined log, speedometer, anemometer and wind direction indicator. One control box is used taking input signals from an underwater unit and a masthead unit. Outputs are taken from the control box to four indicators:

(a) 360° wind direction

(b) Magnified wind direction

(c) 0–60 knot wind speed

(d) 0–10 knot boat speed

The distance indicator is mounted in the control box and is not resettable. The system operates at 12V d.c. from the vessel's main supply. There are no operating controls, the on/off switching being achieved at the boat's switchboard.

The indicators may be either of the 4 in. type with square bezels, or of the 3 in. circular bezel type. The latter are fitted with integral scale illumination operating from 12V d.c. via the indicator cable.

The standard Hornet control unit is calibrated to operate the four indicators only. Special control units for use with extra indicators carry a label on the rear cover stating what extra indicators are to be connected.

The control unit is fitted with two calibration controls in the rear cover:

(a) Speed/log calibrator

(b) Magnified direction misalignment corrector

The speed/log calibrator provides five increments of adjustment, each giving a 3% change. Clockwise rotation of the control causes the log to run more slowly and the speed indication to decrease. The magnified direction misalignment corrector is used to remove any error from the magnified direction indication, after the masthead unit has been adjusted for alignment.

1.2 THE UNDERWATER UNIT AND HOUSING

The standard valveless housing for use with Hornet is shown in Fig. 2. A valve-type housing is available as an alternative for installation in vessels of large draught (Fig. 3). In both types, the underwater unit may be withdrawn into the boat for cleaning while afloat, or may be retracted into the housing for protection when not in use. The impeller fin is secured to the main body of the underwater unit by means of two screws. There are no electrical connections between the two parts, and the impeller fin is easily replaceable at sea.

The impeller is also removable from the fin by unscrewing the rear bearing screw. The rotator is a moulded nylon propeller with a stainless steel shaft running in bearings which do not require lubrication. A weed deflector in the form of a streamlined fin with a sloping leading edge is incorporated in the flange of the valveless housing. For the valve-type model, it is provided as a separate unit and must be screwed to the hull a short distance ahead of the impeller.

Both types conform to 'Lloyds' requirements for classified yachts.

The valveless housing is a simple tubular skin fitting in moulded plastics, which is closed by means of a sealing cap after removal of the underwater unit (Fig. 2). Alignment of the deflector fin with the direction of water flow is achieved by rotating the housing within its outer sleeve, which is fixed to the hull, and then locking it in position by means of its retaining ring-nut. Alignment of the impeller fin with the deflector fin occurs automatically on lowering the underwater unit into its operating position. The plunger of the underwater unit contains two neoprene sealing rings and a bronze piston ring, the purpose of which is to scrape marine growth from the bore of the housing.

The valve-type housing (Fig. 3) is of special design and incorporates a sliding gate valve enabling the tube to be closed when the underwater unit is in the retracted position so that the latter may subsequently be withdrawn without admitting water into the boat. Alignment is maintained by a dowel pin which must be inserted into a hole before the handle can be fully lowered. A lock-nut is provided to clamp the alignment device once the correct setting has been found. The underwater unit is held down against external pressure by means of a threaded retaining ring.

Transmission from the impeller is effected by means of a magnet contained in it, the field from which induces very small pulses of electric current in a coil contained in the pick-up unit. These pulses are carried by a cable to the control unit, where they are amplified and used to actuate the speed and distance indication circuits.

1.3 MASTHEAD EQUIPMENT

1.3.1 Masthead unit

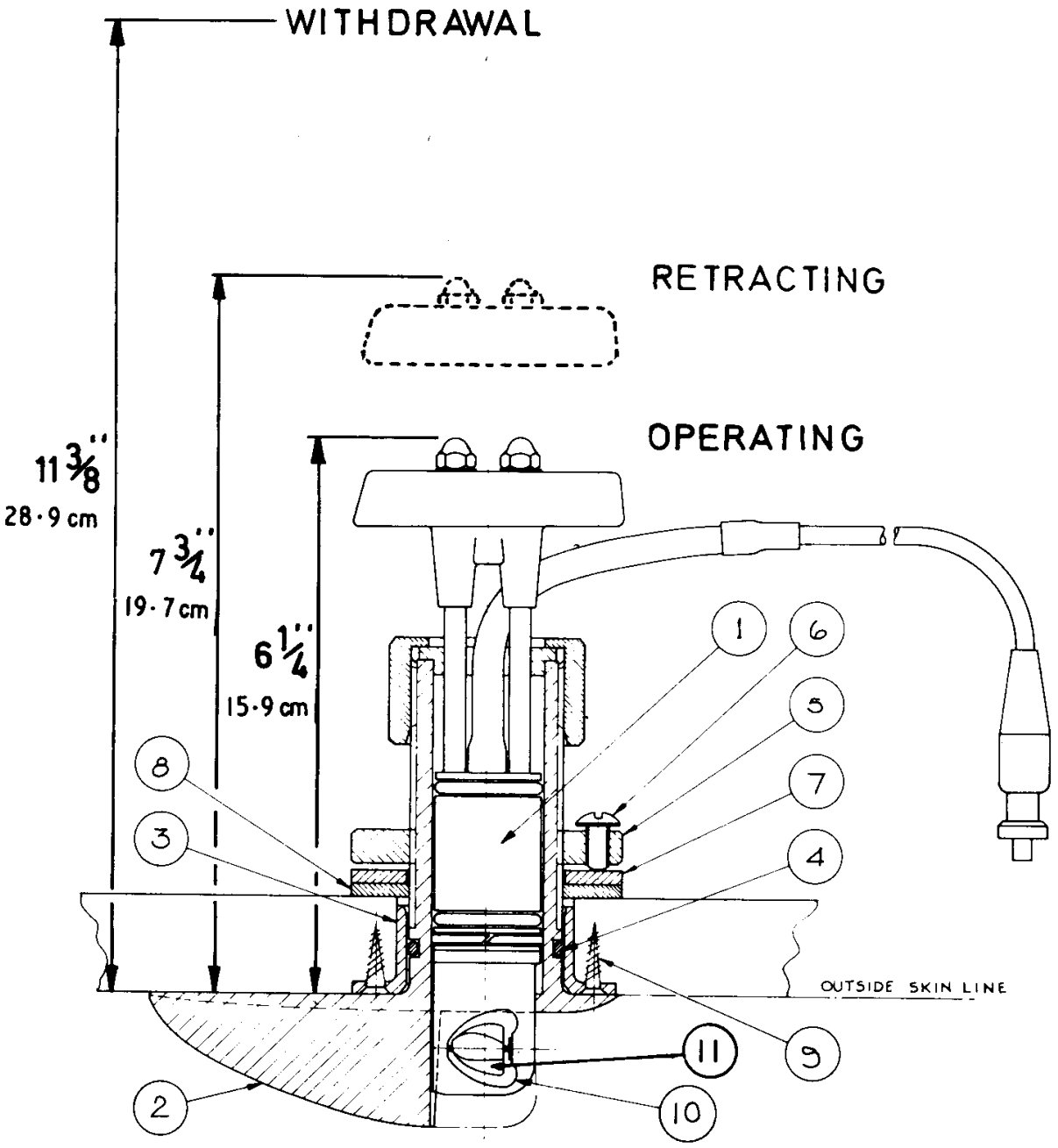
A tapered anodised aluminium spar supports the wind direction and wind speed transmitter units. These transmitter units are of 'plug-in' design for ease of servicing, and can be rapidly removed and replaced after removal of a small locking screw. At the other end of the spar is an electrical plug for connection to the mast cable socket.

1.3.2 Masthead bracket

This is an epoxy coated aluminium bracket which is fixed, via a stainless steel baseplate, to the mast cap. The bracket can be adjusted over 20° on the baseplate, using two lock nuts, to ensure that the spar is in correct fore-and-aft alignment.

1.3.3 Mast Cable

This is a seven-core cable with a ten-pin socket at its upper end which is mounted on the masthead bracket. This connects with the plug at the aft end of the masthead unit. The bottom end connects to a junction box, from which another cable leads to the control box.



KEY TO FIG. 2

1 PLUNGER CONTAINING SENSING COIL
2 HOUSING WITH INTEGRAL WEED DEFLECTOR
3 FLANGE RING
4 NEOPRENE 'O' RING
5 RING NUT
6 JACKING SCREW
7 BRASS WASHER
8 RUBBER WASHER
9 WOOD SCREW
10 IMPELLER FIN
11 IMPELLER

FIG. 2 – VALVELESS UNDERWATER UNIT

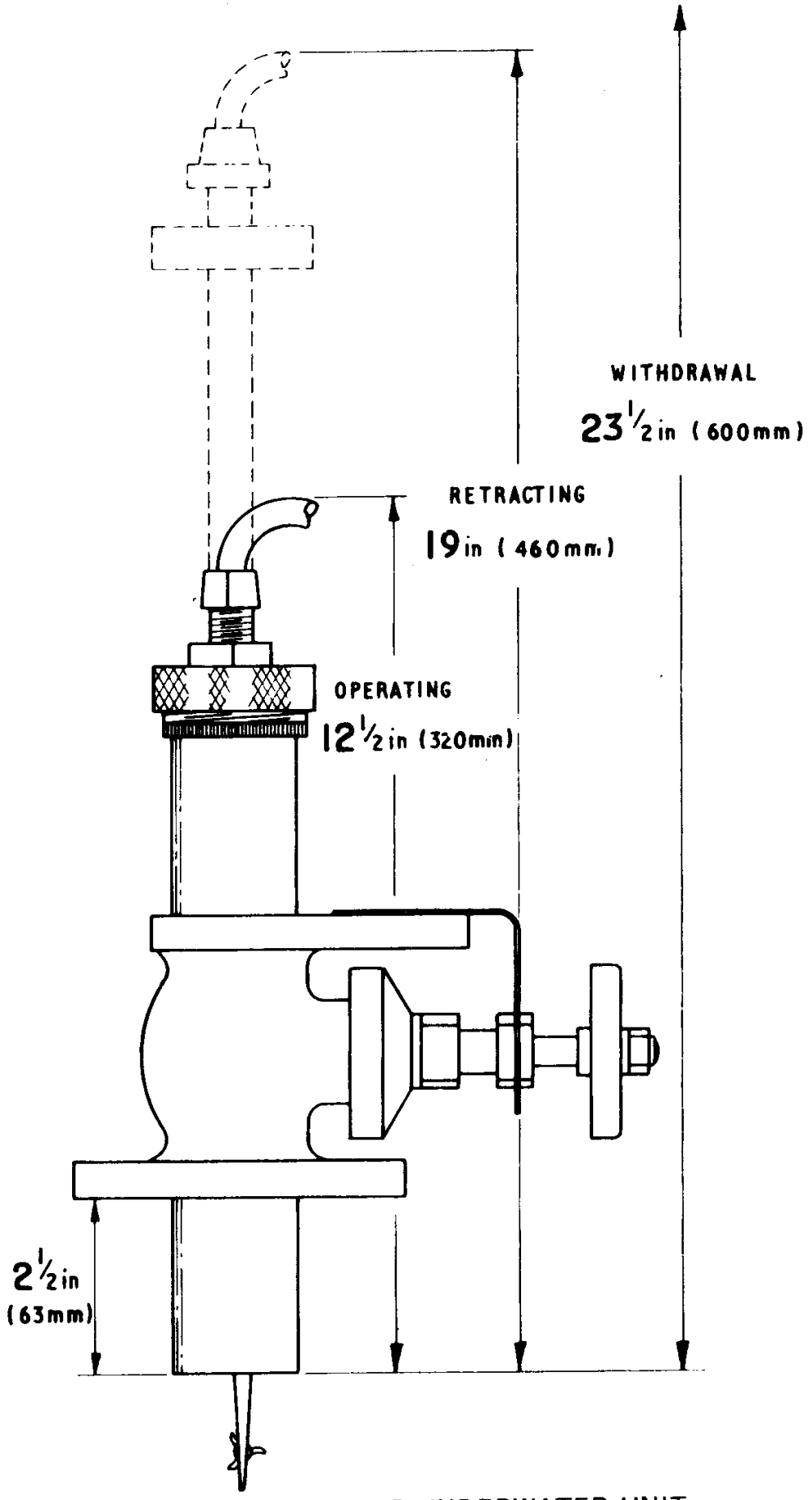


FIG. 3 – VALVE-TYPE UNDERWATER UNIT

1.4 THE CONTROL UNIT

This is an hermetically-sealed, nylon-coated die-cast aluminium case containing the electronic circuits, the distance indicator and necessary electrical connectors for the electrical supply, the input signals and the remote indicators. The control unit has no switches, the on/off function being performed at the ship's main power distribution panel. Two screwdriver-operated calibration controls are provided at the rear of the control unit, the use of which is described in section 4.

A desiccator with humidity indicator is fitted in the rear cover of the case to remove any moisture that may have penetrated the shaft seals in humid climates. The humidity indicator changes colour from blue to pink when the desiccator is approaching saturation. The desiccator should then be re-activated by drying out (see section 6).

1.5 THE INDICATORS

Two styles of indicator are available for use with Hornet: the 3 in. type with circular bezel and the 4 in. type with square bezel. The 3 in. type indicators have internal electrical illumination as standard.

Hornet presents to the helmsman the angle of the apparent wind relative to the ship's head, on two indicators, the apparent wind speed on a third and the boat speed on a fourth indicator. Distance travelled is displayed on a counter mounted in the control unit.

1.5.1 360° indicator

The motion of the masthead wind vane is followed (with a time lag of about three seconds) by the arrow on the meter. The arrow shows the direction from which the wind is blowing in relation to the fore-and-aft line. The boat outline on the indicator does not rotate. There are major graduations every 30° and dots every 10°.

1.5.2 Magnified direction indicator

This indicator is used for close-hauled sailing and running, and comes into operation when the wind direction is within either of two 90° sectors.

These sectors extend 45° either side of both the 0° and 180° positions. The pointer shows the direction from which the wind is blowing. The angular magnification provided is approximately 2½ times. When the wind direction is not within the operational sectors, the indicator pointer is hard over on one side of the scale or the other. The response is electrically damped to reduce fluctuations caused by movements of the mast and turbulence.

1.5.3 Wind speed indicator

Wind speed is presented on a 0–60 knot indicator, the scale of which is more open at the lower end than at the upper end.

1.5.4 Boat speed indicator

Boat speed is indicated on a 0–10 knot scale with equal scale divisions. Indicators with 15 knot scales can be supplied to special order but the control unit must be specially calibrated to suit. (A label to this effect is attached to the rear of specially calibrated control units).

2 PARTS LIST

DESCRIPTION	PART NUMBER
CONTROL BOX	141 – 7
MOUNTING BRACKET	101 – 16
MASTHEAD UNIT	137 – 35
UNDERWATER UNIT	117 – 50 cable length 33 ft (10m)
HULL HOUSING (VALVELESS)	117 – 46
GRAVITY SWITCH	107 – 23
JUNCTION BOX	WI 187
INDICATORS (3 in. type)	
360°	141 – 27
Magnified direction	141 – 26
10 kt boat speed	141 – 28
15 kt boat speed	141 – 49
60 kt wind speed	141 – 25
CABLES	
Mast cable and bracket assembly	137 – 19 length 60 ft (18m)
Power supply	110 – 106 length 10 ft (3m)
Junction box to control unit	135 – 31 length 20 ft (6m)
Control box to indicators	WI 160 length 20 ft (6m)

3 INSTALLATION

3.1 SITING THE UNDERWATER UNIT

In the interest of accuracy, the underwater unit should be placed as far forward as possible consistent with maintaining immersion when pitching or, in the case of a power boat, when planing and pitching.

In a sailing yacht the best position is generally ahead of the ballast or fin keel. It must not be installed further aft than 10 ft (3·0m) from the forward extremity of the water line. The distance from the centre-line should be about 4% of the waterline length. The installation of two underwater units, one on either side of the centre-line together with our gravity-operated selector switch, is recommended (Fig. 7). This switch must be mounted on a transverse bulkhead. If only one underwater unit is fitted there may be a difference of up to 5% between the speed readings obtained on the two tacks when sailing to windward.

Do not install the underwater unit within 6 ft (1·8m) of an alternator, dynamo or electric motor.

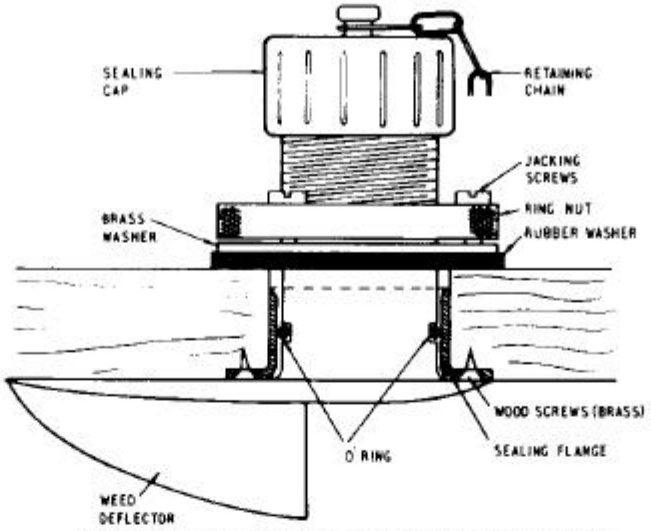
3.2 THE UNDERWATER UNIT HOUSING

Full installation instructions and diagrams are available in 'Underwater Housings — selection, siting and installation' published by Brookes & Gatehouse Ltd.

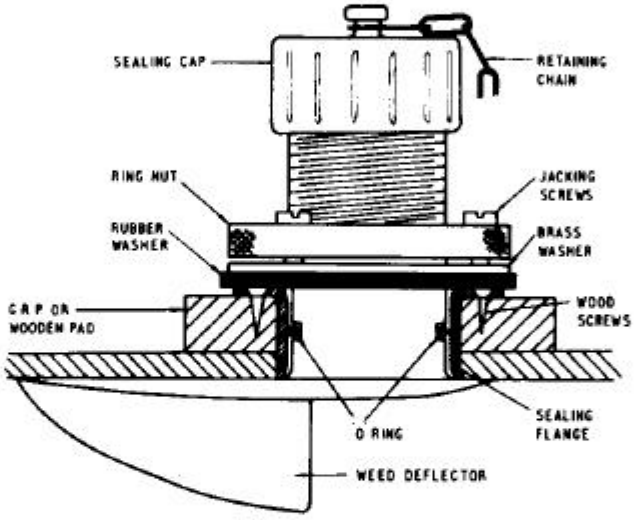
The valveless housing (Fig. 2) requires a hole of 2 in. (51 mm) diameter to be bored through the hull at the selected position. The hole should be counterbored $2^{11}/_{16}$ in. (68 mm) diameter to a depth of $^1/_8$ in. (3 mm) from the outer surface. After sealing the exposed surfaces the flange ring (3) is located in the hole with the flange in the counter-bore bedded down on sealing compound and secured with four No. 8 countersunk head screws (9) of a suitable length. Use self-tapping screws in G.R.P. hulls. The bore of the flange unit must be kept clear of sealing compound, anti-fouling paint etc.

In the case of G.R.P., metal or wooden hulls where the thickness of the hull is less than $1^5/_8$ in. (41 mm) an internal pad must be fitted to match the projecting height of the flange ring. In such cases the flange ring may be reversed so that the flange rests on the internal pad and the outer edge is flush with the surface of the hull. The flange ring is now moulded in Kematal acetal copolymer and may be installed in any type of hull material without risk of electrolytic corrosion. It is intended to be used as a liner for a ship-yard made hole and must be a close fit in it. The flange ring must be fitted with its axis perpendicular to the local hull surface. The correct method of installation in metal hulls is shown in Fig. 4.

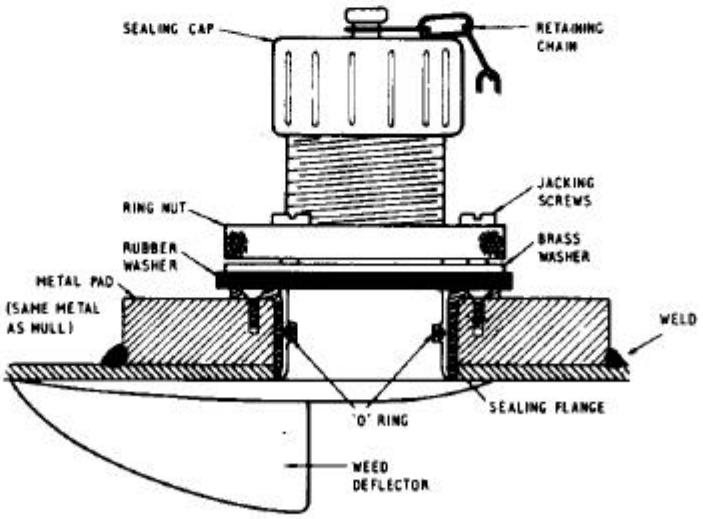
The external portion of the housing including the weed-deflector fin must be coated with anti-fouling paint before insertion. This is essential as the housing must be free to rotate when the ring nut is released in order to carry out the alignment procedure (section 4.1). The plastic housing (2) is inserted from outside the boat. Apply grease to the rubber O-ring. Do not use a sealing compound. The rubber washer (8), brass washer (7), and ring nut (5) are then assembled on to the threaded portion of the housing in that order and the ring nut screwed down by hand. Ensure that the fin points forward. Insert the



'KEMATAL' PLASTICS HOUSING IN THICK WOODEN HULLS



'KEMATAL' PLASTICS HOUSING IN G.R.P OR THIN WOODEN HULLS



'KEMATAL' PLASTICS HOUSING IN METAL HULLS

FIG. 4 – INSTALLING THE VALVELESS HOUSING

impeller unit (1) and screw down the retaining collar. Alternatively the impeller unit may be inserted after the vessel is afloat, in which case the sealing cap must be screwed on in its place. The end of the chain attached to the sealing cap should be screwed down so that the cap is not accidentally lost in the bilges. Final adjustment of the housing alignment should be made with the vessel afloat as described in section 4.1. The clearances required inside the boat measured from the outer surface of the hull and perpendicularly to it are as follows:—

With impeller in operating position:	6¼ in. (159 mm)
With impeller retracted:	7¾ in. (197 mm)
To withdraw impeller from housing:	$11\frac{3}{8}$in. (289 mm)

The $11\frac{3}{8}$ in. clearance is only momentarily required during withdrawal.

3.3 THE MASTHEAD BRACKET AND BASEPLATE

The stainless steel baseplate must be rigidly mounted at the masthead, meeting the following requirements:

(a) The free end of the tube is to point forward with its axis parallel to the fore-and-aft line.

(b) The baseplate (in which eight $\frac{7}{32}$ in. diameter holes are provided) is to be mounted flat to the masthead. Allowance has been made for a mast rake of 2°. Angles of rake in excess of this should be compensated by suitable packing. The angle of tilt of the tube to the horizontal plane should be approximately 20°.

(c) Remove the bracket if the baseplate is to be welded to the masthead and replace it after welding, as the heat may cause damage to the cable.

(d) Should the masthead light be already fitted in the way of the masthead bracket it will be necessary to move the light to a position aft of the bracket.

3.4 THE MAST CABLE

The cable run will vary with different types of mast, but in all cases it must be terminated below decks and close to the mast by means of the junction box. Leave the protecting cap in position on the cable socket until the masthead unit is put in place; then leave it attached to its lanyard at the masthead for subsequent use when the transmitting unit is unshipped, as the contacts must not be exposed to rain or dust.

3.4.1 Wooden masts

Run externally with cleats approximately every 10 in. — 12 in. avoiding sharp bends. Lead it below decks by means of a watertight gland. In the case of hollow masts under construction, the cable should be built-in internally.

3.4.2 Alloy masts

Run internally, suitably protected against damage from internal wire halyards etc. The cable must be protected at points of entry and exit at the mast by means of rubber grommets etc. When the mast is stepped on deck, the cable should be led through the deck by means of a watertight gland. Ensure that when the mast is subsequently unstepped, the cable is not cut, but that it is released from the junction box and pulled up through the gland.

3.5 THE JUNCTION BOX

This is mounted below decks and close to the mast partners. The end of the mast cable and the cable to the control box are connected together, colour to colour, in this junction box using the terminal block inside the box.

3.6 THE MASTHEAD UNIT

The wind vane and anemometer cups are dismantled from the transmitting unit before despatch in order to minimise the risk of damage in transit.

3.6.1 Fitting the vane (Fig. 5)

(1) Unscrew the knurled balance weight from the vane.

(2) Insert the projecting stud of the vane into the hole passing through the hub of the uppermost transmitting unit. Ensure that the flats on this stud engage with the groove in the hub and that the leading edge of the vane enters the slot at the top of the hub.

(3) Screw on the knurled balance weight and tighten firmly.

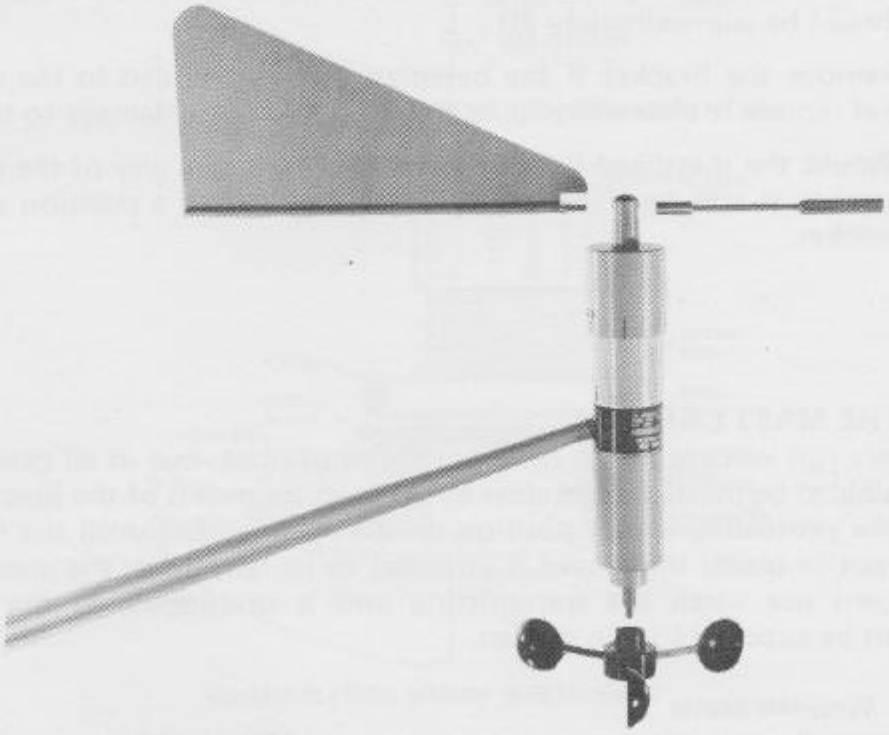


FIG. 5 – WIND VANE AND ANEMOMETER CUPS ASSEMBLY

3.6.2 Fitting the anemometer cups (Fig. 5)

(1) Remove the knurled screw from the stub on the shaft of the anemometer transmitter.

(2) Slide the anemometer cup assembly on to the stub, ensuring that the two hexagonal shaped parts engage with each other.

(3) Holding the cup assembly at the hub, screw on the knurled screw, tightening it by means of a screwdriver or coin, using only moderate force.

3.6.3 Mounting the masthead unit on the bracket (Fig. 6)

(1) Before taking the unit aloft, ensure that both the vane and the cup assembly rotate freely, and that neither is distorted.

(2) Slide the tubular arm onto the projecting tube of the masthead bracket, engaging the slot in the spar with the locating stud on the top of the tube. The wind vane must be uppermost.

(3) Twist the plastic spring clip through 180° to lock the arm in position.

(4) Remove the plastic cap from the socket of the masthead bracket, and ensure that it remains attached to its lanyard for further use.

(5) Insert the plug, which is hanging from the arm, into the socket. Note that there are keys on the body of the plug and keyways on the socket, which must be brought into line before the plug can be pushed home.

(6) Lock the plug by twisting the sleeve on the plug clockwise until it clicks into position.

(7) The slotted hole at the rear of the masthead bracket allows the whole spar assembly to rotate over 20° about the other stud. By this means the spar of the masthead unit may be aligned with the boat's fore-and-aft axis, e.g. parallel with the forestay. After adjustment of the masthead bracket, ensure that the two locknuts are screwed down tightly.

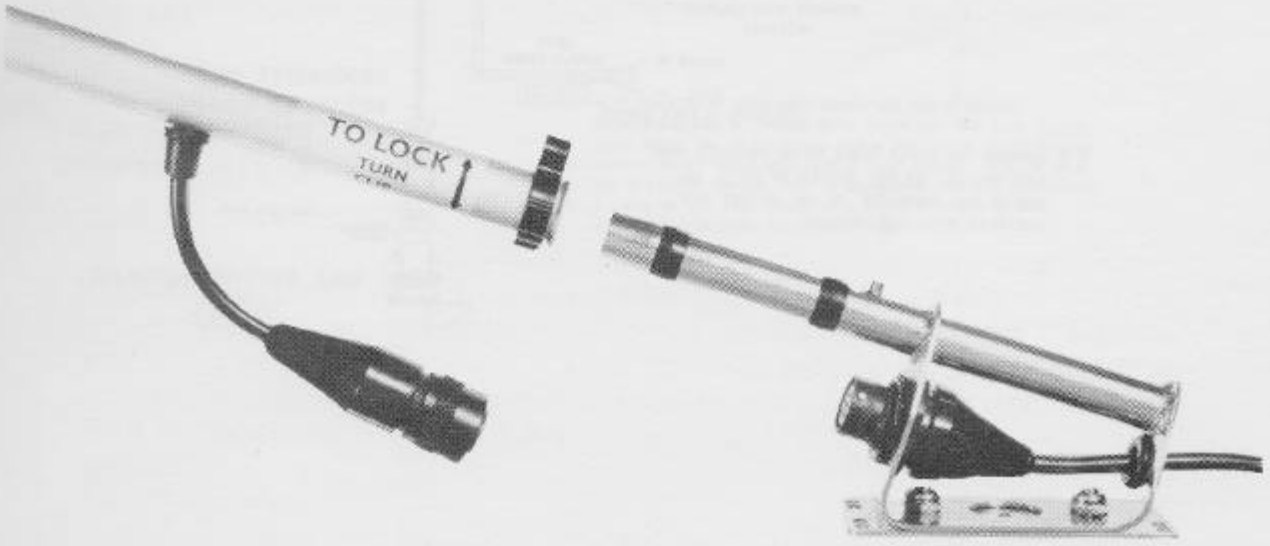


FIG. 6 – MASTHEAD UNIT AND BRACKET ASSEMBLY

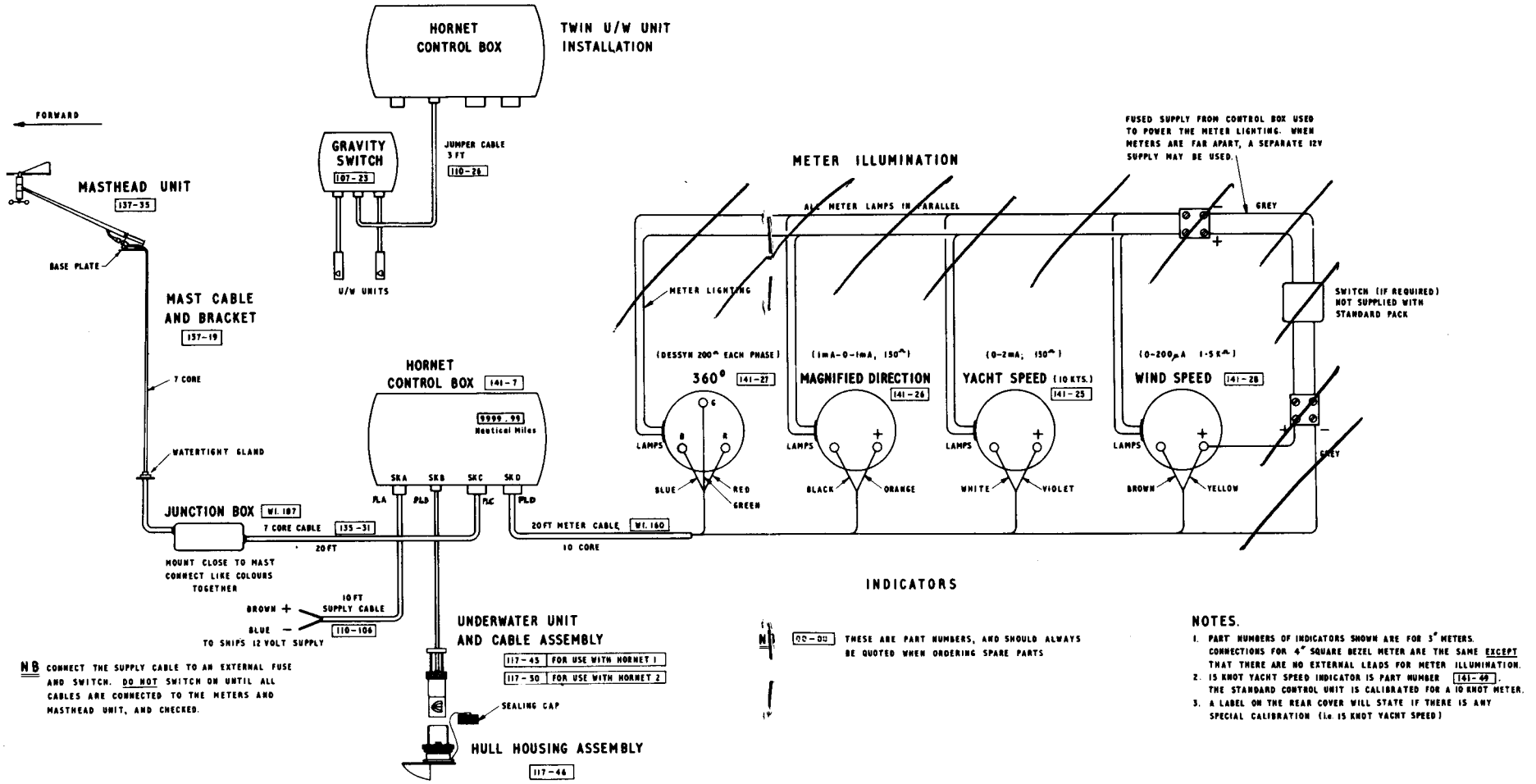


FIG. 7 – CONNECTION DIAGRAM

3.7 THE CONTROL UNIT

This may be installed in any convenient position, either on deck or below. Its 'safe distance' from the compass is 10 inches (250 mm). Normally, it will be placed within view of the navigator, while the remote speed indicator, remote distance indicator and amplified speed indicator are installed close to the helmsman. The mounting bracket for the control unit is fixed by six wood-screws to a bulkhead. The cable connections are shown in Fig. 7. Ensure that the plug retaining rings are firmly locked in position. Cables of any length will be supplied to order. If two underwater units are fitted, port and starboard, their cables are plugged into the two outer sockets of the change-over switch without crossing one another. Ensure that the port-side cable is inserted into the socket nearest to the port side of the yacht and starboard cable to starboard socket. The centre cable is connected to the control unit. Before connecting the supply cable ensure that the polarity of the leads is correct (brown to positive). The body of the underwater unit is electrically insulated from the instrument, and hence from the d.c. supply line. Consequently no damage by electrolysis can occur, whether the ship's supply is earthed at its positive or negative side. The changeover switch should be fitted on an athwartships bulkhead.

3.8 THE INDICATORS

These are normally mounted in a console in the cabin or in the cockpit bulkhead. Fitting instructions and drilling templates are provided with each indicator. Electrical connections should be made following the colour coding given in Fig. 7. Use the solder-type eyelet tags supplied, for terminating the leads.

3.8.1 Electrical illumination

Electrically lit 4 in. indicators carry five terminals at the rear of the instrument. The terminals for the internal illumination system are identified by a stiff card label marked 'LAMPS'. The terminals should be connected to the ship's d.c. supply via a switch. Where more than one remote indicator is installed the lamp terminals should be connected in parallel. Note: It is important that the positive line be connected to the terminal marked + and the negative supply to the terminal marked −.

If 3 in. (circular bezel) indicators have been selected, the ship's 12V d.c. supply is connected to the red (+) and blue insulated wires protruding from the rear of the indicator via a switch. Where more than one remote indicator is installed, a parallel connection should be made for the illumination circuits.

4 CALIBRATION

4.1 SPEED/DISTANCE

4.1.1 Adjusting the alignment of the underwater unit (Fig. 2)

Slacken off the three locking screws (6) fully by means of a screwdriver and then slacken the ring-nut (5) if necessary so that the housing is free to rotate. With the boat making constant speed under power, or running under sail, turn the handle slowly through a small angle on either side of the fore-and-aft line until a maximum reading is shown on the speed indicator. (The flow-lines beneath the hull are not necessarily parallel with the boat's fore-and-aft line). Then re-tighten the ring-nut by hand and screw down screws (6) fully, ensuring that their heads 'bottom' on to the shakeproof washers on the ring-nut (5). Subsequent re-alignment after removal of the underwater unit for cleaning is obtained automatically when the unit is lowered fully into its operating position.

4.1.2 Calibrating the log and speedometer

It is essential to calibrate the log before using it for dead reckoning as the scaling is affected by the shape of the boat's hull and the position of the impeller. The log/speed calibrator, which is located at the rear of the control unit is set in our works on the assumption that the flow rate of water beneath the hull is 6% less than the true speed. This is normally correct for a conventional 'displacement' – type hull when the housings have been sited well forward, as is recommended.

Having checked that the underwater unit is pushed down completely and is properly aligned (see section 4.1.1), run the vessel up and down a standard measured distance under power at a constant speed which should be at least ten times greater than the speed of the current.* Choose a time when the tidal current is constant. Note the log readings at the start and finish of each run and so obtain the total indicated distance sailed on the two runs. The difference between the total indicated distance and twice the standard measured distance is the log error and should be expressed as a percentage of the standard measured distance.

The log calibrator control is a screwdriver operated rotary switch having six positions which provide five 3% increments of correction. Clockwise rotation causes the log to run more slowly. One 'click' movement in an anticlockwise direction would therefore reduce the 2% under-reading error in Example 1 below to a 1% over-reading error. The control is found at the rear of the control box. If it is found that there is insufficient clockwise movement of the calibrating shaft available to correct the error, an impeller of longer pitch, coloured white, can be fitted in place of the standard black impeller. This will reduce the rate of the log by 15%. If there is insufficient anticlockwise movement available, consult Brookes & Gatehouse Ltd., or your nearest B. & G. agent who can make internal adjustments to the instrument to extend the calibration range by a further 15%.

Example 1 If the standard measured distance were 6,080 ft. (one nautical mile) and the two indicated distances were 1·01 miles upstream and 0·95 miles downstream (total 1·96 miles), as against 2·00 miles made good, then the log error is 4 parts in 200, or 2% under-reading.

*For ship/current ratios lower than 10 a correction factor must be applied to convert the standard measured distance to the distance actually sailed through the water. Multiply twice the listed distance by this factor, before comparing it with the log reading.

Speed of ship / Speed of current	10	7	6	5	4·5	4
Correction factor	1·01	1·02	1·03	1·04	1·05	1·07

Provided that constant speed was maintained, the ship/current speed ratio is simply calculated as the sum of the two indicated distances divided by their difference.

Example 2

Standard measured distance 6,080 ft. (1·00 nautical mile)
Indicated distance upstream 1·18
Indicated distance downstream 0·93
Total 2·11

$$\frac{\text{Ship speed}}{\text{Current speed}} = \frac{1{\cdot}18 + 0{\cdot}93}{1{\cdot}18 - 0{\cdot}93} = \frac{2{\cdot}11}{0{\cdot}25} = 8{\cdot}4$$

Correction factor (from table) = 1·015
Distance sailed = 2·00 x 1·015 = 2·03 miles (as against 2·11 indicated)
∴ Log error = 0·08 miles or 4%, over-reading
To correct this error, rotate switch one 'click' clockwise
Residual error is thus (4—3)% = 1% over-reading.

Calibration of the log as described above automatically calibrates the speed circuits.

4.2 WIND DIRECTION

If the masthead bracket is not correctly aligned parallel to the fore-and-aft line of the boat, an error appears on both the 360° and magnified direction indicators, equal to the angle of misalignment.

In order to compensate for this, the bracket can be adjusted by up to 10° either side by sliding it over the baseplate. This is achieved by slackening off the two $^{7}/_{16}$ in. AF lock nuts and re-tightening after adjustment.

Fine adjustment of the magnified direction indicator only may then be carried out using the control at the rear of the control box. If the masthead unit misalignment is to port, the control is turned clockwise and vice versa, each division on the control compensating 1° of misalignment.

5 OPERATION

5.1 GENERAL CONSIDERATIONS

All four indicators are brought into operation when the 12V supply is connected to the supply cable. A switch should be fitted on the yacht's fuseboard. The four indicators are individually damped to an optimum degree. When sailing to windward, tacking downwind or running, the magnified direction indicator should be used, as its sensitivity is 2½ times that of the 360° indicator.

5.2 GETTING THE HIGHEST PERFORMANCE

By observing the magnified direction indicator, the speedometer and the anemometer, it is possible to calculate the speed that the boat is making good into the eye of the wind with considerable accuracy. If this resolved speed is maintained at its maximum value, the boat will take the least possible time to reach the windward mark when tacking.

When sailing down-wind in light to moderate winds it frequently pays to steer an indirect course since the yacht's speed may increase considerably when the wind is brought from dead astern to the quarter. The leeward mark will be reached in the shortest time if, again, the resolved speed in the direction of the true wind is maintained at a maximum value, the yacht being gybed at the correct point to fetch the mark of the last leg of the zig-zag course. This rule holds good even if the wind is not blowing directly from, or towards, the mark. To windward, it holds good wherever it is impossible to fetch the mark without tacking. To leeward it applies if, when the speed made good in the direction of the true wind is a maximum, the mark is on the leeward side of the boat. One then tacks down-wind to reach it. If it is on windward side it pays to alter course and head straight for it.

The main purpose of Hornet is to enable the 'speed made good' to be determined and, having found the apparent wind angle corresponding to maximum 'speed made good', to enable the helmsman to steer accurately to this angle. Other uses are to improve the accuracy of down-wind steering, to obtain the best sail trim on a reach and to predict the sail requirements and the gybe after rounding the next mark of the course. These uses are described in detail below:

5.3 DETERMINING SPEED MADE GOOD (Fig. 8)

The meaning of speed, or velocity, made good (which is usually abbreviated to Vmg) is the speed at which the yacht is closing an imaginary, very distant, mark placed dead to windward of the boat. Mathematically, it is the boat's speed times the cosine of the angle between the direction of the true wind and the fore-and-aft axis of the boat, if leeway angle is ignored (i.e. Vs cos γ). The wind angle measured by the masthead wind vane is not that of the true wind owing to the fact that the boat's own velocity is, in effect, creating another wind in a direction along the boat's axis. It is the vector sum, or combination, of these two winds (which is called the apparent wind) that is measured by the instruments. The true wind direction therefore, has to be derived either mathematically, by graphical construction or by a calculator

such as the Brookes & Gatehouse Hawk, from the measured values of boat speed (Vs), apparent wind speed (Va), and apparent wind angle (β). Fig. 8 shows how Vmg is obtained graphically for the windward and downwind cases, by dropping a perpendicular from the tail of the boat's speed vector (Vs) on to the true wind vector.

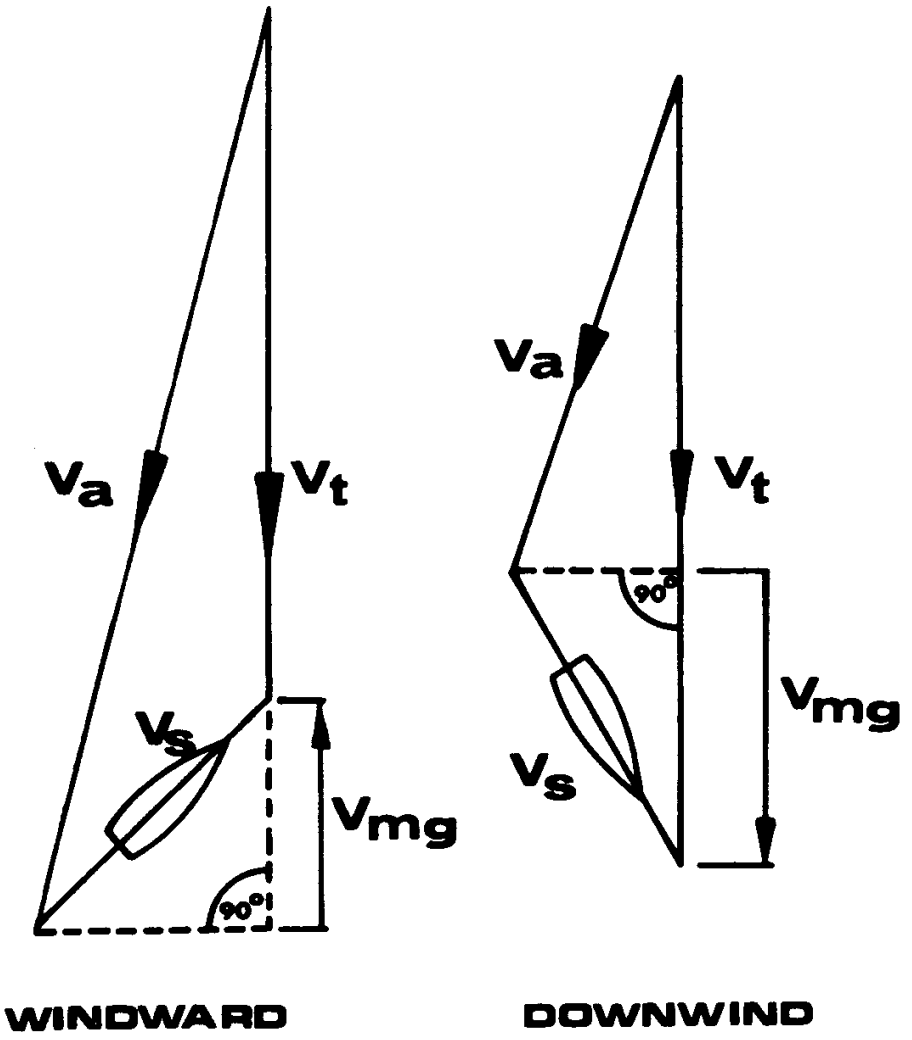


FIG. 8 – VECTOR DIAGRAMS TO OBTAIN SPEED MADE GOOD (Vmg)

5.4 MAXIMISING Vmg

The maximum value of Vmg for a given wind strength and sea state is arrived at by trial and error, the apparent wind angle and sail trim being adjusted by stages while the wind speed remains constant. The results may be taken ashore for analysis, or Vmg at each stage may be calculated on board by means of the Brookes & Gatehouse Yacht Performance Tables or the Hawk calculator.

The procedure is explained by the examples below. The calculation of Vmg to windward is complicated by the fact that when the yacht is heeled, the vane and anemometer are not measuring in a horizontal plane and are consequently under-reading. Correction factors have to be applied. These factors have been taken into account in the design of the tables and Hawk, using the heeling angle/wind velocity curve of a typical modern ocean-racing yacht. Variations in stiffness as between different mono-hull boats do not greatly affect the accuracy of the result. The equations for the exact determination of Vmg can be provided by Brookes & Gatehouse Ltd. on application. Trials carried out in a masthead sloop have shown that, when sailing to windward, the wind stream at the wind vane is deflected outboard by $2^\circ - 3^\circ$ due to the influence of the sails. For a ¾ rig sloop the corresponding angle was $1^\circ - 2^\circ$. This error must be subtracted from the reading to obtain the correct value of wind angle. If the leeway angle exceeds about 2°, it should be taken into account when optimising the windward performances. Leeway angle is to be added to the apparent wind angle before proceeding to calculate Vmg. Since no instruments are available for measuring leeway angle, theoretical values from the designer's office will have to be used. Since the sail deflection and leeway corrections are of opposite sign, and are generally approximately equal, the error in calculating Vmg if both are ignored is likely to be small.

Examples of trials to obtain best windward performance

(a) All readings obtained when apparent wind speed was steady at 15 knots.

Apparent wind angle	*30°*	*32°*	*34°*	*36°*	*38°*
Boat speed at best trim (knots)	*4.2*	*4.8*	*5.0*	*5.2*	*5.4*
Vmg from tables	*3.1*	*3.3*	*3.2*	*3.1*	*3.0*

Apparent wind angle for best Vmg = 32°

(b) All readings obtained when apparent wind speed was steady at 20 knots.

Apparent wind angle	*30°*	*32°*	*34°*	*36°*	*38°*
Boat speed at best trim (knots)	*4.4*	*4.8*	*5.2*	*5.4*	*5.6*
Vmg from tables	*3.3*	*3.4*	*3.5*	*3.4*	*3.3*

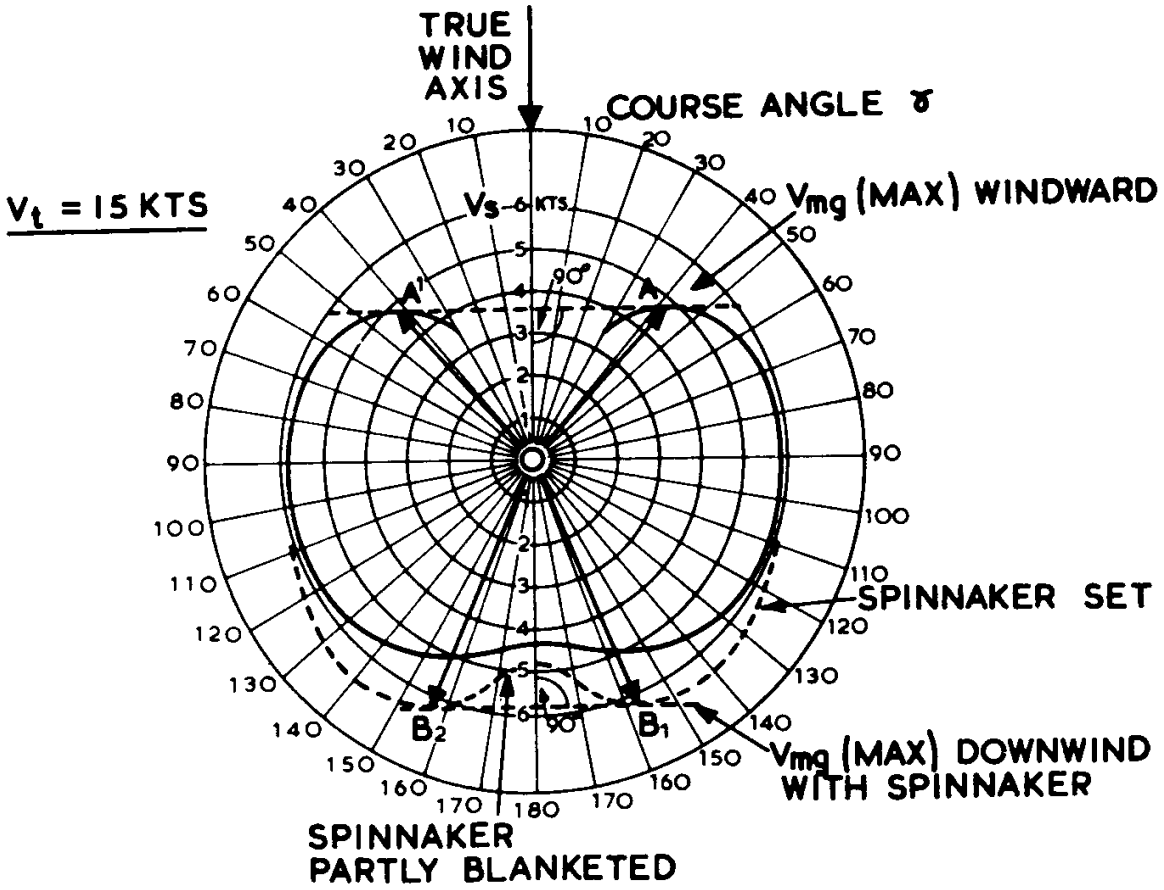
Apparent wind angle for best Vmg = 34°

5.5 PREPARING PERFORMANCE DIAGRAMS (Fig. 9)

The results of sailing trials should be recorded for future use. The most convenient method by which to present the results is the polar diagram, an example of which for a particular wind speed is shown in Fig. 9. The true wind direction is from 12 o'clock on the diagram and the boat's speed at any given angle to the true wind is given by the distance from the centre of the diagram to the curve. Measurements are made on all points of sailing and under different combinations of the sail. The value of the true wind angle on each heading may be calculated by means of HAWK. Vmg is a maximum windward and leeward at the points A and B respectively, where a line drawn perpendicular to the vertical axis is tangential to the curve. The boat should be tacked in direction 0A to windward and 0B to leeward.

The curves are particularly useful in showing the best sail combination for a particular course, so that the sails may be prepared in readiness for the next 'leg'. In Fig. 9 for example, it is seen that it pays to set the spinnaker in 15-knot wind when the true wind angle is greater than 90°. Separate curves should be prepared for the true wind speeds of 5, 10, 15, etc., knots.

The curves show how rapidly Vmg changes with small changes in wind angle when sailing to windward, and hence demonstrate the importance of sailing by the magnified direction indicator with its 'open' and accurate scale.



Polar performance diagram of a high-performance yacht for one particular true wind speed V_t. The distance from the centre O to any point on the curve represents the speed of the boat V_s in that direction. Dropping a perpendicular from that point on to the vertical axis gives the speed made good (Vmg). When the perpendicular is tangential to the curve, Vmg is at a maximum. In the diagram, the maximum Vmg, which is 3·6 knots, occurs when the yacht is sailed in direction OA. The yacht is sailing at 42 degrees to the true wind and speed through the water is 4·8 knots. By calculation we could discover that the angle to the apparent wind would be 27 degrees. When running under spinnaker, it will be seen that it is worth "tacking" down-wind in order to make maximum speed towards a point lying within the sector B_1 O B_2.

FIG. 9 – TYPICAL POLAR PERFORMANCE DIAGRAM

5.6 STEERING AN ACCURATE WINDWARD COURSE

Use the magnified direction indicator only. In daylight, the helmsman will glance frequently at the indicator to take advantage of freeing windshifts with the least possible delay. Ideally, duplicate indicators are used, one on each side of the boat, so that one of them is always within his field of view. By night, when the sail-luffs and approaching waves are invisible, it generally pays to steer entirely by the indicator.

5.7 STEERING AN ACCURATE DOWN-WIND COURSE

The magnified direction indicator (or the 360° indicator if the former is not fitted) should be used for running by night and day, as it enables windshifts to be observed with much greater accuracy than when sailing by burgee and the boat can consequently be run off 'dead before' with much less risk of a gybe occurring.

5.8 TRIMMING SHEETS ON A REACH

Establish the correct trim for various wind angles by the use of the 360° indicator and speedometer adjusting the sheets for highest yacht speed.

Mark the sheets with coloured whippings so that they may on all future occasions be adjusted at once without trial and error.

5.9 FINDING THE DIRECTION AND STRENGTH OF THE TRUE WIND

If the true wind is known a prediction can be made of the sails required and of the correct gybe after rounding a windward mark. The true wind direction in relation to the boat's fore-and-aft line (i.e. the relative bearing of the true wind) is obtained from the circular scale around the edge of the Hawk calculator. The sum of this relative bearing, the compass heading and the variation correction gives the actual direction of the true wind, which is ruled in pencil on the chart through the position of the next mark.

Example:	*Apparent wind angle*	*32°*
	Apparent wind speed	*15 kts*
	Boat's speed	*6.0 kts*
	Compass course	*280°*
	Variation correction	*−8°*

From Hawk, true wind angle to bow (i.e. relative bearing of true wind) = 52°
hence true wind direction = 52° + 280° − 8°
= 324° true.

Rule this line on the chart through the next mark of the course. The course for the next 'leg' is then also ruled through the same mark, allowance having been made if necessary for the set of the current. The true wind speed is obtainable with sufficient accuracy by subtracting the speed made good (Vmg) from the apparent wind speed when sailing to windward, or by adding the two speeds together when sailing to leeward. A simple rule when sailing to windward, which is generally sufficiently accurate, is to subtract two-thirds of the

boat's speed from the apparent wind speed to obtain true wind speed. When running 'dead before', the wind speed and boat speed readings are simply added together. The anemometer under-reads slightly when sailing to windward owing to the effect of heeling. For example, the error is 2% when heeled by 20° and 4% when heeled by 30°.

5.10 INSERTING AND RETRACTING THE UNDERWATER UNIT

Remove the sealing cap from the housing and quickly insert the underwater unit. Once the plunger is in the housing the neoprene rings form a perfect seal. Screw down the retaining ring. Push the handle down *to the fullest extent.* This is only possible when the fin is in line with a slot in the bottom of the housing. Align the unit with the direction of water flow in accordance with the instructions given in section 4.1.

6 MAINTENANCE

6.1 ROUTINE MAINTENANCE

6.1.1 Underwater unit

The impeller must be kept free from marine growth. Use a stiff toothbrush. The impeller is removable from the fin for examination of bearings by slackening the aft-end screw. A bearing side-play of up to 0·015 in. (0·38 mm) is allowable. If it exceeds this figure the screw and impeller should be changed.

In the underwater unit for the valveless housing the sealing ring must be kept liberally greased (water-pump or silicone type). In the valve type the rubber sealing gland through which the operating shaft slides should also be greased.

6.1.2 Control unit

Plugs and sockets should be kept clean using a dry cloth. Do not use an abrasive cleaner. Ensure that the plug retaining rings are firmly screwed up. Keep the window of the desiccator blue. When it becomes pink, the silica-gel crystals require drying out. Unscrew the desiccator by means of the rectangular aluminium key provided and place it in a drying cupboard or very low temperature oven until the indicator is deep blue. Do not allow the temperature to exceed 270°F (130°C). Keep the instrument in a dry place while the desiccator is removed.

6.1.3 The indicators

Ensure that the terminals are clean and free from corrosion. If necessary remove terminal nuts, clean and treat with silicone grease. If the glass window should 'mist' up internally, remove the desiccator capsule from the back of the meter by means of a large screwdriver, *temporarily remove the rubber sealing ring from it,* and place the desiccator in an oven at a temperature of 512°F (250°C) for one hour. Replace it rapidly in the indicator.

6.2 WINTER STORAGE/LAYING UP

6.2.1 Masthead unit

Storage of the masthead unit when the yacht is laid up afloat will increase the life of the transmitters. It should always be removed from the masthead before the mast is unstepped. It should be stored in its packing box with the vane and cups removed. The exposed plug at the top of the mast must be protected with the plastic cap supplied with it. This cap is attached to the masthead bracket by a lanyard and must not be detached when the unit is installed. The body of the plug should be smeared with silicone grease such as MS4 (Midland Silicones Ltd). The transmitting units can be unplugged by removing the locking screw. The contacts should be inspected for cleanliness and sprayed with a water-inhibitive oil (e.g. WD 40). The O-ring should be greased (e.g. with silicone grease type MS4), and the units replaced.

The masthead unit must never be oiled. The bearings are of the sealed self-lubricating type and any additional oil may cause chemical breakdown of the existing lubricant. Any scratch marks or corrosion on the masthead transmitters should be rubbed clean with a soft cloth and lightly covered with silicone grease. This should not be necessary if care is taken when hoisting and lowering the masthead unit, to protect it from collisions against the rigging.

If the mast is unstepped care must be taken to ensure that the cable is not cut through, but disconnected at the junction box below decks. The bare ends of the cable should be smeared with silicone grease.

To remove the masthead unit:

(1) Disconnect the plug and socket by twisting the sleeve on the plug in an anti-clockwise direction. The plug may then be withdrawn.

(2) Fit the plastic cap over the socket after smearing with a waterproof grease.

(3) Twist the black plastic spring clip on the spar through 180° to release the spar.

(4) Pull the spar off the bracket tube.

(5) When lowering the masthead unit, prevent it from striking the mast or rigging.

Both the direction and speed transmitting units can be removed. The knurled locking screw is released and the unit simply pulled off. Any electrical continuity tests can then be carried out on the exposed pins, taking care not to scratch or bend them. Replacement units can be plugged in (using the slot for alignment) and the knurled screw replaced. If a unit is removed, the masthead unit should not be replaced at the top of the mast until either a new unit or a blanking cap is fitted.

6.2.2 Underwater unit

Remove underwater unit from the housing and grease sealing rings and threads. Place sealing cap on housing. Check that the underwater unit cables are not suffering unfair wear due to stowage arrangements etc., and re-arrange cable run if necessary.

6.3 FAULT FINDING

The most common causes of faults are:

(a) bad connections inside the junction box.

(b) ship's supply not connected (e.g. ship's fuses blown, main switch off) or wrong polarity.

(c) bad connections at rear of indicators.

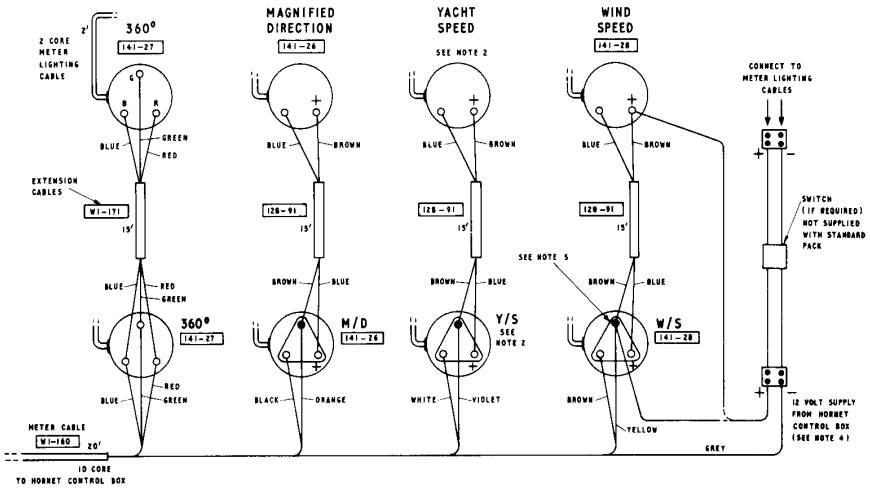
(d) battery voltage too low.

All these items should be checked. If they fail to point out the fault, the procedures of the Fault Finding Chart (Fig. 10) should be carried out.

METER READINGS					MOVE TO THE RIGHT IF THE TEST RESULT IS CORRECT MOVE DOWNWARDS IF THE TEST RESULT IS INCORRECT
360° INDICATOR	WIND SPEED INDICATOR	MAGNIFIED DIRECTION INDICATOR	LOG (DISTANCE)	YACHT SPEED INDICATOR	
STATIONARY	ZERO	ZERO	DOES NOT OPERATE	ZERO	Test 1 – Test 2 – Test 3 – Test 5 (Check cable and supply) – Test 6 (Faulty installation) – Test 7 (Faulty control box) – Test 8 (Faulty masthead unit) – Check mast cable Test 4 – Faulty control box Check cable
FAULTY	CORRECT	FAULTY	–	–	Test 1 – Test 10 – Test 7 – Test 11 – Test 8 – Check mast cable Faulty Masthead unit Test 8 – Check cable to control box Test 12 – Faulty control box Faulty indicator
FAULTY	CORRECT	CORRECT	–	–	Test 1 – Test 10 – Test 12 – Faulty control box Faulty meter
CORRECT	CORRECT	FAULTY (ALSO SEE BELOW)	–	–	Test 1 – Test 10 – Test 9 – Faulty control box Faulty meter
CORRECT	CORRECT	WRONG CALIBRATION	–	–	Test 5 – Test 6 – Faulty control box
CORRECT	CORRECT	REVERSE READING	–	–	Test 10 – Test 7
CORRECT	ZERO	CORRECT	–	–	Test 1 – Test 10 – Test 7 – Test 13 – Test 8 – Check mast cable Faulty masthead unit Test 9 – Faulty control box Faulty indicator
CORRECT	WRONG CALIBRATION	CORRECT	–	–	Test 5 – Test 6 – Faulty control box or masthead unit
CORRECT	REVERSE READING	CORRECT	–	–	Test 10 – Test 7
–	–	–	–	REVERSE READING	Test 10
–	–	–	CORRECT	ZERO WHEN SAILING	Test 10 – Test 9 – Faulty control box Faulty meter
–	–	–	FAULTY	ZERO WHEN SAILING	Test 14 – Faulty underwater unit, or it is weeded up or not pushed down Check underwater unit cable continuity – Faulty control box. It should be approx. 7 k ohms
–	–	–	WRONG CALIBRATION	WRONG CALIBRATION	Check over measured distance. Correct calibration should be obtained. Check underwater unit, it may be weeded up, misaligned, or in wrong position.
–	–	–	CORRECT	WRONG CALIBRATION	Test 5 – Test 6 (Check Supply; Faulty installation) – Test 10 – Test 9 (Faulty indicator) – Faulty control box
–	–	–	WRONG CALIBRATION	CORRECT	Faulty control box.

TEST	REQUIRED RESULT
1. Check the four plugs in the control box.	They should be clean and dry, and fully pushed home with retaining ring turned to click into position.
2. Check ship's main switch.	Should be turned ON.
3. Check ship's fuse to which Hornet is joined.	Should be intact. 2 Amp minimum rating.
4. Fit new fuse with control box disconnected.	Fuse should remain intact.
5. Remove 2-core cable from control box. Measure voltage between hollow pins of supply cable plug.	Voltage should be at least 11 volts. Pin A is positive. Pin B is negative.
6. Inspect rear of Hornet control box to see if 'special calibration' label is fitted.	No label fitted means the unit is calibrated for one of each meter. If a label is fitted, the indicator installations should agree with the label.
7. Open junction box at foot of mast. Check that cables from masthead and control box are correctly connected. Measure voltage between orange (+ve) and black (–ve) wires.	Both cables should be joined in the terminal block with wires connected colour to colour. Each screw should be tight – not into insulation of wires. Voltage should be between 7¾ and 8½ volts d.c.
8. Bring down the masthead unit. Remove the mast cable from the control box, and plug in the masthead unit.	Indicators should operate as normal when vane and cups are turned.
9. Test continuity of indicators.	Resistance of indicators: Yacht speed = 85 ohms ± 10% Magnified Direction = 150 ohms ± 2% Wind Speed = 1500 ohms ± 2%
10. Check connections at rear of indicators, also check cables to indications and junction box.	There should be no sign of any misconnections, short circuits, or open circuits.
11. Open junction box at foot of mast. Disconnect from terminal block the red, orange, green, blue and black wires of cable to control box. (a) Join orange, blue and green together; also red and black together. (b) Join blue and orange; also red and black. (c) Join green and orange; also red and black. (d) Join black, blue and green together; also red and orange together.	Indicators should read as follows: (a) 360° INDICATOR 0° — MAGNIFIED DIRECTION INDICATOR 0° (b) 30° Starboard — Hard over Starboard (c) 30° Port — Hard over Port (d) 180° — 180°
12. Disconnect the three wires from the 360° indicator. Connect orange and black wires to +ve and –ve of any 9–12 volt battery. (These are separate lengths of wire joined only to the battery). Thus using these two extra leads and the R, G and B terminals of the 360° indicator. (a) Connect orange wire to terminals B and G. Connect black wire to terminal R. (b) Connect orange wire to terminal B. Connect black wire to terminal R. (c) Connect orange wire to terminal G. Connect black wire to terminal R. (d) Connect black wire to terminal B and G. Connect orange wire to terminal R.	Needle should move correctly over scale and not stick. Re-connect wires after test. Indicator should read:– (a) 0° (b) 30° starboard (c) 30° port (d) 180°
13. Open junction box. Disconnect violet wire at control box side. Touch it against the black wire, and then break contact. Repeat rapidly.	The wind speed indicator should jump at each contact, and rise to 1 knot for 1 contact/second or for example 4 knots for 4 contacts/second.
14. Remove the underwater unit from its housing and rotate the impeller by blowing on it.	The yacht speed indicator should read, and the log should 'click' (providing the impeller is rotated for enough time).

FIG. 10 – FAULT-FINDING CHART



NOTES

1. SOME EARLY HORNET CONTROL BOXES WERE 1 AMP FUSED AND WOULD ONLY SUPPLY 4 METERS FOR ILLUMINATION. LATER HORNETS ARE 2 AMP FUSED AND WILL SUPPLY UP TO 12 METERS FOR ILLUMINATION. THE FUSE RATING IS WRITTEN ON THE REAR COVER OF THE CONTROL BOX. ANY EXTRA LOADING MUST BE SUPPLIED DIRECT FROM THE SHIPS 12 VOLT SUPPLY.

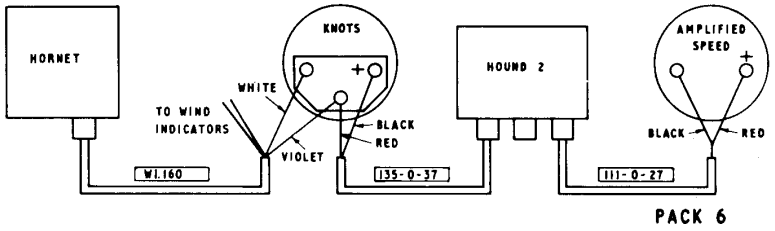
2. 10 KT YACHT SPEED 3" INDICATOR PART No. IS 141-25
   15 KT YACHT SPEED 3" INDICATOR PART No. IS 141-49
   } CONNECTIONS ARE THE SAME ALTHOUGH THE BOX MUST BE SPECIALLY CALIBRATED FOR 15 KTS.

3. **4" INDICATORS** THE CONNECTIONS FOR THESE ARE AS SHOWN ABOVE OMITTING THE LIGHTING DETAILS.

4. **SPECIALLY CALIBRATED CONTROL UNITS.** THE STANDARD UNIT IS CALIBRATED FOR ONE OF EACH METER (THE YACHT SPEED BEING 10 KNOT). AN EXTRA 10 KT YACHT SPEED MAY BE CONNECTED WITHOUT ALTERING THE CONTROL BOX. EXTRA METERS OF THE OTHER TYPES MUST BE USED WITH A SPECIALLY CALIBRATED CONTROL BOX. LABELS ON THE REAR COVERS OF THESE BOXES WILL STATE NUMBER OF METERS OF EACH TYPE AND ANY OTHER SPECIAL CALIBRATION (e.g. 15 KT YACHT SPEED).

5. ● THESE ARE EXTRA TERMINALS MOUNTED ON TERMINAL BOARD PART No. 102-92.

FIG. 11 – DUPLICATE INDICATOR CONNECTIONS
USING A SPECIALLY CALIBRATED CONTROL BOX



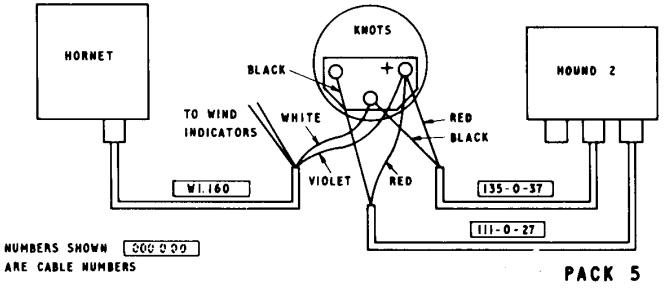


FIG. 12 – HORNET TO HOUND 2 CONNECTIONS