The "Direction To" is the mean of the directions indicated by the balls, weighted according to the number of balls in each compartment. For instance, if the balls fall thus :

10°	20°	40°
2	5	3

then the mean direction would be,

$$\frac{2 \times 10 + 20 \times 5 + 40 \times 3}{10} = 24^{\circ}$$

GENERAL NOTES.

Always press the double spring "*T*" towards the wire before lowering.

Before putting the meter away, take out the propeller and compass needle, wash them in fresh water and put them in their places in the bow, and wash the whole meter.

Bronze balls measuring 1/8 in. (= 0.3 cm.), preferably nickel-plated, should be used. Do not allow them to become greasy. Washing in petrol is recommended.

Steel or lead balls should not be used. The steel is magnetic, and the lead balls lose their shape and stick in the magazine.

The best supporting wire is a flexible bronze cord, since it has no magnetic effect.

In the absence of a bronze wire a flexible steel cord gives excellent results. Whatever wire is used, care should be taken that the messengers slide on it easily. The eye in the end should be made so short that no part of the splice is visible above the head ; if it projects it may prevent the messenger from working properly. A wire which has been kinked and straightened should not be used.

The messengers should fall at the same rate, but it is always advisable to keep the hand on the wire so as to feel the shock of their reaching the meter.

If the current is strong it may be found that the vibration of the wire is so great that the messenger cannot be felt to strike even at 30 fathoms. In such cases the wire may be felt with a hook of stout iron wire held in the hand. A more sensitive device is a kind of telephone which is made by fastening a stout iron wire, about a foot or eighteen inches long, into the outside of the bottom of a cigarette tin, and turning the other over into a hook.

Another method is to press one end of a wooden spar about 8 feet long and 3 to 4 in. diameter against the wire and the other end to the ear.

The direction of the current cannot be determined close to an iron ship. Errors as great as 5° have been found at depths of 10 or 12 fathoms below a steel ship 150 feet long.

The sinker should oppose as little resistance as possible to the current. A horizontal fish-shaped sinker weighing about 30 lbs. has been found suitable.

Measurements at anchor in deep water are very difficult since it is almost impossible to allow for the revolutions of the propeller caused by the ship sheering and yawing. On some occasions good results have been obtained by anchoring a small buoy on a fine wire such as that used for a sounding machine and allowing the ship to drift away from it freely while the meter is in use. The drift found on running back to the buoy is substracted from the current shown by the meter.

THE WOLLASTON CURRENT METER.

Some information concerning this apparatus is given in the *Hydrographic Review*, Vol. VI, N° 1, May 1929, page 231. Further information regarding the new model of this apparatus designed in 1935 by Messrs. Henry HUGHES & Son, Ltd., 59, Fenchurch Street, London, E.C. 3., is given here-under.

THEORY OF THE INSTRUMENT.

When a heavy stationary vertical disc is held immersed in a current of water, the water exerts an horizontal pressure on the disc, proportional to the square of the velocity of the current ; if the disc be attached to some external pivot it will be translated

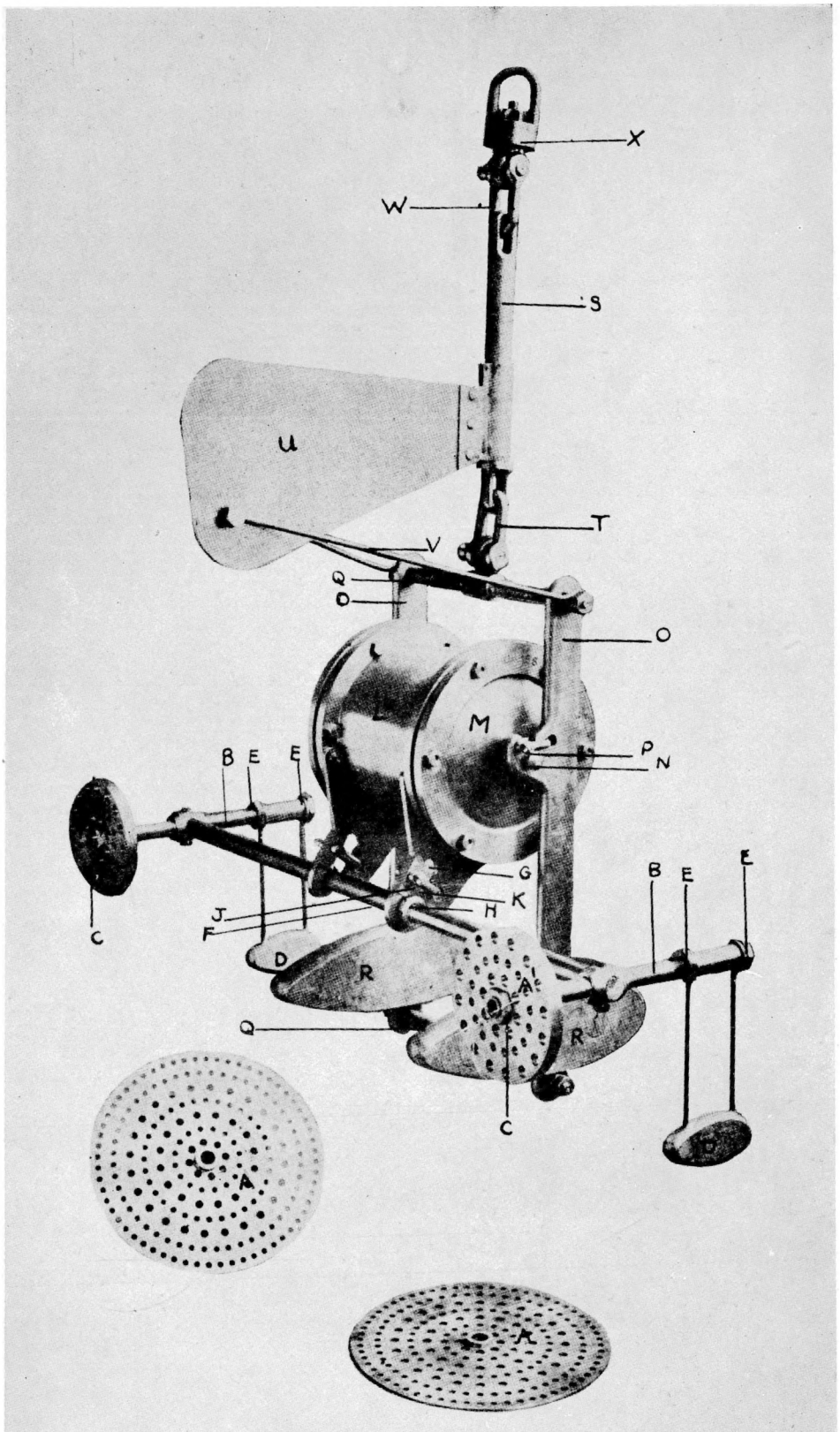

FIG 1

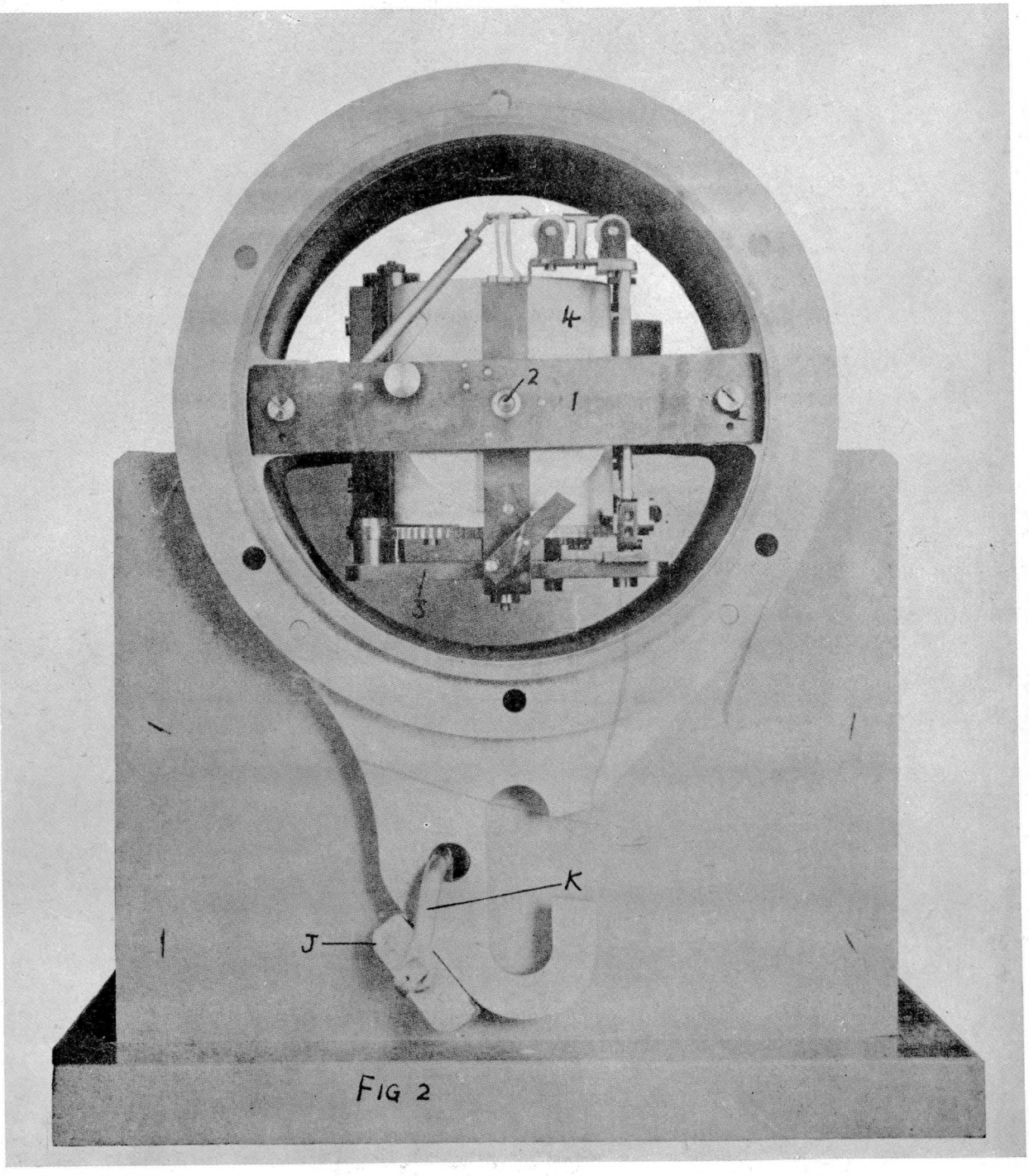

FIG 2

by the current till the line of connection between plate and pivot forms the diagonal of a parallelogram of forces of which the sides are the horizontal pressure due to the current and the weight of the disc, when it will remain in equilibrium.

The horizontal force exerted by the current is then equal to the weight of the pressure plate multiplied by the tangent of the angle of deflection of the connecting line from the vertical from which the speed of the current can be ascertained.

In the WOLLASTON current meter there are two pressure plates which are mounted on rods, secured to a connecting bar, and this pressure plate system is balanced about the bar so as to bring the plates vertical when immersed in water; the bar is free to rotate in a pair of supporting hangers rigidly attached to a watertight drum which also is free to rotate on trunnions in a supporting main frame. Thus drum will rotate till the moments of the horizontal pressures due to the current are equal to the moments of the weights in water of the parts moved (pressure plate system and hangers), the moments being taken about the drum trunnions; the pressure on and weight of the drum do not affect this.

The recorder gear inside the drum records the inclination of the drum and the direction of the current, the latter being obtained from a special type of magnetic compass.

The records taken are compared with the results obtained on standard calibration charts of known speeds and directions.

DETAILS OF CONSTRUCTION.

External Construction, Fig. 1.

The interchangeable pressure plates *AA*, *A'A'*, are mounted against fixed stops at the after ends of the pressure plate rods *BB* and held in place by nuts *C,C*; suspended from the forward ends of the rods *BB* are lead counterbalances *DD* mounted between nuts *EEEE*. The pressure plate rods are mounted at the ends of the pressure bar *F* and the nuts *EEEE* pinned in place after balancing. The two sizes of pressures plates are made to the same weight and are interchangeable without affecting the balance as the larger and therefore thinner plates are provided with fixed washers on their inner surfaces, equal to half the difference of thickness, so as to bring the centre of gravity of both large and small plates into the same position when mounted.

The pressure plate system is carried centrally on two hangers *GG* secured to the instrument drum *L* and is located by two collars *HH*. The pressure plate system is prevented from being accidentally unshipped by two retaining pieces *JJ*, secured in place by shackles *KK*; it is free to rotate as required under the forces acting on it.

The drum *L*, carrying the hangers *GG*, contains the recording gear, to be described later, and is provided with two circular end plates *MM*, fitted with dermatine washers to ensure the joints being watertight; these end plates *MM* have centrally projecting trunnions *NN*, which support the drum in the main frame and on which the complete system, as hitherto described, can rotate.

The main frame consists of two side members, *OO*, provided with slots to receive the trunnions *NN*, which are retained in place against accidental displacement by shackles *PP*. The side members are spaced out and held together by upper and lower members *QQ*, consisting of tie rods and spacer tubes; streamlined sinkers *RR* are mounted on the lower parts of the side members. The upper member of the main frame carries an eye mounted at its centre to which a rod *S* is secured by a shackle *T*. Just above the shackle *T* a vane *U* is mounted on the rod *S* and is prevented from slipping down by a collar. The vane *U* is further secured near its outer edge by stay rods *VV* to the outer ends of the top member of the main frame and so serves to steer the current meter into the current. Another shackle *W* connects the top of the rod *S* to a ball bearing shackle *X* and the lowering line is attached to the loop of this last shackle.

Internal Construction, Figs. 2, 3 and 4.

Fig. 2 shows the drum with end plates removed, on the wooden block provided for its support when changing records. The drum is provided with a pair of internal diametrically opposite lugs at each end which carry two bars *1* secured in place by screws and steady pins. At the centre of these bars *1* and so on the axis of the drum are ball bearings to receive the internal trunnions *2* by means of which the recorder gear is freely suspended.

The recorder gear Figs. 3 and 4, (there are really two, one for speed of the current and one for direction) is mounted on a base-plate *3* suspended between the inner trunnions *2* and carries a central clock-driven drum *4* on which the blank paper chart is secured; the standard clock rotates the drum once in 24 hours and runs for 8-days; a second fast running clock is supplied as an extra when required, and this rotates once in 1 hour and will run for 30 hours; the fast clock is provided with stopping and starting mechanism accessible through a screw plug at the top of the drum and easily operated by a short rod, penholder, or the like; the standard or slow clock is not provided with stopping and starting mechanism.

The speed recorder gear consists of a *Ditmar* Pen *5* mounted on a carriage *6* which is drawn between vertical guide rods *7* by a fine flexible cord *8* attached to a lever *9* which in turn is connected to a pin *10* on the bar *1* by means of a connecting piece *11*. Since the recorder is slung on trunnions *2*, carried in ball bearings, it is not tilted by a rotation of the outer drum. Any rotation of the outer drum rotates the bar *1* about the drum axis and the internal trunnions *2* thus actuating the system of pin *10*, connecting piece *11*, lever *9*, flexible cord *8*, carriage *6* and pen *5*.

Any oscillation of the drum due to the effect of waves and surging would cause a wide belt to be recorded instead of a line; this is avoided by the insertion of a simple spring and oil damping system.

The lever *9* is produced below its pivot, which is coaxial with the trunnions, and carries a paddle inside the oil chamber *13* which is arranged to provide very heavy damping. The connecting piece *11* is constructed of a spring enclosed in a tube which carries an external *long* wire loop to receive the pin *10*, and the spring tension is made to balance twice the pull exerted on the flexible cord *8* by the pen carriage. By this means a sudden motion of the bar *1* towards the zero or horizontal position merely frees the lever *9* from all pull from the connecting piece *11* so that it moves very slowly against the oil damping owing to the weight of the pen carriage; a sudden movement of the bar *1* in the reverse direction, is taken up by the spring inside the connecting piece *11* and exerts a pull on the lever *9* equivalent to twice the pull of the pen carriage which leaves the effective pull on the lever *9*, the same as before, but in the reverse direction.

Any oscillatory rotation of the outer drum due to any cause will thus be damped out almost completely, without affecting the sensitiveness of the recording gear to any change in the average deflection from the original position.

Other details of the construction such as the pulleys 12 over which the flexible cord *8* is guided, the safety cord-retaining tube *14* and the pen contact adjusting screw *15* are obvious as regards their construction and functions.

In order to facilitate shipping and unshipping the recorder inside the drum *L*, the connecting piece *11* is arranged to be easily removable. Pressure on the knob *16* pushes back a flat spring *17* which retains the wire loop of the connecting piece *11* on the pin *10*, so that the connecting piece can be readily slipped on or off the pin *10*. When free from the pin *10* the connecting piece *11* can be unhooked from the lever 9, if desired, for greater convenience but this not is necessary.

The oil chamber *13* consists of the oil chamber proper, which is fitted with two non-return oil valves in its upper wall, one on each side of the central pivot, and an upper cover provided with a slot through which the lever *9* moves. The oil chamber is completely filled with Castrol XXL Oil a small quantity of which should be present above the chamber and beneath the slotted cover. It is not practicable to make the working joint at the lever pivot absolutely oil tight so that when the lever moves and the paddle exerts pressure on the oil on one side of the chamber there is a small leakage up through the centre joint in addition to the desired slow flow through an aperture in the paddle and the clearances between paddle and chamber walls; whenever pressure due to paddle movement is exerted on one side of the chamber, there is an equal suction on the other side which is relieved by a flow of oil from that present above the chamber but below the slotted cover-plate, so that the oil chamber itself is always entirely filled with oil. Any loss of oil can be made good by adding a little more Castrol XXL oil through the cover-plate slot by means of a pipette, fountain pen filler, or other suitable means.

To prevent damage to the speed recorder gear by sudden movements which may occur when being hoisted in or vice-versa a mechanical stop 18 limits the relative movement between recorder, base-plate *3* and bar *1* in both directions, but the presence of this stop does not lessen the necessity for careful handling.

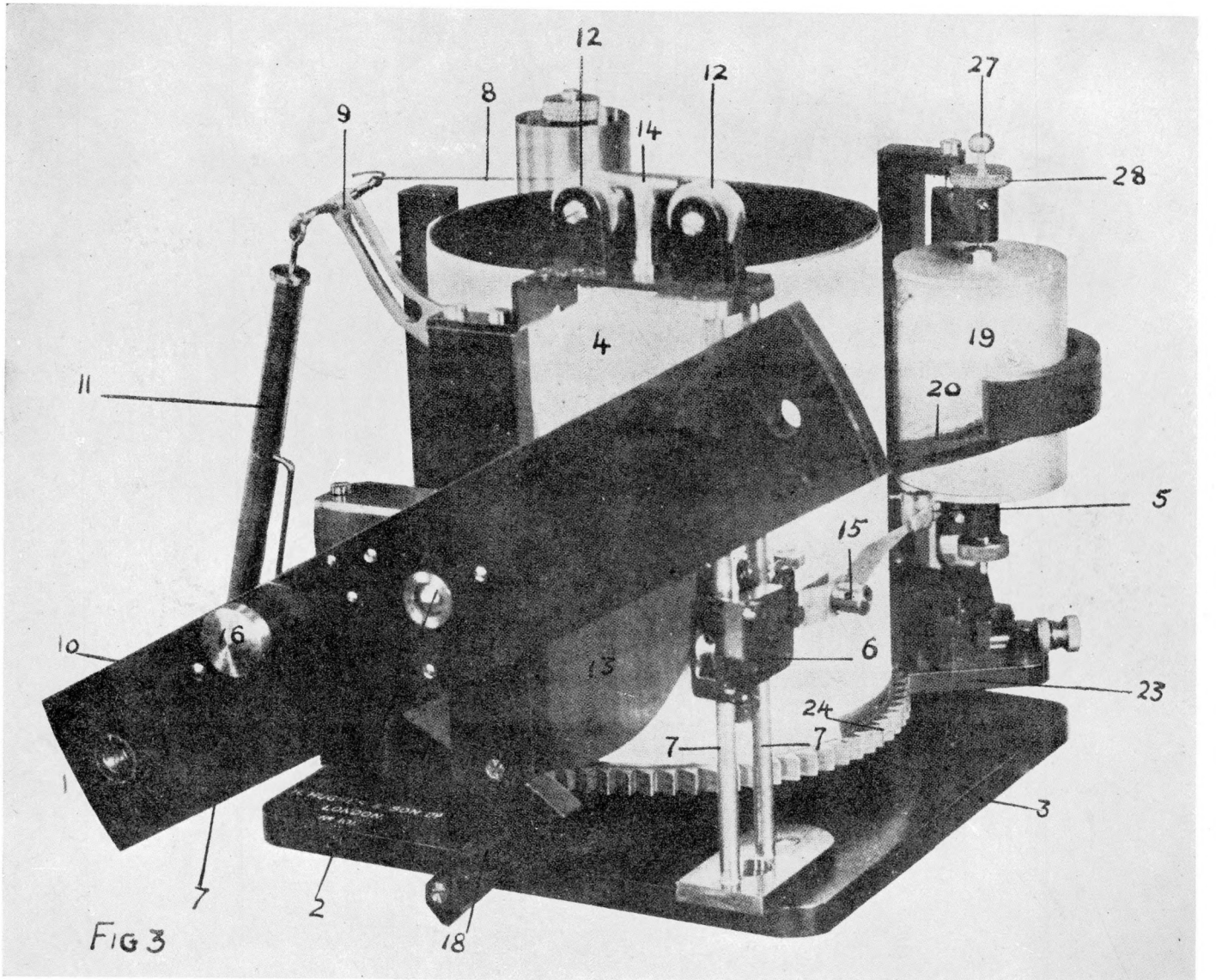

FIG 3

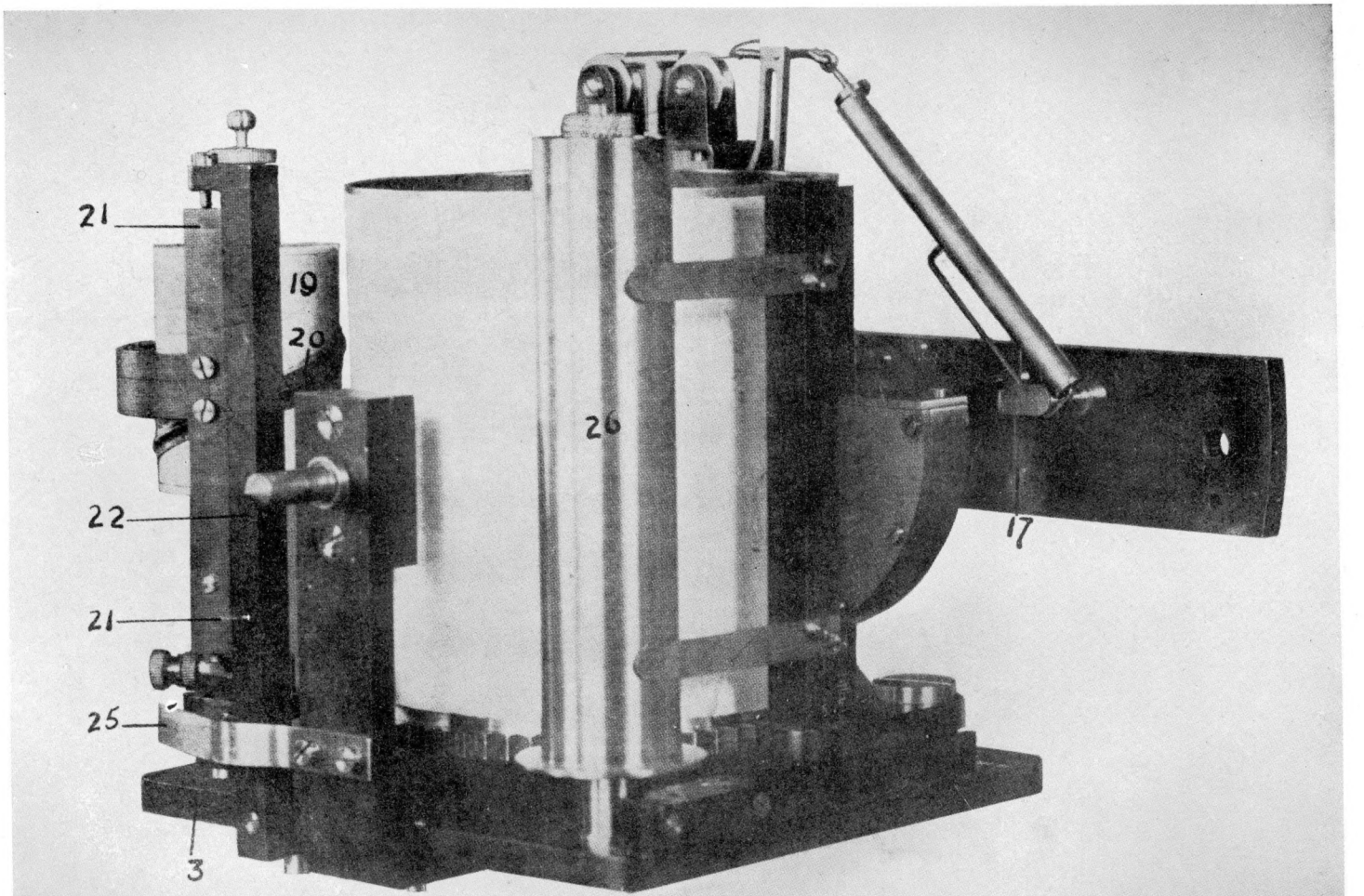

FIG 4

The direction recording gear consists of a cylinder *19*, mounted on jewels between pivots, containing two parallel magnets, and having on its outer surface a raised spiral covered with inked ribbon *20*; the cylinder carrier *21* is pivoted, parallel to the cylinder pivots, between other pivots attached to an upright *22* secured to the base-plate *3*.

The carrier *21* is provided with a pawl *23* arranged to engage with 72 teeth *24* on the base of the clock drum; there is also an arrangement of two springs and an adjustable stop in order to obtain the motion now described.

As the record drum revolves the pawl *23* is alternately lifted on a tooth *24* and allowed to fall into a space between two teeth; when the pawl drops, the cylinder with its ribbon covered spiral *20* is propelled towards the drum by the driving spring *25* until the pawl is stopped by the base of the next tooth; the cylinder having acquired momentum, over-runs until the spiral strikes the paper-covered clock drum, making a mark, and is then returned clear of the paper ready for the next time of operation by a second spring. The parts are so adjusted that the height of the mark on the paper above the clock drum base indicates the direction toward which the current was flowing.

A supply of paper can be carried on the cylinder 26.

In order to avoid uncertainty as to the exact position occupied by the record paper with regard to the recorder due to variation in securing the paper to the clock drum, and, where required, the use of more than one clock drum, a datum marking device has been added.

This marking device consists of a sharp edged wheel carried on a pivoted spring driven arm in such a way as to be held positively away from the drum or hard up against it, these two positions being on opposite sides of a dead centre. The wheel is intended to be snapped in and out in one or two positions round the drum, when it will leave a definite impression on the paper, a straight line through these positions is the required datum line. Thus, the normal position of the datum marker is out of contact with the drum,

On no account should the clock be run with the datum marker wheel in contact with the drum as this may cause the paper to be dragged up or down the drum, so spoiling the record.

The datum marker is not shown on the illustrations but is secured to the upper side of the base-plate *3* between the oil chamber *13* and the square pillar carrying the two flat springs which bear on the paper storage cylinder *26*.

SCALES.

Each instrument is supplied with a glass plate having the necessary scales etched on the underside.

As there are two pairs of pressure plates, there are two sets of scales on each glass, one for each size.

The scales show the datum line, the speed scale, and also the direction scale displaced by the correct distance obtaining in the instrument to which it belongs; thus, when the scale is placed on the chart, with datum lines superimposed, the direction scale will read the direction corresponding to the speed read on the speed scale.

INSTRUCTIONS FOR USE.

Assembling the Instrument.

The instrument is supplied packed in two boxes, the larger one containing all the external parts together with a wooden supporting block for the drum, the smaller containing the recorder, magnetic system, and extra clock if supplied.

It is assumed that the instrument will be hoisted outboard for lowering by a derrick or the like.

From the large box take the main frame, vane shackles etc., assemble these and attach to the lowering line allowing the bottom of the main frame to rest on the deck; next add the drum *L* and secure in place by shackles *P,P*, finally assemble the complete pressure plate system and secure this in the hangers by the retaining pieces *JJ* and shackles *KK*.

Reference to figure 1 will greatly facilitate the first assembly especially when it is also noticed that the streamline shape of the lead sinkers shows the difference between fore and aft and the drum *L* is engraved *AFT* on the after side of the top plug.

Next remove the pressure plate system as a whole, fastening the retaining pieces by the shackles forward of the hangers, for which purpose the shackles can be swung over

before lifting the bar of the pressure system. Now remove the drum and hangers by undoing the shackles *PP* and carry the drum into the chart-room in slings keeping it upright; in the chart-room it is placed in the cradle provided for this purpose, packed in the large box.

After placing the drum in the cradle, undo the six nuts securing each endplate and remove the endplates, noticing that they are marked on their edges with one and two nicks respectively and that these markings correspond to similar markings on the drum flanges.

Now open the small box and take out the recorder; the magnetic compass is packed separately and requires to be put in place; unclamp the milled head *28* shown in Fig. 3 and lift the pivot *27* so as to admit the compass cylinder with the end marked *TOP* upwards; see that the lower jewel is correctly on its pivot and push down the upper pivot *27* till it engages with the very slightest trace of vertical shake; screw up the clamp *28* and retest the vertical shake; the compass should now swing freely. While doing this the compass carrier frame may be swung outwards over the dead centre with advantage, as it gives better accessibility.

Now attach the end of a piece of paper carried on the supply from cylinder to clock drum using any suitable adhesive, the adhesive being applied in a narrow band to both paper and drum; wind up the clock and swing the compass round to its working position with the pawl *23* engaging the teeth *24*. See that the inked spiral is very nearly in contact with the paper when the pawl is housed in an interspace of the toothed ring.

Wash the pen *5* with a little spirit; clear the bore of the horizontal part used to mark the chart with the fine wire provided, and fill with the special barograph ink supplied. See that the pen marks the paper when the drum is slightly rotated by hand. The pen must, however, only just touch the paper. Test the vertical movement of the pen by careful movement of the lever *9*. This test should be repeated with the bar *1* and connecting piece *11* in place. Move the bar *1* to an angle and watch the pen rise. Move bar *1* back to horizontal and watch the pen fall. Rise and fall should be so slow as to be hardly perceptible. See that each movement is complete and pin *10* in contact with wire loop on *11* and cap at top of tube *11* in contact with tube on completion of each mcvement. Set zero as explained in General Notes. The recorder is now ready for mounting in the instrument drum.

From the drum on the cradle remove the bar carrying the actuating pin *10* and the knob *16*, and slide it on the trunnion of the recorder, adjacent to the oil chamber *13*; now place the recorder on the right hand, bar over wrist, and slide it into the instrument drum, steadying it with the left hand. Lift recorder and guide the other trunnion into the other bar which has not been removed. This is quite simple after short practice. The first bar can now be carefully entered by means of its steady pins, pushed home and screwed down firmly. The connecting piece *11* is now attached to the hook on the lever *9* (Fig. 3) with its loop downwards and inwards, the knob *16* depressed, the loop entered over the actuating pin *10*, and the knob *16* released completing the connection between the bar *1* and the recording gear.

Replace the endplates seeing that all nuts are tightened up equally; replace the drum in the frame; replace the pressure bar system and the apparatus is ready for hoisting out.

REMOVAL OR CHANGING OF CHARTS.

After hoisting in the apparatus, the pressure bar system is removed and then the drum, which is carried to the charthouse and placed in its cradle, hangers downward, as before.

The endplate marked "Open this side" is then removed, the connecting piece *11* unshipped after pressing the knob *16*, the bar *1* unscrewed and removed while supporting the recorder gear by the right hand which can then be used to withdraw the recorder gear. The old chart is then cut from the clockdrum after swinging the compass cylinder outwards for convenience.

A new chart can now be fixed to the drum ready for a new record.

If the apparatus is to be stored the compass cylinder should be unshipped and stored with the recorder in the small box and the remainder stripped down and stored ln the large box together with the cradle according to the stowage plan affixd inside the lid of the box.

SERVICING.

The following points require lubrication with Castrol XXL oil; *very slightly* oil the trunnions on the recorder; the compass actuating pawl, the teeth on the ring and the two springs operating the compass marking.

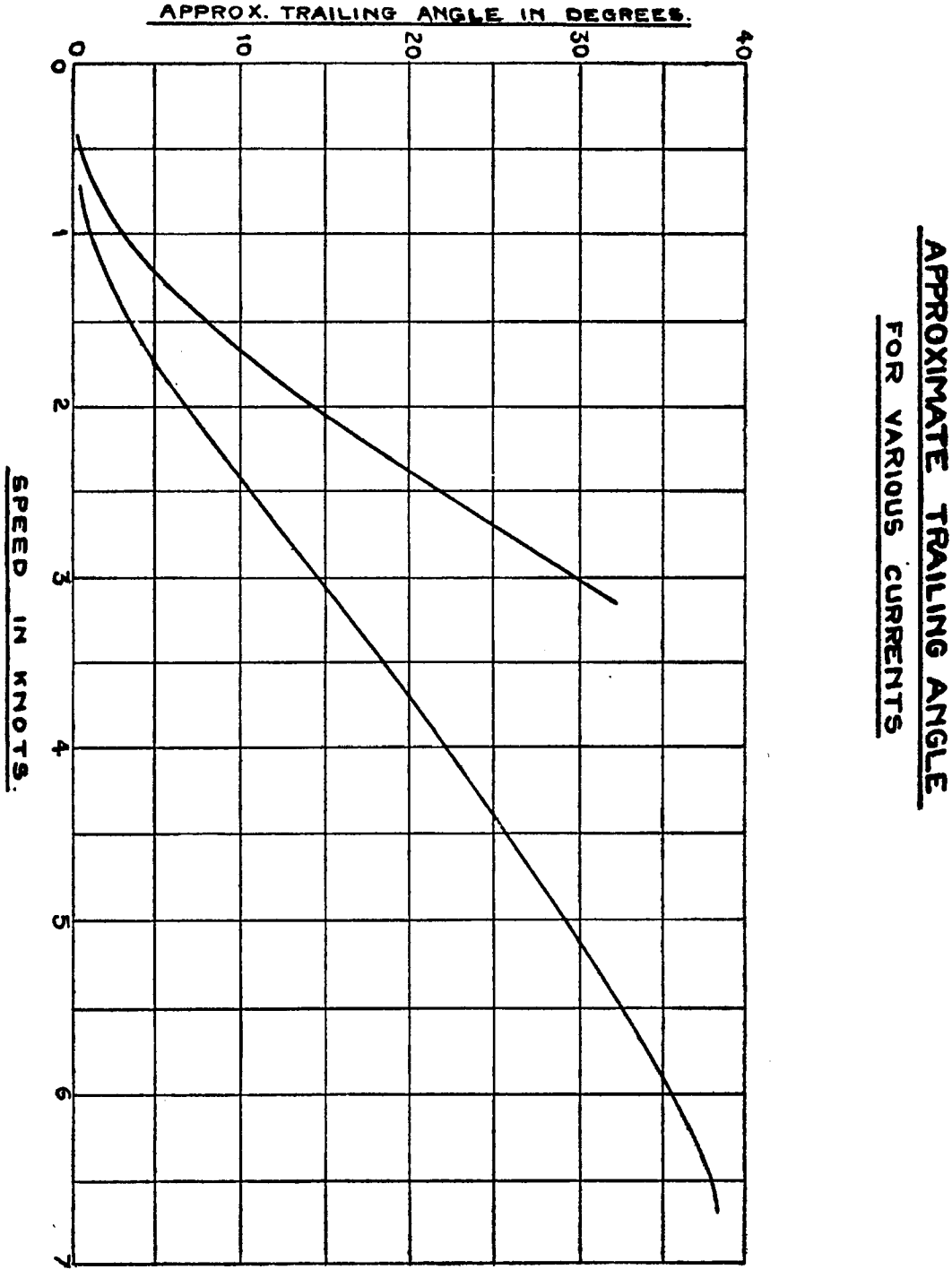

FIG. 5

Approximate trailing angle in degrees for various speeds of current in knots.

The main ball-bearing shackle by which the gear is suspended should be packed with a good grease.

No other lubrication is necessary.

The *Ditmar* pen may gum up in course of time and will certainly do so if not in use. It can be cleared by means of the fine wire supplied which can be pushed through the ink channel. Keep a small piece of horse hair in the pen channel when pen is not in use.

The gear should be overhauled at the end of every season when the ball-bearing in the main suspension shackle will require renewal.

GENERAL NOTES.

All shackles are so arranged as to be capable of being screwed up in some position after releasing the parts they secure so that there need be no small loose parts to get lost.

See all shackles, set-screws, and nuts are tight before hoisting out.

When carrying the drum to and fro use slings and be careful to keep the screw plug at the top; handle very gently and steadily. See that the small balance weights *D* hang exactly vertically below *B*, and face exactly fore and aft. The ends of bar *F* must be flush with the holes in *BB*.

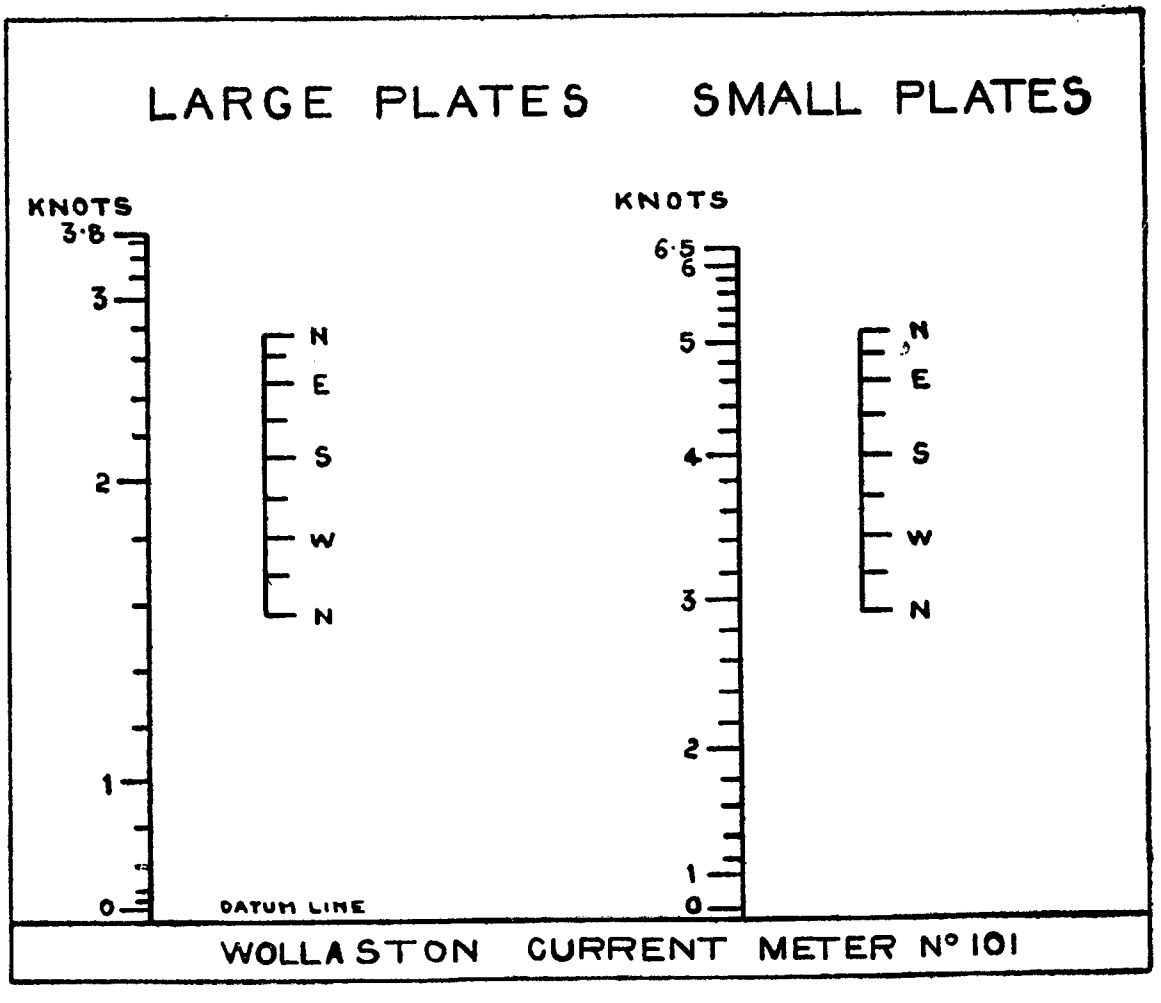

FIG. 6

Figure 6 represents the glass scale to half size of the WOLLASTON *current meter N°* 101 *(large plates and small plates).*

This instrument was awarded by the Society of Arts, London, the Thomas GRAY *Memorial Prize for the most valuable aid to the science of Navigation in* 1935.

Watch zero of compass and speed recorder, and see that the paper fits right down to the base of the drum. The compass spiral is set so that the spiral is just out of contact with the paper when the pawl is right home on the root of a tooth. The pen is at zero when the bar *1* is at right angles to the trunnion bar of the recorder. See that the pen is free to move slightly below zero. Make a pencil mark at zero. See there is always a little oil above the oil chamber proper and below the slotted cover-plate; add Castrol XXL as required.

Brush over compass ribbon with typewriter ink when the marks become too faint to be easily read.

Always swing the compass away from the clock drum when not in use, or when working on the recorder.

Do not lower the apparatus into the water except when facing approximately against the current.

The complete pressure plate system may be kept ready assembled throughout the season of operations.

SPECIAL OPERATIONS.

Changing the pressure plates.

The apparatus is supplied with two pairs of pressure plates, large and small, the large ones being intended for use with currents up to about 3 ½ knots, and the small ones for currents up to 7 knots.

The plates are all of the same weight, and the large ones therefore thinner; these have washers permanently secured to one face of such thickness as to bring the centre of gravity of all plates the same distance from the face of the small plates or the face of the washer of the large plates.

To change the plates the outer securing nut is unscrewed, the plate removed, the other plate put in place (washer inwards if a large plate), and the nut replaced and screwed home.

CHANGING THE CLOCK-DRIVE. (*Where supplied*).

The recorder gear is removed from the apparatus, the central nut found in the centre of the underside of the base-plate undone, and the compass gear swung to the out position.

By carefully holding back the speed recording pen just sufficiently to clear, the clock-drum can be removed by withdrawing it vertically upwards.

The other clock drive can be mounted carrying out the operation in the reverse order, not forgetting to tighten up the nut under the base-plate which serves to anchor the whole drive and keep it from slipping.

EVALUATION OF RECORD CHARTS.

The charts obtained from the instrument can be read off by means of the transparent scales supplied with the instrument.

SPECIAL CAUTION.

When hauling in at the end of an observation, if a strong side is running, the gear must not be hauled at a speed in excess of *2 knots or it may be damaged.*

DIMENSIONS & WEIGHT.

Height	4-ft.
Width	4-ft.
Depth	2-ft.
Weight	182-lbs. net.