THE JACOBSEN CURRENT METER.

Although the Jacobsen Current Meter is not a new instrument, it has not previously been described in this *Review*. It is thought that an account of it may be of interest, particularly in view of its simplicity and ease of operation by unskilled personnel, *e. g.* on board a lightship.

The following information is taken from a paper by the inventor and from *Fishery Notice N° 17* of the *Ministry of Agriculture and Fisheries.*

The picture (Fig. 1) shows the apparatus as rigged for use from a ship, and its size can be roughly judged from the man standing beside it. Fastened firmly to the ship's rail is a strong bracket, usually secured at the inboard end by two stout clamps the jaw-widths of which are adjusted by stout screw-bolts under the rail. The bracket carries a flat iron plate swung in gimbals, and on the upper surface of this plate are two circular levels.

From the underside of the plate an iron tube projects downwards from the centre for a short distance. This tube is actually screwed into the plate at its upper end and above it is a small bushed hole through the centre of the plate. This hole is exactly midway between the levels.

The davit seen in the picture carries a small handwinch which can be locked at will. From this winch a stranded steel wire is led over a measuring block, passed down through the centre hole in the plate, and on through the iron tube; the free end is then secured to a cylinder something like a small ash-bin with no bottom. Alternatively a special sinker can be attached to the end of the wire, or even a sinker and the cylinder. When the wire is paid out from the small drum and the cylinder allowed to submerge (this from a ship anchored in a tideway) the cylinder is borne aft and the level-plate consequently tilted. (Fig. 2).

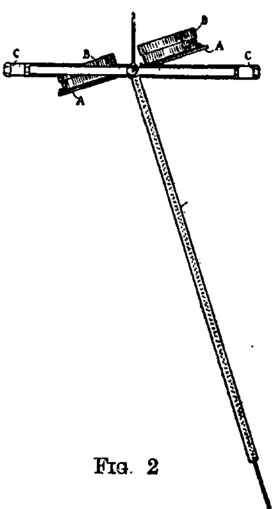

FIG. 2

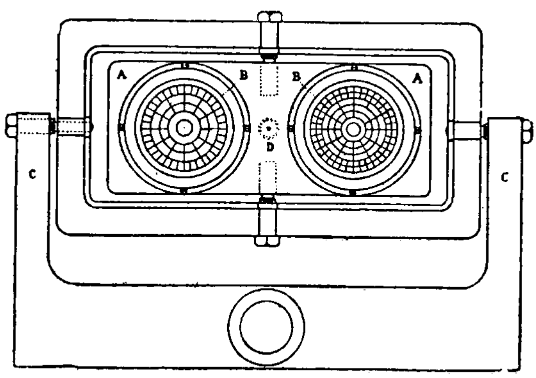

FIG. 3

The glass covers of the spirit-levels are marked with concentric circles denoting the inclination of the levels for every five degrees up to 20° and 30° respectively, and with radii denoting the direction of tilt to the nearest ten degrees (Fig. 3).

An observer working the meter can be provided with a record book of very simple forms on which to write the bubble positions as so many angular dial divisions to port or starboard of the forward or aft points of the dials, and as being under the first or second or third circle from the centre, and so on. Then he logs the ship's head at the time and he has made a written record of all that is wanted. The remaining calculations can be made in office.

INSTALLATION.

The instrument is first calibrated against some other meter such as the Ekman.

It is usually advisable to instal the meter about half way between the bow and stern, and in such a way that it may be transferred from one side of the vessel to the other to avoid the wire fouling the ship's side. When possible it should be fixed in the fore and aft line of the ship, but if this is not possible the angle between its longitudinal axis and that of the ship must be determined and this angle allowed for when logging the readings.

SPIRIT LEVELS. (*see* Figs. 3 & 4)

Each of the spirit levels consists of two adjacent but independent chambers, the lower one having a domed glass top and the upper one a plain glass window. The graduations are marked on the convex glass only, the upper bubble being used merely as a rough guide to the general direction of the tilt. The 30° level is used for stronger, and the 20° for weaker, currents.

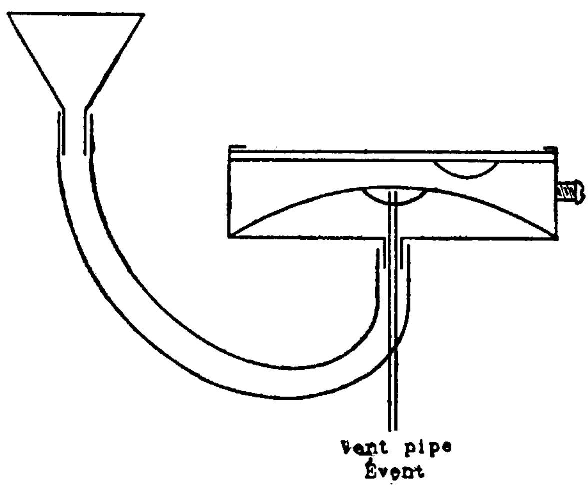

FIG. 4

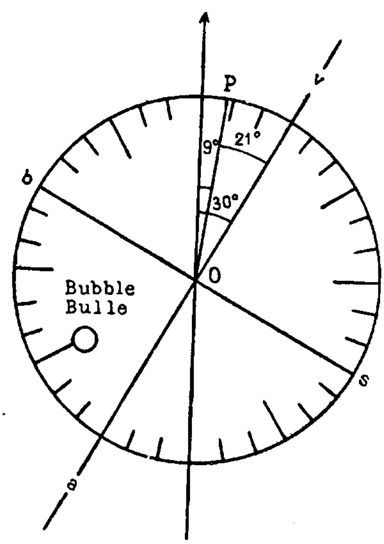

FIG. 5

The size of the bubble is normally from 5 to 10 m/m diameter. As this may be affected by changes of temperature, small air-leaks etc. each chamber is provided with arrangements for adjusting it. Should the bubble in the lower chamber be too large, a device is used consisting of a funnel and tube with a small vent-pipe fixed in the latter. The plug is removed from the filling orifice, and the tube of the filler placed over the neck of the orifice. The liquid (alcohol and water) is then poured in and will fill the chamber, the air escaping through the vent pipe. If too much air should escape, or if the bubble should be too small to begin with, air in small quantities may be admitted through the filling hole before finally screwing home the plug.

The same proceeding holds good for the upper chamber, the level being then held on its side.

Before use, the zero position of the bubble must be verified. With the ship at rest and upright, a sinker is attached to the wire below the pipe and any eccentricity in the position of the lower bubble corrected by means of adjusting screws which will be found under the level.

STREAMING THE CYLINDER.

The wire is veered by the hand-winch, the amount paid out being shown by the measuring block. Owing to the obliquity of the wire in a current, the length to be veered will exceed the depth at which the observation is to be made. This length depends on the formula $L = \frac{d}{\cos V}$, where d is the depth of the cylinder and V the angle of slope of the wire as measured by the spirit level. The curvature of the line, which is discussed below, may be neglected for this purpose, and the observer can be provided with a table giving values of L for different values of d and V.

When observations are being made at varying depths, it may be necessary to use two cylinders, generally a smaller one for the upper strata and a larger one for the lower strata. For the larger one to reach the lower strata without drifting too far in the upper strata it may be necessary to veer the wire very quickly.

READING THE LEVELS.

Owing to the motion of the ship, the bubbles move from their position of equilibrium during the readings. It is therefore important to find the mean position.

Fig. 5 shows the markings of the periphery of the levels. The four principal directions are marked *v*, *a*, *b*, and *s* signifying *vor* (forward), *achter* (aft), *backbord* (port) and *steuerbord* (starboard). The line *av* shows the longitudinal axis of the apparatus. A point P is marked on the rose to show the position of the ship's head. The level may be read as one would a compass rose, and in the case shown in the figure the ship's head would be entered as "*v* 21° *b*" and the position of the bubble as "*a* 30° *b*".

Readings for 2 ½, 5, 10 and every 5 metres up to the maximum observed must be entered in the record book, to enable corrections for curvature to be applied afterwards. It is possible to obtain the necessary readings up to 25 metres in a quarter of an hour, even if the cylinder has to be changed during the operation.

The results are entered as sohwn in Table I.

EFFICIENCY.

The inventor claims to have obtained good results in Danish waters up to a depth of 30 metres in good conditions. But if the surface current is strong and the deeper current weak, good results will not be obtained even at less than 30 metres.

CORRECTION OF READINGS IN OFFICE.

I. — Direction.

A convenient ready reckoner can be made from two pieces of cardboard to ensure the correct entry of the bubble directions (*see* Fig. 6). From one piece a disc is cut and marked to correspond with the graduations round the levels, and this is mounted axially on the other piece which is marked as a compass rose. The inner card is rotated to apply compass error and difference between longitudinal axes of ship and instrument, and the correct direction of the bubble position can then be read directly from the outer card in line with the position where it appears on the inner card (the latter being the same as its position on the level). The result is entered in Col. 6 of the form (Table I).

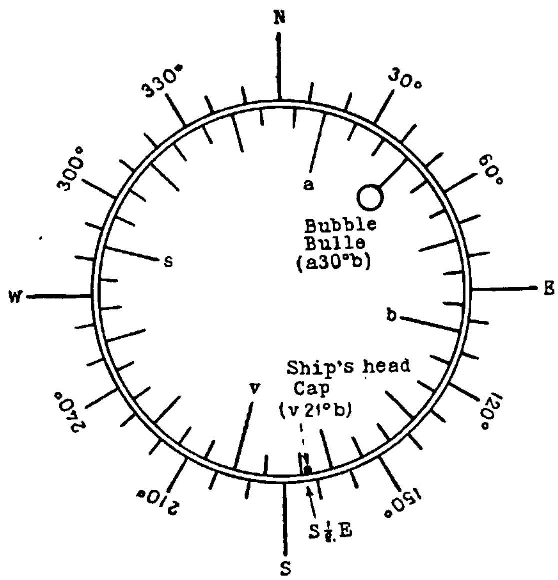

Fig. 6

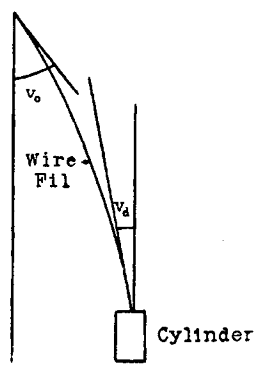

Fig. 7

II. — Correction for curvature.

As already mentioned, the wire is curved by the current. The curvature may be represented (*see* Fig. 7) by the difference between the angles subtended by wire and vertical at the spirit level (V_o) and by wire and vertical at the depth d (V_d).

Table II and the diagram reproduced at the end of this article are intended to provide the necessary corrections, due to this curvature, to be applied to the readings to obtain the correct velocity and direction. They are worked out empirically and based on summer temperatures; probably a difference of the order of 10 % will be found between summer and winter velocities, the directions remaining unaltered. They are also based on a wire of 1.7 m/m (0.067 ins.) and a cylinder weighing 15 kg (33 lbs.) in air. Only a portion of the diagram is illustrated, and in practice it is constructed with the circles at 1 c/m intervals. A centimetre ruler and a protractor, or a centimeter parallel ruler, are required, as well as some pins.

The method of use will be described by taking the readings shown in Table I as an example.

For a depth of 2 ½ metres the direction shown in Col. 6 is merely transferred to Col. 8. The strength of the current at 2 ½ metres depth is obtained from the table, in the column appropriate to the size of cylinder in use and in line with the angle shown by the spirit level. In the present case this is 105 c/m/sec., which is entered in Col. 9.

At the same time we find that the curvature as represented by $V_o - V_d$ is equal to 2.6° for a 5 metre length of cable, and assuming a regular increase of curvature, the latter will be 1.3° at 2 ½ metres. We now enter the diagram, representing the curve by a pin placed 1.3 c/m from the centre in a direction 045° (point *b*).

In the figure, the current at 2 ½ metres has been drawn through position *A*, but this is not necessary for the calculation.

The spirit level angle for the 5 metre depth, in this case 19°, is now plotted by placing a pin 19 c/m from the centre in a direction 045° (point *B*).

Pin *B* thus lies 17.7 c/m 045° from pin *b*. The figure 17.7 represents the inclination of the cable at 2 ½ metres when the cylinder is at 5 metres. Entering the table with this figure we obtain a current velocity at 5 metres of 98 c/m/sec. which we enter in Col. 9, and the line joining the pins gives us the direction 045°, which we enter in Col. 8.

According to Table II, a current of 98 c/m/sec. produces a curve of 2.3° in a 5 metre length of cable, and we know that this curve is in a direction of 045°. To find the curve of the upper 7 ½ metres of cable, the curve (1.3°) of the upper 2 ½ metres and the curve (2.3°) of the cable between 2 ½ and 7 ½ metres must be added together. As both these curves occurred in the same direction, the calculation can be made arithmetically; or it may be made graphically by drawing a line *bc* 2.3 c/m in the direction 045°, and moving pin *b* to *c*. From the record we find that the deflection of the line at 10 metres was 22° in a direction 055°. This is shown by moving pin *B* to a point *C* lying 22 c/m from the centre in the direction 055°.

TABLE I

1918 — MARCH 3rd / 3 MARS — SCHULTZ'S GROUND. — VARIATION OF COMPASS 9° W / DÉVIATION 9° W

Direction of centre line of apparatus with reference to fore & aft line of ship 30° to Stbd.

Direction de la ligne de foi de l'appareil par rapport à la ligne de foi du navire. 30° à tribord.

Columns marked (*) to be filled in office.
Les colonnes marquées d'un astérisque sont remplies au bureau.

Time. *Temps* 1	Cylinder. *Cylindre* 2	Angle of Tilt. *Angle d' inclinaison* 3	Ship's Head. *Cap du navire* 4	Direction of bubble. *Direction de la bulle* — on scale. *sur l'échelle* 5	true. *vraie* 6*	Depth of cylinder. *Profondr du cylind.* 7	Current. - *Courant* — Direction 8*	Strength. *Force cm./sec.* 9*
19 h. 35 m.	50×20	20°	S ½ E.	*a* 30° *b*	*045*	2 ½	*045*	*105*
	»	19°	»	*a* 30° *b*	*045*	5	*045*	*98*
	»	22°	»	*a* 40° *b*	*055*	10	*057*	*100*
	90×28	27°	»	*a* 50° *b*	*065*	15	*069*	*63*
	»	11°	»	*a* 50° *b*	*065*	20	*085*	*25*
19 h. 55 m.	»	7°	»	*a* 50° *b*	*065*	25	*149*	*12*

DIAGRAM — DIAGRAMME

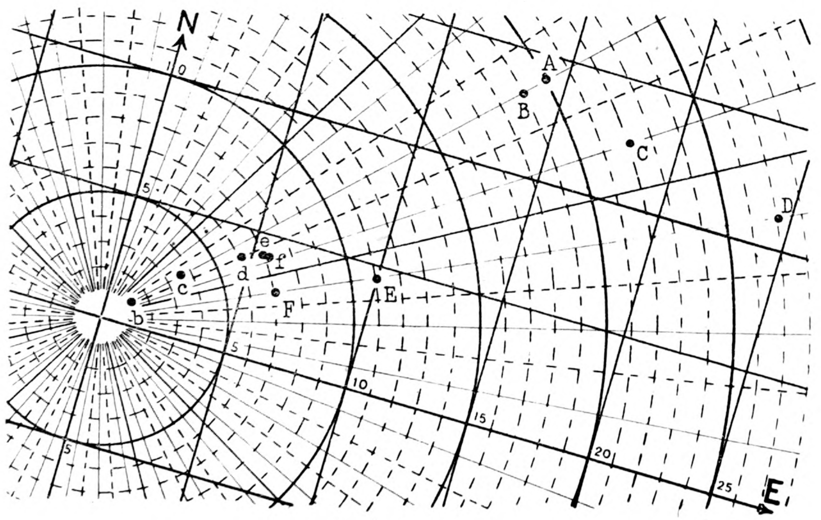

TABLE II

VELOCITY AND CURVATURE. — *VITESSES ET COURBURES*

The Table gives current velocities in c/m/sec. for angles up to 30° as measured by the meter, with the cylinder lowered to a depth of 2 ½ metres; also the curvature of a 5-metre length of cable corresponding to these velocities. Figures calculated for a cable of 1.7 m/m and a cylinder weighing 15 kg. in air, under summer conditions.

Cette Table donne les vitesses du courant en cm/sec. pour des angles allant jusqu'à 30° mesurés par l'appareil, le cylindre étant immergé à 2 m. 50 de profondeur, ainsi que les courbures d'un câble de 5 mètres de long correspondant à ces vitesses. Ces chiffres sont calculés pour un câble de 1 m/m 7 et un cylindre pesant 15 kgs. dans l'air, en été.

Dimensions of cylinder. *Dimensions du cylindre*	90×56		90×28		50×20		30×15	
Angle.	Velocity. *Vitesse*	Curvature *Courbure*	Velocity. *Vitesse*	Curvature *Courbure*	Velocity. *Vitesse*	Curvature *Courbure*	Velocity. *Vitesse*	Curvature *Courbure*
1	8	0.0	9	0.0	15	0.1	23	0.1
2	14	0.0	15	0.1	24	0.1	39	0.4
3	17	0.1	19	0.1	30	0.2	52	0.6
4	20	0.1	23	0.1	37	0.3	62	0.9
5	23	0.1	26	0.2	43	0.4	71	1.2
6	25	0.2	29	0.2	48	0.6	80	1.5
7	28	0.2	32	0.2	53	0.7	88	1.9
8	30	0.2	34	0.3	59	0.8	95	2.2
9	31	0.2	37	0.3	63	1.0	102	2.5
10	33	0.3	39	0.4	67	1.1	108	2.8
11	35	0.3	42	0.4	72	1.2	115	3.2
12	36	0.3	44	0.5	76	1.4	120	3.5
13	37	0.3	46	0.5	80	1.5	126	3.8
14	38	0.3	49	0.6	84	1.7	131	4.1
15	39	0.4	51	0.6	88	1.9	138	4.6
16	40	0.4	53	0.7	92	2.0	142	4.8
17	41	0.4	55	0.7	95	2.2	146	5.1
18	42	0.4	57	0.8	99	2.4	150	5.4
19	43	0.4	59	0.8	102	2.5	155	5.8
20	44	0.5	60	0.9	105	2.6	159	6.1
21	45	0.5	62	0.9	108	2.8		
22	46	0.5	64	1.0	111	3.0		
23	46	0.5	66	1.0	114	3.1		
24	47	0.5	68	1.1	116	3.2		
25	47	0.5	69	1.1	119	3.4		
26	48	0.6	71	1.2	121	3.5		
27	48	0.6	73	1.3	123	3.6		
28	49	0.6	75	1.3	124	3.7		
29	49	0.6	76	1.4	126	3.8		
30	50	0.6	78	1.5	127	3.9		

The line *cC* gives us the direction of the current at a depth of 10 metres, namely 057°, which is entered in Col. 8 ; and entering Table II with the length of the line *cC*, which we find to be 18.4 c/m, we obtain the strength of the current at 10 metres, namely 100 c/m/sec, which we enter in Col. 9.

This current produces in a 5 metre length of cable a curve of 2.4° in the direction 057°. This curve is shown on the diagram by the line *cd*, and the point *d* (to which the pin is moved from *c*) represents the total curve from the surface to a depth of 12 ½ metres. The curve of the cable for the 15 metre depth (now using a 90 × 28 cylinder) is found to be 27° in a direction 069°. This is represented by moving pin *C* to *D*. The line *dD* is found to be 21.3 c/m in a direction 069°. The direction of the current at 15 metres is therefore 069°, and its strength (from the Table) 63 c/m/sec.

The process is continued to find the direction and strength at all depths. It is claimed that with a little practice the values for Table I, for instance, can be worked out in five minutes.

The calculations may also be worked mathematically by a method, based on the above procedure, demonstrated by A. T. Doodson in the *Journal du Conseil* (1). The time taken will probably be about the same.

W. G. G.

(I) A. T. Doodson : Current Observations at Horn's Rev, Varne and Smith's Knoll in the years 1922 and 1923. *Journal du Conseil,* V, 1, p. 22, Copenhagen 1930.