NEW CURRENTMETER
FOR MEASURING CURRENTS NEAR THE BOTTOM

by Commander Georges ORTOLAN, French Navy (Retd.)
Naval Adviser to DORIS

Introduction

While studying the layout for submarine oil pipelines SEGANS found it necessary to measure currents in the water-layer immediately above the bottom.

When the first work was started around 1958-1959 the existing measuring equipment did not include any instrument for continuous recording capable of producing data that were sufficiently close together in both time and space. We therefore conceived an instrument specially adapted to our needs and to the required accuracy for our work.

The principle adopted was that of an inclinometer as already used by Professor CARRUTHERS in devising his " pisa ".

The required data essentially concerned the range 0.5 to 2.5 knots (within which a measuring accuracy of the order of 0.2 knots was sufficient). The data had to include as complete a picture as possible of the variations in time of this current in order to be able to go very closely into the nature and the magnitude of the essential phenomena.

These are the basic motives which led us to develop the " courantophote " which the reader will find described hereinafter.

SEGANS conducted operations up to the point intended. Its personnel and techniques are at the present time being used by DORIS (Développement Opérationnel des Richesses Sous-marines) one of whose principal aims is to study the instrumentation required in the exploitation of oil drilling at sea.

We thank the Service Central Hydrographique de la Marine, the Bassin des Carènes (Experimental tank) management, and in particular Messieurs EYRIES, Ingénieur Hydrographe, BINDEL and GARGUET, Ingénieurs du Génie Maritime, most warmly for the help and understanding that they have extended us in the course of the production and development of this " courantophote ".

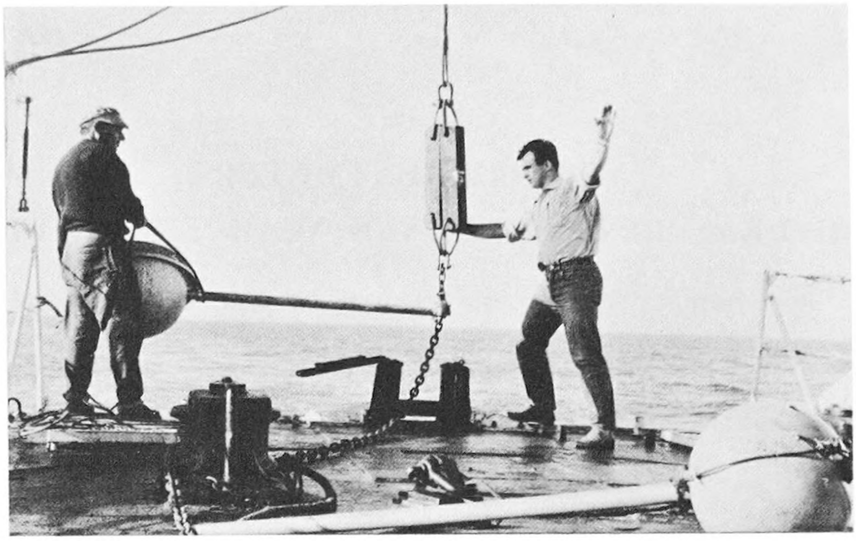


FIG. 1

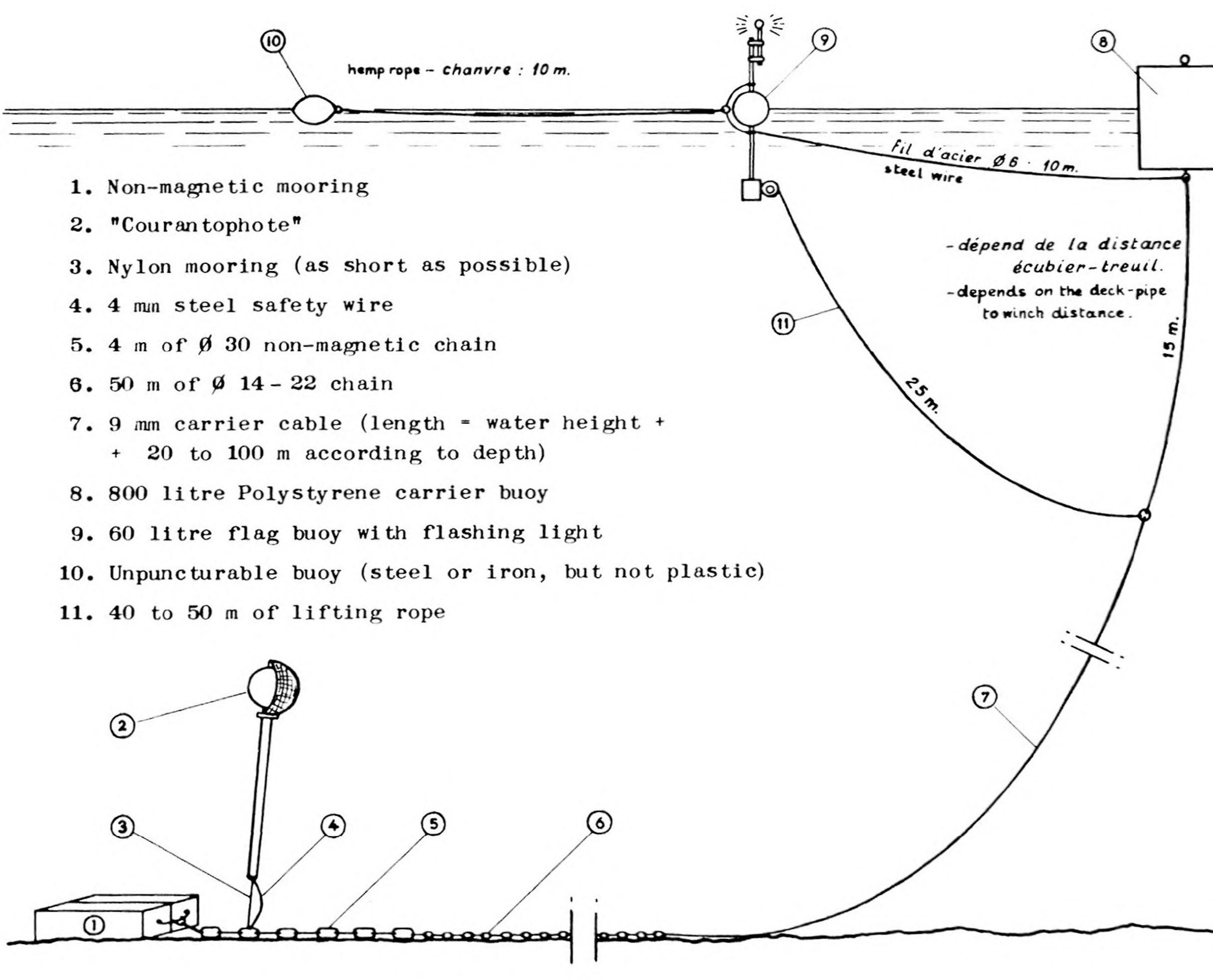

hemp rope - chanvre : 10 m.
Fil d'acier Ø6 · 10 m.
steel wire
- dépend de la distance écubier-treuil.
- depends on the deck-pipe to winch distance.
15 m.
25 m.
1. Non-magnetic mooring
2. "Courantophote"
3. Nylon mooring (as short as possible)
4. 4 mm steel safety wire
5. 4 m of Ø 30 non-magnetic chain
6. 50 m of Ø 14 - 22 chain
7. 9 mm carrier cable (length = water height + + 20 to 100 m according to depth)
8. 800 litre Polystyrene carrier buoy
9. 60 litre flag buoy with flashing light
10. Unpuncturable buoy (steel or iron, but not plastic)
11. 40 to 50 m of lifting rope

FIG. 2

I. — General

Constructed during the summer of 1960, with the help of the Bassin des Carènes, this instrument is intended for measuring currents in the immediate vicinity of the bottom. It is fixed to a mooring anchored on the bottom and connected to a surface buoy by a steel or nylon cable.

Figures 1 and 2 give block diagrams of the whole " courantophote " and its anchoring on site.

The handiness and the light weight of the equipment, excluding naturally the winch, are such that one man can, without difficulty, carry out by hand, in a fairly calm sea, all the manipulations necessary for putting it into action.

II. — Birth of the instrument

The various graphs showing the lifting forces in terms of the thickness of the globes to be used for the different depths envisaged were computed by the constructor and then used with the other parameters (shapes, weights, velocities, limits of the possible angles of inclination, measuring range, etc.) for carrying out a preliminary study of the equilibrium of the instrument set in a current.

We give below the elements of this preliminary study.

Figure 3 gives the various parameters. The principle proposed involves the measurements being made at the instant when, under the action of the forces applied, the system is in equilibrium, i.e. that the moment resulting from the external forces in relation to the point of attachment 0 is zero.

This may be written :

$$(1+r)\ P_s\ \sin\ \theta = \frac{1}{2}\ P_c\ \sin\ \theta + \frac{1}{2}\ N_c + (1+r)\ R_s\ \cos\ \theta$$

The computations of N_c and R_s give :

$$N_c = 79.71\ dV^2 \cdot \cos^2\theta$$

and

$$R_s = 16.01\ r^2 \cdot V^2$$

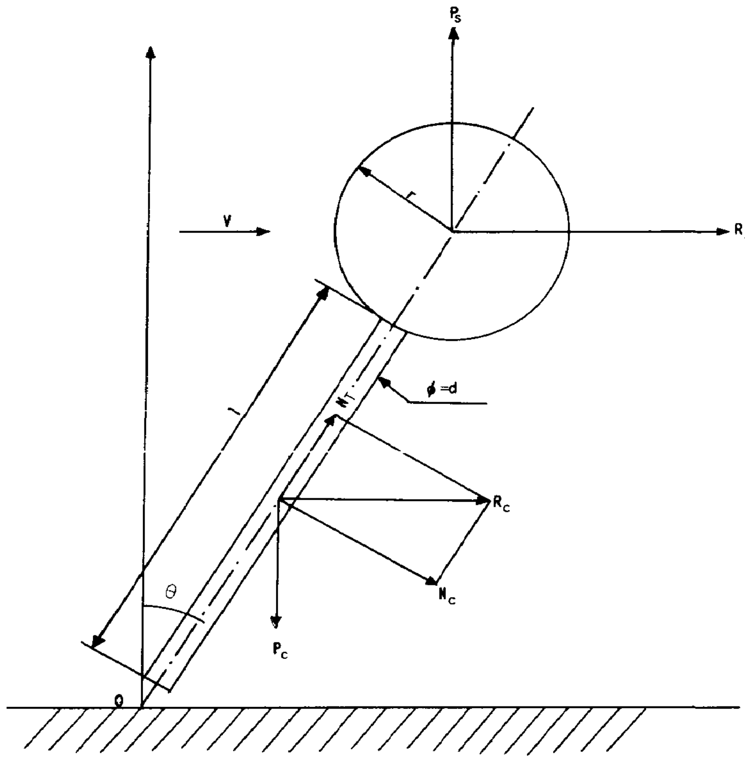
The equilibrium equation is therefore :

$$[3\,980\,(r+2)\ r^3 - 10.61]\ \tan\ \theta = V^2\ [6.216\ \cos\ \theta + 16.012\,(r+2)]$$

which allows V to be computed in terms of θ, the other parameters being already known.

From these data we have decided on the choice of globes and recorders to use in the construction of an experimental prototype.

These are the following. Globes with external diameters of 300, 400 and 500 mm able to resist a maximum pressure of 60 kg/cm². An Eastman recorder of the clinometer type covering a recording range of 0-17°.



V = Velocity of current
P_c = Apparent weight of cylinder
P_s = Apparent weight of globe
P_c = Hydrodynamic force exerted on the clinometer (N_c N_T components)
l = Length of clinometer
d = Diameter of clinometer
r = Radius of globe
O = Point of attachment

FIG. 3

This experimental prototype was tried out in the Bassin des Carènes for developing an anti-vibration device, checking of the instrument's dynamic behaviour, and calibration.

As expected, certain velocities caused alternating eddies which caused fluctuations in ranges and frequencies that hindered the photographic recording.

Various devices were tried out for reducing these vibrations, the device proposed by the Bassin des Carènes being adopted as the most efficient. It consists, for the tube, of the milling of the entire surface of the cylinder; and for the globe, of the setting of a special semi-spherical vane freely rotating around the sphere's vertical axis.

Provided with these devices the dynamic behaviour proved excellent, and the photographic recordings were readable for all velocities in the ranges corresponding to each sphere. (Figure 4 shows the " courantophote " photographed whilst on trial in the Bassin des Carènes with a current velocity of 1.5 knot (0.77 m/s).

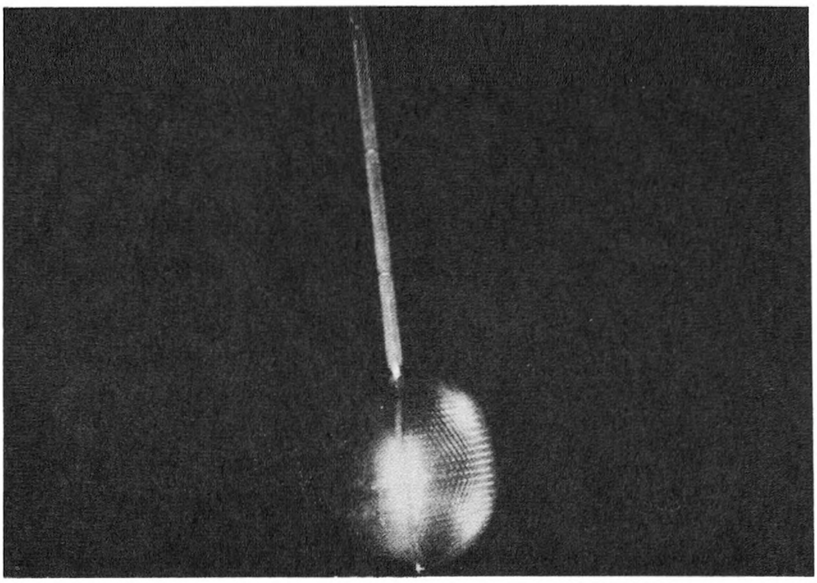


Fig. 4

III. — General description of the instrument

The details of this instrument are given in figures 5 and 6 which give the general layout and a brief description of its various parts.

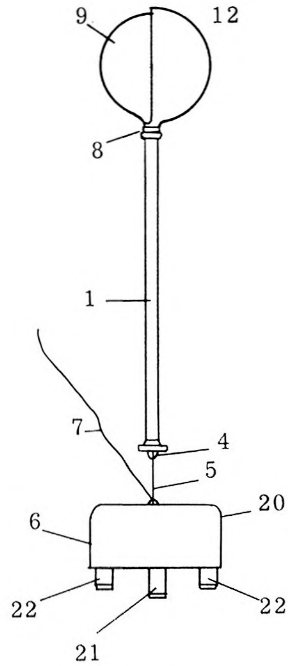


Fig. 5

The instrument is made up of a hollow water-tight cylinder (1) in light alloy, which is appropriately pressure-resisting. This cylinder is closed at

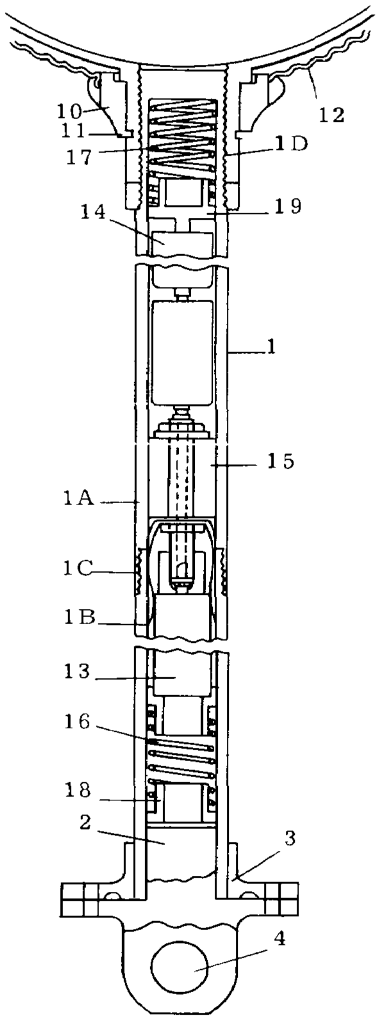


FIG. 6

the bottom by a plug (2) which is bolted to a bed-plate (3) welded onto the end of the cylinder and having an eyelet making it possible to fasten the end of the cable (5) to it. This cable is linked at the other end to a mooring or mud anchor (6) which will rest on the bottom. The mud anchor (6) can be lowered and raised by means of a cable (7).

The outer wall of the cylinder is fluted.

The float is a suitably pressure-resisting hollow globe of light metal which gives the instrument a positive buoyancy. There are several globes of different diameters. Each globe gives a positive buoyancy, and their interchangeability makes it possible to maintain the cylinder within the best inclination limits in relation to the measuring ranges.

A semi-sphere (12) of wire-net is movable, and can pivot around the globe.

Inside the cylinder (1) are housed :

— A clinometer adapted to the various ranges of inclination to be measured.

— Several cylindrical batteries (14).

— A component (15) called the coupler-contact which assures the supply of electricity from the batteries to the measuring instrument and between the two parts of the cylinder.

The electric contact between these various components is secured by means of pressure on springs (16) and (17) resting on the two ends of the cylinder, via supporting components (18) and (19).

The way this instrument is to be used is evident from the above description.

According to the probable intensity of the currents, the cylinder is fitted with a globe of the appropriate size, and the measuring device is also chosen accordingly.

The mud-anchor (6) has sufficient weight to obtain a convenient hold whatever the strength exerted by currents on the instrument and the cable (7) connected to the buoy. The instrument is then lowered and measurements and recordings of the inclination and orientation of the cylinder (1) take place in working conditions that are normal for an inclinometer. Inspection of the photo records provides data on the cylinder's (1) inclination and orientation. The fluting of the cylinder on one hand, and on the other the semi-spherical wire-net vane give the instrument a great stability by dampening oscillations caused by the current.

The Mud Anchor

The mud anchor is composed of either non-magnetic metal pigs or a set of bottom samplers (short corer, tallowed suckers, and sand traps, etc.). In both cases the weight of the mud anchor is calculated in order to avoid any movement on the bottom for a predetermined depth and pre-evaluated maximum currents.

We generally use 200 kg lead mud anchors, with a short corer, tallowed suckers and sand traps, for a depth of 500 m, with a 9 mm cable for currents less than 2 knots. The exact knowledge of the currents in contact with samples is of great interest.

IV. — **Processing**

a) *Equipment and camera*

The recordings gathered are in the form of 10 mm film obtained with 16 mm commercial negatives. The reduction from 16 to 10 mm is carried out by a very simple apparatus either in a dark room or under a red light. The loading and unloading of the recorder are normally carried out under a red light. These operations can if necessary be performed in full daylight but inside a sack made of black light-proof material into which the operator plunges his hands. This procedure necessitates a preliminary rehearsal, but is without difficulties.

The spool holds 390 exposures, i.e. 52 hours of recording at a rate of a photo every 4 minutes by means of cam shifting.

A 15-day recorder including a special clock (periodic winding by an electric motor) permits one measurement per hour.

The films are processed as ordinary film by a briefly trained personnel. The baths may be prepared in advance. After washing and drying the films may be interpreted on the spot.

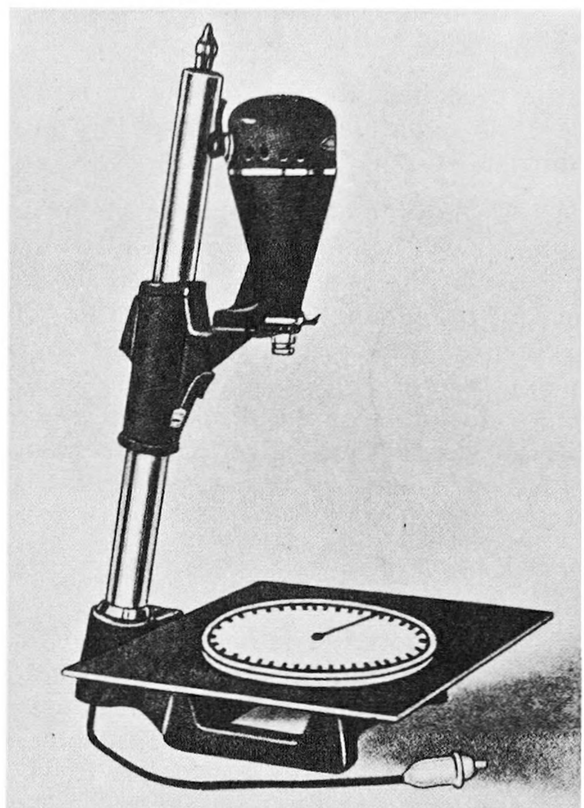


Fig. 7

Reading may be by means of a special reader or by a standard microfilm reader.

This reading gives the value and direction of inclination of the instrument in the current for any point, as may be seen in figure 8.

b) *Reading and Interpretation*

The instrument was calibrated at the Bassin des Carènes with globes of various diameters, and at various speeds. Curves showing inclination versus velocity of current are given in figure 9.

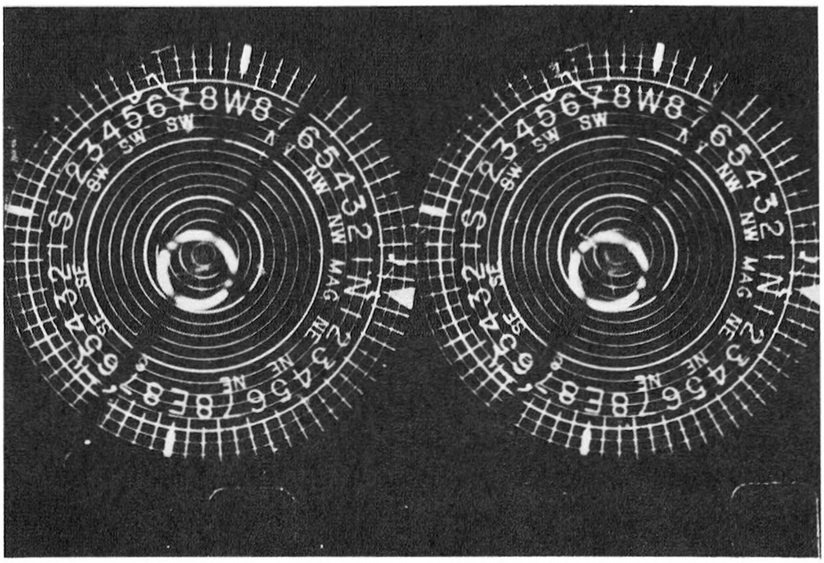

S
1
2
3
4
5
6
7
8
W
8
6
5
4
3
2
N
2
3
4
5
6
7
8
E
8
7
6
5
4
3
2
SW
SW
SW
NW
NW
MAG
NE
NE
NE
SE
SE

FIG. 8

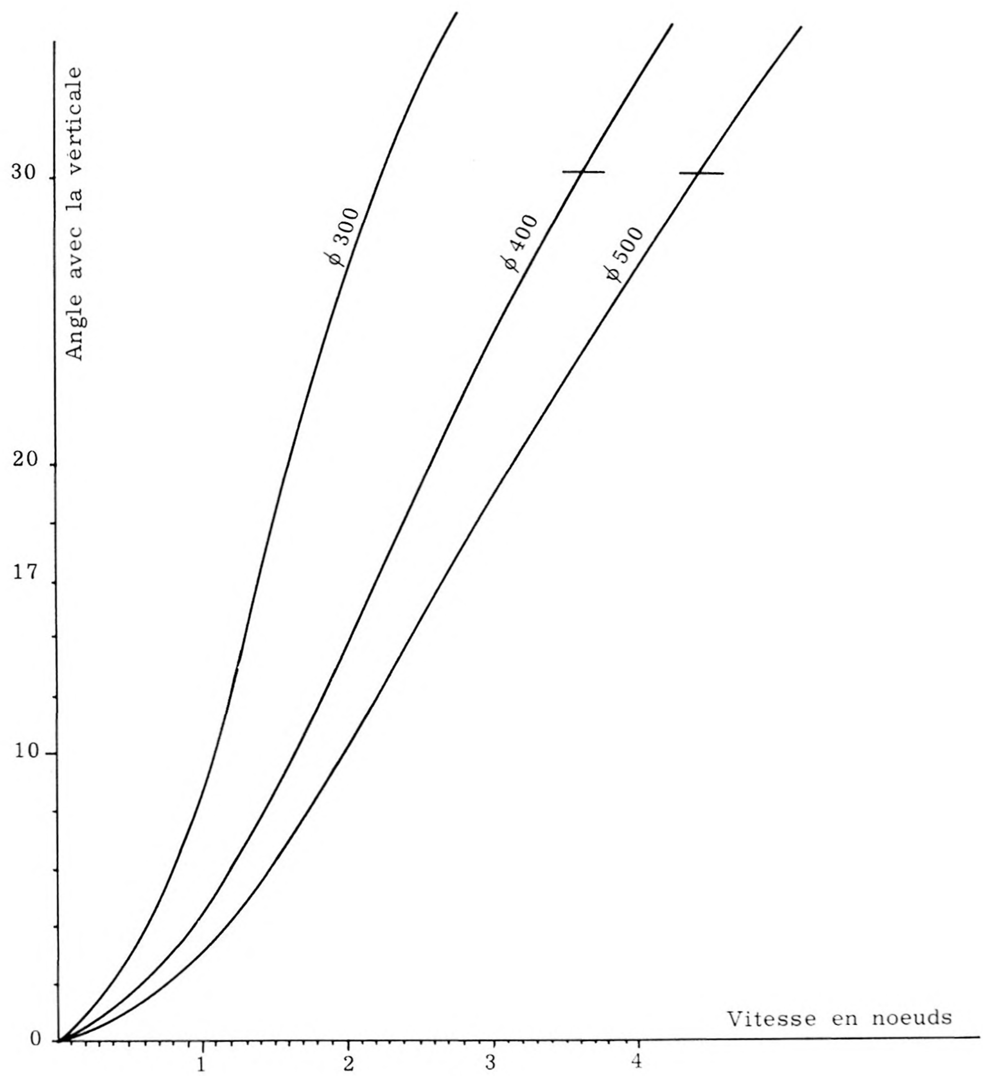

Angle avec la verticale
30
20
17
10
0
Vitesse en noeuds
1
2
3
4
ϕ 300
ϕ 400
ϕ 500

FIG. 9

Inspection of these curves allows advance choice of the globe and the pendulum device to be used. This choice depends on the current velocity range to be expected, and on the reading sensitivity required.

In these curves it is seen that the maximum velocity measurable with the 0-17° pendulum equipment is 3 knots.

The sensitivity is all the greater when the curve relating to the smallest globe is concerned, particularly the part of this curve closest to the vertical, and when the range of the pendulum apparatus is small.

In fact between 0.5 and 1.5 knots, in the case of a 30 cm globe, the reading accuracy is about 2 cm per second, or 1/25th of a knot.

This range of speed is in fact the one most frequently encountered.

In its present state the instrument is not conceived for measuring velocities lower than 0.5 knots. However by reducing the globe's buoyancy and using a compass-pendulum unit of 0-12° it is quite possible to improve sensitivity in this range.

Conclusion

After some irregularities of functioning due to normal new equipment defects these instruments are now used in the routine way. Servicing poses no problems and does not require a specialist, but rather personnel briefly instructed and acquainted with this equipment.

The lowering of the instrument is carried out in the same way as for any fishing gear placed on the bottom and connected to a surface buoy. This is a very easy problem for an ordinary crew.