DESCRIPTION OF A PROTOTYPE GAUGE TO MEASURE MAGNITUDE AND DIRECTION OF HYDROWIRE SLOPE *IN SITU* BETWEEN REVERSING BOTTLES AT ALL DEPTHS AND UNDER ALL CONDITIONS OF SHIP DRIFT

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ABSTRACT

The discovery in recent years of vast deep oceanic currents running in a direction contrary to those at the surface provides additional evidence of our need for instrumental means to obtain accurate data on subsurface waters, particularly in little-known oceanic areas where pioneer lowerings are to be made. A description is given of a prototype messenger-operated wire-angle gauge which, used intermediately between reversing bottles, can furnish information on the direction of slope of the hydrowire and its actual degree of obliquity at a number of points. It is only the latter, of course, which can be computed from results obtained when unprotected reversing thermometers are used with the pressure-resisting type.

INTRODUCTION

Some years ago, after reading a number of papers, mainly theoretical, on the subject of wire angle in oceanography, the writer became convinced that there need be little difficulty in designing a simple instrument that would be usable between bottles of a routine cast to reveal the actual slope of the hydrowire at as many points on it as weight tolerance might permit. Such an instrument, referred to as a wire-angle gauge, was duly made and described (Carruthers, *et al.*, 1954), and Lee's contribution to that paper tells of its practical use in the Barents Sea. Two forms of it were made, both messenger-operated; one was able to reveal slope magnitude only whereas the other could reveal both degree and azimuth of hydrowire obliquity. Extensive use of our simpler nondirectional form of the gauge has been made from oceanographical survey vessels of the Argentine Navy and a version of it has since been manufactured by the French firm of Mécabolier. Subsequently Mosby (1955), whose 1957 paper is referred to in ours of 1954, published a note evoked by E. E. Watson's criticism; Watson's paper is also mentioned in our 1954 publication. More recently the writer's interest has been particularly aroused by a paper which not only describes a Japanese version of the simpler gauge but which goes into some detail regarding the value of instrumental "depth determination in oceanographical observations" (Teramoto, 1958). This recent paper is well spiced with calculations.

So far as the writer is aware, that version of the wire-angle gauge which measured azimuth as well as obliquity has not been copied. This seems a little surprising because when a vessel has had to approach the hydrowire to achieve virtual verticality of its uppermost portion, it is surely of great interest to learn what the direction of "carry-away" down below must have been if it later becomes known thermometrically that there had been a considerable wire angle in the depths. Much information regarding the direction of deep currents could easily be obtained from use of messenger-operated gauges of the directional variety. Used in the Barents Sea from the F.R.V. ERNEST HOLT which cannot be steamed up to the hydrowire, one of the directional wire-angle gauges showed Lee that at some places "the bottom water was moving in a different direction to the surface water".

The writer has recently given further attention to his gauges because of the great present-day interest in deep currents. It was found that the two instruments described and illustrated in the 1954 paper could be much improved. When used from a ship making only slow leeway, the previously-described instruments can be expected to give acceptable results because, in such cases, they will remain truly pendulous beneath the wire as they must to provide satisfactory data. Because their pendulums are heavy, however, there is some possibility that, even when truly pendulous, towards and from-ship oscillations might on occasion be great enough to cause error. This could happen if the messenger should strike when the pendulum was not at its modal inclination with the frame of the gauge.

Furthermore, if these same instruments are used from a vessel drifting briskly to leeward, error is certain because such flat-framed instruments cannot then remain truly pendulous beneath the wire in defiance of water pressure upon them. They will lift to the side of the wire or perhaps even ride above it if ship drift is fast enough. Thus the recorded angle will be much in defect of truth—perhaps zero. Because of these considerations the gauge has been completely redesigned and has been given certain internal rolling features similar to the writer's jelly cylinder slope indicators made for use on trawl warps and other towed cables which are described elsewhere.

The redesigned hydrowire slope gauge remains messenger-operated and usable between bottles of a routine cast, but only the obliquity-plus-azimuth variety has been produced anew. The main feature of the new directional wire-angle gauge is that it behaves correctly whether it be pendulous beneath the wire when leeway is small or to the side or above the wire when the ship is drifting briskly downwind. There is no call here for a long and detailed description because we are here dealing exclusively with the prototype instrument made largely in the workshops of the British National Institute of Oceanography. The manufacture of a sales version of it incorporating various desirable modifications (one of them being greatly decreased weight), has been confided to the Norwegian firm of Bergen-Nautik. Therefore, for present purposes, the accompanying photographs will suffice.

The new instrument, which is cylindrical, naturally operates like a reversing water bottle in that, after having been operated by messenger impact from above, it releases a second messenger to trip another bottle or gauge below it. The prototype weighs eight pounds. In a casing of perspex tubing $8^1/_2$ inches in length, 4 inches in outside diameter, and with wall thickness of $^1/_4$ inch is a skeleton rectangular metal frame which turns on two end bearings which are central in the inner sides of the two brass discs which close the tube. At the lower end of the instrument, the bearing is virtually a pivot turning in a seating made of ferobestos, which is especially suitable for use under water; ferobestos is an asbestos fibre material impregnated with a special thermo-setting synthetic resin which affords a sort of self-lubrication. At the upper end, inside of the perspex cylinder, the frame turns round a tube through which a piston enters. Mounted on an axis pivoted across the frame is a wheel of tufnol that is a trifle less in diameter than is the internal diameter of the perspex cylinder. A quadrant of this is engraved in degrees, and within it is a cut-away portion which houses a freely-pivoted compass (see accompanying photographs).

The perspex cylinder has strong metal ends furnished with the necessary clamps for attachment on the hydrowire. The upper end carries the tripping lever as well as a release point from which hangs a lanyard supporting the pass-on messenger. When the messenger from above trips the gauge, the spring-loaded piston seen in the pictures travels inwards to press a rubber pad against the finely-serrated rim of the graduated tufnol wheel; in doing so it locks the latter effectively so far as angle of slope is concerned. That is not the end of the piston's duty however. After the rubber pad has pressed on the wheel, a small spike emerges from its centre to stab into a cavity milled round the rim of the wheel. In this cavity is a snug-fitting arc of thin brass so pivoted that inwards pressure of the spike at any point on the graduated rim rocks a pair of light L-shaped levers (one on each side of the wheel) in such manner that they lift the compass off its pivot to jam it tightly but harmlessly up against a cylindrical block of tufnol (integral with the wheel). A weight is affixed to the rim of the wheel below the compass to ensure that the compass is always at bottom vertically below the midpoint of the wheel's axis. This weight, which is of lead, is heavy enough to turn the wheel so resolutely that it will always accord correctly with the slope of the gauge. The lead strip is so distributed as to weight that, when the cocked gauge is vertical, the compass is on an even keel at bottom with its pivot in line with the axis of the piston. In that position the zero mark on the graduated quadrant is against a line scribed round the inside of the perspex cylinder for easy and parallax-free angle reading. From the photographs the reader will now be able to make out for himself how the gauge behaves in use. No matter what position the untripped gauge may take on the wire due to water pressure occasioned by ship drift, the internal mechanism rolls accommodatingly in such manner that the graduated tufnol wheel remains always vertical. That being so, the compass remains always horizontal and perfectly free to turn on its pivot until such time as the messenger strikes from above. The rolling of the rectangular frame is greatly assisted by the caged ball seen in the picture. This is a solid phosphor-bronze sphere $1^1/_4$ inches in diameter.

Apart from incorporation of this rolling ball and a few recent modifications of the compass-locking levers, the gauge here described and photographed is just as it was when it was used from the F.R.V. ERNEST HOLT during an Arctic cruise in May 1958. On this cruise it was useful to learn reliably that small wire angles existed near the bottom of a deep cast at times when the uppermost portion of the wire was sloped at 40° and more.

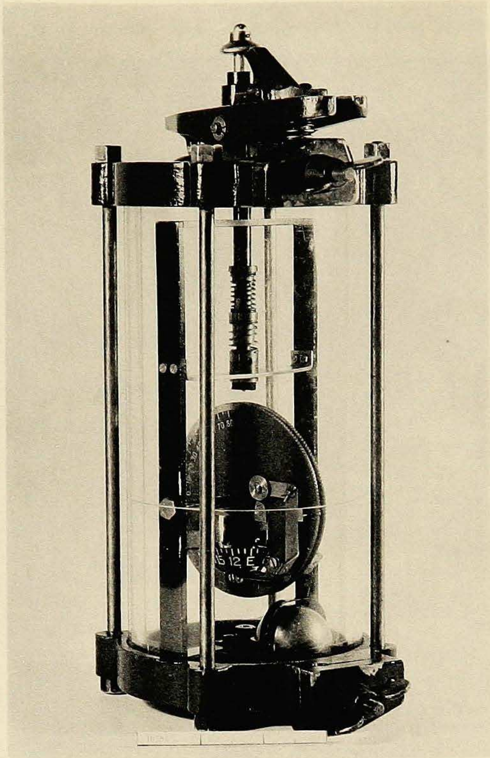

Figure 1. Showing the entire gauge in the cocked position. [Angles are read against the line scribed round the inside of the cylinder.]

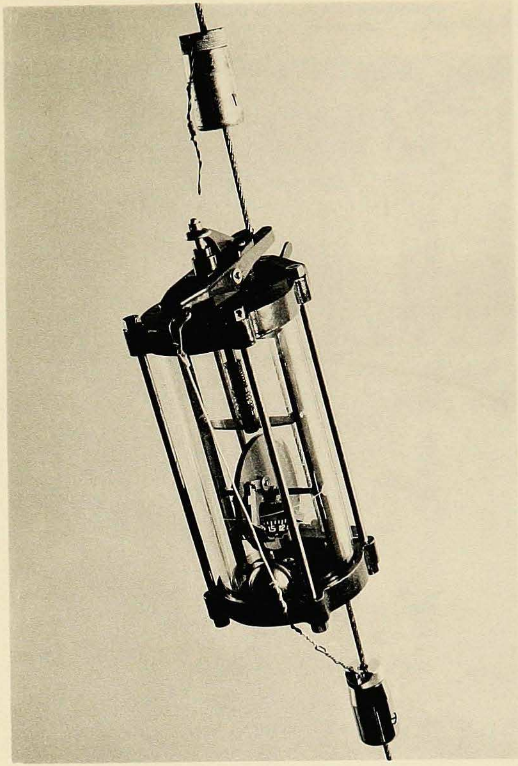

Figure 2. Showing the cocked gauge on the hydrowire ready to receive the messenger from above and to release one beneath.

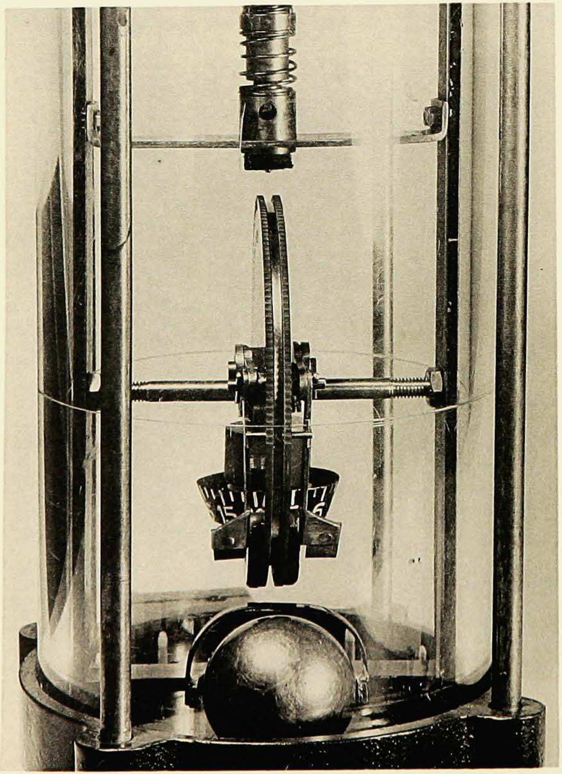

Figure 3. A close-up view of the internal parts. [Gauge cocked.]

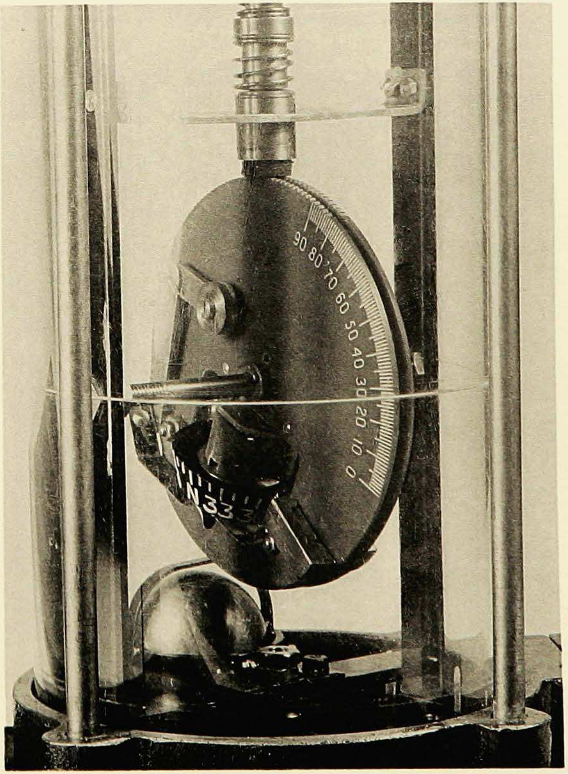

Figure 4. Close-up view showing protractor wheel and compass locked as when removed from the hydrowire.

The illustrations are numbered in sequence in the usual manner although they have not been referred to individually. This has been done for the convenience of any reader who might wish to send in an inquiry about any part of the gauge.

ACKNOWLEDGMENTS

The writer is greatly indebted to his colleague, Mr. J. T. R. Wood, for the exercise of much painstaking skill in constructing the internal mechanism of this directional wire-angle gauge. Initially, when the piston had only one movement, the compass could not be locked without the wheel turning enough to falsify the slope angle recorded. By recessing the rim of the wheel and fitting into it the curved lever operated by the second movement of the piston as described, Mr. Wood solved the difficulty. Moreover, besides devising and constructing the compass-locking mechanism, to him also goes credit for the caged ball which rolls the rectangular frame. For the photographs of the gauge the writer tenders thanks to his colleague Mr. A. F. Magdwick.

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