AN EXPERIMENTAL AIR-PRESSURE DEPTH-METER FOR USE WITH MIDWATER TRAWLS

By Keith A. Smith*

While conducting experimental midwater trawling for herring in the Gulf of Maine during the spring and summer of 1956, an experimental air-pressure depth-meter was developed by the Service's Maine Herring Exploratory Fishing and Gear Research Station at Boothbay Harbor, Maine. This instrument was specifically designed to meet the program's need for a shallow-water net depth indicator. Compared to existing electronic devices for this purpose, it is simple and inexpensive to construct. The method of operation involves towing one end of an air-pressure tube at the same depth as the net. When used for the deeper tows the tube is cumbersome, but it is expected that this device will fill a transient need until a simple electronic depth meter can be developed.

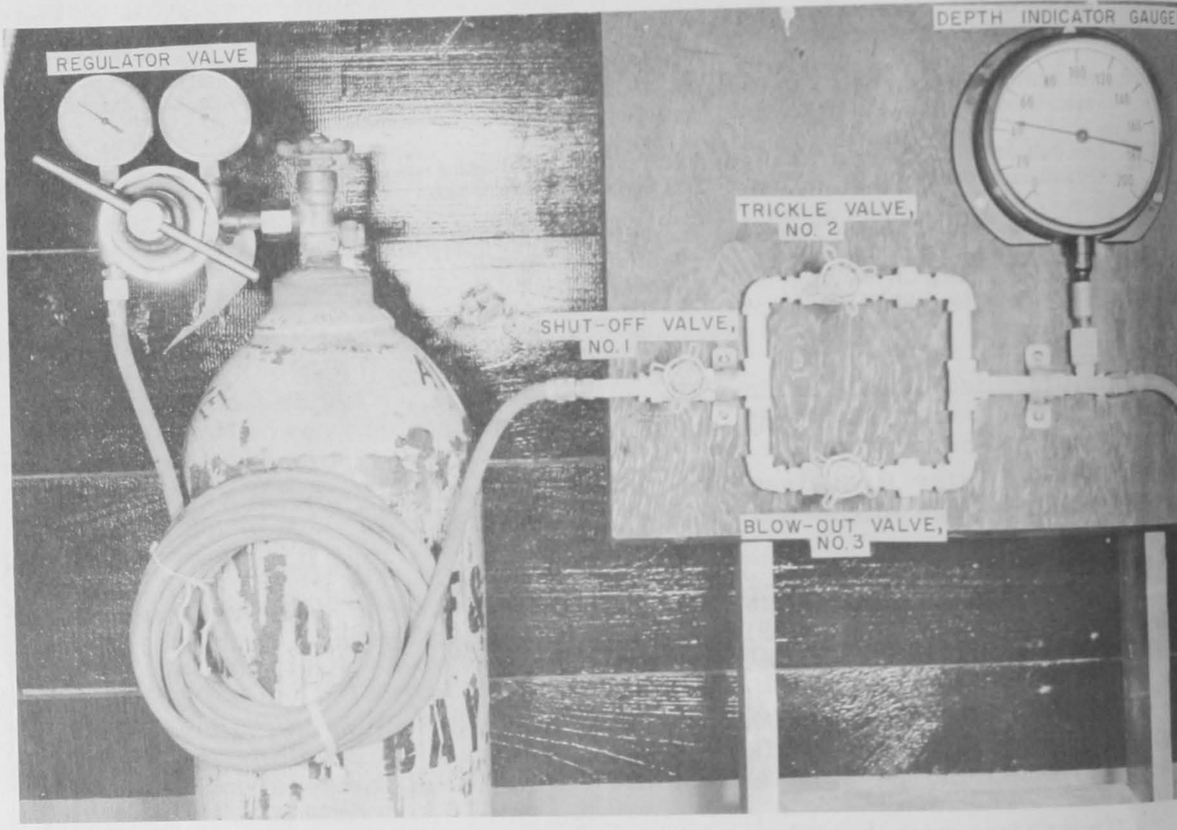

FIG. 1 - AIR SUPPLY, REGULATOR GAUGE, CONTROL VALVES AND DEPTH-PRESSURE INDICATOR GAUGE ASSEMBLED TO INDICATE DEPTH.

Necessity for a depth-meter became apparent during the early midwater trawl tests and fishing trials, because fishing success depends upon knowledge of the exact fishing depth of the net. A midwater trawl is towed neither at the surface of the water nor on the sea's bottom but somewhere between these two extremes, and it is not possible to know by direct observation through what stratum of water the trawl is moving. Measurement of depression angles of the towing warp gives an approximate net depth, but when great lengths of towing warp are out and thin schools of fish are detected, this method of determining depth is not sufficiently accurate.

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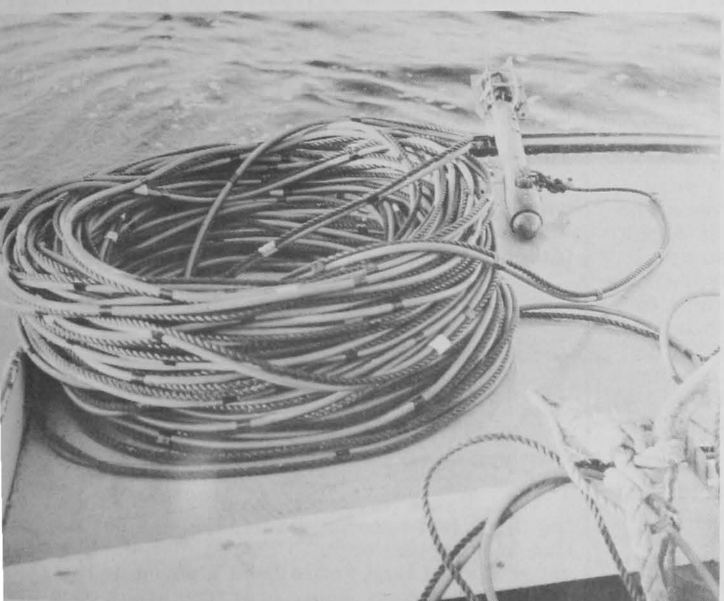
To meet the practical need for midwater trawling, an experimental depth-meter vas built that would meet the following conditions:

1. It must be dependable and accurate within narrow limits.
2. The design and operation of the instrument must be simple and easy to understand.
3. Construction of all components of the equipment must be rugged and resistant to breakage to insure trouble-free operation.
4. The complete unit should be of low cost and made of materials readily available.

It is known that the pressure in a body of water varies directly with the increase n depth. Determination of the pressure at any certain point in an open body of sea water of a given density is tantamount to knowing the depth at that point. This direct proportion seemed to offer the best basis for an indicator of the depth of a trawl in midwater.



IG. 2 - 100 FATHOMS OF PRESSURE HOSE. IN ORDER TO SUPPORT THE PRESSURE HOSE WITHOUT CONSTRICTING IT, A 3/8" DIAMETER NYLON ROPE WAS FASTENED TO THE HOSE WITH PLASTIC ELECTRICIAN'S TAPE AT SPACES OF APPROXIMATELY 18 INCHES. THE BATHYTHERMOGRAPH WAS USED FOR CHECKING DEPTH READINGS.

If a continuous and unobstructed column of air confined inside a tube could be maintained from the foot rope of the trawl to the deck of the fishing vessel, the air pressure at the top of the tube must equal the pressure at the bottom of the tube (minus the negligible weight of the air in the tube). If such a tube were open to the water at the bottom end, the pressure throughout the tube must then be equal to the water pressure at the depth of the bottom end of the tube, provided sufficient air remained in the tube at all times to prevent any water rom entering the tube. It was decided that the best method of insuring that such a ibe remained clear of water would be to add air continuously at the top of the tube, orcing a small amount of air out of the tube at the open bottom end.

This method of determining depth seemed to offer the best solution to the probem encountered. After several preliminary tests, the following gear components ere assembled:

1. A source of compressed air. (A standard compressed air cylinder containing 300 cubic feet of air at a maximum pressure of approximately 2,000 pounds per square inch (p.s.i.) was used. A regulator valve was added to give a reduced and constant pressure.)
2. A group of three needle valves to control the flow of air into the pressure tube.

3. A simple air pressure gauge. (The gauge originally used was calibrated in five p.s.i. steps, but it was found that a more sensitive gauge with finer graduations was needed. For best results, the gauge should be graduated in steps no greater than two p.s.i.

4. 100 fathoms of $\frac{3}{16}$" inside diameter reinforced rubber hose designed for a maximum working pressure of 300 p.s.i.

5. 100 fathoms of $\frac{3}{8}$" diameter rope to support the hose.

This gear was assembled as shown in figures 1 and 2.

The gear is operated in the following sequence:

1. All valves are closed at the start.

2. The air tank valve is opened and the pressure regulator valve set to deliver air at 200 p.s.i. pressure.

3. The open end of the hose is put into a bucket of water, Valve No. 1 (fig. 1) is opened wide and Valve No. 2 is opened very slightly until a very thin stream of air bubbles comes out the open end of the hose. The opening of Valve No. 2 is adjusted carefully at this point so that although some air is flowing through the hose, the back pressure showing on the depth-indicator gauge is very close to zero. The pressure reading obtained at this point is due to air friction within the tube and must be subtracted from the reading later when the gauge is indicating depth. After the setting of Valve No. 2 is made it should not be disturbed throughout the tow.

4. The open end of the hose is attached to the midwater trawl or other object on which depth data is desired and then lowered into the water. As the open end of the hose is lowered, air pressure builds up until it approximately equals the water pressure at the hose opening. This pressure will show on the indicator gauge and will not be exceeded because the open end will allow any excess air to exhaust out into the water.

5. When the net has been lowered to the approximate working depth, Valve No. 3 is opened momentarily allowing a strong flow of air to bypass Valve No. 2. The purpose of this is to blow an excess of air through the hose to insure that the hose is free of any water that may have entered it as it was lowered. The reading on the indicator valve rises considerably during the operation and does not indicate depth. After the hose is "blown out," Valve No. 3 is closed and the pointer of the depth-indicator gauge settles back and stops at the value of water pressure at the end of the hose, plus the very small reading obtained in step 3 which should be subtracted to obtain the actual water pressure. The pressure thus obtained, divided by 2.66 gives the depth at the hose end in fathoms.

0.43 = lbs./sq. in. pressure per foot depth of pure water

1.025 = density standard sea water

6 ft. = 1 fathom

(0.433 (1.025) (6)= 2.66 pounds of pressure per square inch per fathom depth.

6. Valve No. 1 may be closed after the towing depth has become stable, i.e. the net has settled at a certain depth. The pointer of the indicator gauge should then settle back a pound or two and indicate the exact water pressure at the open end of the hose since no air is moving and air friction inside the hose is not involved. The initial reading in step 3 should be disregarded when taking this reading. After a reading is obtained, Valve No. 1 should be opened allowing a trickle of air to pass through Valve No. 2 again into the hose to insure that no water enters the hose should the net sink deeper. Valve No. 2 should not be disturbed after the initial setting is made in step 3.

Two types of tests have been made on this equipment. They are (1) vertical lowerings on a measured line, and (2) towing tests, using a 0-200' bathythermograph as a testing standard.

Results of the first type of test are shown in tables 2 and 3. Note that a positive error is shown in each test. These errors are apparently due to air friction inside the hose caused by the flow of air. The error was greater in test 1, probably due to the trickle valve being opened slightly more in this test. It was not possible to evaluate this error at the start of the tests because the gauge used shows no reading until a pressure of five p.s.i. is reached. Since these tests were made, a larger more finely calibrated gauge has been employed (fig. 1) and has been found to operate more satisfactorily.

able 1 - Pressure in Pounds Per Square Inch
Considering Surface 000; 1 Atmosphere = 14.7)

epth	Pressure	Depth	Pressure
athoms	Lbs./Sq. Inch	Fathoms	Lbs./Sq. Inch
1	2.7	26	69.2
2	5.3	27	71.9
3	8.0	28	74.6
4	10.7	29	77.2
5	13.3	30	79.9
6	16.0	31	82.6
7	18.6	32	85.2
8	21.3	33	87.9
9	24.0	34	90.5
10	26.6	35	93.2
11	29.3	36	95.9
12	32.0	37	98.5
13	34.6	38	101.2
14	37.3	39	103.9
15	40.0	40	106.5
16	42.6	41	109.2
17	45.3	42	111.8
18	47.9	43	114.5
19	50.6	44	117.2
20	53.3	45	119.8
21	55.9	46	122.5
22	58.6	47	125.2
23	61.2	48	127.8
24	63.9	49	130.5
25	66.6	50	133.1

A towing test was made to check the accuracy of the device while moving through the water. In this test, a towline and the pressure hose along with its supporting line were let out 100 fathoms to a skiff that was towed behind the testing vessel. The open end of the pressure hose with a bathythermograph and depressor attached were lowered from the skiff on a $\frac{5}{32}$" wire rope to various depths while the skiff was being towed. Results of this test are tabulated in table 4. Note that a positive error also resulted in this test. Since this error is consistently present and always positive, two pounds pressure representing approximately $\frac{3}{4}$ fathom should be subtracted from the gauge reading. The reading thus obtained in all tests is accurate within less than one fathom.

The above-described equipment might find practical application where underwater fishing or sampling devices are used on which depth data is required. Within close limits,

able 2 - Depth-Indicator Test (Vertical suspension test starting at 2 fathoms and lowering to 29 fathoms)

Line Out	Pressure	Pressure Depth Indicated	Error
athoms	Lbs./Sq. Inch	...... (Fathoms)	....
1	-	-	-
2	8.0	3.0	+1.0
3	11.5	4.3	+1.3
4	14.5	5.5	+1.5
5	17.0	6.4	+1.4
6	19.5	7.3	+1.3
7	22.0	8.3	+1.3
8	24.5	9.2	+1.2
9	27.0	10.1	+1.1
10	29.5	11.1	+1.1
11	32.0	12.0	+1.0
12	35.5	13.3	+1.3
13	38.0	14.3	+1.3
14	41.0	15.4	+1.4
15	44.0	16.5	+1.5
16	46.5	17.5	+1.5
17	49.0	18.4	+1.4
18	51.0	19.2	+1.2
19	54.0	20.3	+1.3
20	56.5	21.2	+1.2
21	59.0	22.2	+1.2
22	61.5	23.1	+1.1
23	64.0	24.1	+1.1
24	67.0	25.2	+1.2
25	70.0	26.3	+1.3
26	73.0	27.4	+1.4
27	75.5	28.4	+1.4
28	78.0	29.3	+1.3
29	80.5	30.2	+1.2
30	-	-	-
	Average error = +1.27 fathom		

Table 3 - Depth-Indicator Test (Vertical suspension test starting at 33 fathoms and raising)

Line Out	Pressure	Pressure Depth Indicated	Error
Fathoms	Lbs./Sq. Inch	...... (Fathoms)	....
33	90	33.8	+0.8
32	88	33.0	+1.0
31	85	31.9	+0.9
30	82	30.8	+0.8
29	79	29.7	+0.7
28	77	28.9	+0.9
27	75	28.2	+1.2
26	73	27.4	+1.4
25	70	26.3	+1.3
24	68	25.6	+1.6
23	65	24.4	+1.4
22	62	23.3	+1.3
21	59	22.1	+1.1
20	55	20.7	+0.7
19	51	29.2	+0.2
18	49	18.4	+0.4
17	46	17.3	+0.3
16	44	16.5	+0.5
15	41	15.4	+0.4
14	38	14.3	+0.3
13	35	13.2	+0.2
12	33	12.4	+0.4
11	30	11.3	+0.3
10	27	10.2	+0.2
9	24	9.0	+0.0
8	22	8.3	+0.3
7	19	7.1	+0.1
6	17	6.4	+0.4
5	14	5.4	+0.4
4	11	4.1	+0.1
3	8	3.0	+0.0
2	6	2.3	+0.3
	Average error = +0.62		

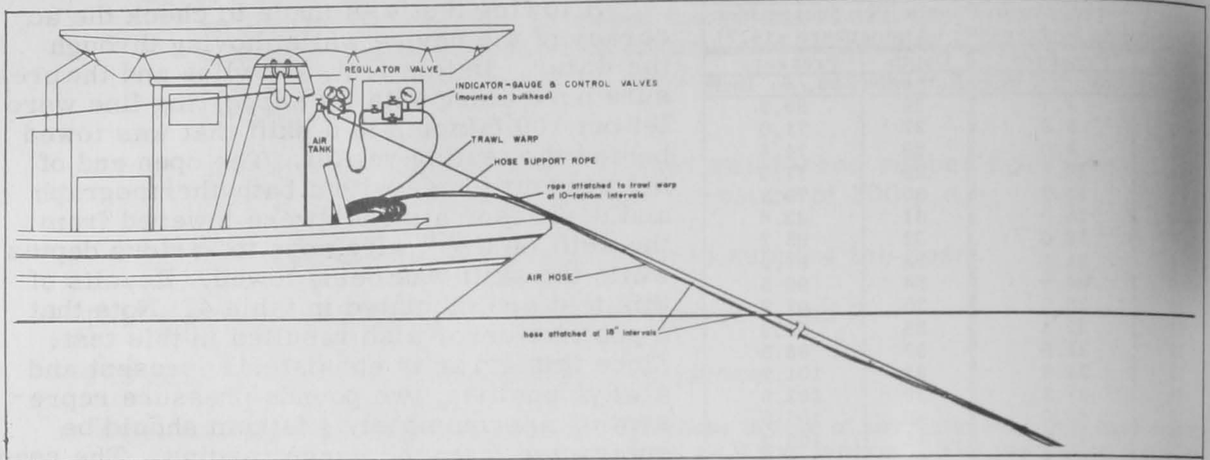


FIG. 3 - DIAGRAM OF DEPTH-INDICATOR AS USED WITH MIDWATER TRAWL.

Table 4 - Depth-Indicator Test
(Towing test using bathythermograph as standard depth-indicator)

BT Reading	Pressure	Pressure Depth Indicated	Error
Fathoms	Lbs./Sq. Inch	...... (Fathoms)	......
5.7	18	6.8	+1.1
10.7	31	11.6	+0.9
15.5	42	15.8	+0.3
20.2	56.5	20.8	+0.6
25.0	70	26.3	+1.3
30.0	82	30.8	+0.8
	Average error = +0.8 fathoms		

the depth indicator is accurate and dependable. It is of simple design, easy to operate, and trouble free. Compared to some other types of depth-telemetering equipment, the cost is low. The prices of the components of gear assembled are:

Air cylinder	$ 60.00
Regulator valve	42.50
300 cubic feet of air	4.00
$\frac{3}{8}$ in. needle valves 3 @ $2.26 ea. ..	6.78
Pressure gauge	6.38
100 fathoms $\frac{3}{16}$ in. hose 300 p.s.i. cap.	82.61
100 fathoms $\frac{3}{8}$ in. nylon rope	86.50
Total	$295.77

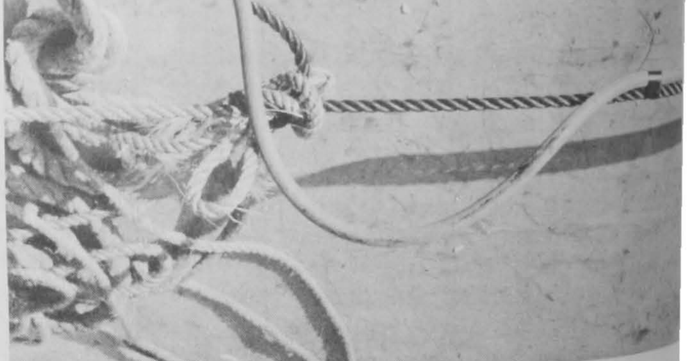


FIG. 4 - A $\frac{3}{8}$ IN. NYLON ROPE WAS USED TO SUPPORT THE PRESSURE HOSE. THIS PROVIDES A MEANS OF ATTACHING THE HOSE TO THE TRAWL WARP ALONG ITS ENTIRE LENGTH. ALTHOUGH CONSIDERABLE TENSION IS APPLIED TO THE ROPE, NO CONSTRICTION OR BINDING OF THE HOSE IS EFFECTED. A SUPPORT ROPE IS NECESSARY FOR PROPER OPERATION OF THIS GEAR.

This equipment is limited to a maximum depth of 113 fathoms by the pressure capacity of 300 p.s.i. of the hose used. When used with a 0 to 200 p.s.i. pressure gauge the maximum depth limitation is 75 fathoms. While these depths are sufficient for the specific use for which this equipment was designed, greater depth capacity may be attained by using a hose and gauge of greater pressure capacity.