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A PRACTICAL DEPTH TELEMETER FOR MIDWATER TRAWLS

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SUMMARY

A direct-reading electrical depth telemeter for midwater trawls has been developed and used successfully in the northeastern Pacific. The system utilizes an electrical trawl cable to transmit continuous depth information from a pressure-sensing unit on the gear to a pilothouse meter which shows trawl depth in feet and fathoms. Slip rings and brushes on the trawl winch complete the electrical circuit, which is powered by a 45-volt battery located in the control box in the radio-chart room. Maximum depth range of the system with the present potentiometer is 225 fathoms, but this can be increased or decreased as may be required. Advantages of the system are its simplicity and practicability, requiring no extra handling on deck and no specially-trained operator. It has been tested and used successfully during the spring and summer of 1957 aboard the U. S. Bureau of Commercial Fisheries exploratory fishing vessel *John N. Cobb* based at Seattle.

Fig. 1 - Pilothouse depth meter for the electrical telemeter, calibrated to show depth of the trawl in feet and fathoms.

INTRODUCTION

A depth telemetering system, utilizing a low-voltage electrified trawl cable for determining the depth of midwater trawls, was installed and used successfully aboard the U. S. Bureau of Commercial Fisheries exploratory fishing vessel *John N. Cobb* in the northeastern Pacific during the spring and summer of 1957.

Accurate knowledge of the depth of the net is essential to successful midwater trawling. No matter how efficient the gear might be, unless it is placed at the proper depth indicated by fish signs on the echo-sounder or by other means, the school of fish will be missed entirely or only a small catch will be made. This problem has been apparent during the several years of intermittent midwater trawling research by the Bureau's Branch of Exploratory Fishing and Gear Research. A variety of methods have been used in various parts of the world to determine the depth of midwater trawls, but there has always been the need for a more practical instrument which is accurate, simple to use, and economically within reason for commercial

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fishermen. The electrical depth telemeter, which was designed, constructed, and installed at Seattle by Bureau personnel, appears to meet this need.

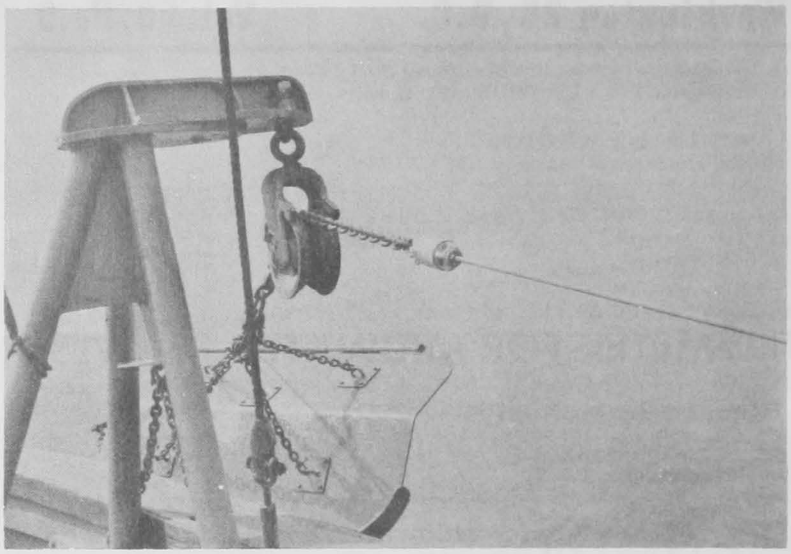


Fig. 2 - Pressure-sensing unit attached to the end of the electrical trawl cable just in front of one of the trawl doors.

Although midwater trawling by commercial fishing vessels thus far has been limited primarily to herring in northern Europe and British Columbia, there is evidence that at times other species of fish may be available to midwater gear, thus opening up vast new fishing areas of the ocean. Echo-sounders and sonar-type instruments have shown that schools of fish may be found at any depth between the surface and the bottom. A method to permit accurate positioning of the net is necessary because some schools of fish occupy a relatively thin vertical layer of water and can be missed easily if the net is a few fathoms too high or too low. During a single tow separate schools of fish may be found at different depth levels, necessitating raising or lowering the net at intervals (Richardson 1957). Also, when attempting to catch fish very near hard or uneven bottom, the position of the gear must be accurately known in order to avoid contact with the bottom which could snag the trawl doors and depressors or damage the net itself.

EARLY METHODS OF TRAWL-DEPTH DETERMINATION

Many methods and devices have been used in attempts to accurately determine the depth of midwater trawls. None have been entirely satisfactory due to inaccuracy, cost, depth limitation, operating difficulties, or fragility.

Calculation based on length and angle of towing warp to determine the gear depth is one of the oldest methods. Also, a second vessel has been used to sound the net as it is being towed at various depths. Bathythermographs have been attached to the trawl to record the depth range and to check other methods of calculation. Tables and graphs have then been prepared to show the probable trawl depth for each wire angle-length combination (Barraclough and Johnson 1956). Shortcomings in these methods arise from the effects of currents, wind, and tide on the wire angle at any given throttle setting and length of towing warp, and from the unknown changes in the underwater wire angle with varying sea conditions.

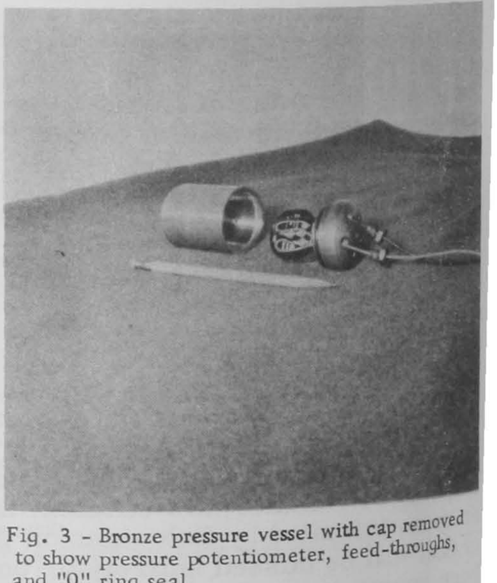


Fig. 3 - Bronze pressure vessel with cap removed to show pressure potentiometer, feed-throughs, and "O" ring seal.

Several accurate depth telemetering systems have been used with a fair degree of success. An electronic-acoustic telemeter was built and tested by the Woods Hole (Mass.) Oceanographic Institute (Dow

1954). An improved version of that instrument was constructed by the University of Miami Marine Laboratory under contract with the U. S. Fish and Wildlife Service (Stephens and Shea 1956). This instrument was used in midwater trawl research on several of the Bureau's vessels and on the John N. Cobb until the present electrical

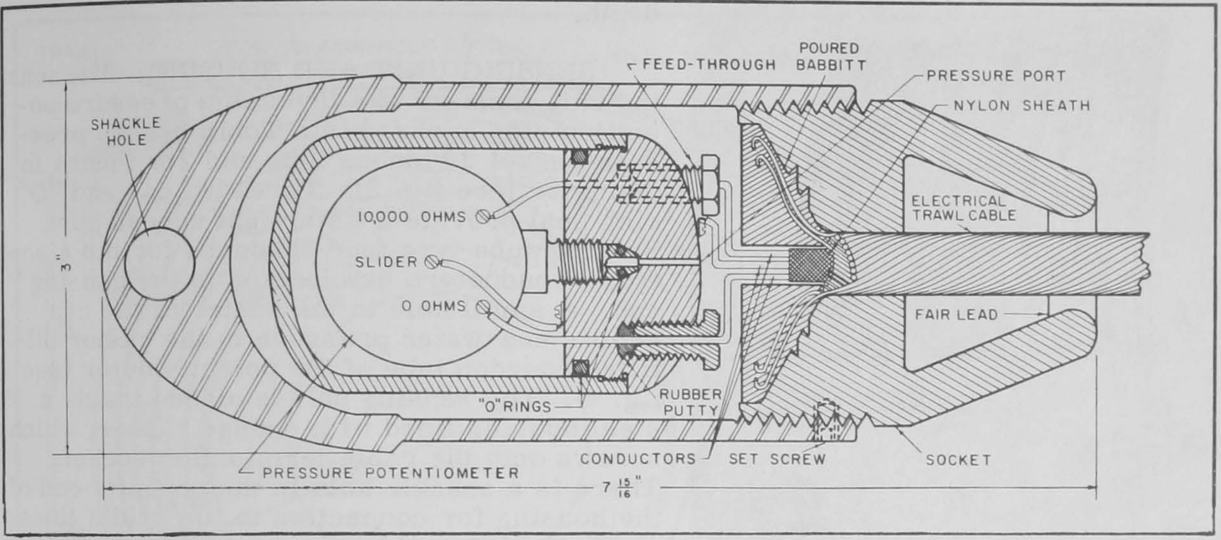


Fig. 4 - Sensing unit, housing, and cable termination of the electrical depth telemeter.

telemeter was installed. Although it was satisfactory in determining trawl depth during approximately 200 tows ranging in depth from surface to 225 fathoms, disadvantages of cost, maintenance, size, weight, and need for a specially-trained operator make any commercial application doubtful.

A unique and accurate air-pressure equalization system for trawl depth determination has been developed and used recently during midwater explorations for herring in the Gulf of Maine (Smith 1957). Activities were confined to relatively shallow water, with the equipment having a maximum operating depth of about 100 fathoms.

DESCRIPTION OF THE ELECTRICAL DEPTH TELEMETER

The system transmits continual depth information from the midwater trawl gear to the pilothouse of the vessel. A small pressure-sensing unit (see fig. 2) located on the end of the trawl cable at one trawl door actuates a pilothouse-mounted milliammeter which is calibrated to read depth in both feet and fathoms (see fig. 1). Electrical continuity at the trawl winch is through a slip-ring and brush assembly mounted on the outside of the winch drum. Steel trawl cable having insulated conductors for a core provides a full electrical circuit for the system.

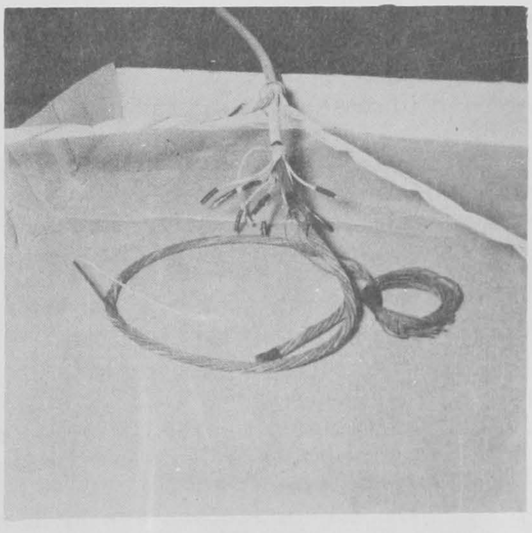


Fig. 5 - Electrical trawl cable prepared for splicing, showing core, fillers, conductors, and the two layers of steel strands.

The dial of the depth meter in the pilothouse is calibrated in one-fathom and 5-foot intervals from 0-50 fathoms and 0-300 feet. An off-on range selector switch permits selection of successive 50-fathom segments from 0-225 fathoms (which is the maximum depth of the particular pressure potentiometer used). The captain refers to the meter and adjusts the length of towing cable or speed of the vessel in order to raise or lower the trawl to any desired depth.

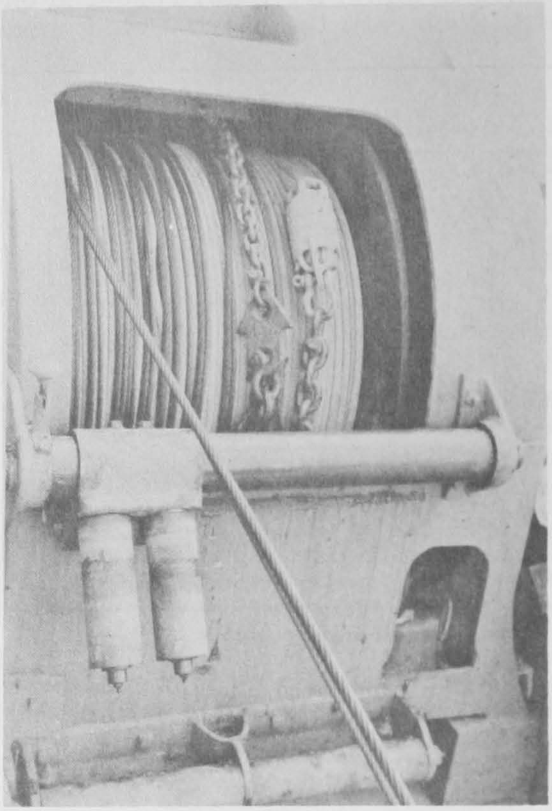


Fig. 6 - Electrical trawl cable, midwater trawl bridles, and the telemeter sensing unit on winch of the *John N. Cobb*.

SENSING UNIT AND HOUSING: The sensing unit consists of a precision pressure potentiometer encased in a Tobin bronze pressure vessel $3\frac{3}{8}$ inches long and $2\frac{1}{16}$ inches in diameter (see fig. 3). Threaded cap and "O" ring seal provide a watertight access port. Stuffing-tube type feed-throughs for the electrical conductors are located in the housing cap. A small hole in the center of the cap admits sea-water pressure to the castor oil-filled bourdon tube of the potentiometer (see fig. 4). The sensing unit is placed inside a steel housing lined with sponge rubber, which screws onto the cable termination socket. There is a shackle hole in the opposite end of the housing for connection to the bridle lines or chain of the midwater trawl gear. The housing is $7\frac{15}{16}$ inches long by 3 inches in diameter, over-all size.

The sensing unit potentiometer has a pressure range of 0-600 p.s.i., with an electrial resistance differential of 10,000 ohms. Thus, the depth range of the instrument is 0-225 fathoms. Linearity deviation is less than one percent, with friction of the potentiometer slider accounting for the major part.

Other pressure potentiometers having greater or lesser pressure-resistance values are available commercially. The 225-fathom depth range was selected as the most practical for present use.

Fig. 7 - Access port of the trawl winch showing location of the slip rings between the winch shaft bearing cap and the drum flanges.

CABLE AND TERMINATION: The electrical trawl cable is 0.528 inches outside diameter, double-armored steel, consisting of an electrical conductor core and two layers of 24-strand opposed helical-wound high tensile galvanized steel (see fig. 5). The six rubber-covered conductors are each made up of seven strands of 0.012-inch diameter copper wire and are wrapped around a solid-rubber center filler. Only three conductors are used, the remaining three being spares. The wire size of each conductor is equal to No. 21 a.w.g., and resistance is 11.1 ohms per 1,000 feet. Nylon fillers and sheath encase the conductors, making a round electrical core approximately $\frac{5}{16}$-inches in diameter. Breaking strength of the cable, according to the manufacturer, is 18,000 pounds.

Type of termination developed for the cable used on the John N. Cobb is an extreme wide-angle and shallow poured-babbitt socket (see fig. 4). Glass tape is wrapped around the conductors for protection during babbitting. This termination relieves external pressure on the conductors, as opposed to the common deep narrow-

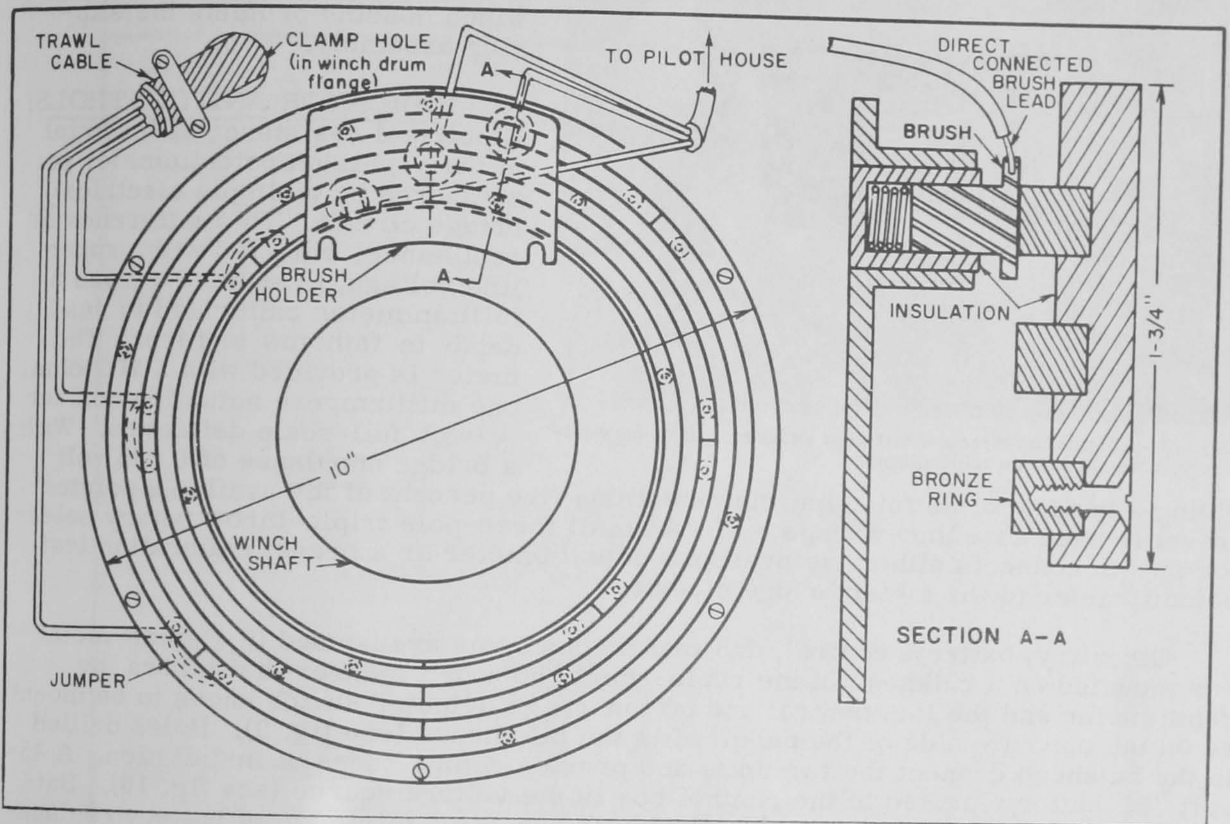


Fig. 8 - Slip-ring and brush assembly for the electrical depth telemeter.

angle socket which tends to squeeze and cause shorting. The wide-angle socket also requires a minimum of length making it possible to contain the cable termination and pressure-vessel sensing unit in a single small housing which will pass through the trawling blocks and wind up on the winch (see fig. 6).

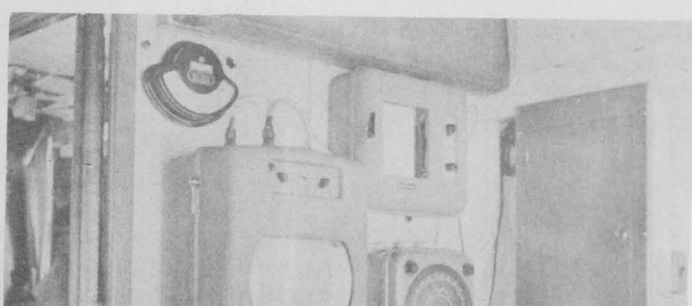


Fig. 9 - Arrangement of instruments in the pilothouse of the John N. Cobb showing trawl depth meter in lower right corner.

SLIP RINGS AND BRUSHES: A set of three bronze face-type slip rings are groove mounted in plexiglass and installed on the outside of the drum near the shaft (see figs. 7 and 8). In order to utilize a minimum of space in the winch-drum housing area and avoid disassembly of the winch, the rings and mountings are split halves with the ring joints rotated 45° so that on assembly around the winch shaft they become a solid unit. Jumper wires on the back of the mounting provide electrical continuity across the ring joints. Spring-mounted, solid brass, button-type brushes with direct connected pilothouse leads are bolted to the winch shaft bearing cap. The winch end of the electrical trawl cable is fed through the clamp hole of the drum, and the conductors are connected to the slip ring terminals to complete the circuit from potentiometer to pilothouse. A weathertight cover on the winch housing protects the slip-ring assembly.

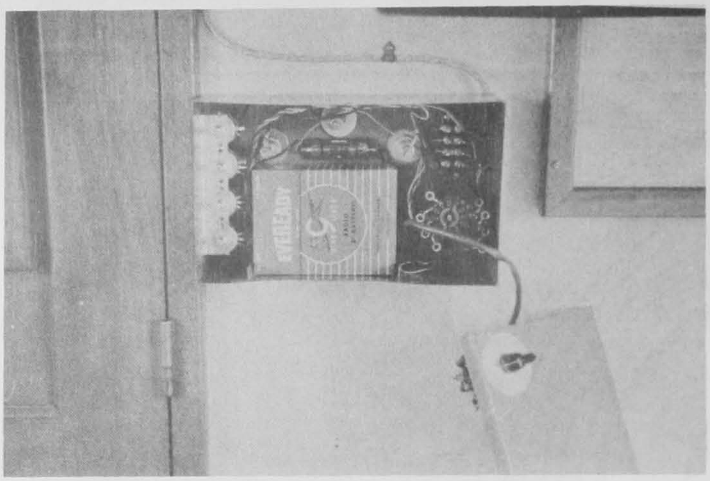


Fig. 10 - Control box in radio-chart room with cover off to show battery, controls and test mechanisms.

INDICATOR AND CONTROLS: Electrical resistance differential in the precision potentiometer is measured by a simple electrical bridge circuit. This difference in resistance, when fed with proper line voltage, is shunted across a milliammeter calibrated to read depth in fathoms and feet. The meter is provided with a 100-ohm, one milliampere actuation coil for $\frac{1}{10}$-volt full-scale deflection. With a bridge unbalance of 0.095 volt giving a readout of 50 fathoms, the remaining five percent of the available pointer travel is used as a line-voltage test. A small three-pole triple-throw rotary selector switch connects either the pressure potentiometer or a preset calibrating test potentiometer to the meter bridge circuit.

Circuitry, battery, control, and test mechanisms are housed in a small metal box mounted on a bulkhead in the radio-chart room in a manner that allows the depth meter and the line control and off-on range selector switch knobs to be mounted on the opposite side of the bulkhead in the pilothouse (see fig. 9). Holes drilled in the bulkhead connect the two units and provide compactness of installation. A 45-volt "B" battery located in the control box is the voltage source (see fig. 10). Battery drain is 4.2 milliamperes, which should require a minimum of battery replacements. Actual line voltage is 28 volts; thus the 32-volt battery system carried on most fishing vessels could be used as a power source provided that voltage changes were checked and compensated for during telemetering operations. The low voltage used presents no hazards to personnel.

Range selection is divided into four-and-one-half 50-fathom increments. To accomplish this, eight precision 2,222-ohm resistors are mounted on a two-pole six-throw rotary selector switch, which is used to return the meter pointer to zero at the end of each 50-fathom deflection.

SEA TESTS AND TRIALS

A series of calibration tests were made aboard the John N. Cobb at sea by lowering and raising the sensing unit to measured depths. A ten-minute warm-up period with the sensing unit immersed in sea water, to neutralize capacitance and temperature effect, preceded all tests. Accuracy of the electrical depth telemeter was found to be at least 98 percent during all tests. A slight lag of one-half fathom was noted during ascending and descending at normal winch speed. Depth readings of the telemeter agreed closely with two types of echo depth sounders during comparison tests when the sensing unit was dropped to the bottom at intervals out to a maximum depth of 187 fathoms.

Chief concern during construction, testing, and early use of the new telemetering system was the unknown ability of the electrical trawl cable to withstand the punishment of regular fishing operations. Full-power test runs towing a 70-foot-square-opening nylon midwater herring trawl were executed with normal turns and excess cable played from the opposite drum to put the greater load on the electrical trawl cable. A cable dynamometer showed a maximum cable strain of 4,700 pounds at full throttle with 360 fathoms of cable out and the net at 83 fathoms. To date the cable has been used during some 50 tows with no sign of damage or fatigue noted. There has been no apparent damage to the electrical conductors.

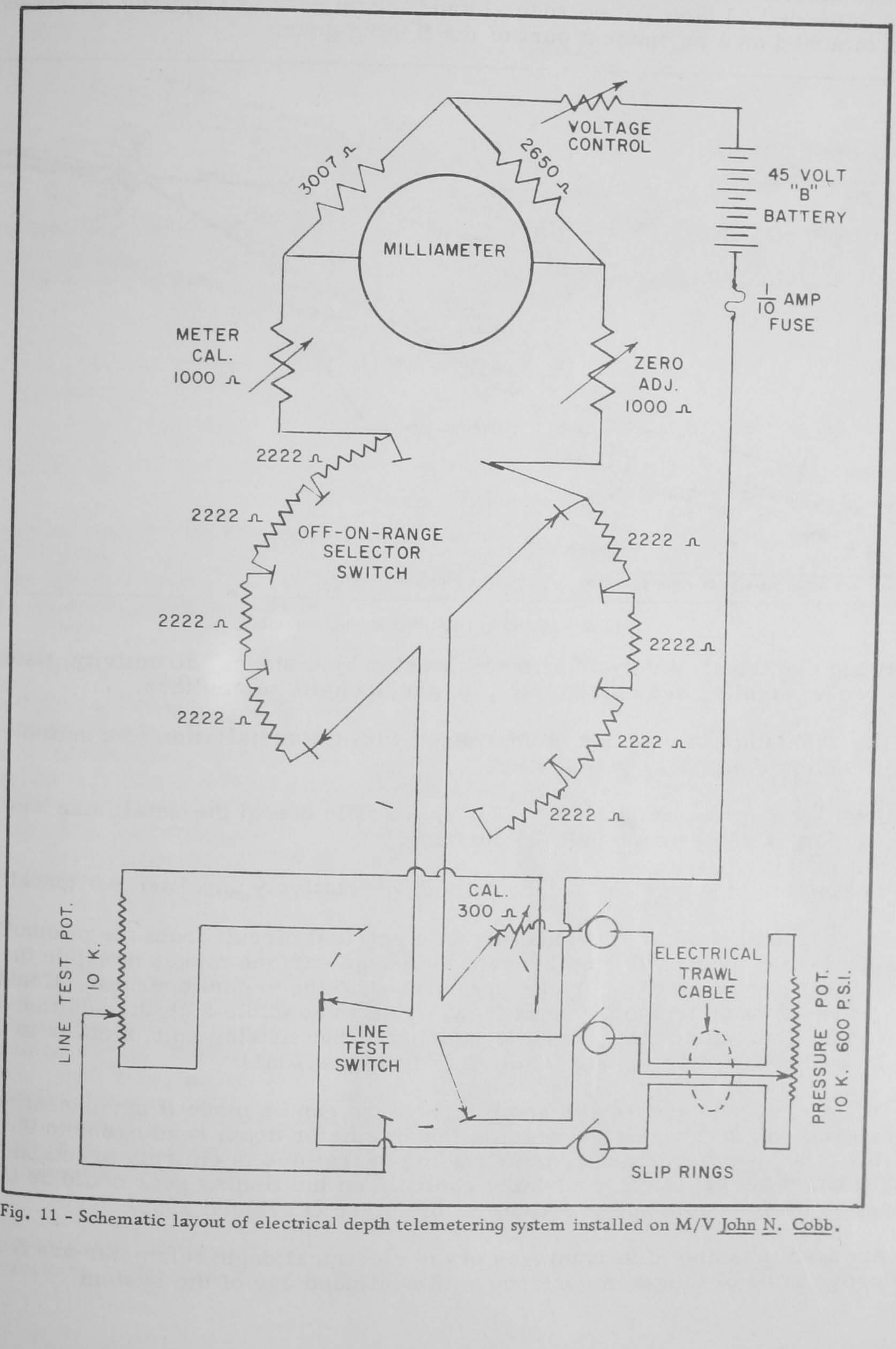


Fig. 11 - Schematic layout of electrical depth telemetering system installed on M/V John N. Cobb.

ADVANTAGES AND DISADVANTAGES

The greatest advantage of the electrical depth telemetering system is its simplicity and practicability. Since it is a direct-reading instrument with a simple off-on range selector switch and line control rheostat to set, no specially-trained operator is needed. Likewise, no special handling on deck is required as the sensing unit is attached as a permanent part of the fishing gear.

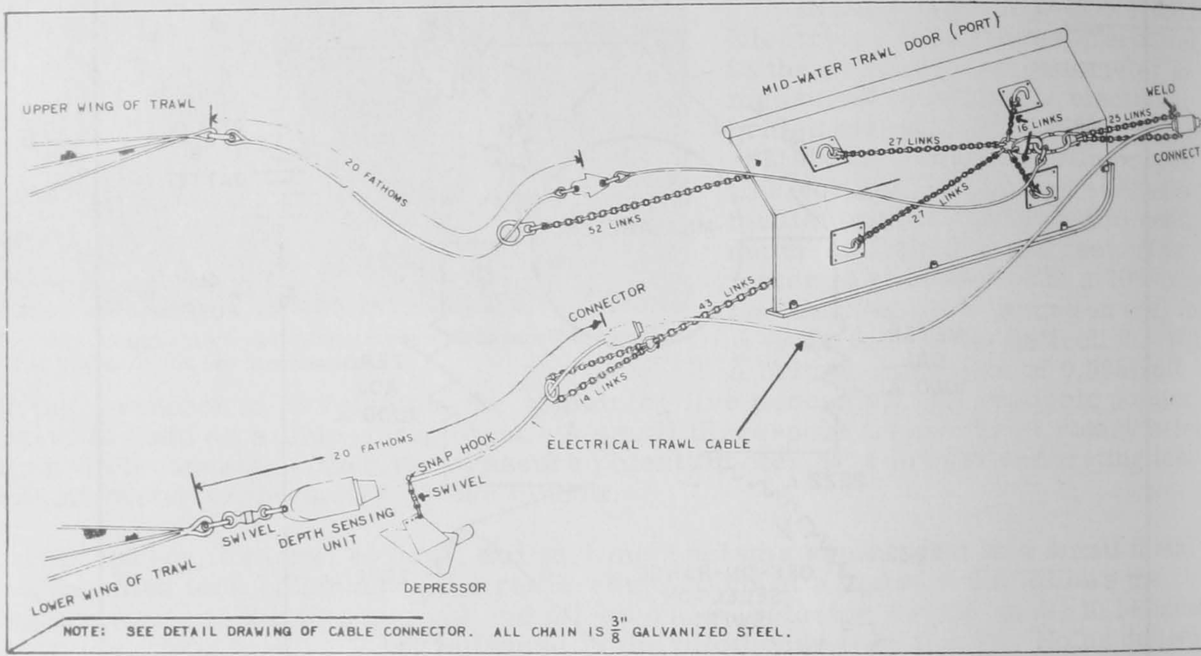


Fig. 12 - Midwater trawl door-to-net assembly.

Being electrical, the system is not affected by distance, directivity, water currents, wake, ambient sea noises, etc., as are acoustic telemeters.

The 225-fathom range can be increased with the installation of a suitable pressure potentiometer, and recalibration.

Use of the system on bottom trawls is feasible due to the small size and rugged construction of the sensing unit and housing.

Routine maintenance can be performed by relatively unskilled personnel.

The accomplishment of connecting an electrical circuit from the pilothouse of a fishing vessel to a trawl deep beneath the ocean surface makes possible the transmission of other types of desirable information to the vessel operator. Constant monitoring of water temperature at trawl depth is possible with the addition of a small thermistor inside the pressure housing of the sensing unit, similar to the S-T-D used by oceanographers (Collias and Barnes 1951).

Ink pen recordings of depth and temperature can be made if permanent records are desired. Also, graphic presentation of telemeter depth readings onto the echo-sounder recording paper used during fishing operations is entirely practical. Even some form of automatic or adjustable controls on the fishing gear could be installed if found to be desirable and practical in the future (Fryklund 1956).

Apparent possible disadvantages of the electrical depth telemeter are few and may prove to be of minor importance with continued use of the system.

Splicing the electrical trawl cable is more difficult and time-consuming than splicing standard cable used on fishing vessels. A 50-foot long-splice is required, which was found to be not unduly difficult after some experience. The 3,000-foot cable in use on the John N. Cobb is made up of two sections which were spliced together by two staff members in approximately two working days.

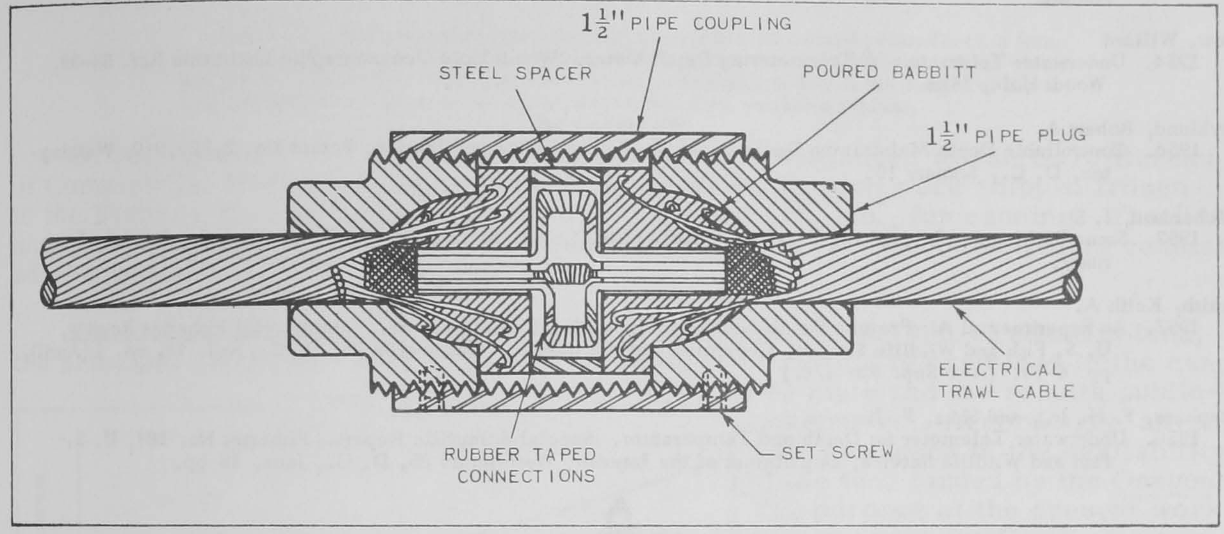


Fig. 13 - Connector for electrical trawl cable.

Present cost of the electrical cable is roughly 60 percent higher than the cost of regular plow steel trawl cable, but this cost differential cannot be properly evaluated until the life expectancy of a new cable is determined through actual service over an extended period of time.

LATEST REFINEMENTS

Certain refinements to the electrical telemeter hook-up were made on subsequent field trials to provide more accurate lead-line depth when midwater trawling very near the bottom. The depth-sensing unit was moved from in front of the trawl door to the lower port wing of the trawl (see fig. 12). This necessitated use of two electrical trawl cable connectors at the trawl door (see fig. 13).

Some breaking of the electrical conductors in the core of the trawl cable was experienced during later bottom trawling operations. This was caused by the stresses created as the electrical trawl cable passed around the standard size 9-inch diameter towing blocks (see fig. 2).

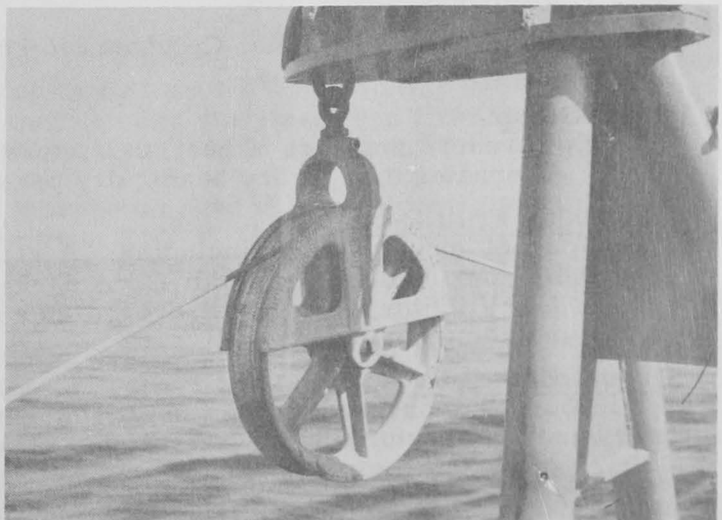


Fig. 14 - Large Block--20-inch diameter, aluminum--used with electrical trawl cable.

The use of specially-designed and fabricated 20-inch diameter aluminum trawl blocks has apparently remedied this condition (see fig. 14).

LITERATURE CITED

Barraclough, W. E., and Johnson, W. W.
1956. A New Midwater Trawl for Herring. Bulletin No. 104, Fisheries Research Board of Canada, Ottawa.

Collias, E. E., with Barnes, C. A.
1951. The Salinity-Temperature-Depth Recorder. University of Washington Oceanographic Laboratories, Seattle, August.

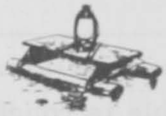
Dow, Willard
1954. Underwater Telemetry: A Telemetering Depth Meter. Woods Hole Oceanographic Institution Ref. 54-39, Woods Hole, Mass.

Fryklund, Robert A.
1956. Controllable Depth Maintaining Devices. U. S. Patent Office publication, Patent No. 2,729,910, Washington, D. C., January 10.

Richardson, I. D.
1957. Some Problems in Mid-Water Trawling. World Fishing, vol. 6, No. 2, John Trundell, Ltd., London, February.

Smith, Keith A.
1957. An Experimental Air-Pressure Depth-Meter for Use with Midwater Trawls. Commercial Fisheries Review, U. S. Fish and Wildlife Service, Department of the Interior, Washington 25, D. C., vol. 19, no. 4 (April), pp. 6-10. (Also Sep. No. 474.)

Stephens, F. H. Jr., and Shea, F. J.
1956. Underwater Telemeter for Depth and Temperature. Special Scientific Report.- Fisheries No. 181, U. S. Fish and Wildlife Service, Department of the Interior, Washington 25, D. C., June, 15 pp.



FOOD FOR FITNESS - A DAILY FOOD GUIDE

Food for Fitness - A Daily Food Guide, Leaflet No. 424, compiled by the Institute of Home Economics, U. S. Department of Agriculture, which supercedes The Basic Seven is now available to the public. In this guide, the main part of the daily diet is selected from these four broad groups:

Milk Group:
Some milk for everyone. Children 3 to 4 cups; teen-agers 4 or more cups; adults 2 or more cups.

Meat Group:
Two or more servings of beef, veal, pork, lamb, poultry, fish, or eggs. Alternates may be dry beans, dry peas, and nuts.

Vegetable Fruit Group:
Four of more serving including: A citrus fruit or other fruit or vegetable important for vitamin C. A dark-green or deep-yellow vegetable for Vitamin A--at least every other day. Other vegetables and fruits including potatoes.

Bread-Cereal Group:
Four or more servings of bread and cereals that are whole grain, enriched, and restored

Choose at least the minimum number of servings from each of the four food groups. Make choices within each group according to suggestions given in the leaflet. Choose additional foods to round out your meals both from foods in the four groups and from foods not listed in these groups. Try to have some meat, poultry, fish, eggs, or milk at each meal.

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