# UNDERWATER WARP TENSION METER

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A self contained electronic solid-state instrument capable of measuring the tension between the different parts of a trawl net in operation, has been designed and developed for the measurement in the range 0 to 300 kg with an accuracy of ± 2 kg. The instrument is useful for measuring the resistance to motion of various accessories of a trawl net. It consists of an inductive type underwater tension transducer and an electronic indicating meter kept on board the vessel, both the units being connected by electric cable.

## INTRODUCTION

The underwater 'dynamometers' or 'line tension meters' described by de Boer (1959), Nicholls (1964) and Hamuro and Ishii (1964) are all based on mechanical hydrostatic principles. They are all very heavy and bulky as they include the heavy hydrostatic pick up cells and the underwater self recording units. The electronic type underwater line tension meter described by Carrothers (1966) is based on converting the strain produced on a metal strip into variations in electrical resistance by using semi-conductor strain gauges. Since all the above instruments are underwater recorders, they are heavy and bulky and are unsuitable for comparatively smaller types trawls used in Indian coasts. Further, the operating ranges of the above instruments are in the order of a few tons and hence the measurements are not sufficiently accurate for smaller trawls. This paper describes a simple, light and comparatively inexpensive instrument for the continuous measurement of the warp tension under water.

## DESCRIPTION OF THE INSTRUMENT

The instrument consists essentially of two parts: (1) an underwater tension transducer and (2) a transistorized electronic indicating meter, both the units being connected by electric cable. The transductance is based on the principle of converting the mechanical strain in a coil spring due to the tension applied across it into corresponding variations in the inductance of an inductance coil. The coil whose inductance is to be varied was kept at one end of the brass cylinder as shown in Fig 1. A strong coil spring was provided inside the cylinder and the tension to be measured was applied across the two hooks A and B provided in the piston and

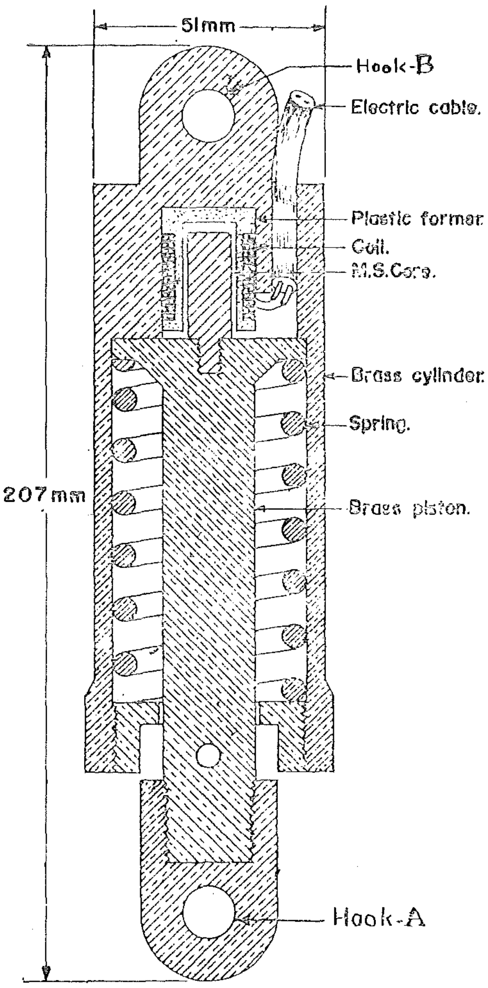

Fig.1. UNDER WATER TENSION TRANSDUCER.

the cylinder respectively. When tension is applied, the spring is loaded and the movement of the piston is controlled by the strain produced in the spring. A small mild steel core fixed on the cylinder keeps its position inside the inductance coil and moves inside it corresponding to the movement of the piston, with the result the strain produced in the spring is converted into variations in inductance of the coil. The inductance coil is connected to the electronic indicating meter on board the vessel by means of two-core, insulated and sheathed PVC wire.

The indicating part consists of an audio-oscillator, a two stage amplifier and an output meter. The oscillator produces audio sinusoidal waves at 1200 c/s with very low impedance compared to that of the transducer, so that the voltage of the audio source is not much affected due to the variations in the impedance of the transducer when the former is connected to the latter. When the audio oscillator source is fed to the transducer coil in series with the primary of the transformer T (Fig. 2), the total voltage is distributed across the coil according to the

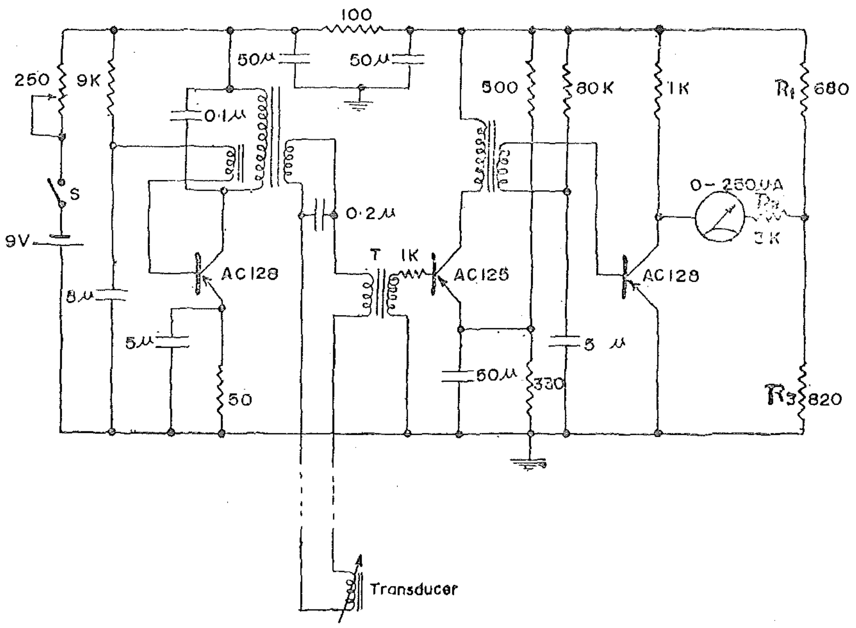

Fig 2. Electronic circuit of the instrument.

ratio of their impedances. As the impedance of the transducer coil is varied due to the tension applied accross the transducer the impedance ratio of the two coils is affected with the corresponding variation in voltages accross the two coils. The voltage across the primary of the transformer T is induced in the secondary and amplified with the transformer-coupled amplifier using the transistor AC 125. The entire signal induced in the secondary of the transformer varies from 2.1 to 2.3V corresponding to the tensions 0 kg and 300 kg respectively. As the amplification of the entire signal is difficult and unnecessary, the unwanted lower part of the signal is clipped off at a point slightly below the lower limit. The point of clipping is well adjusted without affecting the linearity of the gain of amplification by adjusting the value of the emitter resistance which is a part of the potential divider for providing constant emitter voltage to the transistor. The selected and amplified signal is further amplified and fed to a microammeter with a potential divider comprising of $R_1$ and $R_3$, and a series resistance $R_2$, for exact coincidance of the minimum and maximum deflections of the meter with 0 kg and 300 kg tensions respectively. The meter deflections were graduated in terms of tensions in kg. The supply voltage is initially set the same with the help of the 250 ohms wire wound resistance by bringing the meter deflection to 0, keeping the tension across the transducer at 0 kg.

The following are the important features of the instrument developed for trials. Range of measurement: 0 to 300kg, accuracy: ± 2 kg, weight in air of the transducer: 2.25 kg, weight in water of the transducer: 1.97 kg, cable length provided: 100m. The instrument was made fully out of indigenously available components and the cost of construction was estimated to be Rs 1500/- approximately.

### OPERATION OF THE INSTRUMENT

Before fixing the transducer, the instrument was calibrated. The transducer was first connected to the indicating meter and the switch put on. The deflection of the pointer was brought to the reading corresponding to zero tension, keeping the transducer at zero tension, by working on the voltage adjusting knob provided in the instrument. Now the transducer was fixed in between two objects (say between otterboard and net), with the hook B nearer to the side of the boat, for the convenience of of handling the cable. The schematic diagram in Fig 3 shows the tension transducer fixed in between the net and the otterboard for measuring the resistance to motion of the trawl net alone. A dummy object of almost the same weight and size as that of the transducer was fixed in the other otterboard in the corresponding point for maintaining the stabililty in performance between the two sides of the trawl net.

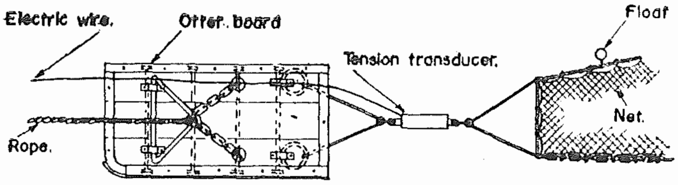

Fig. 3. THE SCHEMATIC DIAGRAM OF THE TENSION TRANSDUCER FITTED BETWEEN NET & OTTER BOARD.

## RESULTS AND DISCUSSION

### (1) The linearity of the scale:

The inductance variation of the coil in the transducer is linearly proportional to the movement of the core inside it and the strain of the coil spring is proportional to the tension applied, thereby making the inductance variation of the transducer linearly proportional to the tension. The gain of amplification is linear in every stage with the result, the tension displayed in the meter is linearly proportional to the deflections. The curve in Fig. 4 shows the relation between the tension and the meter deflections. The deflection in the meter was then graduated in terms of tension.

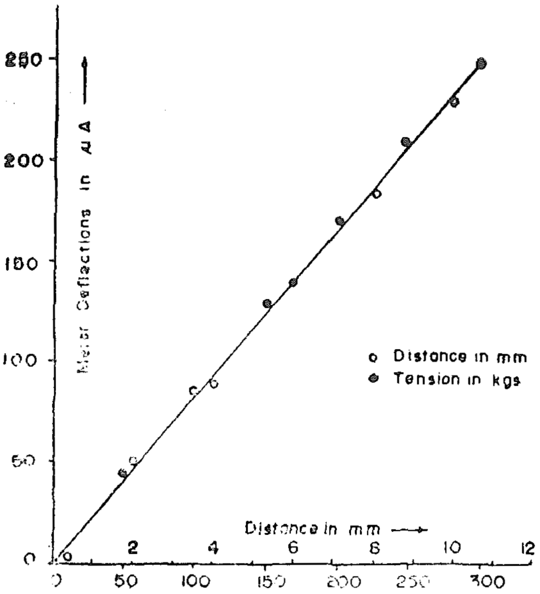

Fig 4 The graph shows the linear relationship between meter deflections and tension/distance.

### 2. The consistency of readings:

Since the consistency of readings very much depends upon the fatigue characteristics of the spring, the spring is compressed to a very limited range (10.7 mm), much below the elastic limit for ensuring consistency of the transducer performance. The solid state electronic unit is free from drift, within reasonable limitations, making the amplifier sufficienily stable to produce consistent readings.

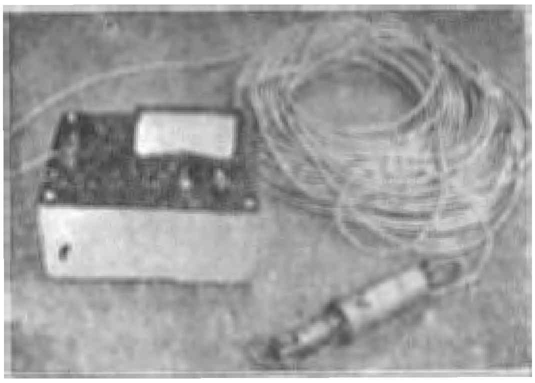

Fig 5. Tension transducer indicating meter and connecting wire.

### 3. Graduation of the meter

The meter was graduated by applying known tensions accross the two hooks in series with a dial type spring balance. As the sea water is conductive in nature and has got its effect in the readings of the meter during the course of graduation, the space between the mild steel core and the coil was filled with sea water and the error thereby was avoided. However this has been found to be less than 5% for full scale of the meter.

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