MARITIME UNIVERSITY IN SZCZECIN

ORGANIZATIONAL UNIT:

FACULTY OF NAVIGATION - DEPARTMENT OF NAVIGATION DEVICES

Instruction

1

PRINCIPLE OF OPERATION AND HANDLING OF SPEED LOG
Lab

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Subject: CONSTRACTION AND MAINTENANCE OF THE SPEED LOG

1. Purpose of exercise

The purpose of the exercise is to familiarize students with the construction of the difference types of Speed log and its operation. Particular attention should be paid to the co-operation of individual parts of speed log, which have a decisive influence on the accuracy of the determination of the speed.

2. Theoretical preparation

Before beginning classes, students should read theoretical exercises.

- The main division of logs due to the measurement of speed relative to SOG and measuring the movement of vessel through water
- The basic construction of the Speed logs:
- Hyrdo-mechnical Log, propeller Log
- EM - Electromagnetic Log
- Hydrodynamic Log
- Hydro-acoustic Log

3. Exercise course and report

The report should be a relation of the course activities with the purpose of the exercise and according to the instructor's instructions. Do

1. Speed measurement using electromagnetic induction

Electromagnetic speed logs continue to be popular for measuring the movement of a vessel through water. This type of log uses Michael Faraday's well-documented principle of measuring the flow of a fluid past a sensor by means of electromagnetic induction.

The operation relies upon the principle that any conductor, which is moved across a magnetic field, will have induced into it a small electromotive force (e.m.f.). Alternatively, the e.m.f. will also be induced if the conductor remains stationary and the magnetic field is moved with respect to it. Assuming that the magnetic field remains constant, the amplitude of the induced e.m.f. will be directly proportional to the speed of movement.

In a practical installation, a constant e.m.f. is developed in a conductor (seawater flowing past the sensor) and a minute current, proportional to the relative velocity, is induced in a collector. The magnetic field created in the seawater is produced by a solenoid which may extend into the water or be fitted flush with the hull. As the vessel moves, the seawater (the conductor) flowing through the magnetic field has a small e.m.f. Induced into it. This minute e.m.f., the amplitude of which is dependent upon the rate of cutting the magnetic lines of force, is detected by two small electrodes set into the outer casing of the sensor.

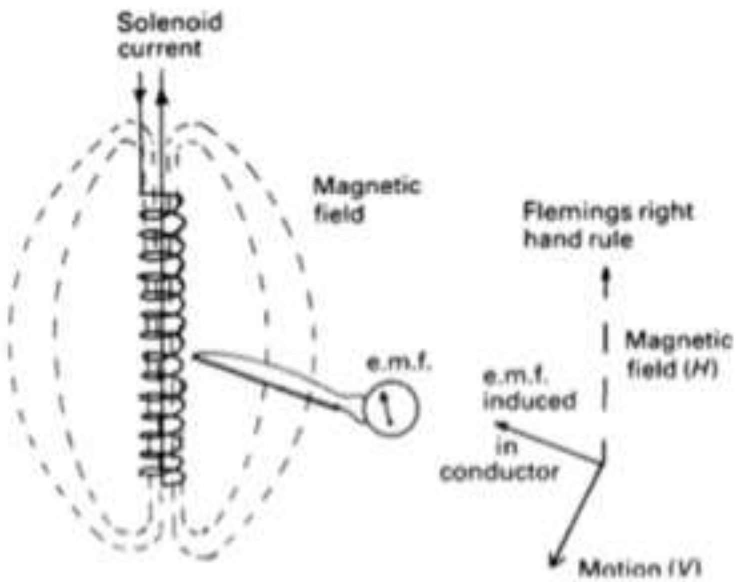

Figure 1.1 Effect of moving a conductor through a magnetic field.

Figure 1.1 shows a solenoid generating a magnetic field and a conductor connected in the form of a loop able to move at right angles to the field. If the conductor is moved in the direction shown, a tiny current will be induced in the wire and a small e.m.f. is produced across it. In the case of an electromagnetic speed log, the conductor is seawater passing through the magnetic field. Fleming's right-hand rule shows that the generated e.m.f. is at right angles to the magnetic field (*H*). Induced current flowing in the conductor produces an indication of the e.m.f. on the meter. If we assume that the energizing current for the solenoid is d.c. the induced e.m.f. is *lv*, where = the induced magnetic field, *l* = the length of the conductor, and *v* = the velocity of the conductor.

is approximately equal to *H*, the magnetic field strength. Therefore, e.m.f. = *Hlv* assuming no circuit losses.

To reduce the effects of electrolysis and make amplification of the induced e.m.f. simpler, a.c. is used to generate the magnetic field. The magnetic field strength *H* now becomes *H*msin t and the induced e.m.f. is: *H*m*lv*sin t. If the strength of the magnetic field and the length of the conductor both remain constant then, e.m.f. velocity.

Electronic Navigation Systems

Ocean currents may introduce errors. Pitching and rolling will affect the relationship between the water speed and the hull. Error due to this effect may be compensated for by reducing the sensitivity of the receiver. This is achieved using a CR timing circuit with a long time constant to damp out the oscillatory effect.

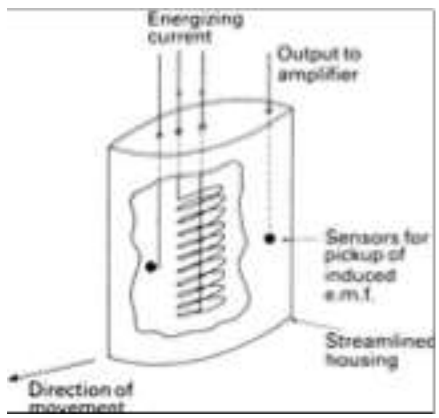

Figure 1.2. shows a typical sensor cutaway revealing the solenoid and the pick-up electrodes.

2. Speed measurement using acoustic correlation techniques

Unlike the previously described speed log, which measures the vessel’s speed with respect to water only, the SAL-ICCOR log measures the speed with respect to the seabed or to a suspended water mass. The log derives the vessel’s speed by the use of signal acoustic correlation. Simply, this is a way of combining the properties of sonic waves in seawater with a correlation technique. Speed measurement is achieved by bottom tracking to a maximum depth of 200 m. If the bottom echo becomes weak or the depth exceeds 200 m, the system automatically switches to water-mass tracking and will record the vessel’s speed with respect to a water mass approximately 12 m below the keel.

The transducer transmits pulses of energy at a frequency of 150 kHz from two active piezoceramic elements that are arranged in the fore and aft line of the vessel (see Figure 3.12). Each element transmits in a wide lobe perpendicular to the seabed. As with an echo sounder, the transducer elements are switched to the receive mode after transmission has taken place.

The seabed, or water mass, reflected signals possess a time delay (T) dependent upon the contour of the seabed, as shown in Figure 3.13. Thus the received echo is, uniquely, a function of the instantaneous position of each sensor element plus the ship's speed. The echo signal, therefore, in one channel will be identical to that in the other channel, but will possess a time delay as shown.

The time delay (T), in seconds, can be presented as:

$$T = 0.5 \cdot sv$$

where s = the distance between the receiving elements and v = the ship's velocity. In the SAL-ACCOR log (see Figure 3.14), the speed is accurately estimated by a correlation technique. The distance between the transducer elements (s) is precisely fixed, therefore when the time

(T) has been determined, the speed of the vessel (v) can be accurately calculated. It should be noted that the calculated time delay (T) is that between the two transducer echoes and not that between transmission and reception. Temperature and salinity, the variables of sound velocity in seawater, will not affect the calculation. Each variable has the same influence on each received echo channel. Consequently the variables will cancel. It is also possible to use the time delay (T) between transmission and reception to calculate depth.

In this case the depth (d), in meters, is:

$$d = \frac{T}{2} \times C$$

Where:

C = the velocity of sonic energy in seawater (1500 ms^{-1}). Dimensions of the transducer active elements are kept to a minimum by the use of a high frequency and a wide lobe angle. A wide lobe angle (beamwidth) is used because echo target discrimination is not important in the speed log operation and has the advantage that the vessel is unlikely to 'run away' from the returned echo.

3. Principles of speed measurement using the Doppler effect

The phenomenon of Doppler frequency shift is often used to measure the speed of a moving object carrying a transmitter. Modern speed logs use this principle to measure the vessel's speed, with respect to the seabed, with an accuracy approaching 0.1%.

If a sonar beam is transmitted ahead of a vessel, the reflected energy wave will have suffered a frequency shift (see Figure 3.16), the amount of which depends upon:

- the transmitted frequency
- the velocity of the sonar energy wave
- the velocity of the transmitter (the ship).

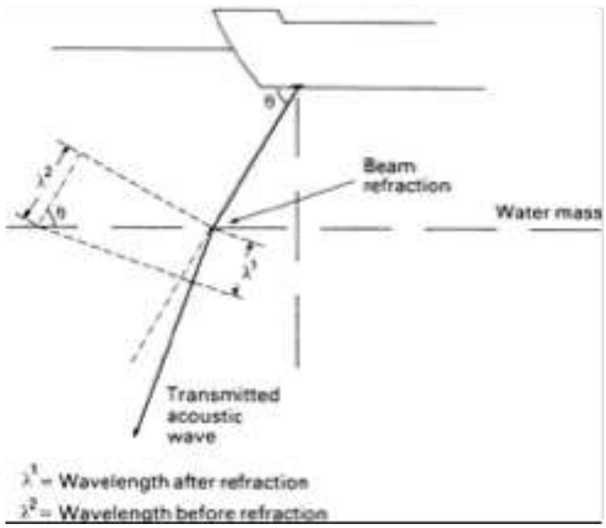

Figure 3.1 Illustration of the change of wavelength that occurs when an acoustic wave crosses a water mass.

The frequency shift, in hertz, of the returned wave is:

$$fd = ft - fr$$

where:

ft = the transmitted wave frequency,
fr = the received wave frequency.

The Doppler shift formula, for a reflected wave, is given as:

$$fd = \frac{2vft}{c}$$

where:

v = the velocity of the ship,
c = the velocity of the sonar wave (1500 ms^{-1} in seawater).

The addition of a second transducer assembly set at right angles to the first one, enables dual axis speed to be indicated (Figure 3.19).

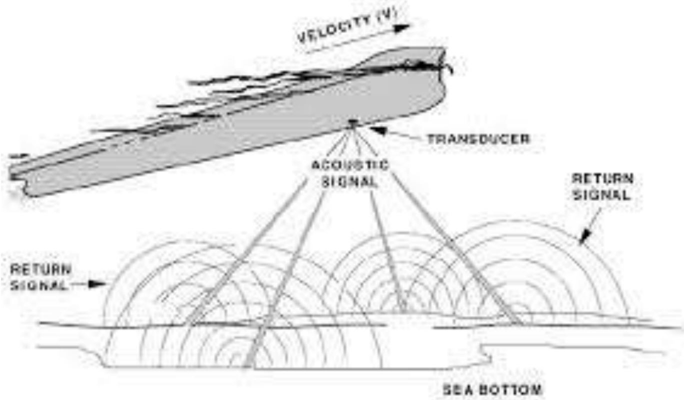

Figure 3.2 dual axis speeds is measured by transmitting sonar pulses in four narrow beams towards the seabed.

4. Speed measurement using water pressure

When a tube, with an opening at its base, is vertically submerged in water, a pressure, proportional to the depth to which the tube is submerged, will be developed in the tube. If the tube is held stationary the pressure remains constant and is termed 'static' pressure. If the tube is now moved through the water, whilst keeping the depth to which it is submerged constant, a second pressure called 'dynamic' pressure is developed. The total pressure in the tube, called a Pitot tube, is therefore the sum of both the static and dynamic pressures.

To ensure that the dynamic pressure reading, and thus speed, is accurate, the effect of static pressure must be eliminated. This is achieved by installing a second tube close to the first in such a way that the static pressure produced in it is identical to that created in the Pitot tube but without the pressure increase due to movement through the water (see Figure 4.1).

In a practical installation, tube B, the Pitot tube, extends below the vessel's hull to a depth *d*, whereas tube A, the static pressure intake tube, is flush with the hull.

With the vessel stationary, the static pressures from tube A to the top of the diaphragm and tube B to its underside almost cancel. The unequal pressures, which cause a small indication of speed to be displayed when the vessel is stationary, are compensated for in the log electromechanical system and the erroneous indication is cancelled. As the vessel moves through the water, in the direction shown, water is forced into tube B producing a combined pressure in the lower half of the chamber equal to both the static and dynamic pressures. The difference in pressure, between upper and lower chambers, now forces the diaphragm upwards thus operating the mechanical linkage. Obviously the greater the speed of the vessel through the water, the more the diaphragm will move and the greater will be the speed indicated.

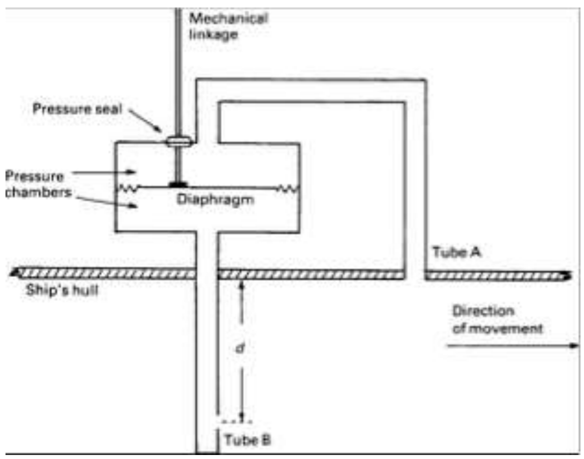

Figure 4.1 The pressure tank and tube intakes of a pressure tube speed logging system.

Unfortunately, the dynamic pressure developed in tube B, by the relative movement through the water, is proportional to the square of the vessel's speed. Pitot's Law states that this pressure p is proportional to the square of the ship's speed v multiplied by the coefficient K.

$$p = K \cdot v^2$$

where the constant K is derived from the vessel's tonnage, shape of hull, speed of the ship, and the length of the protruding part of the Pitot tube (distance d).

As shown in Figure 3.2, the speed indication produced is not linear. It is necessary therefore to eliminate the non-linear characteristics of the system and produce a linear speed indication. This is achieved mechanically, by the use of precisely engineered cones or electronically using CR (capacitive/resistive) time constant circuitry.

Biography:

1. www.salnavigation.com

2. www.Speed_logs_description.pdf