NATIONAL INSTITUTE OF OCEANOGRAPHY

WORMLEY, GODALMING, SURREY

Acoustic Command System

by

M. J. HARRIS

N.I.O. Internal Report No. A. 61

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CONTENTS

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Summary

The acoustic command system has been developed to provide the facility of remote controlled switching for underwater devices. This is achieved by transmitting from the command station a 10kHz carrier frequency modulated by a precise sub-carrier tone in the region of 500Hz. The acoustic signal on being received by a hydrophone is amplified and fed to a discriminator. The signal after demodulation passes through an RC active filter which in turn activates the switching circuit. To avoid erroneous switching the system relies on the following factors.

(a) The good signal to noise ratio provided by the FM transmission.

(b) The high signal to noise acceptance from the RC active filters. These filters are adjusted to provide a Q of about 100.

(c) A transmission time for switching of approximately 60 seconds.

The maximum operational range for the present system is 5 N. miles.

Introduction

The system was developed in the first place for releasing the anchors of submerged buoy systems thus allowing them to rise to the surface for recovery and also to switch acoustic beacons. At the time development was undertaken, satisfactory commercial systems were not available. It was later adapted to open and close deep-sea research nets allowing catches to be obtained from a single depth without contamination during lowering or recovery.

At the time of development there was a requirement for a slant acoustic range of 5km with the receiver having an operating depth of 5000m and a life of six months. The whole system being operative in sea state 4. This specification together with the convenience of compatibility with previously existing equipment led to the choice of 10kHz for the carrier frequency. The absorption in sea water at this frequency is approximately 1dB per 1000m and the deep water ambient noise -50dB relative to 1μbar.

The system has now been in use for 5 years and has proved to be operative in sea states up to 8 while ranges of 6Kms are obtained in depths up to 5000m.

Design factors - shipboard equipment

It was calculated that 5 acoustic watts at 10kHz would be required to obtain an acoustic link over an 8Km range. Allowing a 50% efficiency for the transducer, the transmitter (Fig.2) was designed to produce 10 watts of electrical power. As there was a requirement for at least 10 channels a variable frequency oscillator with good long term stability (Fig.2) was used to

produce the sub-carrier. This allowed the selection of any frequency, the precise frequency being checked with a frequency meter (Fig. 2). To obtain maximum efficiency, the output impedance of the transmitter was matched to that of the transducer (Fig. 2) and its cable. This transducer is a lead zirconate titanate stack resonant at 10kHz with a Q of 5 and with a nearly omnidirectional beam pattern. The deviation of the FM transmission is limited to approximately ±1kHz by the Q of the transducer. If the Q were reduced at the expense of efficiency, it would be possible to increase the value of the sub-carrier frequency. However, in the present system it has proved practical to use sub-carriers as high as 530Hz.

Design factors - acoustic receiver

The transmitted signal is received by a magnetostrictive nickel scroll (Fig. 1) which resonates at 10kHz and has a Q of 10. After acoustic reception the signal is fed to an amplifier that has a band pass filter shaped to compensate for the frequency characteristics of the scroll. The gain of the amplifier is such that it will limit on ambient sea noise. The amplified signal is demodulated by a cross-over discriminator network using two tuned circuits and then passes through an RC active filter. The filter is adjusted to have a Q of 100 giving a bandwidth of about ±2Hz. Narrower bandwidths are not possible because the relative motion of the transmitter on board a ship and the receiver can introduce an appreciable change in frequency due to the doppler effect. A relative velocity of 6 knots changes the sub-carrier frequency by 1Hz. The output provided by the filter is used to charge a large capacitor. When the potential across this capacitor reaches 24V a zener diode conducts and operates a triggering circuit which discharges the capacitor through the electromagnetic device of the command system. The circuit has been designed to make it relatively easy to set up. This is particularly useful when effecting repairs at sea. In order to have a working life in excess of six months in the standby mode, the receiver was designed to draw 6mW of power from a battery pack. Mallory cells are used in the battery pack as they have the required high capacity and long storage life. The electronics are protected from the high pressure by being housed in high strength aluminium alloy (Type RR77) tubular canisters and the end caps of which are screwed in using castellated threads. These units are sealed with face mounted 'O' ring seals. Marsh and Marine plugs and sockets are used for the cable connectors.

Safety Precautions

Certain precautions have been taken to reduce the chance of accidental switching to a safe level. The 10kHz carrier signal is frequency modulated instead of amplitude modulated because apart from the gaussian 'sea-state' noise, most noise in the sea due to ships, biological sources etc. is amplitude modulated. Some animals such as whales and porpoises do produce frequency modulated signals but these are of a completely different nature to that used in the present FM system. In the receiver there are three stages of tuning and a narrow band filter. Thus the receiver is a highly selective system and it is most unlikely that any naturally produced noise could have just the right characteristics to activate it. The RC time constant

of the capacitor being charged by the filter is made as long as possible to give safety against accidental operation. An electrolytic capacitor is used to store the charge required, and apart from its natural leakage, a leakage resistor is connected across it to prevent the slow build up of charge by an occasional break-through of noise at the filter. In practise it has been found that a 5 second switching time gives adequate protection over a period of six months.

Application of the Acoustic Command

At the present time the command unit is being used to switch acoustic beacons, release underwater buoy systems, and operate the opening and closing mechanism of biological nets.

In the first application (Fig. 3) two frequency channels are used to switch the acoustic beacon on and off. The beacon used is type BMK III pinger. This instrument emits keyed 10kHz pulses with an adjustable duration in the range 1 to 5 milliseconds and has a pulse repetition frequency controlled by a multivibrator running at a P.R.F. in the range 0.9 to 1.4 P.P.S. Once fixed, this P.R.F. remains stable to better than 1 part in 1000 over the working ranges of battery voltages and temperature, allowing pulse-to-pulse correlation to be used in the receiving display.

The second application (Fig. 4) requires maximum safety in all respects. The release receiver must be capable of releasing the ballast of a buoy system at any time during a six month period. To guard against the loss of costly equipment and data due to accidental release, the following additional precautions are taken.

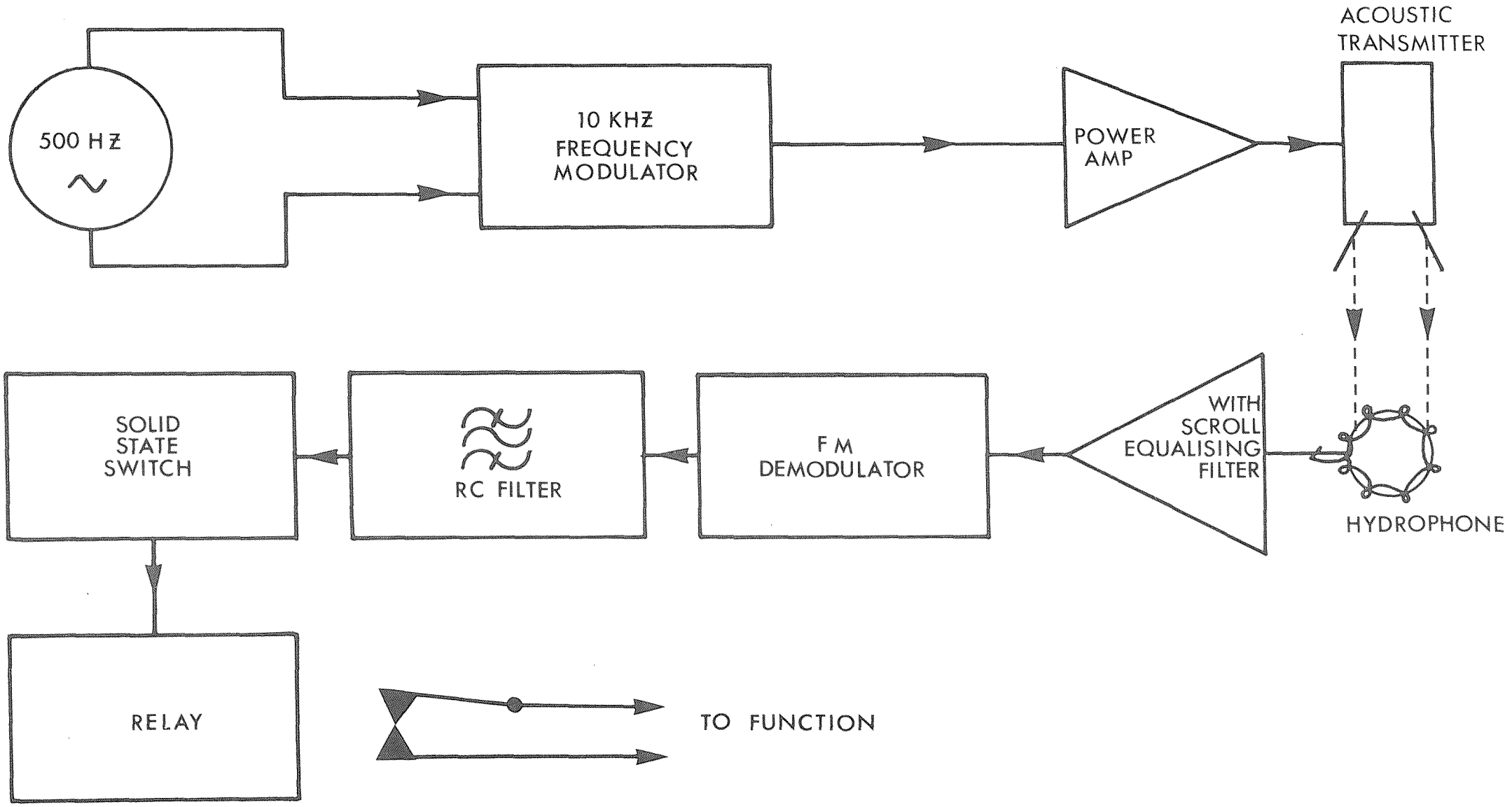
The release relay is a 12 position uniselector. This makes it necessary to activate the uniselector 11 times before the release position is reached. One bank of the uniselector switches is connected to an acoustic pinger. The pinger provides an audible signal on the first operation of the uniselector. This enables the correct operation of the receiver to be monitored before final release. Also since the release is armed with a detonator, for the safety of the operators it is essential to have audible warning of accidental switching of the release. Apart from this warning there is also a hydrostatic pressure switch in series with the explosive release which arms the release only when it is in the water.

These command systems are arranged to have a working life of six months and an operating depth of 5000 metres.

In the third application (Fig. 5) the command system is mounted on the bridle of a biological trawl. Two sub-carrier channels are used to open and close the net. Despite the additional noise generated by the trawl the command link has been used at ranges of 3000m and depths of 2000m. In this application the transmitting transducer is mounted on a depressor in such a way that the signal is beamed on to the command receiver.

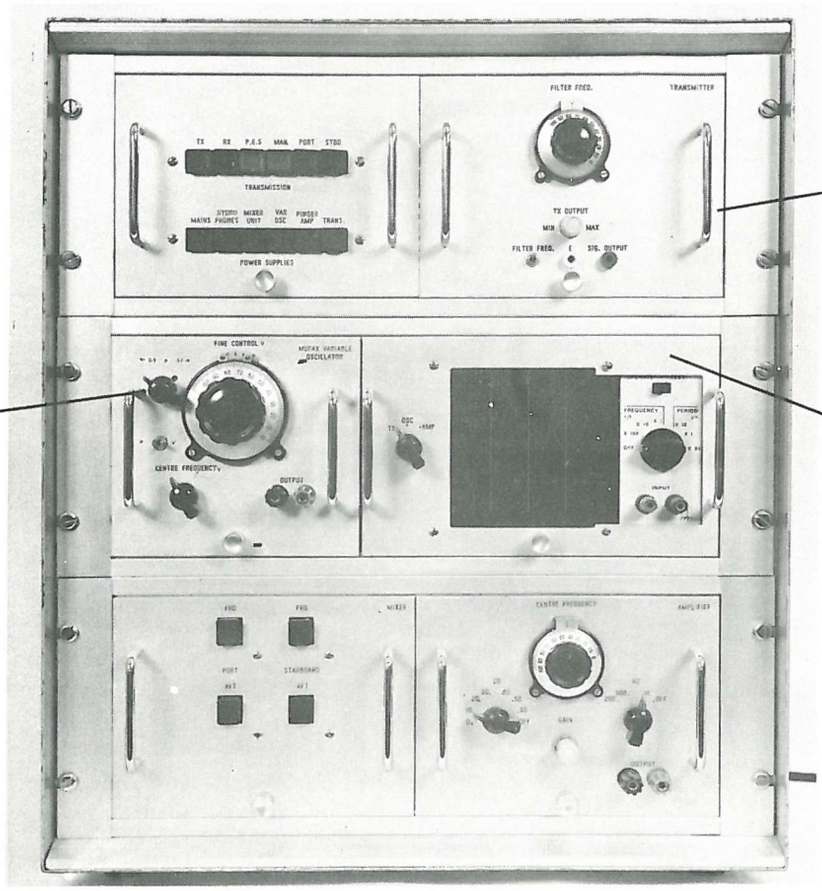
Conclusion

This system has been used over 150 times in different mooring applications over the past 6 years and there has not been any evidence to suggest that it has been switched on by noise. Where moorings have not been recovered and the cause has been positively established, it has not been due to a failure of the acoustic electronic system.

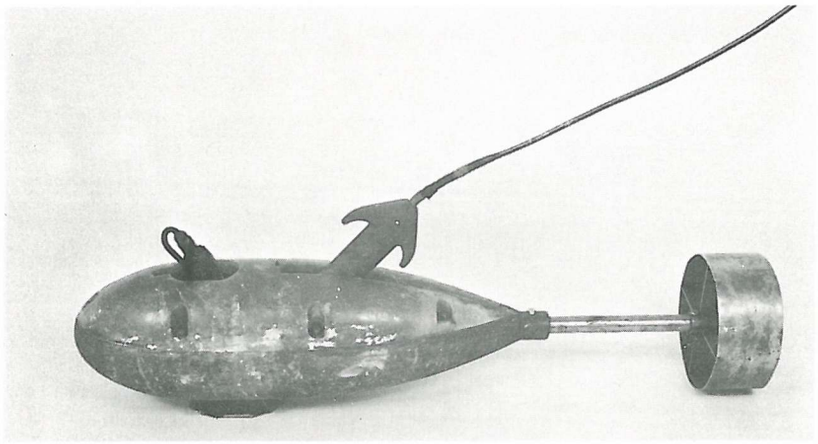


BLOCK SCHEMATIC OF ACOUSTIC COMMAND SYSTEM

FIG. 1.

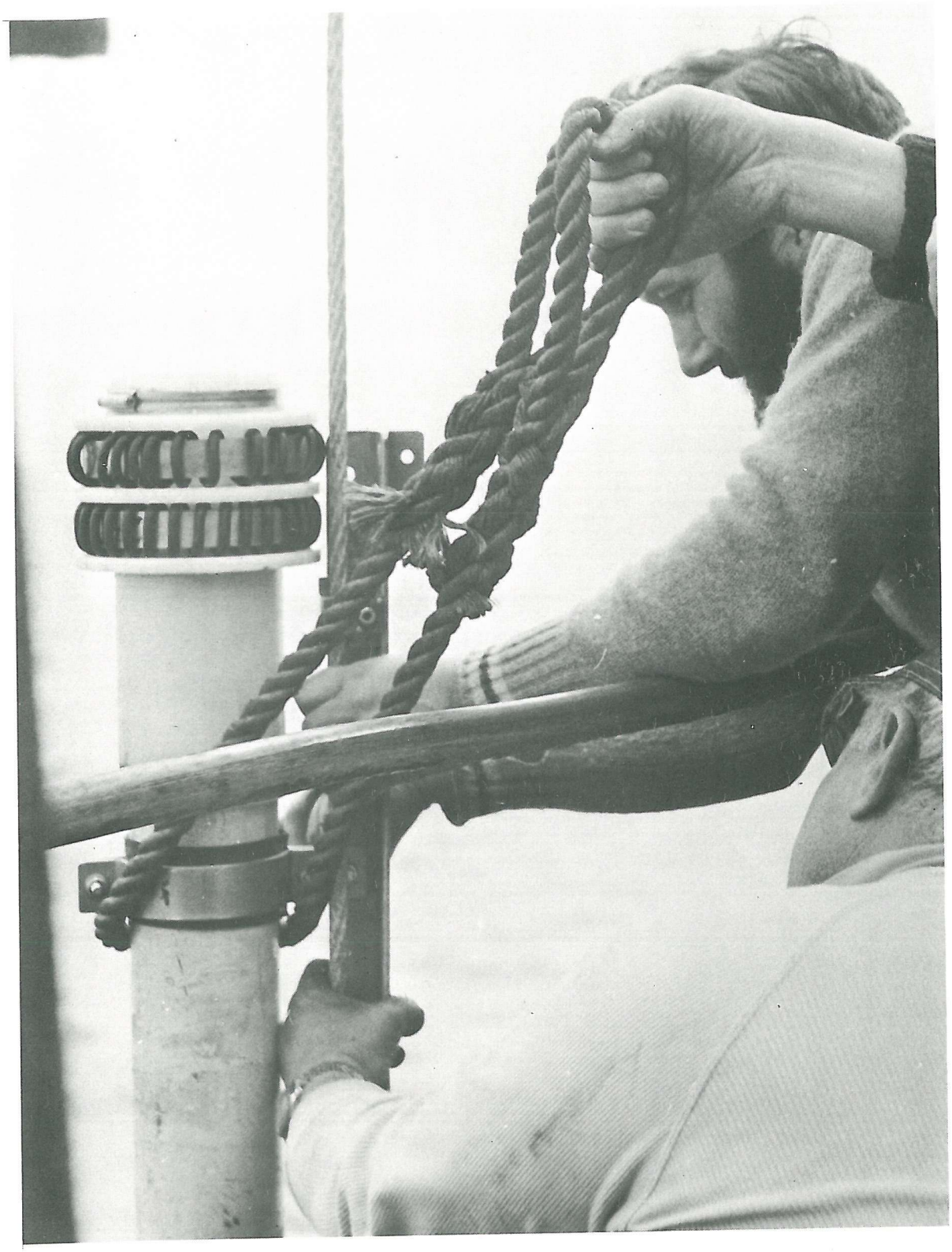


TRANSMITTER / TRACKER

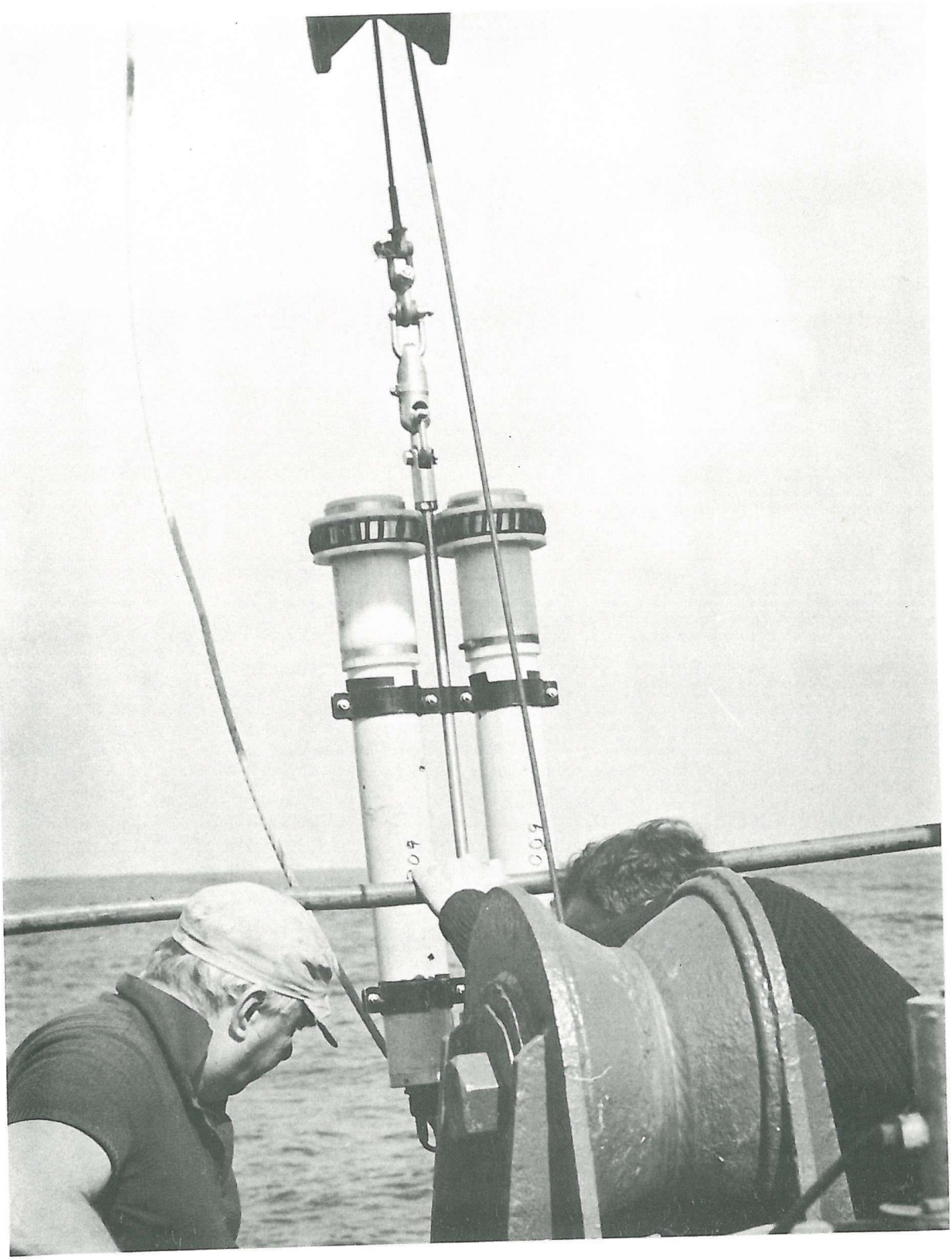


TRANSDUCER

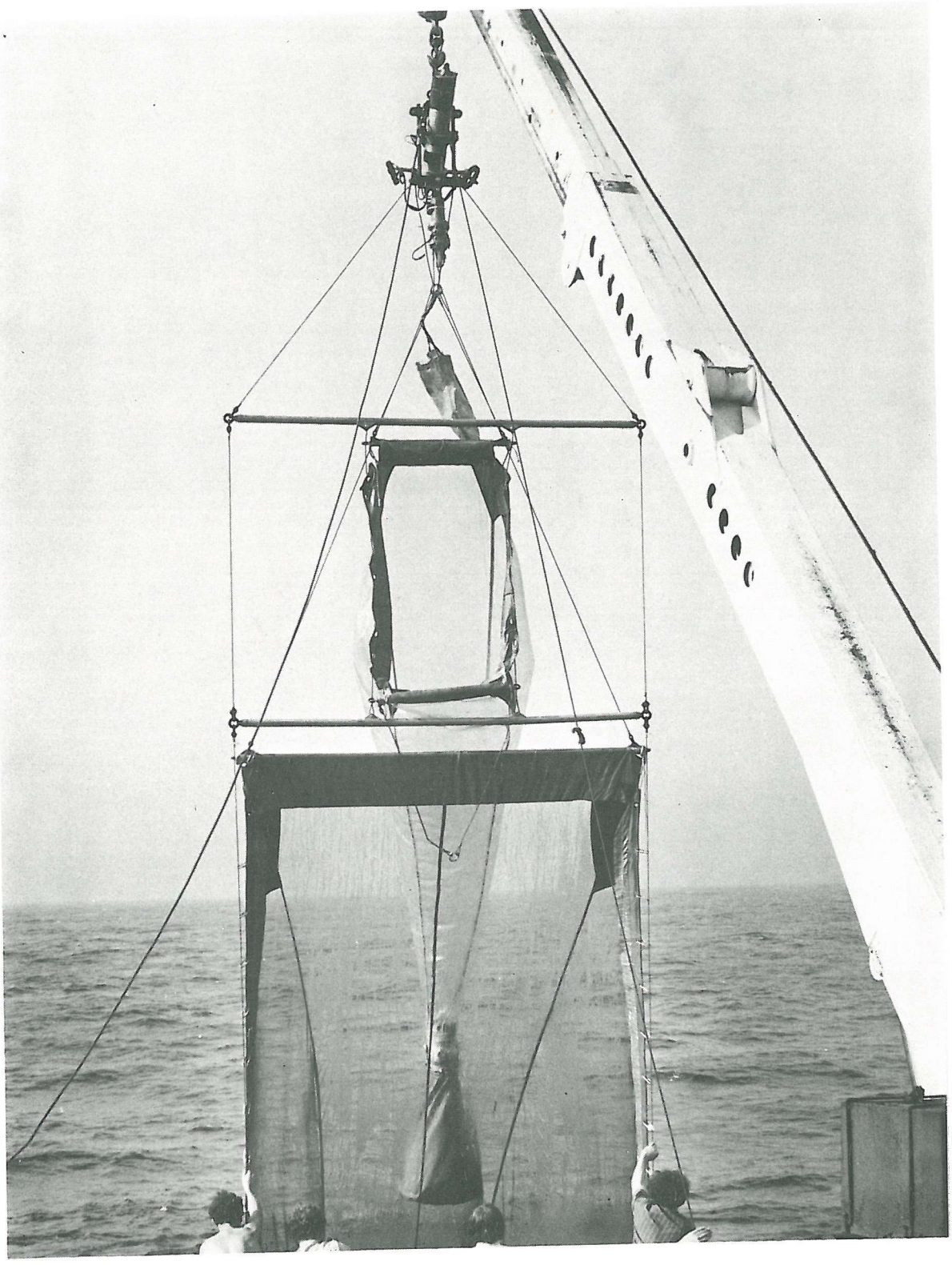
FIG. 2



ACOUSTIC COMMAND BEACON
FIG. 3



RELEASE RECEIVER
FIG. 4.



ACOUSTIC NET RELEASE
FIG. 5