A Fisherman's Guide to Echo Sounding and Sonar Equipment: Acoustic Fish Detection Instruments

Duncan Amos

Marine Advisory Service
NOAA/Sea Grant

University of Rhode Island

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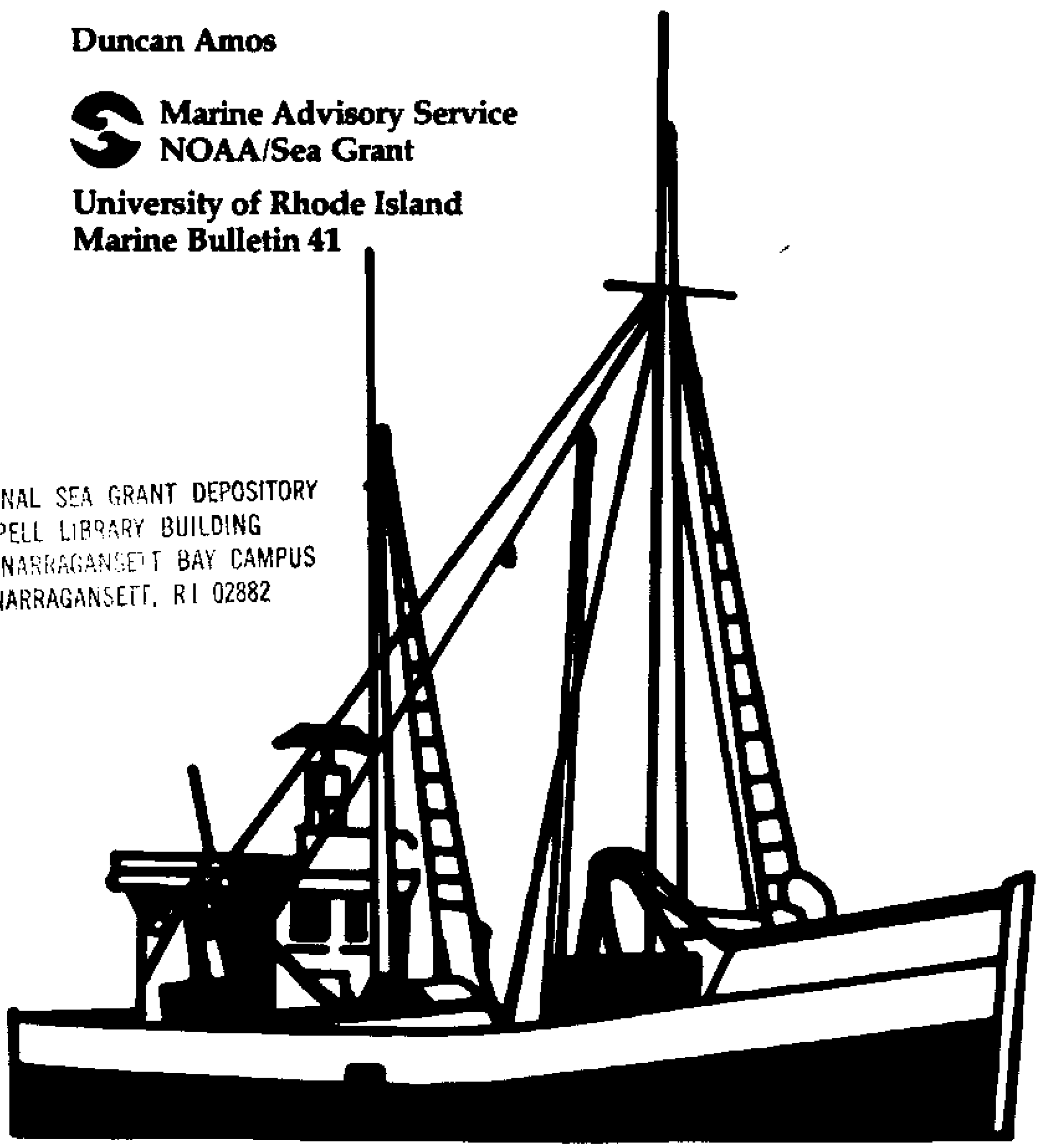

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A FISHERMAN'S GUIDE TO ECHO SOUNDING AND SONAR EQUIPMENT: ACOUSTIC FISH DETECTION INSTRUMENTS

Duncan Amos
Commercial Fisheries Specialist
Marine Advisory Service

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CONTENTS

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Introduction

With the advent of sophisticated acoustic devices for the detection and capture of fish, many fishermen find that they overspecify the equipment they need or they merely order equipment that is already being used by other fishermen in the area or is recommended by a salesman.

With the high cost of these instruments, the correct specification, installation, and operation of equipment is an absolute requirement to ensure that the fisherman gains maximum benefit, both financially and operationally, from his equipment.

This guide will provide the fisherman with an understanding of how echo sounders and sonars work, how to specify equipment for his needs, how to ensure its correct installation, how to adjust the equipment correctly, and, finally, how to interpret the information presented on the equipment displays.

SECTION I

The Basic Principles

The term echo sounder suggests that, in seafarer's terms, the user is sounding the depth of water below the keel of his vessel using an echo technique. Today's mariners are already familiar with echo techniques when it is applied to RADAR with its familiar display of echo returns from other targets. However, RADAR transmissions and echo returns travel at great speed through the air while the sound waves used in echo sounding and sonar equipments travel at relatively slow speeds.

Since sound waves behave differently in various mediums, it is important that the fisherman or equipment user appreciates what is happening to his sound transmissions and what causes the resultant echoes from beneath his vessel.

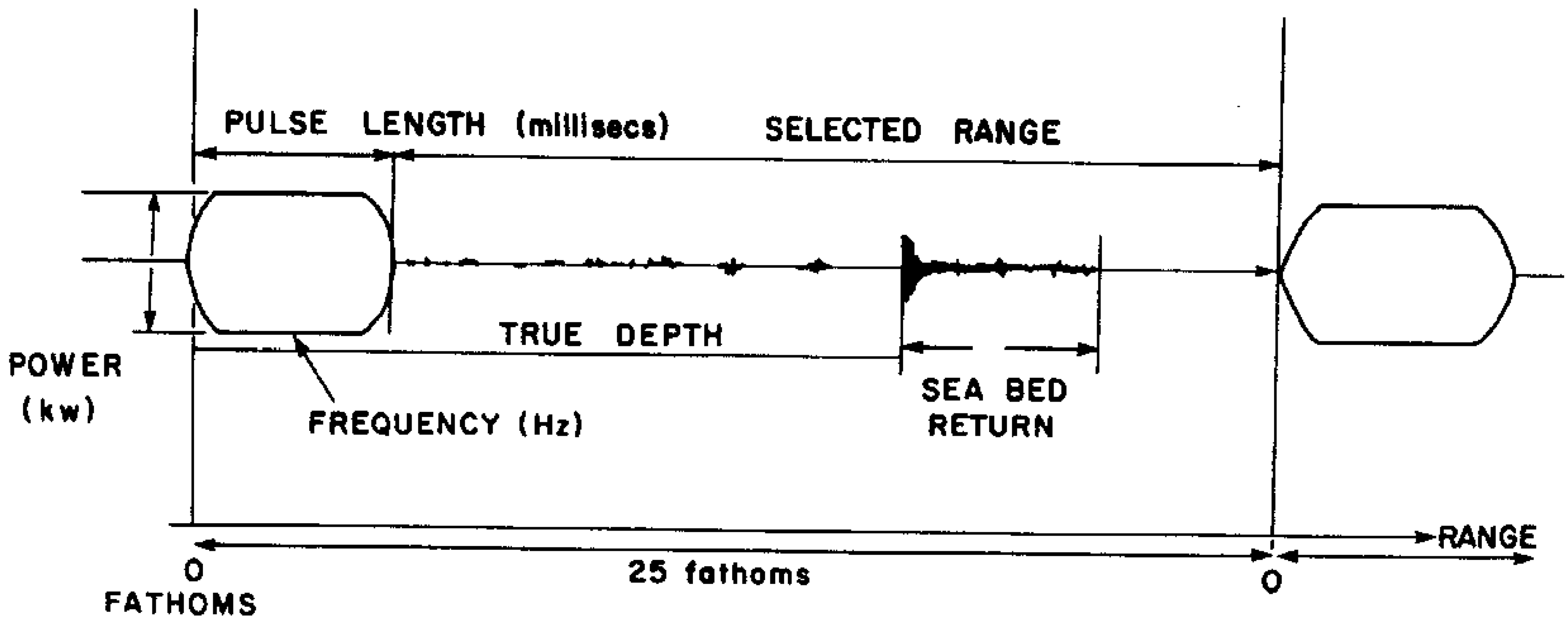
Many years ago, it was determined that sound waves travel through the air at 331 meters per second (approximately 1 mile in 5 seconds). It was also determined that this speed was the same for loud sounds as it was for quiet sounds, and the same for high pitched sounds as for low pitched sounds. However, it also became apparent that this speed was dependent on the density of the medium carrying the transmission. Generally the more dense the material the faster will be the speed of the sound.

In water, which is more dense than air, the speed of a sound transmission increases up to 1500 meters per second (approximately 4800 feet per second or 800 fathoms per second). Sounds of different pitch or frequency also travel different distances in water, low pitched sounds travelling much further than high pitched sounds. When a sound is transmitted into rock, its speed can increase up to 5,000 meters per second (16,250 feet per second or 2708 fathoms per second).

The change in transmission speeds associated with sound in different mediums forms the basic principle behind reflections or echoes when using echo sounding equipment.

Echo Formation

Having already determined that the sound wave will travel downwards through the water from the vessel's hull at a speed of approximately 800 fathoms per second, when it strikes the sea bed, which will be more dense than the water, the sound wave will attempt to increase its speed. When this happens, some of the energy in the sound wave will be reflected away from the interface or joining line between the water and the sea bed. The reflected sound wave will now travel back through the water at the same speed as the original sound, i.e. 800 fathoms per second, until it either strikes the hull of the vessel or the seawater/air interface at the surface.



CHARACTERISTICS OF ECHO SOUNDER SOUND PULSES

FIGURE 1

If the initial sound wave strikes a fish with a swim bladder or air sac in its body during its downward travel, the sound will attempt to slow down as it strikes the air pocket, and as before some of the energy in the sound wave will be reflected upwards. Travelling at the same speed as the initial wave, it will strike the vessel's hull or the air/sea interface at the surface. Other species of fish without swim bladders will still cause an echo but much smaller, as the density of fish flesh is not much different from the surrounding sea water.

At this stage, the general terms associated with the sound wave from echo sounding equipment should be appreciated.

An echo sounder does not transmit a continuous sound wave, but a series of pulses or bursts of sound. Each pulse will be of a specific duration, measured in milliseconds (1/1000 of a second), contain a number of vibrations or oscillations, measured in cycles per second (c/s) or Hertz (HZ), and as there is usually thousands of vibrations per second, the term Kilo Hertz (KHZ) is used, e.g. 48KHZ comes out as 48 thousand cycles per second or Hertz. The pulse will also have a power rating usually termed in Watts or Kilowatts (KW). The higher the number of Watts the greater the pulse power. See Figure 1.

SECTION II

The Simple Echo Sounder

As the speed of sound in sea water has been determined at a basic 800 fathoms per second, or 4.8 feet per millisecond, the simple echo sounder need only be comprised of a sound source or transmitter, a listening device, or receiver and a timing device or recorder.

Studying Figure 2 shows the basic arrangement where the sound source is the transducer driven by an electrical energy unit, or transmitter, a listening device or receiver, and a pen traversing across a paper at a set speed, or recorder. The pen speed is set by the range the user wishes to employ to measure the depth, and for convenience the maximum range scale shown in the diagram is 400 fathoms.

As the sound wave travels at 800 fathoms per second, a vessel floating in 400 fathoms of water will receive an echo from the sea bed one second after the transmission of the pulse - true depth =1/2 times the sound path. The pen will need to traverse the full width of the paper in one second. If the basic range of the machine is reduced to 200 fathoms, the pen speed will need to be twice as fast and traverse the paper in half a second. If the basic range of the machine is only ten fathoms, the pen will need to traverse the paper in only 0.25 seconds or 250 milliseconds. <u>The shorter the display or paper range the faster the pen speed</u>.

To ensure that a continuously accurate display of the vessel's depth is recorded, the paper must also move through the machine. As the vessel is probably moving across the water and the seabed may be varying in depth, the paper would ideally move through the machine at the ship's speed. This would ensure a true profile of the seabed. Economics dictate that this would be an extremely wasteful way of recording depth, so the paper moves much slower than the vessel, causing distortion of the seabed profile and notably the shape of any fish shoals that may be in the water. <u>The slower the paper speed the more echo distortion</u>.

Major Components of the Echo Sounder

1. <u>The Transmitter</u>

This unit generates an electrical pulse or burst of power. The unit also determines the frequency of the transmitted energy and also the length of the pulse. In a paper recording echo sounder the number of transmitted pulses, or pulse repetition rate, is determined by the speed of the recording pen, which also determines the maximum range to be used. Whenever the pen passes the zero mark on the range scale the transmitter will be energized.

2. The Transducer

The transducer is probably the most important unit in an echo sounding system, and is often the most neglected and wrongly located on the hull of the vessel.

Its major function is to convert the electrical energy from the transmitter into sound or mechanical energy, and to perform the reverse function of converting the sound or mechanical energy from an echo into electrical energy for the receiver.

There are two basic forms of transducer, the nickel or magneto striction transducer and the ceramic transducer. Both types do the same job with different degrees of efficiency, but at this stage the method of working is of more importance.

As stated earlier, the transducer converts electrical energy into mechanical or sound energy and vice versa. Basically the electrical energy causes the transducer face to vibrate mechanically, thus creating areas of increased and decreased pressure in the water at the transducer surface. The frequency of the vibrations being determined by the transmitter, and the duration of the vibrations being determined by the transmitter pulse length.

The reverse situation applies when an echo of sound energy strikes the transducer face. The vibrations are converted to electrical energy, once again at the frequency of the echo vibrations. If the transducer is subject to any other form of vibration due to mechanical shock caused by the vessel motion or continuous vibration because the transducer is located too near the engine or other machinery, the resultant energy conversion from mechanical to electrical vibrations will cause echo marking on the recording paper, which in general terms is called noise. Noise will reduce the efficiency of the machine for navigation and fish finding use. Transducer location is discussed under the section headed "Echo Sounder Installation."

3. The Receiver

The basic function of the receiver is to amplify or enlarge the small electrical signals from the transducer so that they can be used to mark the paper. However, today's more modern and sophisticated fish finding echo sounders have various signal processing circuits contained in the receiver section. They include white and grey line presentation, automatic gain control (AGC), swept time constant (STC), suppression (SUP), seabed or bottom lock processing, and midwater expansion. The receiver may also provide outputs to peripheral devices such as cathode ray tubes (fish loops or lupes), etc.

The receiver also contains the gain and sensitivity controls and various controls covering the intensity of echo marks on the paper (contrast or mark density).

BASIC ECHO SOUNDER

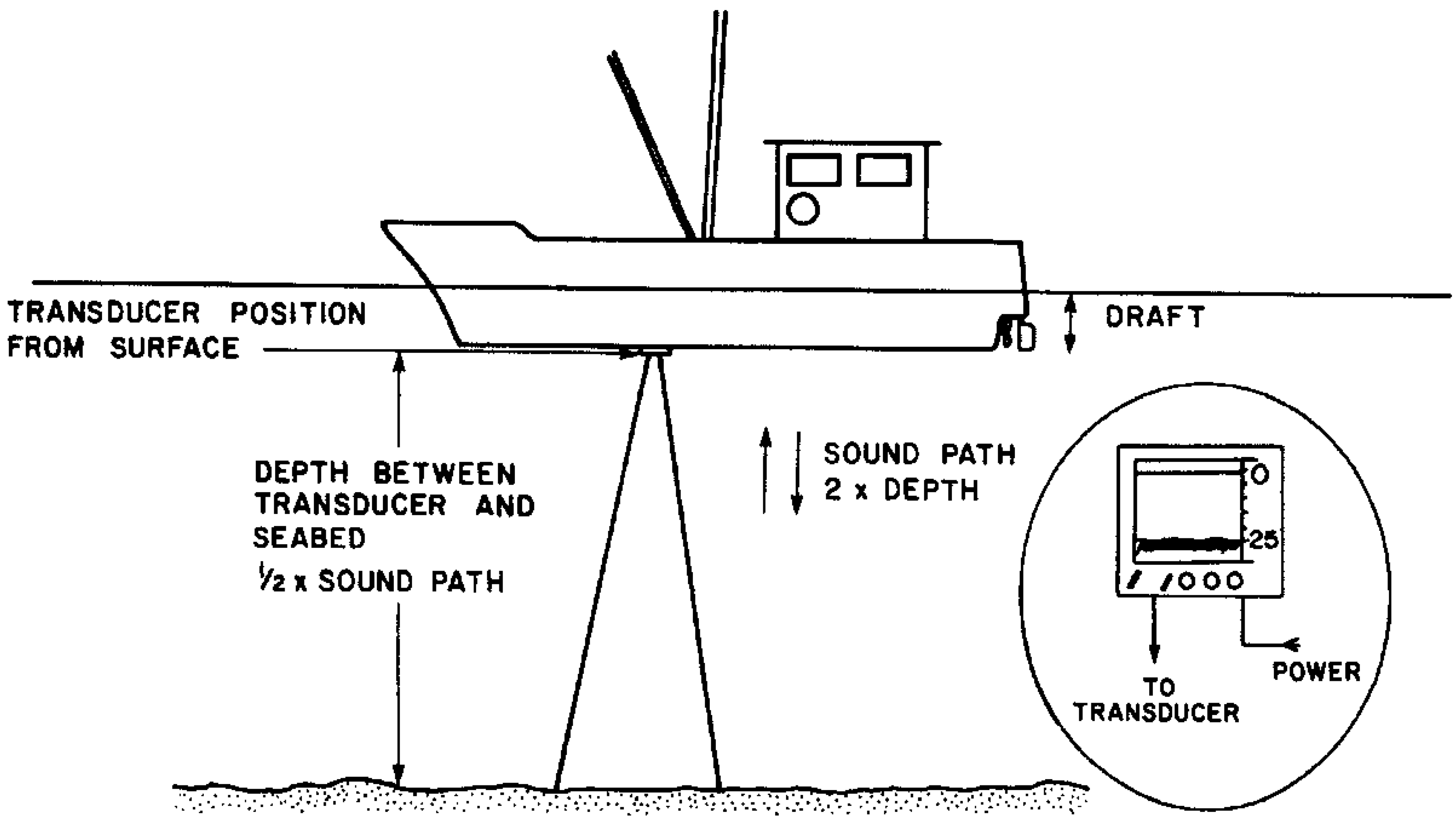
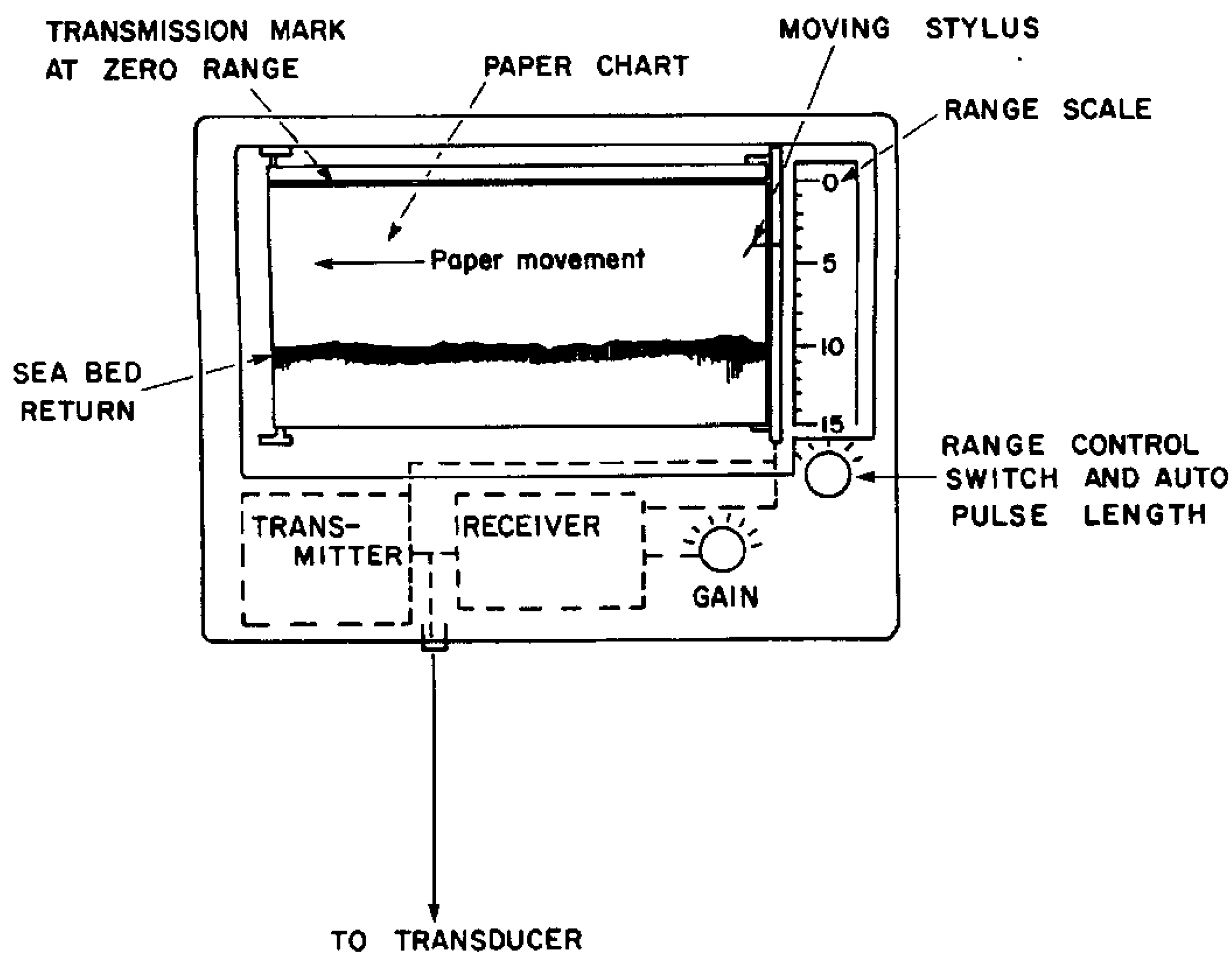


FIGURE 2



BASIC ECHOSOUNDER

FIGURE 3

All the major functions of the receiver are covered in the section headed "Echo Sounder Adjustment and Interpretation."

4. The Recording or Display Unit

So far the basic echo sounder has comprised a paper and single pen arrangement. Other systems are available using multistylus or cathode ray tube displays, both in monochrome and color. Whatever unit is used, the display basically shows the echo information as processed by the receiver.

The major controls associated with the display unit are: basic and phased range, zero line adjustment or draft adjustment, and where a cathode ray tube is used, brilliance or intensity, focus and color.

The function and use of these controls is discussed under the section "Echo Sounder Adjustments and Interpretation."

SECTION III

Echo Sounder Specification

There are many echo sounding machines available to the fisherman, but his first considerations must be: will the machine he buys do the work he expects from it, will it improve his fish detection and fishing performance, and finally will it provide him with an economic improvement through increased catches of fish.

Fishermen use echo sounders for a multitude of purposes, amongst them are:

1. Depth recording for navigation purposes
2. Ground or seabed discrimination, i.e. to determine soft mud, sand, gravel, and rock
3. To determine the seabed contours
4. To locate wrecks or other potential areas of hangups
5. To locate fish and to determine at what depth the fish are
6. To examine closely the size of the fish, and whether they are shoaling species or single swimming species
7. To study the general behavior patterns of fish over a fixed period of time.

Variations of the seven uses above are:

1. With the use of a net sounder, determine the position of the midwater trawl in the water column
2. Estimating the performance of a midwater trawl by observing the trawl mouth opening under varying towing conditions
3. Observing the potential catch rate of a midwater trawl and the behavior of the fish in the mouth of the trawl
4. Using a combination of the vertical echo sounder on board the vessel and the net sounder to ensure the midwater trawl is not damaged by too much fish in the net.

Basic Guidelines to Determine the Echo Sounder Needed by the Fisherman

Manufacturer's sales brochures and publications list a number of performance parameters that a potential buyer should study before making a decision on the machine he requires.

The essential ones are listed below with some comments on the fisherman's use of the machine.

1. Frequency

Echo sounders range from 20 KHZ to 200 KHZ in their working range for fish finding. Many machines are now fitted with a dual frequency capability, one in the low and one in the high range. The higher the frequency selected, the lower the effective detection range, so if a fisherman always works in waters of less than fifty fathoms, he can consider the higher frequency machines. Higher frequencies also provide better detection of species without swim bladders, such as mackerel and squid, etc. Lower frequencies provide better ground discrimination results, and also work better for fish detection in deeper waters, i.e. above 60-80 fathoms. A good compromise is a machine between 40 KHZ and 60 KHZ for most fishing purposes where working depths may vary between 30 and 150 fathoms. Dual frequency machines are generally in the low band around 40 KHZ and the high band between 160 KHZ and 200 KHZ, giving the ideal choice for the multipurpose fisherman.

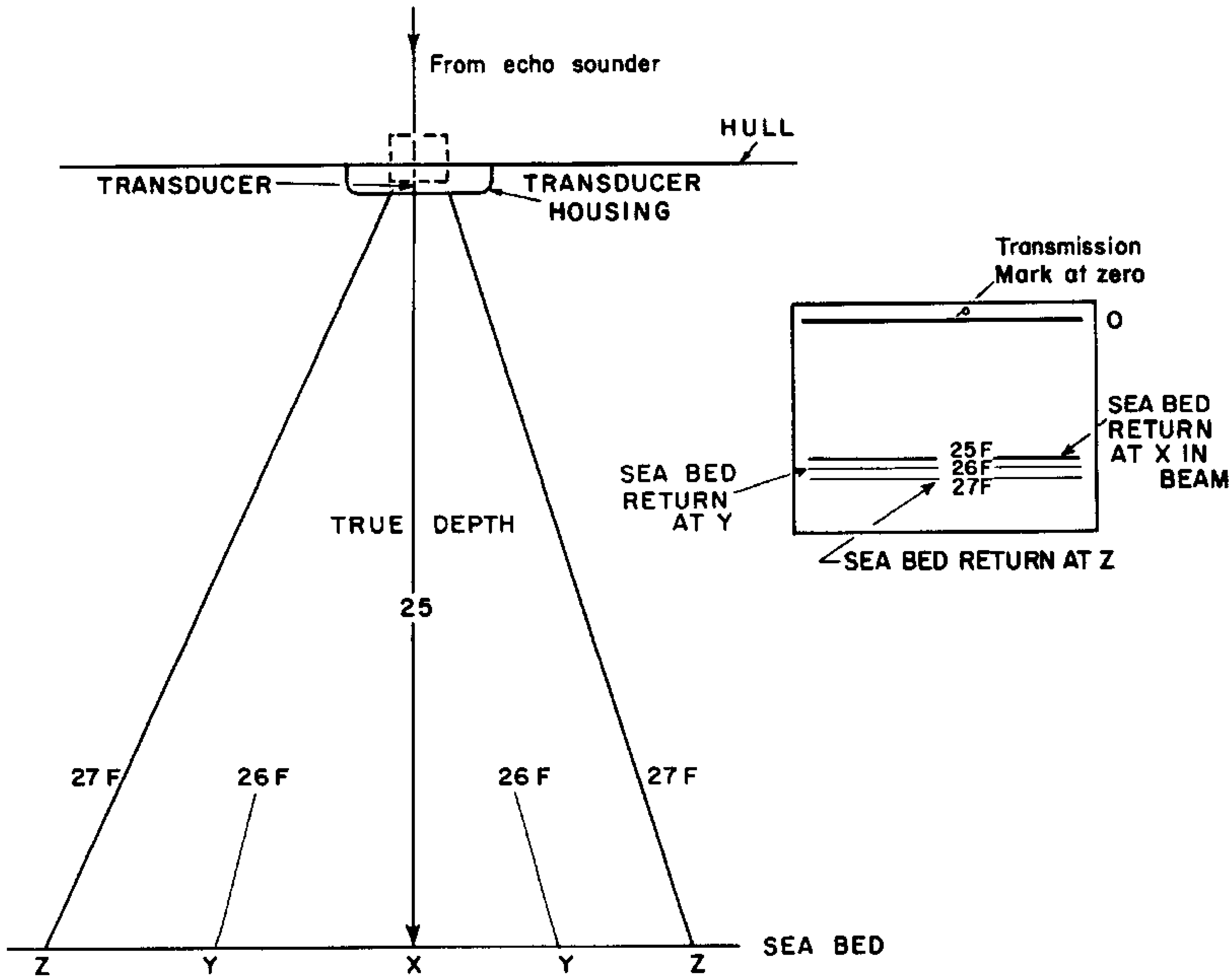
2. Transducer Beam Angle

The beam angle of an echo sounder transducer is an often neglected area of a potential buyer's deliberations. The beam angle chosen can directly affect the shape of fish echoes on the recorder, the quality of the ground discrimination recording, and the ability of small targets to be located at greater depths. Beam angles of transducers can be anything from 9° to 25°. Referring to Figure 4, a general rule of thumb is to select a wide beam angle for shallow water working and a narrower beam for deep water working, the break line between shallow and deep being at 50 fathoms.

If the wrong beam angle is selected, the fisherman will either "see" too much seabed or not enough. It is much better for a trawl fisherman to observe the fish near the seabed that is within the scope of his trawl gear, in other words his potential catch. A wide angle beam of 25° used in a water depth of 100 fathoms would probably show many more fish targets than the trawl would catch during the tow. A narrow beam angle used in shallow water would severely limit the targets displayed to the operator. Know your working depth, know your beam angle.

3. Sounding Ranges

Echo sounders have two distinct range selections. They are step basic ranges, which increase the working range with the movement of a switch, but the zero line is always at the top of the recording paper or scale. The other is more suitable to the fisherman, which is stepped basic ranges with phased range selection. When the basic principles of pen speed were illustrated in the first



BEAM ANGLE

FIGURE 4

section of this publication, it was demonstrated that the pen speed increased as the range across the recording paper decreased. As the pen passes the zero mark on the range scale, the transmitter was energized, and sent a pulse of sound into the water; thus on short ranges the pulse repetition rate must be increased. If pulse repetition rate is linked to a data rate, then the information passed to the operator must be increased. In fish detection machines, phased ranging means that a fast pen speed can be maintained across the paper, as only 20 fathoms, for example, will be displayed across the paper. However, the zero line need not be displayed on the recorder. This concept is illustrated in Figure 5. The echo sounder user should try to retain the fastest pen speed applicable to the water depth being worked. Phased ranging also allows maximum useful information to be displayed across the full width of the recording paper.

Pulse Length

Many modern echo sounders have automatic selection of pulse length, whilst others have an independent pulse length selector switch.

Pulse length is important when target discrimination is required, i.e. the wrong pulse length can make small fish look like large fish or shoals of fish look much more dense than they really are.

In basic principles of echo sounding, the speed of sound in water was discussed. If the reader now considers a pulse length at the transducer of 1 millisecond, then the face of the transducer will vibrate for 1/1000 of a second. At the beginning of the pulse, a wave front will move away from the transducer at 4875 feet (1500 meters) per second. The vibrations will continue for 1/1000 of a second, and by the time the pulse ends, the initial wave front will be 4.8 feet away from the transducer face. Thus a block of water, vibrating at the frequency of the echo sounder, 4.8 feet thick, will now travel down through the water at 4875 feet per second. If the pulse length is now doubled to 2/1000 of a second (2 milliseconds), then the vibrating water column will be 9.6 feet.

As a transmission pulse strikes a target, it will be reflected back to the transducer, and the echo will be 4.8 feet long on a 1 millisecond pulse, and 9.6 feet long on a 2 millisecond pulse. If two fish targets are within the span of a sound pulse in water, they will echo as one target and obviously mark on the recorder as one fish target.

Generally speaking, where an echo sounder has no pulse length selector switch, the pulse length is changed as the basic range is increased. Therefore the user should refer back to the section on phased ranging and use the range controls accordingly to avoid increasing the pulse length.

Where an independent pulse length switch is fitted, then the shortest possible pulse should be used to give consistent results in varying water depths.

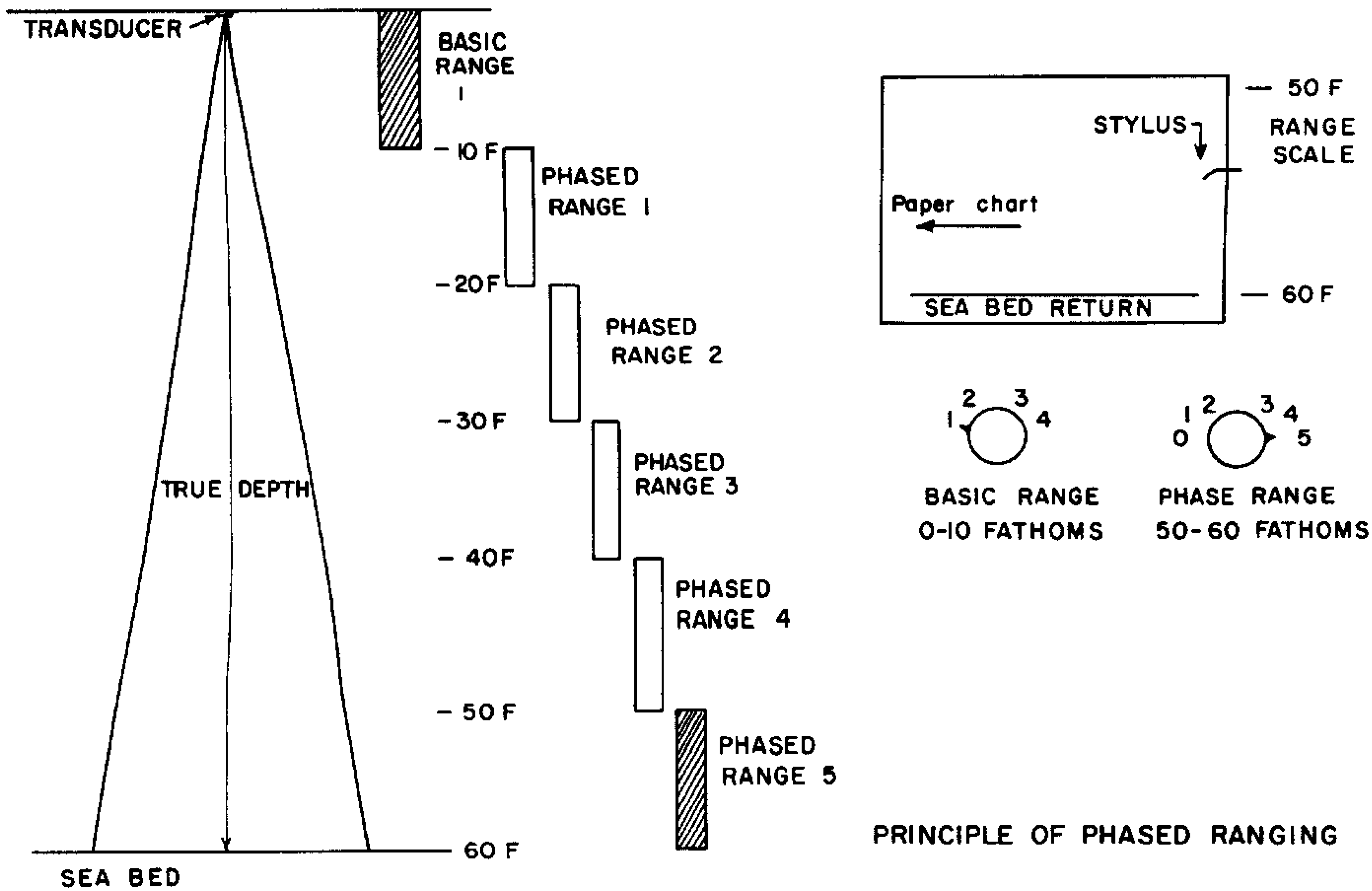

TRANSDUCER
BASIC RANGE 1
TRUE DEPTH
SEA BED
- 10 F
- 20F
- 30F
- 40F
- 50 F
60 F
PHASED RANGE 1
PHASED RANGE 2
PHASED RANGE 3
PHASED RANGE 4
PHASED RANGE 5
STYLUS
Paper chart
SEA BED RETURN
— 50 F
RANGE SCALE
— 60 F
1 2 3 4
0 1 2 3 4 5
BASIC RANGE
0-10 FATHOMS
PHASE RANGE
50-60 FATHOMS
PRINCIPLE OF PHASED RANGING

FIGURE 5

Recording Display

With paper chart echo sounders, there are two basic types: dry paper sounders and wet paper sounders. The recording system itself can be either moving stylus or fixed stylus, each with their own advantages and disadvantages.

Recording paper of the dry type has no limited shelf life, modern papers do not make excessive dust and do not deteriorate in the sounding machine. The moving stylus generally associated with this type of paper does, however, wear out, and needs regular simple maintenance (see section on adjusting the echo sounder).

Wet recording paper generally has a shelf life limit in the region of one year, but is usually cheaper than dry paper. The fixed stylus machines associated with wet paper are generally easier on maintenance requirements and cleaning. However, fixed stylus arrangements can be expensive to replace when damaged by misuse or badly cleaned. Wet paper can deteriorate in the machine over a period of time, particularly during long periods of shutdown.

Proper care in use and simple maintenance should enable both types to give good reliable service.

Summary

To specify a new echo sounder for fishing purposes, consider the following points:

1. Depth of water normally worked--this influences beam angle, machine ranges, and frequency.

2. How is the pulse length changed.

3. Recording paper width, the wider the paper, the better the data interpretation.

4. Type of stylus system, fixed or moving, which will also influence the type of recording paper used.

SECTION IV

Echo Sounder Installation

Once the purchase of an echo sounder is finalized, the next step is its installation in the vessel.

The equipment supplier will usually have the machine fitted to the vessel, but the owner/operator should be aware of the correct procedures to be followed and should be able to indicate the preferred location of the major units of the equipment.

Transducer Location

The previous sections outlined the basic principles of operation of the transducer and its major function in transmitting the sound pulse into the water and receiving the echoes from fish and the seabed.

Because of the method of operation of transducers, it is always desirable to mount the unit on the vessel's hull in what can be considered the quietest area with the minimum acoustic interference, either from ship's noise, vibration, or areas of heavy water disturbance.

The transducer should never be mounted immediately below the main engine or gearbox, and remember the auxilliary engine is another source of noise and vibration.

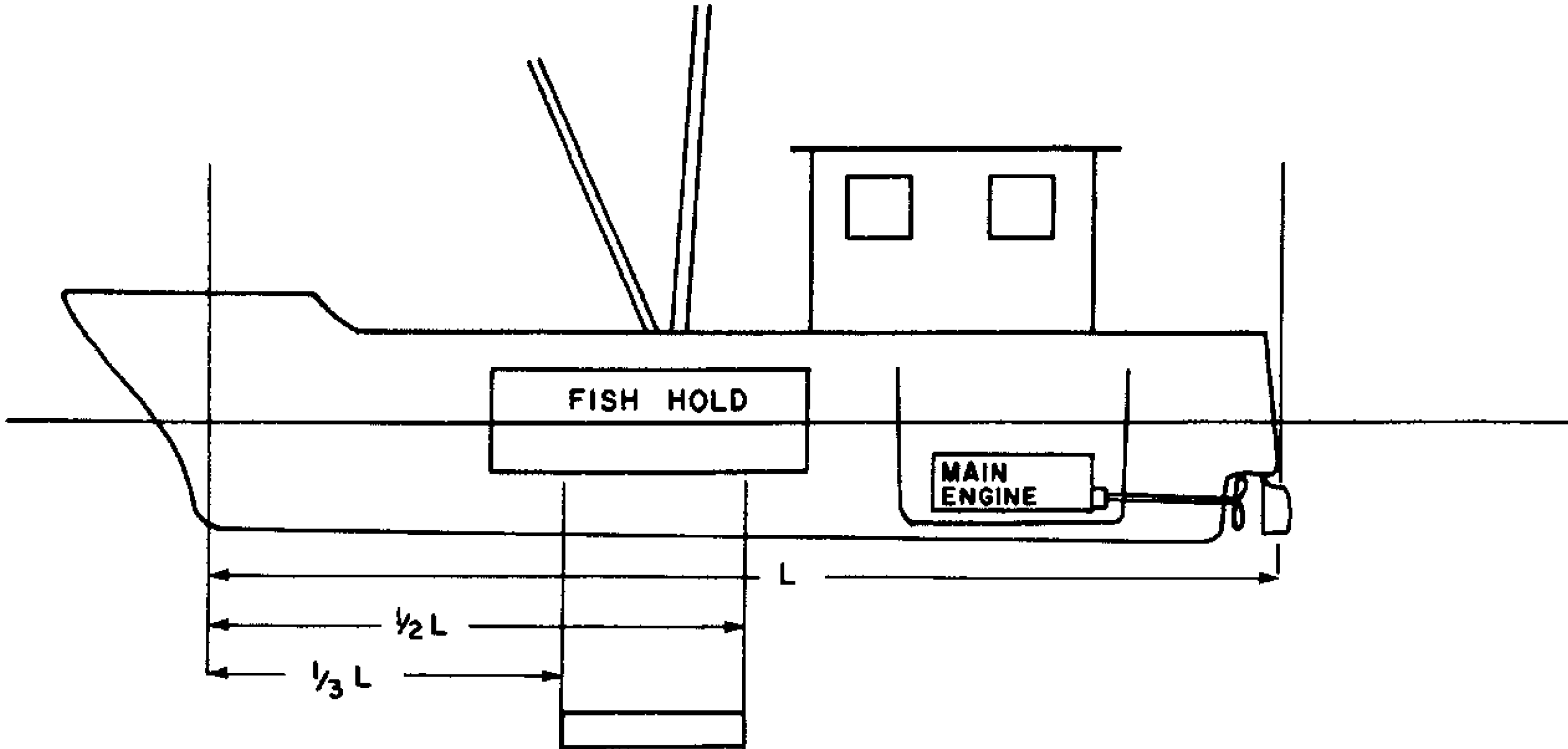
The correct position for the transducer is no less than one third of the vessel's length from the stem post, and no greater than half the vessel's length from the stem post. If possible, mount the transducer below the fish storage area if it falls within the lengths listed in the previous paragraph.

Always mount the transducer on the side of the hull that corresponds to the downward swing of the propellor when viewed from the stern. That is a clockwise rotating propellor means mount the transducer on the starboard side of the keel.

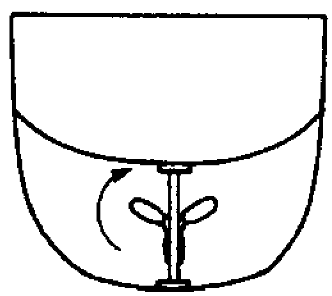
Ensure the transducer is as near the keel as possible. Mounting the transducer too high on the bilge could mean aeration of the water around the transducer face during heavy rolling of the vessel.

Many transducers are supplied with a faired mounting pad; if this is not the case with the supplied unit, have a faired housing and pad produced locally prior to mounting the transducer on the hull.

If your vessel sometimes lays in a dry harbour, remember that today's modern ceramic transducers are relatively fragile and would be destroyed if the weight of the vessel was allowed to bear on the transducer face.



TRANSDUCER LOCATION



TRANSDUCER LOCATION STARBOARD SIDE

FIGURE 6

Display Unit

The only major points regarding the fitting of an echo sounder display used for fishing are as follows:

1. Easily seen from your normal working position.

2. Mounted so that paper changing is easy when the access panels are opened at sea.

3. That the working sections of the display unit are easily opened and not obstructed by other equipment, or that when an echo sounding machine is opened for adjustment or maintenance it does not obstruct other essential equipment.

Always consider the ingress of sea water, and keep the machine mounting away from windows that open. Where a machine is mounted in an open deck vessel, enclose the echo sounder in a splashproof box, adequately ventilated.

Power Supplies and Cabling

Today's machines come in a variety of primary power requirements. Always ensure that the supply cables are adequate to prevent voltage drop, and are rated to carry the full load current of the machine.

Avoid running the transducer feed cable alongside other cables or wires carrying alternating currents or high frequency signals.

Ensure that the equipment case is effectively grounded.

When the installation is complete, have the engineer or supplier's representative check the matching of the echo sounder, transducer feed cable, and the transducer to obtain the maximum power transfer.

Many of the internal equipment adjustments should be made in a water depth compatible with the machine's normal working range before the machine is accepted in providing the service it was specified to do.

Once the section on Echo Sounder Adjustment and Interpretation has been read, the fishermen should be able to check that his machine is working at its best, and also where a machine is thought to be deteriorating in its performance, then the appropriate readjustments can be made.

SECTION V

Echo Sounder Adjustment and Interpretation

Before attempting to adjust any echo sounder, spend sufficient time with the manufacturer's handbook so that you are familiar with the names and the locations of all the variable controls and switches.

Accurate adjustments can only be successfully attempted while the vessel is at sea and under way. The usual sequence of operator adjustments are outlined below, and should be followed each time the machine is used.

1. Switch on the main power switch, and where a voltage adjust control is fitted, set the supply to the recommended output.

2. Press the event marker control, and check the thickness and density of the resultant line on the recording paper. This operation checks the function of the stylus arrangement and the cleanliness of the platen or writing bar. (See simple maintenance procedures).

3. Adjust the basic range switch to determine the depth of water below the vessel. If the sounder is being used for navigation purposes only, the phased range control need not be used at this stage. If the machine is to be used for fish finding, readjust the basic range control and the phased range control until the seabed appears towards the lower half of the paper. This will ensure the fastest pen speed, and therefore the fastest data rate compatible with the depth of water the vessel is working in. Correct adjustment of the range switches will also determine the correct pulse length on automatic pulse length selection machines.

4. Where a variable pulse length control is fitted, select the shortest pulse length position for fish target discrimination. Where a ground discrimination mode is required, select the medium pulse length position.

5. The gain or sensitivity control is probably one of the most important variable controls on the echo sounder, and requires careful adjustment to ensure the machine is working at its peak efficiency. Adjustments should always be carried out at the steady speed of the vessel, i.e. when a fishing vessel is running out to the grounds the gain control should be adjusted when the vessel has reached its normal cruising speed. If the skipper wishes to search for fish, then the control should be readjusted when the vessel slows down to the searching speed. Once the trawl has been set, the gain control should be readjusted once again when the vessel is at towing speed.

    Each adjustment should be carried out in the following manner:

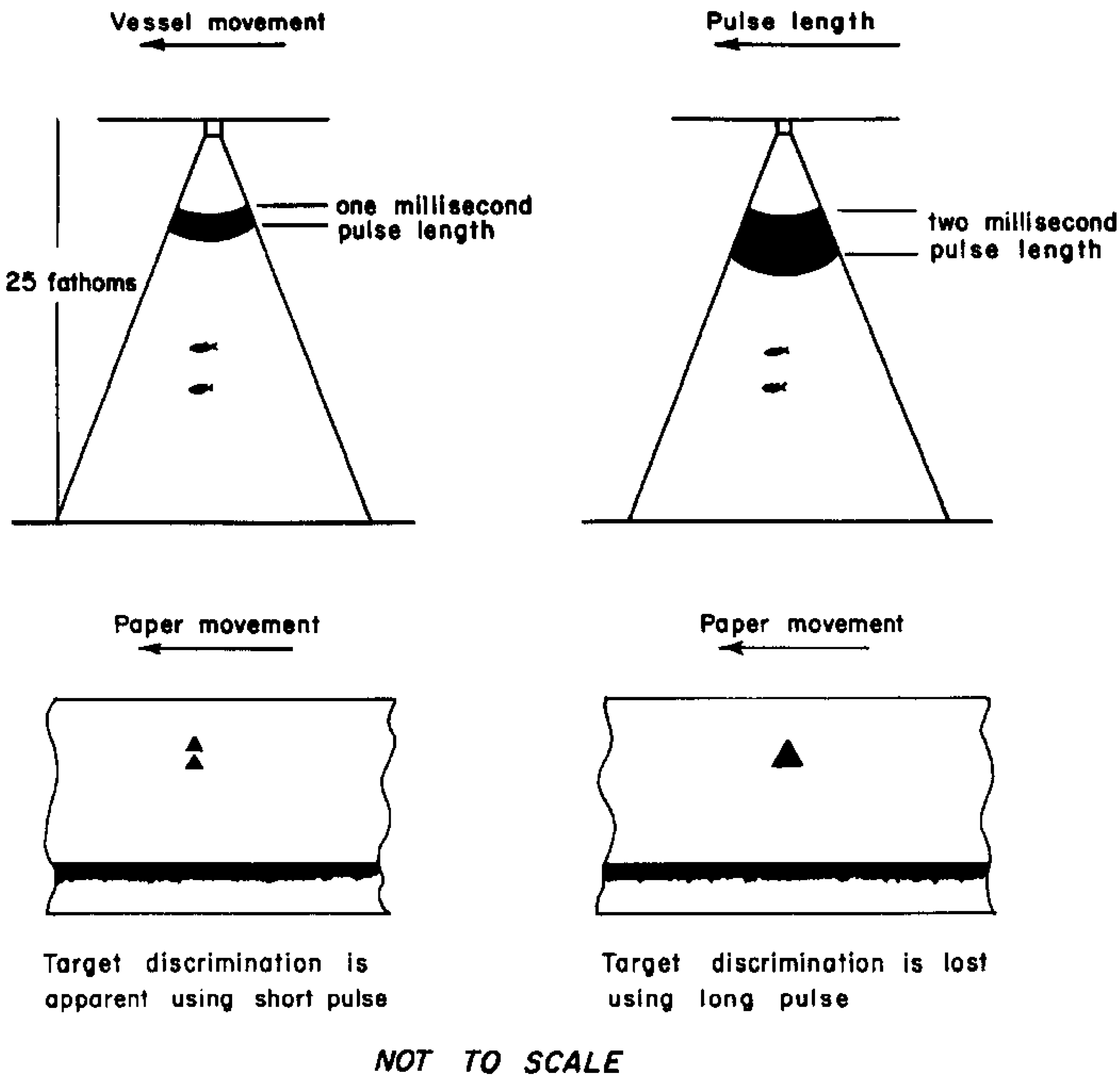
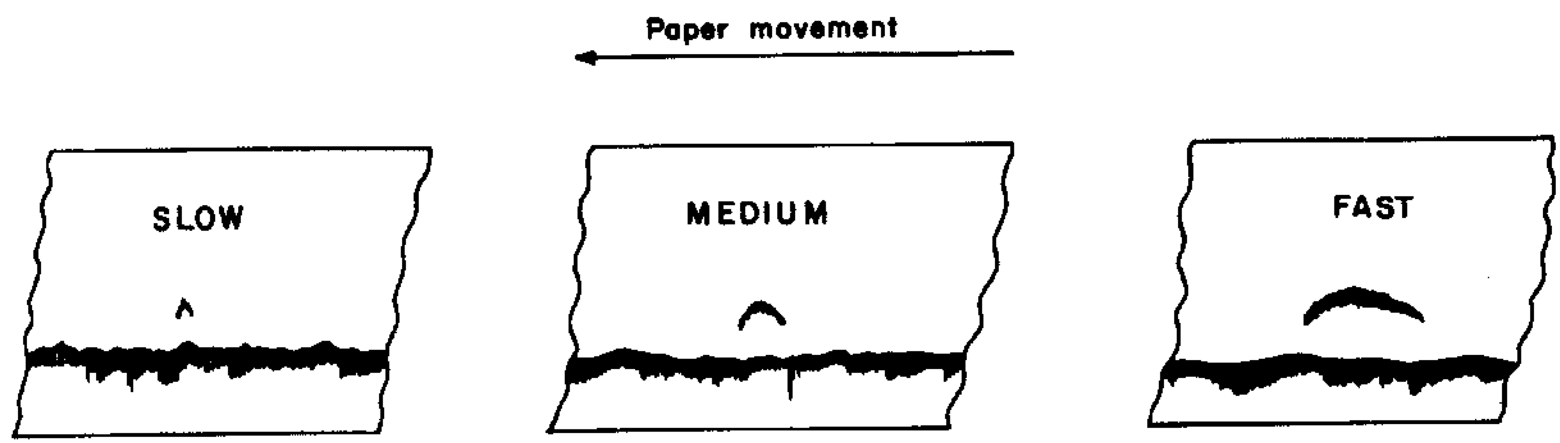
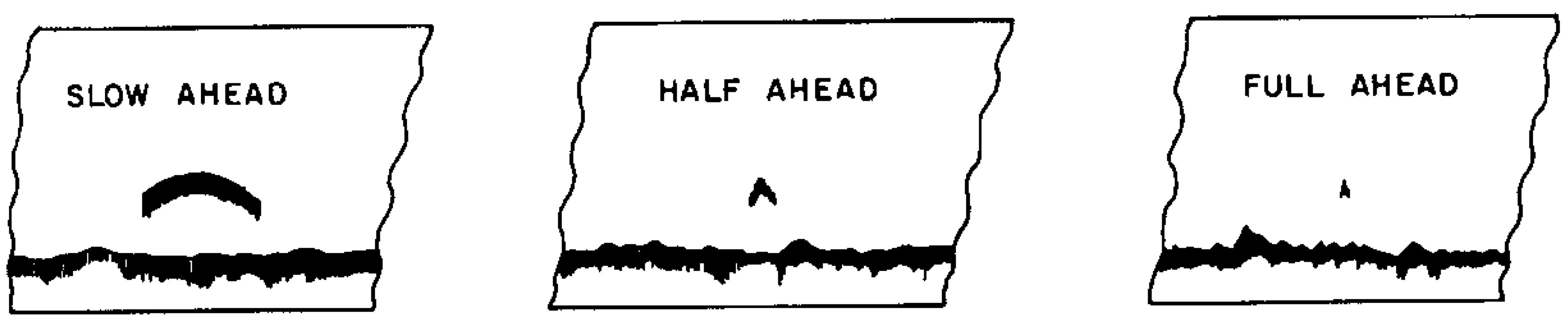

Vessel movement
Pulse length
one millisecond
pulse length
two millisecond
pulse length
25 fathoms
Paper movement
Paper movement
Target discrimination is
apparent using short pulse
Target discrimination is lost
using long pulse
NOT TO SCALE

FIGURE 7



Variation of target shape with changing paper speeds with a constant vessel speed.



Variation of target shape with changing vessel speed with a constant paper speed.

FIGURE 8

Turn the gain control fully counterclockwise; where two controls are fitted in tandem ensure both are turned counterclockwise.

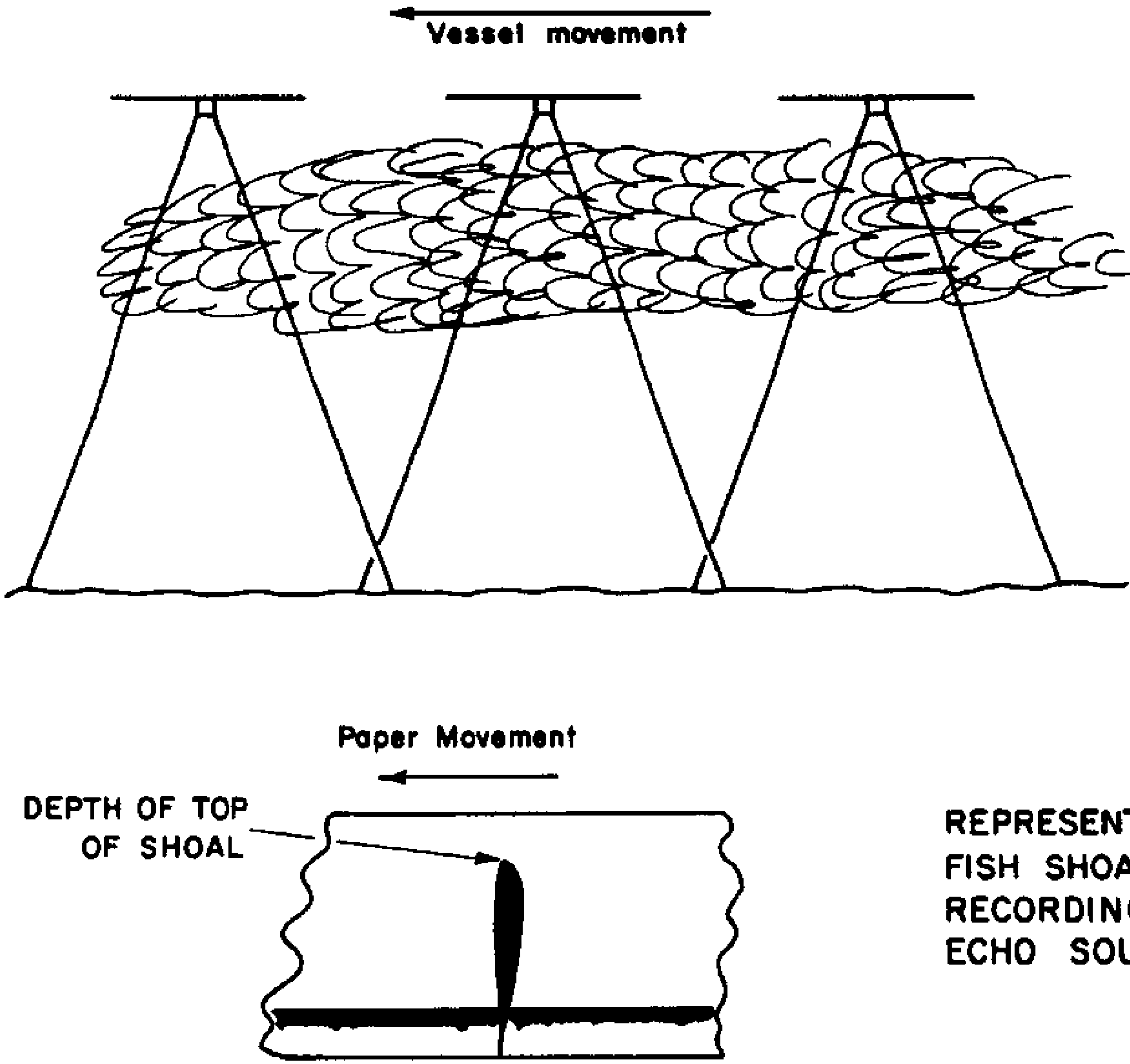
Increase the gain control slowly while observing the recording paper or display. Ignore the seabed returns or any fish marks that may appear, and continue to increase the control setting while observing the full paper width of the machine. Look for a fine grey speckle or a change of color across the full width of the paper. As soon as the speckle or color change occurs, stop turning the control. This procedure establishes the optimum sensitivity of the echo sounder relative to the ambient noise level caused by the location of the transducer and the speed of the vessel through the water. As the vessel slows down from running off speed to searching or towing speed, the noise level apparent on the machine will reduce. An increase in sensitivity can now be achieved by increasing the gain control until the fine speckle returns. As the vessel speed is increased, the noise level will increase, causing the speckle markings to get heavier, and in the worst cases to completely black out the display.

6. TVG or STC or suppression controls work in the same manner as anticlutter controls on a radar set. Correct adjustment ensures equal levels of sensitivity across the full range of the chart. The basic setting is best achieved by adjustment of the controls, once again at a steady speed, using the noise speckle achieved when the gain control was adjusted. The TVG controls should be adjusted to give an equal level of speckle across the full width of the paper. Readjustment will be necessary in heavy sea conditions or where there are heavy plankton concentrations near the surface. Always use the TVG controls with caution, as overadjustment can blank out fish echoes in the pelagic regions. If in doubt, turn the controls to the zero position and start again.

7. The white line function and control is designed to provide the fisherman with location of echoes from fish swimming close to the seabed, and where it is adjusted correctly, the definition of wrecks or other artificial debris lying on the seabed.

   The control should be readjusted whenever the water depth increases or decreases by more than 10% of the basic range scale in use.

   The setting of the white line circuits should commence with the control in the fully counterclockwise position. Slowly increase the setting while observing the seabed return. As soon as a gap appears between the seabed line and the remainder of the seabed return, stop the adjustment. Rock the control slowly backwards and forwards and watch the white line gap. Adjust the control for the most narrow white line. This will ensure that fish close to the seabed will be



REPRESENTATION OF A
FISH SHOAL ON A
RECORDING PAPER
ECHO SOUNDER

Note the distortion of the shoal on the echo sounder paper chart and the apparent depth anomaly.

FIGURE 9

detected as fish and wrecks or debris as potential hangs. A correctly adjusted white line control shows fish as a black mark or thickening of the seabed line whereas a wreck will have a white line mark running across it. Remember, the white line circuits are linked to the gain and sensitivity functions, and when the gain is readjusted, the white line should be readjusted immediately afterwards.

The grey line option available on some machines should be adjusted in the same manner and treated in the same way as the white line control. The control being adjusted to provide a grey line above the seabed return without a black seabed line, and should be set to achieve the most narrow grey band.

8. Paper speed is normally adjusted for the slowest movement of paper through the machine, mainly for economic reasons. Remember, however, that the slowest paper speeds distort the seabed contour and the fish echoes displayed. If some doubt exists about the nature of a seabed obstruction or a number of fish echoes, increase the paper speed to provide a clearer picture, and then return the control to the slowest speed once the detailed information has been observed.

9. Zero Line or Draft controls should be set initially to allow for the position of the transducer on the hull or the deepest draft of the vessel in a fully laden condition. Once set, they can be left alone unless special requirements call for their readjustment.

All the controls listed above should be adjusted with care; under or over adjustment can seriously impair the efficiency of the machine, provide the wrong data, and be a money waster instead of a money earner.

Basic Interpretation

The few points listed here are only a guide to the functioning of an echo sounding machine. Long and continuous use, by fishermen, of their echo sounders will provide them with data that can be linked to the state of the trawl and the contents of the cod end on completion of the haul.

Shape of the Fish Echo

Echoes from single large fish, with swim bladders, are displayed on the echo sounder because of the phenomena of sound propagation in the sea. Their shape on the recorder is influenced by the beam angle, their relative position in the beam, the speed of the paper, and the pulse length emitted from the machine. Generally where all the correct functions have been selected, and the variable controls properly adjusted, the echo from a single large fish will be displayed as an inverted V.

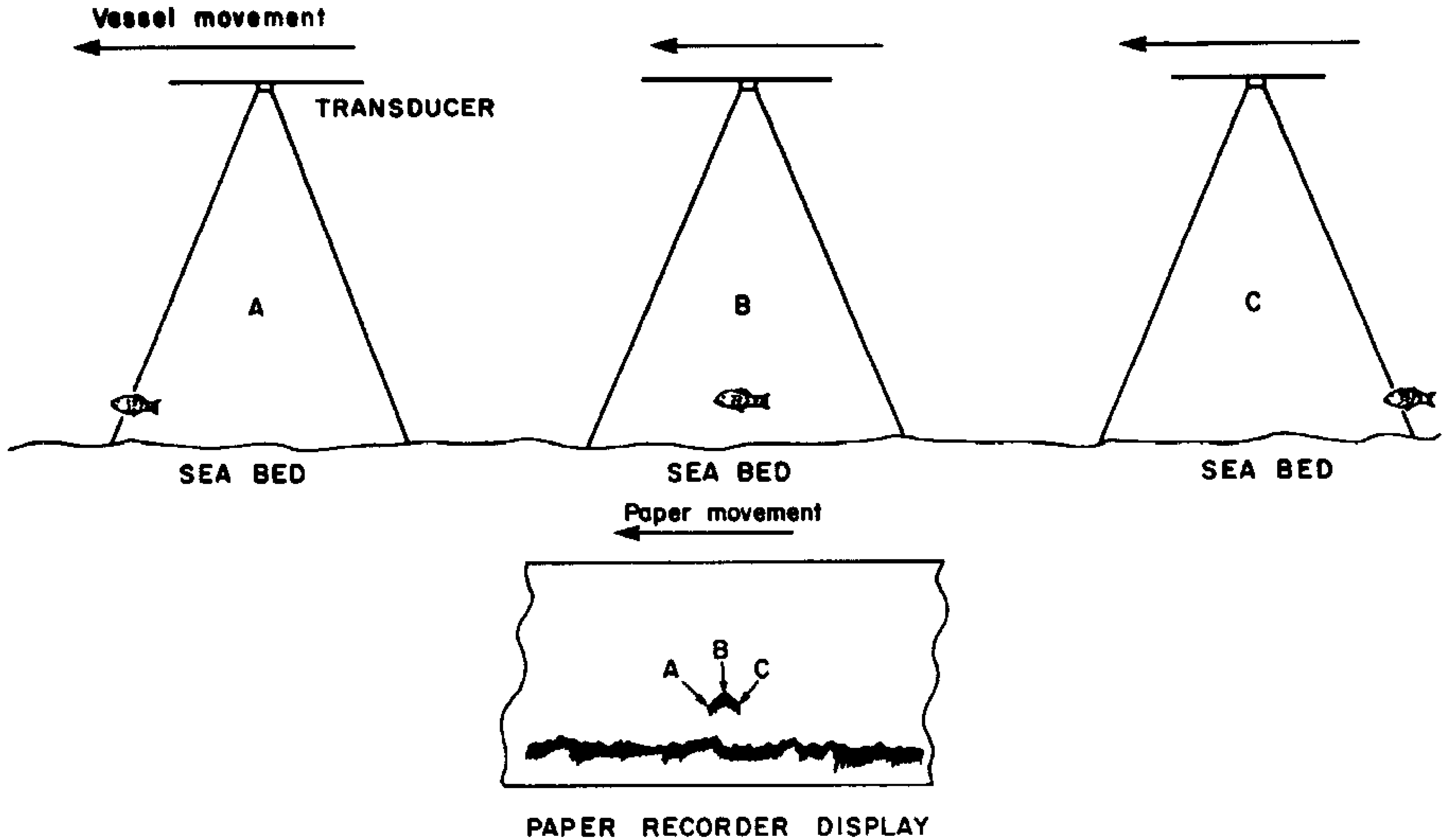

Vessel movement
TRANSDUCER
A
B
C
SEA BED
SEA BED
SEA BED
Paper movement
A
B
C
PAPER RECORDER DISPLAY

FIGURE 10

WHITE LINE FUNCTION

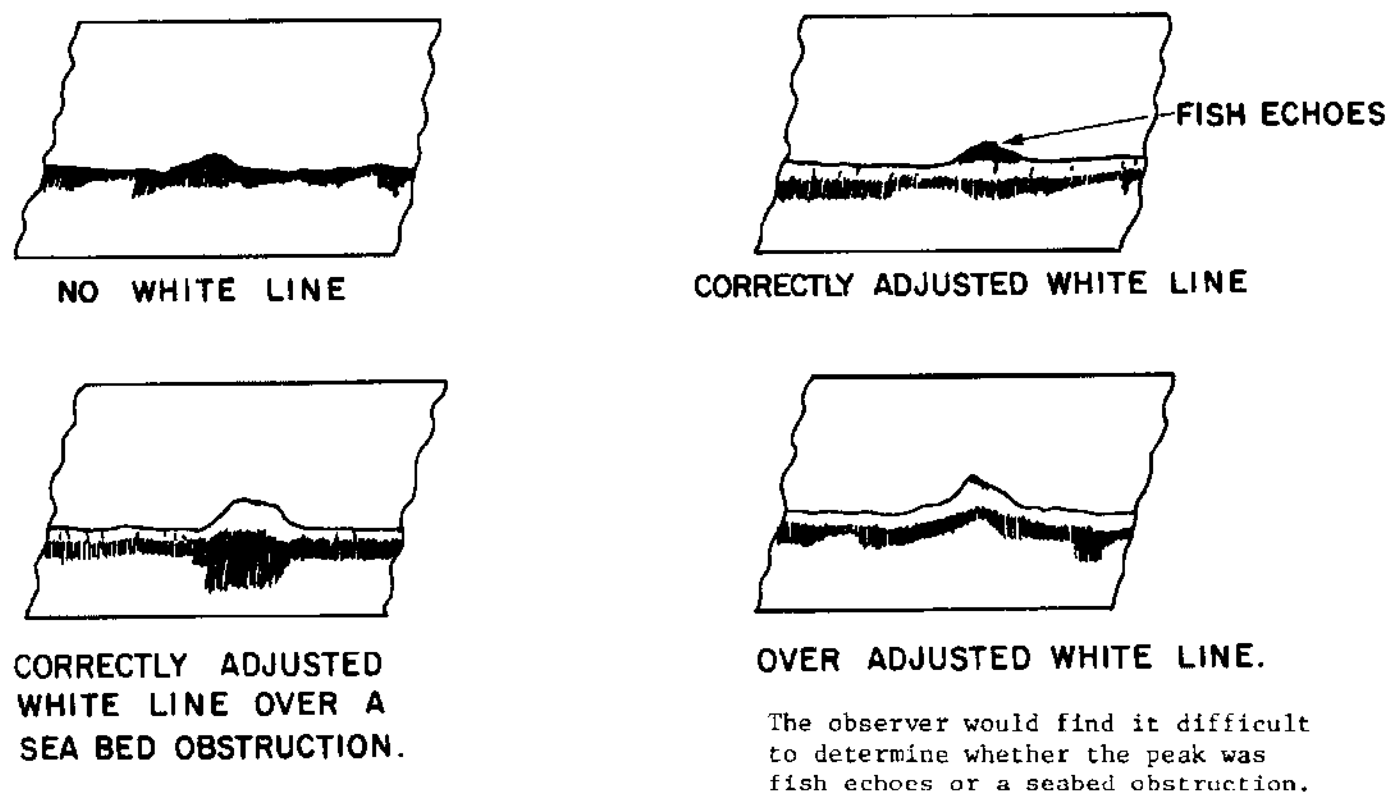


FIGURE 11

The major information gained from this echo is the true depth of the fish target which is the top of the mark, not the center or anywhere in between.

This same information comes from shoaling species such as herring or mackerel, the true depth of the shoal is the top of the mark. The true shape of the shoal cannot be determined from a vertical echo sounder due to the limitations already mentioned. The density of various shoals of fish can be estimated, however, from their color or blackness on the paper. If the white line control has been properly adjusted, really dense shoals of fish will probably have a white line running through the echo, whereas weaker shoals will echo as normal black to grey marks.

Where fish are very close to the bottom, and the white line facility is being used and is correctly adjusted, the fish echoes will cause the seabed line to thicken, heavy concentrations of fish will cause an apparent black hump to print on the seabed line. Closer study of this area of the seabed is best achieved by using a scale expansion, seabed locked unit described in the Echo Sounder Options section of this publication.

Seabed or Ground Discrimination

The echo sounder is an ideal instrument for determination of the nature of the seabed.

Initial data comes from the length of the seabed echo. The softer the ground, the shorter the echo, and as the seabed changes through mud to sand to gravel to rock, the seabed echo will lengthen. Conventional fish finding echo sounders do not have the power, nor are they designed to penetrate the seabed to provide information from below the seabed. On really hard ground, multiple echoes may appear on the recorder. Correct phased ranging and white line adjustment will ensure that when multiple echoes appear, confusion as to the correct depth of the water will not arise. The correct depth is the echo with the white line. Multiple echoes also show some distortion from the original true echo in the vertical displacement of the seabed.

Finally, if the white line control is correctly adjusted, as hard ground is encountered the white line gap will widen and subsequently narrow as softer ground is crossed. If the white line control was adjusted while the vessel was running across a hard seabed, then it may well disappear when soft or muddy ground is crossed.

Always remember the variables that can influence the data displayed on the echo sounder. A change in any of the major operating controls or output parameters can dramatically change the display. Today's echo sounders may have a dual frequency function, selectable beam angles, and variable pulse length, and the latest video type displays will have color controls, contrast controls, and noise rejection switches. Any change from the usual operating mode should be considered when studying the display. Always keep in mind what the various changes mean to the sound beam and the display unit, and apply these changes to the displayed data.

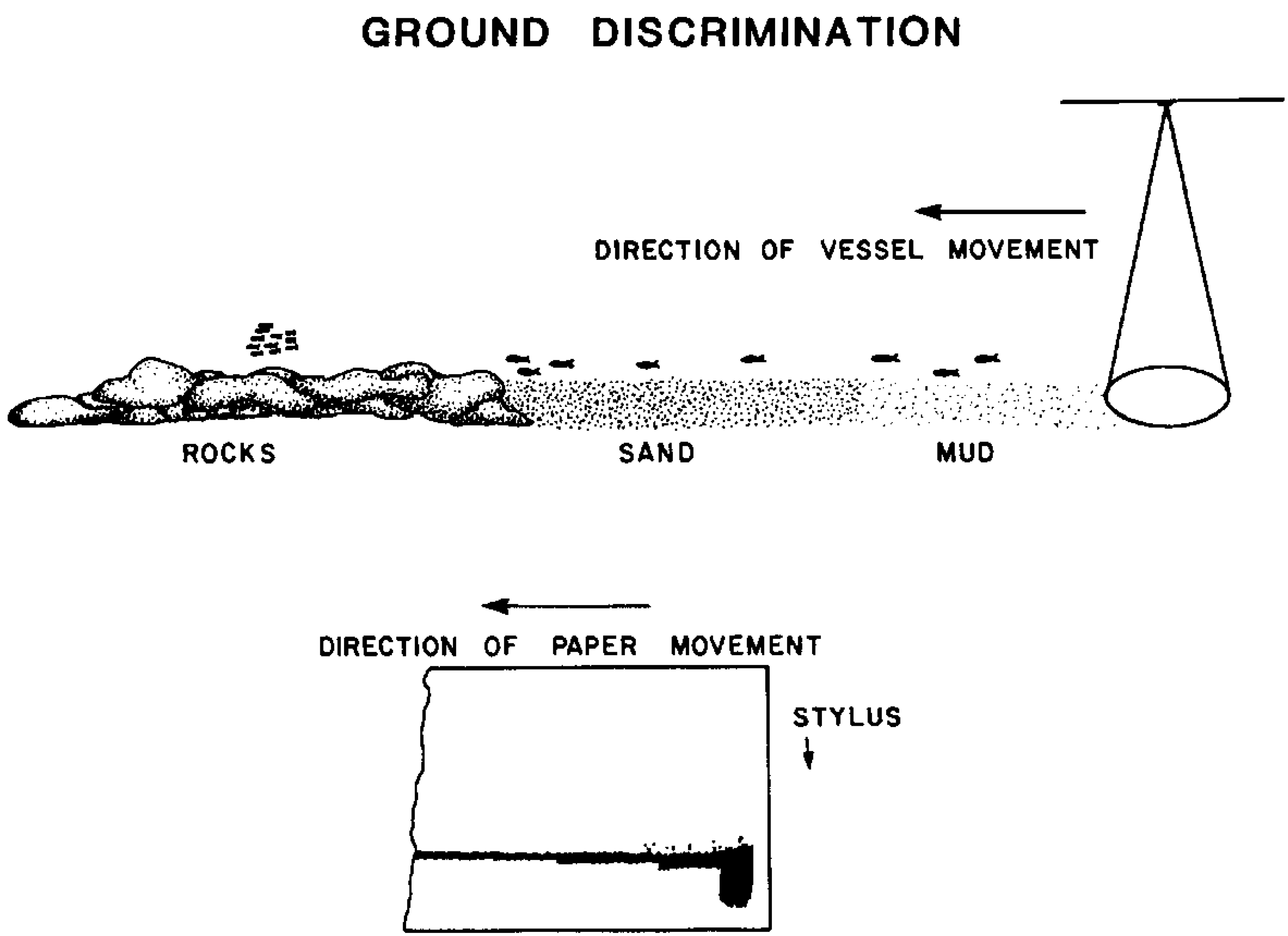

GROUND DISCRIMINATION
DIRECTION OF VESSEL MOVEMENT
ROCKS
SAND
MUD
DIRECTION OF PAPER MOVEMENT
STYLUS

FIGURE 12

SECTION VI

Additions to the Echo Sounder

The added facility of extra functions in echo sounding techniques can assist the fisherman to study various areas of the seabed and the midwater regions, where more accurate information than that presented by a straightforward echo sounder would be advantageous.

Whatever the "add on" facility chosen, the correct adjustment of the echo sounder as previously described is essential to ensure that the extra function will give the desired information. Many of the "add on" units are electronically processing the data already present on the echo sounder, and a wrongly adjusted or badly used echo sounder will not be improved by further sophistication.

Perhaps the most common "extra" to an echo sounder is the seabed locked scale expansion unit. This provides the fisherman with an area magnifier, in that he can select an area of water above the seabed and have it presented on the echo sounder display over a greater area of paper or CRT unit. The term "seabed locked" means that the data presented has been stored within the unit, and presented on the display after the seabed echo has returned to the machine. The stored information is referenced to the seabed echo, and on the majority of displays it means the seabed in the expansion area appears as a straight line with the relevant selected data printed above it. This allows accurate measurement of the fish echoes and their exact depth above the seabed. No ground discrimination or seabed contours are shown on this expanded area of the display.

Associated with a seabed lock, expansion unit will be a control that allows some variation in the performance of the unit. Sometime referred to as a "Trigger Control," this variable allows the machine to detect the arrival of the seabed echo. If it is wrongly adjusted, the machine may not detect the seabed echo and stop the expansion unit functioning or alternatively the machine will accept a large fish echo as the seabed return and trigger from that. The result shown on the display will appear as a normal flat seabed with echoes displayed above, but in fact the operator will be seeing an area of water immediately above the strong fish echo.

If a separate operator control is not shown on the machine or in the manufacturer's handbook, then the white line control is usually used as the trigger for the seabed lock unit. If this is the case and the operator wishes to use the expansion facility, then he should follow the procedure outlined below.

a. Select the range of expansion required, i.e. 5, 10, or 20 fathoms.

b. Switch to seabed or bottom lock on the function switch.

c. Turn the white line control fully anticlockwise.

d. Gradually increase the white line control setting while looking at the area of the display where expansion will take place. As soon as a straight seabed line appears on the display, stop adjustment of the white line control. The correct expansion data will now appear on the display. Remember that if the normal water depth changes by more than 10% of the basic range selected, then some readjustment of the White Line/Trigger control will be required to ensure continued correct operation of the unit.

Where a separate trigger control is fitted, the white line adjustment should not be moved when expansion is required. The procedure to follow there is:

a. Select the range of expansion required.

b. Switch to seabed lock on the function selector.

c. Turn the Trigger control fully anticlockwise.

d. Slowly increase the Trigger level control while observing the expansion area of the display. As soon as a straight seabed line appears in the expansion area, stop the adjustment. Generally, once this control has been set, it does not require further adjustment, but if the depth of water being worked changes by more than 20% then some adjustment may be necessary. To ensure the correct operation of the unit, follow the procedures outlined above.

Midwater expansion works on a different basis, and the data displayed can be affected by various factors.

When the operator selects an area of the water column for expansion, the data is not locked to the seabed, but to the transmission pulse. In this case vessel movement in the vertical plane affects the expanded data, causing it to move on the display by the same distance as the vessel's pitching motion. The procedure to follow when using midwater expansion is as follows:

1. Select midwater expansion on the function switch.

2. Adjust the variable depth marker to the appropriate position on the main display. Establish whether the range marker determines the expansion area above the line, either side of the line, or whether two range markers at a preset distance should straddle the area of interest. This information will be in the manufacturer's user's handbook.

3. Select the expansion area required, i.e. 2.5, 5, 10, or 20 fathoms, and observe the results on the display.

As the system is locked to the transmission pulse, no trigger level control is incorporated and no other adjustment is necessary.

One other extra usually associated with an echo sounder is the Fish Loop, or Fisch Lupe, or Add Scope, a term usually applied to a CRT type of expansion display.

The unit can be seabed locked or transmission locked, single stroke or multistroke. The multistroke picture gives a flicker-free steady picture for each transmission, while the single stroke gives a single shot of the data each transmission, which means the operator is required to watch the unit continuously.

Associated with the Fish Loop are the normal controls associated with a CRT, i.e. Brilliance, Focus, and in some instances a gain control. Operator preference will dictate the setting of these variables.

Once again, if the data being shown on the main echo sounder display is poor because of maladjustment of the basic controls, the Fish Loop display will only repeat the errors with magnification.

The net sounder or net monitor is another unit using acoustic or echo sounding methods for the benefit of the fisherman.

Designed primarily to provide data on the performance of a Trawl Net, the net sounder comes in two distinct forms, the Acoustic Link unit or the Cable Link unit. Both have distinct advantages and disadvantages in their performance.

The Acoustic Link system relies on a complete transmitter/receiver transmitter, mounted on the Trawl headline, sending the information via a sound beam, to a receiver unit mounted in the vessel. The major disadvantage with this system is alignment of the data sound link from the net to the vessel. Slight misalignment in the initial fitting of the headline unit can cause loss of the data link, particularly as the vessel makes a change of course. The headline unit also relies on batteries for its power, which means the operator's attention at regular intervals.

The Cable Link system has a simple transducer unit on the headline of the trawl, linked to the towing vessel by a cable and winch arrangement. The major disadvantage of this system is the extra expense of the vessel mounted winch and connecting cable, but as long as the cable remains intact the data link is secure regardless of the relative positions of the net and the vessel.

Adjustment of the Net Sounder display should follow the same routine established for a normal vertical echo sounder. Particular attention should be paid to the display ranges to ensure that the full width of the available display is being utilized for data interpretation.

CABLE LINK NETSOUNDER

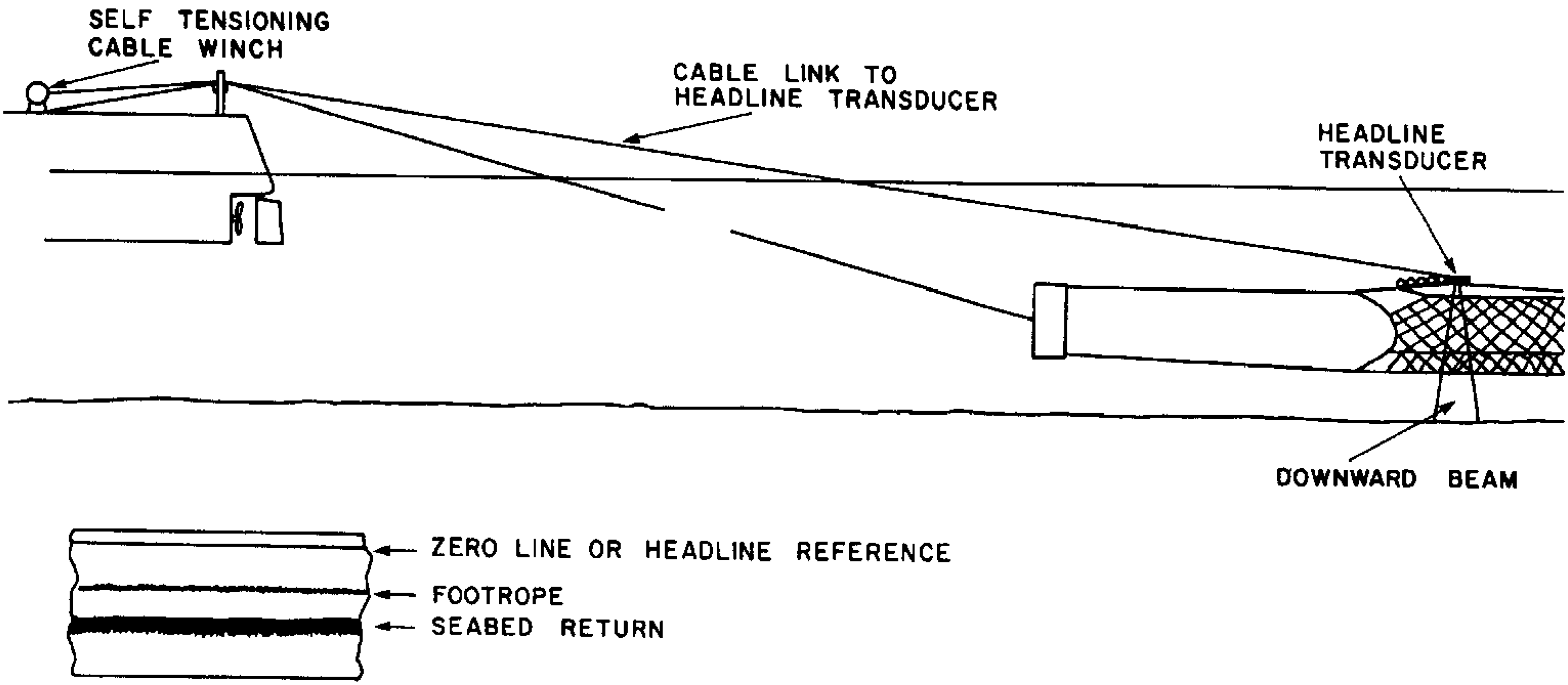
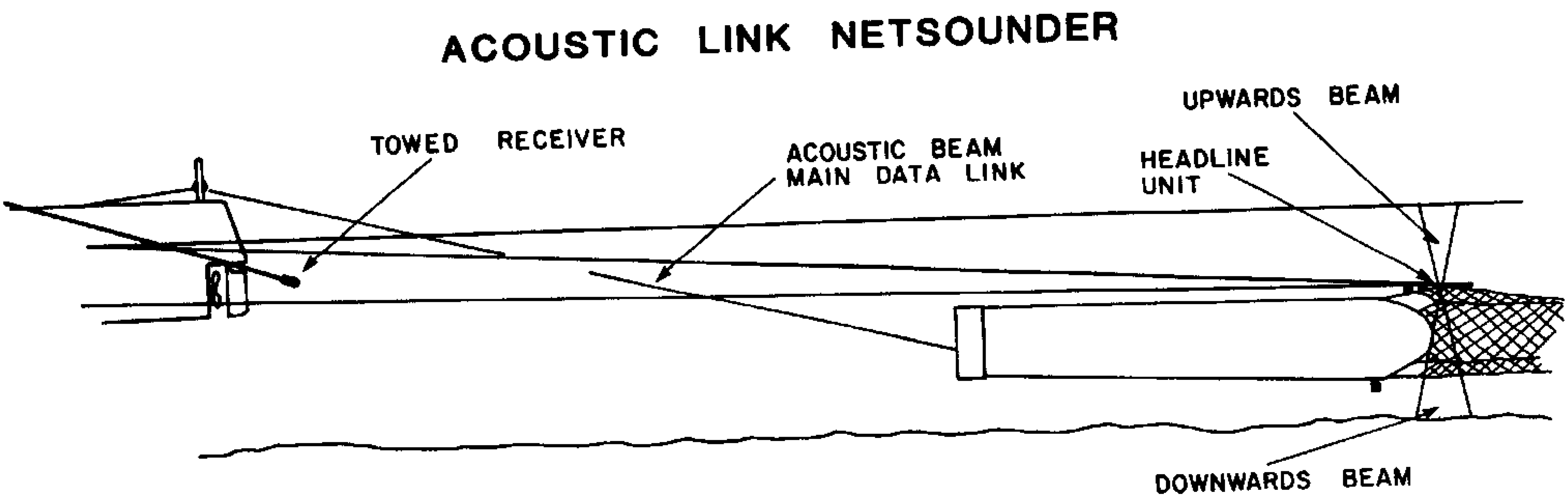
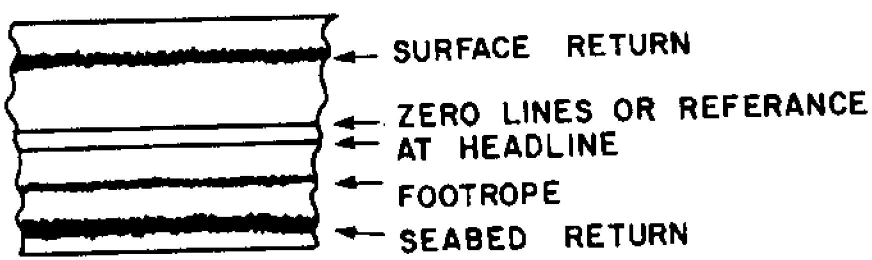


FIGURE 13





The headline unit was an upward transducer, a downward transducer and a main link transducer.

<u>ACOUSTIC LINK NETSOUNDER</u>

FIGURE 14

Various forms of display are used with net sounders. The simplest is where a normal downwards-looking transducer is fitted to the headline of the trawl. Received data will include the mouth opening of the trawl measured from the headline to the footrope immediately below the transducer, the behavior of fish in the net mouth, and the distance or depth of the footrope from the seabed. Remember the headline is always displayed as a straight line, because this is where the transmission pulse or reference point originates. All data is measured relative to this point, and the range scale will read zero at this point. Because of midwater trawl movement whilst maneuvering, the displayed data will change with each movement of the headline. Always refer to the vessel's vertical echo sounder whenever the trawl's position is being changed, and also to check for any high pinnacles or seabed obstructions that may damage the net during the tow.

The mental picture to visualize is that the transducer is on the net, moving upwards and downwards as the trawl is maneuvered, and it is also some distance depending on warp out behind the towing vessel. Other forms of net sounder display show areas above the headline as well as below. This generally means that the display is in two distinct portions, but the headline is still the reference, and will appear on the display as a straight line.

A useful addition to the net sounder system is the temperature readout unit. This helps to correlate water temperature to fish concentrations, and can assist the fisherman in determining seasonal variations in fish behavior, and also to aim his midwater trawl into a range of water of suitable temperature where he is likely to catch the desired species.

Simple Maintenance

The modern echo sounder and its associated equipment is a reliable electromechanical unit. They are usually built to withstand the rigours and sometimes the mishandling of being used in the marine fisheries environment.

The owner/operator can, however, ensure the machine is kept at its peak efficiency by following a few simple routine maintenance checks.

A good guide to the equipment's continued peak performance is to note the positions of the various variable controls on a day to day basis. If it is noticed that more adjustment of the sensitivity/gain control or the white line control is being used to obtain what the operator considers to be a normal display, then it is obvious that something is deteriorating. This need not be a complicated electronic problem, but something the fisherman can check.

As previously emphasized, the transducer mounted on the vessel's hull is extremely important to the echo sounder's efficient operation. Although it may have been correctly installed on the hull, it should not be considered as "out of sight out of mind." If more gain adjustment is required to obtain the best display, the transducer may be at fault through marine growth on its face, or it may have been damaged by severe vessel motion. The next time the vessel is dry, check the transducers on the hull; if they are covered by marine growth, then have them carefully cleaned.

If the display appears to be fading or becoming lighter in color on a paper chart recorder, check the stylus arrangement. If it is a moving stylus, check the condition of the pen tip, the cleanliness of the writing bar beneath the drive belts, and the spring tension on the stylus.

When the machine is running, press the event marker switch. Check the density of the line across the paper; it should be consistent across the full width of the paper. If the machine has a fixed stylus arrangement, repeat the operation with the event marker control, and where excessive breakup of the mark is shown clean the stylus tips using the maker's recommended instructions and supplied equipment.

Whenever the machine needs a new roll of paper, use a few extra minutes to clean the machine with a soft dry brush, often supplied in the spare kit. If a wet paper machine is used, clean the writing bars or rollers with a non-abrasive solvent, and always ensure the new paper roll is loaded correctly and tensioned before switching the machine on again.

Keep the machine dry, which means not only from seawater but also from coffee and chocolate.

SECTION VII

Sonar

The basic principles of transmitting sound in water apply equally to today's sonar equipment. However, certain changes are obvious when the use of sonar is considered.

The transducer is no longer fixed in position on the vessel's hull, but arranged to turn in azimuth and tilt in the vertical plane. The information now displayed on the chart or CRT is horizontal or slant range bearing of the target relative to the vessel, and if the data is correctly interpreted, the target depth.

There are two distinct types of equipment available to the fisherman; they are sector scanning or searchlight sonars and omni sonars.

Sector scanning sonars, as their name implies, are designed to transmit a sound pulse on a sector bearing, listen for the echoes, and on completion step to a new bearing before transmitting again. This is illustrated in Figure 15, with various stepping modes shown. Omni sonars transmit one pulse of sound, which effectively radiates from the transducer through a complete 360° and electronically scans the entire area while listening for echoes. The operator then sees on his display a complete picture around his vessel from each transmission. Interpretation of both types of display is discussed later.

Sonar sets come in various frequency ranges, and as in vertical echo sounding equipment the frequency will dictate the maximum detection ranges. High frequency sonars of 60KHZ plus usually have an effective range limitation of between 800 and 1200 meters, depending on target type, density, and water depth.

Lower frequencies of between 20KHZ and 60KHZ can detect up to 2000 meters, once again depending on target type, density, and water depth.

Power levels and pulse lengths are higher and longer respectively when compared to vertical echo sounders. This increased performance level is required to give the ranges required for detection of targets, and although target discrimination suffers because of this, all sonars have a pulse length control, which should be used correctly to improve the discrimination of a target as the vessel closes on it. Typical small sonar specifications for pulse length and power are one to four milliseconds and one kilowatt respectively. Longer range sonars may have variable pulse lengths up to or exceeding 8 milliseconds and 5KW of transmitted power.

Another facility available on a sonar, and not normally associated with a vertical echo sounder, is a audio output through a loud speaker. This is normally provided for the operator's convenience to enable him to work his sonar equipment without watching the display continuously. This means that he can attend to the multitude of the tasks demanding his attention without losing

SECTOR SCANNING SONAR

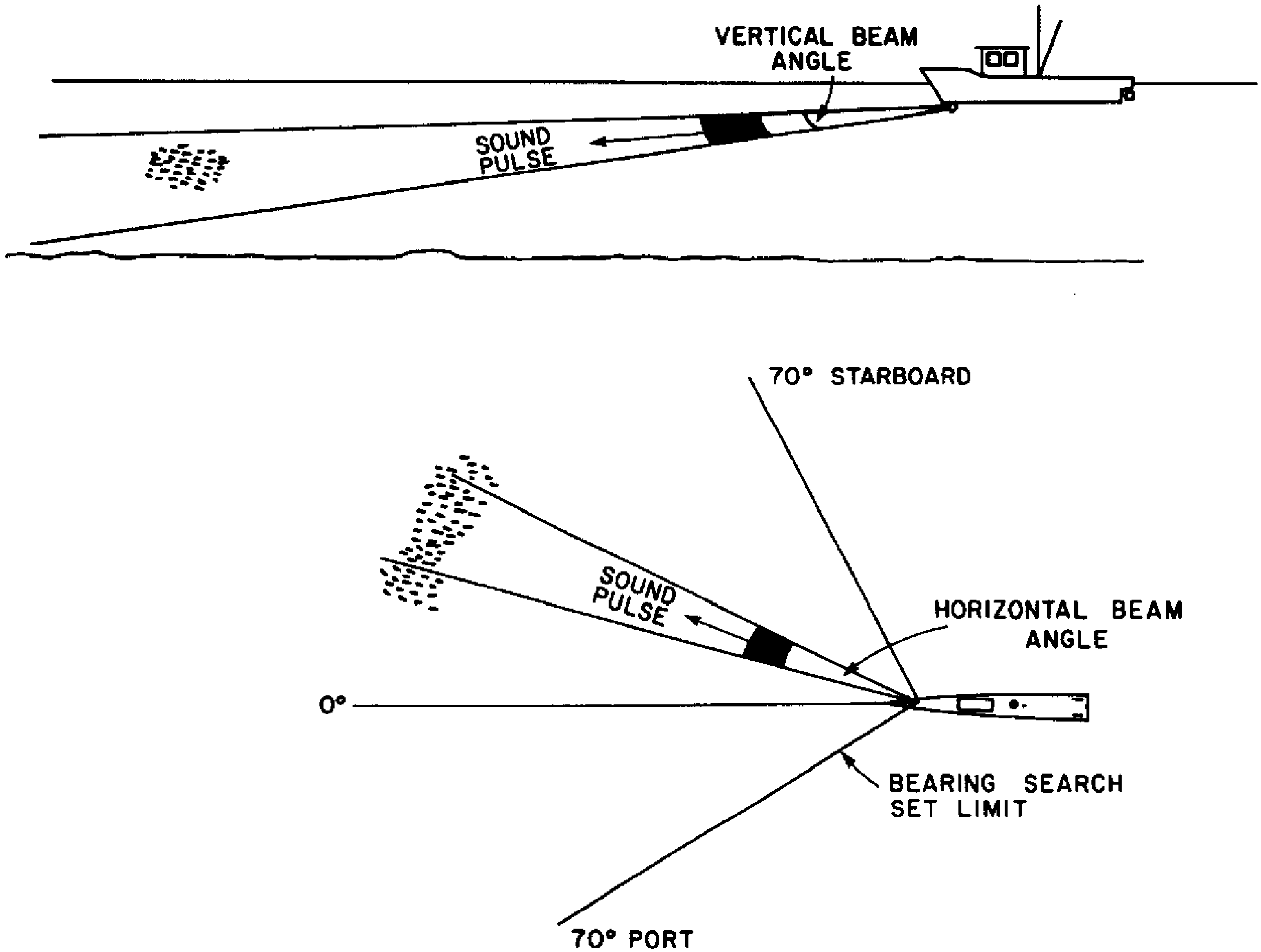


FIGURE 15

completely his sonar search capability. A skilled sonar operator can detect, in the sound from the loudspeaker, potential fish targets, seabed echoes including pinnacles or wrecks and other echo returns caused by vessel wakes.

Sonar Installation

As with vertical echo sounders, the transducer installation for sonars is very important. The size of the transducer will be influenced by the working frequency and beam angle. The transducer is generally mounted forward on a fishing vessel, and because of the water flow associated with that area of the hull, it is mounted on a raise/lower mechanism. This means that in its operating position the transducer will protrude at least three feet below the keel. The position of the transducer in its lowered position, the shape of the vessel's hull, and the location of machinery will dictate the maximum search speed of the vessel to give maximum range of detection.

Try to avoid running the transducer cabling along with other electrical wiring carrying A.C. voltages or high frequency signals.

Locate the display unit in the best position for operation of the controls and viewing of the display. Ensure that all the controls both internally and externally have easy access for adjustment, and that a paper display machine can have its paper magazine easily replenished. All primary power cabling should be adequate to carry the full load of the machine without voltage drop at the equipment terminals.

Sonar Operation

Once the fisherman has had a sonar equipment fitted to his vessel, he has a sophisticated aid to his fishing operations. This equipment sophistication needs careful consideration when it is in operation, and the operator needs to fully understand the limitations of the equipment, his vessel, and the type of fishing gear being used.

With sector scanning sonars, a control to determine the bearing limits of the search is fitted. Although this control will allow a search to be made through a complete 360°, the operator should consider exactly what he hopes to achieve whilst searching for fish or ground.

Take the following example: a sonar equipped vessel has arrived at a potential midwater fishing area. The sonar operator wishes to search for targets ahead of the vessel as it proceeds ahead at normal searching speed. The first priority is to determine the maximum bearing angles to provide the fastest usable data. Obviously, the area beyond 90° port and 90° starboard is of no interest, because the sonar will be looking at an area already covered. The type of step pattern generated by the equipment and the vessel's speed will also influence the maximum bearing angles to be considered. If the vessel decides to shoot the midwater trawl on arrival at the fishing grounds, his forward speed will be reduced in the towing mode. The vessel will also be limited in its ability to change course or come around. Under these circumstances a maximum of 60° out to out will be sufficient in the bearing search limits.

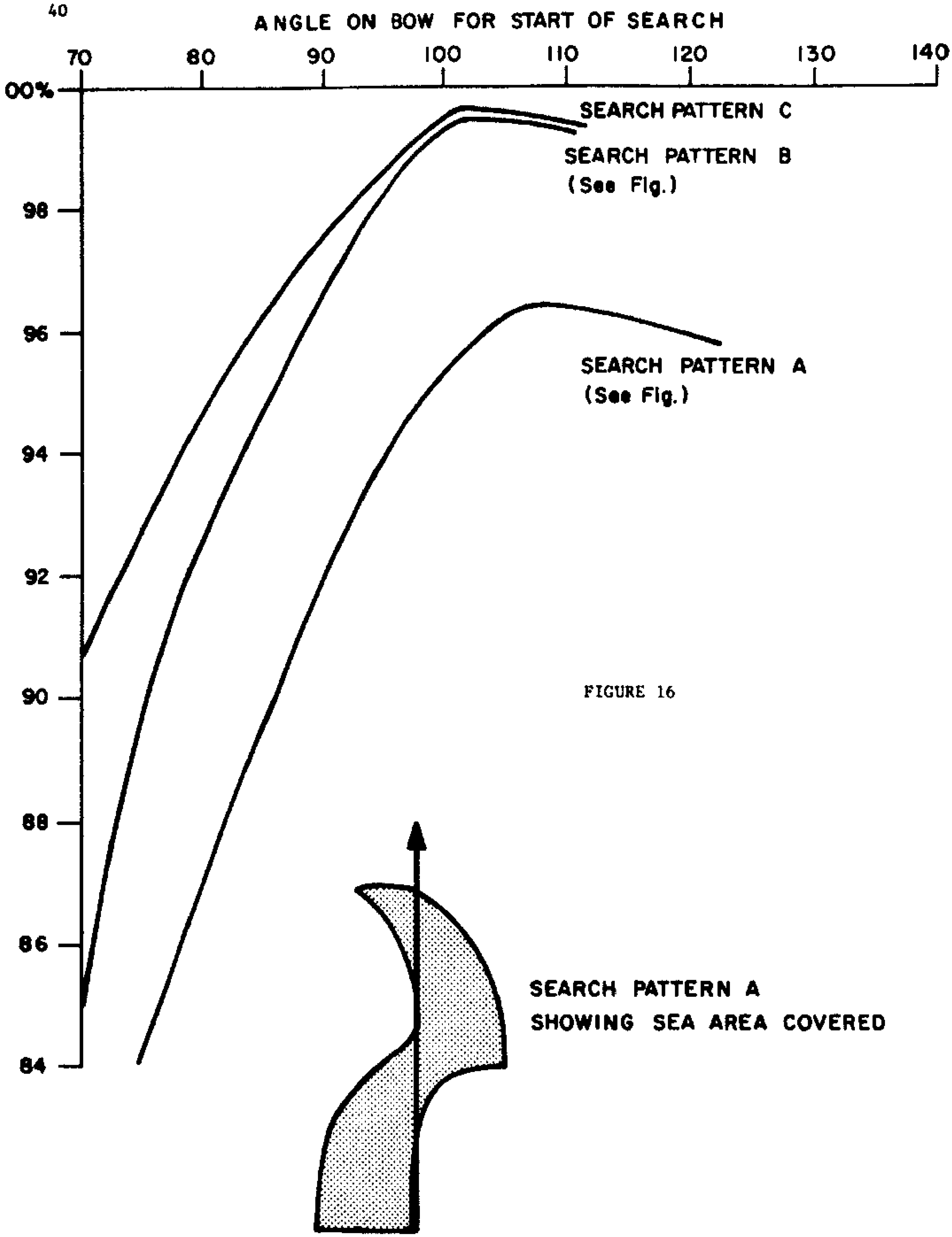
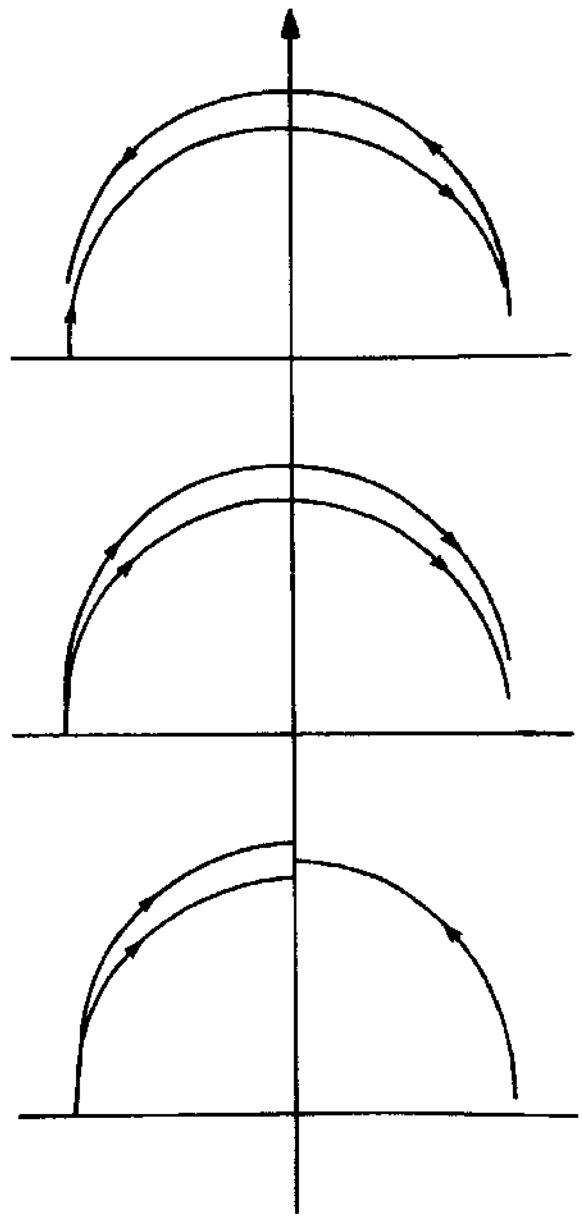

ANGLE ON BOW FOR START OF SEARCH
70
80
90
100
110
120
130
140
00%
98
96
94
92
90
88
86
84
SEARCH PATTERN C
SEARCH PATTERN B
(See Fig.)
SEARCH PATTERN A
(See Fig.)
SEARCH PATTERN A
SHOWING SEA AREA COVERED

FIGURE 16



A.
Steps from port to stbd. and steps from stbd. to port.

B.
Steps from port to stbd. returns quickly to port and steps from port to stbd.

C.
Steps from port to dead ahead moves quickly to stbd. and steps from stbd. to dead ahead.

VARIOUS SECTOR SCANNING SONAR BEARING SEARCH PATTERNS

FIGURE 16

Figure 16 illustrates the consideration to be applied to the bearing search angles.

Range selection or maximum range ability will be dictated by the depth of water being worked and the beam angle of the transducer. If the water is shallow and the beam angle wide, seabed return will limit the maximum range that can be selected. Valuable search time can be lost by selecting the equipment's maximum range when half the display area is being swamped with seabed returns. Always select the range initially to place the seabed return at the bottom or edge of the display. In deep water, the operator must consider the bearing search pattern already established, the vessel's speed, and the transducer tilt angle.

Transducer tilt angle and any change to it during the sonar's operation can change the display information and the maximum range of operation.

To find the optimum tilt angle for the transducer, start with the control at zero degrees, increase the tilt angle towards 90°, and note at what angle the seabed return indicates on the maximum range of the display. Now decrease the tilt angle until sea surface returns start to mark on the display, note this angle, the optimum search tilt angle compatible with the range selected, and the water depth is the mid angle between the two noted in the previous operation. For example, if the seabed returns, mark at maximum range with the transducer tilt angle at 40°, and sea surface returns show at 5° the optimum tilt angle for searching is 22° approximately. The tilt angle employed by skilled sonar operators will be influenced by previous fishing knowledge and the limitations of the sonar set. Pulse length should be set at maximum concurrent with the range selected. On some sets, this is achieved automatically, but when a variable pulse length can be selected by the operator, the following range to pulse length guide gives optimum pulse lengths that can be used.

1. Up to 1500 meters range - maximum selectable pulse length.

2. Between 500 and 1000 meters - 4-8 milliseconds.

3. Between 250 and 500 meters - 2-4 milliseconds.

4. Between 100 and 250 meters - 2 milliseconds.

5. Less than 100 meters - the shortest selectable pulse length.

If a target is detected at the maximum range, and the vessel closes the target, remember to reduce the pulse length as the target range decreases. This will enable some target discrimination to be applied.

Gain and TVG are worked together on sonar equipment, and the adjustment of the two are more important than when applied to a vertical sounder. The noise speckle referred to under the section on vertical sounders is used again in adjustment of sonar equipment. Vessel speed and pulse length will affect the adjustments. Using both controls, the aim is to achieve an equal level of noise across the full width of the display. Continuous adjustment may be necessary as a vessel closes a target. The controls are sometimes referred to as "near" and "far" gain.

The previous discussions will only give starting positions for the various controls. Sea conditions, species sought, mode of sonar use, seabed conditions, and fishing method will dictate the final setting of many controls.

The sections following should provide a guide to further fine adjustments that may be necessary. Only experience gained through continuous use will enable the sonar user to become completely competent in the use of the machine.

SECTION VIII

Sonar Chart Interpretation

This section will deal exclusively with the interpretation of paper display sonars; other types of display (i.e., CRT and Sonar Loop or Scope) will be dealt with later.

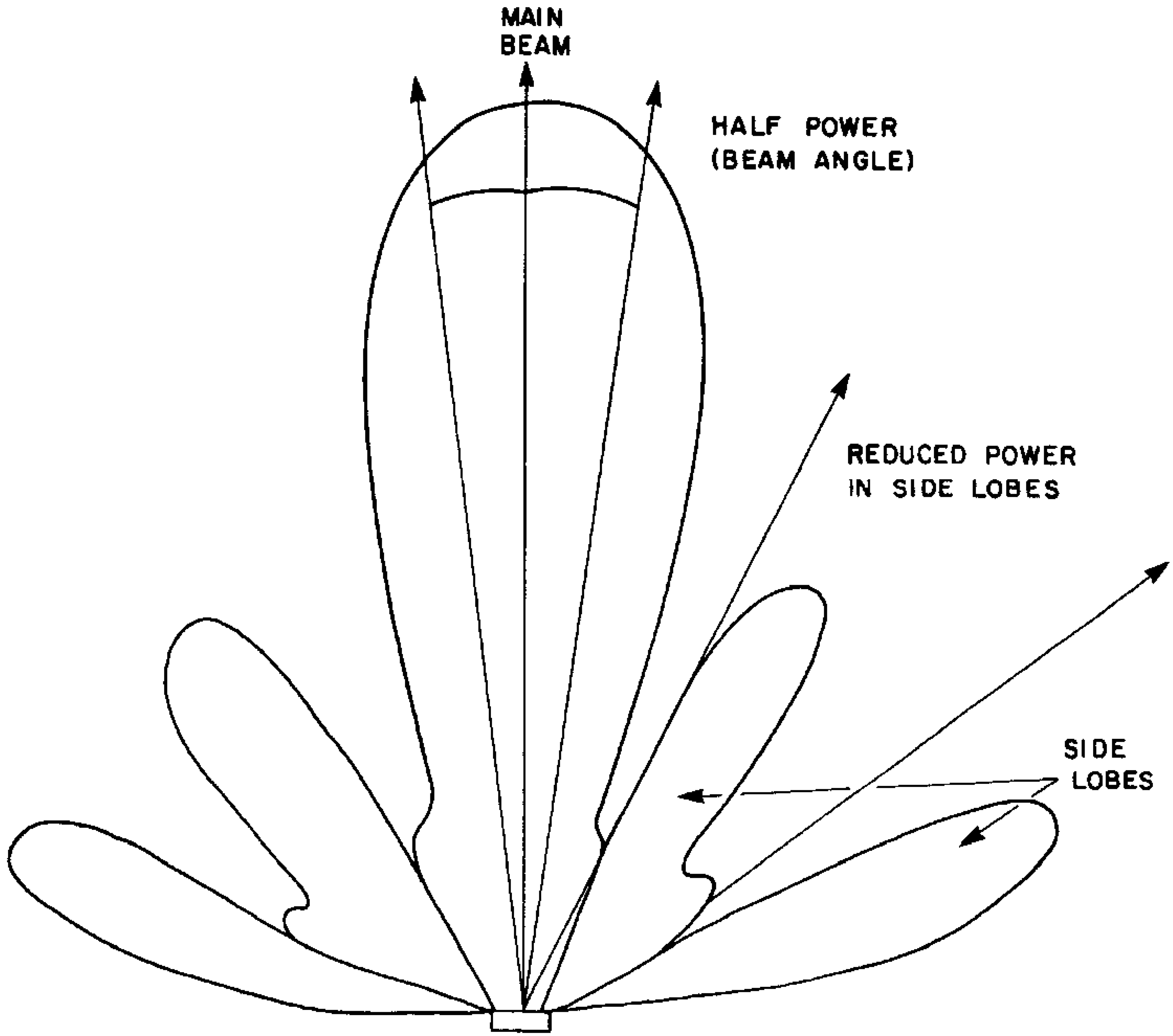
Because of the complex nature of a sonar's acoustic beam, various echoes on the display can give the operator information other than just midwater fish marks. Using the display in conjunction with the audio output, the operator can determine various types of seabed ahead of the vessel, read out the depth of water immediately below the vessel without tilting the transducer vertically downward, and locate wrecks or obstructions on the seabed that may cause damage to the fishing gear.

Because a sonar acoustic beam is transmitted in the horizontal plane initially, and can be moved through 90° to the vertical at the operator's command, it is influenced by different temperatures in the water column. After reading this section, the operator should be able to recognize when his sonar beam is being distorted by various temperature layers.

Referring to Figure 17, a sonar beam comprises a main beam and a multitude of smaller beams adjacent to the main beam--these are referred to as side lobes, and carry some of the transmitted power and will pick up echoes within their normal span.

When the lower edge of the main beam strikes a hard, rocky seabed, the large echo returned to the transducer will mark the display paper with a large heavy stroke, which will increase in length as the remainder of the beam echoes back. Under these conditions, the detection of fish close to the seabed is virtually impossible. However, if the seabed is smooth, soft, and made up of mud, sand, or gravel, the beam will tend to bounce away from the transducer at an angle equal to the original beam strike angle. Shoaling fish fairly close to the seabed may well echo back to the transducer and print on the display, appearing to be a target below the seabed. Under ideal sonar conditions, this skipping of the main beam can show an apparent increase in detection range, but if the observer studies his chart closely he will see that the beam has bounced, and the fish target at a greater distance than the weak seabed return is only showing the correct bearing and not the correct range.

As each transmission occurs at the transducer, some of the energy will spill into the side lobes. Some transducer designs will have a side lobe that points vertically downwards, and thus create an echo from the seabed which will mark the display chart. This echo, which is much weaker than the main beam seabed return, will indicate the water depth below the vessel. This light echo can be useful to the operator in determining the water depth without reference to the vertical echo sounder.



TYPICAL BEAM PATTERN FROM A SONAR TRANSDUCER

FIGURE 17

If a wreck or other heavy object is lying on the seabed, the sonar will detect it. Depending on the transducer tilt angle, the first echo from such an object on the seabed will indicate on the chart at an apparently greater range than the main beam seabed. As the vessel closes the wreck or other hard object, the range will decrease, and the echo from it will appear to rise up through the main beam seabed echo. This echo will not, however, come very much higher than the seabed return, and will never clear the side lobe seabed echo until the vessel is virtually on top of the object with the sonar transducer tilted vertically downwards. A strong fish mark, however, arising from say a shoal of herring or mackerel swimming above the seabed, will cause a similar echo to appear at a range greater than the main beam seabed echo, and as the vessel closes this fish target it will rise clear of the main seabed echo and will clear the side lobe seabed echo as the range decreases.

Figure 18 illustrates how a simple fish shoal would echo and build up a record on the paper chart if the vessel held its transducer fixed at 90° on the starboard beam.

A similar exercise with the transducer dead ahead and fixed, whilst the vessel moves forward over an undulating seabed, is illustrated in Figure 19.

The beam shown in both figures is a simple main beam without side lobes. Referring to the previous information, it can be appreciated that side lobe information and echoes will be added to the chart.

If other vessels are working within the range of the sonar, echoes will be shown on the display caused by the wakes of the other vessels. If other sonars are being used in the vicinity of the user's sonar, then their transmission pulses will cause black stripes or dots to appear on the chart display, and if the other sonar is very close, it can cause the operator's sonar to blank out echoes as its TVG circuits operate.

If the operator appreciates where all the echo information is coming from, he will be able to interpret his display.

Mention was made earlier of temperature layers in the sea which can affect the sonar beam. This is illustrated in Figure 20, and a general "rule of thumb" is that the beam will bend towards the cold layer and away from the warm.

These conditions are influenced by the seasons of the year, and tend to be worse in the summer when a cold layer of water can lie some distance below the surface. This will cause the beam to bend downwards and to strike the seabed and echo prematurely. Many sonars are fitted with a slant range

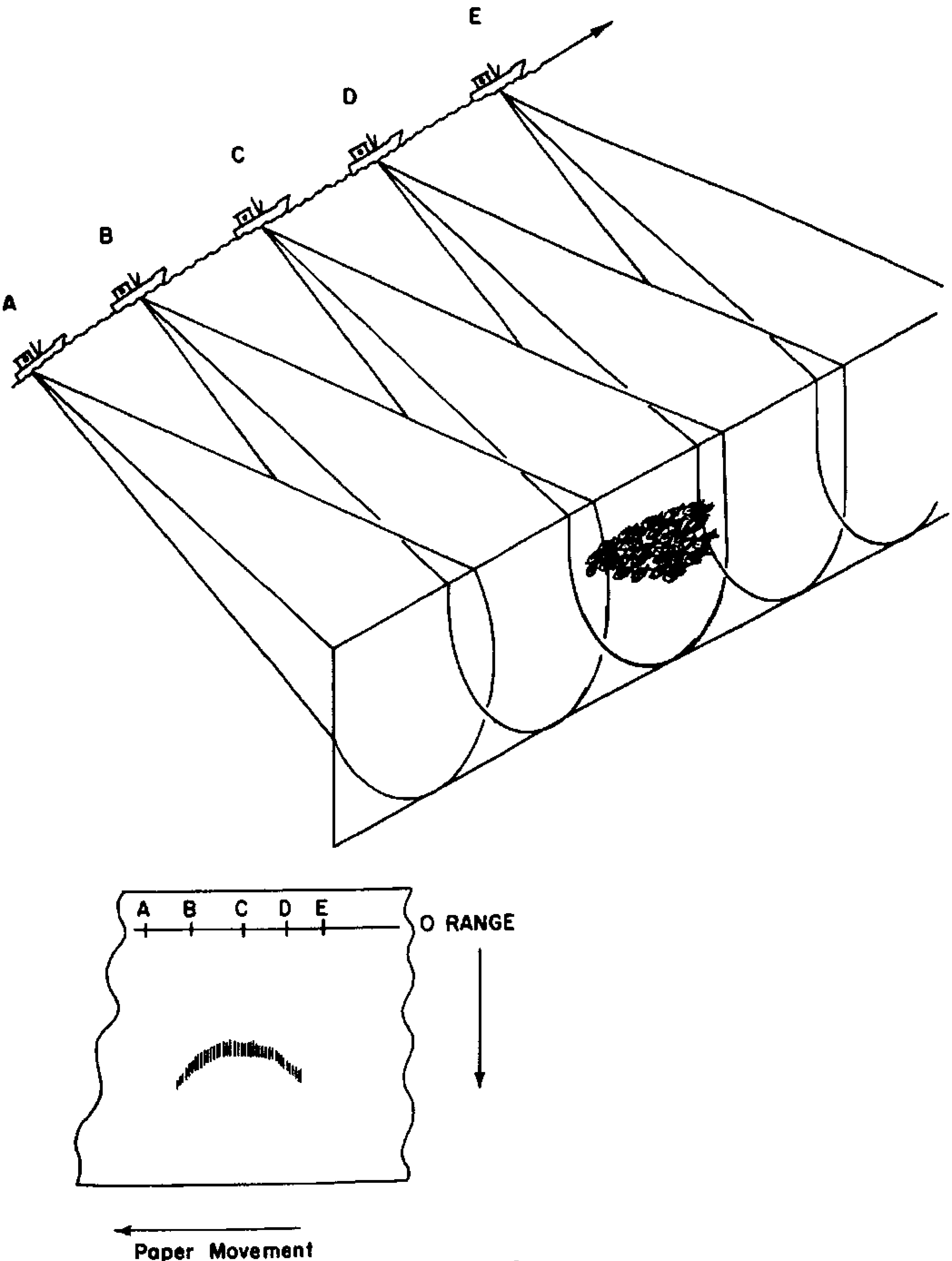
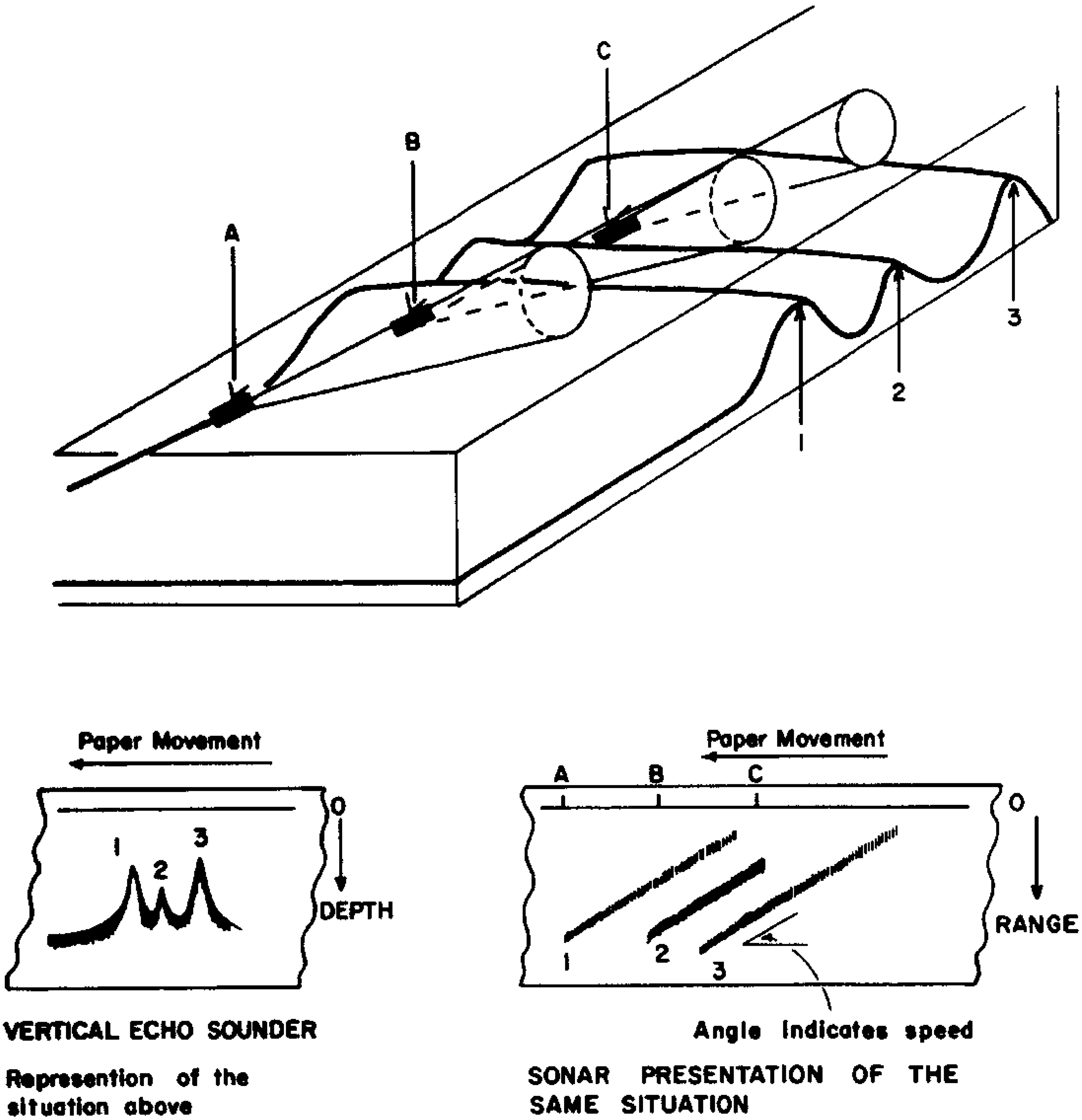


FIGURE 18



A
B
C
1
2
3
Paper Movement
O
DEPTH
1
2
3
VERTICAL ECHO SOUNDER
Represention of the
situation above
Paper Movement
A
B
C
O
RANGE
1
2
3
Angle indicates speed
SONAR PRESENTATION OF THE
SAME SITUATION

FIGURE 19

indicator either as a direct reading to an echo or an indicator associated with the transducer tilt angle meter. The operator should check his vertical depth from his main echo sounder and apply this information to his sonar, taking into consideration his transducer tilt angle and the range that the main beam seabed echo is showing on his chart. If the main beam seabed return is indicating at a short range, then the beam is bending downwards. Some correction to this phenomena can be achieved by tilting the transducer upwards, but care must be taken to avoid a heavy series of echoes from the surface.

This beam refraction can become even more complicated as fall approaches, and this is illustrated in Figure 21.

Summary of Sonar Operation

Range

Estimate the effective sonar range, taking into consideration weather conditions, type of seabed, season of the year, and species sought. The following list provides general guidelines:

1. Summer conditions are generally worse than winter, so a shorter range should be considered in the summer.

2. Range is reduced by working in shallow water; 20 fathoms depth will limit the effective range to 500 meters.

3. Where other vessels are working around the sonar vessel, their wakes will reduce sonar range.

4. Ship's speed will reduce effective sonar range as it increases.

Tilt Angle

Adjust the angle for minimum surface and seabed echoes. In shallow water, the angle will be between 2-5 degress (20 fathoms or less). In deep water the tilt angle can be increased to between 5-10 degrees. If the sonar vessel is working amongst other vessels, increase the tilt angle to 10-15 degrees to avoid echoes from vessels and wakes.

Search Pattern

This depends on the type of equipment fitted and the transducer stepping pattern. Various types of stepping patterns are:

1. Step from port to starboard through the bow and back from starboard to port.

BENDING OF A SONAR BEAM DUE TO TEMPERATURE LAYERS

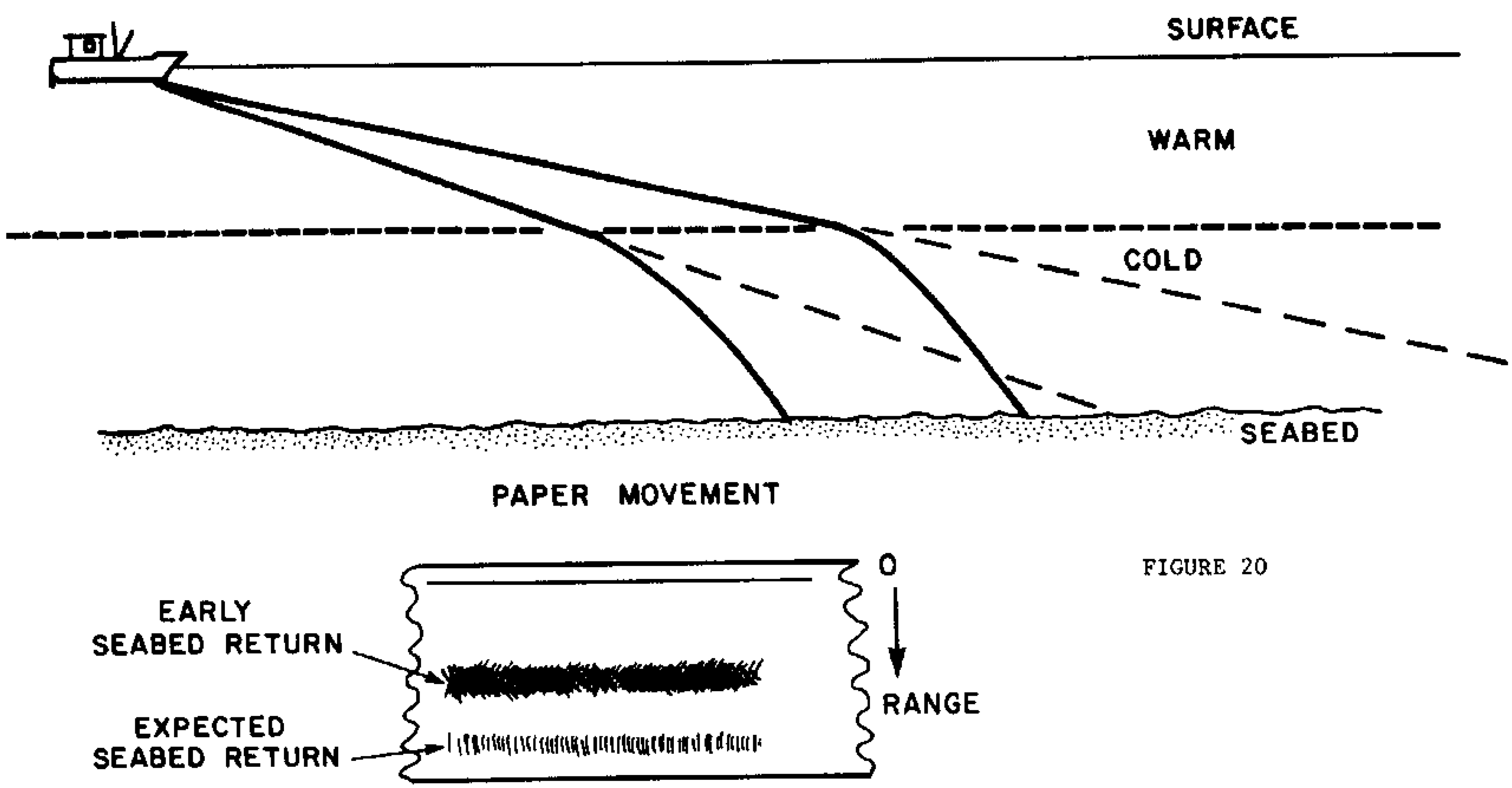


FIGURE 20

FALL CONDITIONS AND THE RESULTANT SONAR BEAM

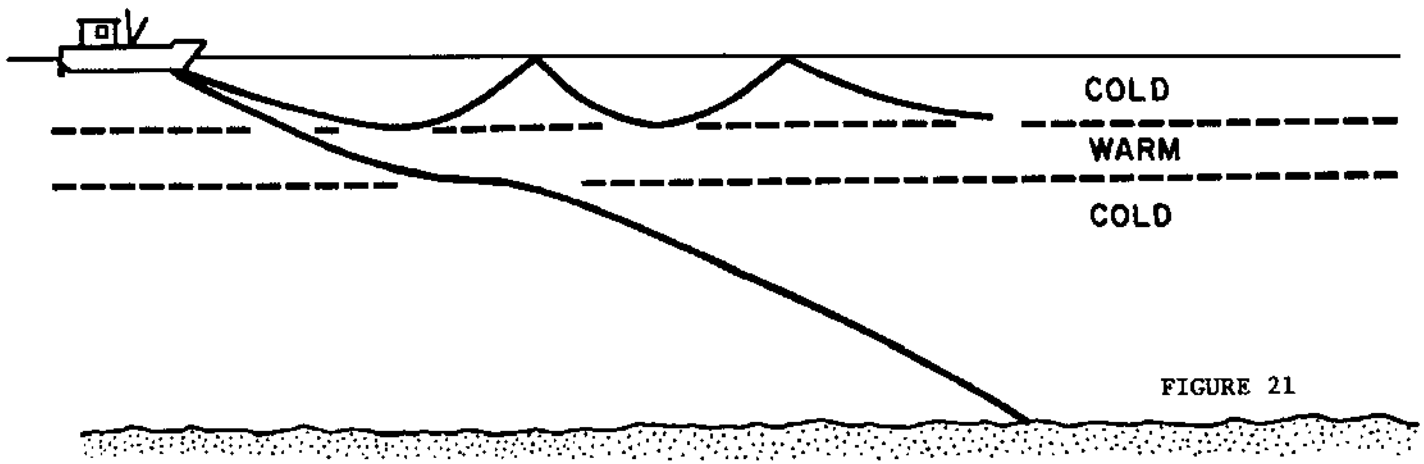


FIGURE 21

THIS DIAGRAM IS EXAGERATED BUT SHOWS THE REASON FOR APPARENT ANOMOLIES IN THE SONARS BEHAVIOUR

2. Step from port to starboard through the bow, and return quickly to port before starting again.

3. Step from port to bow and move quickly to starboard before stepping from starboard to bow.

A normal pattern is 70° port to 70° starboard in deep water, greater than 20 fathoms. When searching in shallow water adjacent to a shoreline, it is better to search from near the shore out into the deep water, i.e. portside to the shore, transducer search pattern set to 10° starboard to 90° starboard.

If working with a partner vessel fitted with sonar, it is always advisable to work in collaboration. In this case, estimate the practical sonar range and position the vessels twice the maximum range apart. Steam in line abreast, working the bearing scales on each vessel at 70-0-70 degrees. Never search a sea area when a vessel is running dead ahead of the sonar vessel.

Pulse Width

Pulse widths should be set as follows:

1. Narrow pulse in shallow water or poor sea conditions.

2. Narrow pulse at short ranges to improve target discrimination.

3. Long pulse for long range searching.

Gain/Sensitivity and AGC

Adjusted to show equal sensitivity across the full range of the display.

Operation on Target Contact

As soon as the operator has determined that the received echoes are coming from a target of interest, the following procedures should be used.

Bearing Search Pattern. Select manual search and scan the target either side to determine the area of the target. Continue to scan manually as the vessel's head is brought around to the target bearing. Select Automatic Search, and adjust the search limits to 5° either side of the predetermined target area. Keep a close watch on the movement of the target if it is a shoal of fish to ensure the echo is not lost.

Tilt Angle. Scan the target vertically to determine the depth and thickness of the target. Set the tilt angle to the midpoint of the shoal. As the vessel closes the target, adjust the tilt angle downwards to retain contact.

An estimate of the depth of a target or shoal of fish can be obtained directly from the sonar instrument displays; a table of approximate depths against range and tilt angle are shown in Figure 22.

Pulse Length. As the range reduces to the target, reduce the pulse length. Remember, as the pulse length gets shorter, target discrimination improves and allows the operator to get a clearer picture of the size of the shoal of fish.

Sensitivity and AGC

As the target gets nearer the vessel, some reduction of sensitivity may be required to reduce the near reverberations and volume noise usually associated with close range sonar work.

Other Uses for a Sonar System

Fishing vessel sonars can be used for other purposes besides detecting midwater fish shoals or pinnacles and wrecks on the seabed.

If an operator requires information regarding the type of seabed ahead of his vessel, the sonar set is ideal when used in the following manner:

1. Steam the vessel to a known soft ground area.
2. Set the transducer tilt angle at 30-45°.
3. Set the Bearing Search to 0° ahead and fixed.
4. Move the vessel ahead at normal searching speed.
5. Adjust the sensitivity and AGC and the loudspeaker volume control so that the seabed return sounds like a prolonged "shuffling" sound after each transmission.
6. Do not adjust the controls again.
7. Steam to the fishing ground.
8. When fishing, the loudspeaker output will continue to provide the information to the operator of soft ground ahead.
9. Adjust the bearing search pattern to 10° port/10° starboard.
10. Should any change in the seabed occur ahead of the vessel, such as hard rocky formations, the loudspeaker output will increase to a much higher and more harsh tone. The operator can then refer to the chart display and determine the cause of the increased output.

Transducer Tilt Angle	Range in Metres								
	200	300	400	500	600	700	800	900	1000
5	175	26	35	44	52	61	70	78	87
10	35	52	70	87	104	122	139	156	174
15	52	78	104	130	155	181	207	233	259
20	58	103	137	171	205	239	274	308	302
25	85	127	169	211	254	296	338	380	X
30	100	150	200	250	300	350	X	X	X
35	115	172	229	287	344	X	X	X	X
40	129	193	257	321	X	X	X	X	X
45	141	212	283	354	X	X	X	X	X
50	153	230	306	X	X	X	X	X	X
55	164	246	328	X	X	X	X	X	X
60	173	260	X	X	X	X	X	X	X

Echo Depth
Metres

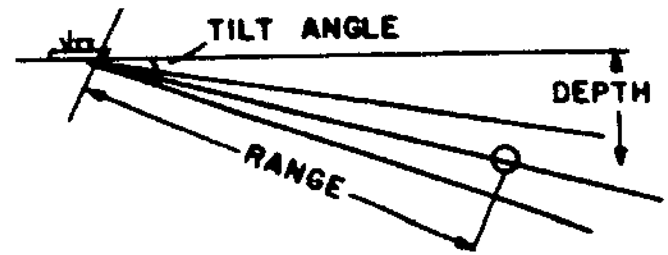


FIGURE 22

Keeping station on an edge or other seabed point can be useful in fishing a seine net or trawling adjacent to a pipeline.

The usual procedure is to set the transducer to the beam of the vessel where the edge lies, set the bearing search pattern to 10°-0-10° about 90° or 270° relative to the ship's head, depending on the side being observed. Remember, a straight edge such as a pipeline will appear as an undulating line on the sonar display because of range variations as the beam is moved in azimuth.

Wreck Tangle Net Fishing

This form of fishing is quite popular in European waters, particularly by Danish vessels in the North Sea. A sonar is highly desirable for this type of fishing because of its ability to accurately locate the wreck and enable the skipper/operator to place his tangle nets across the wreck in three fleets.

Pair Midwater Trawling

Besides locating the shoal of fish to be caught, the sonar system allows the fisherman to check the relative movement of the shoal towards the net and between the two vessels, allowing small corrections in the net's position, and helping to ensure that the correct part of the shoal is taken.

SECTION IX

Other Types of Sonar Display

One other popular form of sector scanning sonar display is the Cathode Ray Tube or CRT.

It is somewhat similar to a radar type of indicator, except that the speed of sound in water makes the display look something like a bicycle wheel.

The principles of transmission and reception are exactly the same as a paper chart display sonar, but of course the display on a CRT cannot be historical, since each series of echoes will fade over a period of time. This limitation can reduce the maximum detection range available to the operator, but all the other relevant information of a paper chart display can be indicated on a CRT sector scanning sonar.

When the various controls associated with a CRT, i.e. Brilliance and Focus, are correctly adjusted, the display is ideal for ground detection and wreck or obstruction location.

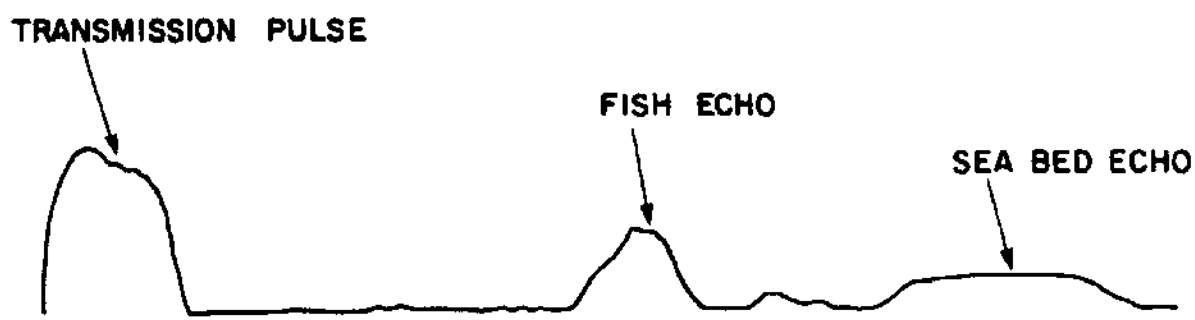
A similar procedure is followed as that applied to a paper chart display. The operator should choose a known section of smooth soft ground, adjust the Gain and Brilliance to show a fine speckly indication on the time base. The Brilliance should now be reduced until the trace just disappears. Should the sonar now encounter hard ground, the intensity of the trace will increase with the resultant echoes and show clearly on the tube.

One other feature associated with some CRT sonar displays is the ability to select what is known as an "A" trace or display. This is a straight horizontal line on the tube face, with echoes showing as an amplitude modulation. (See Figure 23.) This feature allows the operator to pinpoint wrecks or obstructions on the seabed. A point to note is that the bearing search should be in manual under operator control, as there is no indication on the display as to where the transducer is pointing. Skilled operators also use this form of display in bad weather conditions to give a better chance of locating a target.

This form of single time base line is also applied to the Sonar Loop or Sonar Scope. Again, the operator has to check the bearing indicator, on a paper chart sonar, to show where the sound beam is pointing. (See Figure 23.)

Omni Sonars

The Omni Sonar is a completely different form of sonar display. In an Omni Sonar, each transmission pulse is caused to radiate completely around the vessel, covering a full 360° or alternatively a sector of 170° to 190°, depending on the manufacturer. This form of display approaches that of a



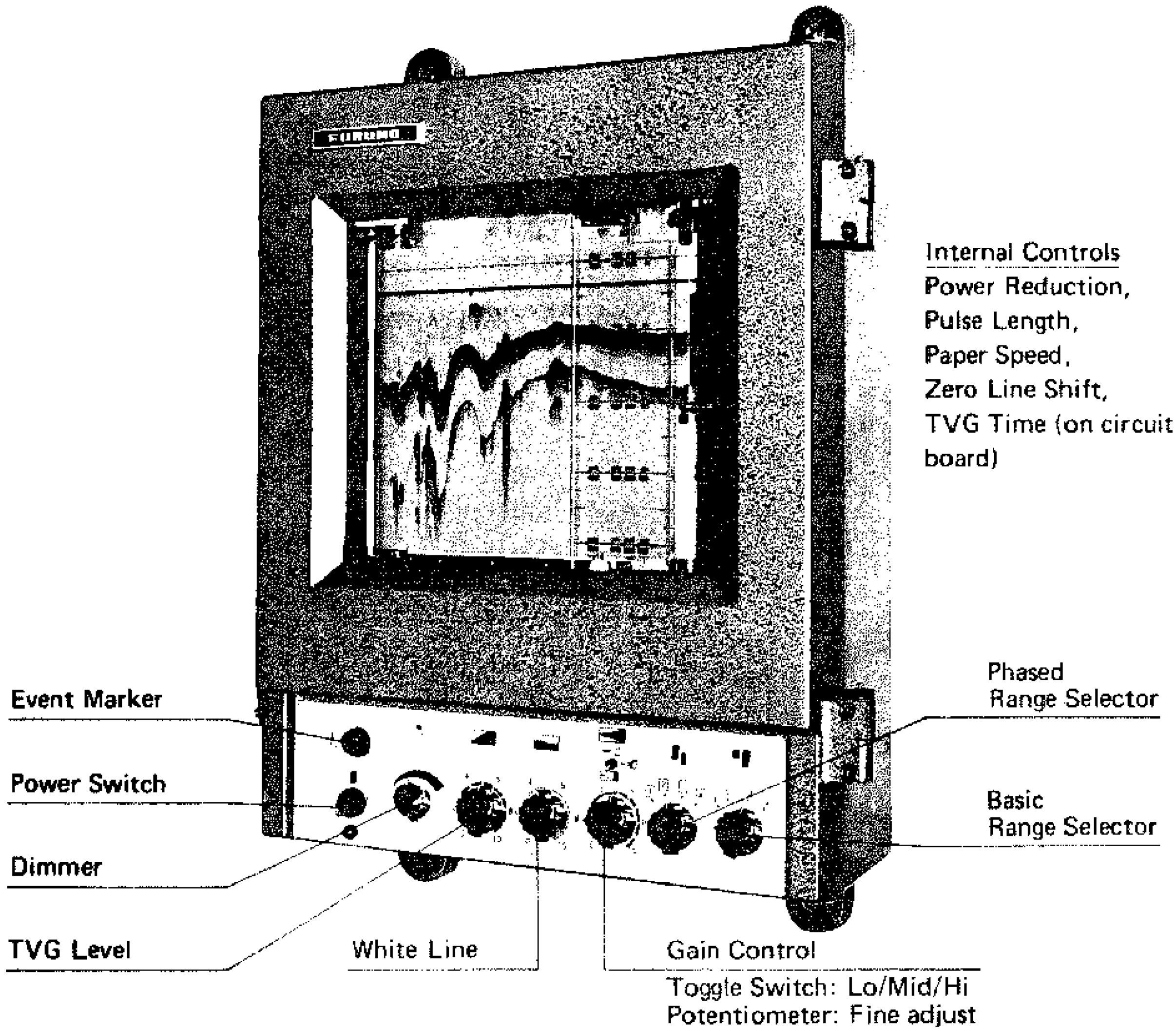
'A' TRACE FUNCTION ON CERTAIN SONAR DISPLAYS

FIGURE 23

radar set showing the underwater situation around the vessel with a very high data rate.

In all sonar systems, whatever the type of display, the operator must appreciate the various sources of data being presented, and also how he can influence that data presentation by altering the various controls available on the equipment.

Some form of introductory training should be contemplated prior to the purchase or operation of any sonar or acoustic fish detection equipment. Maximum benefit from the equipment will only come after long hours of use to provide the data the operator is seeking.



Typical Echo Sounder Control Layout

Acknowledgement: Furano, U.S.A., Inc.

AND NOW . . . FISH IN COLOR

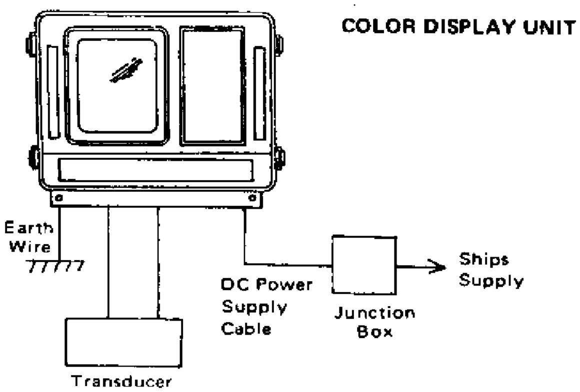
The sounder is capable of distinguishing the reflected echo signals and displaying them respectively in up to 8 different colors (red, orange, yellow, green, blue green, white, greenish blue and blue) on a cathode ray television-type screen.

SPECIFICATIONS

Display	11-inch, 3 electron gun, magnetic deflection color CRT
Range Scale (Fathoms)	0-40, 0-80, 0-160, 0-320, 0-640
Spread Scale (Fathoms)	10, 20, 40, 80
Spread/Depth Position	Variable in full width of CRT with accuracy of 0.5 Fa. 4-digit LED readout
Frequency	Dual - selected from 28, 50, 75 and 200 KHz.
Depth Scale	4 white horizontal lines dividing full width of CRT into four equal parts.
Noise Rejection	On/Off
Power Supply	On/Off
	11-40 VDC (115-230 Optional)
Display Mode	a. High frequency normal range b. High frequency range spread c. Low frequency normal range d. Low frequency range spread 4 modes can be selected by using FREQUENCY and RANGE SPREAD SCALE switches
Power Consumption	Max. 130 VA.
Transmitter Power	1.5 KW
Power Reducer	4 position
Time Marker	Every 30 seconds

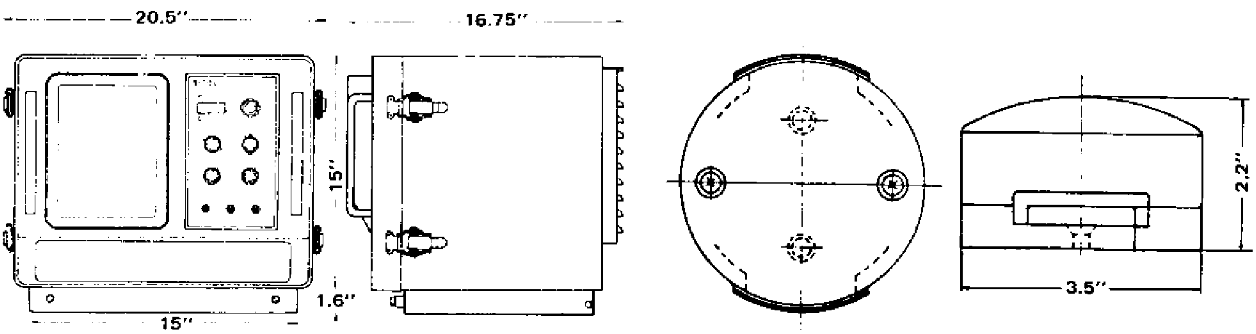
Specifications subject to change without notice.

COMPOSITION



Color Display Unit	1, with mounting bracket
Cover	1 Vinyl cover for Color Display Unit
Transducer	1 Set, Dual transducers housing in a Tank with 20 m cable for each transducer
Cable Gland	For two cables
DC Power Supply Cable	2 cond. shielded VSV-2T11; 3 m
Junction Box	1, for DC Power Supply Cable
Spare Parts	1 set
Installation Materials	1 set

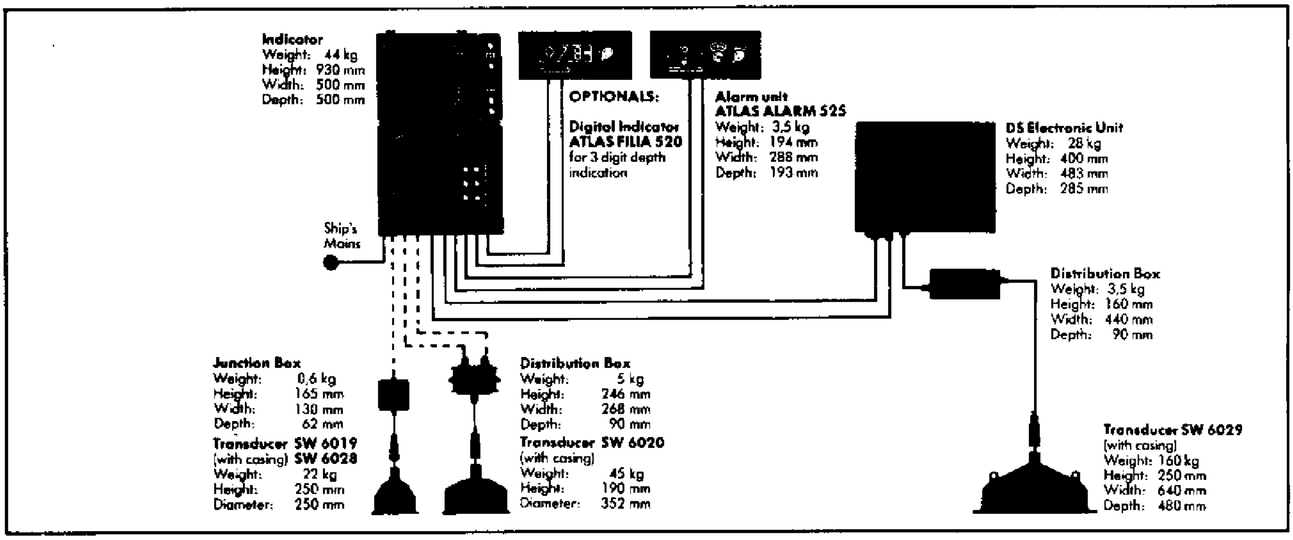
DIMENSIONS



COLOR DISPLAY UNIT 82 lbs. JUNCTION BOX 9.35 oz.

Typical Color Tube Echo Sounder Specification.

Acknowledgement: Epsco Marine



Range scales								
Basic ranges	METRES	0 ... 20 (24)	0 ... 50 (60)	0 ... 100 (120)	0 ... 200 (240)	0 ... 500 (600)	0 ... 1000 (1200)	m
	FATHOMS	0 ... 10 (12)	0 ... 25 (30)	0 ... 50 (60)	0 ... 100 (120)	0 ... 250 (300)	0 ... 500 (600)	fms
Phased ranges		Continuous phasing down to 9000 m or fms						
Recording scale	m range	8,0	3,2	1,6	0,8	0,32	0,16	mm/m
	fm range	16,0	6,4	3,2	1,6	0,64	0,32	mm/fm

Recording and CRT display data								
Graphic Scale Expander		Bottom locked 32 mm paper width			Pelagic scale expansion 64 mm paper width			
Range scales		5 / 10 / 20 m or 2,5 / 5 / 10 fm			20 / 50 / 100 m or 10 / 25 / 50 fm			
Recording scale		6,4 / 3,2 / 1,6 mm/m or 12,8 / 6,4 / 3,2 mm/fm			3,2 / 1,3 / 0,64 mm/m or 6,4 / 2,6 / 1,3 mm/fm			
Steady Picture Scope		Bottom locked			Pelagic scale expansion			
Range scale simultaneous with Graphic Scale Expander		5 / 10 / 20 m or 2,5 / 5 / 10 fm			20 / 50 / 100 m or 10 / 25 / 50 fm			
When recording without Graphic Scale Exp., the range scale on the scope corresponds to the recording range scale								
Sounding rate	at depth	to 250	250-650	650-1050	1050-1450	1450-1850	1850-2250	etc.	m
	(indep. of range)	120	60	40	30	24	20		sound./min.
Transmitting pulse length		1 ms or 3 ms; switchable independent of the range scale						
Paper transport speed		16 /8 /4 /2 /1 mm/min; switchable independent of the range scale						

Acoustic data and sounding depth						
Equipment Type	721		781		791 DS	
Transducer Type	SW 6019	SW 6028	SW 6020		SW 6029	
Frequency	33		33		33	kHz
			switchable			
Transmitting pulse power	600		600	1500	4000	W
Beamwidth of cone	19°		19°	10°	6°x 8° or 6°x 4°	∢°
Acoustic source level	115		115	125	133	dB rel 1 μbar
Transverse training					-15°..0°..+15°	∢°
Max. sounding depth*)						
Large fish (T = -30 dB)	250		250	500	1000	m
Fish school (T = 0 dB)	650		650	1000	2000	m
Bottom	2200		2200	3500	5000	m
*) with favourable acoustic conditions						

Power Supply						
Ship's mains supply voltage	DC				AC	
	24 V	32 V	110 V	220 V	115 V	220 V
Permissible volt. fluct.	+30 % −10 %	+30 % −20 %	±10 %	±10 %	±10 %	±10 %
Connection	via inverter				direct	
Power consumption						
721/781	ca. 230 W		ca. 220 W		ca. 150 VA	
791 DS	ca. 380 W		ca. 370 W		ca. 280 VA	

SCOPE OF DELIVERY (721, 781, 791 DS)

1 Indicator
1 Set of standard spare parts A
1 DS electronic unit (791 DS)
1 PZT high performance ceramic transducer incl. approx. 10 m cable
1 Steel casing for transducer
1 Distribution box
1 Stuffing tube
1 Set of plugs (791 DS)
1 Brief Operating Instructions
1 Service Manual with list of Service Stations and Operating Instructions

OPTIONALS (721, 781, 791 DS)

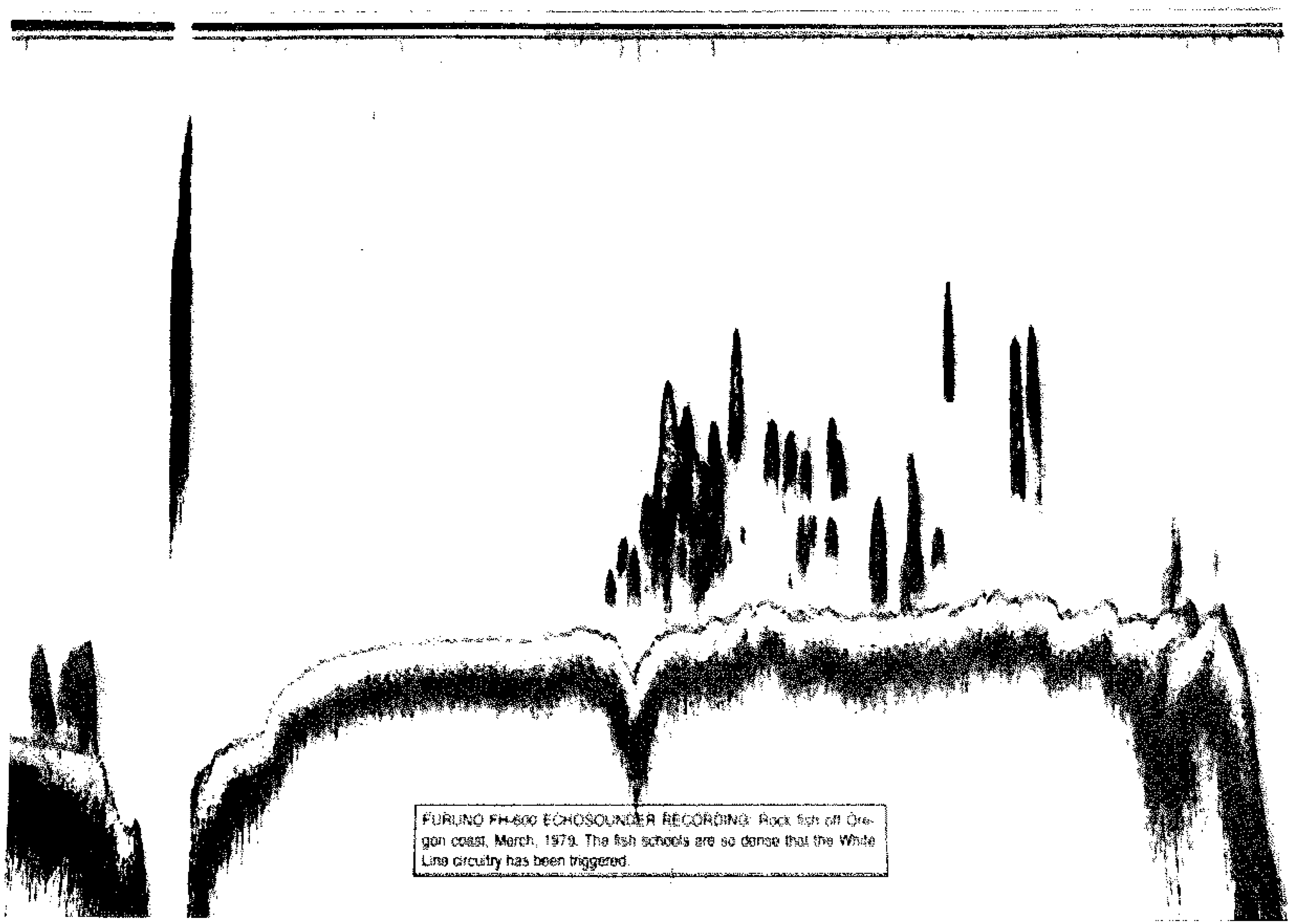
1 Digital Indicator ATLAS FILIA 520
1 Alarm Unit ATLAS ALARM 525
1 Set of spare parts B
2 Static converter for supply voltages 24 / 32 / 110 / 220 V DC (791 DS)
1 Static converter for supply voltages 24 / 32 / 110 / 220 V DC (721, 781)

SPECIAL CABLE (791 DS)

For the connection between distribution box, DS electronic unit and indicator a special cable is required.

Typical Paper Chart and C.R.T. Echo Sounder Specification.

Acknowledgement: Krupp-Atlas Elektronik



FURUNO FH-600 ECHOSOUNDER RECORDING: Rock fish off Oregon coast, March, 1979. The fish schools are so dense that the White Line circuitry has been triggered.

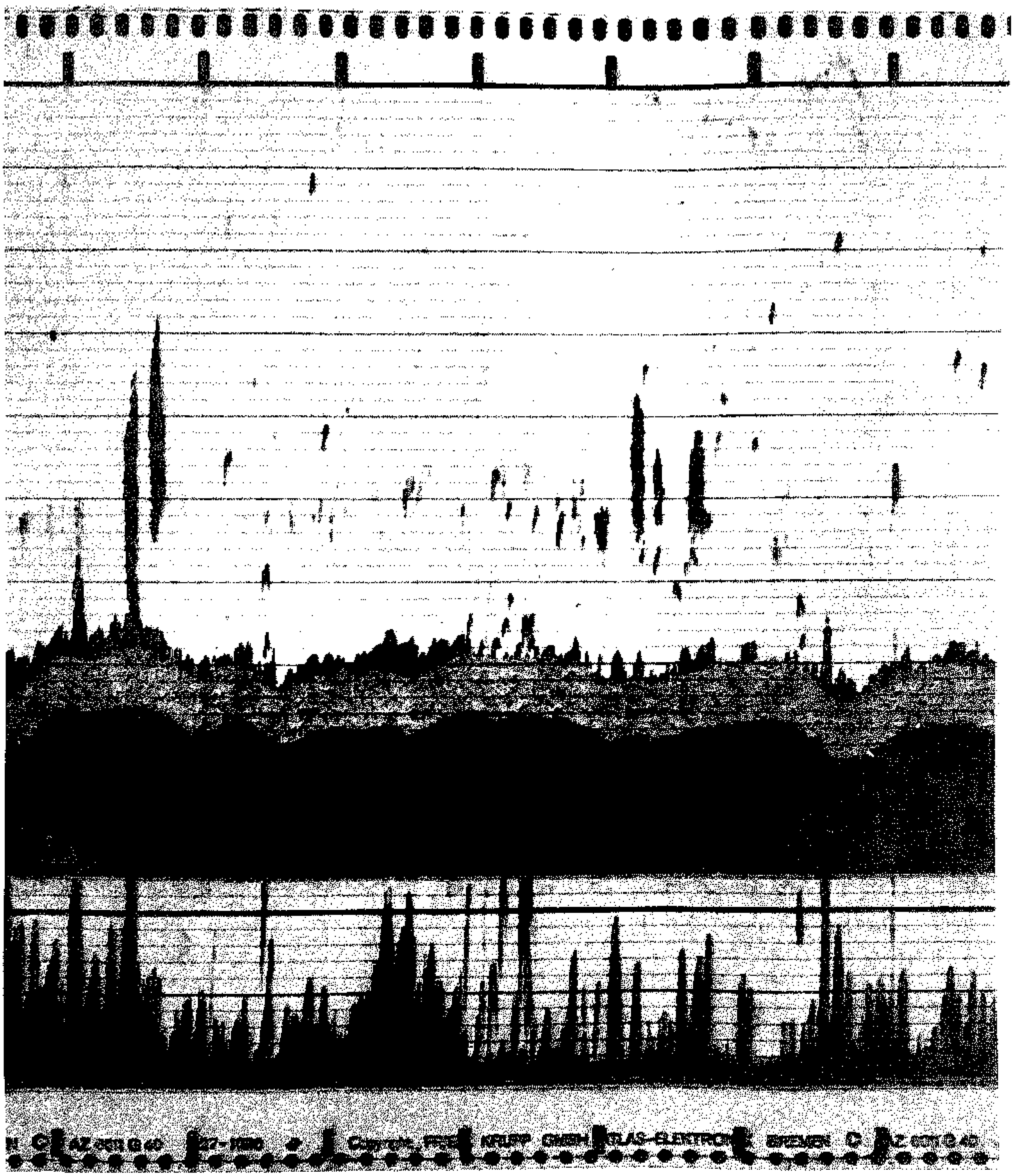
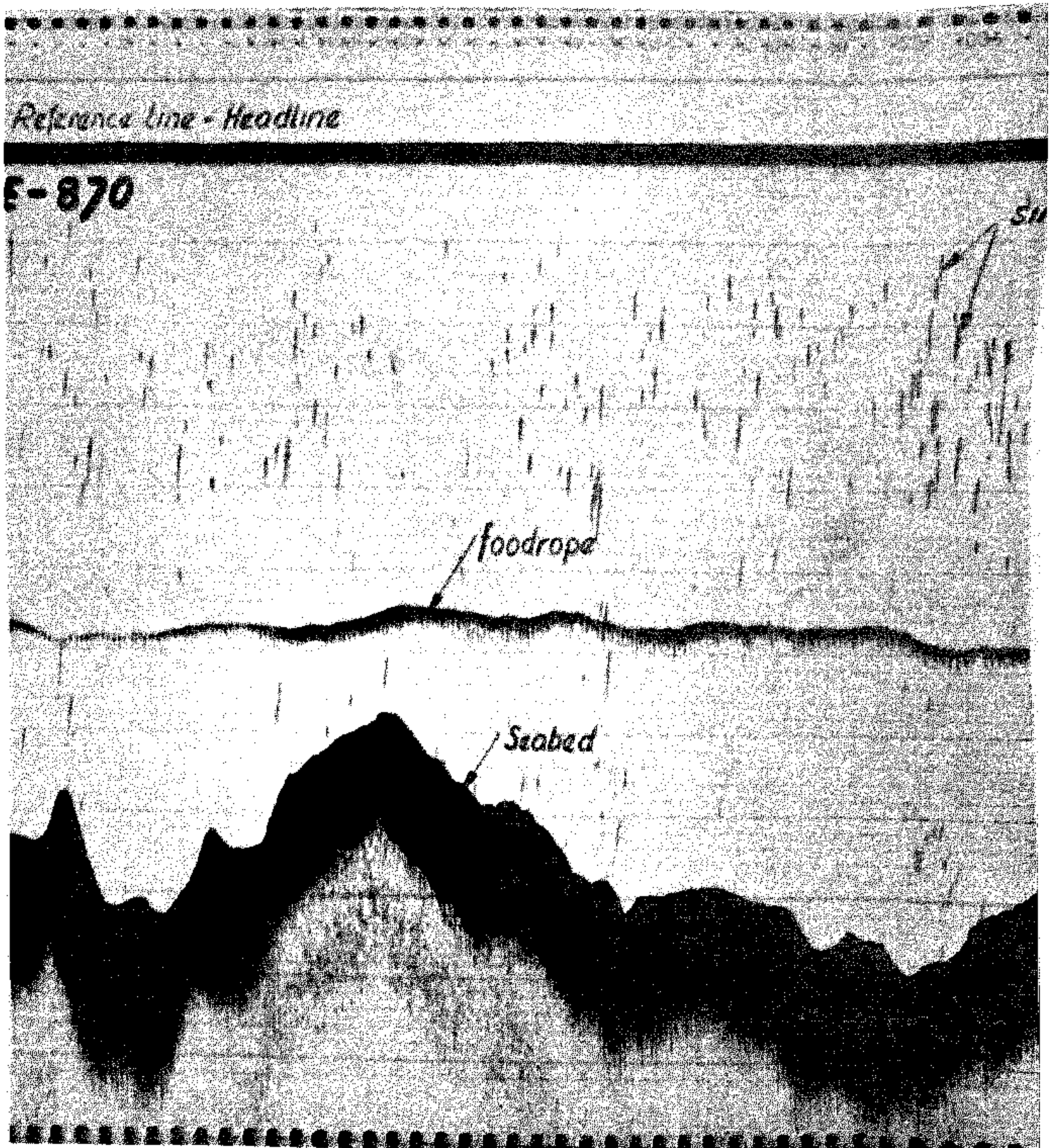
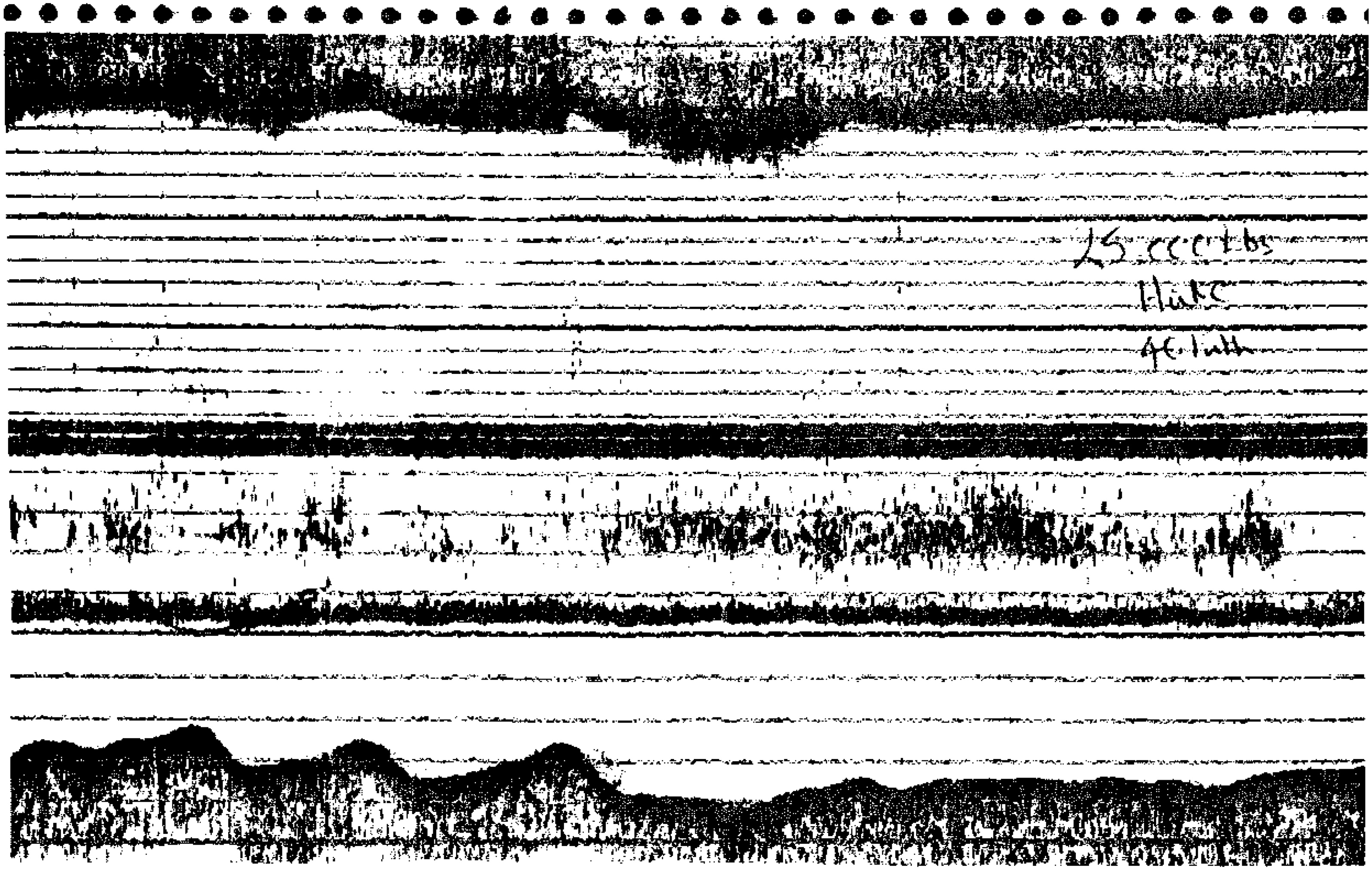


Chart from a correctly adjusted grey line echo sounder with bottom lock scale expansion.

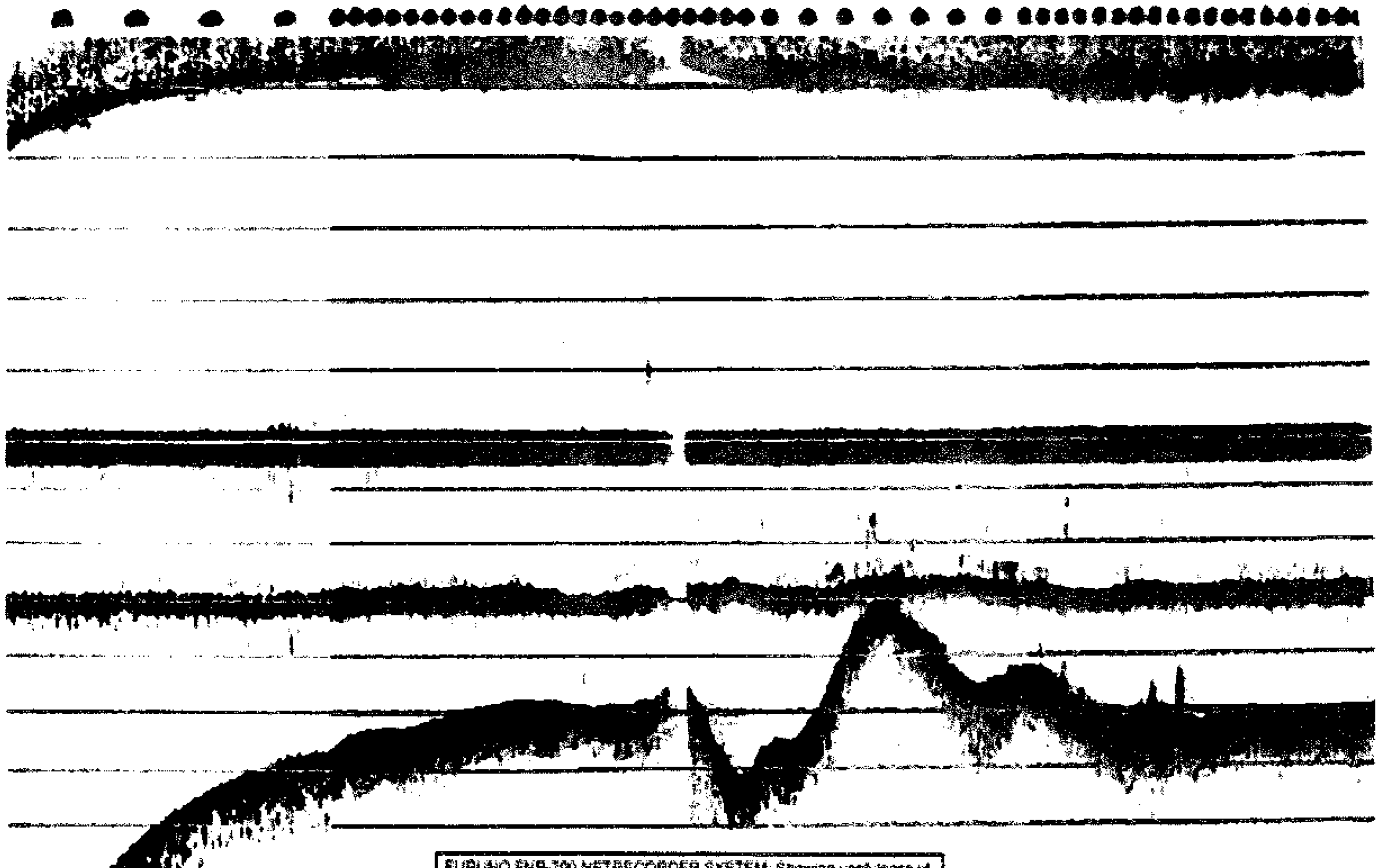


Typical Net Sounder Chart.

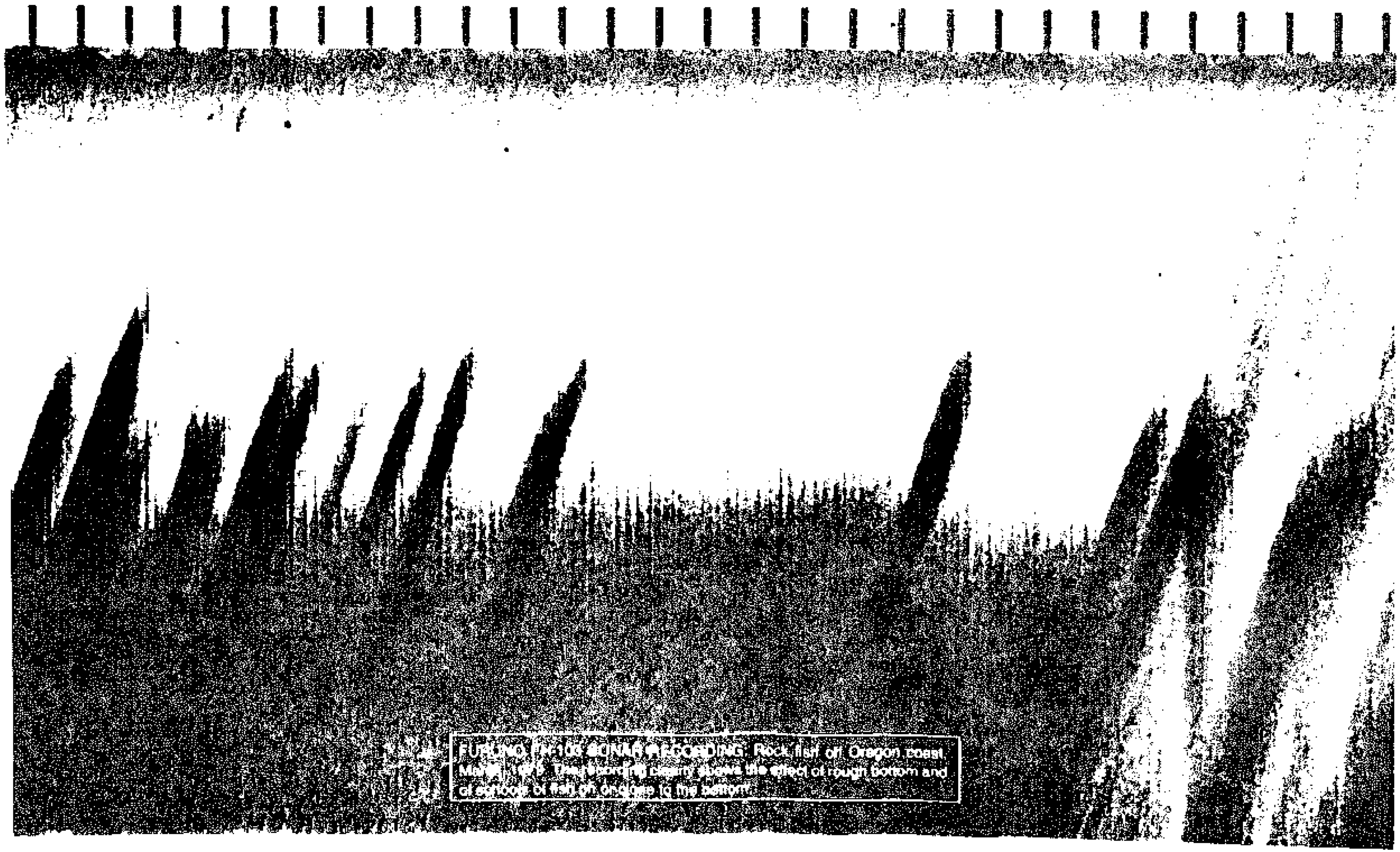
Acknowledgement: Krupp-Atlas Elektronik



FURUNO FNR-700 NETRECORDER SYSTEM: Pacific hake off Oregon coast, July, 1979. From F/V Mista Sea, Capt. Dan Heasley.



FURUNO FNR-700 NETRECORDER SYSTEM: Showing usefulness of simultaneous recording of surface and bottom.


FURUNO FH-103 SONAR RECORDING: Rock fish off Oregon coast,
March, 19[illegible]. The recording clearly shows the effect of rough bottom and
of schools of fish on or close to the bottom.