UNITS (NON-METRIC)

1 NAUTICAL MILE = 1852 M

= 6074 FT.APP

SPEED IN KNOTS = NAUTICAL MILES/HR

1 YARD = 0.9144 m

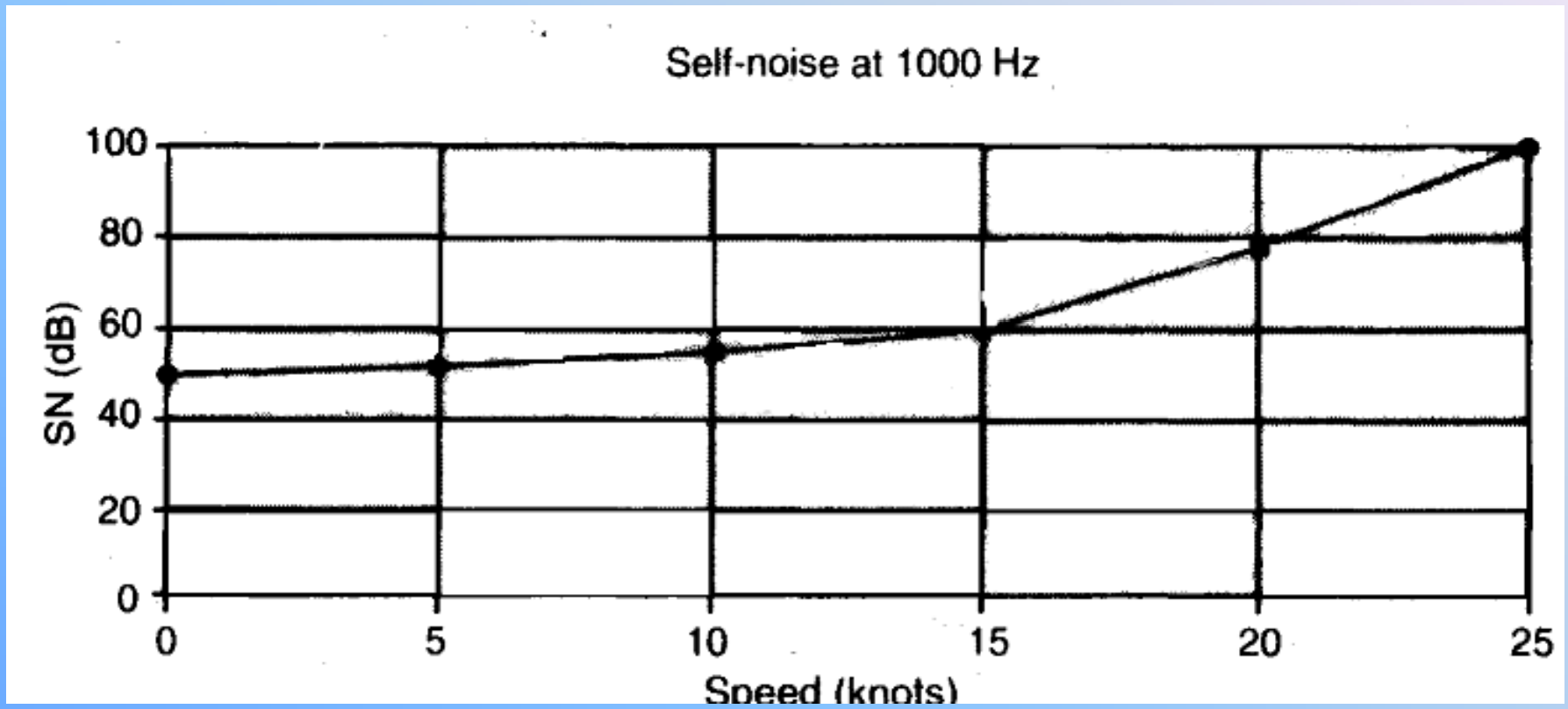
UNIT FOR MEASURING DEPTH

1 FATHOM = 6 FT

= 1.8288M

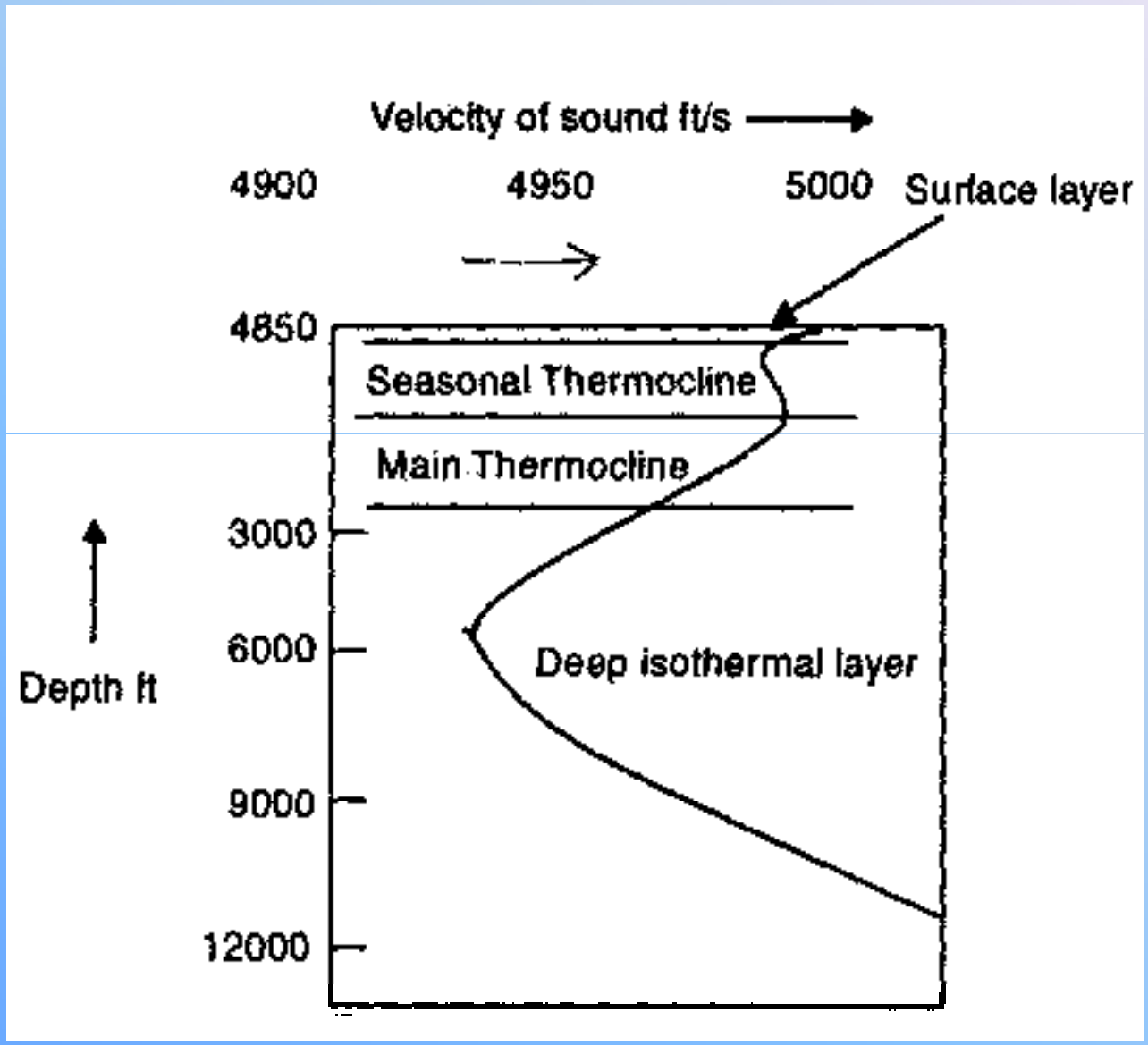
- **AMBIENT NOISE(AN) = SEA STATE+SHIPPING LEVEL+SEA LIFE**

WIND SPEED(KNOTS)	SEA STATE
<1	0
1 – 6	1
7 – 10	2
11 – 16	3
17 – 21	4
22 – 27	5
28 – 47	6
48 – 55	7
56 – 63	8
> 64	9


Self-noise at 1000 Hz
SN (dB)
100
80
60
40
20
0
0
5
10
15
20
25
Speed (knots)

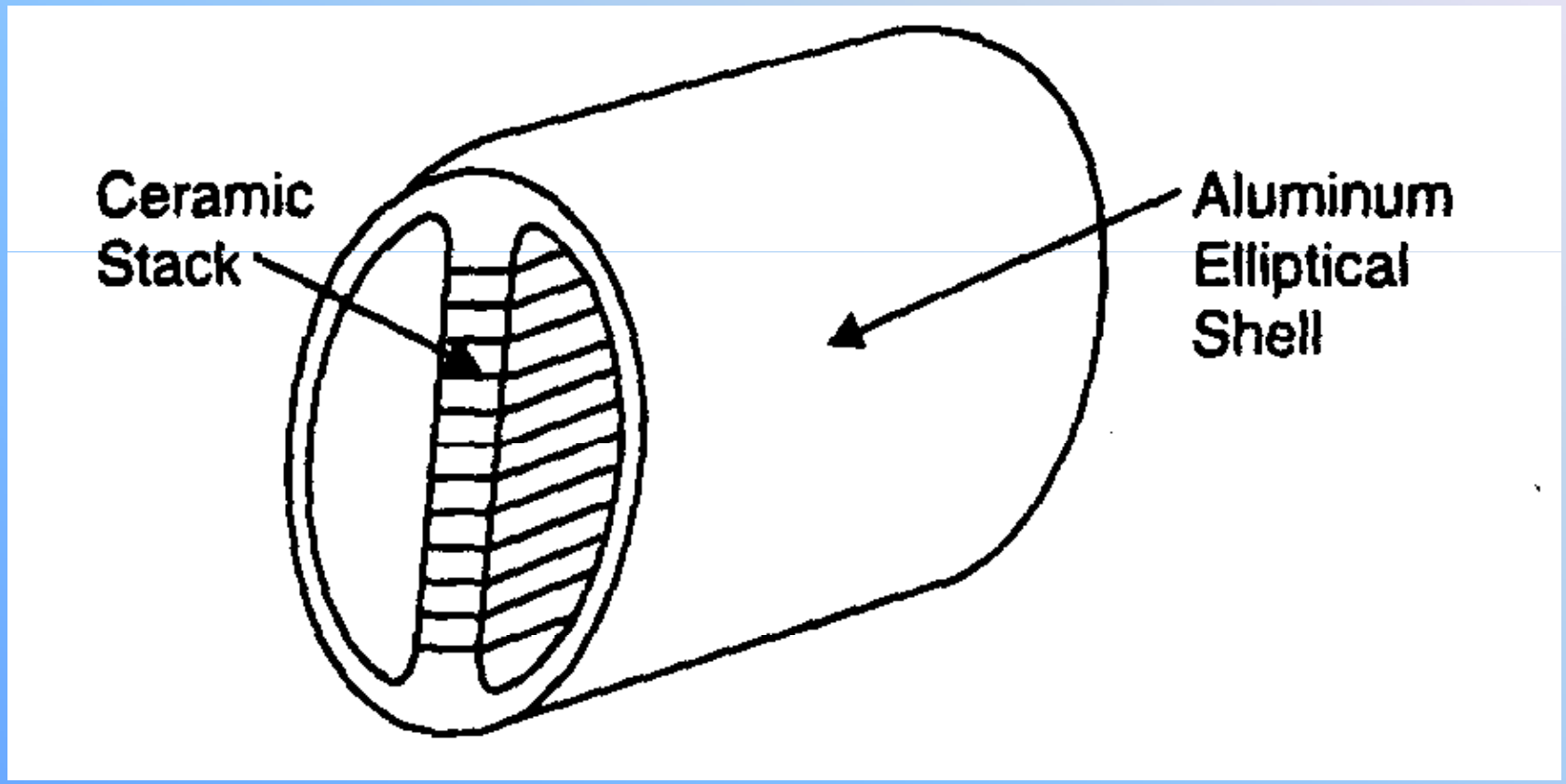
THREE TYPES OF ACTIVE SONAR SYSTEM

- **MONOSTATIC –**SOURCE & RECEIVERS ARE LOCATED ON THE SAME PLATFORM
- **BISTATIC** –TRANSMITTER & RECEIVERS ARE ON DIFFERENT PLATFORMS
- **MULTI-STATIC** –ONE OR MORE TRANSMITTERS AND MULTIPLE RECEIVERS ARE LOCATED ON DIFFERENT PLATFORMS.


Velocity of sound ft/s
4900
4950
5000
Surface layer
4850
Seasonal Thermocline
Main Thermocline
3000
6000
9000
12000
Depth ft
Deep isothermal layer

SONAR TRANSDUCER

-IT IS SONAR UNIT'S ANTEENA
-IT CONVERTS ELECTRICAL ENERGY FROM TX TO HIGH FREQ SOUND.
-ON RECEPTION OF SOUND ECHO,IT CONVERTS THE SOUND BACK TO ELECTRICAL ENERGY, WHICH IS SENT TO THE RECEIVER.
-THE FREQ OF TRANSDUCER MUST BE THE SONAR UNIT'S FREQUENCY.

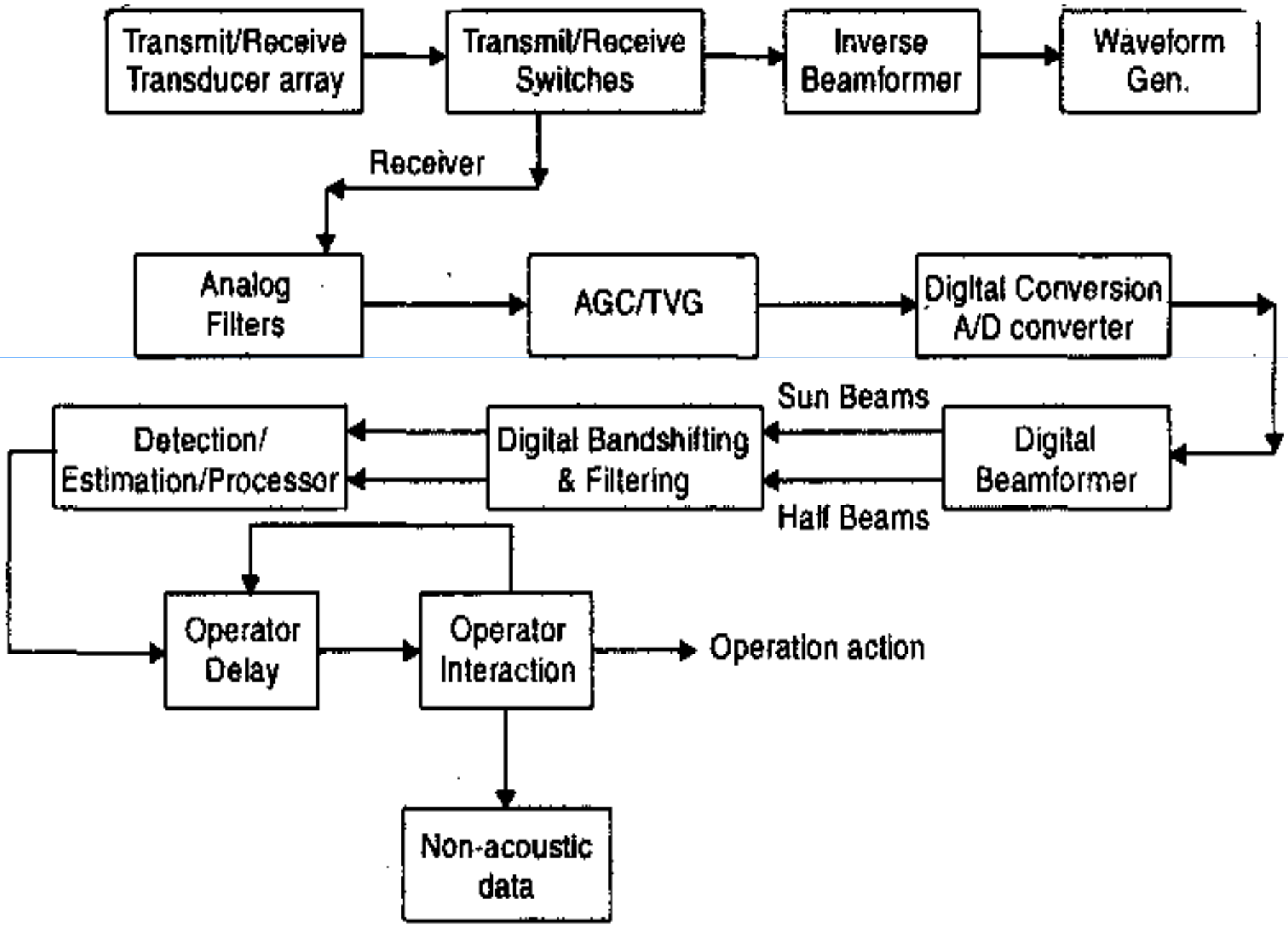

Ceramic
Stack
Aluminum
Elliptical
Shell

SONAR TRANSDUCER

- TRANSDUCER MUST BE VERY EFFICIENT. IT MUST WITHSTAND HIGH TX POWER IMPULSES,CONVERTING MAX.OF THE IMPULSE TO SOUND ENERGY
- AT THE SAMETIME ,IT MUST BE SENSITIVE ENOUGH TO RECEIVE THE SMALLEST OF ECHOES.
- THE ACTIVE ELEMENT IN A TRANSDUCER IS A MAN –MADE CRYSTAL (BARIUM TITANATE)

SONAR TRANSDUCER

- EXAMPLE-A 192 KHZ, 20^0 CONE ANGLE CRYSTAL IS APP. ONE INCH IN DIA; WHEREAS A 8^0 CONE REQUIRES A CRYSTAL OF ABOUT 2 INCH DIA.


Transmit/Receive Transducer array
Transmit/Receive Switches
Inverse Beamformer
Waveform Gen.
Receiver
Analog Filters
AGC/TVG
Digital Conversion A/D converter
Sun Beams
Detection/ Estimation/Processor
Digital Bandshifting & Filtering
Digital Beamformer
Half Beams
Operator Delay
Operator Interaction
Operation action
Non-acoustic data

SONAR-BLOCK DGM

- **INVERSE BEAMFORMER**-APPLIES TIME DELAYS OR PHASE SHIFTS TO EACH SIGNAL SO AS TO CREATE A NARROW BEAM IN A PARTICULAR DIRECTION
- A SEPARATE PROJECTOR IS USED TO TRANSMIT EACH OF THE DELAYED SIGNALS BY TRANSFORMING THE ELECT SIGNAL INTO AN ACOUSTIC WAVE

SONAR-BLOCK DGM(contd)

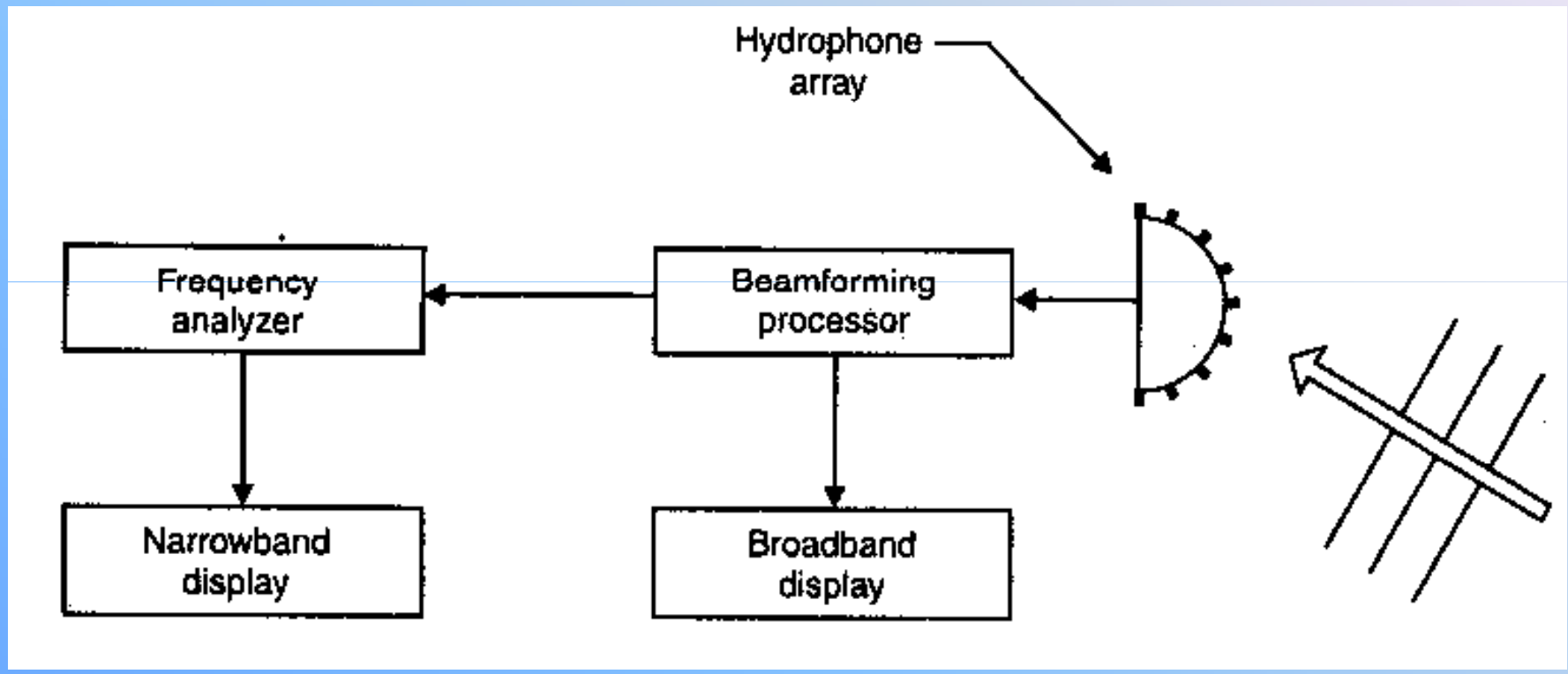
- **AT THE RX END THE ACOUSTIC WAVE IS CONVERTED BACK TO ELECT SIGNAL**
- TVG/AGC IS USED TO AMPLIFY OR ATTENUATE THE SIGNAL
- DIGITAL BEAM FORMER COMBINES THE O/Ps OF INDIVIDUAL DIGITAL SENSORS TO FORM A SET OF BEAMS.
- **EACH BEAM REPRESENTS A DIFFERENT SEARCH DIRECTION**

SONAR-BLOCK DGM(contd)

- THE BEAM O/P IS FURTHER PROCESSED (BANDSHIFTING/FILTERING etc) TO DETECT,CLASSIFY AND LOCALISE THE TARGETS
- THIS DATA IS DISPLAYED ALONGWITH OTHER NONACOUSTIC DATA TO THE OPERATOR FOR MAKING THE FINAL DECISION

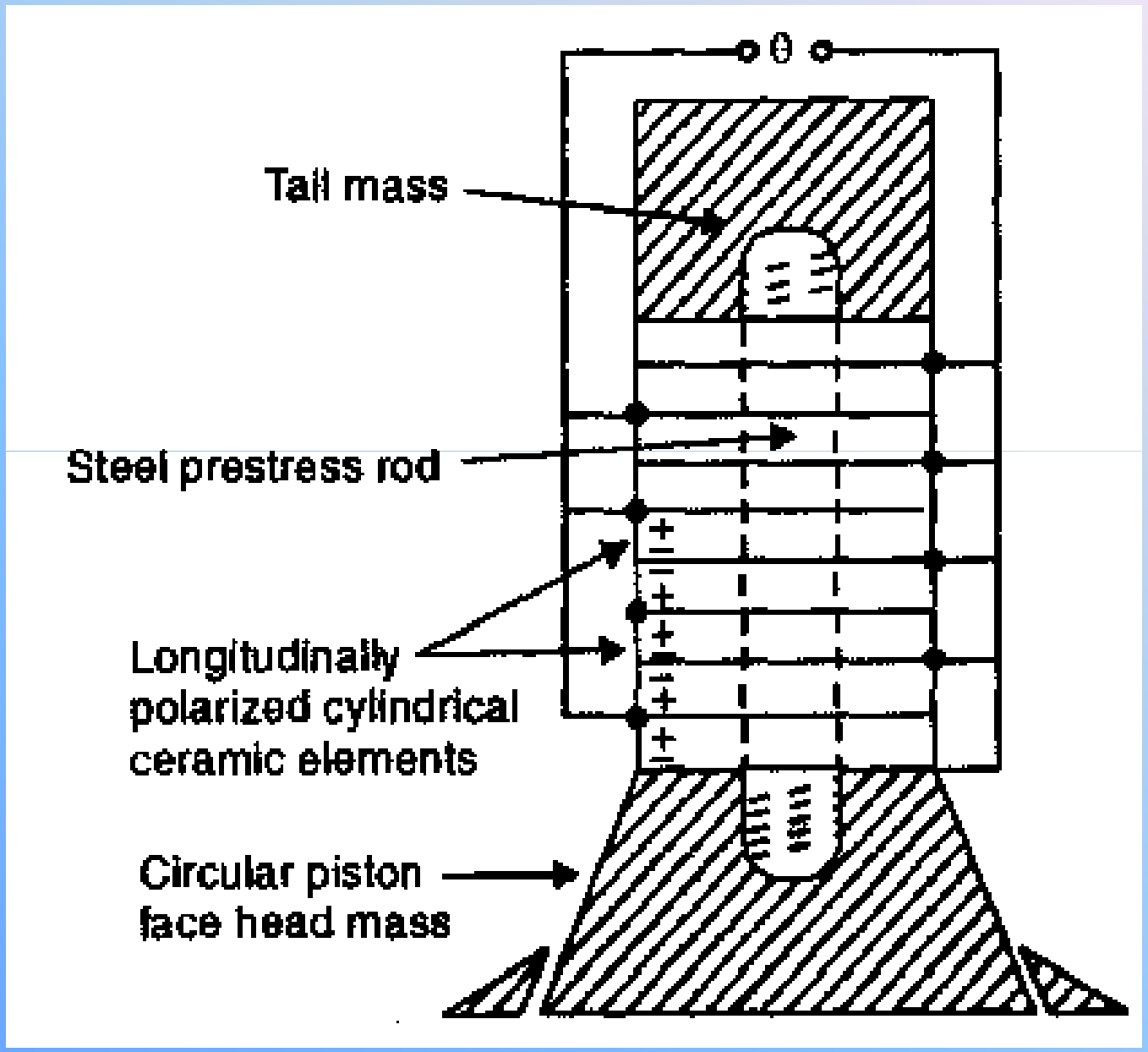
PASSIVE SONAR

- IN PASSIVE SONAR, THE TARGET ACTS AS THE SOURCE
- HYDROPHONE ARRAY ARE THE SENSITIVE ELEMENTS TO DETECT ACOUSTIC ENERGY EMITTED FROM THE TARGET
- BEAM FORMING PROCESSOR IS USED TO BREAK DOWN THE FIELD-OF-VIEW INTO INDIVIDUAL BEAMS IN THE VERTICAL AND AZIMUTH DIRECTIONS


Hydrophone
array
Frequency
analyzer
Beamforming
processor
Narrowband
display
Broadband
display

SONAR PROJECTOR(TRANSMITTER)

- A SONAR PROJECTOR IS A TRANSDUCER DESIGNED PRINCIPALLY FOR TRANSMISSION.
- MOST SONAR PROJECTORS ARE OF TONPILZ (SOUND MUSHROOM) DESIGN,WITH THE PIEZOELECTRIC MATERIAL SANDWITCHED BETWEEN A HEAD AND A TAIL MASS.
- **PROJECTOR IS λ/2 LONG AT ITS RESONANCE FREQUENCY**.

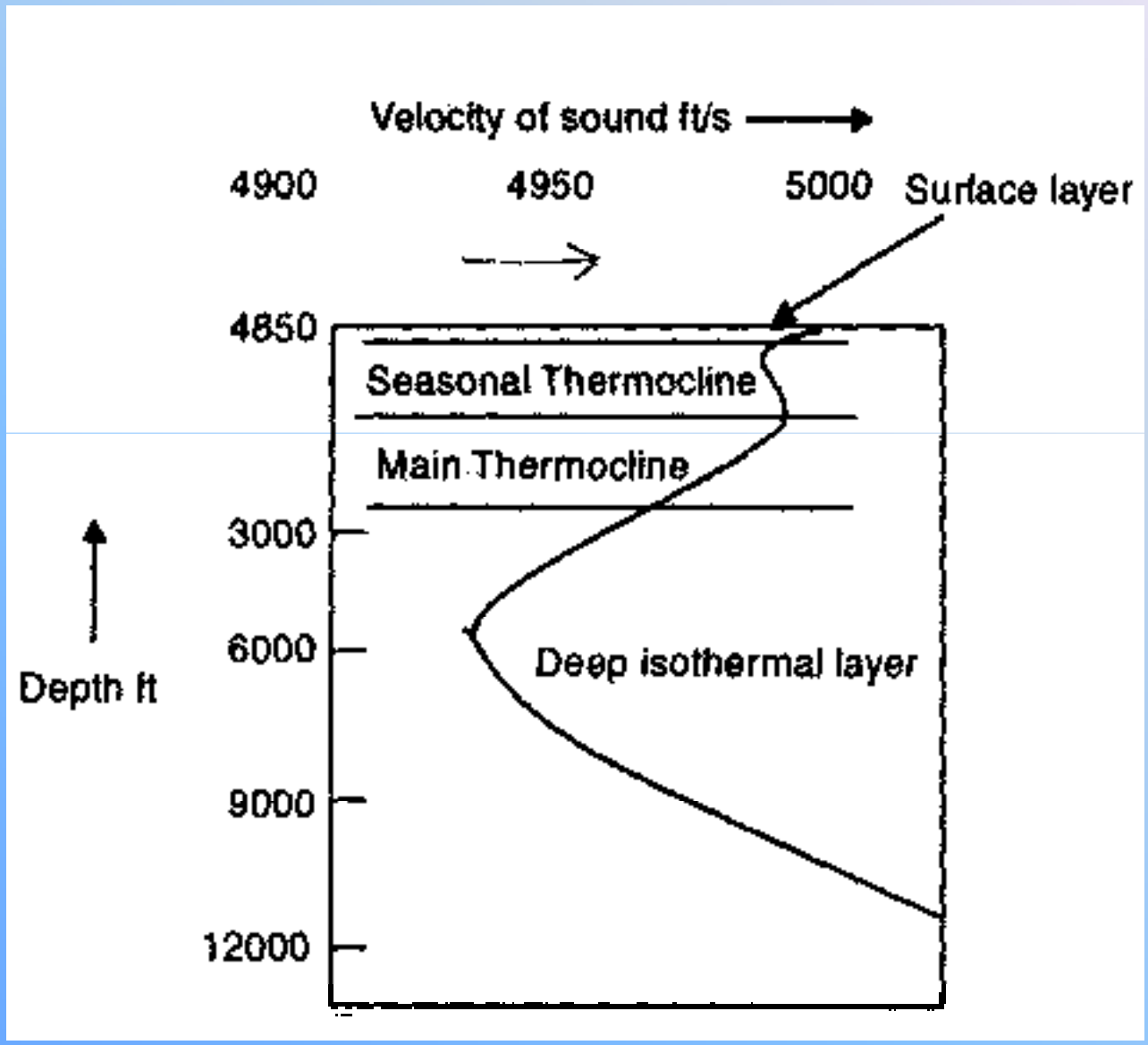

Tail mass
Steel prestress rod
Longitudinally
polarized cylindrical
ceramic elements
Circular piston
face head mass

SONAR PROJECTOR(contd)

- PIEZOELCTRIC MATERIAL IS A DIELECTRIC AND ACTS AS A CAPACITOR
- THE TONPILZ RESONATOR IS HOUSED IN A WATER –TIGHT CASE SO THAT IT CAN FREELY VIBRATE WHEN EXCITED.

SOUND VELOCITY PROFILE (SVP)

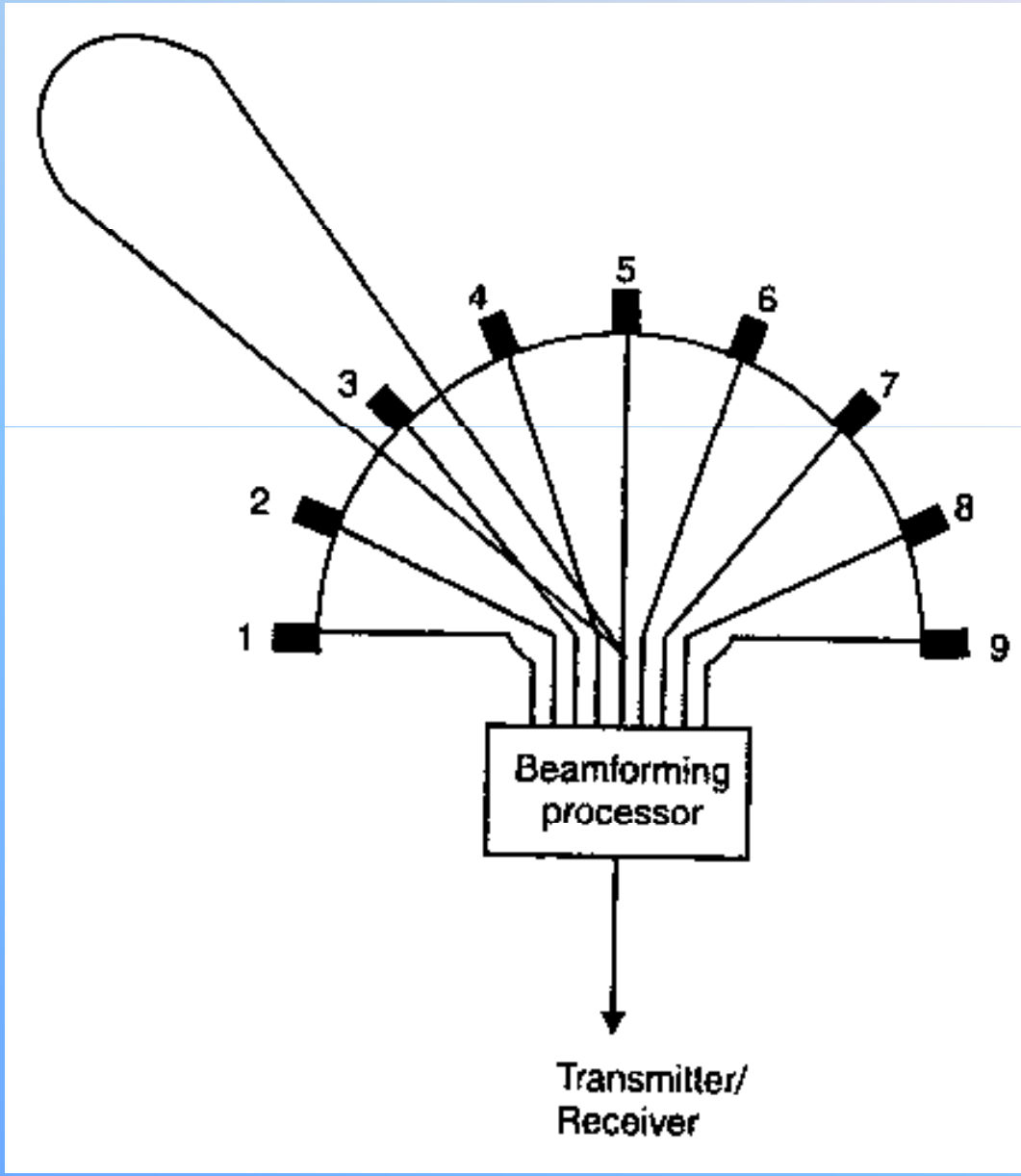
- A COUSTIC RAY PATHS ARE NOT STRAIGHT, THEY BEND.THE RAY PATH IS DETERMINED BY SVP.


Velocity of sound ft/s
4900
4950
5000
Surface layer
4850
Seasonal Thermocline
Main Thermocline
3000
6000
9000
12000
Depth ft
Deep isothermal layer

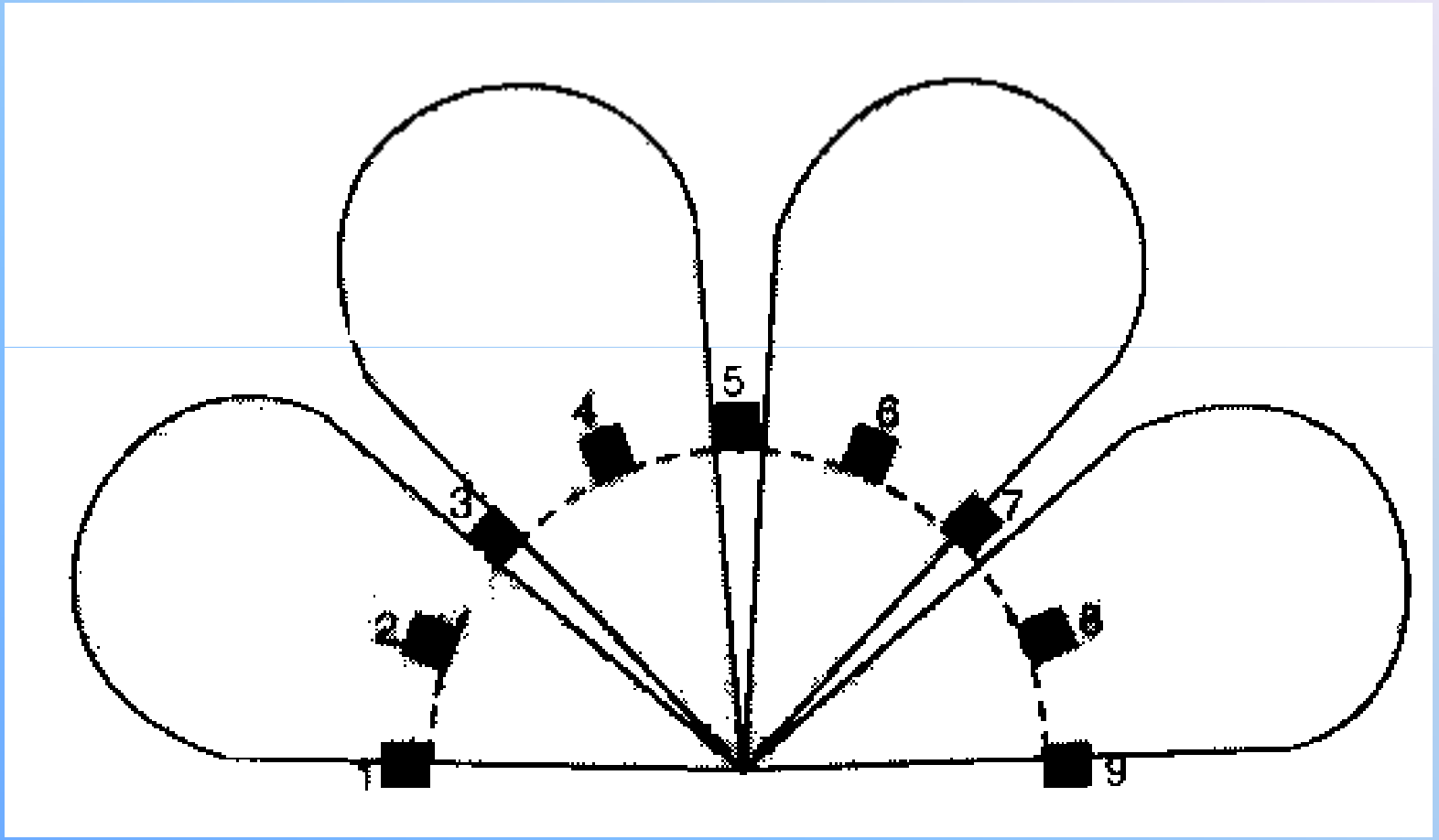
- **SURFACE LAYER:**SOUND SPEED IS GREATLY AFFECTED BY TEMP &WIND DIRECTION
  SEASONAL THERMOCLINE:TEMP &SPEED DECREASE WITH DEPTH. VARIATIONS ARE SEASONAL.
- **MAIN THERMOCLINE:**TEMP &SPEED DECREASE WITH DEPTH. LITTLE SEASONAL EFFECT.
- **DEEP ISOTHERMAL LAYER:** SOUND VELOCITY INCREASES LINERLY WITH DEPTH.

  TEMP IS NEARLY CONSTANT AT 39^0 F.

ACTIVE BEAM FORMING PROCESSOR



PASSIVE BEAM FORMING PROCESSOR



BEAM FORMING PROCESSOR (contd)

- THE BEAM FORMING PROCESSOR APPLIES TIME DELAYS OR PHASE SHIFT TO EACH OF THE SIGNALS SO AS TO CREATE A NARROW BEAM IN A PARTICULAR DIRECTION (ACTIVE)

- IN PASSIVE SYSTEM , THIS PROCESS IS REPEATED SEVERAL TIMES EACH WITH A DIFF.SET OF TIME DELAYS / PHASE SHIFTS IN ORDER TO LISTEN TO MANY NARROW BEAMS SIMULTANEOUSLY.

SONAR SYSTEM PERFORMANCE

SONAR EQUATION

- MAJOR PARAMETERS:
- **L_S=SOURCE LEVEL**
  - RADIATED SIGNAL STRENGTH.(PASSIVE)
  - TRANSMITTED SIGNAL STRENGTH(ACTIVE)
- L_N=NOISE LEVEL=(AN+SN)= Ambient+ Self Noise
- **N_{DI}=DIRECTIVITY INDEX-**
- **IT IS A MEASURE OF THE CAPABILITY OF A RECEIVING ARRAY TO ELECTRONICALLY DISCRIMINATE AGAINST UNWANTED NOISE.**

- N_{TS}=ECHO LEVEL(RECEIVED)
- N_{RD}=RECOGNITION DIFFERENTIAL OF THE PROCESSING SYSTEM.
- FOM=FIGURE OF MERIT ≈ SNR >DETECTION THRESHOLD(DT)
- **FOM(PASSIVE SONAR)=$L_S-(L_N-N_{DI})-N_{RD}$**
- **FOM (ACTIVE SONAR)=$(L_S+N_{TS})-(L_N-N_{DI})-N_{RD}$**

- NOTE:N_{TS} VARIES AS A FUNCTION OF OBJECT SIZE, ASPECT ANGLE ,SURFACE MATERIAL ETC.
- **SIGNAL EXCESS=AMOUNT OF SIGNAL IN DB ABOVE THE FOM.**
- THE FOM IS A BASIC PERFORMANCE MEASUREMENT INVOLVING PARAMETERS OF SONAR SYSTEM ,OCEAN AND TARGET.
- FOM PARAMETERS FLUCTUATE WITH TIME

APPLICATIONS OF SONAR

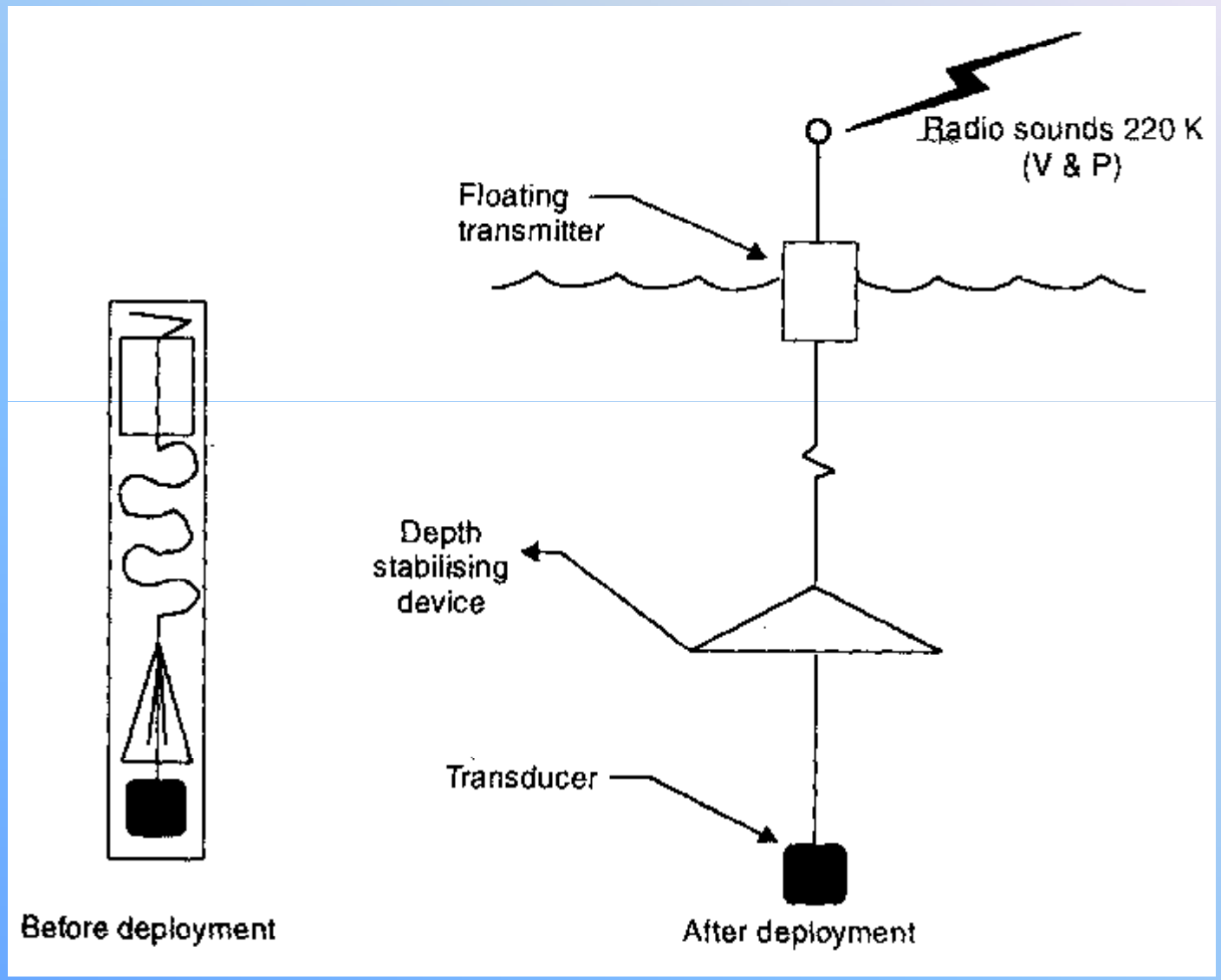
- **MILITARY APPLICATIONS**
- **A)DETECTION**
- **B)CLASSIFICATION**
- **C)LOCALISATION(MEASURING RANGE, BEARING)**
- **D)NAVIGATION**
- **E)COMMUNICATION**
- **F)CONTROL (USE OF SOUND ACTIVATED RELEASE MECHANISM)**
- **G)POSITION MARKING(BEACONS,TRANSPONDERS)**
- **H)DEPTH SOUNDING (SENDING SHORT PULSES DOWNWARD AND TIMING BOTTOM RETURN)**

- **COMMERCIAL APPLICATIONS**

INDUSTRIAL	OCEANOGRAPHIC
FISH FINDER	-SUB BOTTOM GEOLOGICAL MAPPING
FISH POPULATION ESTIMATION	- ENVIRONMENTAL MONITORING
OIL &MINERAL EXPLORATION	- OCEAN TOPOGRAPHY -SIGNAL &NOISE MEASURMENT
RIVER FLOW METER	
VISCOSIMETER	-SUBMARINE DETECTION
UNDERWATER TELEPHONE	

SONOBUOYS

- SONOBUOYS ARE SELE-CONTAINED SMALL SONAR SYSTEMS.
- THEY ARE DROPPED INTO WATER BY AIRCRAFT
- THE INFORMATION FROM SONOBUOYS TO AIRCRAFT/SHIP IS TRANSMITTED BY VHF RADIO LINK.
- SONOBUOYS CONSIST OF A TX AND A SIGNAL HYDROPHONE TO RECEIVE THE SIGNAL.
- AFTER SOME PERIOD,SONOBUOY WILL SCUTTLE ITSELF.


Radio sounds 220 K
(V & P)
Floating
transmitter
Depth
stabilising
device
Transducer
Before deployment
After deployment

SONOBUOY AFTER DEPLOYMENT

- SONOBUOYS HAVE LIMITED SIZE (SO POOR DI)
- THEY HAVE LOW SELF-NOISE ,SO FOM IS NOT ALWAYS LOW.
- SONOBUOYS CAN ACTUALLY OUTPERFORM SOME LARGE HULL-MOUNTED SYSTEMS

FIGURE OF MERIT(FOM)

- **THE RATIO OF SIGNAL –TO-NOISE IN LOGARITHMIC SCALE IS THE SNR=FOM**
- MIN SNR FOR DETECTION=DT (DETECTION THRESHOLD)
- **TRANSMISSION LOSS(TL**) THE TX LOSS FROM SOURCE TO RX INCLUDES THE EFFECT OF ENERGY SPREADING OUT,ATTENUATION AND VARIOUS OTHER EFFECTS

- **FOM OR SNR=SL+DI-TL-NL (PASSIVE SYSTEM)**
- WHERE SL=SOURCE LEVEL
- TL=TRANMISSION LOSS
- NL=NOISE LEVEL (AN+SN)
- DI=DIRECTIVITY INDEX
- TS=TARGET STRENGTH OR ECHO LEVEL

- **FOM OR SNR=SL-TL+TS-TL+DI-NL(ACTIVE SYSTEM)**
- **=SL-2TL+TS+DI-NL**

FIGURE OF MERIT(FOM)-contd

- THE TARGET STRENGTH IS A FUNCTION OF TARGET SIZE, SURFACE MATERIAL AND SHAPE.
- DIRECTIVITY INDEX IS A MEASURE OF THE CAPABILITY OF A RECEIVING ARRAY TO ELECTRONICALLY DISCRIMINATE AGAINST UNWANTED NOISE.