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INSTRUCTION BOOK
FOR
SONAR TRANSDUCER
TR5014/SQS-505(V)
AND
TR5014A/SQS-505(V)

OCT 16 1985

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INSTRUCTION BOOK

FOR

SONAR TRANSDUCER

TR5014/SQS-505(V)

AND

TR5014A/SQS-505(V)

RECORD OF CORRECTIONS

IDENTIFICATION OF CORRECTION OR AMMENDMENT LIST	DATE ENTERED	BY WHOM ENTERED (Signature, rank, name of Command)

SAFETY WARNING

1. Personnel engaged in the installation, operation and maintenance of this equipment are urged to become familiar with the following rules both in theory and the practical application thereof. It is the duty of every person connected with electronic equipment to be prepared to give adequate first aid and thereby prevent avoidable loss of life. Your own life may depend on this.

2. Operation of this equipment involves the use of high voltages which are dangerous to life. Operating personnel must observe all safety regulations at all times. Do not change tubes or make adjustments inside the equipment with the high voltage supply on. Do not depend upon door switches or interlocks for protection but always shut down motor generators or other associated power equipment and open main switch in the power supply circuit. Under certain conditions, dangerous potentials may exist in circuits with the power control in the "off" position owing to charges retained by capacitors, etc. To avoid casualties, always discharge and ground circuits prior to touching them. Keep them away from live circuits. Do not service or adjust alone. Do not tamper with interlocks.

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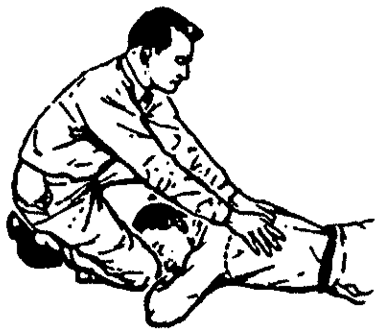
HOLGER-NIELSON METHOD OF ARTIFICIAL RESPIRATION

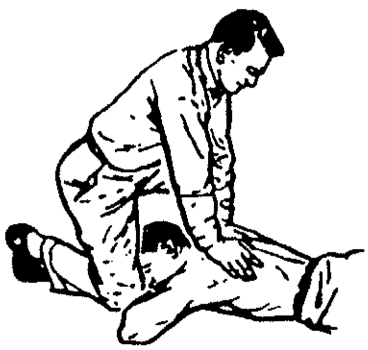
If breathing stops because of electrocution, drowning, sedative poisoning, gas poisoning, suffocation, or poliomyolitis, start artificial respiration immediately Don't delay - seconds count. As soon as possible send someone for a physician.

THE STANDARD TECHNIQUE FOR THE BACK PRESSURE-ARM LIFT METHOD IS AS FOLLOWS:

PLACE THE PATIENT FACE DOWN, ELBOWS BENT, ONE HAND ON THE OTHER WITH THE FACE TURNED TO ONE SIDE.

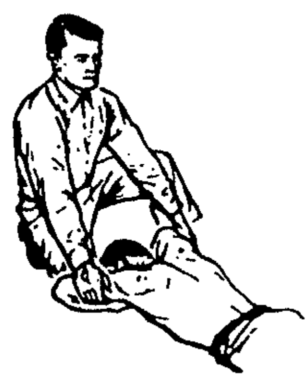


PLACE YOUR HANDS, THUMBS TOUCHING, JUST BELOW A LINE RUNNING BETWEEN THE ARMPITS.



ROCK FORWARD SLOWLY, ELBOWS STRAIGHT, UNTIL ARMS ARE VERTICAL.

ROCK BACKWARD, SLIDING YOUR HANDS TO THE PATIENT'S ARMS, JUST ABOVE THE ELBOWS.



RAISE THE ARMS UNTIL RESISTANCE AND TENSION ARE FELT AT THE PATIENT'S SHOULDERS.

REPEAT THE CYCLE 12 TIMES PER MINUTE

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

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INTRODUCTION AND GENERAL DATA

1. INTRODUCTION

(a) Sonar Transducer TR5014/SQS-505(V) and TR5014A/SQS-505(V) are transducers for the AN/SQS-505(V) Sonar System. The TR5014 is the original design, produced between 1965 and 1985, with serial numbers beginning with the letters A through E. The TR5014A is a redesigned transducer, using modern materials and technology, with serial numbers beginning with the letter F and higher. The TR5014 will not be produced after 1985 and will be replaced by the TR5014A as necessary.

(b) Although the Single Element Transducer (S.E.T.) of both the TR5014 and the TR5014A appear identical in "form and fit", the redesign has introduced improvements in function which makes it undesireable to mix S.E.T.s of the two different designations except in an emergency.

(c) Both versions have been designed for use either as a hull mounted or a variable depth transducer capable of operation at any temperature between 0°C and 80°C. The TR5014 was tested to a pressure of 2.41 MPa (350 psi) and certified for operation to a depth of 275 meters whereas the TR5014A was tested to a pressure of 3.79 MPa (550 psi) and certified for operation to a depth of 380 meters.

(d) The Transducer has been constructed in such a manner that the terminals of the 360 S.E.T.s comprising the complete Transducer are available for interconnection and connection to the sonar transmitter and receiver in any combination desired. Normally, the 10 S.E.T. of each vertical grouping are connected in parallel and driven as a single stave. By driving individual staves with signals of appropriate phase and amplitude, the Transducer may be made to generate acoustic outputs omnidirectionally or in formed beams.

(e) The Transducer is capable of handling sufficient electrical power at the design frequencies of operation to produce an omnidirectional source level of 128 dB or a beam source level of 136 dB. Reduction of these source levels may occur due to static pressure limitation or transmitter power limitations.

2. REFERENCE DATA

(a) <u>Nomenclature</u>. 1. Transducer, Sonar TR5014/SQS-505(V)

2. Transducer, Sonar TR5014A/SQS-505(V)

(b) <u>Manufacturer</u>. C-Tech Ltd., Cornwall, Ontario

(c) Configuration. Hollow right circular cylinder with 36 staves each containing 10 S.E.T.

(d) Dimensions. Outside diameter : 48 in.
Inside diameter : 27-1/2 in.
Outside height : 48 in.
Weight (with frame) : 5400 lb.

(e) Shipping Data. 360 S.E.T. are shipped in 36 crates, with 12 crates on each of 3 pallets. Each crate contains the 10 S.E.T. from one stave and are identified by stave number and as part of a complete transducer group. Shipping weight approximately 4400 lbs. The frame is supplied separately as part of Hull Outfit ~~C-2~~, C-3, C-4, C5, or VDS towed body as appropriate.

(f) Modes of Operation. Dependent on method in which S.E.T. are driven by the associated transmitter and connected to the associated receiver.

(f) Frequency Range.

(i) Useful range for transmission: 5 kHz to 11 kHz.

(ii) Useful range for reception: 4 kHz to 12 kHz.

(iii) Tuned frequency: TR5014 - 7.5 kHz; TR5014A - 7.1 kHz.

(iv) Normal operating frequencies, 6.4, 7.2, 8.0 kHz.

(h) Horizontal Beam Width. Nominal 3 dB beam width obtainable with 13 staves when phased to a plane:

6.4 kHz - 9.0 degrees

7.2 kHz - 8.5 degrees

8.0 kHz - 8.0 degrees

(j) Vertical Beam Width. Nominal vertical beam width to 4 dB points:

6.4 kHz - 10 degrees

7.2 kHz - 9 degrees

8.0 kHz - 8 degrees

(k) Power Handling Capability.

(i) 200 watts acoustic power output per S.E.T. when under sufficient hydrostatic pressure to prevent cavitation.

(ii) Nominally 85 watts acoustic power output per S.E.T. at a hydrostatic pressure of 6.5 psi.

(m) Electro Acoustic Efficiency.

	TR5014	TR5014A
6.4 kHz -	70%	70%
7.4 kHz -	70%	70%
8.0 kHz -	60%	60%

(n) S.E.T. Dimensions.

(i) Maximum outside dimensions:

Length - 9.537 in.

Width (front boot) - 3.960 in.

Height (front boot) - 5.177 in.

(ii) Weight: 10 lb., 12 oz.

(iii) Cable: two-conductor twisted pair in a watertight (non-hosing) neoprene sheath, 26 ft. min. long.

3. SCOPE OF HANDBOOK

This handbook contains technical details pertaining to the design and construction of the Transducer TR5014/SQS-505(V) referred to as TR5014 and Transducer TR5014A/SQS-505(V) referred to as TR5014A.

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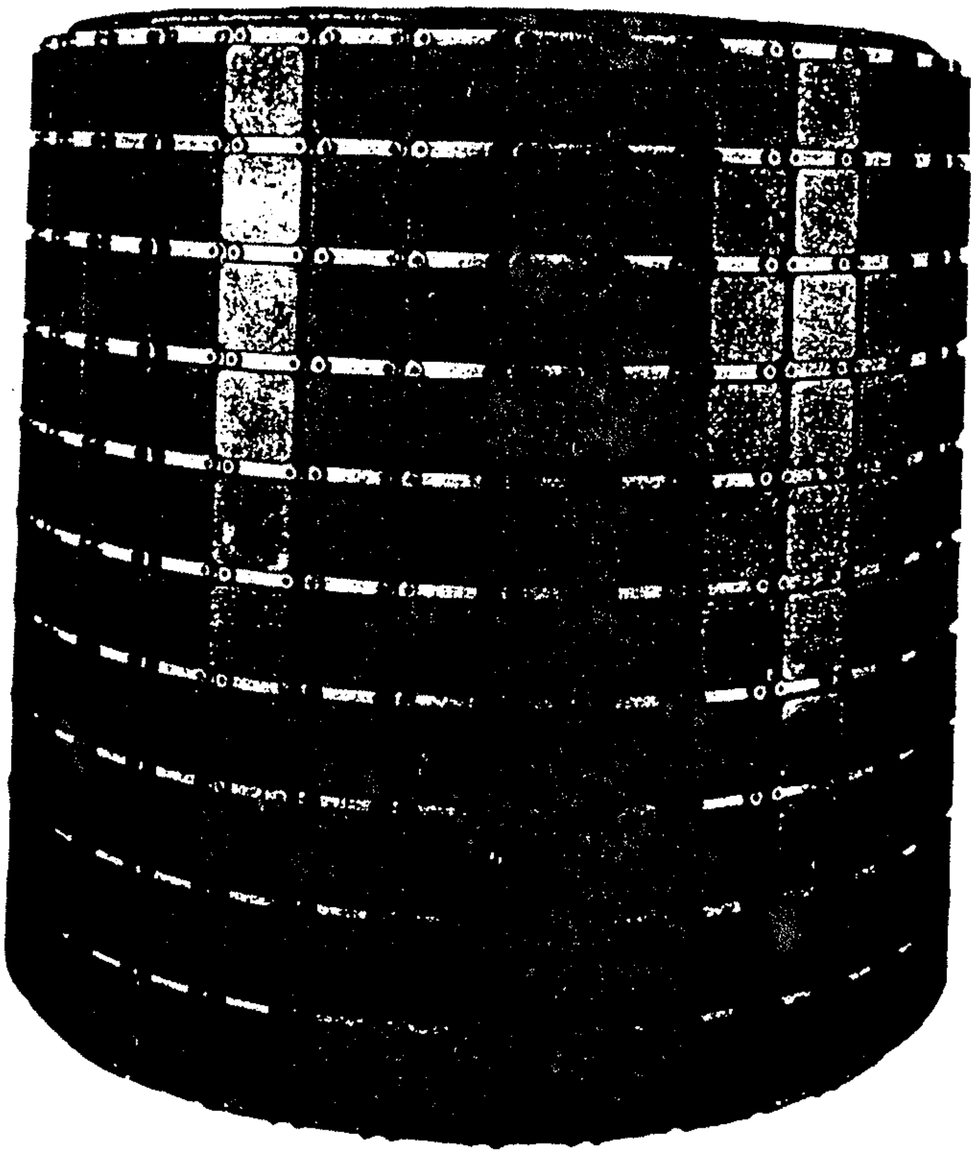


Frontispiece Sonar Transducer TR5014/SQS-505(V) and TR5014A/SQS-505(V)

PART 1
DESCRIPTION

CONSTRUCTION

1-1 GENERAL

The transducer TR5014/SQS-505(V) and TR5014A/SQS-505(V) (herein referred to as the Transducer) consists of a frame and 360 Single Element Transducers (S.E.T.). The S.E.T. are arranged in 10 row and 36 staves around the circumference of the frame and held in place by clamping strips and mounting screws. In the hull mounted Sonar (HMS), the cables from the S.E.T. are brought out of the frame through holes (one per S.E.T.) in the inner cylinder. In the variable depth Sonar (VDS), the cables from the S.E.T. are brought out of the frame in groups of 10 (1 stave set) through holes in its top flange.

1-2 FRAME

The frame consists of two concentric cylinders welded between top and bottom flanges; all of which are made of alloy steel (ASTM A242). The outer cylinder is 44-3/4 inches in diameter and 5/8 inch thick and the inner cylinder is 27-1/2 inches in inside diameter and 3/4 inch thick. The top and bottom flanges are 1.5 inches and 1.0 inch thick, respectively. The outer cylinder is machined with 360 holes, 3-3/8 inches in diameter, arranged in 36 vertical rows; these holes provide access for the bodies of the S.E.T. In addition, 792 3/8-inch tapped holes are provided for the S.E.T. mounting screws. The entire frame is coated in baked epoxy by the fluidized bed process to guard against corrosion.

1-3 SINGLE ELEMENT TRANSDUCER

(1) Components. The Single Element Transducer, Figure 1-1, consists of a vibrator assembly, a rear boot assembly, a housing and miscellaneous parts. Figures 1-2, 1-3, and 1-4 illustrate the main assemblies. A complete breakdown of parts, sub-assemblies and assemblies

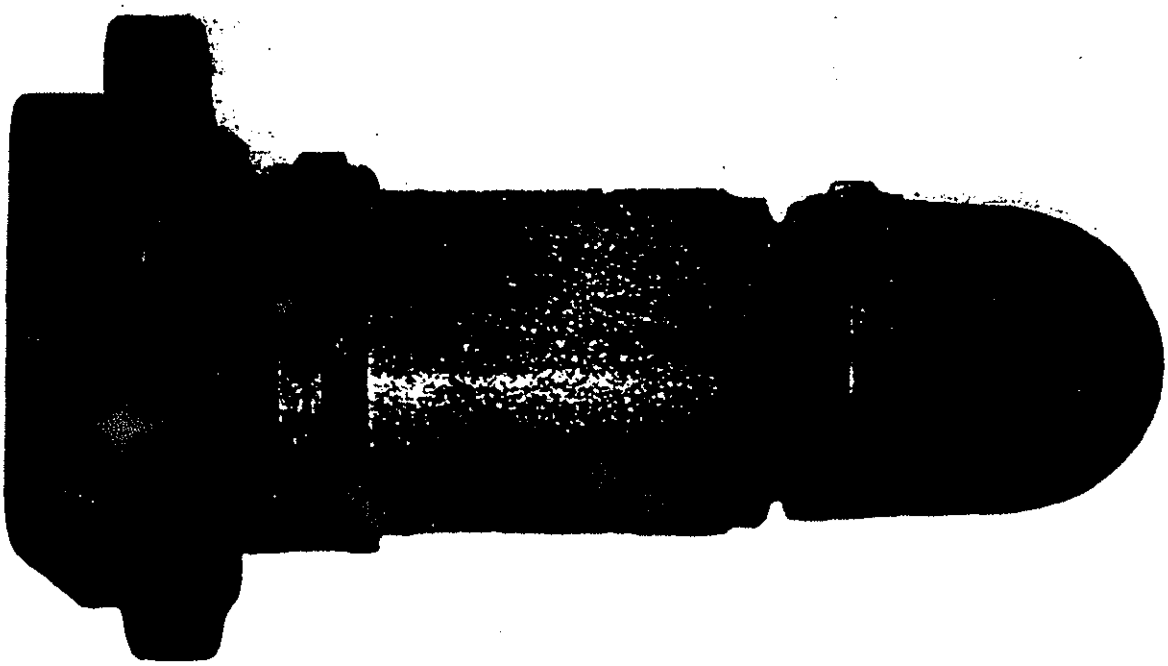


Figure 1-1 Single Element Transducer (S.E.T.)

for each transducer is given in Table 1-1. These parts are described below:

(a) Front Mass and Front Boot. The front or radiating mass is made of aluminum alloy. Its radiating face is approximately 3.6 inches square with rounded corners; it has a face area of 12.84 square inches. In the TR5014, the back of the mass is a truncated cone terminating in a ring 2 inches in diameter and 1/4 inches thick which provides a seating for the first ceramic ring. In the TR5014A, the ring is 2.05 inches in diameter and .318 inch thick and provides a seating for the front washers. The ring also provides a predetermined mechanical compliance. A tapped hole in the centre of the back accepts the threaded end of the bias stud. A neoprene boot is molded around and bonded to the front face and edges to form an integral assembly. The boot incorporates a cylindrical section which fits over the housing to form a watertight seal when banded to the housing. The boot is molded with three projections which are used for securing the S.E.T. in the frame.

(b) Front Mass Pressure Release. Four corprene (cork and neoprene) sections are cemented to the truncated cone portion of the front mass. It serves to inhibit back radiation from the corners. As a secondary function, it isolates the front mass from the S.E.T. housing.

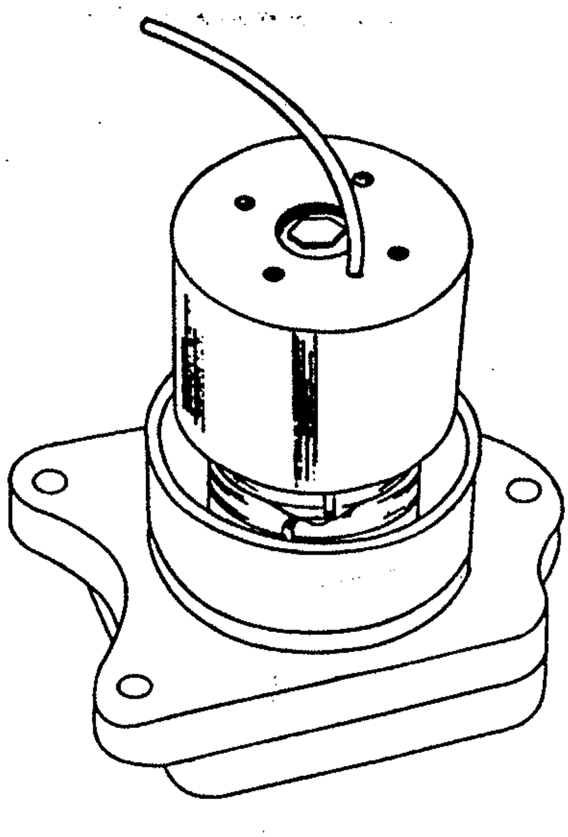


Figure 1-2 Vibrator Assembly

PART	NO. REQUIRED TR5014	NO. REQUIRED TR5014A	SUB-ASSEMBLY	ASSEMBLY
Mass, Front	1	1	Front Mass Sub-Assembly	Vibrator Assembly
Boot, Front	1	1		
Pressure Release, Front Mass	4	4		
Mass, Rear	1	1		
Ring, Ceramic	4	4		
Electrode	4	5		
Washer, Front	-	1		
Washer, Rear	-	1		
Stud, Bias	1	1		
Nut, Hex, Self-Locking	1	1		
Wire				
Cement				
Boot, Rear	1	1		Rear Boot and Cable Assembly
Cable	28 Ft.	28 Ft.		
Bulkhead, Rear Boot	-	1		
Mount, Transformer	1	-		
Housing - S.E.T.	1	1		
Pressure Release, Rear Mass	1	1		
Pressure Release, Mounting Screw	3	3		
Mounting Screw, Vibrator Assembly	3	3		
Washer, Flat	3	3		
Tube, Teflon	3	3		
Lug, Terminal	1	-		
Pad, Transformer Mounting	-	1		
Transformer, Tuning and Matching	1	1		
Terminal, Turret	3	3		
Nut, Hex	1	-		
Screw, Pan Head	-	1		
Washer, Lock	1	1		
Washer, Flat	-	1		
Band, Preformed, Front	1	1		
Band, Preformed, Rear	1	1		

Table 1-1 Breakdown of Parts, Sub-assemblies, and Assemblies, S.E.T.

(c) Rear Mass. The rear mass is made of mild steel. It is cylindrical in shape and has an axial hole for the bias stud; the hole is counterbored to accept a self-locking nut. There are also three tapped holes to take the vibrator assembly mounting bolts, a hole for the electrode wiring and a small radial hole to prevent the build up of internal pressure during heat curing of cemented joints in the vibrator assembly. The exposed surfaces of the mass are subjected to a phosphating process, "Parkerizing", which helps to prevent corrosion.

(d) Ceramic Ring. The ceramic rings are made of Lead (Plumbum) Zirconate Titante (PZT). They are 2 inches in diameter, 1/2 inch long and have a wall thickness of 1/4 inch. A thin film of silver is deposited on the end surfaces to provide electrical contact with the electrodes. The material has electrostrictive characteristics; during manufacturing it is permanently polarized to impart piezoelectric properties.

(e) Electrode. Electrodes made from 5-mil brass shimstock are interleaved with the ceramic rings to interconnect them and to provide external connections to them. There are 4 electrodes in the TR5014 and 5 in the TR5014A.

(f) Washers (TR5014A only). The front and rear washers are made of laminated plastic type G10 Class III. The thickness of the washer ranges from .007 to 0.27 inches. The washers provide electrical insulation between the ceramic stack and the masses, and frequency adjustment.

(g) Bias Stud. The bias stud is made of high strength steel rolled to shape and shot peened to provide high compliance together with high tensile strength. The bias stud is used to compress the vibrator assembly so that when in operation under the most severe conditions the cement joints will remain in compression. The compliance of the bias stud must be greater than that of the ceramic stack so that it will not adversely affect the operation of the vibrator assembly.

(h) Hex Nut. The cadmium plated nut is of the self-locking type made from non-corrosion resistant steel. It it used in conjunction with the Bias Stud to compress the vibrator assembly.

(j) Wire. Wire is provided to connect the vibrator assembly to the tuning and matching transformer and to interconnect appropriate electrodes.

(i) TR5014. The front and rear masses, connected by the bias stud, provide one terminal of the vibrator assembly; these are wired to the tuning and matching transformer by a single wire to a terminal lug under one of the vibrator assembly mounting bolts. The other terminal is provided by one of the electrodes which is wired to the tuning and matching transformer by a single insulated wire routed through a hole in the rear mass.

(ii) TR5014A. The terminals of the vibrator assembly are provided by two of the electrodes which are wired to the tuning and matching transformer by two insulated wires routed through a hole in the rear mass.

(k) Cement. A thin layer of epoxy cement is placed between all the components of the vibrator assembly (ceramic rings, electrodes, plastic washers, front and rear masses) to assist the bias stud in stabilizing the assembly and to ensure consistent mechanical properties for all vibrators.

(m) Rear Boot and Cable Assembly. The rear boot is molded of a harder neoprene than the front boot. In the TR5014, the transformer mount is molded as an integral part. In the TR5014A, a bulkhead is used in place of the transformer mount. A hexagonal cavity is molded into the back of the rear boot; this cavity accepts the round stud protruding from the frame inner cylinder. These studs accurately align each S.E.T. in the frame. Twenty-eight feet of two-conductor, twisted pair, non hosing, double jacketed, flexible cable is molded into the rear boot to form a pressuretight seal.

(n) Tuning and Matching Transformer. This transformer is an autotransformer which performs the dual function of tuning out the blocked capacitance of the ceramic rings and matching the transducer impedance to the transmitter impedance. The transformer windings are enclosed in a pair of Permalloy cores for maximum efficiency. The complete assembly is encapsulated in an epoxy compound to improve its shock resistance and to prevent the ingress of moisture.

(p) Housing. The housing consists of two mild steel cylinders brazed either side of a mild steel mounting plate on a common axis. The larger (front) cylinder houses the vibrator assembly; it is flared 60 degrees at the open end to form a lip behind the truncated cone portion of the front mass. The smaller cylinder houses the tuning and matching sub-assembly. In the TR5014 a locating notch is machined in the edge of the rear cylinder to facilitate alignment of the rear boot assembly to the housing. In the TR5014A the locating notch is omitted to provide uninterrupted support to the rear boot and the cylinder is slightly tapered near the leading edge. The housing is covered with a baked epoxy coating identical to the coating on the frame.

(q) Transformer Mounting Pad (TR5014A only). A molded neoprene pad shaped to fit over the vibrator mounting screws and with a centre hole for the transformer mounting screw is placed in the bottom of the rear cylinder to provide a cushion for the T/M Transformer. It is truncated on one side for the passage of the vibrator wiring.

(r) Rear Mass Pressure Release. The rear mass pressure release is a pad of oven dried rag paper. It is nominally .269 inch thick and fits between the Rear Mass and the housing mounting plate. The thickness may be adjusted to make up for dimensional tolerances in the housing and the vibrator.

(s) Mounting Screw Pressure Release. The mounting screw pressure releases are 1/4 inch thick pieces of pressed wood (masonite) fitted in countersunk holes on the rear cylinder side of the housing mounting plate under the heads of the mounting screws.

(t) Vibrator Assembly Mounting Screws. These are 1/4-28 Hex head screws used to secure the vibrator assembly to the housing mounting plate. They are isolated from the mounting plate by the pressure release pads and teflon tubing.

(u) Terminal Lug (TR5014 only). The terminal lug is fitted under one of the mounting screws to provide a terminal point for connection between the transformer and the rear mass. The terminal lug is insulated from the housing by the pressure release pad and the epoxy coating on the housing.

(v) Preformed Bands. The stainless steel preformed bands are used to seal the front and rear boots about the cylinders of the housing to render the S.E.T. pressuretight to greater than 500 psi.

(2) Assembly Procedures.

(a) Vibrator Assembly. The front mass sub-assembly and other parts of the vibrator assembly are carefully aligned in a jig and fastened together with epoxy cement. The bias stud is carefully adjusted to a predetermined tension. This assembly is then placed in a room at a controlled temperature to cure the cement joints.

(b) Rear Boot Assembly (TR5014 only). The tuning and matching transformer is secured to its mount and the cable is connected to the proper terminals.

(c) Final Assembly. The vibrator assembly and rear mass pressure release are placed in the front cylinder of the housing, the front boot pulled over the lip of the cylinder, and the mounting screws secured in place with a predetermined tension.

(i) TR5014. The single wire from the vibrator assembly is routed through a hole in the mounting plate. The other terminal wire is fastened to the terminal lug under one of the mounting screws. The rear boot and cable assembly is then placed over the rear cylinder of the housing and aligned after connections are made from the transformer to the vibrator assembly wires.

(ii) TR5014A. The two wires from the vibrator assembly are routed through a hole in the mounting plate. The transformer mounting pad and the tuning and matching transformer are inserted in the rear cylinder of the housing and secured to the mounting plate. The rear boot and cable assembly is then placed over the rear cylinder of the housing and aligned, after the conductors and the vibrator assembly wires are connected to the transformer terminals. Bands are placed over each boot and tightened to seal the boots to the housing. A buckle secures each band and maintains the tension.

THEORY OF OPERATION

1-4 GENERAL PRINCIPLES

(1) Type of Transducer. Most transducers used for propagation and reception of underwater acoustical energy, operate on either the magnetostrictive or the piezoelectric principle. Piezoelectric transducers are in turn divided into those groups utilizing naturally piezoelectric crystals, such as quartz, Rochelle salts or Ammonium Dihydrogen Phosphate ADP), and those which are quazi-piezoelectric, that is, transducers whose active material is an electrostrictive ceramic which has been polarized. quasi

(2) Electrostrictive Transducers.

(a) The active material used in electrostrictive transducers is a ceramic possessing piezoelectric properties because of electric polarization imposed after forming. Some of this polarization is lost as the ceramic ages. The aging is characterized by a gradual increase in impedance and a decrease in efficiency. Most of this effect occurs during the first few weeks after manufacture of the ceramic; thereafter it diminishes to a few per cent per year.

(b) A pre-polarized electrostrictive ceramic such as lead zirconate titanate (PZT), in common with naturally piezoelectric crystals, undergoes electrical polarization when subject to mechanical stress. This polarization is directly proportional to the stress and is dependent for its sign on the direction of the stress. This phenomenon is known as the direct piezoelectric effect. In the converse piezoelectric effect, this process is reversed; as the ceramic is electrically polarized, it becomes stressed according to the strength of the polarizing field. It therefore follows that if an AC voltage is applied across the ceramic it will vibrate at a frequency equivalent to the applied voltage creating a sound pressure wave in the water. Conversely, a sound pressure wave impinging on the ceramic will cause it to vibrate and a small AC voltage will appear across it. These properties are used in the Transducer.

(c) Transducers of this type offer more versatility of operation and are more efficient because of the different types and shapes of ceramic available to meet various design considerations. In addition, eddy current energy loss, typically associated with magnetostrictive transducers, does not exist.

1-5 SINGLE ELEMENT TRANSDUCER

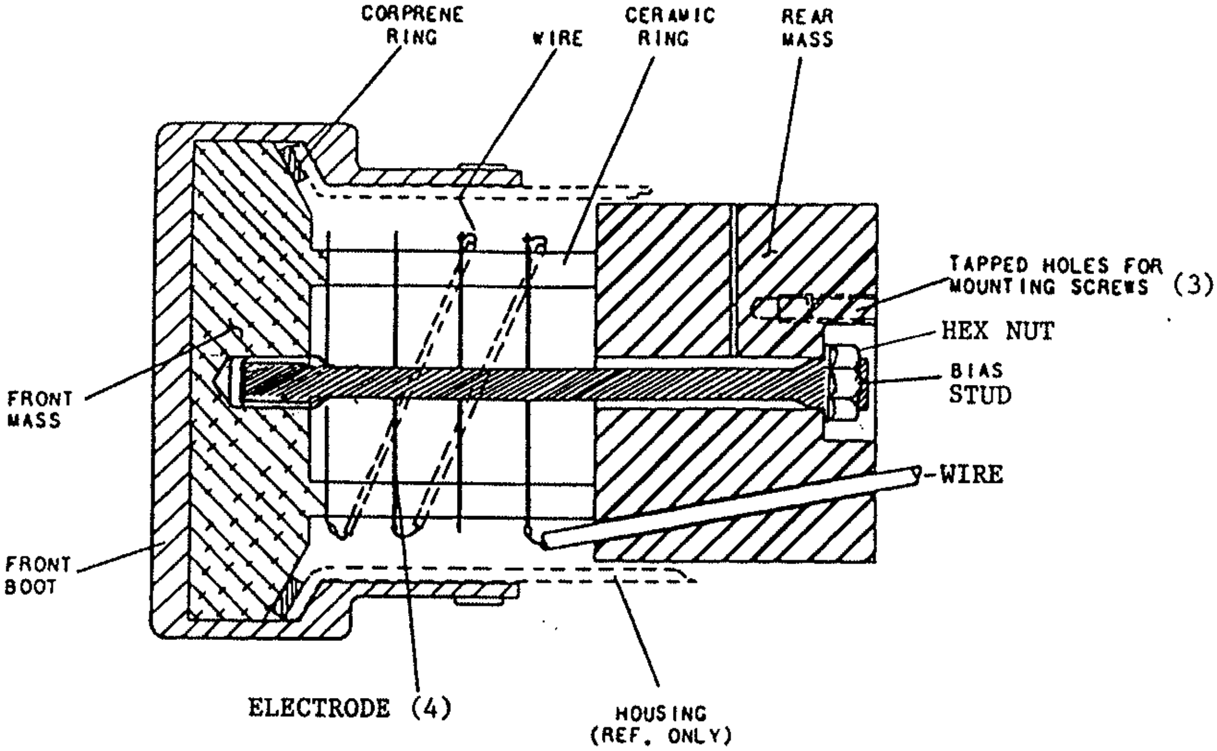
(1) Mechanical Aspects. Each S.E.T. consists of four rings of modified lead zirconate titanate ceramic to provide the energy transduction. The ceramic material is aged for several weeks after manufacture and prior to assembly; the results of this "pre-aging" is to reduce the loss in response and efficiency, after assembly, to the order of 1 dB in five years. The four ceramic rings are connected electrically in parallel and mechanically in series. They are double mass loaded to form a vibrator assembly which is contained in the front section of the cylindrical housing.

(a) During transmission, the applied AC voltage causes the vibrator assembly to vibrate longitudinally. When the frequency of the applied AC coincides with the resonant frequency of the vibrator assembly, the amplitude of vibration is at a maximum.

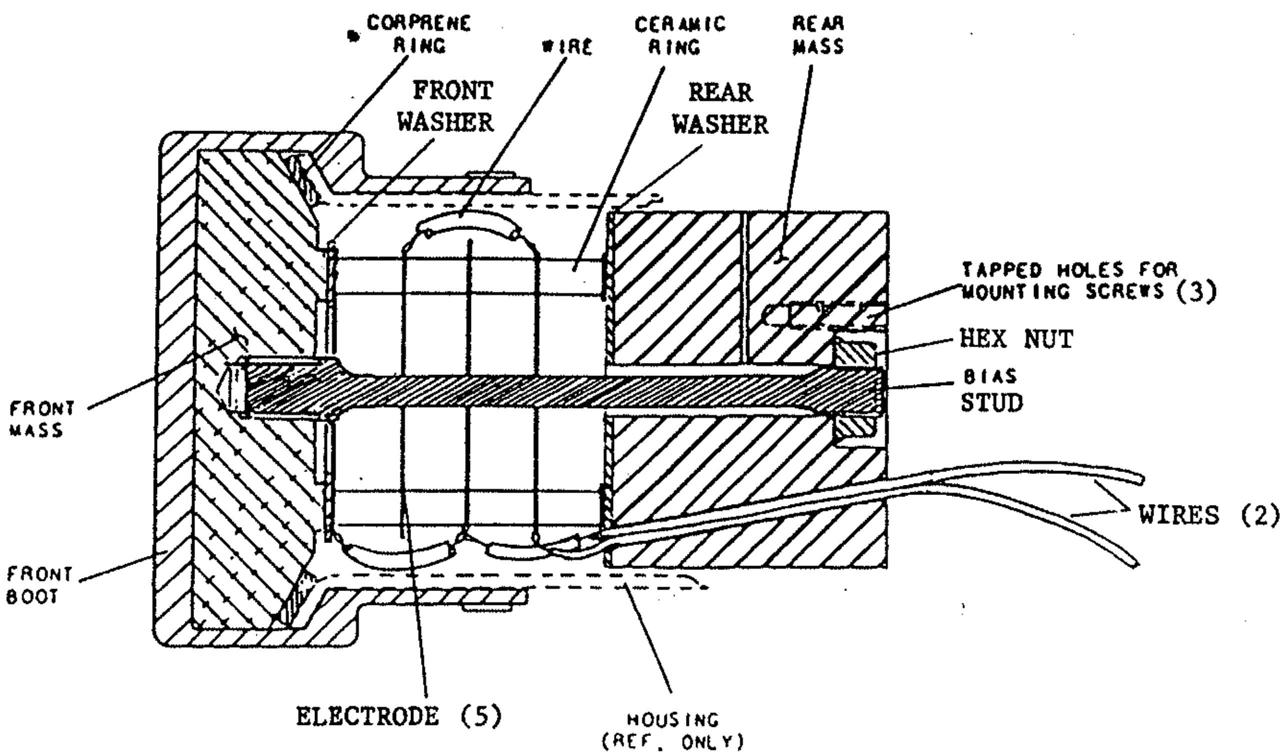
(b) During reception, the system is made to oscillate under the influence of the incoming sound pressure variations. Here, also, the amplitude is at a maximum at resonance.

(c) In order to accommodate the frequency shift (due to Doppler effect) during operation and to permit operation at alternate frequencies, the bandwidth of the transducer has been made relatively wide.

(2) Electrical Theory. An equivalent circuit diagram for an electrostrictive S.E.T. is shown in Figure 1-5. In this circuit, the electromechanical conversion is presented as an electric transformer having a turns ratio of 1:N. Components Cc through Lw and Rw are mechanical parameters of the S.E.T. expressed by their electrical equivalents. By using this electrical analogue, mechanical resonance and loading may be consistently treated in interaction with actual electrical parameters of the system.

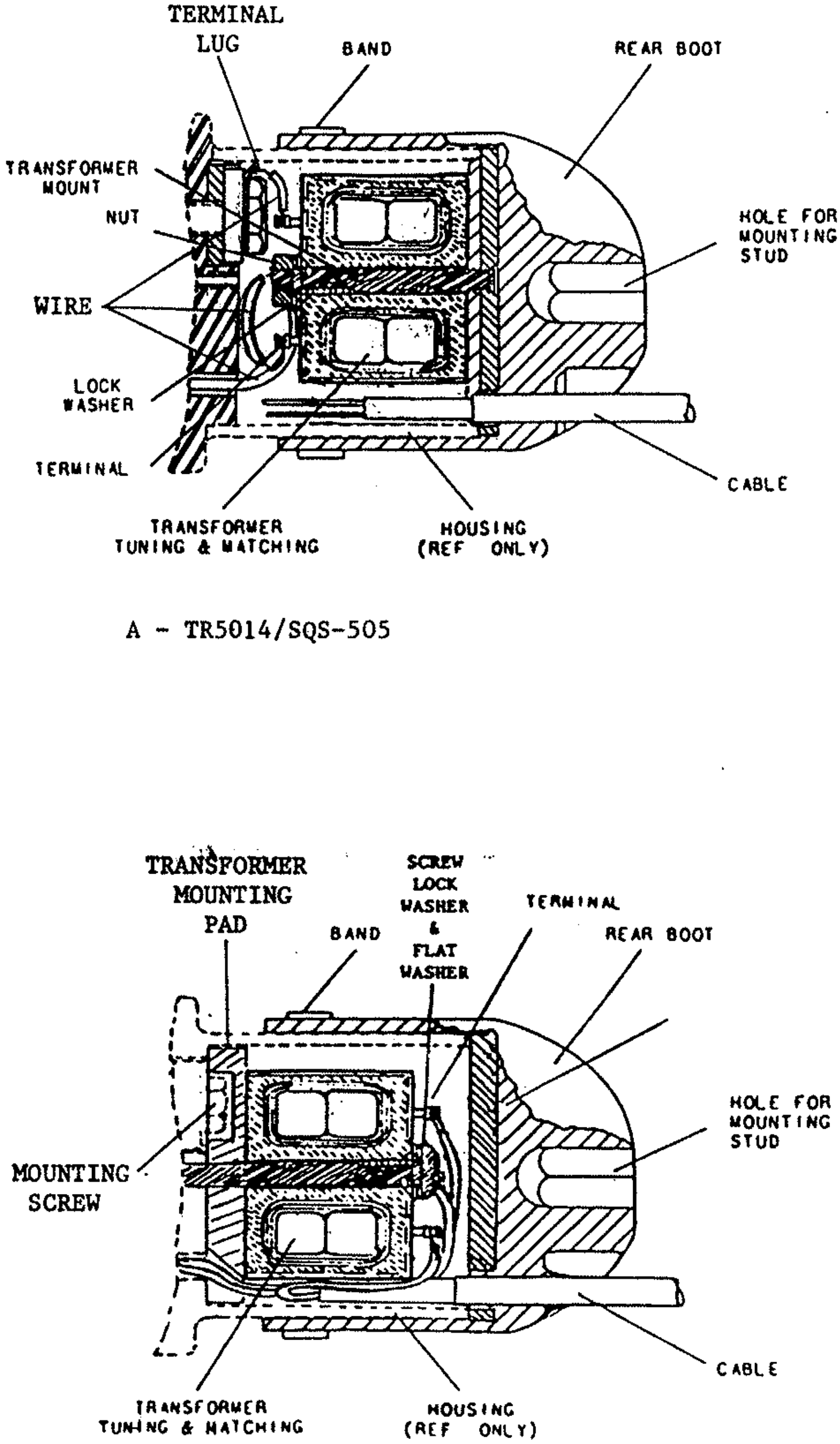


A - TR5014



B - TR5014A

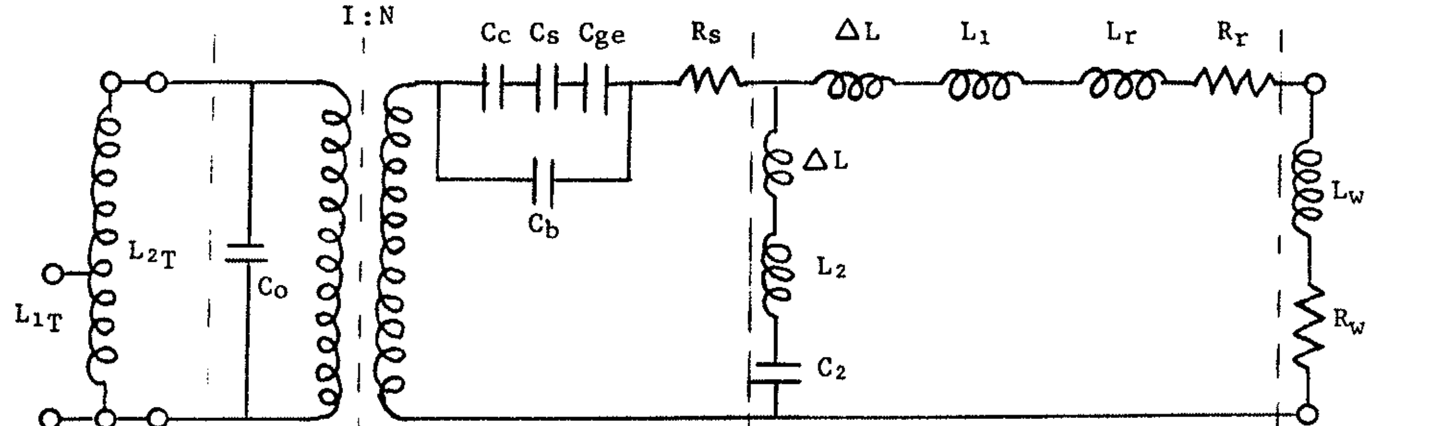
Figure 1-3 Vibrator Assembly, Cross-section View



A - TR5014/SQS-505

B - TR5014A/SQS-505

Figure 1-4 Rear Boot Assembly, Cutaway View



C_0 = blocked capacitance of 4 ceramic rings in parallel at 1000 Hz in farads.

N = electromechanical transformation ratio in Newton/volt.

C_c = compliance of 4 ceramic rings in meter/Newton.

C_s = compliance of electrode washers in meter/Newton.

C_{ge} = compliance of epoxy/glass washers in meter/Newton. (Does not exist in TR5014)

C_b = compliance of bias stud in meter/Newton.

R_s = ceramic stack damping in Newton-second/meter.

ΔL = 1/3 of mass of stack plus compliant portion of bias stud in kg.

L_2 = weight of rear mass in kg.

C_2 = compliance of rear mass to housing pressure release pad in meter/Newton.

L_1 = weight of front mass in kg.

L_r = effective weight of front boot in kg.

R_r = front boot damping in Newton-second/meter.

L_w = reactive component of radiation load in kg.

R_w = real component of radiation load in Newton-second meter.

L_{2T} = inductance of tuning/matching transformer secondary winding in housing.

L_{1T} = inductance of tuning/matching transformer primary winding in housing.

FIGURE 1-5

Configuration of Equivalent Circuit TR5014A Single Element Transducer (Impedance Analogue).

(a) Component C_0 is the blocked electrical capacitance of the ceramic rings in parallel. At the normal operating frequency, close to mechanical resonance, it is tuned out by the inductance of the secondary of the tuning and matching transformer, L_{2T}.

(b) The reactive component of the mechanical circuit determines the resonant frequency of mechanical vibration. The real components of the mechanical circuit are loads on that circuit. The only component that changes significantly from an individual SET through a single stave, to a complete transducer transmitting in OMNI is the reactive component of the Radiation Load, Lw. This change is the reason for the change in resonant frequency apparent in Figures 1.8 and 1.9.

NOTE: ΔL (1/3 Mass of spring) can be found in "Theory of Vibration with Application, by William T. Thomson, Prentice-Hall publication".

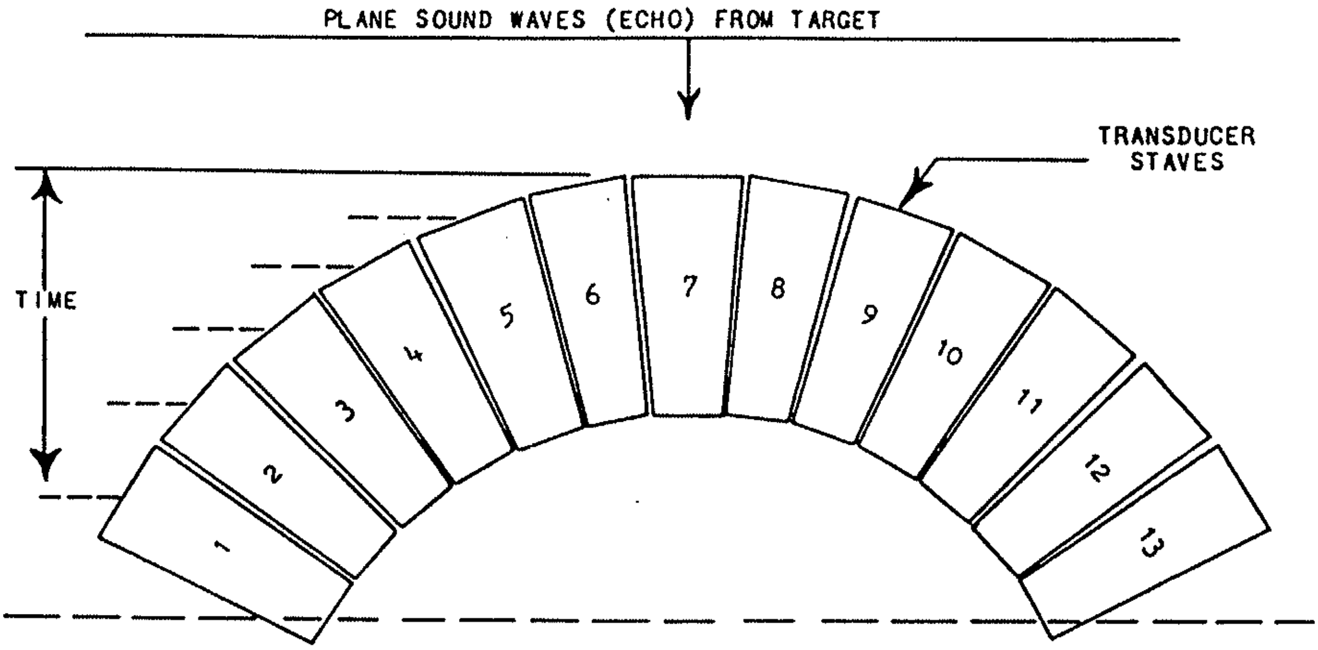
(c) All S.E.T. have the same polarization so that they vibrate in phase when subject to the same phase of electrical input. In the configuration of the complete Transducer assembly, each S.E.T. is subject to mutual mechanical coupling with adjacent S.E.T. The design parameters of the S.E.T. have been so chosen that, in the complete Transducer assembly, the reactive component (Lw) of S.E.T. loading becomes negligible.

(d) When the S.E.T. are operating at electromechanical resonance in the assembled configuration, all reactive components are balanced out in the equivalent circuit. Therefore, the electrical input applied to the S.E.T. is divided between the pure mechanical loads of Rs, Rw, and Rr. The amount of power appearing across these loads are effective radiated sonar power (Rw) and device losses (Rs and Rr).

1-6 TRANSDUCER ASSEMBLY

(1) General. The Transducer consists of 36 electrically independent staves made up of 10 S.E.T. These staves are arranged about the periphery of a cylinder with their faces parallel to the axis of the cylinder. The function of each stave is to convert electrical input into acoustic energy (transmission) and to convert a returning echo into electrical signals (reception). The Transducer can also be used as a passive listening device.

(2) Transmission. Subject to the provision of the appropriate facilities in the electronic units associated with it, the Transducer is capable of operation in a number of active modes, e.g. OMNI-directional scanning, directional BEAM (searchlight) and TRDT (Triple Rotational Directional Transmission) in a trillium pattern. In each active mode, the electrical signals, properly phased to form the desired beam, are generated in the transmitting equipment and fed to the Transducer where they are converted into acoustic signals and radiated into the water.



STAVES	7	6 & 8	5 & 9	4 & 10	3 & 11	2 & 12	1 & 13
APPROXIMATE RELATIVE AMPLITUDE	1.00	0.98	0.94	0.87	0.77	0.64	0.50
APPROXIMATE TIME DELAY (μsec) (FOR C = 4800 FT/SEC)	0	6	25	54	96	150	208
Delay required to form beam at output of transducer (μsec)	208	202	183	154	112	58	0

Figure 1-6 Transducer Stave Voltages

(3) Reception. The sound waves impinging on a transducer have essentially plane wave fronts whose direction of arrival indicates the bearing of the object reflecting the sound waves. When the surface of the transducer is circular in cross section, as are the surfaces of the TR5014/SQS-505(V) and TR5014A/SQS-505(V) Transducers, the voltage produced in the staves will vary in amplitude and phase as indicated in Figure 1-6. This figure represents a plane wave arriving at the Transducer face and impinging on the staves of the array where the acoustic signals are converted into electrical signals and passed on to the receiving system for processing.

1-7 TRANSDUCER CHARACTERISTICS

The electro-acoustic characteristics of typical S.E.T., single staves and the overall assembly are graphically shown in Figures 1-7 through 1-11. Additional information follows:

(a) Receiving Response. Figure 1-7 shows the open circuit receiving response of an S.E.T. for the whole frequency spectrum concerned. Because of interaction effects, the shapes of the corresponding curves for a stave and the Transducer differ slightly from this S.E.T. curve.

(b) Impedance. Impedance loop diagrams for an isolated S.E.T., a single stave, and the complete Transducer are illustrated in Figures 1-8 and 1-9. It will be noted that, due to the different baffling and coupling effects, the point of resonance shifts in progressing from an isolated S.E.T., through a single stave, to the complete Transducer.

(c) Directivity. The patterns of acoustic propagation applying to transducer and assemblies vary with the operating frequency, amplitude and phase of the driving signal, transducer dimensions and configuration. The directivity pattern of a transducer is a measure of its relative response as a function of orientation in a given plane. The pattern is normally plotted on a decibel scale referred to the response on the acoustical axis. The directivity patterns described herein are typical of both the TR5014 and TR5014A.

(i) In the OMNIdirectional mode of transmission of the 36 individual staves combine to produce a circular horizontal beam. Figure 1-10 shows the omnidirectional beam pattern and the degree of uniformity attained in the Transducer.

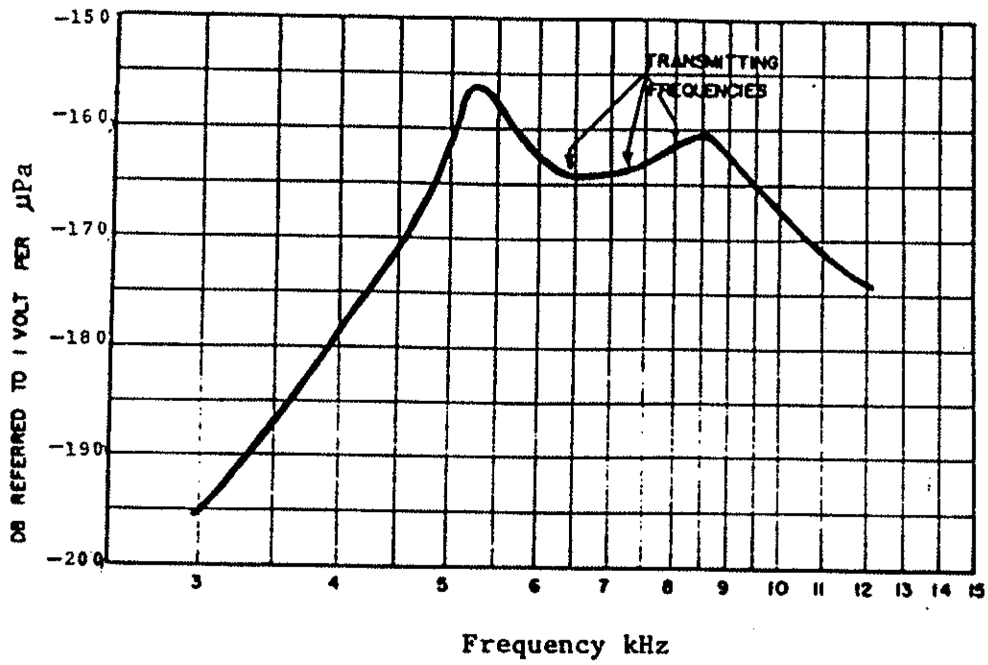
(ii) The propagation and characteristics of the BEAM and TRDT beams are a function of specific phasing and shading characteristics which are an integral part of the transmitting system. Therefore the applicable directivity patterns are not described in this book.

(iii) Figure 1-11 depicts the vertical beam patterns at the three transmitting frequencies. These patterns apply equally to a single stave and to the Transducer complete with all staves in parallel.

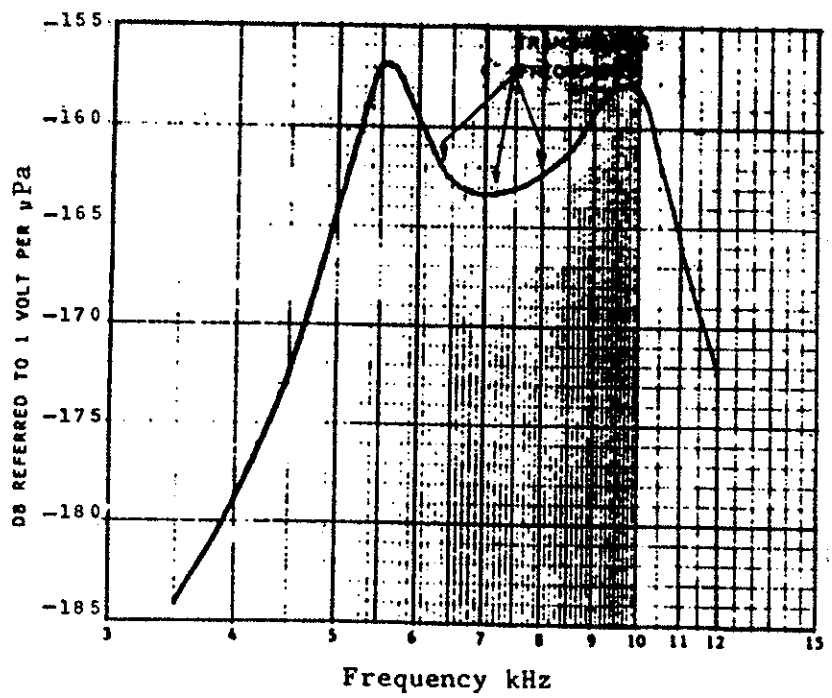
(iv) Table 1-2 gives the directivity and efficiency of the Transducer in the OMNIdirectional mode.

Measurement	Frequency (kHz)		
	6.4	7.2	8.0
Directivity Index	9.6	10.1	10.6
Efficiency: TR5014	70%	70%	60%
TR5014A	70%	70%	60%

Table 1-2 Performance Measurements, Transducer Assembly



A TR5014



B TR5014A

Figure 1-7 Open Circuit Receiving Response

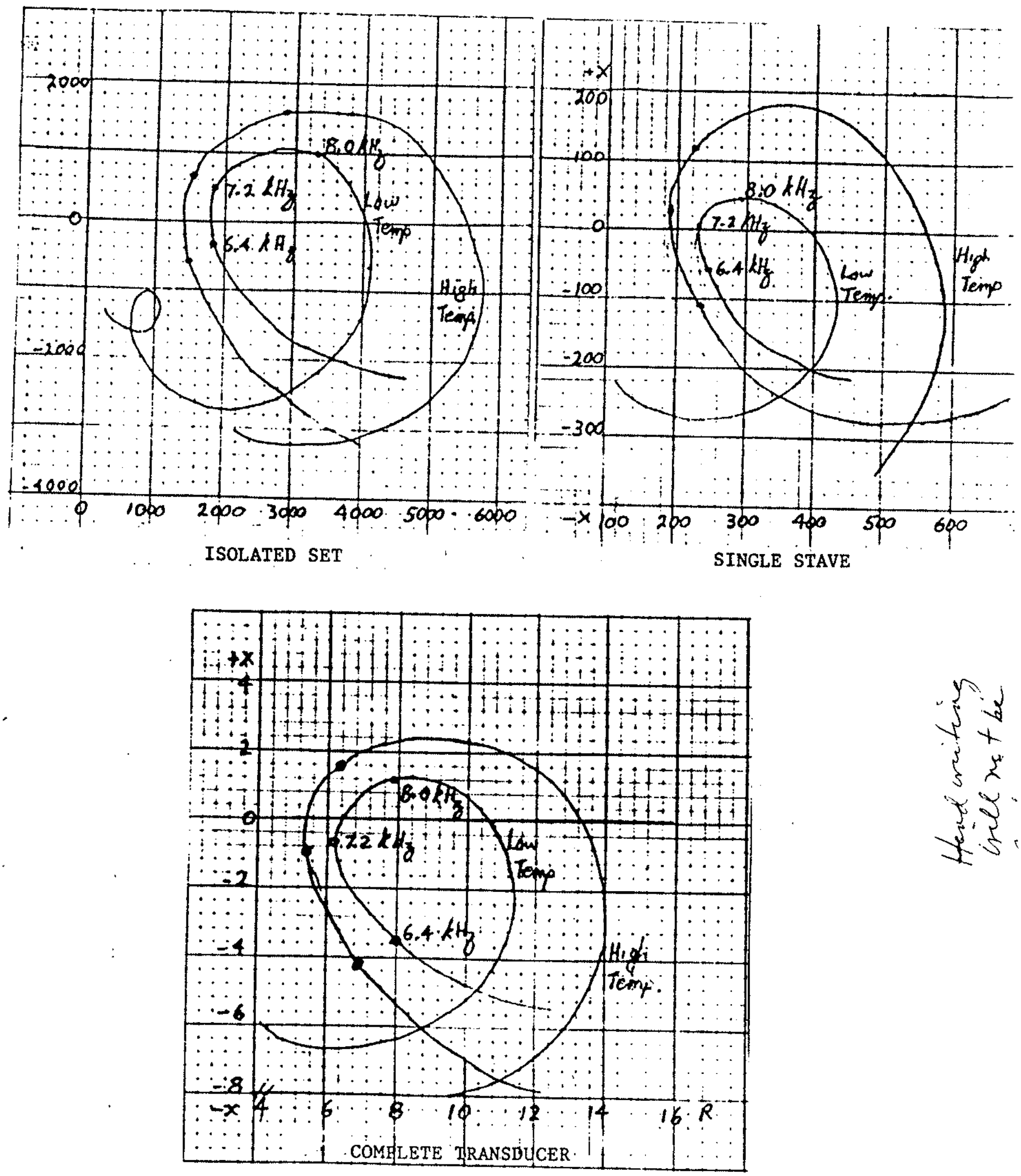


Figure 1-8 Representative Impedance Loop Diagrams - TR5014

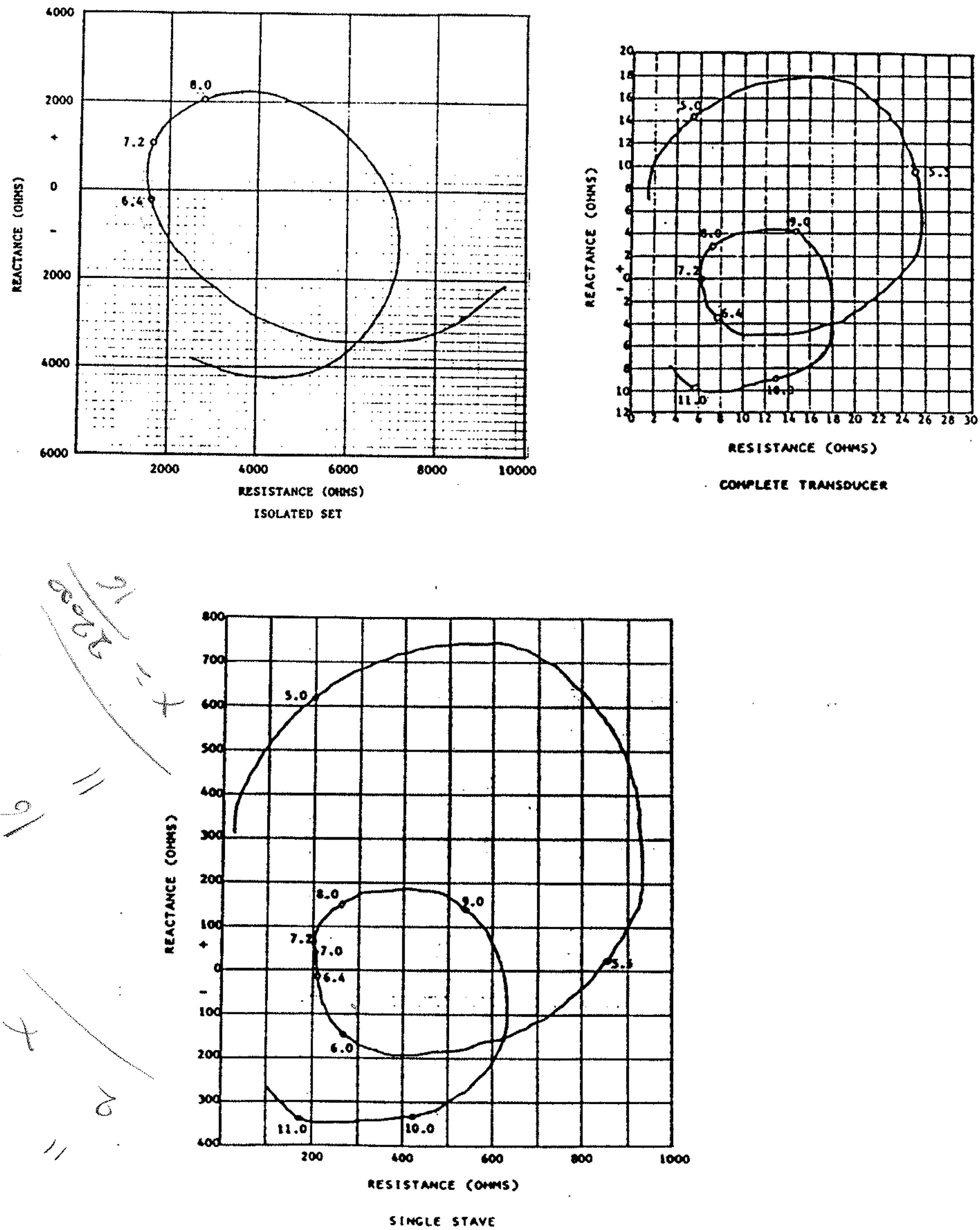


Figure 1-9 Representative Impedance Loop Diagram TR5014A

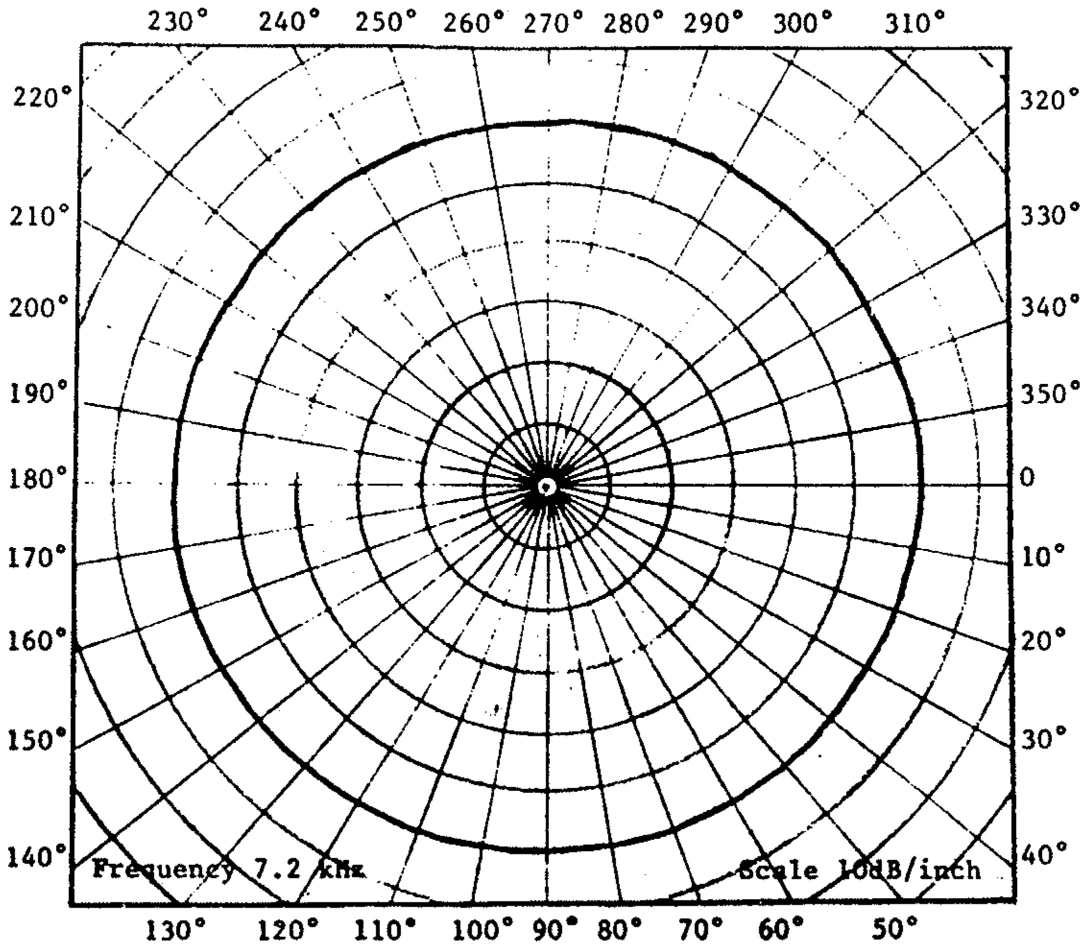
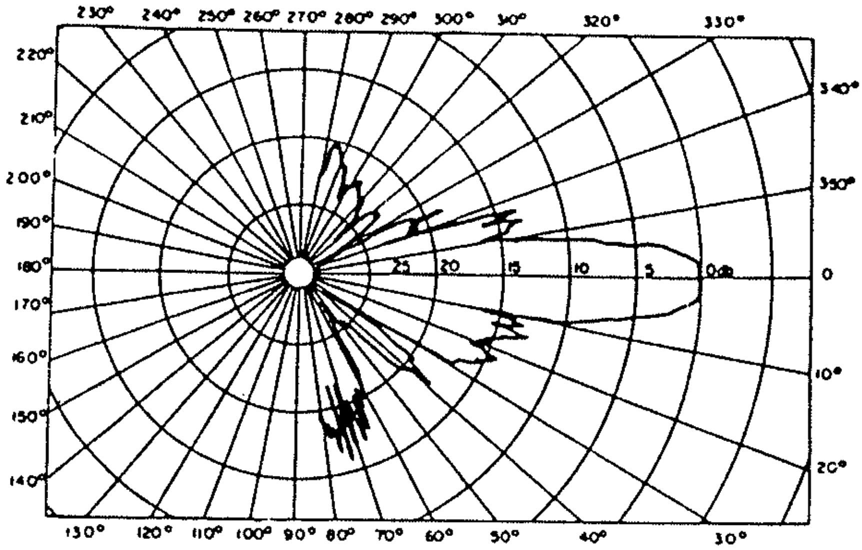
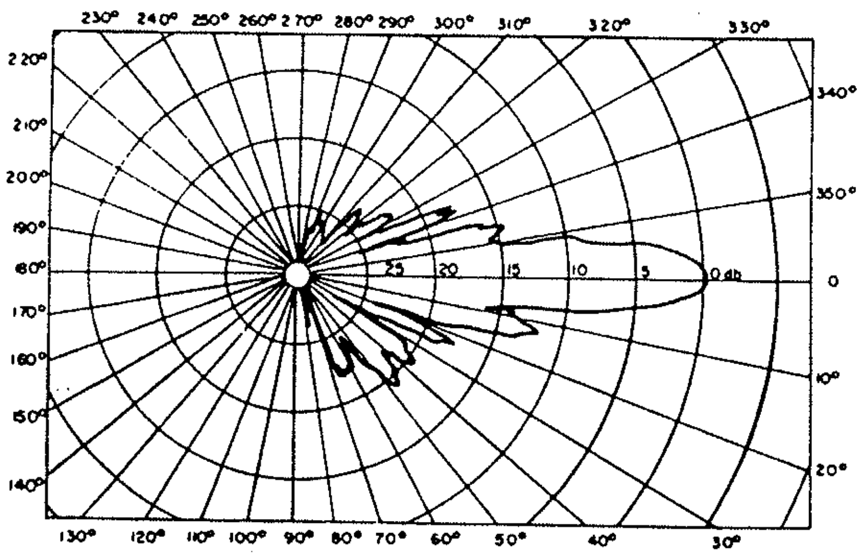


Figure 1-10 Horizontal Beam Pattern

(6.4 kHz)



(7.2 kHz)



(8.0 kHz)

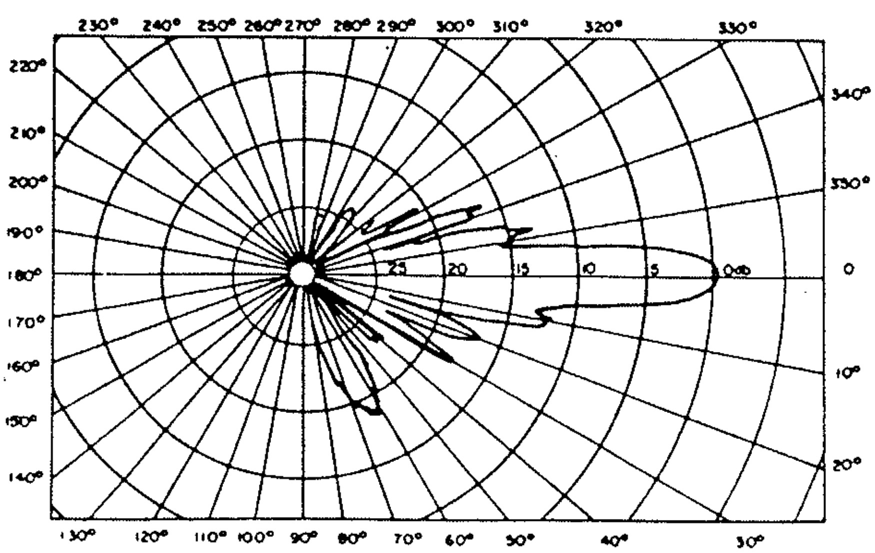


Figure 1-11 Vertical Beam Patterns

PART 2
INSTALLATION INSTRUCTIONS

2-1 GENERAL

For information relating to installation instructions, refer to the CH 1981-11-20.

ADD - C4
" C5

ADD
ADD

PART 3

OPERATING INSTRUCTIONS

3-1 GENERAL

For information relating to operating instructions, refer to the relevant Instruction Manual for the sonar system in which the Transducer is to be incorporated.

PART 4

DRILL PROCEDURE

Not applicable

THIS SECTION SHOULD BE

PART 5

MAINTENANCE INSTRUCTIONS

5-1 PREVENTIVE MAINTENANCE

(1) General.

(a) Preventive maintenance consists of periodic checks of the physical and operating condition of the Transducer. These checks should be carried out in accordance with the maintenance schedule applicable to the sonar system of which the Transducer is a part and with C-03-005-012/AM-000 Maintenance Administration Manual, Sea Environment.

(b) The most significant electrical tests on this type of transducer are impedance checks. Usually, a correct impedance reading indicates that a transducer element or array is in good condition. If an impedance measurement is in question, especially when locating defective S.E.T., the insulation resistance to ground and continuity of the S.E.T. should also be checked.

(c) The following is a list of preventive maintenance duties:

(i) Visual inspection.

(ii) Insulation measurements.

(iii) Impedance measurements.

(iv) Response measurements.

(d) Specific values with tolerances are given for each measurement. If the results of these measurements are not within tolerance, refer to 5-3 Corrective Maintenance. (The Transducer was submerged to a depth of 15 feet in open water with the dome removed for these measurements.)

NOTE

The sonar dome may be left in position if necessary. In such case, allowance should be made for the effect of its acoustic properties upon the sonar performance measurements. The results of preventive maintenance tests should be compared against corresponding measurements made following the initial installation.

(2) Test Equipment. Table 5-3 lists recommended test equipment as required to carry out electro-acoustical tests on the Transducer and S.E.T. When the recommended instruments are not available, units having equivalent characteristics may be substituted.

(3) Special Facilities. The only special tool required for shipboard maintenance of the Transducer is a Kellems Pulling Grip for the replacement of elements. In addition, for a hull mounted unit, the services of divers and diving equipment are necessary for direct visual inspections and for the changing of S.E.T. in the course of corrective maintenance.

(4) Schedule. Table 5-1 lists the various maintenance operations to be performed and suggested periods for each operation. This schedule should be modified to coordinate it with the maintenance schedule of the electronic equipment associated with the Transducer and with access to dockyard facilities where these may be necessary to make visual inspections.

Operation to be Performed	Suggested Period	
	Month	Year
Visual inspection	opportunity	basis
Measure insulation to ground of stave	X	
Measure impedance of staves	X	
Measure impedance of S.E.T.	see note	
Measure insulation to ground of S.E.T.	see note	
Measure transmitting response		X
NOTE: As required to isolate defective S.E.T.		

Table 5-1 Maintenance Schedule

(5) Visual Inspection. Direct inspection of a hull mounted Transducer requires that the sonar dome be removed and that a diver be available except for inspections in dry dock. Proceed as follows:

(a) Check for fouling of S.E.T. due to marine growth on the faces. Clear off growth as required.

(b) Check S.E.T. faces for signs of severe abrasion or other damage.

(c) Check for signs of deterioration of neoprene or corrosion of metal parts.

(d) Check that all clamping strips are in place. Ensure that all mounting screws are tight.

(6) Insulation Measurements. See 5-3 for detailed procedure.

(7) Impedance Measurements. Use the signal generator, frequency counter and impedance bridge to perform these measurements at three frequencies. The results should agree with the values and limits shown in Table 5-2 for the assembly level being checked. See 5-3 for detailed procedure.

(a) Check the impedance of staves at the transmitter/receiver and Dummy Load Box (HMS) or the Tuning and Matching Units (VDS).

(b) To check an individual S.E.T., disconnect it from the paralleled S.E.T.s of its stave configuration.

Unit Under Test	Freq. (kHz)	Vector Impedance			
		TR5014		TR5014A	
		ohms	(degrees)	ohms	(degrees)
Stave	6.4	270 ± 10%	-5 ± 10	269 ± 17%	-23 ± 15
	7.2	235 ± 10%	+8 ± 10	211 ± 22%	0 ± 11
	8.0	310 ± 10%	+22 ± 10	253 ± 25%	15 ± 15
S.E.T.	6.4	2000 ± 20%	-22 ± 15	1600 ± 13%	-20 ± 10
	7.2	2200 ± 20%	+25 ± 15	2085 ± 10%	23 ± 13
	8.0	3500 ± 20%	+18 ± 15	3400 ± 11%	23 ± 13

Table 5-2 Impedance Values and Tolerances

(8) Transmitting Response. A measurement of transmitting voltage response is a desirable annual check on the efficiency of the Transducer and on the uniformity of its horizontal pattern. Performing this test requires that facilities be available to comply with the test arrangement shown in Figure 5-1. The procedure outlined below applies to a hull mounted unit in calm water.

(a) Lower a calibrated hydrophone over the side of the ship, from a boom if necessary, to a point at a known distance from the Transducer and align it with its point of maximum vertical response.

(b) Operate the associated sonar system to transmit in an OMNI-directional mode at 7.2 kHz.

(c) Using a calibrated oscilloscope, measure the input and output voltages in the test system.

WARNING

Exercise caution when measuring. These voltages are dangerous to life.

(i) For V_{in}, measure the maximum RMS voltage appearing across the paralleled staves of the Transducer during transmission pulses.

(ii) For V_r, measure the maximum RMS voltage appearing at the terminals of the calibrated hydrophone.

(d) Using the known distance and hydrophone characteristics and the measured input and output voltages, compute the transmitting response from the formula given in Figure 5-1. The calculated response shall not be less than 171 dB relative to one micropascal per volt at one meter. (See NOTE under 5-1(1)(d).)

(e) Repeat this measurement for several azimuthal positions selected at random.

(f) Note whether response measurements, at all azimuth angles checked, are uniform within a total excursion of 1 dB. If not, corrective maintenance is required.

(9) Receiving Response. The open circuit receiving response is not as readily checked as is the transmitting voltage response; this is because of the preamplifier, scanning and receiver circuits which normally are active when the former measurement is made. Usually, the receiving response may be assumed to be satisfactory if the impedance and the transmitting response are within tolerance. However, if a measurement of receiving response becomes necessary, one of three methods, as outlined below, may be used depending on the maintainer's freedom to alter system interconnections for test purposes. Refer to Figure 5-2 for the basic test arrangement and calculation formula used in measuring receiving response. The physical arrangement is similar to that for measuring transmitting response except that a calibrated projector is used instead of a hydrophone. Tests are performed at 7.2 kHz.

NOTE

It is essential that receiving response be measured in an open circuit condition, that is, without any loading of the staves by external circuits. The provision is automatically made in the SCAN Mode method of measuring. It must be effected by other means when using the Single Stave methods.

(a) SCAN Mode. To use this method, the overall receiving response of the system is measured and compared against a corresponding measurement made when the equipment was initially installed. Allowance must be made, in this comparison, for any changes in the gain of the receiving electronics between the times of the initial and current measurements.

NOTE

Whenever the system's receiving amplifiers are used to make a measurement of receiving response (as for SCAN mode), the AGC and TVG functions must be overruled in order that the maximum gain be continuously effective.

(i) Operate the sonar system in the LISTEN mode.

(ii) Train the audio bearing of the sonar system to the direction of the projector.

(iii) At the output of the sonar aural circuits, measure the output voltage produced due to the cw input to the projector. Use the formula in Figure 5-2 to compute the overall receiving response.

(iv) Measure or compute the gain of the receiving circuits from the Transducer output to the output of the aural circuits making due allowance for preamplifier gain, receiver gain, and the insertion loss and directivity of the scanning circuits.

(v) Subtract the gain of the receiving circuits from the overall receiving response to get the receiving response of the Transducer alone. Compare this response with the corresponding result computed following initial installation. The difference should be less than 2 dB.

(b) Single Stave. This method is similar to that of 5-1(8)(b)(ii) above in that no receiver amplifying circuits are used; however, the response at only one stave is monitored. The projector is so placed with respect to the Transducer that it is directly in line with the stave to be measured. The open-circuit receiving response of any one stave shall not be less than -164 dB relative to one volt per micropascal.

5-2 FAILURE REPORTS

Any failure of the equipment which the maintainer finds significant should be report by Unsatisfactory Condition Report Form CF 777A, in accordance with Maintenance Management Instruction (MMI) 1459. Be sure to identify the equipment, major assembly and component as completely as possible using type numbers, serial numbers, stock numbers and/or references to this book. A complete description of the failure, including an estimate of the "time in use" greatly assists technical authorities in evaluating the report and deciding on possible corrective action.

5-3 CORRECTIVE MAINTENANCE

(1) Scope. Corrective maintenance on the Transducer consists mainly in isolating and replacing defective S.E.T. Mechanically damaged or deteriorated S.E.T. are readily isolated during visual inspections; electrically defective units have to be isolated by electrical tests following unsatisfactory readings during preventive maintenance procedures or following operators' complaints of subnormal system performance. Defective S.E.T. should be returned to the manufacturer.

(2) Isolating Defective S.E.T. If there are indications of incorrect impedance of a stave or the complete assembly, a drop in efficiency or non-uniform response, proceed as follows to isolate the defective S.E.T.

(a) Check the impedance of each of the 36 staves, preceding each check with a measurement of insulation resistance and continuity as detailed below. Note, for further isolating procedures, the positions of those staves which do not show correct test readings. (Refer to Table 5-2 and records of previous measurements.)

CAUTION

> Do not apply the megger across the conductors of a stave or an S.E.T.

(i) Measure the insulation resistance from each stave conductor to ground using a 500-volt megger. The insulation resistance shall not be less than 5 megohms for the TR5014, and not less than 50 megohms for the TR5014A.

(ii) Check the continuity between the conductors of each stave using an ohmmeter. The resistance should be approximately 0.3 ohms. If a short circuit is indicated or if the resistance reading is higher than 0.4 ohms, note the stave number for further isolating procedures as in (b) below.

(iii) Use the signal generator, frequency counter, and impedance bridge to measure the impedance of the stave at 7.2 kHz. The impedance reading should fall within the limits indicated in Table 5-2; however, it may fall outside these limits and still be good. Records of previous measurements and a radical departure therefrom are the best indicators of failure.

(b) Disconnect the leads of each S.E.T. in each stave noted during the procedures of (a) above. Check the insulation resistance, continuity and impedance of S.E.T. individually as detailed. Tag as reject the cables of those S.E.T. which do not show the correct test readings.

(i) The insulation resistance shall not be less than 50 megohms for the TR5014, nor less than 500 megohms for the TR5014A.

(ii) The continuity reading shall be 3.3 ohms ± 20%.

(iii) The impedance at 7.2 kHz shall fall within the limits indicated in Table 5-2. As in stave measurements, a radical departure from a previous recorded measurement is the best indicator of failure.

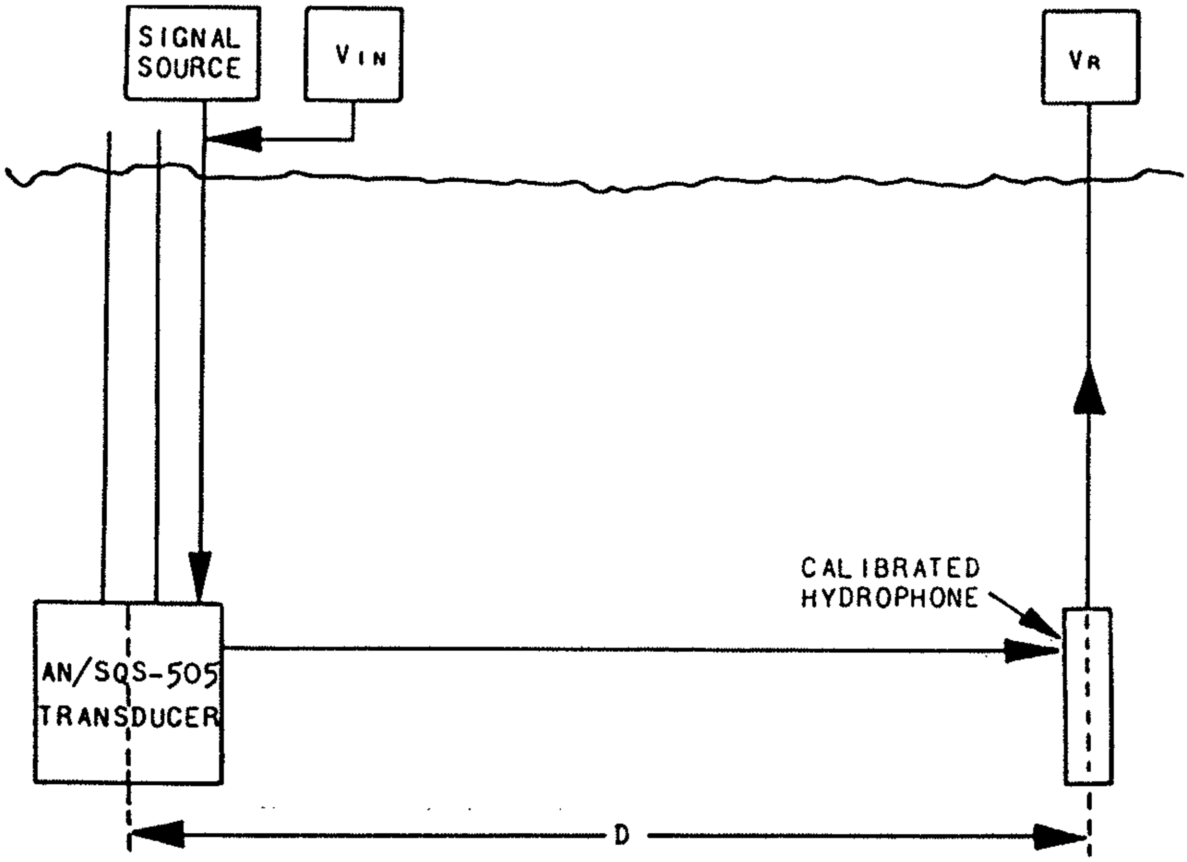
(3) Removal and Installation of S.E.T. See detailed instructions in part 2 of this book.

(4) Cleaning. Single Element Transducers should be cleaned, after removal from the assembly, before storing or shipping. It is recommended that either of the pure detergents listed below be used for this purpose.

(i) Sodium Lauryl Sulfate - manufactured by Dupont.

(ii) Dodecyl Benzine Sulfenate ("Siponate DS-10") - manufactured by Alcolac Corporation, Valleyfield, P.Q.

NSN? for detergents.



$$S = V_R - M + D - V_{IN}$$

WHERE:

S = TRANSMITTING RESPONSE IN DB//1 MICROPASCAL/VOLT AT 1 METER.

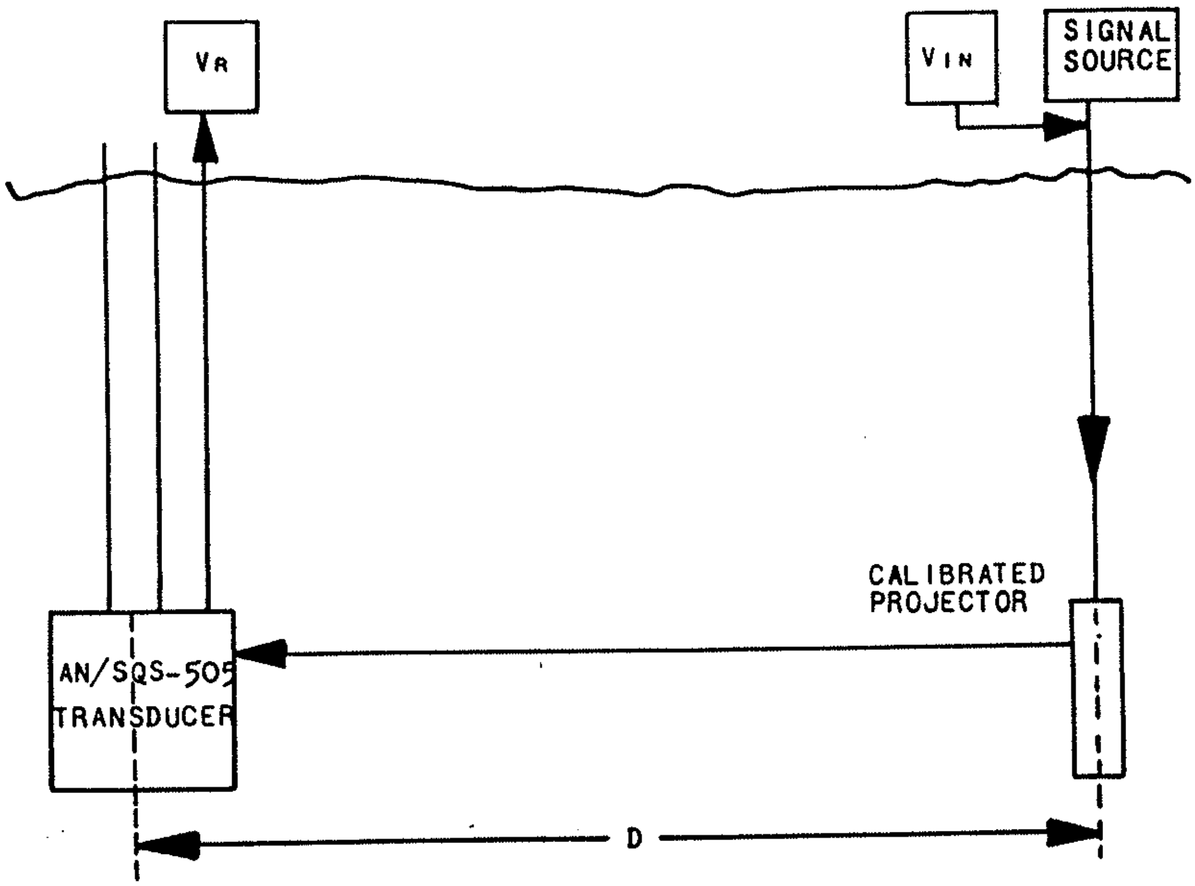
V_R = 20 LOG OF THE OPEN CIRCUIT VOLTAGE OF THE CALIBRATED HYDROPHONE.

M = OPEN CIRCUIT HYDROPHONE RESPONSE IN DB//1 VOLT/MICROPASCAL.

D = 20 LOG OF THE DISTANCE IN METERS.

V_{IN} = 20 LOG OF THE VOLTAGE INPUT TO THE TRANSDUCER.

Figure 5-1 Transmitting Response Test Arrangement



$M = V_R - S + D - V_{IN}$

WHERE:

M = OPEN CIRCUIT RECEIVING RESPONSE IN DB// 1 VOLT/MICROPASCAL.

V_R = 20 LOG OF THE OPEN CIRCUIT VOLTAGE OF THE TRANSDUCER.

S = PROJECTOR RESPONSE IN DB//1 MICROPASCAL/VOLT AT 1 METER.

D = 20 LOG OF THE DISTANCE IN METERS.

V_{IN} = 20 LOG OF THE VOLTAGE INPUT TO THE PROJECTOR.

Figure 5-2 Receiving Response Test Arrangement

Instrument	Required Characteristic or Range
Signal Generator	Range: 4 to 12 kHz flat within ±0.5 db Stability: ± 1% Output: max. 3 vrms - 50 ohms 1.5 vrms - 600 ohms Attenuator: 50 db range for 50-ohm and 600-ohm outputs. Distortion: less than 1%.
Impedance Bridge	Complex Impedance Ranges: from 1 ohm to 5 kohm over frequency range of 4 to 12 kHz Accuracy: error less than ± 2% F.S.
Frequency Counter	Frequency Range: 4 to 12 kHz Input Requirement: 0.2 vrms minimum Accuracy: ± 1 count ± line accuracy 1%
Calibrated Oscilloscope	Input Impedance: 1 megohm. Passband: dc to 12 kHz minimum. Sensitivity (Calibrated): 5u mv/cm to 20v/cm variable to 50v/cm and with 10:1 probe.
Voltmeter	Frequency Range: 10 cps to 12 kHz Voltage Range: 1 mv to 300v. Accuracy: ± 2% F.S. from 10 cps to 12 kHz Input Impedance: 10 megohms. Calibration: rms and db scales.
Megger - 600 volts	Insulation Test Ranges: 0-200 megohm, 0-20 megohm, 0-20 kohm and 0-200 ohm.
Multimeter	Sensitivity: 20,000 ohms/vdc 5,000 ohms/vac
Calibrated Test Transducer Set	Usable Range as Projector and Hydrophone: 4 kHz to 12 kHz.

Table 5-3 Required Test Equipment

PART 6
SHOP OVERHAULS

No shop overhaul procedures are included in this book.

this section should disappear

PART 7
PARTS LIST

7-1 INTRODUCTION

This part of the handbook contains a complete illustrated parts list for the TR5014 and TR5014A Transducers. Figure 7-1 illustrates the parts comprising the overall assembly; Figure 7-2 complements the parts breakdown of the Single Element Transducer.

7-2 REFERENCE DESIGNATIONS

(1) Reference designations for the transducer components have been established as follows:

(a) The Transducer is assigned a unit number, viz 1.

(b) Individual parts of the Transducer, with the exception of the Single Element Transducer, are designated by the unit number followed by a component number, e.g. 1-1, 1-2, etc.

(c) The Single Element Transducer is an assembly and is designated by the unit number followed by the letter A, i.e.: Single Element Transducer 1A. This assembly is then broken down into parts each of which has a numeric suffix. Hence such parts are designated 1A-1, 1A-2, etc.

(2) The reference designation provides the following information:

(a) The first numeral indicates the unit to which the part belongs.

(b) The second numeral indicates the item number on the assembly or sub-assembly.

7-3 MANUFACTURERS

The ~~Federal~~ NATO Supply Code for Manufacturers/Supplier (FSCM) for all parts are listed in Tables 7-1, 7-2, and 7-3.

TABLE 7-1
PARTS LIST TRANSDUCER

Figure No. and Ref. Desig.	Manufac-turer's Part No.	Description	NSCM Number	Number Per Equipment
7-1				
1	568243	TR5014/SQS-505 Transducer NATO Stock # [illegible]	37136	1
		OR		
		TR5014A/SQS-505 Transducer NATO Stock #5845-21-898-5902	37136	
1A	568240	Single Element Transducer	37136	360
1-1	580894	Frame, Transducer Assembly	~~37136~~ 38421	1
1-2	533095	Strip, Clamping	~~37136~~ 38421	396
1-3	533093	Screw, S.E.T. Mounting	~~37136~~ 38421	792

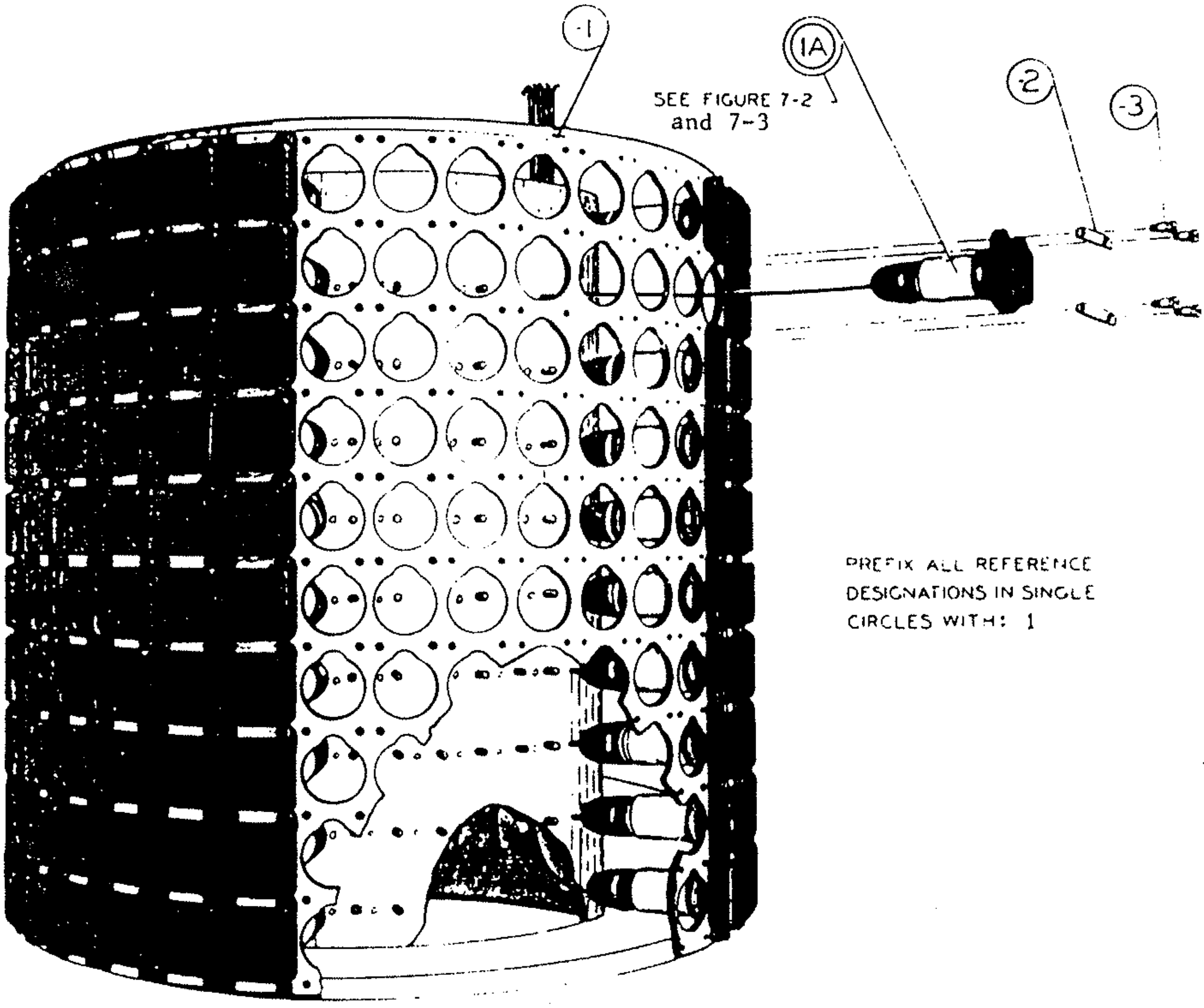


Figure 7-1 Transducer Assembly, Cutaway View TR5014 and TR5014A

TABLE 7-2
PARTS LIST SET TR5014

Figure No. and Ref. Desig.	Manufac-turer's Part No.	Description	FSCM Number	Number Per Equipment
7-2				
1A	568240	Transducer Single Element Assembly	37136	
1A-1	568241	Front Mass Assembly	37136	1
1A-2	533092	Ring, Ceramic	37136	4
1A-3	533099	Mass, Rear	37136	1
1A-4	533101	Stud, Bias	37136	1
1A-5	533091	Ring, Spacer	37136	4
1A-6	533103	Pressure Release, Rear Mass	37136	1
1A-7	533102	Pressure Release, Front Mass	37136	1
1A-8	533100	Pressure Release, Mounting Screws	37136	3
1A-9	550622	Housing, S.E.T.	37136	1
1A-10	535038	Washer, Flat	37136	3
1A-11	MS90727-10	Cap Screw 1/4-28 Hex Head	37136	3
1A-12	MS21042-6	Nut Hex, Self-Locking	37136	1
1A-13	550626	Boot, Rear & Cable Assembly	37136	1
1A-14	550624	Transformer, Tuning & Matching	37136	1
1A-15	MS35650-305	Nut, 10-32 NF	37136	1
1A-16	535039	Band, Rear Boot	37136	1
1A-17	533097	Band, Front Boot	37136	1
1A-18	MS77073-2	Terminal Lug	37136	1
1A-19	MS35333-39	Washer, Lock, No. 10	37136	1
1A-20		Tubing, Teflon, TFT 200/2 x 1/2 Lg.	37136	3

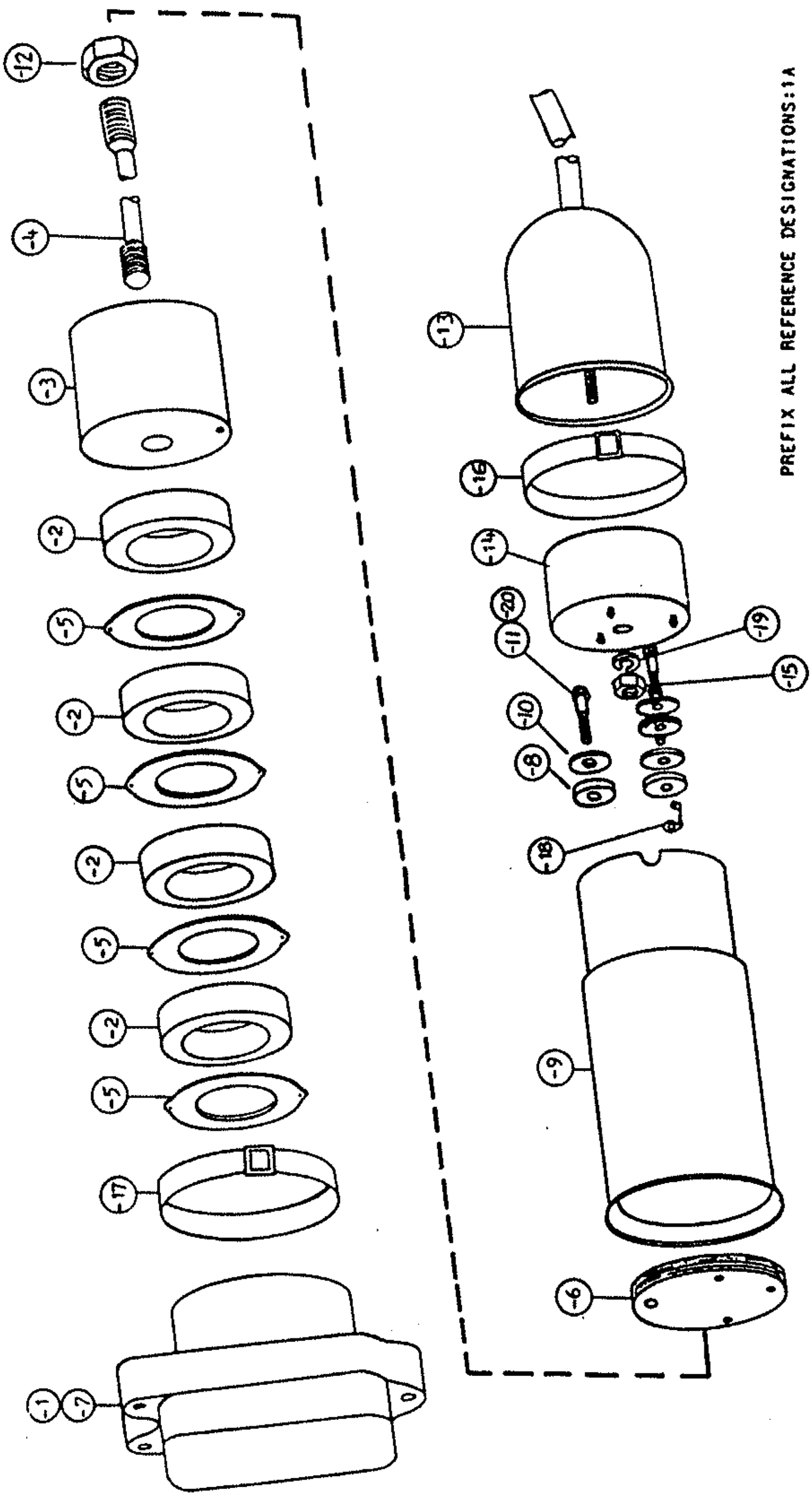


Figure 7-2 Single Element Transducer, Exploded View TR5014/SQS-505(V)

TABLE 7-3
PARTS LIST SET TR5014A

Figure No. and Ref. Desig.	Manufac-turer's Part No.	Description	FSCM Number	Number Per Equipment
7-3				
1A	568240	Transducer Single Element Assembly	37136	
1A-1	568241	Front Mass Assembly	37136	1
1A-2	8459660	Washer Front	37136	1
1A-3	533092	Ring, Ceramic	37136	4
1A-4	8459661	Washer, Rear	37136	1
1A-5	533099	Mass, Rear	37136	1
1A-6	533101	Stud, Bias	37136	1
1A-7	533091	Ring, Spacer	37136	5
1A-8	MS21042-6	Nut Hex, Self-Locking	37136	1
1A-9	533103	Pressure Release, Rear Mass	37136	1
1A-10	533102	Pressure Release, Front Mass	37136	4
1A-11	533100	Pressure Release, Mounting Screws	37136	3
1A-12	550622	Housing, S.E.T.	37136	1
1A-13	535038	Washer, Flat	37136	3
1A-14	MS90727-10	Cap Screw 1/4-28 NF Hex Head	37136	3
1A-15	8459662	Transformer Mounting Pad	37136	1
1A-16	HS51031-47	Set Screw Flat Point 10-32 UNF 2A x 1/4 Lg	37136	1
1A-17	550626	Boot, Rear & Cable Assembly	37136	1
1A-18	550624	Transformer, Tuning & Matching	37136	1
1A-19	MS51951-53	Screw Pan Head 8-32 UNC	37136	1
1A-20	535039	Band, Rear Boot	37136	1
1A-21	533097	Band, Front Boot	37136	1
1A-22	MS15795-807	Washer Flat No. 8	37136	1
1A-23	MS35338-137	Washer, Lock, No. 8	37136	1
1A-24		Tubing, Teflon, TFT 200/2 x 1/2 Lg	37136	3
1A-25	Grade AV	Compound, Locking MIL-S-22473	37136	AR

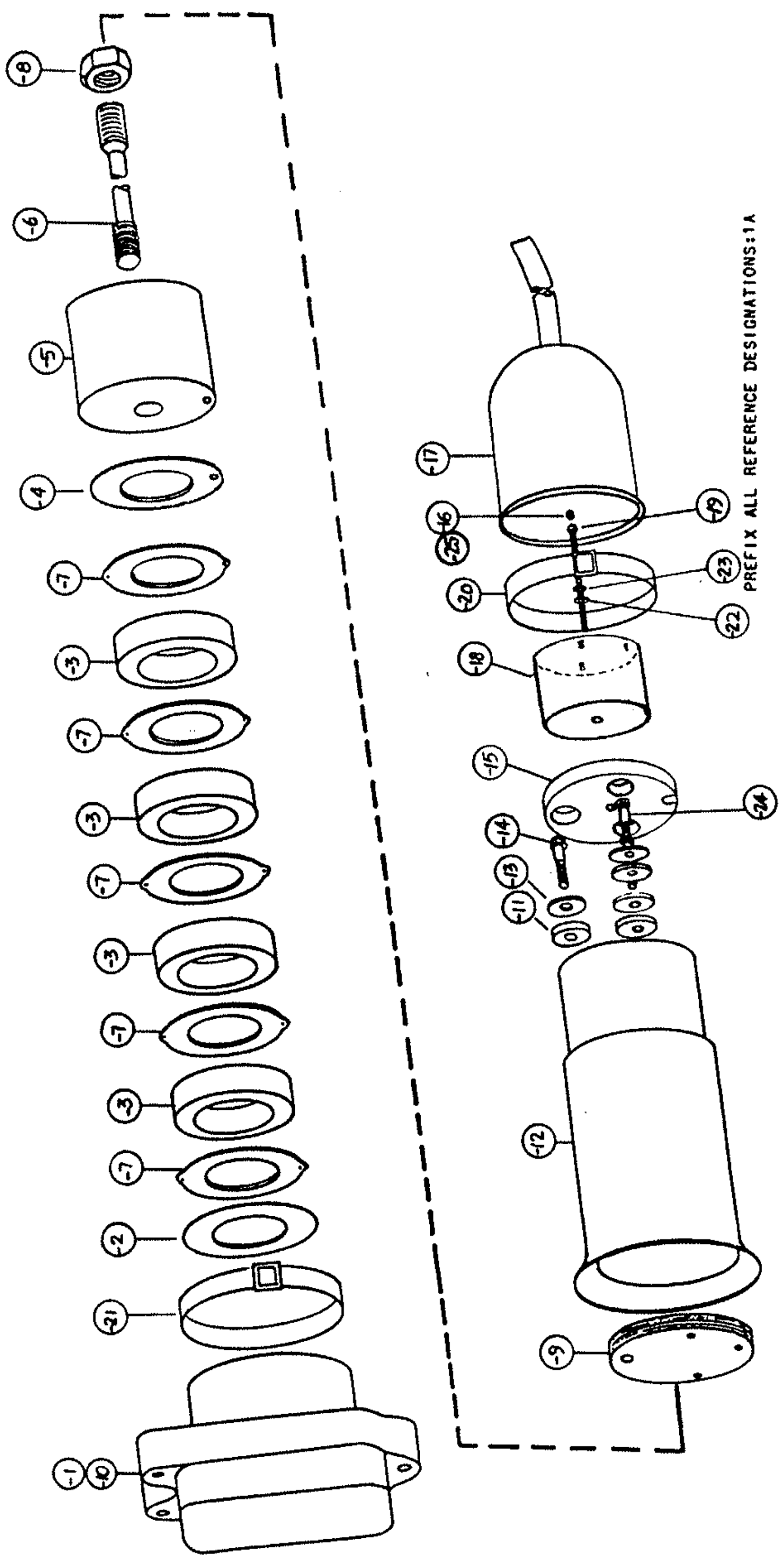


Figure 7-3 Single Element Transducer, Exploded View TR5014A/SQS-505(V)