

TR/XT-6001

RECOVERABLE ACOUSTIC TRANSPONDER

User's Manual

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Preface

This manual describes the installation, operation, and maintenance of the Teledyne Benthos, Inc. TR/XT-6001 Recoverable/Expendable Acoustic Transponder. This manual is divided into the following eight sections:

- 1 Introduction**
- 2 Description**
- 3 Specifications**
- 4 Theory of Operation**
- 5 Operating Instructions**
- 6 Maintenance**
- 7 Return Procedures**
- 8 Warranty**

Proprietary Information

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Changes

Teledyne Benthos, Inc. reserves the right to make changes to meet new specifications at any time without incurring any obligation to modify previously installed units. This manual is provided for informational and reference purposes only and is subject to change without notice.

Notes and Warnings

Where applicable, special notes and warnings are presented as follows:

NOTE:	A reminder to check that certain criteria are met before proceeding further in a step or sequence.
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WARNING:	A reminder that dangerous consequences could result if certain recommended procedures are not followed
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1 Introduction

The TR-6001 Transponder, (shown in Figure 1-1), consists of a deep sea acoustic transponder in either a 17-inch glass housing and a 17-inch super ribbed hardhat or a 13-inch glass housing and a 13-inch super ribbed hardhat. A releasing mechanism, bolted to the bottom of the hardhat, provides a release lever which is tripped by a dissolving wire when activated by the acoustic transponder. The entire assembly is a self-buoyant package which will flip over from the transducer-up position when deployed to the transducer-down position when released and on the surface to continue to allow range communication at the surface (see figure 1-3). Two molded handles in the hardhat are provided for ease of recovery and shipboard handling.

The XT-6001 (shown in Figure 1-2) can be purchased in the same 17-inch or 13-inch, or 10-inch acoustic transponder configuration, but without the release functionality.

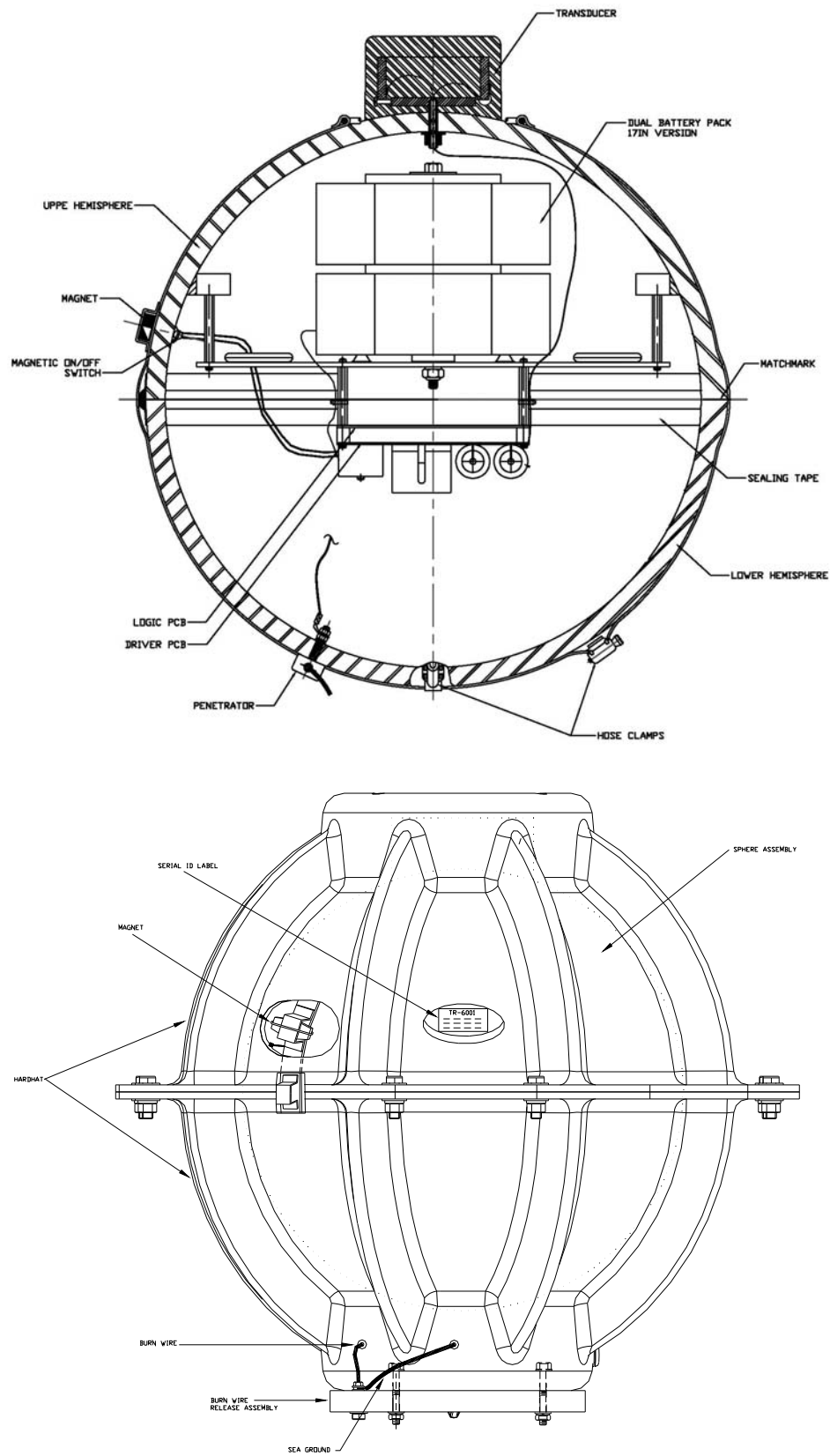
The TR-6001 (shown in Figure 1-1) is intended for acoustic navigation and release of light loads at a 22,000 foot (6700 meter) water depth. For ease of relocation, the unit will transpond when interrogated to determine slant range, and will transpond in different modes for confirmation of release.

Interrogations and commands are transmitted by either the DS-8750 or Model UDB-9000 deck box unit which also provides a visual digital readout of slant range up to 33,000 feet (10,000 meters). The deck box unit can provide all available interrogation frequencies and the thirteen different command codes. The DS-8750 and the Model UDB-9000 deck box unit has its own manual and is not described in detail here.

The XT-6001 provides the same transponder functionality, but without the release option.

Upon completion of a RELEASE command, the TR-6001 will change its transponder reply from one to four pings for every interrogate pulse from the deck unit. At the deck unit, the verification that the RELEASE command has been received and acted upon multiple ping sequence will be displayed and audibly transmitted. The multiple ping sequence will be present only during the time in which current is flowing to the release mechanism. When the wire dissolution is complete, the unit will revert to a single ping upon interrogation.

Upon recovery, the transponder can be re-armed and used again. The TR-6001 reverts to a single ping when the unit is re-armed. This option is not available for the XT-6001.



TR-6001 RECOVERABLE ACOUSTIC TRANSPONDER

Figure 1-1 TR-6001 Acoustic Transponder

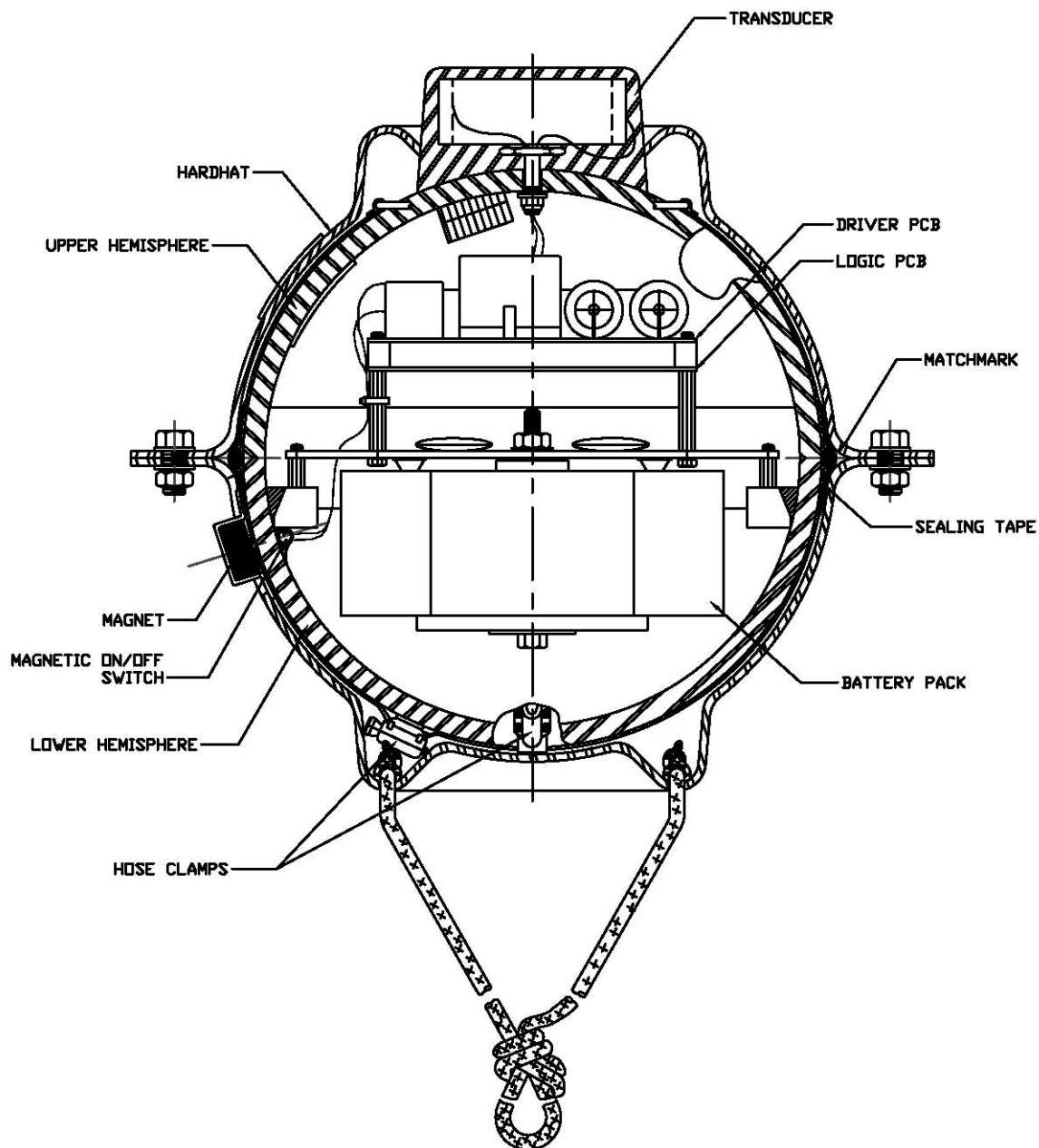


Figure 1-2 XT-6001 Acoustic Transponder

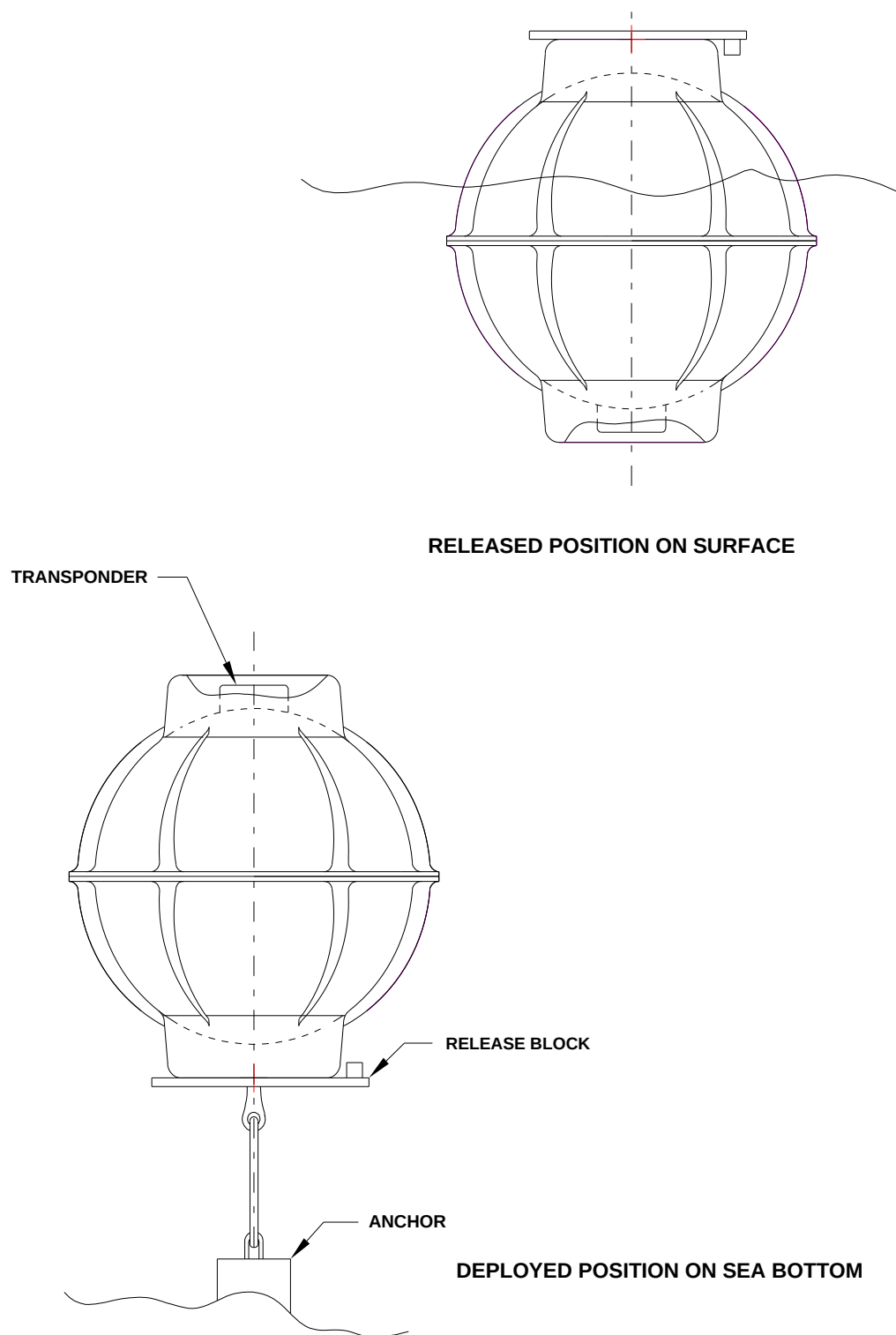


Figure 1-3 The Deployed/Released Positions of the TR-6001

2 Description

The transponders are supplied to the customer with the following major components:

- **Model TR-6001-13 / TR-6001-17**
 - o Glass instrument housing in hardhat, transducer, and release mechanism
 - o 1 release link
 - o 1 burn wire
 - o Magnet
 - o Spare parts and re-arm kit
 - o Manual
- **Model XT-6001-10 / XT-6001-13 / XT-6001-17**
 - o Glass instrument housing in hardhat, transducer, and release mechanism
 - o 1 release link
 - o Magnet
 - o Spare parts kit
 - o Manual

Upon receipt of equipment, the customer should check the shipment to insure that the order is received complete and undamaged. Please contact Teledyne Benthos, Inc. or refer to Section 7 of this User's Manual before returning any equipment damaged in shipment.

Construction

The Model TR-6001 Transponder consists of a board pair and battery pack fastened inside the self-buoyant 17-inch or 13-inch glass instrument housing. One penetrator through the glass housing is used to connect to the transducer in the upper hemisphere and two electrical penetrators through the glass housing are used for the dissolving wire electrodes.

NOTE: The XT-6001 does not contain the two electrical penetrators for the dissolving wire electrodes or the release assembly.

A hose clamp and bail assembly is used to hold the two instrument housing halves together. The entire glass assembly is enclosed in a two piece polyethylene yellow hardhat. The top half has a cutout in the top for the transducer and the bottom half has the release assembly bolted to the bottom, as shown in Figure 1-1.

The printed circuit board assembly consists of two (2) circuit boards back to back separated by spacers.

- **Driver Board (C-855-130)** contains the components required for transmitting, i.e. output transformer, inductor, power transistors and capacitors. It also contains the circuitry for transmit pulse gating, sensitive receiver preamplifier, and the transducer connection. (See figure 2-1)
 - **Logic Board (C-855-132)** contains the remaining receiver circuitry including the limiter amplifier, detector, and the microprocessor based command decoder. (See figure 2-1)
- Other functions on this circuit board are:
- Transmit frequency synthesizer
 - RELEASE acknowledgement (TR-6001)
 - 5-volt regulation

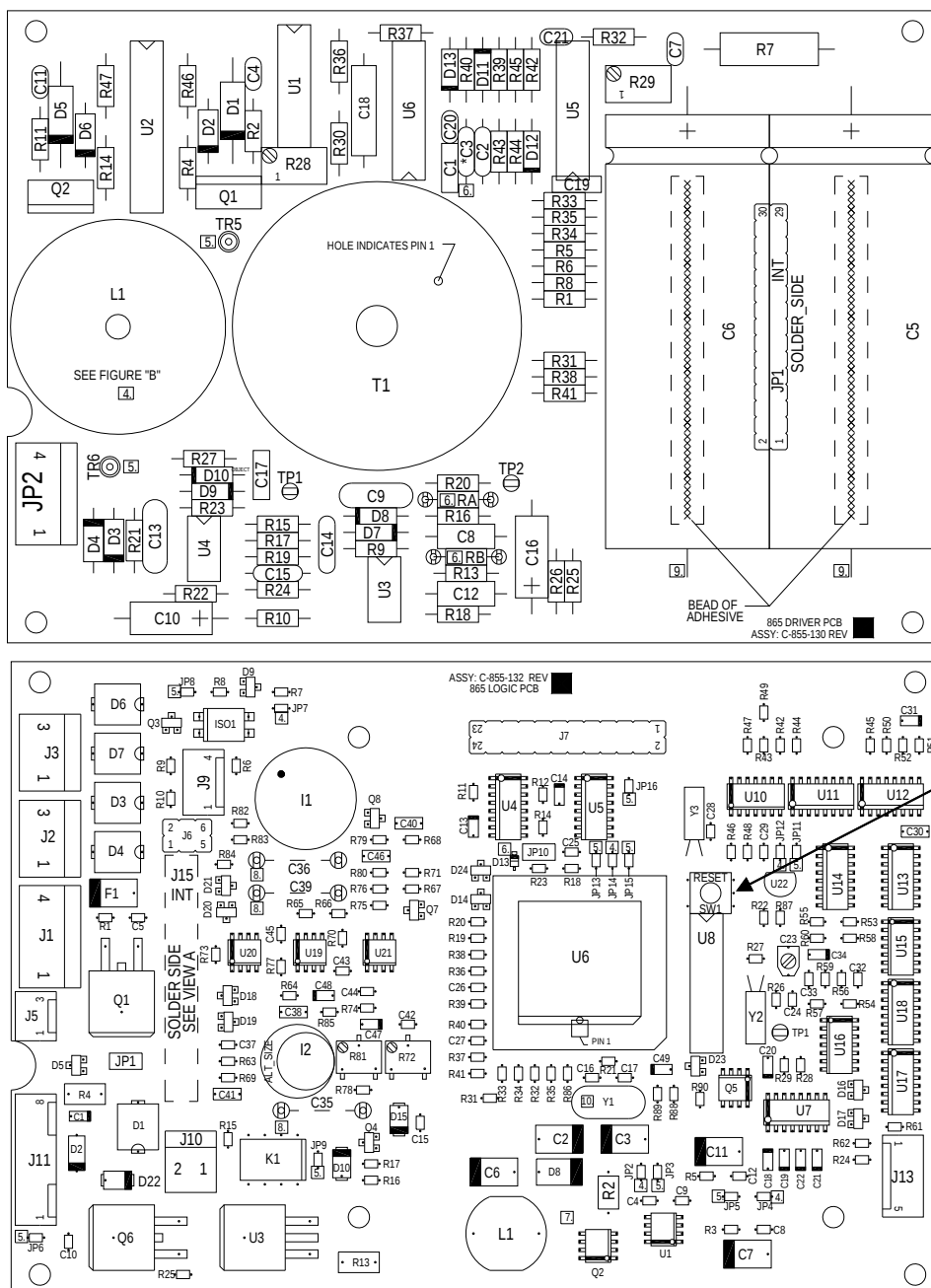


Figure 2-1 Driver and Logic PCB's Top View

3 Specifications

This section provides information on the operating and environmental specifications on the Teledyne Benthos, Inc. TR/XT-6001 Acoustic Transponder.

General Specifications

Transmit Frequency:	User selectable 7.5 to 15 KHz(± 3 Hz) in 250 Hz increments
Receive Frequency:	Factory set user specified 7 to 15 KHz, 250 Hz increments (12.5 KHz is reserved, not a standard receive freq.) (Receiver bandwidth ± 125 Hz)
Receive Lockout Time:	1.5 seconds standard (re-triggerable)
Detection Jitter (repeatability):	± 0.1 ms
Turnaround Delay:	3 ms (standard), 3-30 ms (optional)
Minimal Detectable Signal:	> 85 dB re 1 μ Pa
Operating Depth:	22,000 ft. (6700 m) max
Transmit Pulse Length:	10 ms (± 1 ms)
Operating Range:	10 km slant range with Teledyne Benthos, Inc UDB-9000 Deck Box.
Battery:	18 alkaline 'D' cells two strings in parallel at a nominal 13.5 VDC (P/N C-500-1 or C-210-301)
Operating Life:	
TR-6001 17"	2 years and 500,000 pings (double pack)
TR-6001 13"	2 years and 250,000 pings (single pack)
XT-6001 17", 13", & 10"	2 years and 250,000 pings (single pack)
Acoustic Output:	> 192 dB from 9.5 to 15.0 KHz. > 185 dB from 7.5 to 9.0 KHz.
Activation:	Salt water immersion (TR-6001 not designed to release in fresh water)
Beam Pattern:	Near Omnidirectional from upper hemisphere
Dimensions:	
TR/XT-6001-17:	17 in. glass instrument hsg. 24 in. max diameter x 22.5 in max height
TR/XT-6001-13:	13 in. glass instrument hsg. 19 in. max diameter x 17.5 in max height
XT-6001-10:	10 in. glass instrument hsg. 14.3 in. max diameter x 12.5 in max height

Release Method:	Inconel Electrolytic Dissolving Wire (TR-6001 only)
Release Indication:	Change from single ping to four or five pings when RELEASE command is received. (Reverts back to single ping when wire completely dissolved) (TR-6001 only)
Command Codes:	Thirteen standard Codes (A-H, or F-M). Combination of these and the command frequencies provide 428 unique codes of non-interfering operation.

NOTE: The enable feature and the release feature require and on command code each.

Weight:

TR-6001-17:	74 lbs (33.6 kg) in air 35 lbs (15.9 kg) in water
TR-6001-13:	38 lbs (17.2 kg) in air 15 lbs (6.8 kg) in water
XT-6001-17:	70.2 lbs (31.8 kg) in air 41.9 lbs (19.0 kg) in water
XT-6001-13:	33.5 lbs (15.2 kg) in air 17.3 lbs (7.8 kg) in water
XT-6001-10:	20.7 lbs (9.4 kg) in air 2 lbs (.91 kg) in water

NOTE: Anchors not supplied by Teledyne Benthos, Inc.

4 Theory of Operation

Receiver

The receiver consists of four basic blocks:

1. Transducer
2. Preamplifier
3. Limiter-amplifier
4. Detector.

The hydrophone converts the acoustic energy into an electrical signal. At long ranges, this signal may be very small, approximately 20 microvolts mixed with noise. The preamplifier is a very low noise amplifier which provides approximately 52 dB of gain and some filtering. The limiter amplifier provides another 52 dB of amplification and hard limits the signal to 1.2 volts peak to peak. The total gain of the system is more than 100,000!

The limited signal, plus noise, is then fed into a frequency detector, which is factory tuned to detect a specific frequency between 7.0 and 15.0 kilohertz. If the correct frequency (± 105 Hz) is present, then the detector output goes high.



WARNING: **DO NOT** Attempt to adjust the factory set tuning of the detector circuit

Transmitter

The transmitter consists of three basic blocks:

1. Transmit frequency synthesizer
2. Pulse control
3. Power amplifier

The transmit frequency synthesizer is based on a 50 KHz crystal oscillator. This oscillator feeds a phase lock loop network which synthesizes a particular frequency based on the stored value within the microprocessor.

If the unit is ENABLED and the detector output goes true, then the pulse control circuitry allows the transmit frequency through to the power-amplifier for 10 milliseconds. The power-amplifier consists of two power MOSFET transistors, and a transformer steps up the AC signal to approximately 3,000 volts peak to peak. This is applied across the transducer which converts the electrical energy into acoustic energy. The same transducer element is used for both transmit and receive.

Command Theory

The standard Teledyne Benthos, Inc. acoustic command consists of two separate frequencies alternating at a specific shift rate. One frequency called the “in-band” frequency, is set to the RECEIVE frequency of the release. The other frequency, called the “out-of-band” frequency, is arbitrarily fixed at 12.5 KHz (actually the “out-of band” frequency alternates between 12.5 KHz and 18 KHz on successive command transmissions) which are otherwise unused frequencies. The detector in the underwater release will respond “true” for the in-band frequency and “false” for the out-of band frequency. Its output, therefore, will be a square wave whose frequency is the shift rate of the command. The command receive circuit then checks for a specific frequency of this square wave and, if it is correct for two complete seconds, the release function will be executed.

There are a total of thirteen shift rates, although only eight are supported in the standard release (A-H) and they are designated by the letter part of the code. The shift rates are:

A: 82.5 Hz	B: 110.9 Hz
C: 136.5 Hz	D: 100.0 Hz
E: 71.0 Hz	F: 77.0 Hz
G: 118.8 Hz	H: 127.3 Hz

Codes I thru M require special release software and are typically reserved for special applications, they are:

I: 123.0 Hz	J: 131.8 Hz
K: 107.2 Hz	L: 114.8 Hz
M: 103.5 Hz	

The command code is decoded by a microprocessor on the logic board.

Command Release

Upon receipt of the proper command code for RELEASE, a relay is energized allowing current to flow through the dissolving wire to the release ground. Also, a four-ping acknowledgment is sent automatically. The relay remains energized until the wire is completely dissolved. As long as the relay is energized, the TR-6001 will reply with five pings when interrogated.

Minimum Detectable Signal (MDS)

Teledyne Benthos, Inc. specifies the MDS to less than 85 dB re 1 μ Pascal for our underwater transponders. Most units typically test out to be between 75-80 dB re 1 μ Pascal during our standard acoustic pool test. The noise level in our pool approaches that of the deep ocean, i.e. approximately 50-60 dB re 1 μ Pascal at 10 KHz.

What does this mean in terms of ranging capability? Let's take an example at 10 KHz.

First, assume the Source Level Output (SLO) of the surface unit is 192 dB re 1 μ Pascal at 1 meter. Then, the transmission loss at a maximum range is simply the difference between the SLO at the surface and the MDS on the bottom:

$$\text{Transmission Loss} = 192 \text{ dB} - 85 \text{ dB} = 107 \text{ dB}$$

From transmission loss tables, this figure corresponds to a maximum range of about 28 kilometers. This is more than adequate sensitivity, since the limiting factor in ranging capability is the reception at the surface, where the noise environment may be worse than the deep ocean by a factor of 30 dB or more, due to ship and surface noise. Therefore, further improvement of the sensitivity of the underwater receiver is not only unnecessary, but in fact, somewhat detrimental. As the sensitivity is brought closer and closer to the ambient noise level, the False Alarm Rate goes up resulting in unnecessary transponds that will drain the battery and confuse the surface receiver. Thus, by specifying the MDS to be less than 85 dB re 1 μ Pascal at 1 meter, Teledyne Benthos, Inc. has insured adequate ranging capability while maintaining a negligible False Alarm Rate.

It should also be noted that all Teledyne Benthos, Inc. receivers will maintain a Constant False Alarm Rate even if the ambient noise environment changes. This is known as a Constant False Alarm Rate, or CFAR, receiver. All Teledyne Benthos, Inc. deck units also have sensitivity controls that allow the operator to maximize the sensitivity for a particular noise environment. This essentially allows the operator to choose an acceptable False Alarm Rate, which is held constant at that level by the electronics.

Command Enable/Timed Disable Feature

The ENABLE feature prevents unwanted transmissions from occurring due to unauthorized transponding, other sonar equipment, or random interference. Whatever the source, the result could be a large number of unnecessary transponds by the TR/XT-6001 which could result in premature battery drain.

Basically it works as follows:

The release powers up in the ENABLED state; that is, it will reply when it receives the proper frequency. It will then remain ENABLED for the selected time, up to 255 hours (a setting of "0" hours will disable this function, leaving the release enabled all the time). The default enable time is 12 hours which will usually be enough time to deploy the unit and range on it (if desired). If not, the user may simply send it an "ENABLE" command to extend (reset the timer) the enable time. Once the enable time runs out, the transmitter portion of the release is disabled until an ENABLE command is received or a release occurs.

NOTE: If for whatever reason the unit is not "ENABLED" when a RELEASE command is received, the release will still take place. Upon completion of the release operation the unit will automatically ENABLE itself so that its ascent may be tracked.

The standard command on the TR-6001(ONLY) is the RELEASE command. The following two acoustic command options are available as options from Benthos for the TR/XT-6001:

Backup Timer Feature

If requested at the time of order, the TR-6001(ONLY) features a BACKUP timer function that is both very powerful and very dangerous. All standard releases are shipped with this function disabled (value set to 0). Extreme care should be exercised whenever using this feature.

If enabled, the BACKUP timer will cause the TR-6001(ONLY) to automatically RELEASE a fixed number of hours (up to 65,535 hours, > 7 years!) after the unit is turned on. This feature can be used in the very special applications where a timed release function is desired. When this function is enabled, the unit will still respond to an acoustically transmitted RELEASE command.



WARNING:

Exercise **EXTREME** caution when using the **Backup Timer Feature**.

5 Operating Instructions

Changing the Release Setup

The model TR/XT-6001 is shipped from the factory with all operating parameters set to the values specified by the customer. These values are visible on the waterproof label attached to the outside of the release, and thus in most instances, these values will not need to be changed by the operator.

If, however, changes are required (to any parameter **EXCEPT** the receive frequency which is only set at the factory), they may be easily made via the RS-232 programming cable A-855-171(not supplied with the TR/XT-6001.)

NOTE: To make any changes to the factory settings, the glass sphere must be opened. Refer to section 6.

To connect the serial cable, open the housing to gain access to the electronics boards. Connect the cable to the board via J13 (see figure 2.1). Connect the DB-9 connector on the other end of the cable to a computer running a terminal emulator (Procomm, Hyperterminal etc). Set the communications to the appropriate serial port (normally 1 or 2), with the following operating parameters:

Baud Rate: 9600
 Parity: (N)one
 Data Bits: 8
 Start Bits: 1
 Handshake: None

Turn on the release, or if the unit is already on press the “Reset” switch SW1 (see figure 2.1) on the Logic board. The following opening screen should appear:

Benthos Inc. – A-855-168 Rev X – MM/DD/YYYY

Functions: N=None, R=Release, E=Enable, D=Disable, “+” = Tilt On, “-” = Tilt Off

Command: A B C D E F G H

Function: N E D R - + N N

Transmit Frequency (Hz): 09500

Enable Time (Hrs): 00012

Tilt Sensor Power Up State (E)nabled or (D)isabled: D

Change: (C)ommands, (X)mit Freq, (B)ackup Time, (E)nable Time, (T)ilt:

The following operating parameters may be changed from this menu:

Changing The Command Assignments

In the screen above, each command (A thru H or F thru M) has a function assigned to it. The possible functions for each command are:

N	None	No action taken
R	Release	The release is RELEASED
E	Enable	The release is ENABLED
D	Disable	The release is DISABLED

To change the command mapping: Press the <C> key (it is not necessary to type the <ENTER> key) from the main screen. You will be prompted to enter the desired function for each command as shown below:

Functions: N=None, R=Release, E=Enable, D=Disable, "+" Tilt On, "-" Tilt Off

Enter Desired Function (N,R,E,D, + or -) For Command A: N
 Enter Desired Function (N,R,E,D, + or -) For Command B: E
 Enter Desired Function (N,R,E,D, + or -) For Command C: D
 Enter Desired Function (N,R,E,D, + or -) For Command D: R
 Enter Desired Function (N,R,E,D, + or -) For Command E: +
 Enter Desired Function (N,R,E,D, + or -) For Command F: -
 Enter Desired Function (N,R,E,D, + or -) For Command G: N
 Enter Desired Function (N,R,E,D, + or -) For Command H: N

Changing The Transmit Frequency

From the main the main screen press the <X> key to set the transmit frequency. The unit can be set to transmit any frequency from 7.000 KHz to 17.500 KHz, in 250 Hz increments. The value is entered in Hz, and 5 digits MUST be entered. So to enter 9.5 KHz, enter 09500 (it is not necessary to type the <ENTER> key).

Enter Transmit Frequency, 07000-17500 Hz (Enter 5 Digits): 09500

Changing The Enable Time

To change the enable time, press <E> from the main screen. Enter the desired enable time. The valid range for this function is from 0 (which disables the ENABLE timer, leaving the unit permanently enabled) to 255 hours (>10 days). You MUST enter 5 digits, thus 0 is entered <00000> and 255 is entered <00255>. After power up, or the receipt of an ENABLE or RELEASE command, the 865 will respond to interrogations with an acoustic response until the time period selected has elapsed (unless a <0> is entered), after which the unit will be mute. If an ENABLE time of 0 Hours is selected, the unit will remain ENABLED until shut off or commanded acoustically to DISABLE.

Enter Enable Time, 00000-00255 hrs, 0 = None (Enter 5 Digits): 00012

Changing the Backup Timer

To change the BACKUP timer contact Teledyne Benthos, Inc. for more information.

Pre-Deployment Tests

Before deployment, test that the unit is operational by using the following procedure:

1. Remove the on/off magnet from the hose clamp band bracket; this will turn the unit on. After about 1-2 seconds, the unit will signal that it has been powered-up successfully by transmitting four pings about 200ms apart.
2. To test the transmit and receive frequencies, place the deck unit transducer near the TR/XT-6001 transducer and verify that it will only respond to the proper receive frequency and that it is replying at its proper transmit frequency.
3. To test the RELEASE command, attach both leads of a voltmeter to the electrode wires; positive voltmeter lead goes to the exposed portion of the burn wire loop and the negative lead to the ground screw. Send the proper RELEASE command from the deck unit. The RELEASE command lasts for about 4 seconds. After about two to three seconds into the RELEASE command, the RELEASE command will be received and the voltmeter will indicate approximately 13.5VDC until just after the command is over (or about two or three seconds more). If the measured voltage is less than 12VDC, the battery pack should be replaced. See section 6 for checking and changing the battery pack.

NOTE: Step 3 RELEASE function is not available on XT-6001.

NOTE: Receiving acoustic commands through the air is often difficult. Adjust the position of the deck unit transducer and try the RELEASE Command again until an acceptable position is found.

NOTE: If the measured voltage is negative, then the voltmeter leads are reversed. Confirm that a positive voltage is sent to the burn wire module (the anode) upon receipt of a RELEASE command prior to deploying the unit.

4. After the TR-6001 receives a RELEASE command, the unit will verify with four pings, 200ms apart as a confirmation that the burn wire is burning. After each interrogation the unit will reply with 5 pings, only while there is current flowing through the burnwire.

Rigging

Before deployment, be sure that the dissolving wire module and the ground screw are properly installed and securely tightened. The disposable ballast should weigh between 75 and 100 pounds in seawater and be attached to the release base with the Benthos provided ¼ inch stainless steel shackle. Insure that additional hardware will not cause jamming of the release mechanism.

Deployment

Surface Preparation

After the unit is tested and rigged, remove the on/off magnet prior to deployment. Listen for the four power-up pings. Gently lower the transponder and anchor into the water. Try to minimize the impact loads on the release linkage during deployment.

Anchor Line Configuration

The length between the anchor and transponder should be long enough to provide a clear acoustic path, and short enough to minimize the watch circle errors, or 4 to 10 feet. However, this figure will vary dependent upon bottom relief and individual applications.

Operation

To interrogate a TR/XT-6001 Transponder, first set the TRANSMIT FREQUENCY SELECT switch of the deck unit to the receive frequency of the transponder you wish to command. Send a single transpond from the deck unit and the TR/XT-6001 Transponder will reply with a single ping.

Recovery

To send the RELEASE command, again make sure the TRANSMIT FREQUENCY SELECT switch is set to the receive frequency of the transponder you wish to command. The RELEASE command, or options, and their corresponding codes (A,B,C,D,E,F,G,H,I,J,K,L,M) are clearly indicated on the TR/XT-6001 hardhat label. Set the COMMAND SELECT switch to the proper letter code, as indicated by the label, and send the command transmission. The TR/XT-6001 will respond with four pings, 3.2 seconds apart, after the command has been properly received. These will show up on the display and may also be heard on headphones, if available. To verify that the release wire is, in fact, dissolving, send a single interrogate ping to the transponder. The TR-6001(ONLY) will respond with five (5) pings, 200ms apart while the current is flowing through the dissolving wire electrode circuit. The first reply may be used to obtain slant range to the instrument. Repeat the process periodically to verify that the wire is still dissolving and to check slant range. A normal period of time for release is 5 to 30 minutes, depending upon water salinity, for the wire loop to break through and release; however, the wire loop ends will continue to dissolve until the wire strands are dissolved inside the jacket of the original wire loop. This process may take an additional 1 to 10 minutes during the ascent of the transponder. Once the wire dissolution circuit has shut down, the transponder will revert back to replying with one ping when interrogated. It will float transducer-down when on the surface for acoustic relocation.

There are two handles molded into the hardhat opposite each other on the hardhat flange which can be used for grappling to aid in recovery.

Insert the on/off magnet back into the hose clamp bracket after recovery.

Options

Along with transmit and receive frequencies, all options are specified on the TR/XT-6001 label and defined in the following sections. Any option parameter not specified on the label may be assumed to have been shipped with the following standard parameters.

Receiver Lockout Time

This is the amount of time that the receiver is inhibited after receiving a pulse of the correct frequency. This helps prevent undesirable multiple interrogations which would result from multipath phenomena, thus saving battery energy. The standard lockout time is 1.5 seconds, although .5 second and 2.5 seconds are available as options.

Transmit Pulse Length

This is the duration of the transmit frequency burst. The standard pulse length is 10 milliseconds, and this is the proper pulse length when using Benthos deck units. However, other manufacturers' deck units may require different pulse lengths. Therefore, as an option, any pulse length from 2 to 20 milliseconds may be specified at time of order.

Turnaround Delay

This is the time delay between reception and transmission. It is a constant delay which should be subtracted from the measured travel time in order to obtain the most accurate slant range. In the standard unit this delay is 3 milliseconds; however, any delay between 3 and 30 milliseconds may be requested as an option when ordering the TR-6001 transducer (which converts the electrical energy into acoustic energy). The same transducer element is used for both transmit and receive.

The Re-arming Kit

In order to redeploy the TR-6001, the transponder should be re-armed with a new dissolving wire module and an expendable link. The Benthos Expendable Re-arming Kit (A-210-226) includes three (3) ¼ inch stainless steel shackles and three (3) expendable dissolving wire modules.

Replacing the Dissolving Wire

The old dissolving wire module should be unplugged from the single pin connector and unscrewed from the release base. A new shackle should be installed on the lever arm and a new dissolving wire module should be installed in the release base. These should be saved and returned to Benthos for remolding of new modules. The delrin tip of the release lever should be inserted into the dissolving wire loop. Insure that the wire loop is installed in the necked down section of the delrin tip. Both the expendable dissolving wire module and the ground screw should be tightened and checked for integrity prior to redeployment.

Replacing the Ground Wire

Depending on the deployment environment and amount of use, it is possible that the ground wire (the cathode) may become brittle in time and some of the strands of wire will break at the junction of the wire and the ground screw. Prior to deployment, the ground wire should be lightly flexed and checked for broken strands.

When broken strands are observed, loosen the ground screw, remove the wire from the screw, cut off approximately one inch of wire, re-strip the insulation to expose approximately ½ inch of wire strands and reinsert back into the hole in the ground screw. Make sure that the ground wire is firmly clamped by the large washers of the ground screw assembly.

Redeployment

Once the transponder has been re-armed, follow the normal deployment procedures described earlier in Section 5.

6 Maintenance

Opening the Glass Housing

The following list details the steps required to open the glass housing of the TR-6001.

- a. Materials needed:
 - Heat gun
 - 18-inch diameter hose clamp
 - Small roller
 - Butyl sealant strip (Benthos Part #0900-024)
 - Wide black tape (Benthos Part #0903-013)
- b. Remove the hardhat assembly.
- c. Remove the hose clamp assembly.
- d. Place the transponder in some sort of a cup to prevent it from rolling.
- e. Turn the unit off by taping the supplied magnet over the "match arrow" mark near the equator on the lower hemisphere. Wait approximately two minutes for the capacitor to discharge, then test the transponder with a deck unit to be sure that it is, in fact, off.
- f. The two hemispheres are held together by the tape around the equator and by about four inches of vacuum. Carefully remove all tape and sealant from the equator. The vacuum inside should still hold the halves together.
- g. The best way to separate the halves is to slowly tighten a hose clamp diagonally across the equator, as shown in Figure 6. Often it is possible to tap them apart using the palm of your hand, but in either case you must be very careful not to chip the precision ground surfaces at the equator. Even small chips can ruin the pressure integrity of the housing.
- h. Now remove the upper hemisphere and place it upside down next to the lower half. The transducer makes a convenient stand for this half.

**WARNING:**

BE CAREFUL! If the unit is powered on, there may be potentially harmful high voltage on the board, particularly in the area of the transducer terminals.

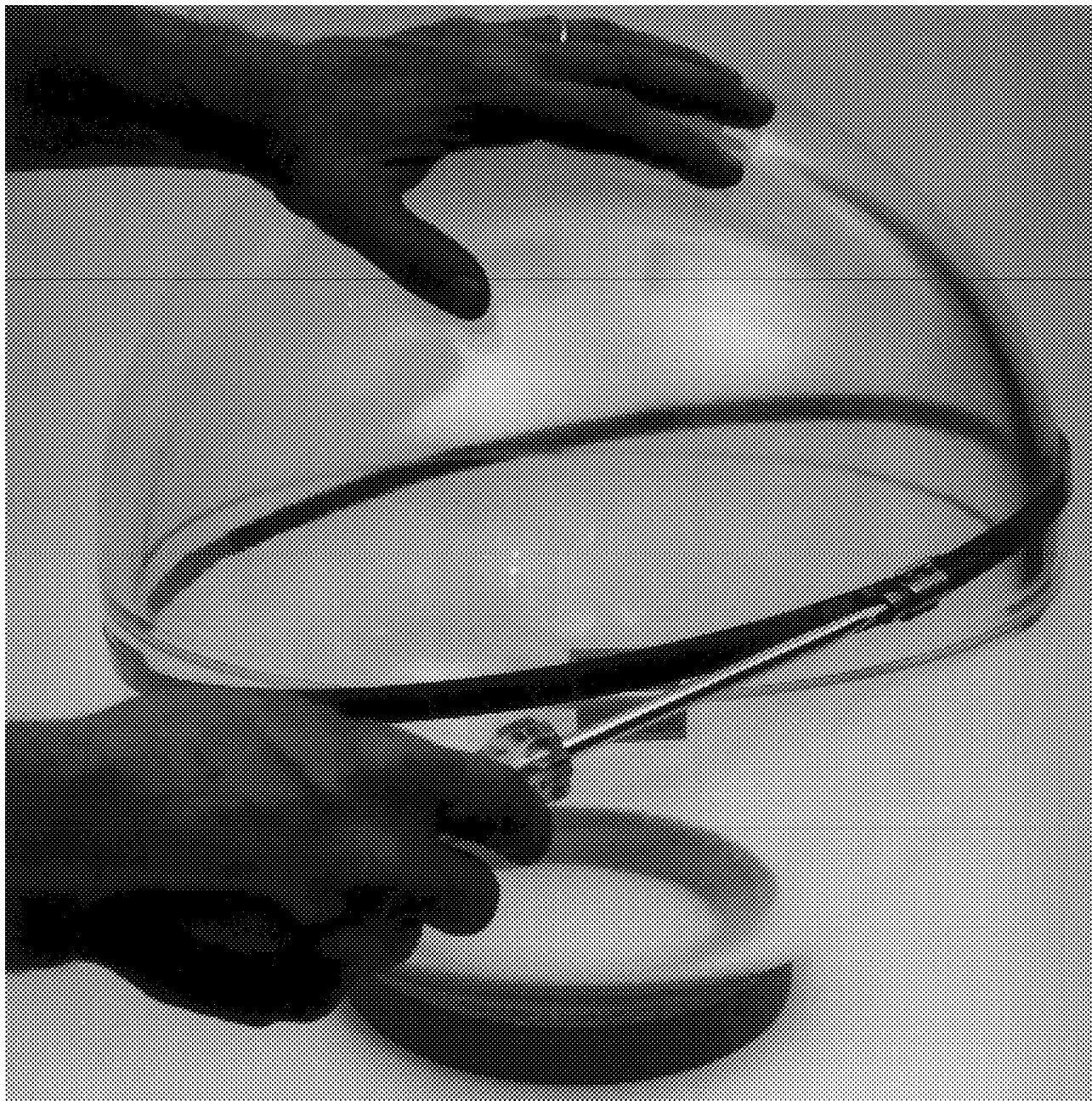


Figure 6-1 Separating the Glass Hemispheres

Changing the Battery Pack

The battery life of the TR-6001 is very long, depending on its use, so rarely will this step be necessary; but if so, it is not difficult to change the battery pack. Replacement battery packs may be ordered from Benthos. Please specify Teledyne Benthos Part No. C-210-301 when ordering.

PROCEDURE:

- a. Open the glass housing by following the steps in Section 6.
- b. Remove the magnet. Place it on the glass, directly above the magnetic switch, and stick it down with a piece of tape.
- c. Wait two or three minutes for the capacitor to fully discharge.
- d. Unplug the reed switch and penetrator wires making note of their locations.
- e. Remove the 8 outer screws holding the electronic/battery plate to the spacers. Now lift out the electronic/battery packs assembly.
- f. Unplug the old pack(s) and remove the $\frac{1}{4}$ -20 hardware holding the pack(s) to the mounting plate. Discard used battery pack(s) in accordance to local regulations.
- g. Install new battery pack(s) and re-secure to plate with $\frac{1}{4}$ -20 hardware. Dry out or replace the desiccant packs if they are pink in color. Re-install electronic/battery plate assembly using the 8 outer screws.
- h. Verify magnet is still taped over the magnetic reed switch. Re-connect battery connection(s) (see Figure 6-2) and all remaining P.C. board connections.

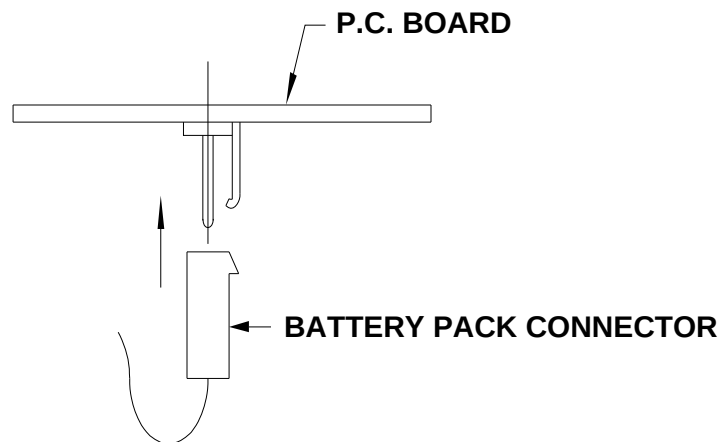


Figure 6-2 Proper Connector Orientation

- i. Remove the magnet and listen for the power-up ping after about three seconds.
- j. Close the glass housing following the instructions in the next section.

Closing the Glass Housing

- a. **Important:** Close the sphere in as "dry" a room as possible, preferably an air conditioned area. Avoid closing in a hot, humid environment, because in the low temperature deep ocean, much of this moisture will condense and may cause serious electrical problems.
- b. Very thoroughly clean off the precision ground mating surfaces of both hemispheres. Use a non-residue forming industrial solvent or Isopropyl alcohol. CLEANLINESS IS VITAL!
- c. Align the match arrows and gently place the two hemispheres together.
- d. Slide the hemispheres slightly apart so that there is a gap. Using a hair dryer or a heat gun, blow hot air into the sphere for about 15 seconds.
- e. Immediately slide the halves back together, keeping the match arrows lined up. You will notice a considerable vacuum force now holding the halves together.
- f. Gently tap the halves in place with the palm of your hand in such a way as to get the best possible "match" at the equator. That is, with the match arrows lined up, try to minimize the overhangs at the equator.
- g. Now thoroughly clean the outside of the equator area using a industrial solvent. Again, CLEANLINESS IS VITAL!
- h. Wrap the soft butyl sealant strip (Benthos Part No. 0900-024) around the joint at the equator, keeping the paper on the outside. Carefully cut the strip so the ends butt together. Do not overlap the ends.
- i. Still keeping the paper on, roll the sealant strip so that it flattens out to approximately double its width at starting. This may be done with a small roller. Be careful that the two halves do not slide during this operation.
- j. After rolling, make certain that the strip is still centered on the glass joint and the sealant has fused together at the ends.
- k. Remove the paper from the sealant strip.
- l. Apply three complete turns of the wide black tape (Teledyne Benthos Part No. 0903-013), centering the tape on the sealant strip. Stretch the tape as it is being wrapped so that it conforms to the curvature of the glass. Rub the tape smooth using hand pressure.
- m. Replace the hose clamp assembly, centering the ring around the transducer. Carefully tighten the adjustment screws. Do not over tighten.

7 Return Procedures

If you need to return a TR/XT-6001 Acoustic Transponder for warranty service, contact Teledyne Benthos, Inc. for a **Return Material Authorization (RMA)** number and shipping instructions.

Teledyne Benthos, Inc.
Tel: 508-563-1000
Fax: 508-563-6444
e-mail: benthos@teledyne.com

You will need to provide the following information to receive a **Return Material Authorization (RMA)**:

- **Reason for return**
- **Number of beacons to be returned**
- **Serial number of each unit**
- **Shipping method, if applicable**

NOTE: Do not return a unit without a **Return Material Authorization**.

8 Warranty



approved 3/27/06

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