WorkHorse Installation Guide

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RD Instruments
Acoustic Doppler Solutions

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WorkHorse Installation Guide

1 Introduction

This book is a *guide* for installing the WorkHorse on a buoy, bottom mount, or vessel. Use this section to plan your installation layout. You can also use this book to see what requirements you must consider before purchasing an ADCP. We recommend you distribute this information to your organization's decision-makers and installation engineers.

We are not experts in installing the ADCP aboard a ship. There are too many installation methods. We suggest you seek expert advice in this area because of its importance in ADCP performance. However, we can give you information about how others have installed their systems. In return, we do appreciate receiving information about your installation and the results.

CAUTION. Always use caution when mounting the ADCP. Never rest the transducer head on a rough surface. Use foam padding to protect the transducers during handling.

NOTE. When an addition or correction to the manual is needed, an Interim Change Notice (ICN) will be posted to our web site on the Customer Service page (www.rdinstrument.com). Please check our web site often.

NOTE. For other resources, see our web site at www.rdinstruments.com.

2 Bottom Mounts

Bottom mounts can range from simple PVC frames to Trawl Resistant Bottom Mounts. Below is a sample of some of the types of bottom mounts available for WorkHorse ADCPs.

Figure 1. RD Instruments Bottom Mount

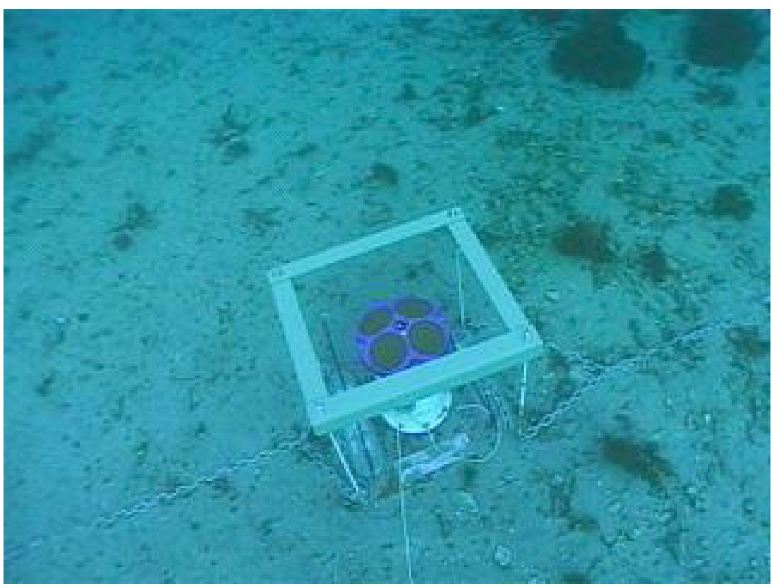


Figure 2. View from the Bottom

Photo courtesy of John Skadberg, US Navy SPAWAR System Center in San Diego, CA. Sent to RDI by Steve Monismith.

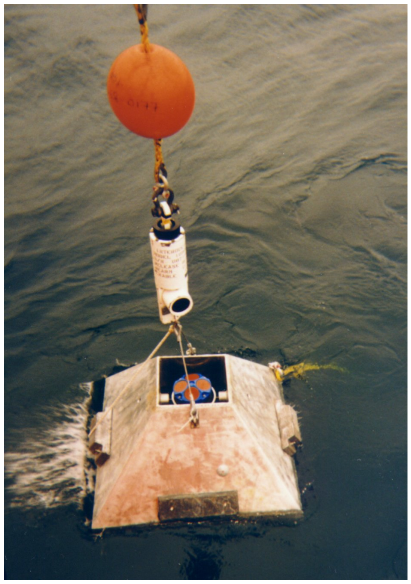


Figure 3. Bottom Mount being Deployed

Photo courtesy of Richard Dewey, UNIZ. The ADCP is deployed in the Juan de Fuca Strait.

Figure 4. Trawl Resistant Bottom Mount

Photo courtesy of J. Bornhoeft.

3 Buoy Mounts and Load Cages

Buoy mounts and load cage frames are designed to allow the Workhorse to profile unobstructed by the mooring hardware. Below is a sample of some the types of buoy and load cage mounts available for WorkHorse ADCPs.

Figure 5. Subsurface Buoy

Photo courtesy of Patrick Lefeuvre, Technicap. The Subsurface buoy was developed by BMTI and Technicap.

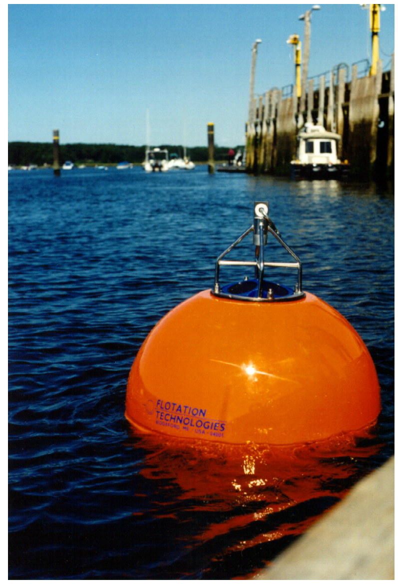


Figure 6. Buoy Mount

Photo courtesy of Flotation Technologies.

Figure 7. Load Cage

Photo courtesy of Angela Cates, UNM.

4 Over-the-Side Mounting

The over-the-side mount is common if you want the ability to move the ADCP from one ship to another. You must make the mount as rigid as possible to limit the amount of pitch and roll applied to the ADCP. Although the tilt sensor can measure a ±20° influence, anything beyond 15° will cause bias to the data that cannot be removed. No matter what mounting type used, the ADCP must be below the bubble layer. Bubbles will cling to the urethane faces of the ADCP and reduce the range to almost nothing. Usually a mount somewhere aft of amidship is used. A stern mount will cause all sorts of problems due to propeller wake, bubbles, and turbulent water conditions.

NOTE. Avoid using ferro-magnetic materials in the mounting fixtures or near the ADCP. They affect the compass. Use 304 stainless steel for fresh water and 316 stainless steel for salt-water applications.

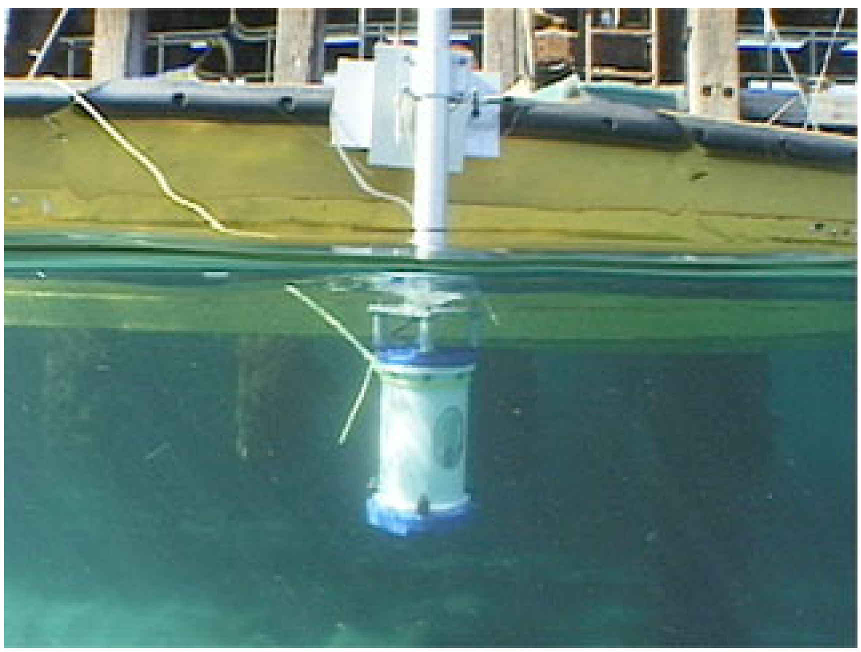


Figure 8. Over-the-Side Mount

Photo courtesy of John Skadberg, US Navy SPAWAR System Center in San Diego, CA. Sent to RDI by Steve Monismith.

4.1 Floating Objects

Our transducer assembly is sturdy, but we did not design it to withstand collisions with all floating objects. We strongly suggest you use the in-hull mount (see "In-Hull Mounting," page 7) if this is a possibility.

4.2 Example of an Over-the-Side Mount

When mounting the ADCP to a boat, use the following sequence.

- Test the ADCP
- Align the compass
- Mount to the vessel (Figure 9 shows an ADCP mounted to a boat).

1. Hand winch with cable or rope.
2. Boat cleat to tie off the lower end of the channel.
3. Aluminum channel, 5" base x 2" high x 3/16" thick. You need to determine how long the channel needs to be as the drawing is not to any scale. The channel should be notched for the end-cap flange of the Housing Assembly. This will give the system a positive lock after the ADCP has been strapped to the channel.
4. Pivot housing - This could be a very heavy one-piece bent housing, or a three-piece assembly. Bolt the pivot housing to the deck of the boat (or buoy).
5. Nylon strap clamps - Two clamps are needed. Place some rubber or foam between the housing and the aluminum channel before clamping to protect the ADCP.

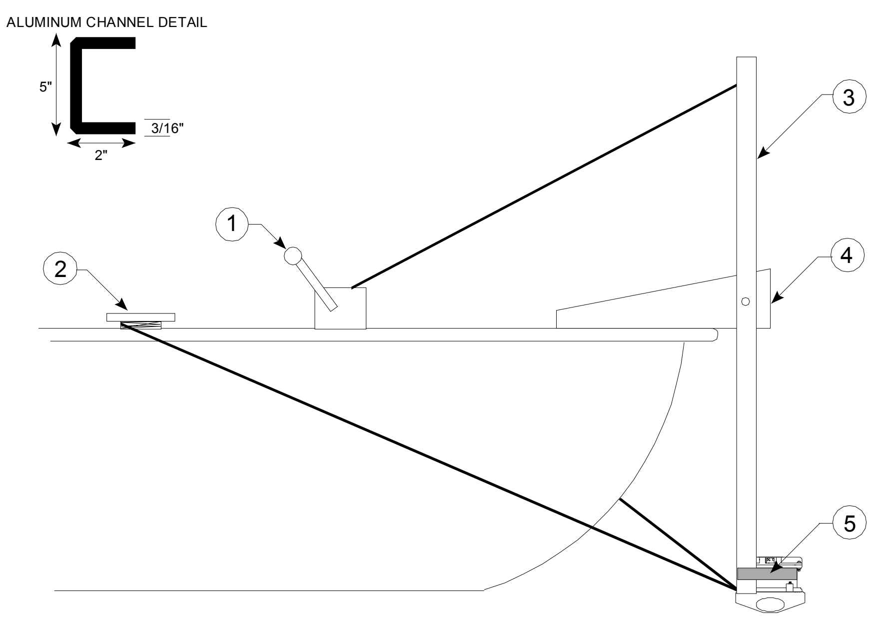


Figure 9. Mounting an ADCP to a boat

4.3 Over-the-Side Mounting Special Considerations

Use the following suggestions when mounting the ADCP to a moving platform.

- It is desirable to rigidly mount the ADCP to the vessel. You want to avoid the free spinning of the ADCP in this application. The ADCP must stay in the water at all times.
- The ADCP must be mounted deep enough so that turbulence caused by its movement through the water does not allow air bubbles to be attached to the transducer faces.
- Avoid mounting the ADCP near motors and thrusters. They cause air bubbles and will cause bias to the internal compass.
- Avoid mountings that will cause the ADCP to see severe accelerations.

5 In-Hull Mounting

The in-hull mounted ADCP is common when it is intended to keep the system on a single vessel or when over-the-side mounting is not practical for your vessel. For this type of mounting, there are issues of beam clearance and access.

5.1 Transducer Head Mounting Considerations

You must consider several potential problems before installing the transducer head assembly. Read this section before deciding where to install the transducer assembly. See the outline installation drawings for specifications on our standard ADCP transducer heads.

5.2 Location

Ideally, you want to install the transducer head:

- Where it is accessible both internally (for access to transducer electronics) and externally (to remove biofouling).
- Away from shipboard protrusions that reflect ADCP energy. Allow for a reflection-free clearance of 15° around each beam (see the outline installation drawings).
- Away from other acoustic/sonar devices, especially those operating at the same frequency (or harmonic) of the ADCP.
- Close to the ship's fore-to-aft centerline. As distance from the centerline increases, vertical accelerations caused by the roll of

the ship also increase. These accelerations can cause additional uncertainties in ADCP velocity measurements.

Other considerations may be:

- Ease of installation.
- Portability (wanting to move the instrument from vessel to vessel).
- Permanent installation.

With all of these choices there are good and bad points. We will show you several options for installation and then go through specific concerns that you may have to deal with once you install or mount the ADCP.

5.3 Sea Chest In-Hull Mounting

A sea chest (Figure 10 and Figure 11, page 9) is a fixture that surrounds and holds the transducer head, protecting it from debris in the water. The bottom of the sea chest must be open to seawater to allow the acoustic beams to pass through freely. If using a sea chest interests you, call us for the latest information. Ask for Application Note 7 - Conceptual Design of a Sea Chest for an RDI ADCP Transducer.

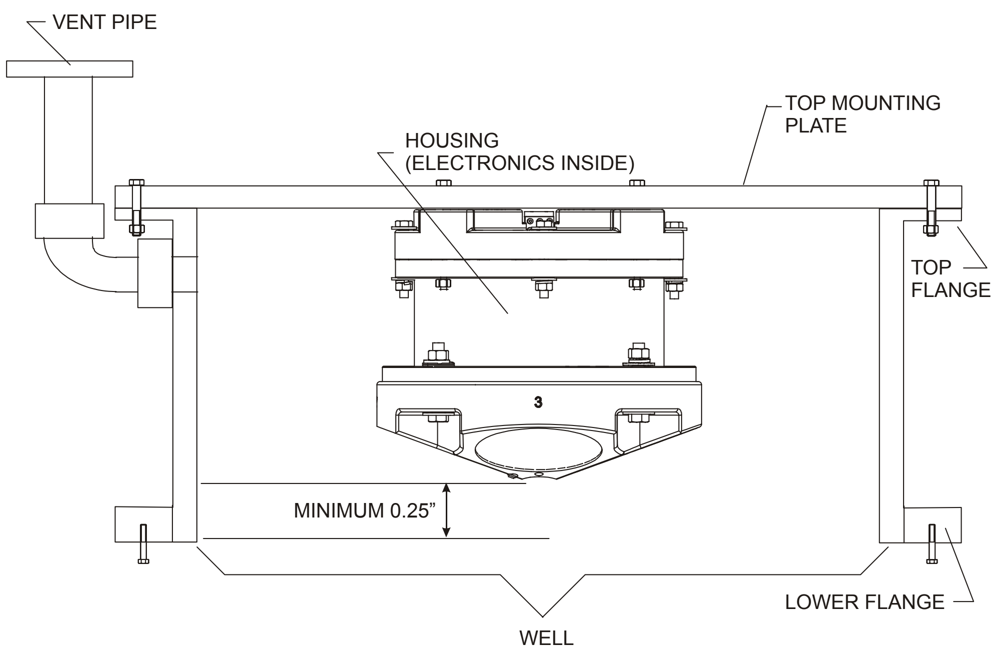


Figure 10. Sea Chest Mounted Transducer (Without an Adapter Plate)

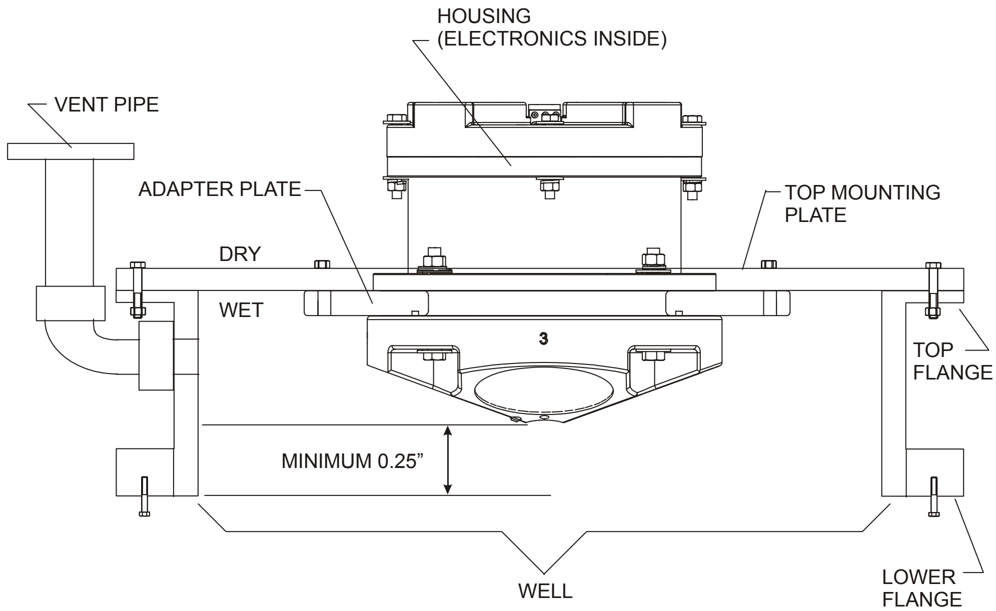


Figure 11. Sea Chest Mounted Transducer (With Mariner Adapter Plate)

NOTE. For instructions on how to install the Mariner Adapter Plate, see the Maintenance Guide.

5.4 Mounting Considerations

Now that we have shown you the main methods of mounting the ADCP, you must be aware of issues that may cause reduction in range, biased data, fouling, and other performance related considerations.

5.4.1 Orientation

We recommend you mount the transducer head with Beam 3 rotated to a ship-relative angle of 45° (Figure 15, page 32 shows beam orientation). This causes the magnitude of the signal in each beam to be about the same. This improves error rejection, reduces the effect of ringing (see "Acoustic Isolation," page 15), and increases the ADCP's effective velocity range by a factor of 1.4. If you align Beam 3 at an angle other than zero, you must nullify this offset. You can do this using a direct command (see the Workhorse Technical Manual) or through our *VmDas* program.

Use the ship's roll and pitch reference to mount the transducer head as level as possible. If the head is not level, depth cell (bin) mapping will be incorrect. Large misalignments can cause large velocity measurement errors. If you cannot mechanically make the transducer head level, you can use *VmDas* to enter offset values for roll and pitch.

5.4.2 Fairing

A fairing is a structure that produces a smooth outline and reduces drag or water resistance. The fairing also diverts floating objects away from the transducer. A fairing that is shaped like a teardrop, slopped such that the leading edge (closer to the bow) is higher than the back edge, and extends below the hull (typically 12 inches) will divert the air bubbles away from the transducer faces.

5.4.3 Acoustic Window

While we do not fully understand windows, we do believe that windows can be used to produce overall performance improvements in vessel-mounted ADCPs. Additionally, if the ship operates where there is danger of barnacle damage or a high density of ice or other floating objects, then the use of an acoustic window is the only option.

It is theoretically possible to use a window successfully, however there are several advantages and disadvantages to consider before using an acoustic window.

Advantages

- Well will not fill with air bubbles caused by the ship moving through the surface water, see “Sea Chest In-Hull Mounting,” page 8
- Flow noise is reduced, see “Flow Noise,” page 14.
- The well can be filled with fresh water to limit corrosion.
- Barnacles can not grow on the transducer faces. Barnacle growth is the number one cause of failure of the transducer beams.
- The transducer is protected from debris floating in the water.

Disadvantages

- The range of the ADCP will be reduced because the window can and will absorb some of the transmit and receive energy.
- The transmit signal could be reflected into the well, causing the well to “ring” like a bell. This will cause the data being collected during the ringing to be biased. Some ships have reported a loss in range as great as 50 meters. The ringing may be dampened by applying sound absorbing material on the well walls (RDI does not have any recommendations for sound absorbing material), see “Ringing,” page 14.
- The transmit signal could be reflected off the window and back into the other beams.

Our experience has allowed us to put together some minimum specific recommendations:

Window orientation. The acoustic window should be flat and parallel to the transducer mounting plate. Note this is not an absolute requirement. However, if the water temperatures inside the window and outside the window are not the same, all four beams will be refracted and actual velocity components will be rotated into a new coordinate system. In particular, some of the horizontal velocity will appear as a vertical velocity.

Window material. Important acoustic properties of the window include acoustic refractive index (which should be as close as possible to that of water), insertion loss (which should be as small as possible) and speed of sound. There are two acoustic refractive indices: one for shear waves and one for plane waves. The acoustic refractive indices are simply the ratios of speed of sound in water to speed of sounds in the material. Insertion loss combines absorption and reflection of sound, and it depends on both the thickness and the material properties of the window. In particular, you should avoid using window thickness equal to odd multiples of shear mode quarter-waves (Dubbelday and Rittenmeyer, 1987; Dubbleday, 1986). Refer to Selfridge (1985) and Thompson (1990) for more information. Note that the speeds of sound in plastics decrease with increasing temperature and that causes the resonant frequencies to shift. This can be a large effect. Neither Selfridge nor Thompson has much information on the temperature coefficients of sound speeds.

Our experience has shown that Polycarbonate windows are very good for the Ocean Surveyor/Observer (OS), WorkHorse (WH), and Broadband (BB) ADCPs. The thickness of the materials depends on the frequency you intend to use. Table 2 will help to choose the maximum thickness you should use.

NOTE. One concern with window selection is that it be able to support the weight of the water inside the well once the ship is dry-docked. RDI recommends that you always fill/drain the well at the same time that you are either filling/draining the dry dock area.

Table 1: Window Thickness

Frequency	Recommended Thickness	Maximum Thickness
75	1 inch	2 inches
300	0.5 inches	1 inch
600	0.25 inches	0.5 inches
1200	0.25 inches	0.5 inches

Spacing between window and transducer. The primary geometrical factor in design of windows is the reflection of one beam into another beam, causing crosstalk between the beams. The distance from the window should be at least 0.25 inches and no more than 0.5 inches for optimal setup.

Window aperture. The window aperture must be sufficient to pass the beams without causing diffraction. If the window is placed next to the transducer, then the aperture diameter should be the same as the distance between transducer cup corners. If the window is placed away from the transducer, then the aperture should be larger than all four beams plus about one transducer ceramic diameter.

5.4.4 Free Flow and Windows

If filling and draining the well is an issue, then you may want to use a window but allow the water to freely exchange from outside the well to inside the well.

Our Japanese representative uses 0.25 inch thick Low Density Polethylene (LDPE). He then drills two 30mm holes in the window along the edges. The inside walls are painted with anti-fouling paint. This allows the water to be full of anti-foulant during the time the ship is docked, which is when the barnacle growth occurs. The holes allow the water to exchange when the ship is in motion and allows for draining when the ship is dry-docked (a 0.25” window will not support the weight of the water). He has never had a failure with the window, and has seen only a minimal loss in range (5-30 meters).

It is best if the window is parallel to the bottom edge of the transducer cups. The transducer cups are at a 30° angle. If the window is at an angle to the transducer, it will change the absorption. We do not have experience with different angles, but we have had customers use domes or have the window follow the contour of the ship bottom without real problems.

The optimum distance for the bottom of the transducer assembly from the window is 0.25 inches ±0.125 inches. Never allow the transducer to touch the window. The farther away the transducer cups are from the window, the more the sound is reflected off of one beam and then reflected into another beam.

Acoustically-absorbing sea chest liner. A sound absorbing material should be used inside the sea chest to minimize the effects of sound ringing within the sea chest. The material should be a minimum of one wavelength thick (include the sound speed of the absorbing material when calculating the size of a wavelength). Approximate wavelengths of sound in seawater are given below in Table 2, page 13. We do not have sufficient experience to recommend a specific absorbing material.

Table 2: Wavelength of sound in seawater (1500 m/s sound speed)

FREQUENCY (kHz)	WAVELENGTH (mm)
75	20
300	5
600	2.5
1200	1.25

Fluid in the sea chest. The sea chest should be filled with fresh water. Seawater can be used, but at the cost of increased corrosion. Seawater should not be circulated through the sea chest because it will encourage growth of biofouling organisms. The pressure within the sea chest should be adjusted to keep the window from bowing in and out, and thereafter, the volume should be kept constant.

Transducer calibration. The factor used to correct velocity for speed of sound variations should be based on the speed of sound of the fluid inside the sea chest. Changes of speed of sound resulting from temperature changes may be computed from the temperature sensor on the transducer.

5.4.5 Air Bubbles

Design your installation to minimize the volume of air bubbles in the path of the acoustic beams. Air bubbles attenuate (weaken) the signal strength and reduce the ADCP profiling range. Ships with a deep draft or a non-flat bottom have fewer problems with bubbles. Ways to reduce bubble flow vary with ship characteristics, but two options are available. Mount the transducers below or away from the bubble layer.

- The flow layer is usually within the first two feet below the hull. Bubbles can get trapped in this layer. Mounting the transducer head amidship on the fore-to-aft centerline may help. For ships with propulsion systems that make large amounts of bubbles, use a mounting technique that lets you lower the transducer head below the hull while underway.

> **NOTE.** If you use locally made or existing extension hardware instead of the hardware available from RDI, you may need to make an adapter plate to connect your hardware to our transducer head. Please call us for the exact dimensions and layout of our transducer head bolt holes for your system.

- Divert the bubble layer so it flows around the transducers - You can use fairings to alter the bubble flow. An acoustic window (see "Acoustic Window," page 10) may help reduce the bubble problem, but can cause ringing (see "Acoustic Isolation," page 15) and attenuation problems.

5.4.6 Flow Noise

Water flowing over the transducer faces increases the acoustic noise level, which decreases the profiling range of the ADCP. You can reduce the flow across the transducer faces with a sea chest, fairing, or acoustic window.

5.4.7 Corrosion and Cathodic Disbondment

Your ADCP is made of plastic and uses titanium bolts. The adapter plate (if used) may be naval bronze, aluminum, or other materials. Although the plastic ADCP will not corrode, the bolts and adapter plate may corrode.

Never attach anodes directly to the transducer head. Standard anode protection used for the ship should be installed outside of the well of the transducer head. Mounting of ship's standard anode protection outside of the transducer well will typically protect the parts that may corrode. However, you should plan regular inspections of mounting hardware and the adapter plate for signs of corrosion. Replace and parts that are questionable (corrosion can be further reduced if the well is covered with a window and then filled with fresh water).

5.4.8 Ringing

The ADCP transmits an acoustic pulse into the water. The main lobe of this pulse bounces off particles in the water and the signals returned from these particles are used to calculate the velocity of the water.

As stated, the main lobe of the transmitted pulse is what we are using to process and calculate a velocity. The transmitted pulse, however, is made up of many side lobes off the main lobe. These side lobes will come in contact with metal of the transducer beam itself and other items in either the water or the well.

The energy from the side lobes will excite the metal of the transducer and anything bolted to the transducer. This causes the transducer and anything attached to it to resonate at the system's transmit frequency. We refer to this as "ringing."

If the ADCP is in its receive mode while the transducer is ringing then it will receive both the return signals from the water and the "ringing." Both of these signals are then processed by the ADCP. The ringing causes bias to the velocity data.

All ADCPs "ring" for some amount of time. Therefore, each ADCP requires a blanking period (time of no data processing) to keep from processing the ringing energy. Each ADCP frequency has a different typical ringing duration. The typical ringing period for each ADCP frequency is as follows; 75kHz is 8 meters, 300kHz ADCPs is 2 meters, 600kHz ADCPs is 1.5 meters, and 1200kHz ADCPs is 0.8 meters. These typical ringing values are recommended as the minimum setting for all ADCPs using default set-ups.

It should be noted, on some installations the effects of ringing will last longer than the recommended settings above. For example, the effects of ringing will last longer if the transmit signal becomes trapped inside the transducer well. This can occur because the well itself is ringing with the transducer or when windows covering the opening of the well reflect the signal back inside the well.

The window causes the transmit signal to reflect back into the well due to the difference in impedance between the window and the water. When the transmit signal is reflected in the well it becomes trapped and this results in longer ringing periods. To keep from processing this signal, the blanking period must be increased.

Lining the inside walls of the well with a sound absorbing material aid in dampening the ringing effect.

5.4.9 Acoustic Isolation

Try to minimize the acoustic coupling between the transducer head and the ship. Without adequate acoustic isolation, the transducer output will “ring” throughout the ship and feeds back into the ADCP receive circuits. Ringing causes bias errors in water-track velocities and results in the loss of data in the closest depth cells (bins). Reflections inside a sea chest with an acoustic window also can cause ringing.

You can attain acoustic isolation several ways. At a minimum, use gaskets to isolate all contact points between the ship and the transducer head. Design your installation for:

- A minimum number of contact points between the transducer head and the ship.
- Minimal contact area.
- Single points of contact for positioning and support (when possible).

You also should try to separate the transducer head from the ship using intermediate connections. This is because direct connections transfer the most acoustic energy. Texas A & M used the following installation technique and had minimal ringing problems.

- Transducer mounted to a thin steel plate
- Steel plate positioned with three pins set into mounting holes on the hull; pins isolated with gaskets
- Steel plate held in place with four I-beams welded to a frame

- Frame bolted to another frame and separated by gaskets
- Second frame bolted to the ship and separated by gaskets

Acoustic isolation from other acoustic devices on the ship is also necessary. You can do this using the following techniques.

- Mount the other acoustic devices as far apart as possible.
- Make sure neither the main lobes nor the side lobes of the acoustic devices point at the transducers, including acoustic reflections.
- Try not to operate devices that use the same frequency or a harmonic of the ADCP's frequency.

5.4.10 Maintenance

The Maintenance book explains routine maintenance procedures. You rarely need access to the electronics inside the transducer head. However, one external maintenance item is important enough to mention here as it may affect how you install the transducer head.

Objects deployed within about 100 meters (328 feet) of the surface are subject to the buildup of organic sea life (biofouling). This means WorkHorse ADCPs are subject to biofouling. Soft-bodied organisms usually cause no problems, but hard barnacle shells can cut through the urethane transducer face causing transducer failure and leakage into the ADCP (see Figure 12).

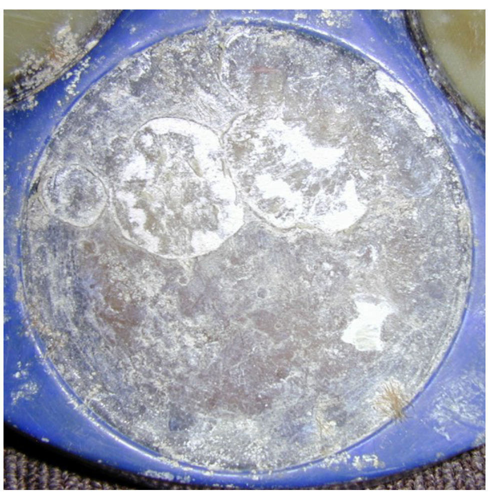


Figure 12. Barnacle Damage to Urethane Face

The best-known way to control biofouling is cleaning the ADCP transducer faces often. However, in many cases this is not possible. The other alternatives include the use of a window or some sort of anti-foulant protection.

Some of our users have had success applying a thin coat (≈4 mm; ≈0.16 in.) of either a 50:50 mix of chili powder and Vaseline or chili powder and silicone grease to the transducer faces. The chili powder should be the hottest that can be found. Water flowing across the transducers will wash this mix away over time. The silicone mixture tends to last longer.

Some organizations may decide to use antifouling grease. However, most antifouling greases are toxic and may cause problems. Recent tests suggest antifouling grease may cause the urethane on the transducer faces to develop cracks. Warmer temperatures accelerate this effect.

The other method is to use antifoulant paint. At present, we recommend the following antifouling paint manufacturer and paint brand: Courtalds Finishes Interlux brand paints, US Telephone: 908-686-1300, Web Page: www.interlux.com.

CAUTION.

1. Read the Material Safety Date Sheet before using any of the listed solvents and paints.
2. Some antifouling coatings may not be legal for use in all areas. Check with your local environmental agency before using the antifouling paint.
3. Do not arbitrarily use antifouling paints. Be aware that antifouling paints can accelerate the dezincification corrosion of brass. Once initiated, dezincificatioin will rapidly destroy the brass.
4. RDI no longer recommends the use of Nopcocide for the prevention of biofouling. If using antifouling grease, remove it immediately after recovering the ADCP.
5. Antifouling grease is toxic. Read the product safety data sheet before using the grease. Wear gloves and a face shield when applying the grease. If the skin comes in contact with the grease, immediately wash the affected area with warm, soapy water.
6. When possible, do not coat the transducer faces with cuprous oxide or related paints that contain chemicals such as copper, chrome, or arsenic. These paints advance the corrosion of the transducer assembly and will cause the urethane to separate from the transducer cups.
7. All US Coastal States prohibit the use of tributyl-tins on boat hulls. The European Economic Commission has released a draft directive that would prohibit the use of many organo-tins after July 1989. We strongly recommend you obey your local laws.

5.4.11 Mariner Deck Box Mounting Considerations

Place the Mariner Deck Box (see “Outline Installation Drawings,” page 39) where there is access to the I/O cable, host computer, gyro interface cable, and navigation interface cable. The chassis needs an input voltage of 90 to

260 VAC or 12 VDC to operate (see "Power Considerations," page 28). Allow enough room around the Deck Box for access, ventilation, and isolation from electronic and magnetic interference.

5.5 Cabling Considerations

Several cables connect to the ADCP system (see Figure 13). Use care when routing these cables through bulkheads, deck plates, cable runs, and watertight spaces. Make allowances in cable length and engineering design plans for cable routing. When necessary, use strain reliefs on the cables.

The input/output (I/O) cable connects the transducer head to the deck box (Mariner systems) or computer. We deliver the cable with both connectors attached. The transducer-end connector is molded on, so you can use it below the waterline. The cable is custom-made in lengths specified by the user. Route this cable so:

- You can install it with the connectors attached.

> **NOTE.** You can order the cable with the chassis-end connector removed. This allows easier cable routing, but requires you to solder the cable connections at your installation site. This is a difficult task.

- It does not have kinks or sharp bends.
- You can easily replace it if it fails.

Other cables that may need routing to the chassis include the computer interface, the navigation interface, and the gyro interface.

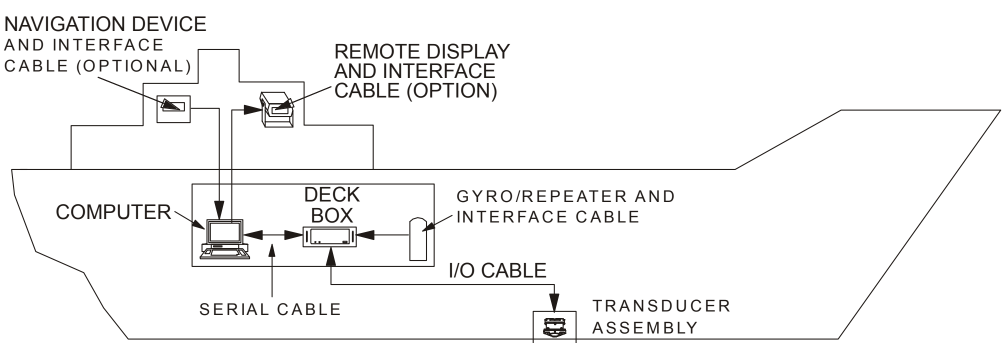


Figure 13. Typical Mariner Interface Cable Layout (Overview)

> **NOTE.** See the appropriate ADCP User's Guide for a detailed view of the cable connections.

6 Computer Considerations

We designed the WorkHorse ADCP to use a Windows® compatible computer. The computer controls the ADCP and displays its data, usually through our *WinSC*, *WinADCP*, *VmDas* or *WinRiver* programs. Table 4 lists the minimum computer requirements.

NOTE. It is highly recommended that you download and install all of the critical updates, recommended updates, and the service releases for the version of Windows® that you are using prior to installing any RDI software.

Table 3: Minimum Computer Hardware Requirements

Windows® 95 (see note below), Windows® 98, or Windows® NT 4.0 with Service Pack 4 installed, Windows® 2000, Windows® XP
Pentium class PC 233 MHz (350 MHz or higher recommended)
32 megabytes of RAM (64 MB RAM recommended)
6 MB Free Disk Space (20 MB recommended)
One Serial Comport (two or more High Speed UART Serial Comports recommended)
Minimum display resolution of 800 x 600, 256 color (1280 x 760 High Color recommended)

NOTE. VmDas has special requirements – see the VmDas User's Guide for detailed information on system requirements.

The computer configuration varies depending of the number of communication ports and the external data refresh rate. Serial communications require a lot of processor resources, and the minimum requirements can vary. A good quality video card is required to operate *VmDas* and *WinADCP* simultaneously. We do not use graphic card 3D functions, however, video memory is needed to display all graphics.

However, with experience we can recommend that:

- If you are using more than two communication ports, you should not use a Celeron processor.
- Intel Pentium III processors work best to operate the ADCP and give access to the display and keyboard without losing ensembles.

7 Gyrocompass Interface Considerations

NOTE. The Gyrocompass Interface is available only for Mariner ADCPs using the Deck Box. If you are using a NMEA external device, see "Navigation Interface Considerations," page 28.

There are two ways to interface sensor data such as heading, pitch, and roll information with the ADCP data, either by analog signal input or by a serial ASCII input.

- Single- or multi-turn synchro heading outputs and single-turn synchro tilt sensor outputs for pitch and roll or
- Stepper heading outputs and single-turn synchro tilt sensor outputs for pitch and roll.
- Serial ASCII data input to the host computer running the RDI ADCP software that conforms to one of the following NMEA standards.
- $_ _ HDT (NMEA 0183 standard of true heading only)
- $_ _ HDG (NMEA 0183 standard of magnetic heading only)
- $PRDID (RDI proprietary NMEA string supporting heading, pitch, and roll)

The analog input is read by the Gyro Interface board in the Mariner Deck Box, and converted to a serial NMEA string to be used by the *VmDas* program at one of the COM ports. The advantage to these options is that gyro outputs can be used on vessels where flux-gate heading sensors and pendulums cannot. This is due to the effects from the hull on a flux gate compass and the accelerations of the ship on pendulum pitch and roll sensors. Table 4, page 21 lists the gyro interface options.

Use the RD-SIC-0 option when only stepper heading is available. Use the RD-SIC-1 option when either synchro or stepper heading is available. This option supports single-turn (1:1), multi-turn (36:1, 90:1, 360:1), and stepper voltage outputs from a ship's gyro or portable gyro. Use the RD-SIC-3 option with a gyro capable of resolving motion across the vertical plane (i.e., tilt synchro gyro). With the RD-SIC-3 option, you can use:

The Gyro Interface board uses up to three synchro-to-digital converter chips, a resistor network is used to configure the board for the input synchro stator voltages, and a DIP switch is used to configure the board for the turns ratio of a specific gyro. The Gyro Interface board supports a wide range of input synchro frequencies (50, 60, and 400 Hz).

We usually configure the Gyro Interface board at the factory to customer specifications for synchro stator voltage and gyro turns ratio. Table 5, page

21 lists the acceptable standard configurations. For us to configure the board you must provide us with either the Stepper

Sometimes, though, the customer chooses to use a gyro other than the one originally specified. Because of the need to change the gyro interface configuration "in the field," we provide technical information below.

Table 4: Gyro Interface Options by Model

Inputs allowed	Natel chips	Typical use
1 (RD-SIC-0)	0	Stepper heading only
1 (RD-SIC-1)	1	Synchro/Stepper heading only
3 (RD-SIC-3)	3	Synchro/Stepper heading, AND Synchro-only pitch and roll

Table 5: Acceptable Gyro Interface Configurations

Gyro Heading Input (Synchro)	
Frequency Input	50Hz, 60Hz, or 400Hz
Stator Voltages	Through a variable scaling resistor package, the stator voltage can vary. Starting with a minimum voltage of 11.6 volts RMS, the most common voltages are 11.8, 26, 50, and 90 volts RMS.
Reference Voltages	20 to 150 VAC
Turns Ratios supported	Through a selectable DIP switch, the turns ratio can be 1:1, 36:1, 90:1, and 360:1
Gyro Heading Input (Stepper)	
Input Voltages	Most common ranges are from 35 to 70 VDC, with a positive or negative common. On special request, other voltages may be possible.

Stepper Ratio	Only a 6-step gyro can be used, where each step stands for 1/6 of a degree. See table below.
	`ST0 ST1 ST2  DEGREE`
	`1   1   0   (0/6) 0.000`
	`1   0   0   (1/6) 0.167`
	`1   0   1   (2/6) 0.333`
	`0   0   1   (3/6) 0.500`
	`0   1   1   (4/6) 0.667`
	`0   1   0   (5/6) 0.833`

Gyro Tilt Input (Synchro Only)	
Input Frequency	50Hz, 60Hz, or 400Hz
Stator Voltages	Through a variable scaling resistor package, the stator voltage can vary. Starting with a minimum voltage of 11.6 volts RMS, the most common voltages are 11.8, 26, 50, and 90 volts RMS.
Reference Voltages	20 to 150 VAC
Turns Ratio	1:1 only
Output Types (ASCII Only)	
Baud Rate	9600
Parity	None
Data Bits	8
Stop Bits	1
String Format	$PRDID,±PPP.PP, ±RRR.RR,HHH.HH (where P is for pitch, R is for roll, H is for heading. All are in decimal degrees.

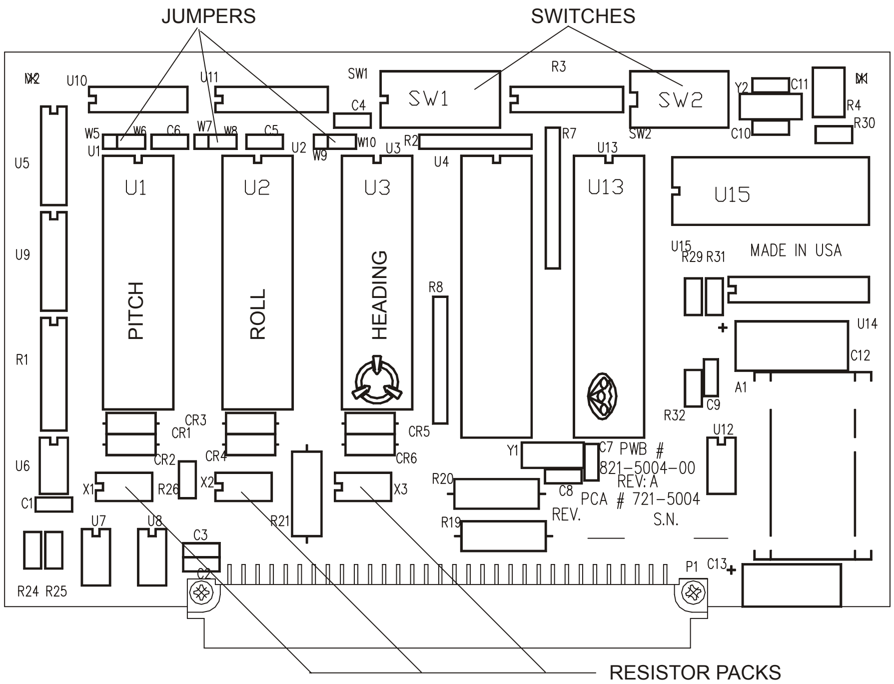


Figure 14. Gyro Interface Board

7.1 Determining the Synchro Stator Voltage

The best way to find the synchro stator voltage is to use the value listed in the gyro manual. If the manual does not list this value, you can determine the stator voltage by using an AC voltmeter and doing some calculations. After finding the stator voltage requirements, you will install one or more scaling-resistor packs on the Gyro Interface board. If you already know the stator voltage requirements, skip the rest of this section and go to "Determining the Size of the Scaling-Resistor Pack," page 23 to find the size of the scaling-resistor pack.

a. With the gyro synchro at a constant angle, measure the AC voltage across the following sets of leads. You must maintain this constant angle during your readings.

1. S1 to S2:______ VAC = S_{12}
2. S2 to S3:______ VAC = S_{23}
3. S3 to S1:______ VAC = S_{31}

b. Calculate the RMS stator voltage, V_S:

$$V_S = \left[\frac{S_{12}^{\;2} + S_{23}^{\;2} + S_{31}^{\;2}}{1.5} \right]^{1/2} = \textit{RMS stator voltage}$$

Usually, V_S will be a common stator voltage (11.8, 26.0, 50.0, or 90.0). If V_S is about equal to one of these values, you can probably assume your gyro is using a common value. If you are unsure of your readings, retake them at a different gyro angle and re-compute V_S. If you know your gyro is using an *uncommon* stator voltage value, you can still modify the scaling-resistor pack value for use with the Gyro Interface board (see "Determining the Size of the Scaling-Resistor Pack," page 23).

Verify the synchro stator voltages are within acceptable limits.

Each stator-pair voltage (S_{12}, S_{23}, and S_{31}) must be less than or equal to V_S.

All pairs of synchro stator voltages must be within the limits given below. For example, the check for one such pair is

$$0.7071 \leq \frac{(S_{12}^2 + S_{23}^2)^{1/2}}{V_S} \leq 1.2247$$

If these voltage checks are not within acceptable limits, then the synchro output is bad, the voltage measurements were incorrect, or the synchro angle was not constant during readings.

7.2 Determining the Size of the Scaling-Resistor Pack

As explained earlier, most synchros use one of the standard synchro stator voltages (V_S) listed in Table 7. The Gyro Interface board will work with any of these voltages by using the associated scaling-resistor pack to adjust the stator voltage input rating to 11.8 VAC.

Table 6: Standard Synchro Stator Voltages and Scaling Resistance

Common synchro stator reference voltages	Scaling resistance
11.8 VAC	0.0 kΩ (jumper)
26.0 VAC	39.2 kΩ, 1/8 W
50.0 VAC	100.0 kΩ, 1/8 W
90.0 VAC	221.0 kΩ, 1/8 W

If the gyro is using non-standard stator voltages, you can find the scaling resistance with the following equation.

$$R = (V_S - 11.8\ \ VAC)\, x\, (2.76\ k\Omega)$$

The tolerance for this can be as large as 10%, but the four resistors in the scaling-resistor pack must be within 0.1% *of one another*. For example, the exact scaling-resistance value for a V_S of 50.0 VAC is 105.4 kΩ. However, resistor values of 100 kΩ are more common. Because this value is within 10% of the calculated value, you can use four 100-kΩ resistors for the scaling-resistor pack if they are within 0.1% of one another.

CAUTION. If you configure the gyro interface board for a lower voltage than the actual synchro stator voltage, you could damage the board or the ADCP.

7.3 Installing the Scaling-Resistor Pack and W-Jumpers

After calculating the size of the scaling-resistor pack, you are ready to install the pack on the Gyro Interface board (Figure 14, page 22). Before you can install the scaling-resistor pack, you may have to change the resistors now in the pack. To do so, pull the resistor pack out of its socket on the Gyro Interface board, unsolder the old resistors, and install the new resistors. When the scaling-resistor pack has the correct resistors soldered in place, re-install the pack in its socket. Also, make sure the appropriate W-jumpers are installed. Table 8 lists the associated resistor sockets and W-jumpers.

Table 7: Natel Chip, Resistor Pack, and W-jumper Sockets

Function	Natel chip socket	Resistor pack socket	W-jumper socket
Pitch	U1	X1	W5
Roll	U2	X2	W7
Heading	U3	X3	W9

7.4 Determining and Setting the Synchro Turns Ratio

The best way to find the synchro turns ratio is to use the value listed in the gyro manual. If the manual does not list this value, you may have to experiment by trying the various settings on the Gyro Interface board. Table 8, page 25 lists the available turns ratios and their switch settings. To set the turns ratio, set the poles of switch S1 on the Gyro Interface board (Figure 14, page 22) to the appropriate position.

If you are guessing, try a 1:1 turns ratio first. The reason you want to use a 1:1 turns ratio is so you do not have to enter a heading bias (or initialization) value in any software program or adjustment on the front panel you are using. That is, whenever you use a *non-1:1 turns ratio* or a *stepper* voltage, it is possible for the Gyro Interface board to be out of alignment with the heading synchro. For example, if the ship's heading is 027° when you initialize the ADCP, the misalignment between the gyro and the Gyro

Interface board will be 27°. When a misalignment condition occurs, you must account for the misalignment either by the front panel set Up/Down buttons, or in the software program you are using. You can use the EB-command (Heading Bias) to align the Gyro Interface board to the gyro if you do not have the ability to initialize the WorkHorse ADCP through he front panel or in the software. Once set, the heading bias value is valid until you turn off the ADCP or gyro.

Table 8: Gyro Interface Switch 1 Settings

Turns ratio	P1	P2	P3	P4	P5	P6	P7	P8
1:1	C	O	C	O	O	C	C	C
36:1	C	O	C	O	O	O	C	C
90:1	C	O	C	O	O	C	O	C
360:1	C	O	C	O	O	O	O	C
Stepper enable	O	C	O	C	O	O	O	O

C = CLOSED O = OPEN

Table 9: Gyro Interface Switch 2 Settings

Pole	Setting	Function		
P1	C	Enables pitch and roll on the synchro board		
	O	Disabled pitch and roll on the synchro board		
P2-3	Baud rate	Baud rate	P2	P3
		2400	O	O
		4800	O	C
		9600	C	O
		19200	C	C
P4-5	Display rate	Display rate	P4	P5
		Continuous	O	O
		10 times per second	O	C
		2 times per second	C	O
		Once per second	C	C
P6	Not used			

7.5 Stepper Interface

If you are using a *stepper* voltage instead of a synchro voltage, remove the Synchro to Digital chip in socket U3 on the Gyro Interface board. Be sure to protect the Synchro to Digital chip from static discharge.

CAUTION. Synchro-to-Digital converter chips are **expensive**, so handle them with care.

Remember the following items when using the stepper interface

- Only a 6-step gyro can be used, where each step stands for 1/6 of a degree (see Table 5, page 21).
- If you are using roll and pitch inputs from a vertical gyro, the turns ratios for these inputs ***must*** be 1:1.
- Most common stepper voltage ranges are from 35 to 70 VDC, with a positive or negative common and this is what the gyro interface board is setup for from the factory. On special request, other voltages may be possible. The gyro Interface board uses resistors R19, R20, and R21 to set the current for the opto isolators on the stepper interface. Use Table 11 to determine the correct value of these resistors.

Table 10: Stepper Interface Resistor Values

Stepper Voltage	Resistor Value	Watt
35 to 70 VDC	8.2kΩ	1
20 to 35 VDC	4.0kΩ	1
70 to 110 VDC	16.0KΩ	2

7.6 Testing the Gyro Interface

You can use the front LCD display on the Deck Box to test the gyro interface. Turn on the Deck Box. If the LCD heading readout agrees with the gyro at several angles, you can assume the settings are correct. You also should have the gyro make a complete turn through 360°. Some lag may appear, but the LCD readout should change smoothly and in the same direction as the gyro.

If you do *not* have a 1:1 turns-ratio synchro input, and the LCD readout follows in the same direction but with a constant offset from the gyro value, you must use the initializing ↑, ↓, and SET buttons on the front of the deck box. if you do not have the initializing buttons, then you can set the offset in the *VmDas* Transforms page. If you are not using RDI's *VmDas* program you can set the offset through the EB-command. This entry will align the two values when properly set, or one of two problems can exist.

- Incorrect turns-ratio value - If you are *not* sure of the turns ratio, try selecting the other turns-ratio values and retest the configuration.

⚠ **CAUTION.** Be sure to power down the Deck Box *before* changing the switch settings. You also should secure the gyro signals to the Deck Box, as these signals are still "live" at the Gyro Interface board terminals.

- Incorrect wiring hookup to gyro - If you *are* sure of the turns-ratio (i.e., found in gyro manual), the problem must be incorrect wiring. That is, the stator lines (S1, S2, S3) or reference lines (RH, RL) may be connected to the wrong gyro terminals. Use Table 12 or systematically swap pairs of stator or reference leads to correct wiring problems.

Table 11: Gyro Interface Troubleshooting Guide

"A" Gyro angle	"B" Angle displayed by heading readout (Shaded areas indicate reverse rotation)											
000	000	120	240	240	000	120	180	300	060	060	180	300
060	060	180	300	180	300	060	240	000	120	000	120	240
120	120	240	000	120	240	000	300	060	180	300	060	180
180	180	300	060	060	180	300	000	120	240	240	000	120
240	240	000	120	000	120	240	060	180	300	180	300	060
300	300	060	180	300	060	180	120	240	000	120	240	000
Gyro conn.	"C" Possible ADCP Connector Configurations											
	1	2	3	4	5	6	7	8	9	10	11	12
RH	RH	RH	RH	RH	RH	RH	RL	RL	RL	RL	RL	RL
RL	RL	RL	RL	RL	RL	RL	RH	RH	RH	RH	RH	RH
S1	S1	S2	S3	S2	S3	S1	S1	S2	S3	S2	S3	S1
S2	S2	S3	S1	S1	S2	S3	S2	S3	S1	S1	S2	S3
S3	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2

NOTE

1. With a gyro angle of "a," the heading readout will show an angle of "b" if the gyro interface cable wires are connected as shown in "c." For example - if the gyro is at an angle of 120° ("a"), and the heading readout is showing a value of 300° ("b"), the interface is wired in either configuration #7 or #10 ("c"). If the heading readings rotate in the same direction as the gyro, the interface is wired as #7; if the rotation is in the reverse direction, the interface is wired as #10.
2. As shown above, only configuration #1 in "c" is correct for gyro interface wiring.
3. Configurations 7-12 occurs when reference wires RH and RL are reversed, producing errors of 180°.
4. Configurations 2, 3, 8, and 9 occur when the S1-S2-S3 wires are rotated, producing errors of 120°.
5. Switching any two of the S1-S2-S3 wires, as in configurations 4, 5, 6, 10, 11, and 12 (shaded in table), cause synchro rotation to be reversed and result in errors of varying degrees.
6. Setting the gyro to 000° will produce an offset that is a multiple of 60° for all possible wiring configurations.
7. Leaving any of the S1-S2-S3 connections "open" will give unpredictable results.

8 Navigation Interface Considerations

VmDas can read in, decode, and record ensembles from an ADCP and NMEA data from some specific (i.e. GPS and attitude sensors) external devices. *VmDas* stores this data in both raw data files (leaving all original data input in its original format) and in a combined, averaged data file. *VmDas* uses all of this data to create different displays for the user.

VmDas looks for, and utilizes the following strings if transmitted: standard GGA (position), HDG/HDT (Heading), VTG (speed and track) messages, and a proprietary PRDID (pitch and roll) message.

As well as being able to input NMEA strings to *VmDas*, it can produce NMEA output strings of speed log information. The speed log contains VDVBW (ground/water speed) and VDDBT (depth).

> **NOTE.** For more information about NMEA data, see the *VmDas* and *WinRiver* User's Guides.

9 Power Considerations

Use the following sections to determine the power requirements for your ADCP system. All Workhorse tests and operations work equally well using any of the listed power sources.

9.1 Monitor/Sentinel Power Considerations

WorkHorse Monitor and Sentinel ADCPs require +20 to 60 VDC to operate. The standard AC Adapter runs on any standard AC power and supplies +48 VDC to run the Workhorse when the batteries are not connected. The Sentinel's internal battery supplies +42 VDC.

> **NOTE.** The AC Adapter input voltage is sufficient to override the internal battery voltage (i.e. the ADCP will draw all power from the AC adapter even if the battery is installed and connected).

Transmitted power increases or decreases depending on the input voltage (within the voltage range of 20 to 60 VDC). A fresh battery provides +42 VDC. Batteries spend most of their life at a nominal voltage of +33 VDC.

> **NOTE.** The transmitted power is decreased 1 DB if the input voltage drops from 42 VDC to 33 VDC. For a 300kHz WorkHorse ADCP, each DB will result in a decrease in range of one default depth cell.

9.2 Rio Grande Power Considerations

The Rio Grande requires a DC supply between 10.5 volts and 18 volts. Either an external DC power supply or battery can provide this power. If you are using a battery, use the largest rated amp-hour battery as possible. A car battery should last one to two days powering a 600-kHz ADCP.

9.3 Mariner Power Considerations

The Mariner deck box automatically scales the input voltage to the proper level. No special jumpers or switch settings are required to select the input voltage. If more than one power source is connected to the deck box, the highest voltage source will be used. Although this is not recommended, it will not damage the deck box.

AC Power. The deck box accepts input voltages of 98-264 VAC, 50-60Hz (J27). This input voltage will be converted to 48 VDC. This is the voltage supplied to the ADCP.

12 VDC Car Battery. Use a 12 VDC car battery (J26) when AC power is not available. The deck box converts the voltage to 48 VDC. This is the voltage supplied to the ADCP. Use the largest rated amp-hour battery as possible. A car battery should last one to two days powering a 1200-kHz ADCP.

DC Power Supply. If you are using an external DC power supply connected to the deck box on J25 (20-60 VDC, 3.0 A), the voltage from the external power supply is sent *directly* to the ADCP. This is useful if you want to increase (higher voltage level) or decrease (lower voltage level) the range of the ADCP. The current requirement for the power supply is listed as a reference. Using a lesser-rated power supply can cause the voltage level to drop. The ADCP will draw only the current it needs.

NOTE. Transmitted power increases or decreases depending on the input voltage. Higher voltage to the ADCP (within the voltage range of 20 to 60 VDC) will increase the transmitted power. The transmitted power is increased 6 DB if you double the input voltage from 24 VDC to 48 VDC. For a 300kHz WorkHorse ADCP, each additional DB will result in an increase in range of one default depth cell.

ADCP Internal Batteries. If you want the ADCP to use internal battery power (Sentinel Workhorse ADCP or external battery pack) rather then the deck box power, do the following.

a. Turn OFF or disconnect all power to all ADCP system equipment.

b. Remove the screws on the top cover of the deck box. Lift the cover off.

c. Locate the Filter Interface board (see the Mariner User's Guide for a drawing of the deck box board locations). Locate connector J18 and disconnect the twisted black and white cable plugged into this connector. The power from the deck box to the ADCP has now been disabled. Only the batteries are powering the ADCP.

10 Installation Procedures (Overview)

Read these steps before doing them. In general, follow them in the order listed. Some may differ for your installation, so modify them as necessary. Some can be done simultaneously (e.g., hardware installation and software loading). If you have problems or questions, call us.

NOTE. The following procedure applies to WorkHorse Mariner ADCPs. Some parts may apply to WorkHorse Monitor/Sentinel and Rio Grande ADCPs if they are being mounted to a vessel.

a. On receipt of the system, read the Read This First book.

b. Before installing the system, test the transducer and deck box right out of the shipping container. Do the following.

   1. All power to the system DISCONNECTED.
   2. Review "Power Considerations," page 28.
   3. Connect the I/O cable from the deck box to the ADCP.
   4. Connect the serial I/O cable from the computer to the deck box.
   5. Connect the power cable to the deck box and apply power to the system (the ADCP User's Guide shows all cable connections).
   6. Follow testing procedures in the Maintenance book. Test the system. If errors occur, use the Troubleshooting book.

c. Prepare the system for shipboard installation. Disconnect all power to the system. Disconnect all interface cables.

d. Review "Transducer Head Mounting Considerations," page 7. Install the transducer head. Mechanically align the system (see "Alignment Procedures (Overview)," page 31).

CAUTION. Take steps to prevent leaks through the hull and gate valves.

e. Review section "Mariner Deck Box Mounting Considerations," page 17. As necessary, do the following.

   1. Install the Synchro Interface board in the chassis (see the Mariner's User Guide).
   2. Check all switch settings on the gyro board (shown in the Mariner's User Guide).
   3. Install the deck box.

f. Review "Computer Considerations," page 19. Install the computer.

g. Review “Cabling Considerations,” page 18. As necessary, route and connect the following cables:

- Transducer to deck box (J17) interface cable.
- Gyro to deck box (J22) cable.

CAUTION. Signals may be present.

- Navigation to computer cable.

CAUTION. Signals may be present.

h. As necessary, load the software on the computer’s hard drive. See the Software User’s Guide and the Help files for each program.

i. Configure *VmDas* or *WinRiver*. See the software’s help file and the *VmDas* or *WinRiver* User’s Guide for help on configuring the program.

j. Do the Dock Side Tests (see the Test Guide). If errors occur, use the Troubleshooting book.

k. Do the Sea Acceptance testing (see the Test Guide). The Sea Acceptance tests include the following checks.

- Interference
- Water Profile Range
- Ringing and (cross-coupling, other pingers, noise)
- Water Profile Reasonableness (transducer alignment)
- Bottom-track (range, accuracy)

11 Alignment Procedures (Overview)

NOTE. This section does not apply to stationary systems (such as bottom mounted Sentinels). These systems use an internal compass by default.

The mechanical alignment of the transducer head is important to ADCP data accuracy. Mechanically mount the head as close as possible to your reference point. This is usually with the Beam 3 mark at 0° or 45° relative to the ship’s fore-to-aft centerline. You also must mount the transducer head as level as possible using the ship’s roll and pitch references. Review the “Transducer Head Mounting Considerations,” page 7 for alignment considerations.

VmDas uses the **Heading Correction Parameters** on the **Transforms** tab to align the ADCP's north reference (Beam 3 mark) to the north reference of an external gyro/compass. Ships use the bow as the north reference.

When the WorkHorse is aboard a vessel, the mechanical alignment of the transducer head (Beam 3 mark) is usually aligned with the ship's fore-to-aft centerline (0°) or rotated 45° clockwise. To conceptually determine the misalignment angle, visually hold the ADCP still and turn the ship gyro's north reference to match the ADCP's north reference. For example, if the Beam 3 mark is pointing at the bow (Figure 15), the misalignment angle is zero. If the Beam 3 mark is pointing 45° to starboard (Figure 15), you must turn the ship a +45° to align the two north reference points. Conversely, if the Beam 3 mark is pointing 45° to port, you must turn the ship a -45° to align the two reference points.

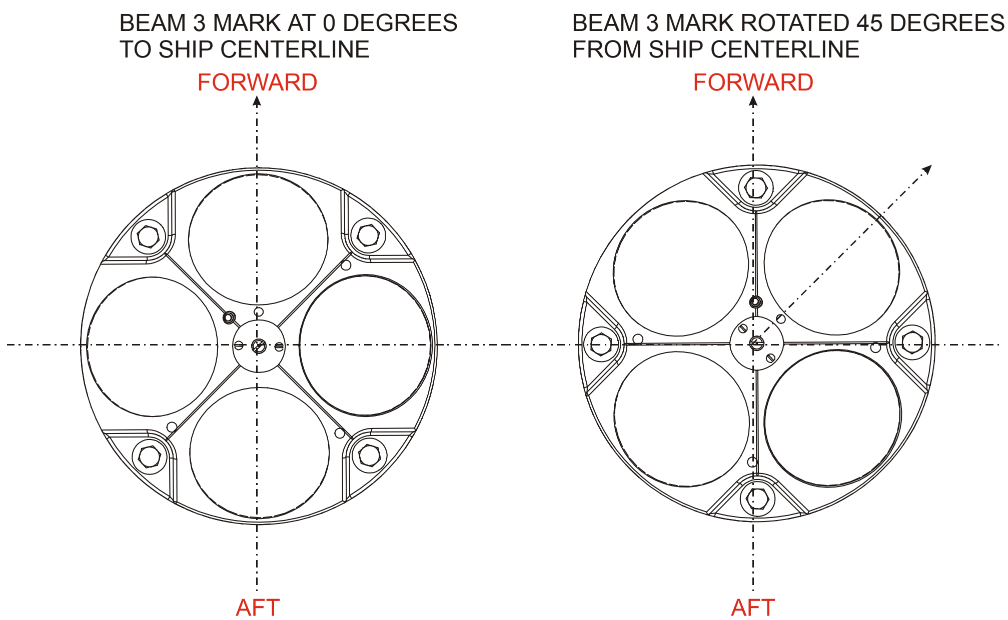


Figure 15. Transducer Misalignment Reference Points

NOTE. The alignment of the transducer installation holes on the Mariner Adapter Plate to the centerline of the transducer is within 0.15 degrees. We recommend you choose a bolt (or stud) that fills the installation holes as close as possible to limit any additional misalignment.

12 Specifications

A brief review of ADCP operation may help you understand the specifications listed in this section.

> **NOTE.** The specifications and dimensions listed in this section are subject to change without notice.

The ADCP emits an acoustic pulse called a PING. Scatterers that float ambiently with the water currents reflect some of the energy from the ping back to the ADCP. The ADCP uses the return signal to calculate a velocity. The energy in this signal is the *echo intensity*. Echo intensity is sometimes used to determine information about the scatterers.

The velocity calculated from each ping has a *statistical uncertainty*; however, each ping is an independent sample. The ADCP reduces this statistical uncertainty by averaging a collection of pings. A collection of pings averaged together is an *ensemble*. The ADCP's maximum *ping rate* limits the time required to reduce the statistical uncertainty to acceptable levels.

The ADCP does not measure velocity at a single point; it measures velocities throughout the water column. The ADCP measures velocities from its transducer head to a specified range and divides this range into uniform segments called *depth cells* (or *bins*). The collection of depth cells yields a *profile*. The ADCP produces two profiles, one for velocity, and one for echo intensity.

The ADCP calculates velocity data relative to the ADCP. The velocity data has both speed and direction information. If the ADCP is moving, and is within range of the bottom, it can obtain a velocity from returns off the bottom. This is called *bottom tracking.* The bottom track information can be used to calculate the absolute velocity of the water. The ADCP can get absolute direction information from a heading sensor.

The following tables list the specifications for the WorkHorse ADCP. About the specifications:

a. All these specifications assume minimal ADCP motion - pitch, roll, heave, rotation, and translation.

b. Except where noted, this specification table applies to typical setups and conditions. Typical setups use the default input values for each parameter (exceptions include Pings Per Ensemble and Number of Depth Cells). Typical conditions assume uniform seawater velocities at a given depth, moderate shear, moderate ADCP motion, and typical echo intensity levels.

c. The total measurement error of the ADCP is the sum of:

- Long-term instrument error (as limited by instrument accuracy).
- The remaining statistical uncertainty after averaging.
- Errors introduced by measurement of ADCP heading and motion.

d. Because individual pings are independent, the statistical uncertainty of the measurement can be reduced according to the equation:

$$\frac{\text{Statistical Uncertainty for One Ping}}{\sqrt{\text{Number of Pings}}}$$

Table 12: Mariner and Monitor Water Profiling

Depth Cell Size[1]	Nominal range 15m[2] 1200kHz		Nominal range 55m[2] 600kHz		Nominal range 135m[2] 300kHz	
Vertical Resolution	**Range[3] (m)**	**Std. dev.[4] (mm/s)**	**Range[3] (m)**	**Std. dev.[4] (mm/s)**	**Range[3] (m)**	**Std. dev.[4] (mm/s)**
0.25m	12	182				
0.50m	13	66	40	182		
1.0m	15	30	45	66	97	182
2.0m	16	18	50	30	110	66
4.0m			56	18	123	30
8.0m					138	18

NOTES

1. User's choice of depth cell size is not limited to the typical values specified.
2. Longer ranges are available.
3. Range, which depends on cell size, is specified here for BroadBand mode at 5° C, typical ocean backscatter, and nominal 48 VDC power.
4. Broad bandwidth mode single-ping standard deviation

Table 13: Sentinel Water Profiling

Depth Cell Size[1]	Nominal range 15m[2] 1200kHz		Nominal range 55m[2] 600kHz		Nominal range 135m[2] 300kHz	
Vertical Resolution	Range[3] (m)	Std. dev.[4] (mm/s)	Range[3] (m)	Std. dev.[4] (mm/s)	Range[3] (m)	Std. dev.[4] (mm/s)
0.25m	11	182				
0.50m	12	66	36	182		
1.0m	14	30	41	66	86	182
2.0m	15	18	47	30	99	66
4.0m			52	18	112	30
8.0m					126	18

NOTES

1. User's choice of depth cell size is not limited to the typical values specified.
2. Longer ranges are available.
3. Range, which depends on cell size, is specified here for BroadBand mode at 5° C, typical ocean backscatter, and nominal 33 VDC battery power.
4. Broad bandwidth mode single-ping standard deviation

Table 14: Long Range Mode

	Range (m) @ 33VDC	Range (m) @ 48VDC	Depth Cell Size (m)	Std. dev. (mm/s)
1200kHz	19	20	2	35
600kHz	67	70	4	38
300kHz	165	175	8	38

Range, which depends on cell size, is specified here for narrow bandwidth mode at 5° C, typical ocean backscatter, and nominal 33 VDC battery power (Sentinel) and 48VDC input power (Mariner/Monitor).

Table 15: Rio Grande Standard Water Profiling

Bin Size (m)	1200 kHz Rio Grande			600 kHz Rio Grande		
	Minimum Range (m)	Typical Range (m)	Std. dev. (mm/s)	Minimum Range (m)	Typical Range (m)	Std. dev. (mm/s)
0.25m	1.2	14	181			
0.50m	1.7	17	66	1.8	50	181
1.0m	2.7	20	30	2.9	56	66
2.0m	4.8	21	18	5	66	30
4.0m				9.2	75	18

Table 16: Rio Grande Shallow Water Mode

Bin Size (m)	1200 kHz Rio Grande			600 kHz Rio Grande		
	Minimum Range (m)	Typical Range (m)	Std. dev. (mm/s)	Minimum Range (m)	Typical Range (m)	Std. dev. (mm/s)
0.05	0.6	2	10			
0.1	0.7	2	7	0.7	4	8
0.25	1	2	4	1	4	5
0.5				1.6	4	4

Table 17: Rio Grande Shallow Water, Slow Flow Mode

Bin Size (m)	1200 kHz Rio Grande			600 kHz Rio Grande		
	Minimum Range (m)	Typical Range (m)	Std. dev. (mm/s)	Minimum Range (m)	Typical Range (m)	Std. dev. (mm/s)
0.05	0.6	2	115			
0.1	0.7	2	80	0.7	4	83
0.25	1	2	48	1	4	51
0.5				1.6	4	35

Table 18: Bottom Track Profile Parameters

System Frequency	1200kHz	600kHz	300kHz
Maximum Altitude (m)	30	100	260
Minimum Altitude (m)	0.75 (Rio Grande), 0.8 (Mariner)	0.75 (Rio Grande), 1.4 (Mariner)	2

Table 19: Profile Parameters

Velocity accuracy	
1200 and 600kHz	± 0.25% of the water velocity relative to the ADCP ± 2.5mm/s
300kHz	± 0.5% of the water velocity relative to the ADCP ± 5 mm/s
Velocity resolution	l mm/s
Velocity range	± 5m/s (default), ± 20m/s (maximum)
Number of depth cells	1 to 128
Ping rate	2 Hz (typical)

Table 20: Echo Intensity Profile

Vertical resolution	Depth cell size
Dynamic range	80 dB
Precision	± 1.5dB (relative measure)

Table 21: Standard Sensors

Temperature (mounted on transducer)

Range: -5° to 45° C

Precision: ± 0.4° C

Resolution: 0.01°

Tilt

Range: ± 15°

Accuracy: ± 0.5°

Precision: ± 0.5°

Resolution: 0.01°

Compass (fluxgate type, includes built-in field calibration feature)

Accuracy: ± 2°[1]

Precision: ± 0.50[1]

Resolution: 0.01°

Maximum tilt: ± 15°

Note: 1) @ 60° magnetic dip angle, 0.5G total field

Table 22: Transducer and Hardware

Beam angle	20°
Configuration	4 beam, convex
Internal memory	Memory card not included with Rio Grande, Monitor and Mariner models. Sentinel comes standard with one 16MB card. Two PCMCIA card slots are available (16 to 220 Mb each).
Communications	Serial port selectable by switch for RS-232 or RS-422. ASCII or binary output at 1200 to 115,400 baud.

Table 23: Environmental

Standard depth rating	200m. Optional 500, 1000, 3000, and 6000-meter housings available.
Operating temperature	-5° to 45°C
Storage temperature	-30° to 75°C
Battery Storage	Batteries should be stored in dry air with a temperature range of O° C to 21° C.
Battery Shelf Life	Use within one year.
Weight in air	7.6kg (Monitor and Rio Grande), 9.1kg (Mariner with Adapter Plate), 13.0kg (Sentinel with battery)
Weight in water	2.2kg (Monitor and Rio Grande), 2.7kg (Mariner with Adapter Plate), 4.5kg (Sentinel with battery)

Table 24: Power

System	Specification
Sentinel	
DC input	20 to 60 VDC external power supply
Battery Voltage	42 VDC (new), 28 VDC (depleted)
Battery Capacity	400 watt hours @ 0° C
External Battery Pack	42 VDC (new), 28 VDC (depleted). Holds up to two 400 watt hour batteries
Transmit	16W @ 35V (1200kHz), 37W @ 35V (600kHz), 115W @ 35V (300kHz)
Monitor	
DC input	20 to 60 VDC external power supply or 42 VDC External Battery Pack
Transmit	22W @ 48V (1200kHz), 60W @ 48V (600kHz), 190W @ 48V (300kHz)
Mariner	
Deck Box Input	12 VDC, 20 to 60V DC external power supply, 110 to 220 VAC
Transmit	22W @ 48V (1200kHz), 60W @ 48V (600kHz), 190W @ 48V (300kHz)
Rio Grande	
DC Input	10.5 to 18 VDC
Transmit	35W @ 13V (600kHz), 25W @ 13V (1200kHz)

13 Outline Installation Drawings

The following drawings show the standard Workhorse Monitor, Sentinel, Rio Grande, Mariner, and Mariner Deck Box dimensions and weights.

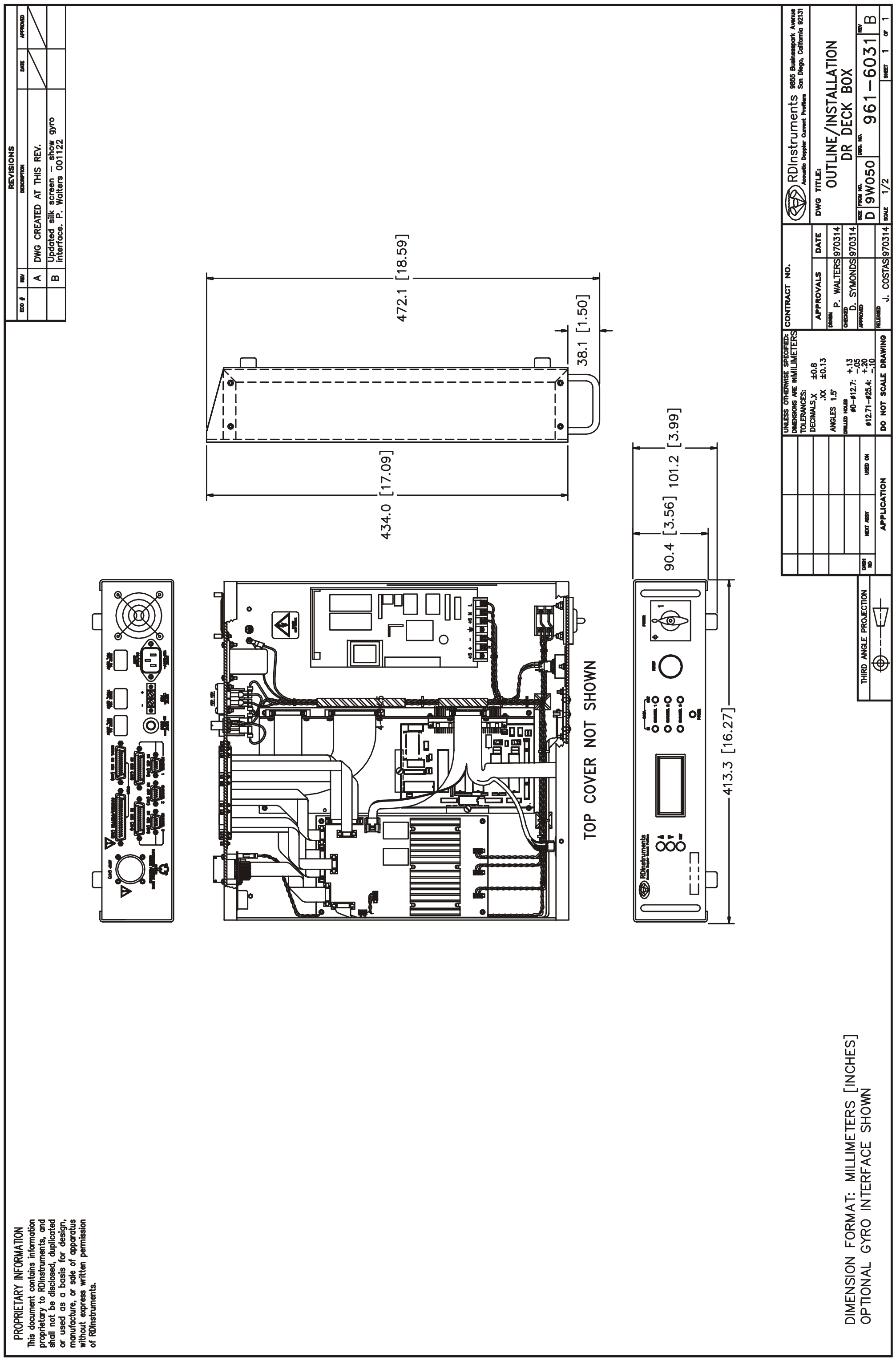
Table 25: Outline Installation Drawings

Description	Drawing #
Mariner Deck Box	961-6031
External Battery Case	967-6007
3000/6000 meter WorkHorse	967-6008
1000 meter WorkHorse	967-6009
600 kHz Rio Grande	967-6025
1200 kHz Rio Grande	967-6026
1200 kHz Mariner	967-6032
300/600 kHz Mariner	967-6033
1200 kHz Monitor/Sentinel	967-6034
300/600 kHz Monitor/Sentinel	967-6035
300/600 kHz 500 meter Monitor/Sentinel	967-6044
1200 kHz 500 meter Monitor/Sentinel	967-6045

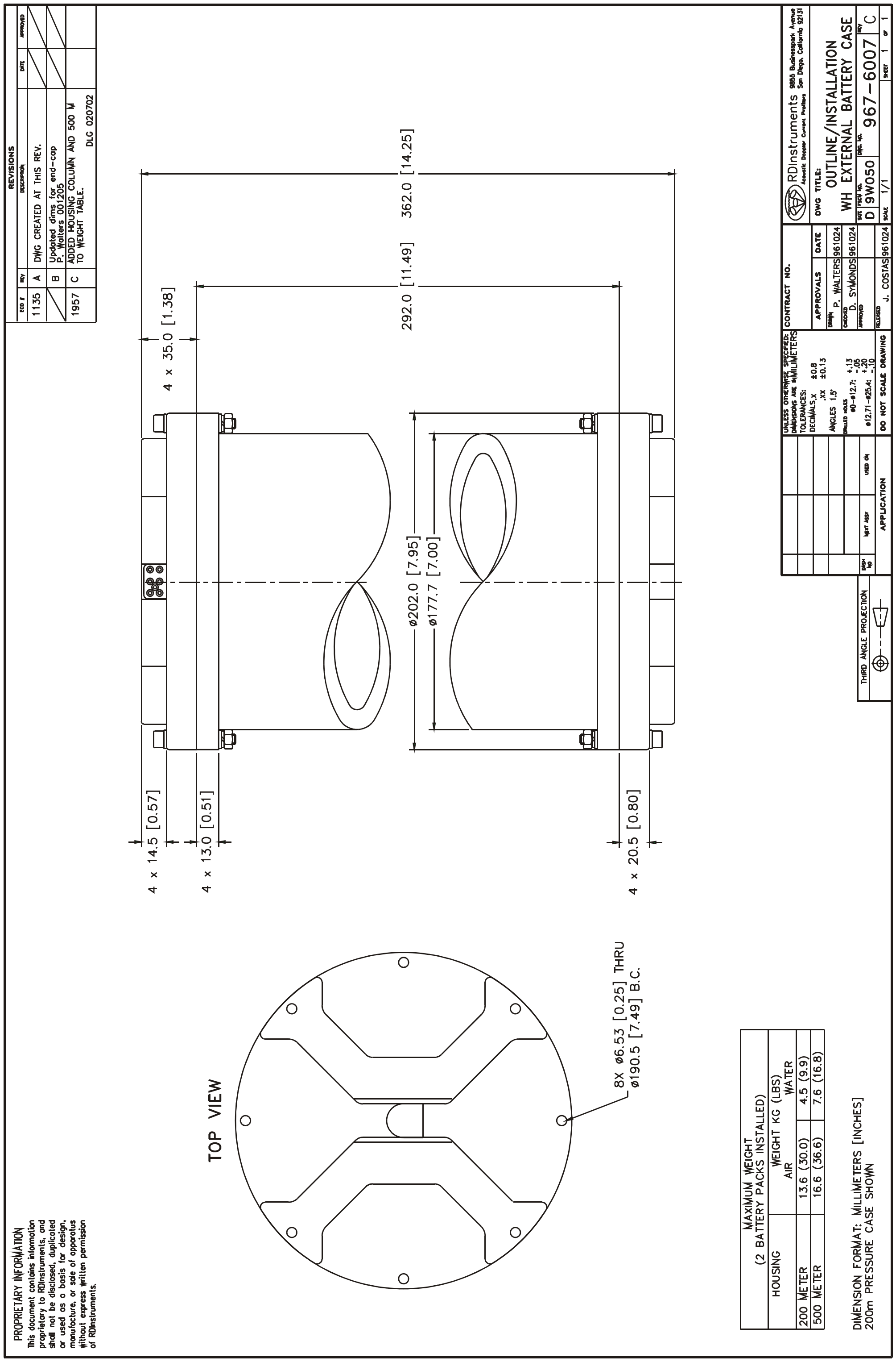
NOTE. If you are having difficulty reading the text on the Outline Installation drawings, please use the electronic documentation. The documentation CD allows you to zoom in and rotate the graphics.

CAUTION. Outline Installation Drawings are subject to change without notice. Verify you have the latest version of the drawing by contacting RDI before building mounts or other hardware.

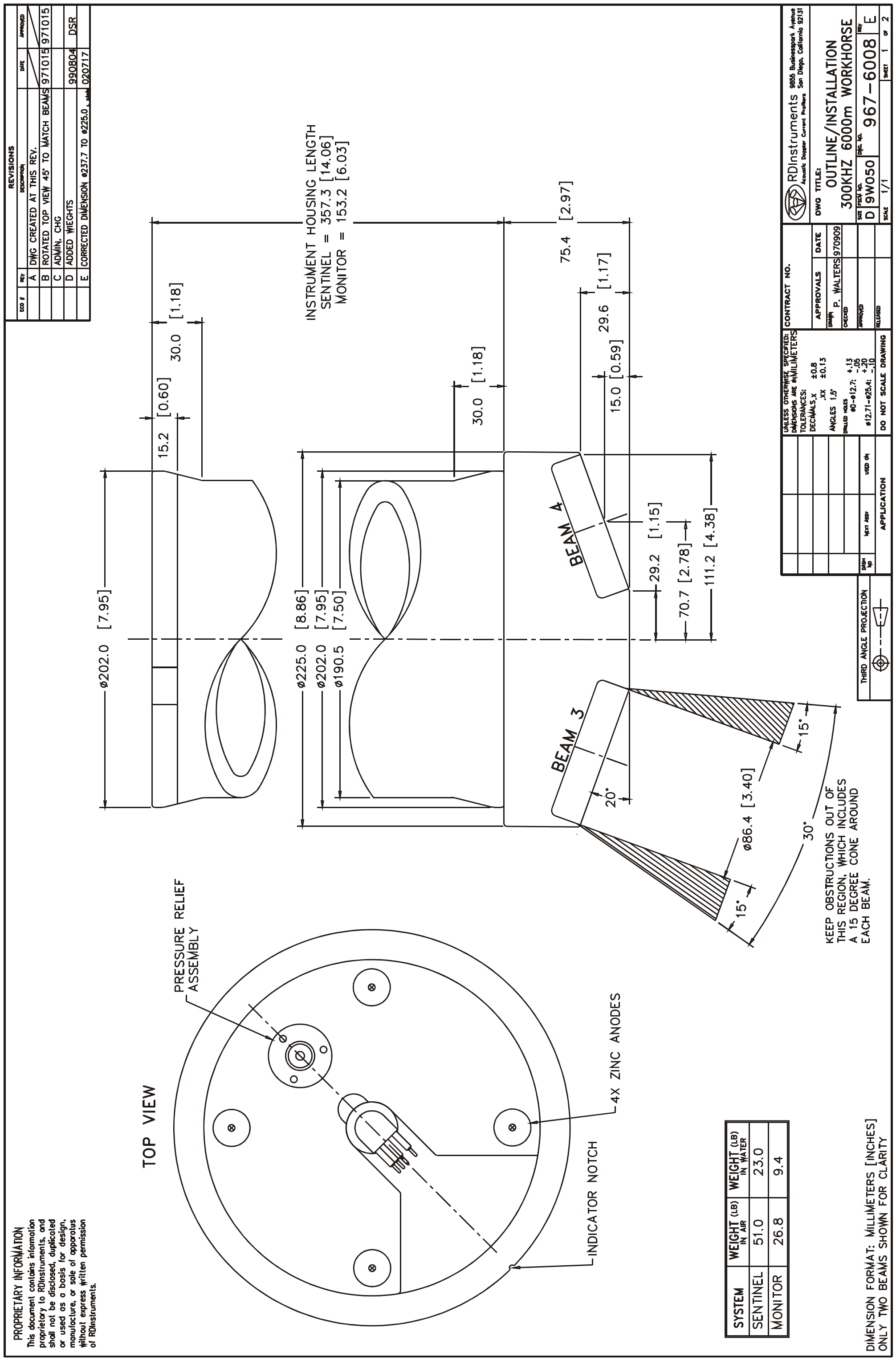
961-6031


REVISIONS
A DWG CREATED AT THIS REV.
B Updated silk screen - show gyro interface. P. Walters 001122
472.1 [18.59]
38.1 [1.50]
434.0 [17.09]
90.4 [3.56]
101.2 [3.99]
413.3 [16.27]
TOP COVER NOT SHOWN
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING
APPLICATION
P. WALTERS 970314
D. SYMONDS 970314
J. COSTAS 970314
RDInstruments
OUTLINE/INSTALLATION
DR DECK BOX
D 9W050 961-6031 B
PROPRIETARY INFORMATION
DIMENSION FORMAT: MILLIMETERS [INCHES]
OPTIONAL GYRO INTERFACE SHOWN

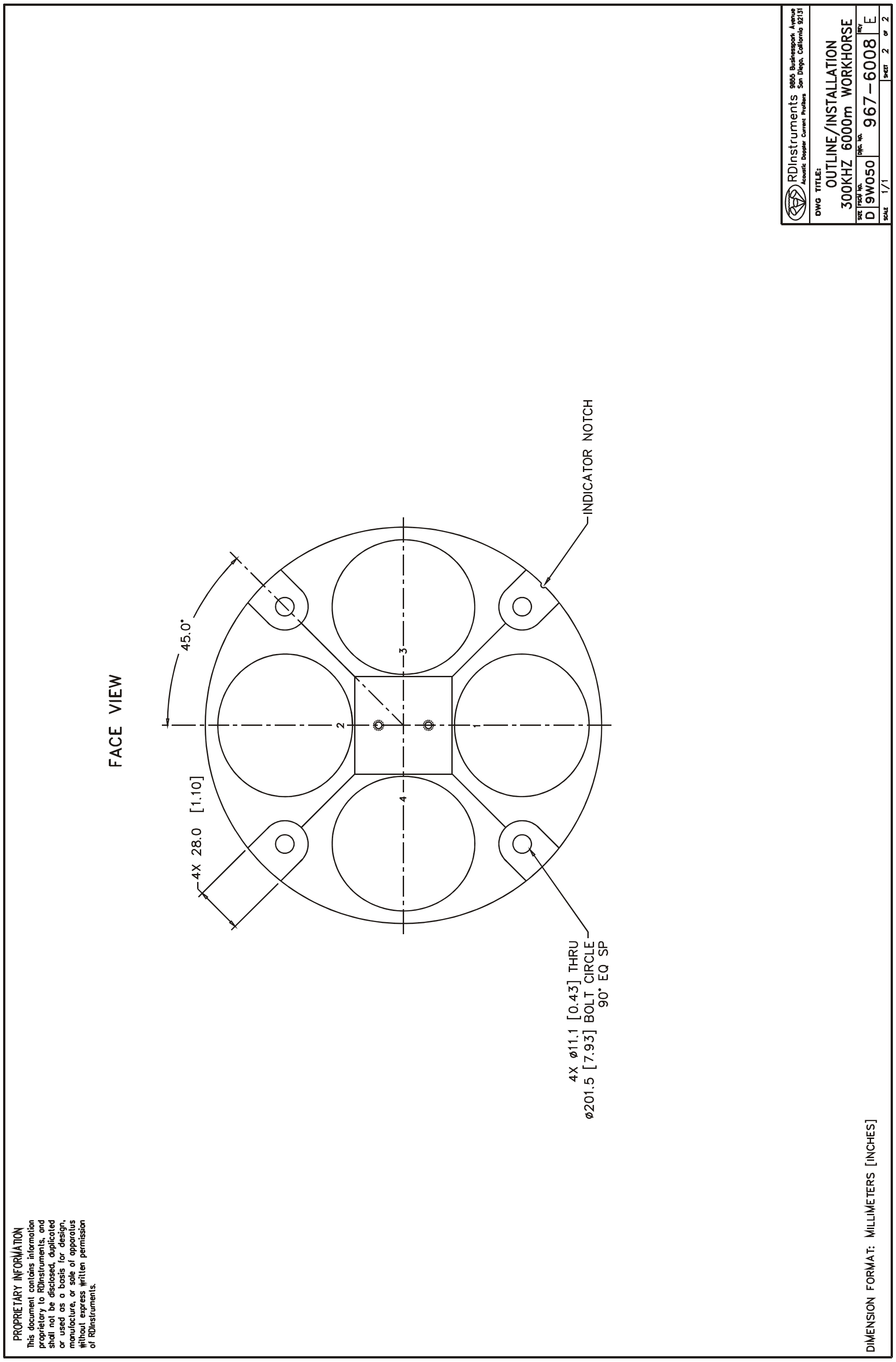
967-6007


REVISIONS
1135 A DWG CREATED AT THIS REV.
B Updated dims for end-cap P. Walters 001205
1957 C ADDED HOUSING COLUMN AND 500 M TO WEIGHT TABLE. DLG 020702
362.0 [14.25]
292.0 [11.49]
4 x 35.0 [1.38]
ø202.0 [7.95]
ø177.7 [7.00]
4 x 14.5 [0.57]
4 x 13.0 [0.51]
4 x 20.5 [0.80]
TOP VIEW
8X ø6.53 [0.25] THRU
ø190.5 [7.49] B.C.
MAXIMUM WEIGHT
(2 BATTERY PACKS INSTALLED)
HOUSING
WEIGHT KG (LBS)
AIR
WATER
200 METER 13.6 (30.0) 4.5 (9.9)
500 METER 16.6 (36.6) 7.6 (16.8)
DIMENSION FORMAT: MILLIMETERS [INCHES]
200m PRESSURE CASE SHOWN
PROPRIETARY INFORMATION
This document contains information proprietary to RDInstruments, and shall not be disclosed, duplicated or used as a basis for design, manufacture, or sale of apparatus without express written permission of RDInstruments.
THIRD ANGLE PROJECTION
APPLICATION
DO NOT SCALE DRAWING
CONTRACT NO.
APPROVALS DATE
P. WALTERS 961024
D. SYMONDS 961024
J. COSTAS 961024
RDInstruments
DWG TITLE:
OUTLINE/INSTALLATION
WH EXTERNAL BATTERY CASE
D 9W050 967-6007 C
1/1

967-6008 Sheet 1



967-6008 Sheet 2



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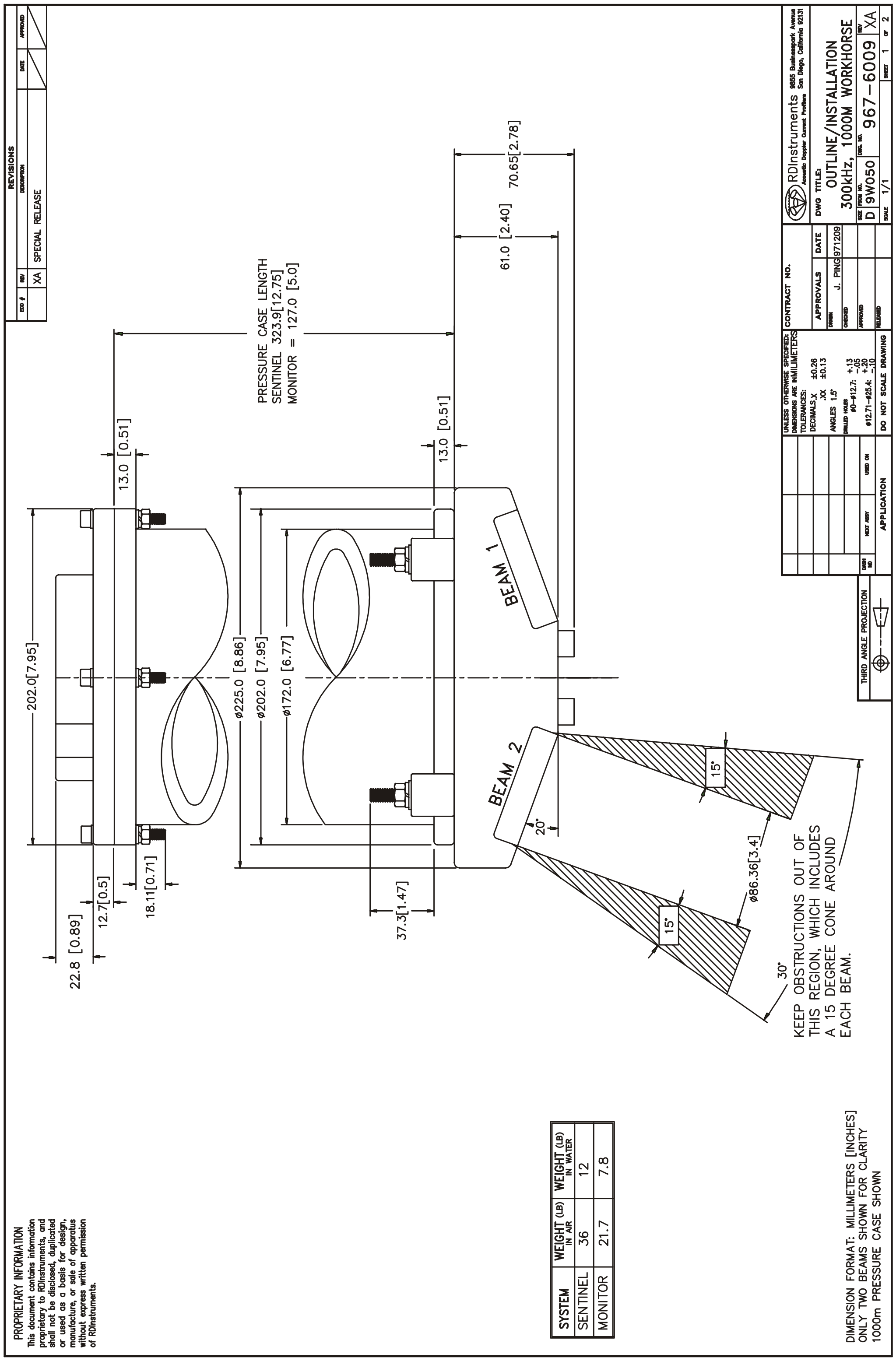

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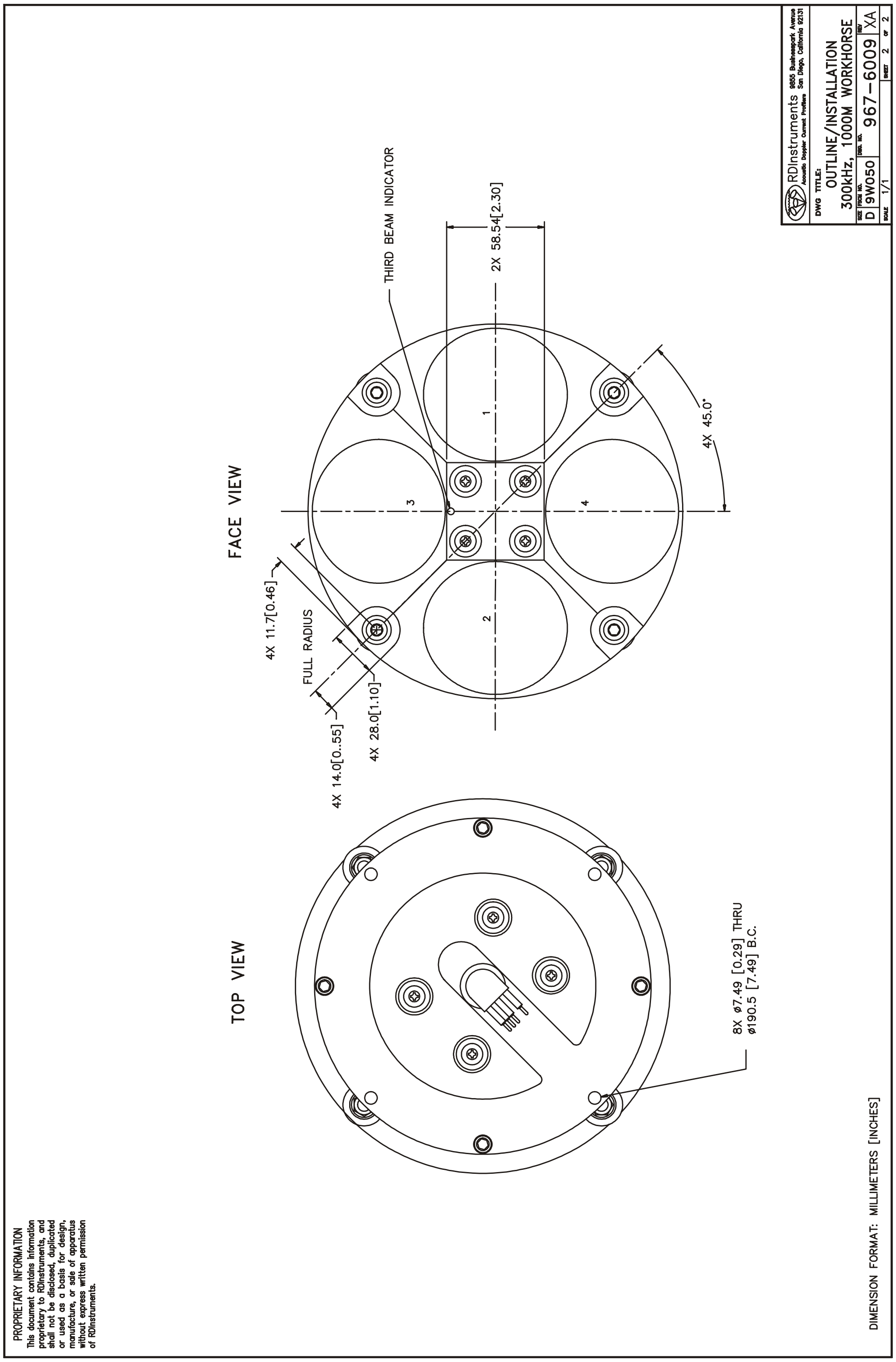

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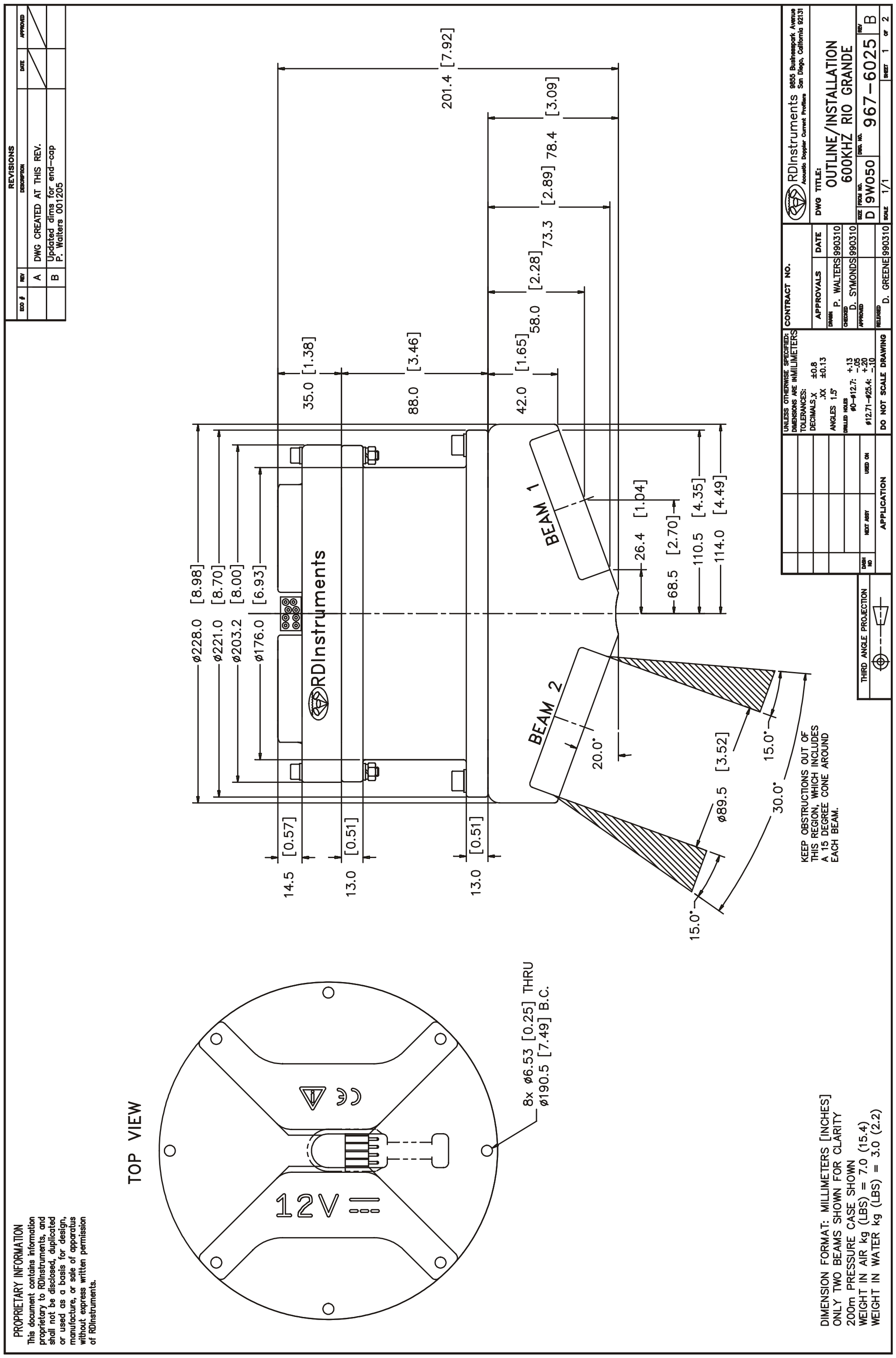

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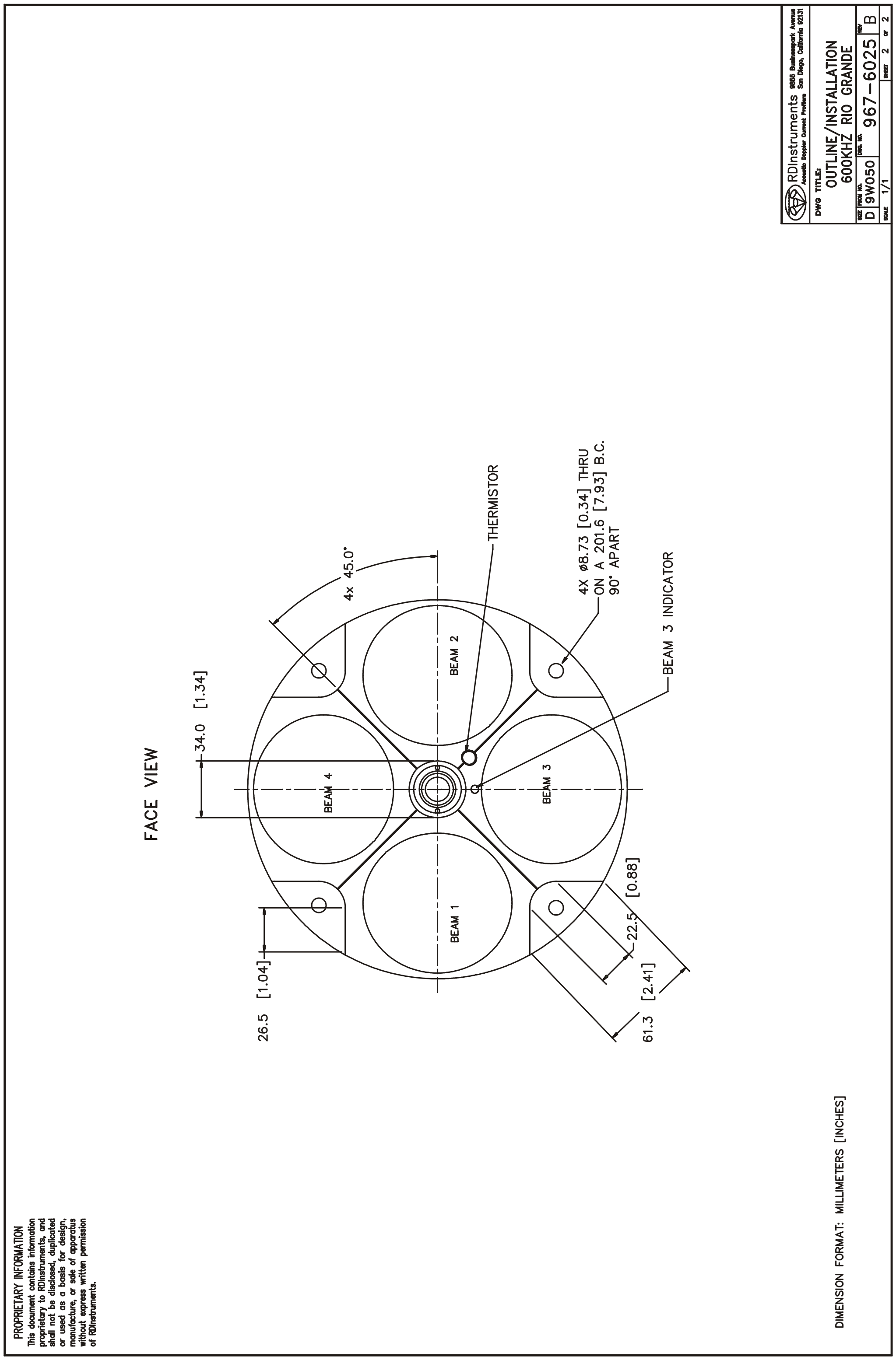

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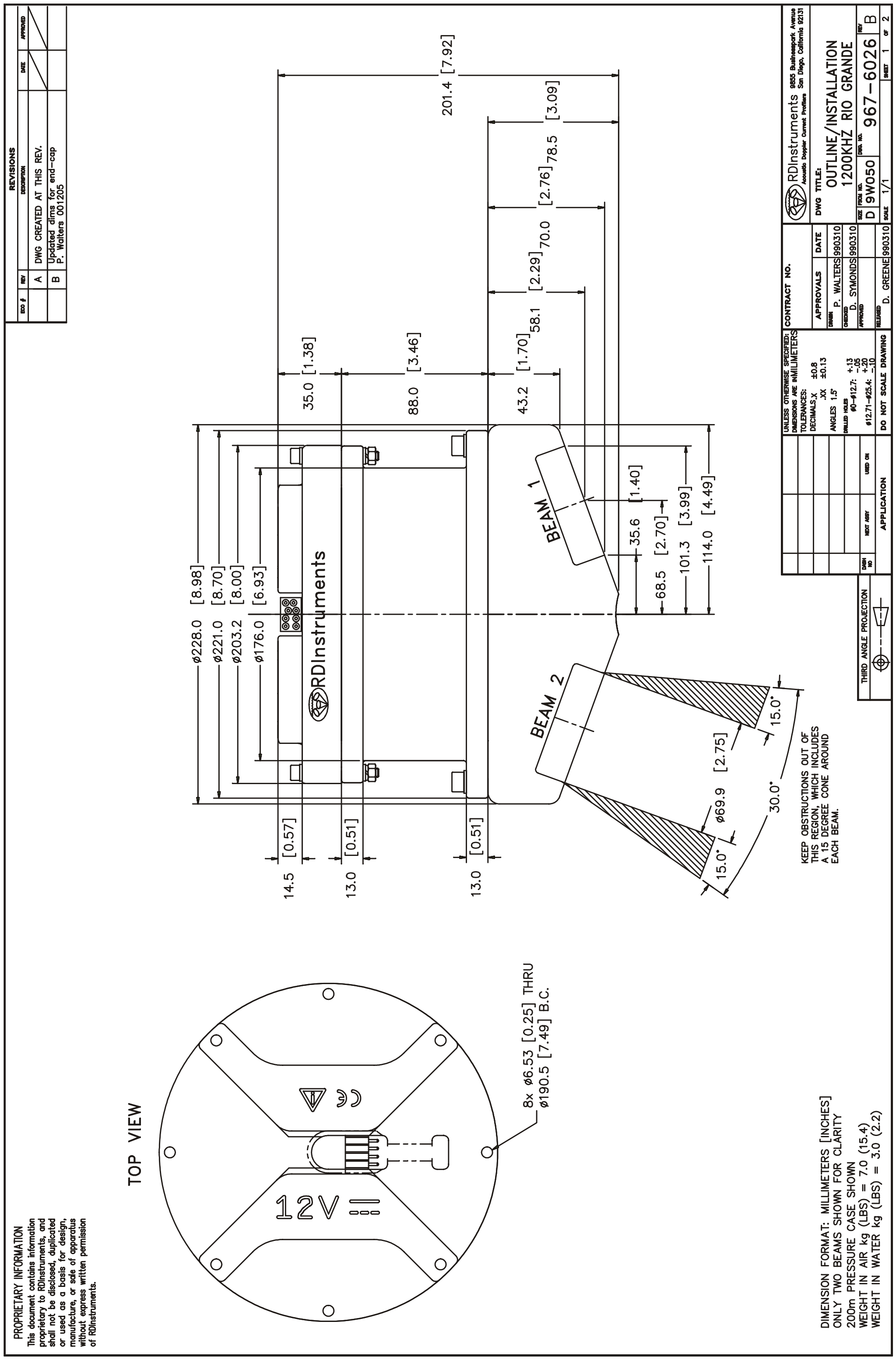

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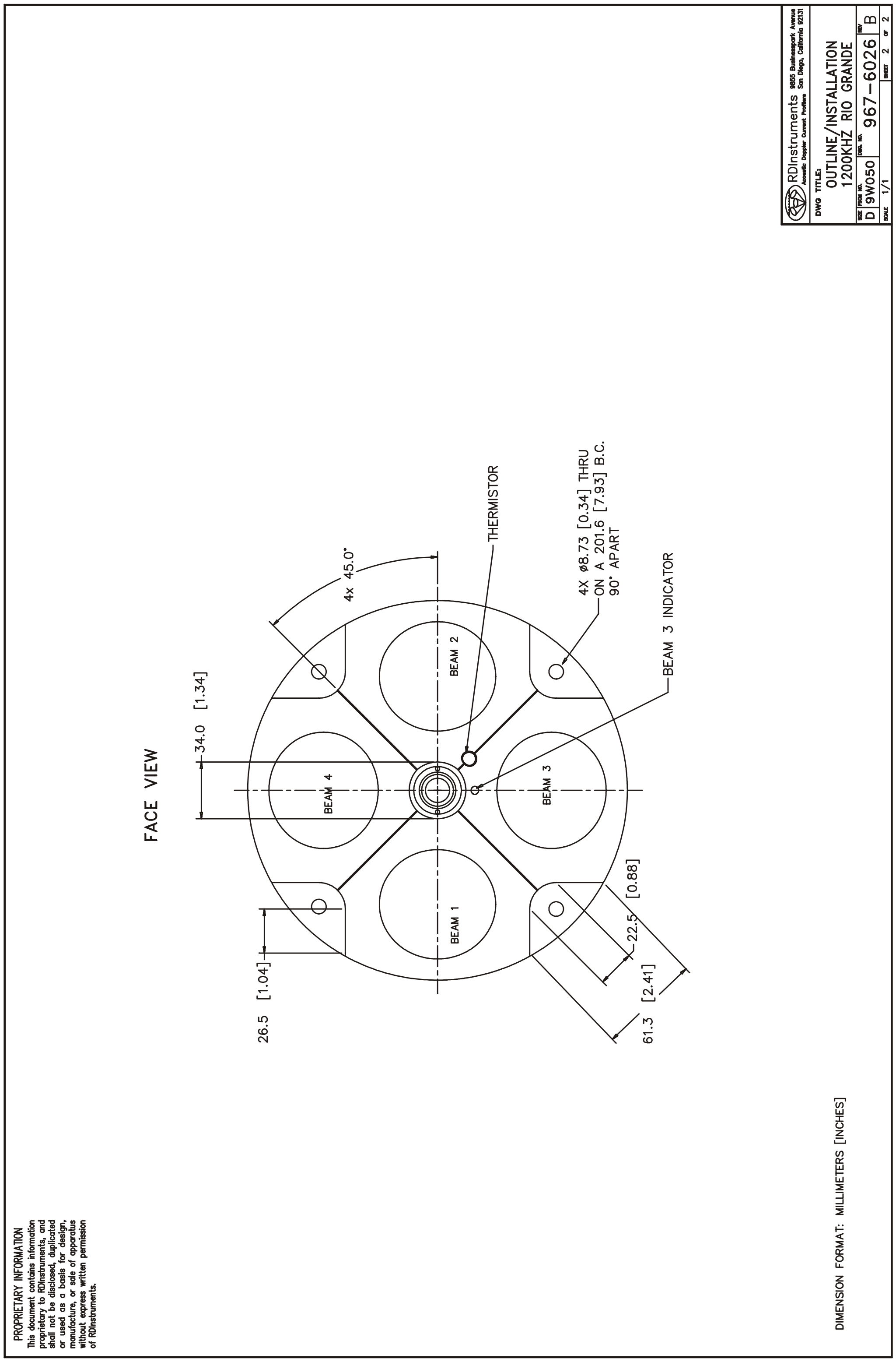

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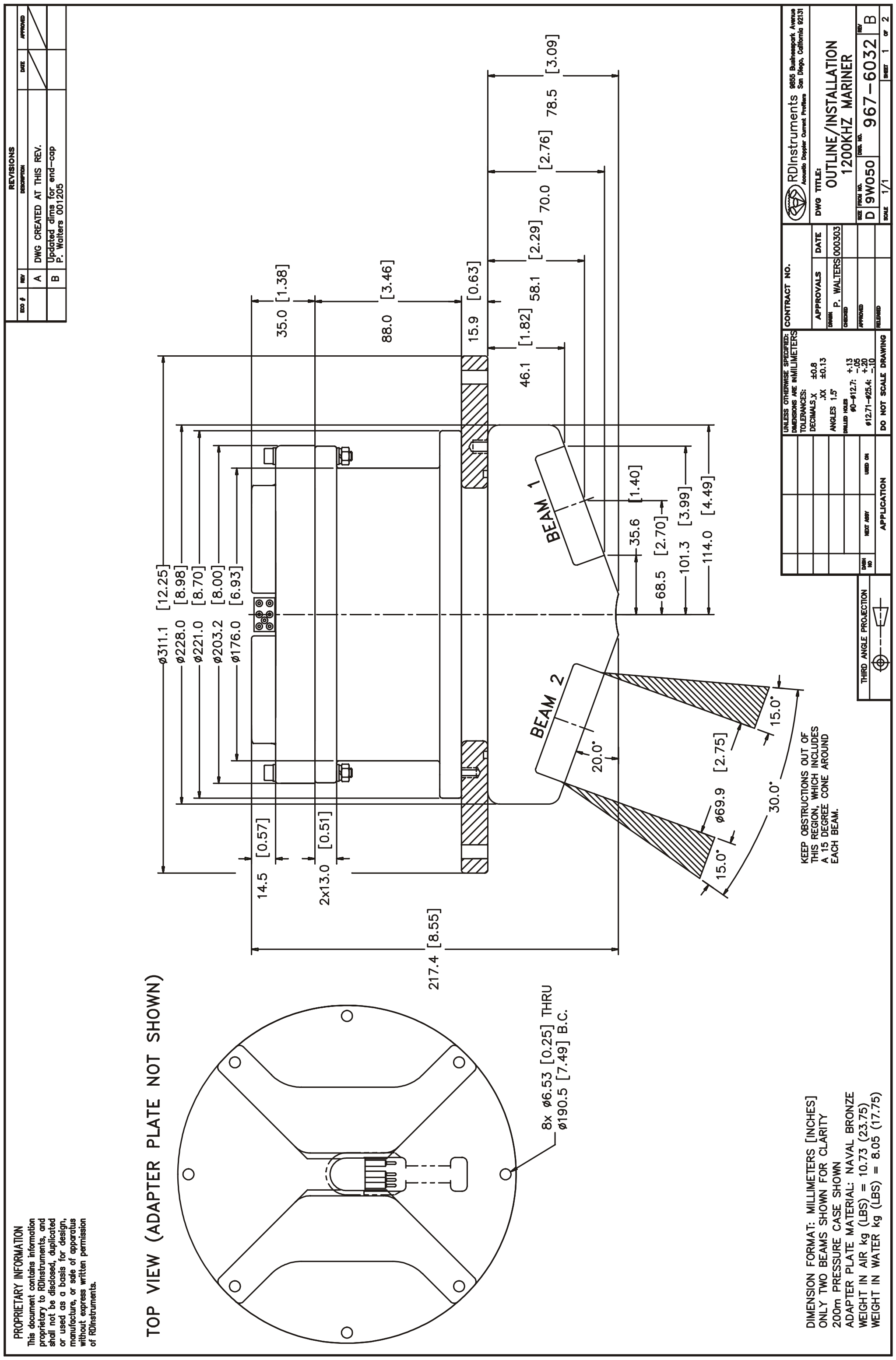

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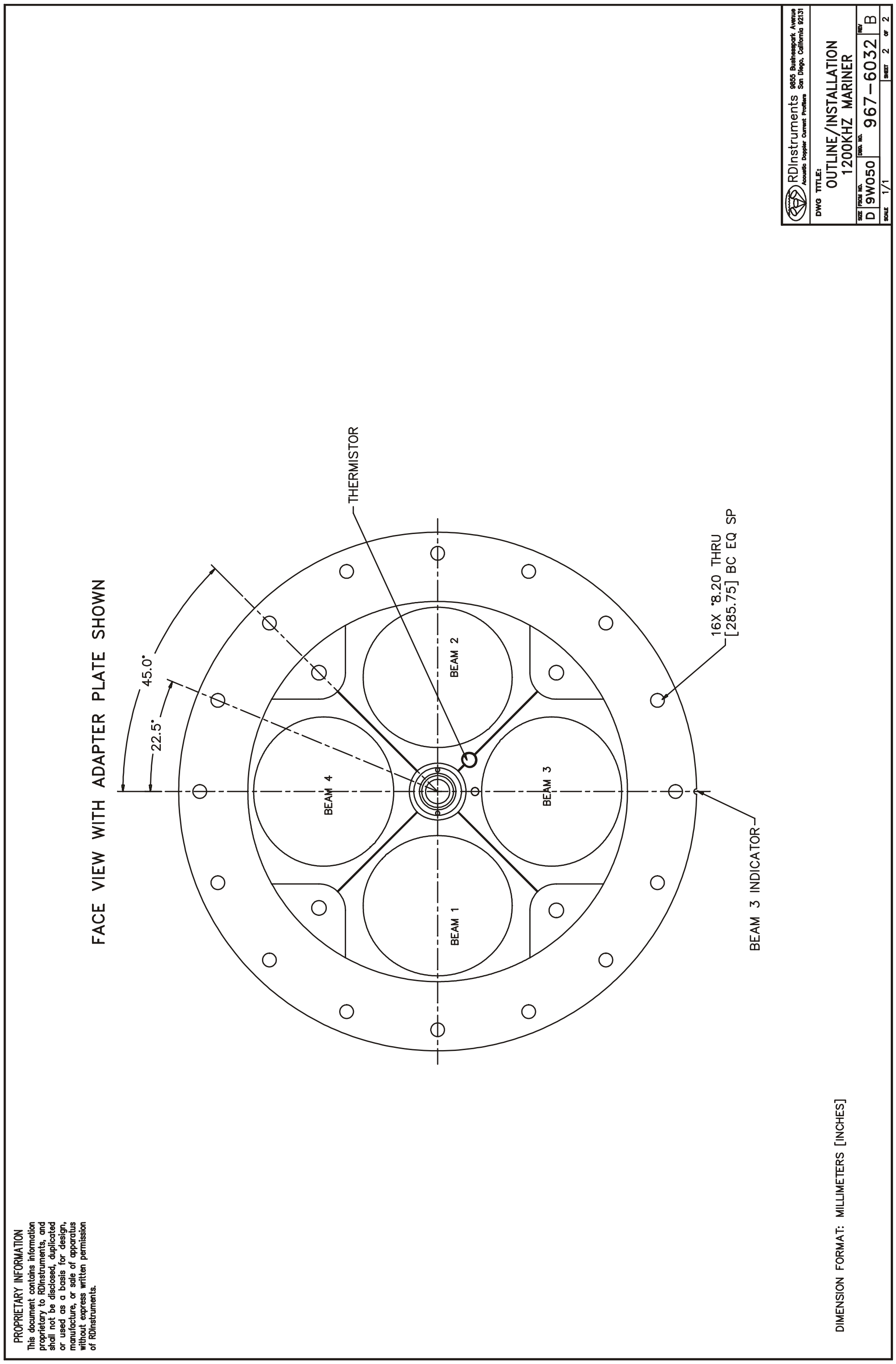

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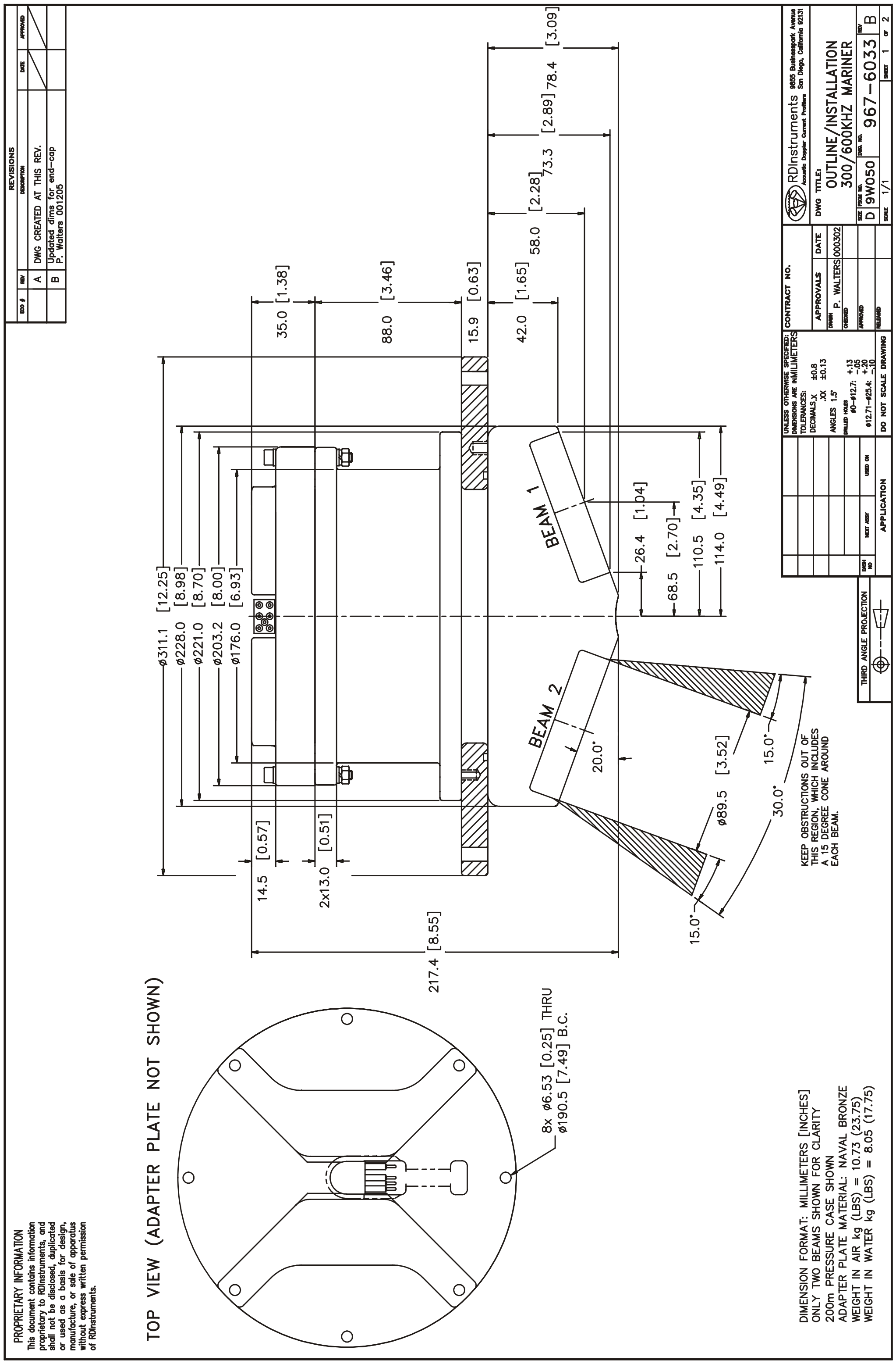

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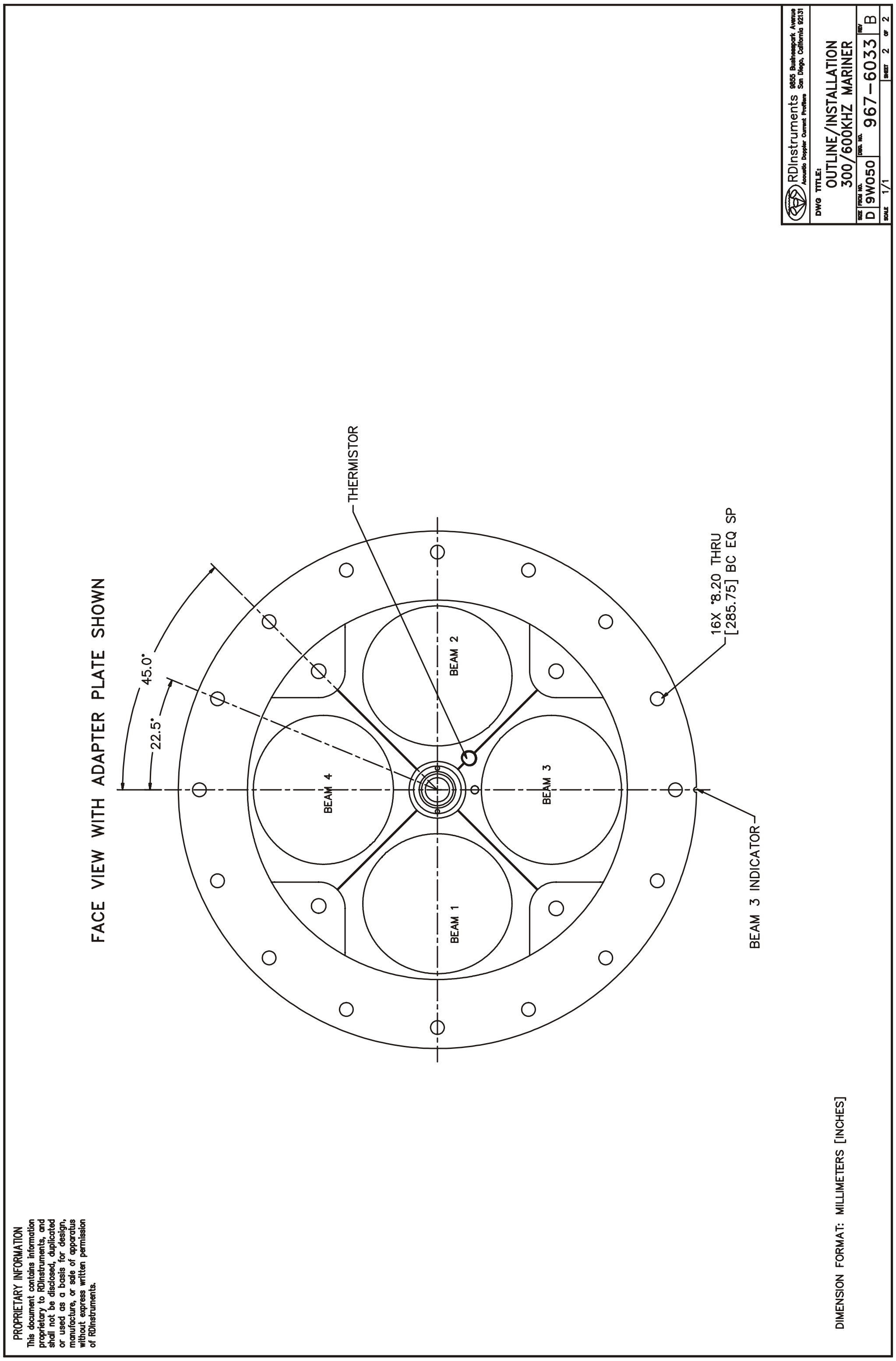

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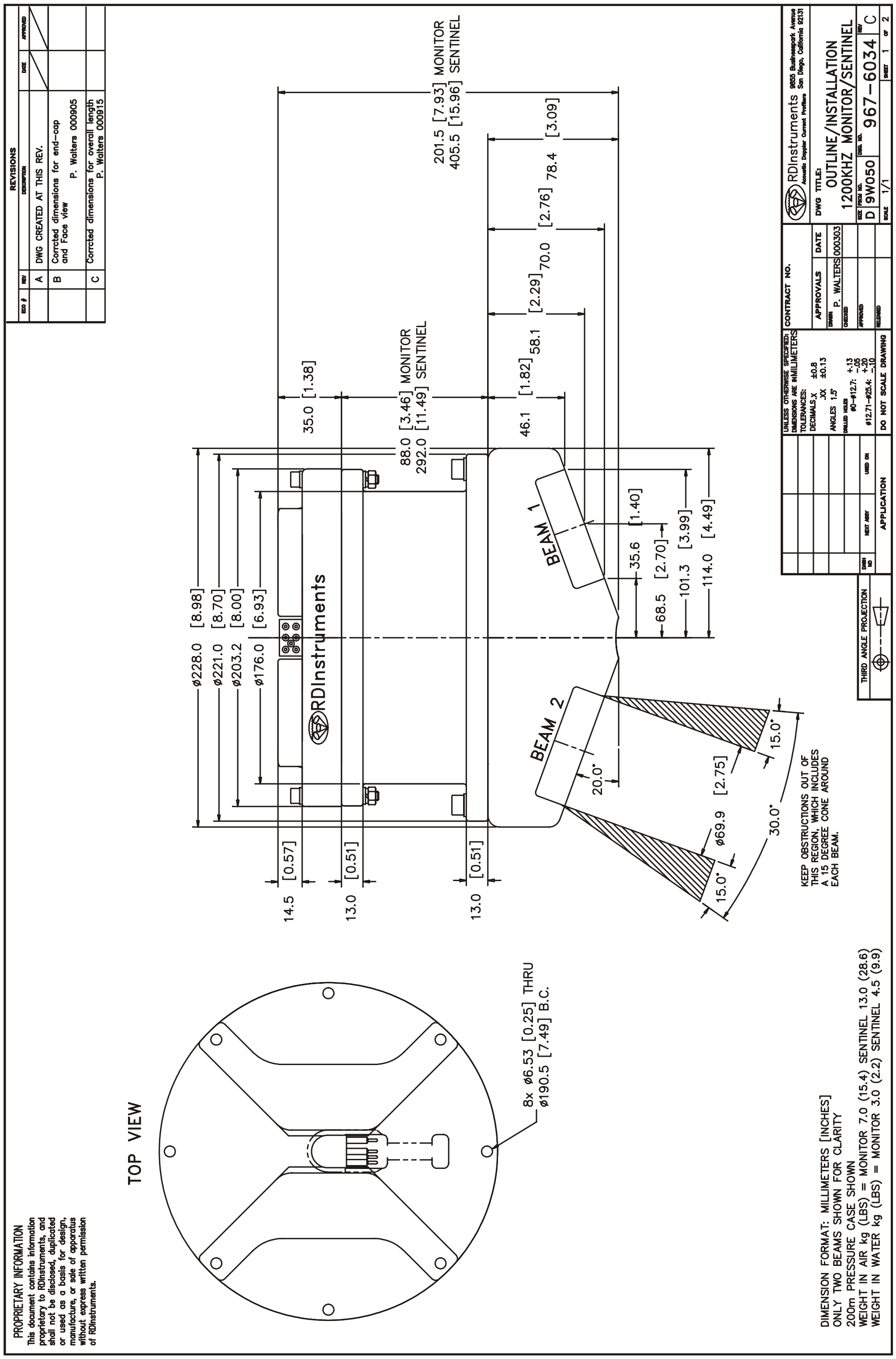

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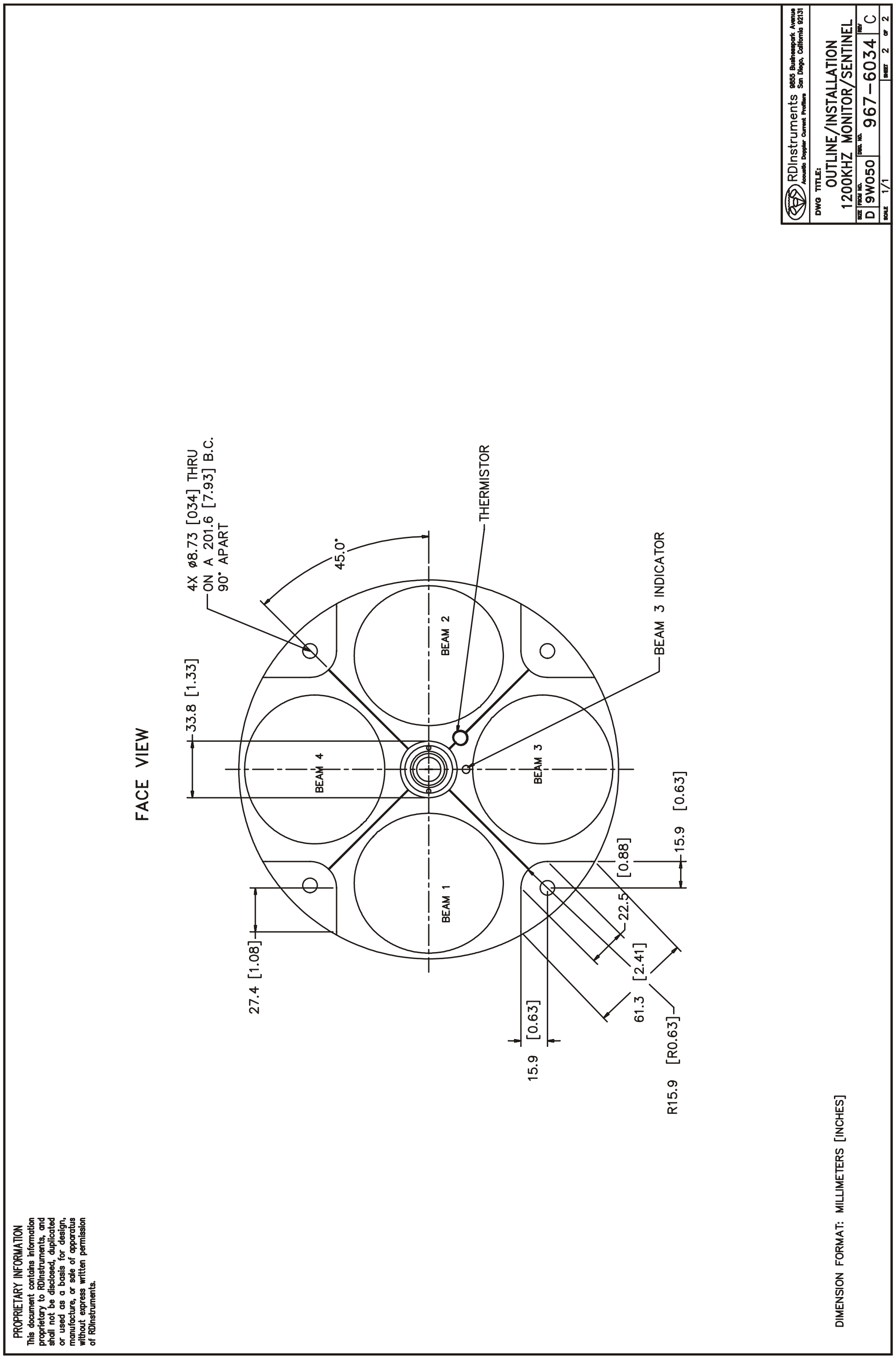

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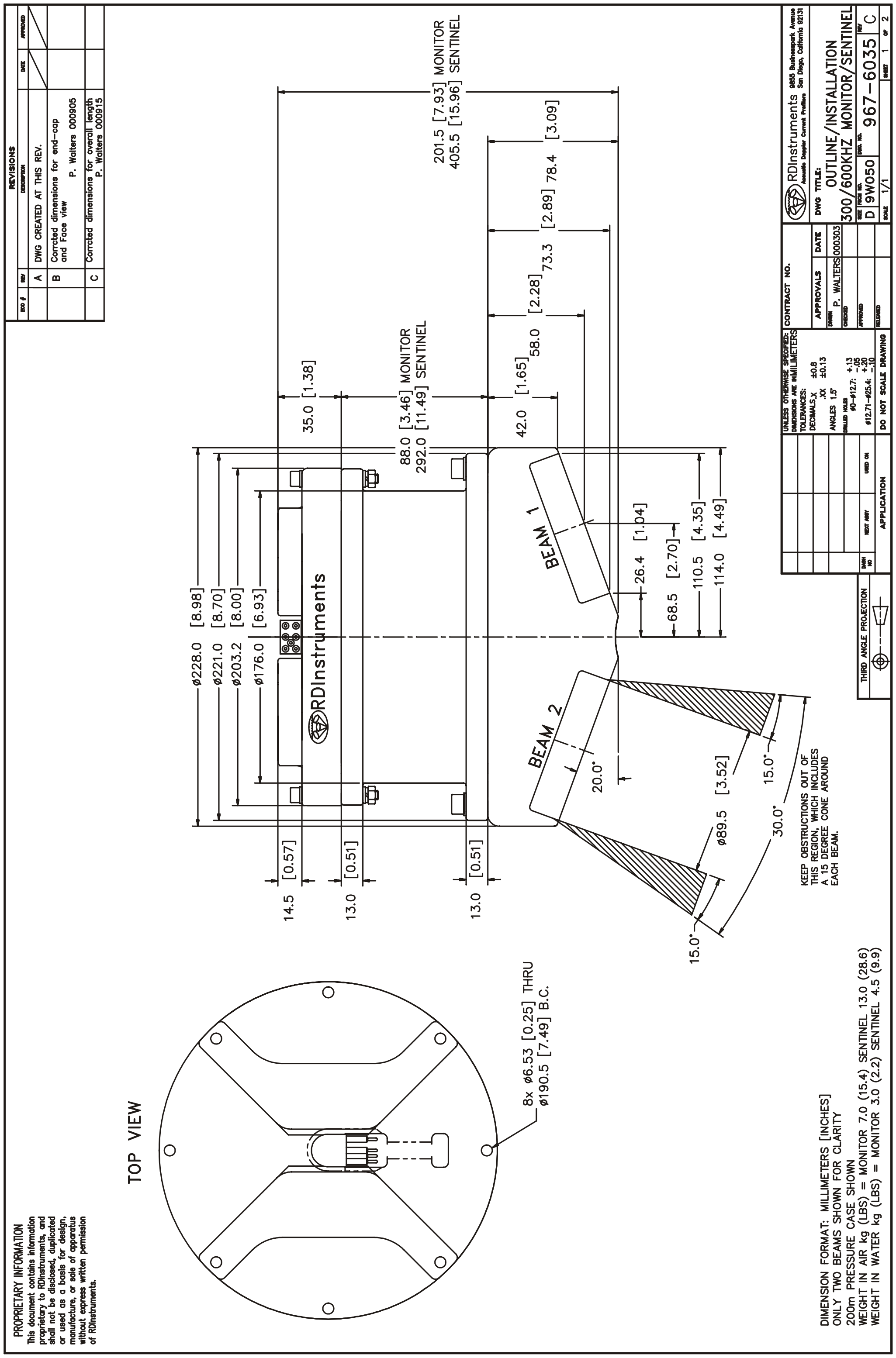

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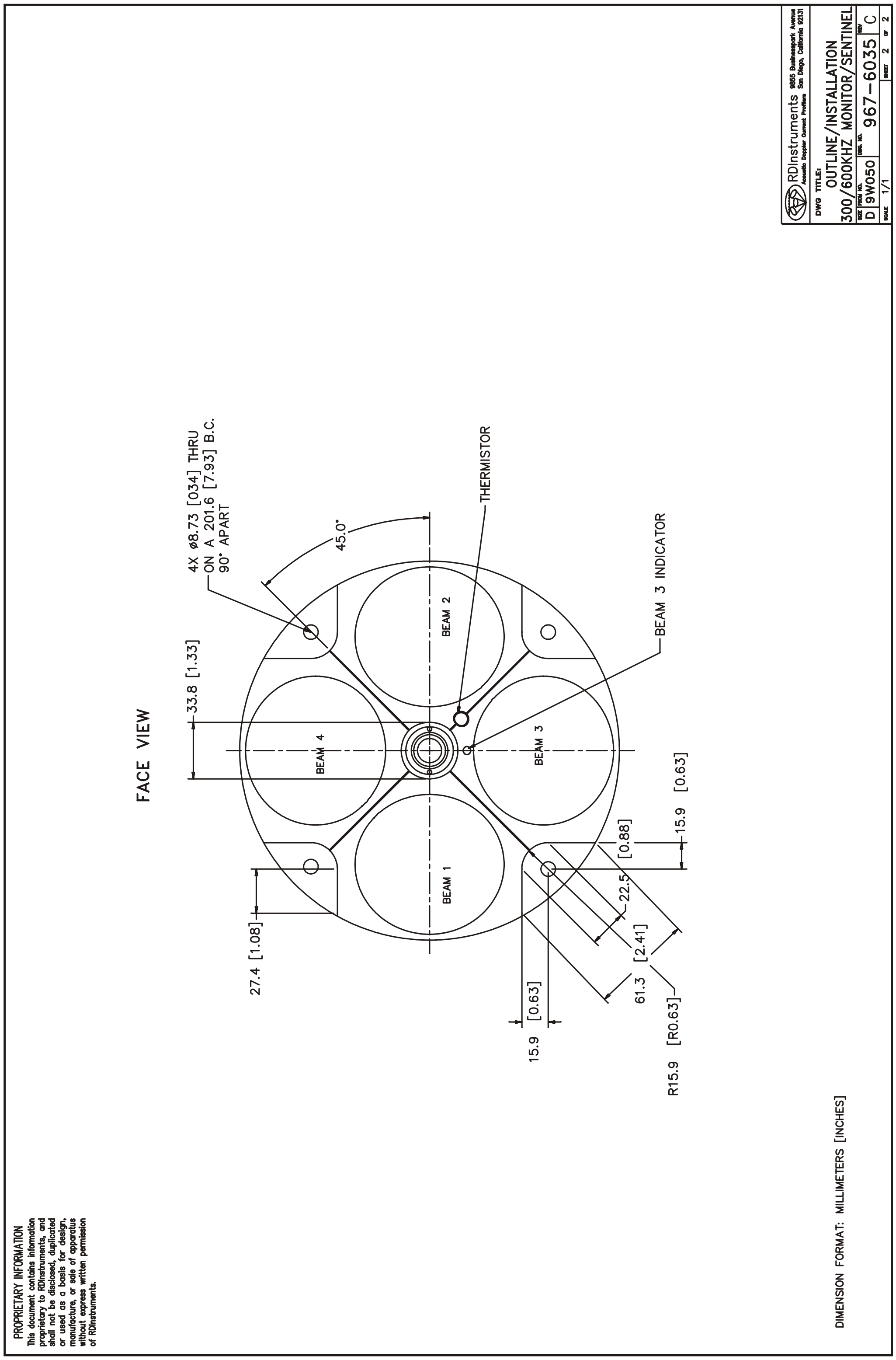

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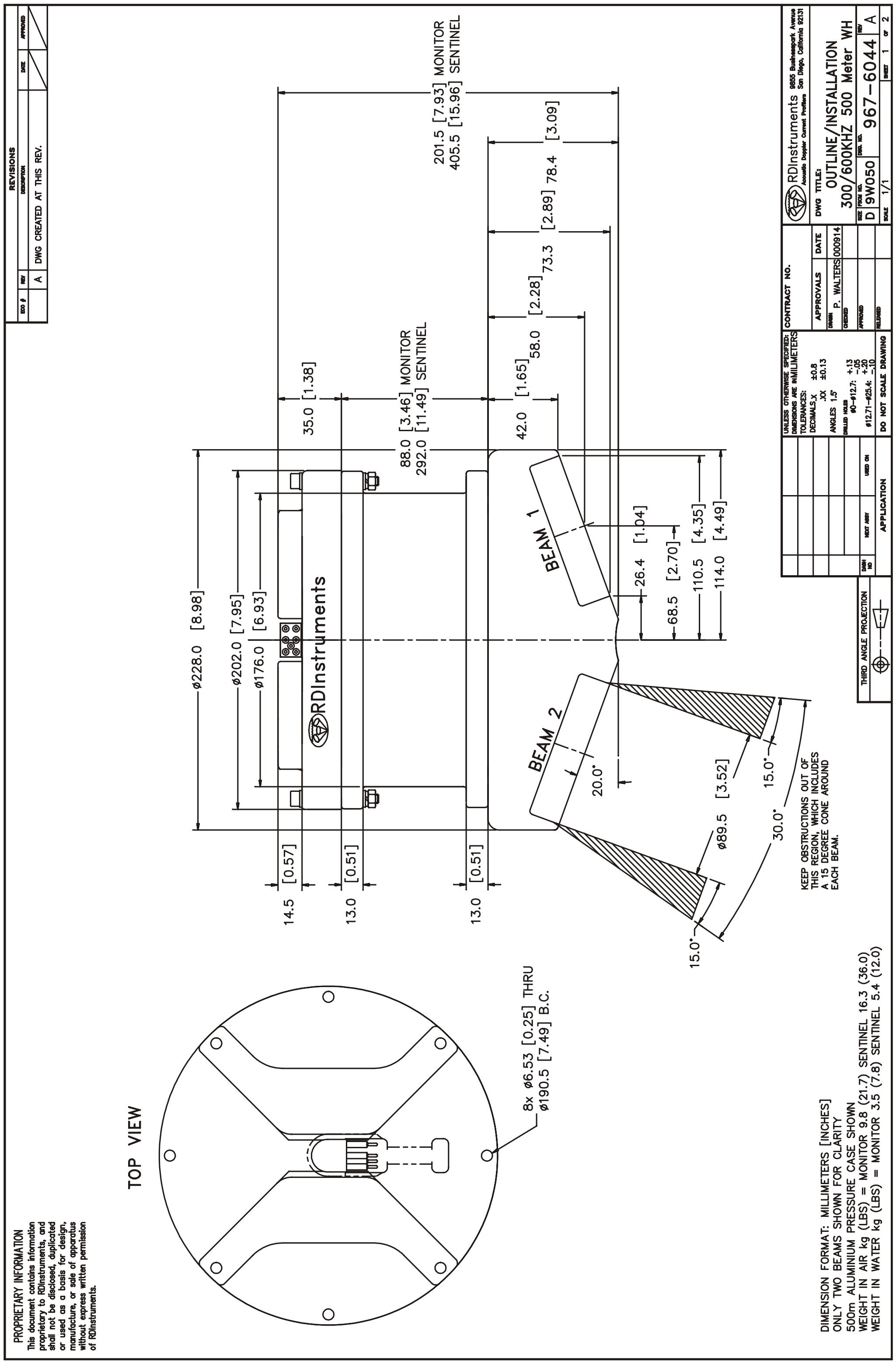

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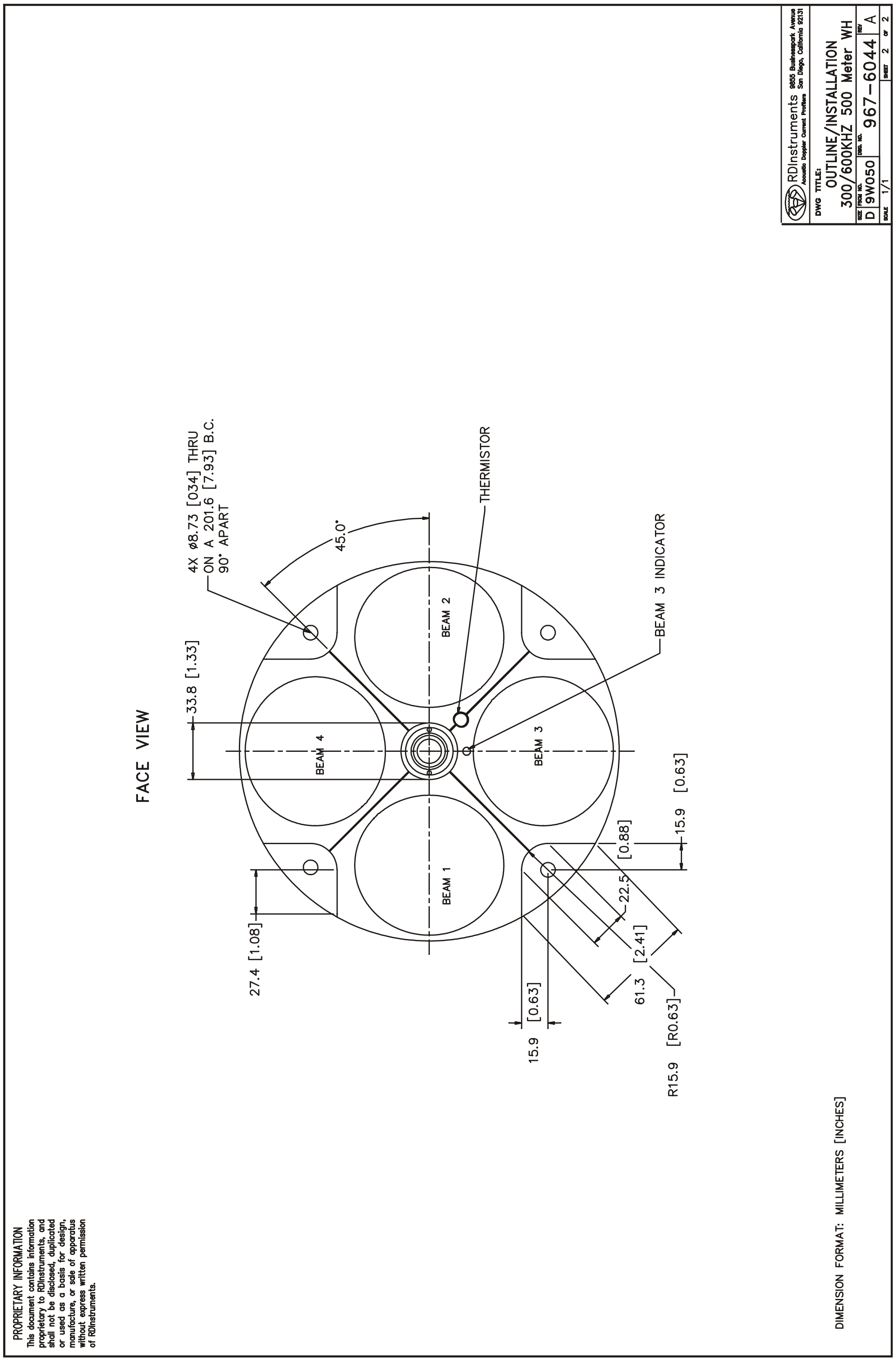

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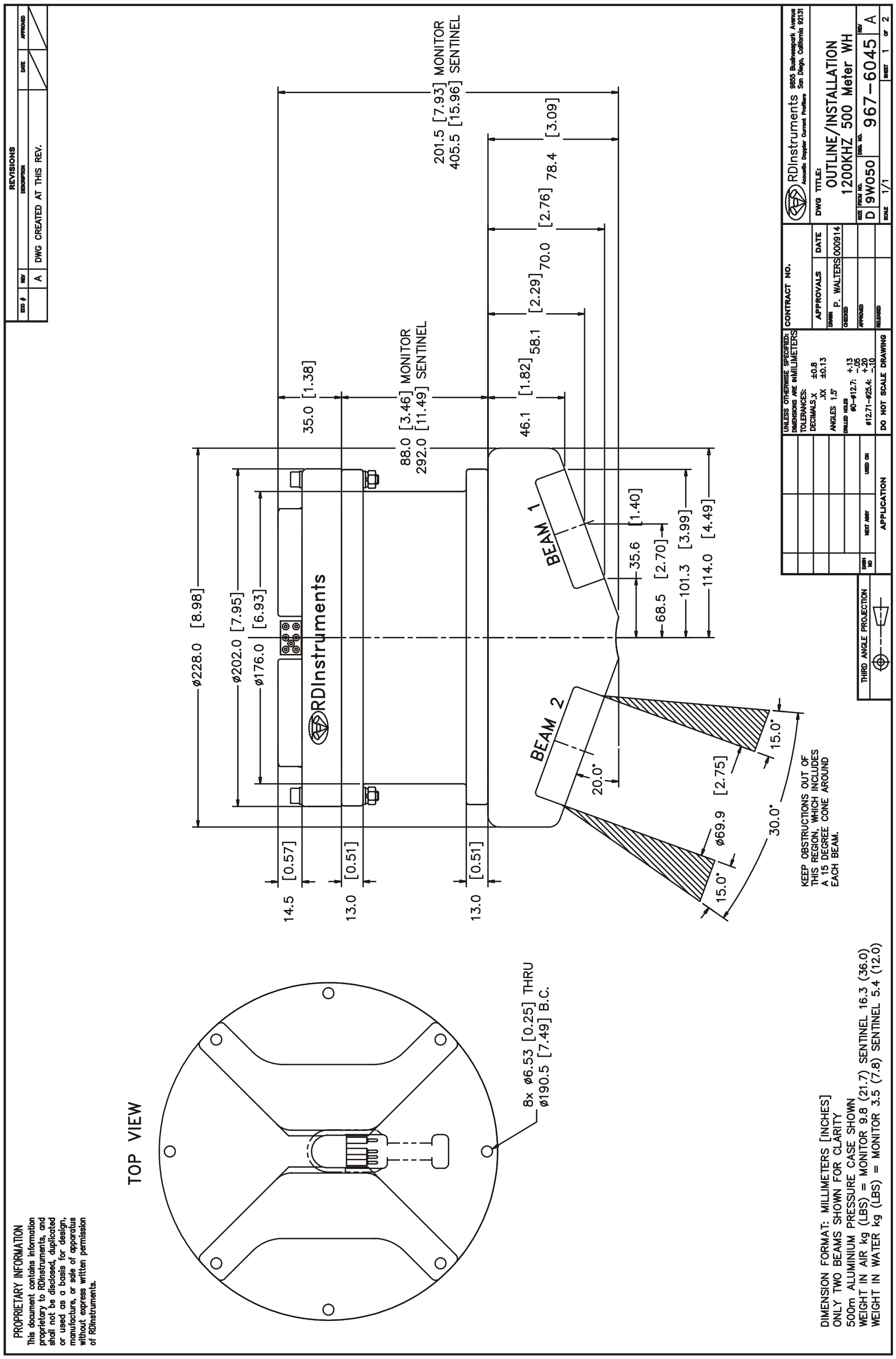

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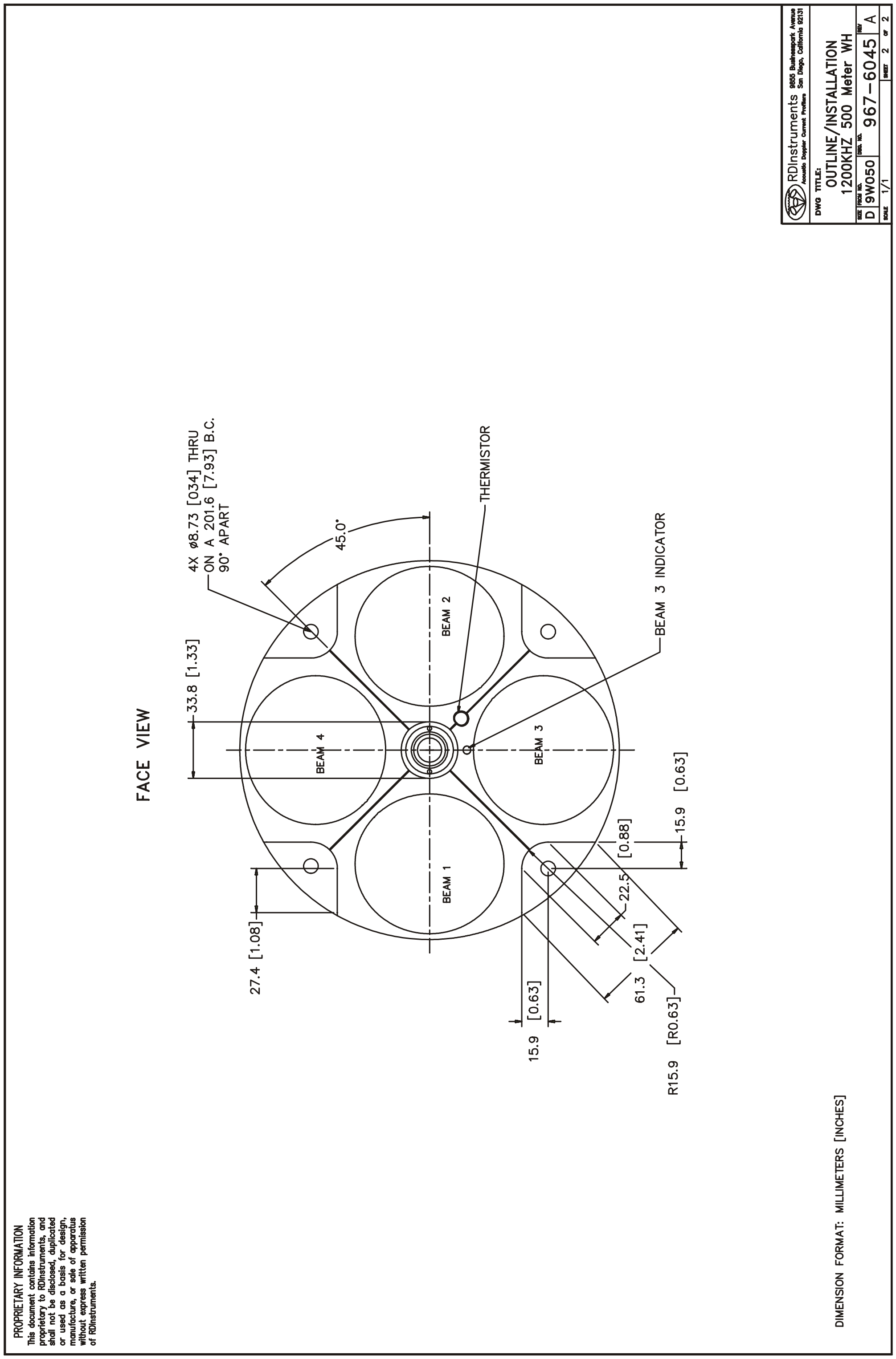

NOTES