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vol. 5 no. 5 a newsletter for ocean technologists

OCEAN BOTTOM SEISMOMETER GIMBAL SYSTEMS

The Hawaii Institute of Geophysics (HIG) has developed two major exploration ocean bottom seismometer (OBS) systems. One operates as a free vertical pop-up ocean bottom seismometer (POBS) and the other is a larger, tethered, ocean bottom seismometer (TOBS). In both instruments it is necessary to maintain proper orientation of the geophones while the instrument is operating. This proper orientation is maintained by gimballing the geophones.

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November 1977

Slip Ring and Brush Assemblies

Both gimbal systems use a printed circuit (PC), slip ring, and 14-kt-gold brush assembly developed at HIG. The slip rings, brush plate, and a PC board (Figure 1), are etched and plated using the following materials and techniques:

- Base Material--G-10 epoxy glass, .062-inch (.157 cm) nominal thickness, 1-oz copper laminate, single side.
- Nickel Plate--.0001-inch (2.54 x 10^{-4} cm) nominal electroplate over copper, (Techni-Nickel WS by Technic, Inc.).
- Gold Plate--.000046-inch (1.168 x 10^{-4} cm) nominal electroplate over nickel. (Orosene PC by Technic, Inc.).

After manufacture the PC cards are machined to fit the gimbal system (Figure 2).

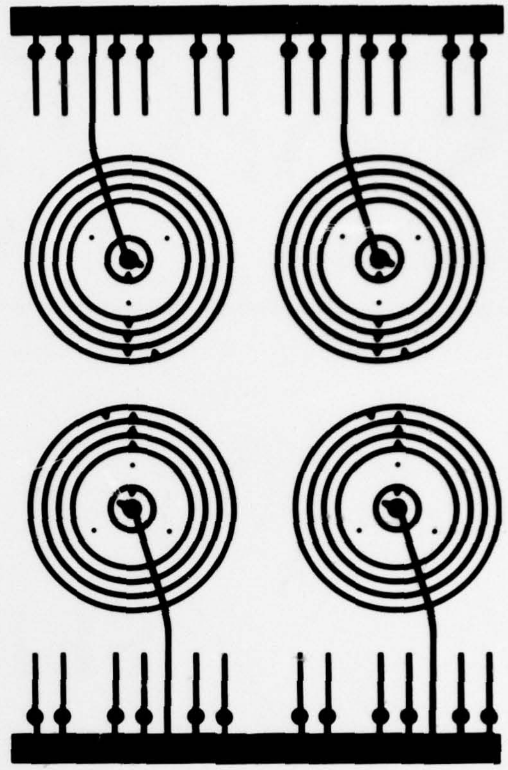

Figure 1.

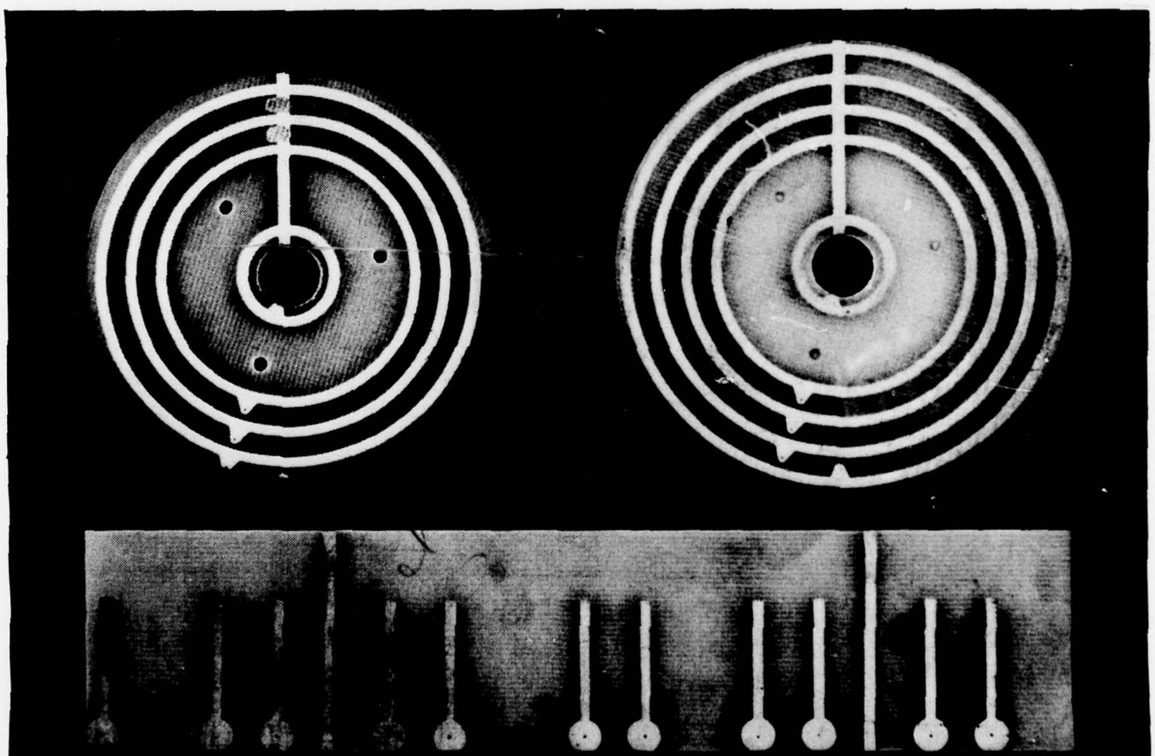

Figure 2.

The brushes are manufactured from 14-kt-gold wire (No. 20 B and S gauge, .032 inch). The wire is hand-drawn to No. 30 B and S gauge (.010 inch). During the drawing process the wire is work-hardened. After the drawing is finished the wire is hand-shaped to fit the gimbal system and is soldered on the brush plate. After assembly, brush pressure is adjusted to insure electrical continuity through 360° of rotation while maintaining a minimum pressure.

In the 40 systems that have been built, the slip ring assembly has been shown to be very reliable. Occasionally a brush will separate from the slip ring when operating temperature is reached (0-4°C); this separation can be detected before deployment by spraying the brushes with cold spray, and it can be corrected by reshaping the brush. The slip ring assembly sometimes becomes dirty and, again, electrical continuity may be lost. The slip rings are cleaned with a common pencil eraser and sprayed lightly with a no-residue cleaner.

The use of gold enables reliable contact with low wiper pressure. Consequently, mechanical resistance to gimbal motion is minimized but the combination of bearing friction and brush pressure is great enough to lock the gimbal for seismic displacement.

<u>POBS Gimbal Systems</u>

The POBS gimbal system (Figures 3 and 4) has two components. The geophones used, one vertical and one horizontal, are the Geospace HS-1-K with an impedance of 900 Ω and a natural frequency of 4.5 Hz. For our purpose, the geophones are slightly modified by Geospace Corp. by removing the threaded bottom stud and replacing it with a flat-head machine screw. They are locked in the gimbal cylinder with two set screws.

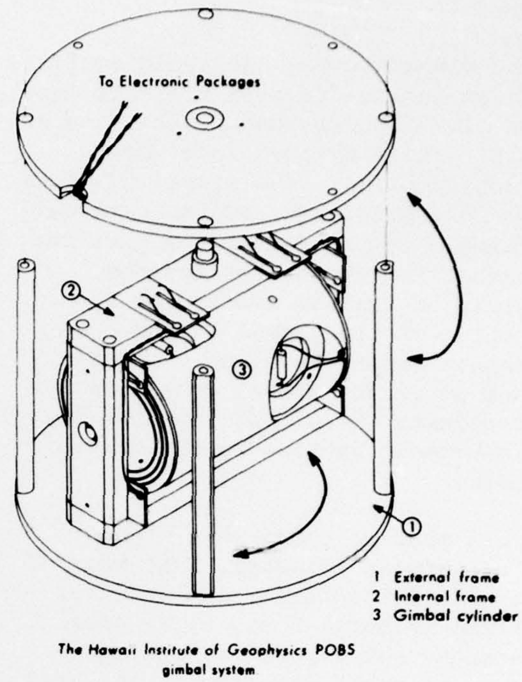

Figure 3. POBS gimbal system, exploded view.

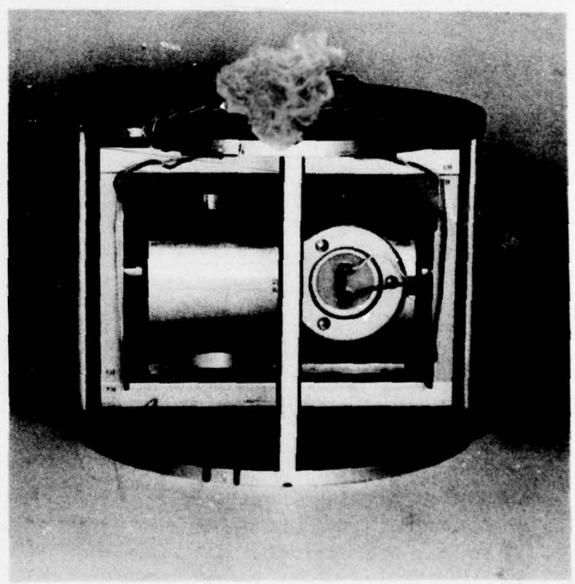

Figure 4. POBS gimbal system.

The gimbal system, designed to fit a 14-cm inside-diameter pressure case, is 11.75 cm long and weighs 2 kg in air. It is divided into three subassemblies: the gimbal cylinder, an internal frame, and an external frame. The subassemblies give the gimbal two degrees of freedom. A strip of lead is mounted on the bottom of the gimbal cylinder to insure proper leveling. Gravity acting on the gimbal continuously readjusts the gimbal level as the instrument settles in the abyssal ooze.

Care must be taken when wiper pressure is adjusted. The mass of the gimbal cylinder and internal frame (Figures 5 and 6) is small enough that wiper friction can prevent their leveling in the gimbal.

The magnitude of the contact resistance is of little consequence because the currents flowing through the slip ring assemblies are very small. The damping resistor (1.8 kΩ) is soldered directly to the geophone terminals; the input resistance of the signal package (greater than 2 MΩ) limits slip ring current to nanoamperes.

<u>TOBS Gimbal Subsystem</u>
The TOBS gimbals (Figures 7 and 8) use three geophones. The gimbal frame allows the geophones to rotate 360° about the long axis of a 19-cm ID pressure case. However, two geophones (a vertical and horizontal) have their own set of bearings, allowing them to rotate up to 45° to compensate for elevation of either end of the pressure case. The second horizontal geophone, perpendicular to the long axis of the pressure case, is capable of operation with 360° of rotation around its axis. Lead weights are attached to each geophone

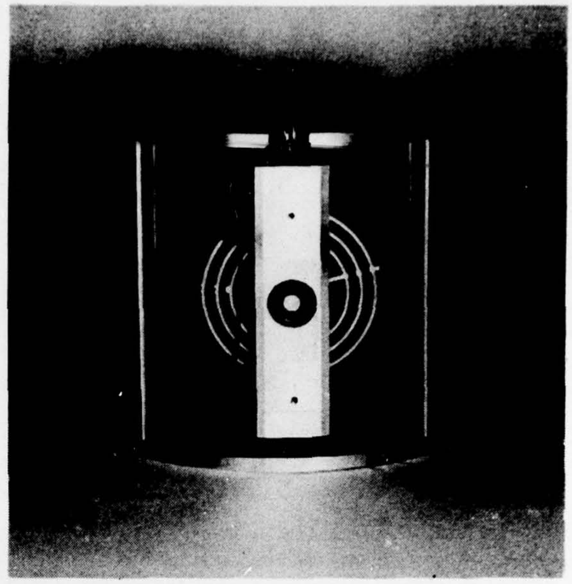

Figure 5. POBS gimbal cylinder slip ring assembly.

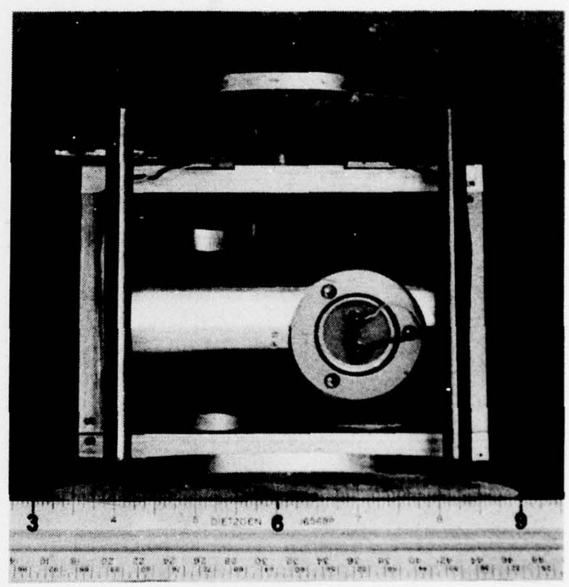

Figure 6. POBS gimbal frame slip ring assembly.

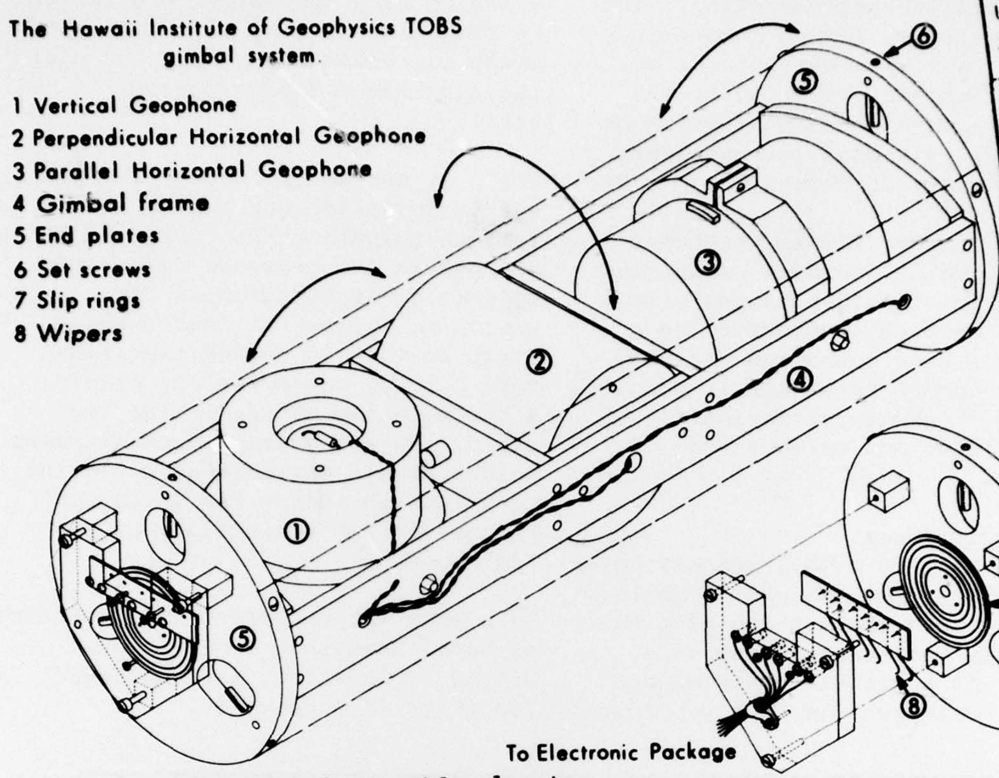

Figure 7. TOBS gimbal assembly drawing.

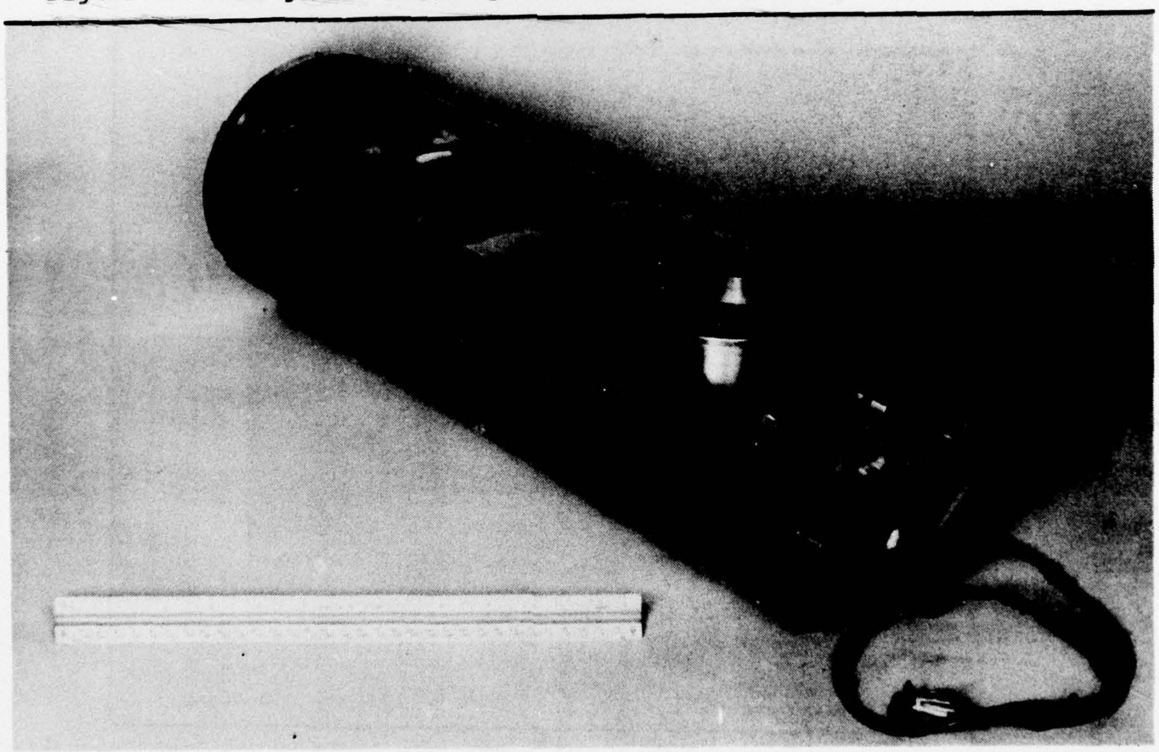

Figure 8. TOBS gimbal system.

so that all are self-leveling. The gimbal system is locked into the pressure case with six set screws. The slip rings are mounted to the gimbal frame in the same fashion as on the POBS gimbals, but the brush assemblies are different (Figure 9).

The HS-10, 2-Hz, 210-kΩ geophones are modified by Geospace Corp., by removing the threaded bottom stud. Critical damping is provided by a 750-kΩ resistor connected directly to the geophone terminals in parallel with the 750-kΩ input resistance of the amplifier and calibration circuits.

Field Experiences

Approximately 40 gimbal systems have been built during the past 5 years. They have been shown to be reliable, relatively maintenance-free, and rugged. As a standard part of our routine prelaunch checkout procedure, all slip ring assemblies are tested. We find that we have to readjust the brushes, retrim the gimbal, or clean the slip rings 3 to 5 percent of the time.

The only mechanical damage the gimbal system sustained was during an air freight shipment. The POBS was being shipped in its pressure case, and apparently it was dropped far enough to deform the lead ballast strip so that it locked the gimbal. This problem was solved by placing a screw in the middle of the lead strip. We are currently considering using the air carriers as a testing technique to insure the mechanical ruggedness and reliability of our instruments.

This work was supported by the Office of Naval Research, IDOE/National Science Foundation, and the Hawaii Institute of Geophysics.

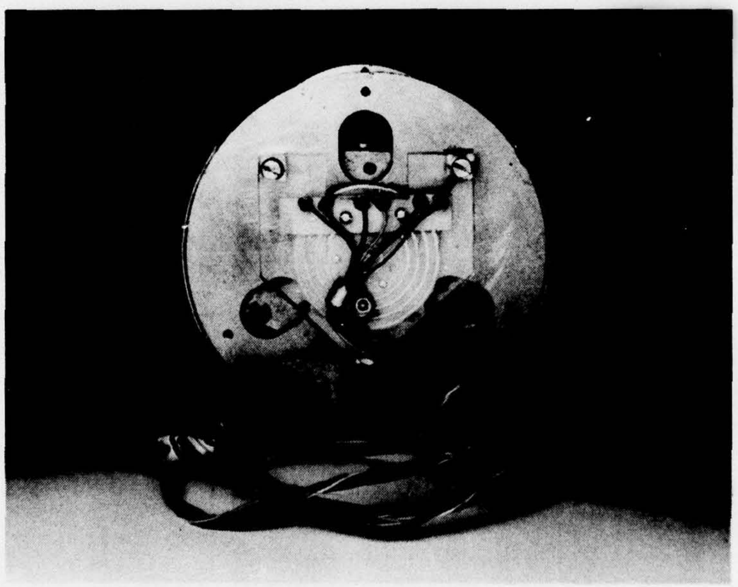

Figure 9. TOBS gimbal slip ring assembly.

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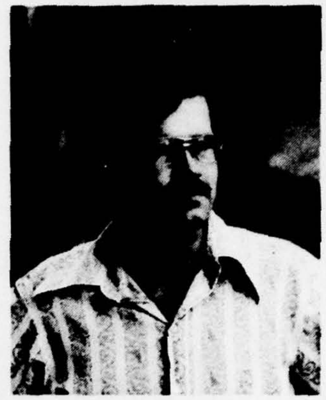

David A. Byrne is project coordinator for the OBS effort at the Hawaii Institute of Geophysics. He received an Associate degree in Electrical Technology from the State University of New York at Morrisville and a B.S. in geology and geophysics from the University of Hawaii. He has been involved in design, development, and testing of ocean equipment and instrumentation since 1972. Dave also serves as diving liaison officer at HIG.

William Ichinose, Jr. is an electronics engineer at the Hawaii Institute of Geophysics, University of Hawaii. He has a B.S. in Physics from the U of H.

AN ELECTRONIC GYRO REPEATER SYSTEM

Most research ships in the academic fleet are equipped with gyrocompasses manufactured by Sperry Marine Systems Division of Sperry Rand Corporation.

The Newsletter also includes an which

~~The following~~ article describes an electronic gyrocompass repeater that was designed (by the Technical Planning and Developement Group, OSU) to provide a digital ship's heading output for automatic data management, with the option of adding repeater stations about the ship, at a much lower cost per station than conventional electromechanical repeaters.

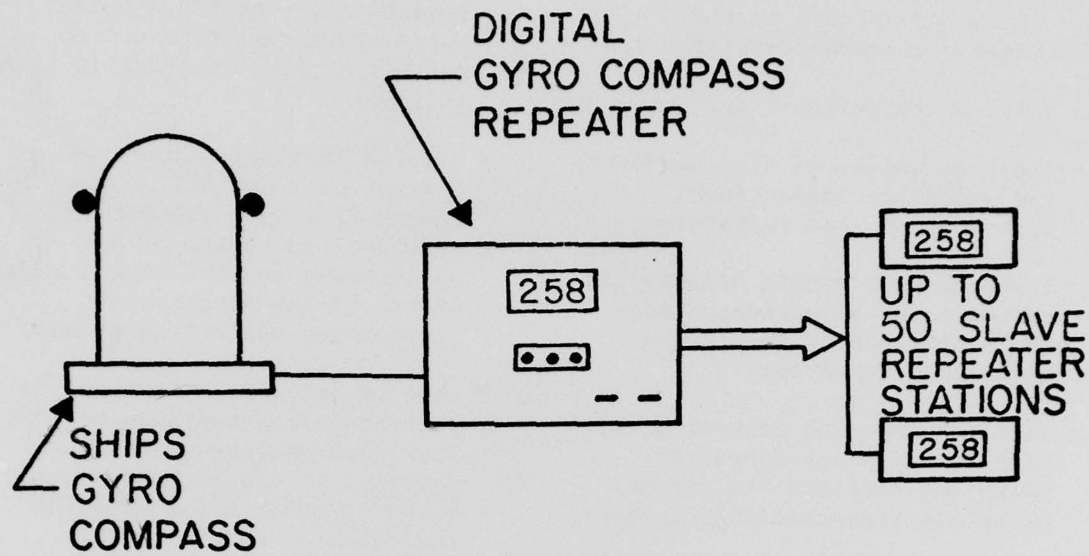

Figure 1.

This repeater system has been interfaced to the Mark 37 and Mark 14 four-wire gyrocompass repeater systems. There is no apparent reason why it wouldn't work with other models that use the same repeater drive concept.

The system consists of a control unit and several remote display units (Figure 1). The control unit contains all of the electronics necessary to interface to the ship's gyro system and provide present heading to the front panel display and to six remote displays. Additional displays can be added by using an external line driver system. In addition, an optically isolated data output port provides heading information in parallel BCD format to an active device such as a computer or a data acquisition system. The control unit is meant to be located near the gyro compass, but it can be located any place on the ship which has access to the four gyro repeater lines.

The remote displays measure 2.5" H x 5" W x 3.3" D and weigh less than 1 pound. All power and data is supplied by the control unit via a 12-wire cable to a D*M connector on the back panel of the remote unit. These units can be mounted anywhere on the ship.

Some of the advantages of the electronic gyro repeater system are:

- solid state reliability;
- light weight--less than one-tenth the weight of conventional electromechanical repeaters;
- lower cost--a remote display can be built for an estimated one-tenth the cost of an electromechanical repeater;
- less loading--the control unit, with six displays connected, draws one-fiftieth the current of an electromechanical repeater;
- readability--the LED display, which shows direction to the nearest degree, is readable from 10 feet;
- ease of initialization--the control unit and all of the remote display units can be synchronized to the ship's gyrocompass by actuating a toggle switch on the electronic gyrocompass control unit; and
- ease of interface--because the control unit interfaces to most four-wire stepper gyrocompass systems, it can be conveniently moved to other ships or other positions on a ship.

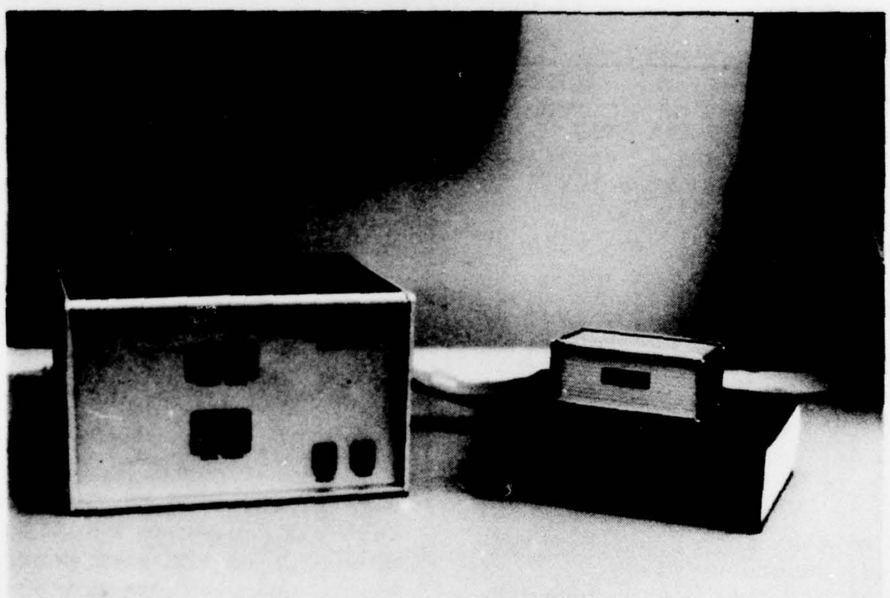

Figure 2.

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The control unit and a remote display unit are pictured in Figure 2. The back panel of the control unit has a three-jack, D*M-type connector. The three center leads of these jacks connect to the three active lines of the gyro repeater system. The three shield leads connect to the common line. The system is designed to interface to a 0, +70 V gyro system but other systems can be accommodated by changing resistors on the control unit input/output board.

After the unit is properly connected to the ship's gyro system, the remote display units are connected, power is applied, and the operator sets the thumbwheel switches on the front panel to correspond to the ship's gyro heading. Actuating the heading-preset switch will cause the ship's heading to be entered into the control unit's direction register, cause it to track the ship's gyrocompass, and to be displayed on the front panel and on the remote display units.

John Vito received his BS in electrical engineering from the City College of New York in 1965. He has spent most of his professional career as a circuit designer/systems analyst, first at Raytheon Company, then at the University of California at Berkeley. He is presently a part of the Technical Planning and Development Group, where he designs data acquisition and data transmission systems.

Rod Mesecar is Head of the Technical Planning & Development Group, School of Oceanography, at Oregon State University. He has BS, MS, and EE degrees in electrical engineering and a PhD in physical oceanography from OSU. Since 1965, his interest has been in applying engineering technology to all disciplines of oceanography.

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