GEOMETRICS

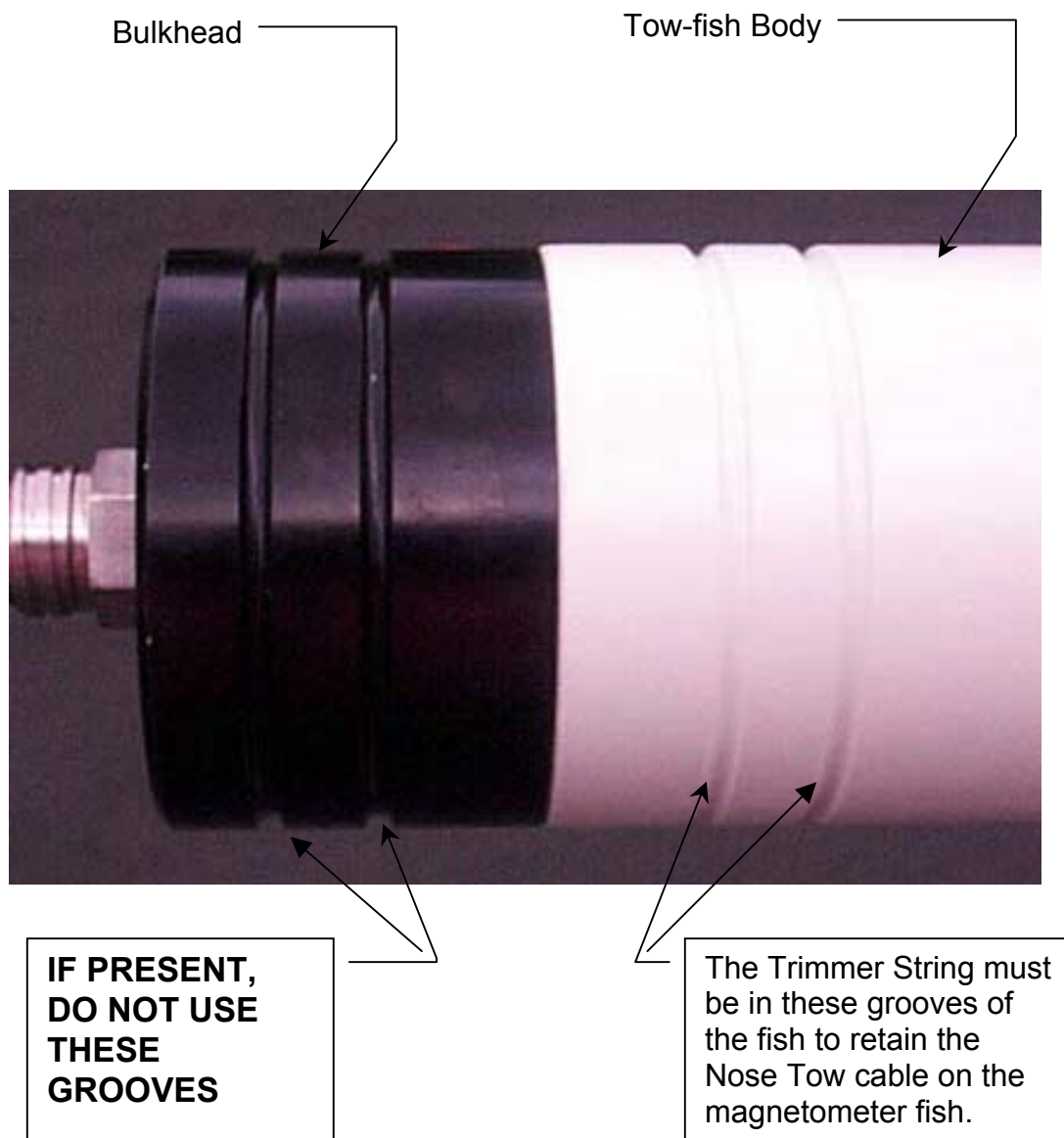# G-881 CESIUM MARINE MAGNETOMETER
25831-OM REV. D

Operation Manual

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PREVENT FLOODING OF YOUR MAGNETOMETER TOWFISH - - SEE BELOW:

THIS INFORMATION ONLY APPLIES TO EARLY MODELS OF THE G-881. LATER MODELS DO NOT HAVE THE GROOVES IN THE BULKHEAD. HOWEVER, READ THE INFORMATION BELOW. IT IS STILL RELAVENT FOR PROPERLY INSTALLING THE NOSE TOW FARING TO PREVENT DAMAGE OR LOSS OF THE TOW FISH.

INSTALLATION OF THE NOSE TOW RETAINER OR NOSE FARING TO THE MAGNETOMETER FISH.

To properly retain the Tow Cable with the Nose Tow Retainer or the Nose Fairing of the CG Tow configuration to the Magnetometer Fish, the Trimmer string must be inserted so that it is in the grooves of the Towfish Body and **NOT** the grooves of the Bulkhead

Bulkhead

Tow-fish Body

IF PRESENT, DO NOT USE THESE GROOVES

The Trimmer String must be in these grooves of the fish to retain the Nose Tow cable on the magnetometer fish.

When the Nose Tow Retainer or Nose Fairing are properly installed the black bulkhead will be visible and completely fill the large hole in the figure below.

If the black Bulkhead is visible in the Trimmer String Slots, slide the nose on further until the white grooves of the Towfish body are visible in the slots. Then insert the Trimmer strings.
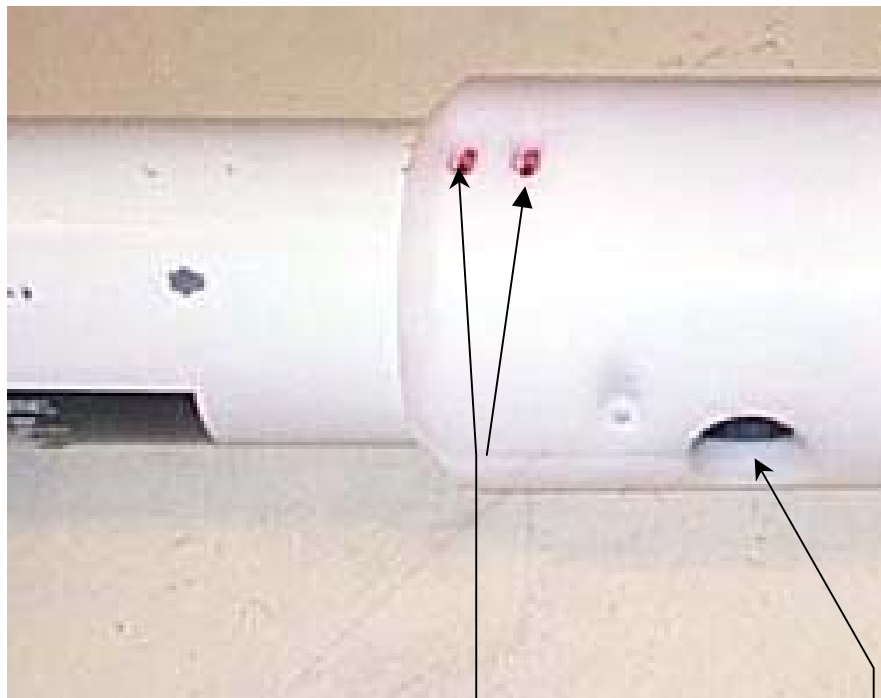
Trimmer string inserted in the grooves of the Magnetometer Fish through the slots in the nose.

Black Bulkhead is visible in this hole if the nose is properly installed.

$C\epsilon$ 97

December 3, 1996

Sunnyvale, California, USA

EC DECLARATION OF CONFORMITY

We,   Geometrics, Inc.
Geometrics Europe
395 Java Dr.
Sunnyvale, CA 94089 USA
ph: (408) 734-4616
FAX: (408) 745-6131

declare under our sole responsibility that our marine magnetometers, models G-880, G-881 and G-886 to which this declaration relates are in conformity with the following standards:

EN 55022 : 1995, EN50082-2 : 1995, ENV 50140 : 1994, ENV 50141 : 1994,
EN 61000-4-2 : 1995, EN 61000-4-4 : 1995

per the provisions of the **Electromagnetic Compatibility Directive** *89/336/EEC* of May 1989 as Amended by *92/31/EEC* of 28 April 1992 and *93/68-EEC, Article 5* of 22 July 1993.

The Technical documentation required by Annex IV(3) of the Low Voltage Directive is maintained by Christopher Leech of Geometrics Europe (address below).

The authorized representative located within the Community is:

Geometrics Europe
Christopher Leech
Manor Farm Cottage
Galley Lane
Great Brickhill
Bucks.MK17 9AB, U.K.
ph: +44 1525 261874
FAX: +44 1525 261867

Steven W. Duckett, President
Sunnyvale, CA, USA

G-881 MARINE MAGNETOMETER

- **CESIUM VAPOR HIGH PERFORMANCE -** *Improved range and probability of detecting all sized ferrous targets*

- **LOW SYSTEM PRICE -** *cost effective compared to competing technologies*

- **HIGH SENSITIVITY** $\_$ *0.01 nT/$\_$Hz RMS with the internal CM-221 Mini-Counter*

- **DIGITAL OUTPUT - COMPUTER LOGGING** *Use your computer with MagLog-Lite™ RS-232 logging/display software or Geometrics supplied CM-201 View utility program*

- **EASY PORTABILITY & HANDLING -** *no winch - single man operation, 44 lbs with 200 ft cable*

- **COMBINE TWO SYSTEMS FOR INCREASED COVERAGE -** *CM-221 Mini-Counter provides multi-sensor data concatenation allowing side by side coverage which maximizes detection of small targets and reduces noise*
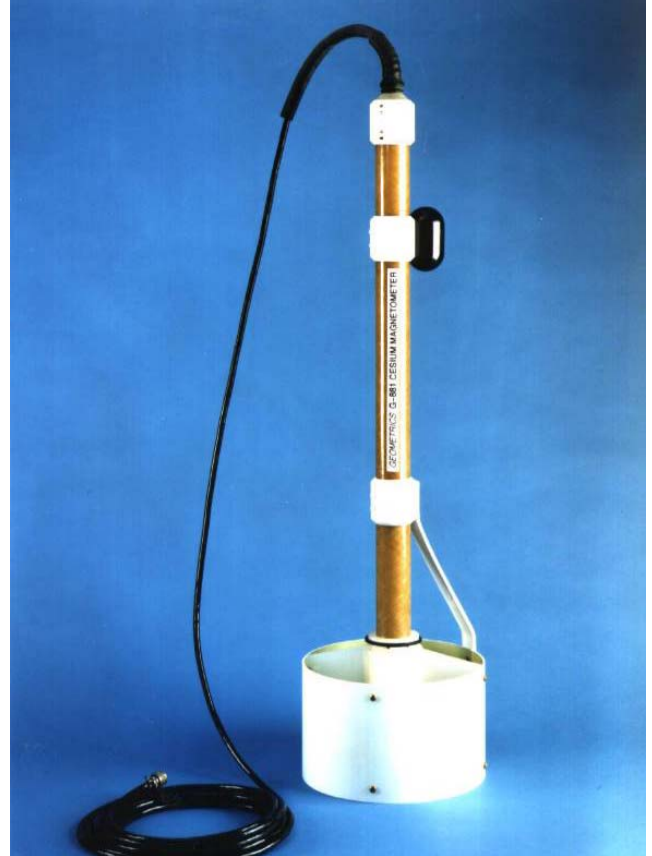
Very high resolution Cesium Vapor performance has been incorporated into a low cost, small size no-frills system for professional surveys in shallow water. High sensitivity and sample rates of total field measurements are maintained for all applications. The well proven Cesium sensor is combined with a unique new CM-221 Larmor counter and ruggedly packaged for small boat operation. Use your computer with our MagLog-Lite™ or MagLog NT™software to log, display and print RS-232 data transmissions from the mag and GPS receiver. Model G-881 is the lowest priced - highest performance fully operational marine mag system ever offered.

The G-881 is focused for operation in small boat, shallow water surveys. Being small and lightweight (44 lbs net) it is easily deployed and operated by one man. Power may be supplied from a 24 to 30 VDC battery supply. The tow cable uses high strength

Kevlar and it's length is fixed at 200 ft (61 m). The shipboard end of the tow cable is attached to a junction box for quick and simple hookup to power and output of data into any small computer. (Upon request Geometrics will provide both computer and logging software for recording and display of magnetics and GPS location.) A rugged fiber-wound fiberglass housing incorporates selective orientation of the sensor and therefore maintains operations throughout the world with small limitations as to direction of survey in Equatorial regions.

The Cesium magnetometer provides nearly the same operating sensitivity and sample rates as the larger model G-880. Utility software is supplied with each magnetometer and allows display of data and recording to hard disk. Available options include a small notebook computer with MagLog™ installed which provides superior visual presentation of magnetics and GPS data, and a dot matrix printer for real time hard copy. Additional options include: Post

acquisition analog trace plotting software MagPlot, The G-881 system is particularly well suited for the detection and mapping of all sizes of ferrous objects. This includes anchors, chains, cables, pipelines, ballast stone and other scattered shipwreck debris, munitions of all sizes, aircraft, engines and any other object with magnetic expression. Objects as small as a 5 inch screwdriver are readily detected provided that the sensor is close to the seafloor and within practical detection range.(Refer to table at right).

The design of this special marine unit is directed toward the largest number of user needs. It is not intended to meet all marine requirements such as deep tow through long cables or monitoring fish altitude. Rugged design with highest performance at lowest cost are the goals.

and Surfer for Windows for generating contour maps.

Typical Detection Range For Common Objects

Ship 1000 tons 0.5 to 1 nT at 800 ft (244 m)
Anchor 20 tons 0.8 to 1.25 nT at 400 ft (120 m)
Automobile   1 to 2 nT at 100 ft (30 m)
Light Aircraft   0.5 to 2 nT at 40 ft (12 m)
Pipeline (12 inch)   2 to 3 nT at 125 ft (38 m)
Pipeline (6 inch)2 to 3 nT at 80 ft (24 m)
100 KG of iron   2 to 3 nT at 50 ft (15 m)
100 lbs of iron   2 to 3 nT at 30 ft (9 m)
10 lbs of iron   3 to 4 nT at 15 ft (5 m)
1 lb of iron   2 to 3 nT at 8 ft (2.5 m)
Screwdriver 5 inch   0.5 to 2 nT at 12 ft (4 m)
1000 lb bomb   4 to 5 nT at 100 ft (30 m)
500 lb bomb   0.5 to 5 nT at 50 ft (16 m)
Grenade   1 to 2 nT at 6 ft (2 m)
20 mm shell   0.5 to 2 nT at 5 ft (1.8 m)

MODEL G-881 CESIUM MARINE MAGNETOMETER SYSTEM SPECIFICATIONS

OPERATING PRINCIPLE:	Self-oscillating split-beam Cesium Vapor (non-radioactive)
OPERATING RANGE:	20,000 to 100,000 nT
OPERATING ZONES:	The earth's field vector should be at an angle greater than 6° from the sensor's equator and greater than 6° away from the sensor's long axis. Automatic hemisphere switching.
CM-221 COUNTER SENSITIVITY:	<0.01 nT/ _Hz rms. Typically 0.5 nT P-P at a 0.1 second sample rate or 0.005 nT at 1 second sample rate. Up to 10 samples per second
HEADING ERROR:	±1 nT (over entire 360° spin and tumble)
ABSOLUTE ACCURACY:	<3 nT throughout range
OUTPUT:	RS-232 at 9600 Baud
MECHANICAL:	
Sensor Fish:	Body 2.75 in. (7 cm) dia., 5.75 ft (1.75 m) long with ring fin (15 in. OD), 27 lbs. (12.3 kg) Includes Sensor and Electronics
Tow Cable:	Kevlar Reinforced multiconductor tow cable. Breaking strength 4,000 lbs, 0.47 in OD, 200 ft maximum. Weighs 17 lbs (7.7 kg) with terminations.
OPERATING TEMPERATURE:	-30°F to +122°F (-35°C to +50°C)
STORAGE TEMPERATURE:	-48°F to +158°F (-45°C to +70°C)
ALTITUDE:	Up to 30,000 ft (9,000 m)
WATER TIGHT:	O-Ring sealed for up to 200 ft (61 m) depth operation
POWER:	24 to 32 VDC, 0.75 amp at turn-on and 0.5 amp thereafter
ACCESSORIES:	
Standard:	CM-201 View Utility Software operation manual and ship case
Optional:	AC Power supply, Surfer for Windows, GPS, Computer
MagLog-Lite™ or MagLog NT™ Software:	Logs, displays and prints Mag and GPS data at 10 Hz sample rate.

TABLE OF CONTENTS

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1.0 Introduction

This manual is produced with the intent that it will offer the marine magnetic survey operator a good understanding of the science involved in alkali vapor magnetometry. It is not meant to be exhaustive for every case as there are many different situations and applications in which the magnetometers are used. We have attempted to discuss the important topics of system theory, equipment configuration, installation and field operation. Please contact the factory should you have specific questions relating to your special application. We assure you rapid and informed support.

The Geometrics G-881 Marine Magnetometer employs a Cesium atomic magnetic resonance system operating as the frequency controlling element of an oscillator. The frequency of the oscillation varies directly with the external magnetic field at the sensor. This frequency can be measured with great accuracy, yielding precise measurements of the magnetic field. This technique has been used in research and production geophysics since the late 1950's, and is now the preferred method for magnetic anomaly detection in military applications as well.

The G-881 Marine Magnetometer consists of two modules: sensor and sensor electronics package mounted in a fish which may be towed for marine applications. The G-881has its own internal counter to count and digitize the Larmor frequency which it then transmits digitally up the tow cable.

A basic understanding of the physics employed in the G-881 Marine Magnetometer, and optically pumped resonance magnetometers in general, will be helpful in achieving optimum results during field use.

2.0 Operation

The G-881 Marine Magnetometer may be purchased with optional software such as **MagLog-Lite**™ or **Maglog NT**™ logging software. Please refer to the Manuals associated with these software, if purchased. If **MagLog-Lite**™ or **Maglog NT**™ are not purchased, terminal software may be used to communicate with the G-881. Refer to Appendix A for a set of **Quick-start G-881 Operating Instructions** to help with the initial setup and running of the magnetometer.

2.1 Performance

Geometrics G-881 magnetometer produces a Cesium **Larmor** frequency output at 3.49872 Hz per nT (in this text, nT refers to nanotesla or gamma or 10^{-5} gauss). Thus, in a nominal 50,000 nT field this frequency is about 175 kHz. The output of the system is a continuous sine wave at the Larmor frequency. The typical signal amplitude is approximately 2 volts peak-to-peak at optimal orientation.

This frequency is counted with the counter at 10 readings per second. The G-881 is intended for use in marine applications, and operates over the earth's magnetic field range of 20,000 to 100,000 nT.

Absolute accuracy depends on sensor orientation, internal light shift and the accuracy of the external counter's time base. Orientation error of the G-881 does not exceed 1 nT p-p (peak-to-peak) throughout the active zone(s) (see auto-hemispheric switching section). This is due in part to the use of a split-beam circular polarizer.

Sensors are compensated to provide a flat response over the center most angular orientation of less than 0.5 nT.

Like all magnetometers, performance of the G-881 in a mobile installation is primarily dependent upon the compensation and noise reduction techniques used on the platform (i.e., ship). Navigation/position errors, radiated magnetic noise and heading error from the ship's induced and remnant magnetic fields are typically the major contributors to "noise" in the marine environment.

The G-881 Sensor Package consists of a sensor head and sensor electronics package joined by a cable. The electronics package contains an integral Geometrics mini-counter which converts the Larmor signal into a magnetometer reading in nano-Teslas. Digital data is transmitted via RS-232 to a data logging system. A five pin underwater connector on the sensor electronics package receives power on two pins. The other three pins are used to provide an RS-232 connection upon which the G-881 transmits magnetometer data readings in digital format.

Environmental conditions for proper operation are -35 to +50°C (-31 to +122° F). The G-881 will operate to a depth of 1000 feet.

2.2 Optical Pumping Theory

Note: The following section is provided for information purposes only. Understanding this theoretical discussion is not required for proper operation of the magnetometer.

For purposes of this discussion, the ambient magnetic field or earth's magnetic field is called H_0. A separate magnetic field generated by an AC signal applied to a coil inside the sensor is called H_1. Refer to the drawing on the next page for the following discussion.
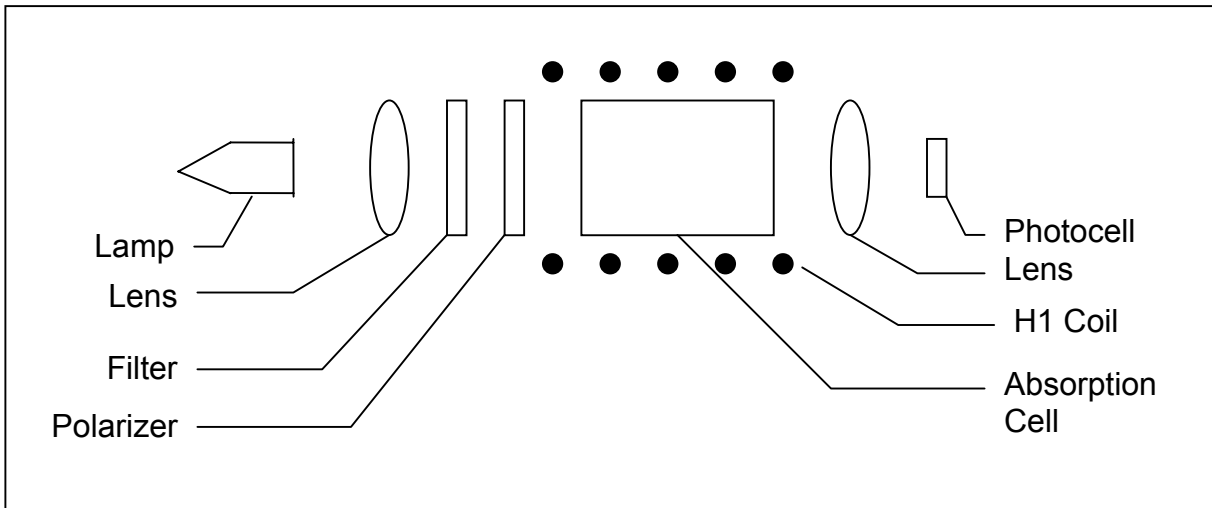
G-881 CESIUM SENSOR

To initiate operation of the sensor, the lamp oscillator's RF power increases until the lamp strikes (plasma ignites and fluoresces). The lamp oscillator then reduces its power to produce the regulated amount of light. The heater warms the absorption cell until a Cesium vapor is formed. A lens bends the light from the lamp to parallel rays. The lamp produces many spectral lines but only one line in the infrared region is employed. All of the other light is blocked by a high grade optical filter.

The infrared line of interest is then passed through a split-circular polarizer. On one side of the polarizer the transmitted light has an electrostatic vector that advances with a right-handed rotation. For conceptual purposes, it can be said that all of the photons in this light have the same right-hand spin direction. The light transmitted through the other side of the split-circular polarizer produces light in which the vector advances with a left-handed rotation, therefore having the opposite spin. Both circular polarized light beams pass through the absorption cell. Because there is a buffer gas in the cell, the single cell can be considered as two separate cells, each having the opposite sense polarized light passed through it. Both light beams exit the cell and pass to a second lens. This lens focuses the light onto an infrared photo-detector.

Because Cesium is an alkali metal, the outer most electron shell (orbit) has only one electron. It is the presence of this single electron that makes the Cesium atom well-suited for optical pumping and therefore magnetometry.

The Cesium atom has a **net magnetic dipole moment**. This net dipole moment, termed **F**, is the sum of the **nuclear dipole moment**, called **I**, and the **electron's angular momentum**, called **J**. In a Cesium atom:

   I = 7/2
   J = 1/2

and thus **F** can have two values depending on whether the electron's angular momentum adds to or subtracts from the nuclear dipole moment. Therefore, **F** can have the value of **3** or **4**. These values are called the hyperfine energy levels of the ground state of Cesium.

Normally the net dipole moments are randomly distributed about the direction (vector sum of the 3 axial components) of the ambient magnetic field (H_0). Any **misalignment** between the net atomic dipole moment and the ambient field vector causes the Cesium atom be at a higher energy level than if the vectors were aligned. These small differences are called **Zeeman splitting** of the base energy level.

The laws of quantum electrodynamics limit the inhabitable atomic magnetic dipole orientations and therefore the atomic excitation energy to several discreet levels: 9 levels for the **F=4** state and 7 levels for the **F=3** state. *It is this variation in electron energy level state that is measured to compute the ambient magnetic field strength.*

When a photon of the infrared light strikes a Cesium atom in the absorption cell, it may be captured and drive the atom from its present energy level to a higher energy level. To be absorbed the photon must not only have the exact energy of the Cesium band gap (therefore the narrow IR line) but must also have the correct spin orientation for that atom.

There is a high probability that the atom will immediately decay back to the initial energy level but its original orientation to the ambient field is lost and it assumes a random orientation. An atom that returns to the base level aligned such that it can absorb another photon, will be driven back to the higher state. Alternately, if the atom returns to the base level with an orientation that does not allow it to absorb an incoming photon, then it will remain at that level and in that orientation. Atoms will be repeatedly driven to the higher state until they happen to fall into the orientation that cannot absorb a photon. Consequently, the circularly polarized light will depopulate either the aligned or inverse aligned energy states depending on the orientation (spin) of light polarization. Remember that one side of the cell is right-hand polarized and the other left-hand polarized to minimize sensor rotational light shifts and subsequent heading errors.

Once most of the Cesium atoms have absorbed photons and are in a state that does not allow them to absorb another photon, the light absorption of the cell is greatly reduced, i.e., more light hits the photo-detector. If an oscillating electromagnetic field of the correct radio frequency is introduced into the cell, the atoms will be driven back (depopulating the energy level) into an orientation that will allow them to absorb photons again. This frequency is called the Larmor frequency and is exactly proportional to the energy difference caused by the Zeeman splitting mentioned previously. This energy splitting is in turn directly proportional to the ambient magnetic field strength. The relationship between frequency and energy is given by:

$$E = f\hbar$$

Where:
        E   is the Zeeman energy difference
        f   is the frequency of the Larmor
        $\hbar$ is Planck's constant

In Cesium this Larmor frequency is exactly 3.498572 times the ambient field measured in nano-Teslas (gammas). In the G-881 this radio frequency field is generated by a coil, called the H1 coil, wound around the tube holding the optical components. When the RF field is present the total light passing through the cell is reduced because atoms are in an energy state in which they can again absorb the infrared light.

There is a small variation in the atomic light absorption at the frequency of the applied H1 depopulation signal. This variation in light intensity appears on the photo-detector as a small AC signal (microvolts). If this AC signal is amplified and shifted to the correct phase, it can be fed back to the H1 coil to produce a self sustaining oscillation. In practice simply connecting the 90° phase shifted and amplified signal to the H1 coil will cause the oscillation to spontaneously start. Reversing the direction of the earth field vector (H_0) through the sensor requires the drive to the H1 coil to be inverted to obtain oscillation. (See Automatic Hemisphere Switching, section 2.4.3).

2.3 Sensor Orientation Guide

The G-881 is designed such that the sensor 's optical axis is always perpendicular to direction of the tow and may be towed at any angle from vertical to horizontal along the towing path. This angle should be adjusted to optimize the magnetometer's performance depending upon where in the world it will be operated.

The sensor head should be oriented so that the earth's field vector arrives at an angle of from 15° to 75° to the optical axis of the sensor, for all towing attitudes. For optimal performance the sensor orientation should preferably be such that

the earth's field vector arrives at a angle of from 30° to 60° to the optical axis of the sensor. The sensor will not produce usable data when the angle between the earth's field vector and a plane perpendicular the optical axis of the sensor is less than 15°. In this "equatorial dead zone" the pumping and Zeeman splitting phenomena fails to function, as the signal to noise ratio falls off proportional to the function $2\sin\theta\cos\theta$ where θ is the angle between the optical axis and H_0 (external field). Similarly when the optical axis of the sensor is within 15° of parallel with the earth's field it will be in the "polar dead zone." In latitudes where the inclination of the earth's field vector is 45°±15°, vertical orientation will allow operation in all practical towing directions. In equatorial regions it may be necessary to orient the sensor horizontally or at 45°. This will allow all towing directions except within ±30° of North- South. In more Northern latitudes where the dip angles become much steeper, rotate the sensor to either ±45° of vertical to enable towing in all directions.
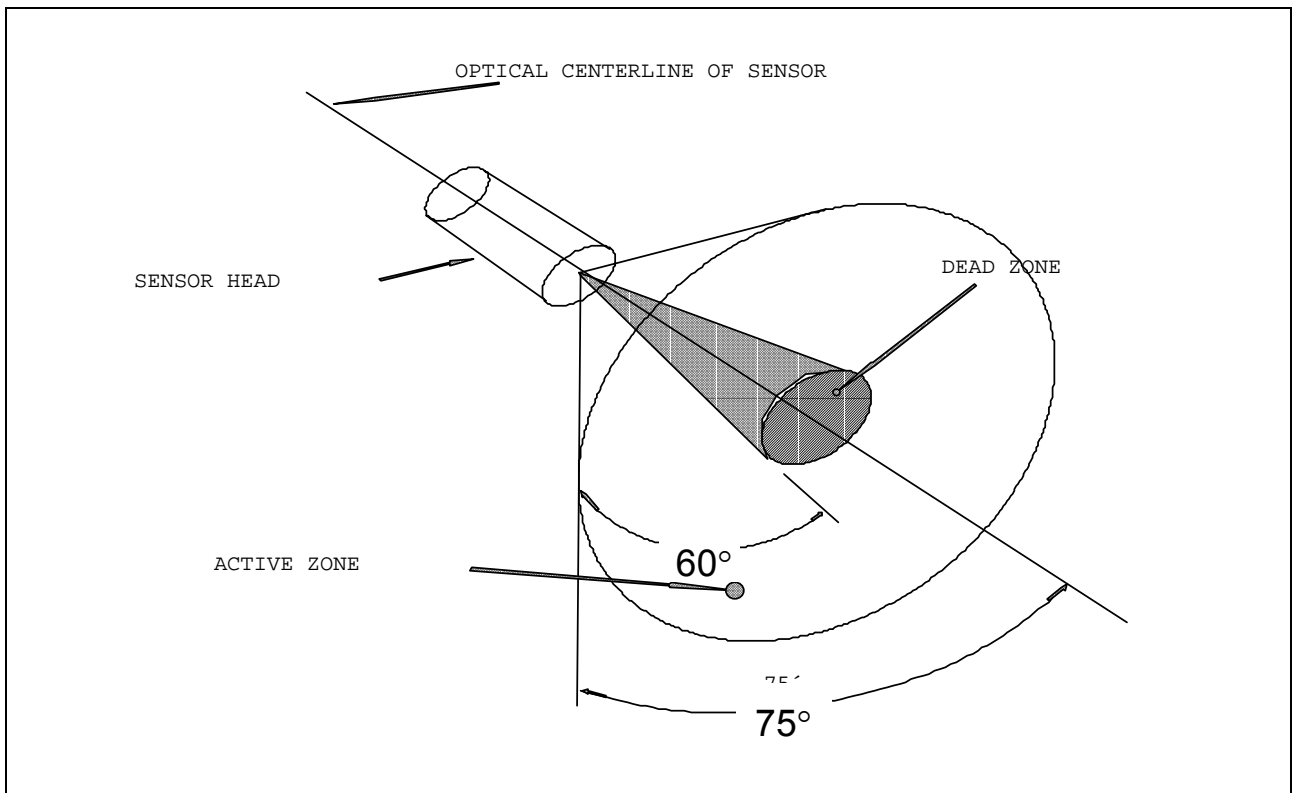
The G-881 Sensor must be oriented for best performance in any particular survey or search application. The program named "CsAz" will give the user the ideal sensor angles for the area of interest. See section **2.5.2** of this manual for further explanation of the use of CsAz.

There is a single adjustment which can be made to get to the best sensor position. This adjustment will allow the sensor 's optical axis roll angle to be set to any angle from vertical to horizontal.
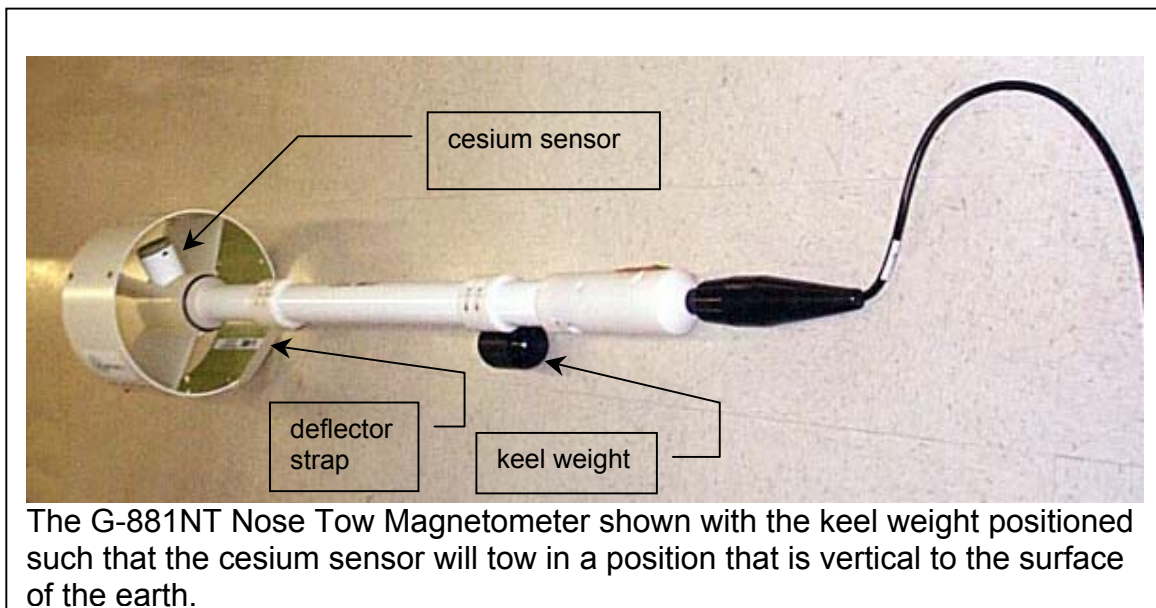
This roll angle is set by the position of the keel weight on the tow fish body in relation to the tee containing the sensor. To change this angle, loosen the two keel weight clamping screws, rotate the keel weight to the desired position and then tighten the clamping screws.

2.3.1 Sensor Positioning in Relation to the Dip Angle of the Survey Area

Optimal positioning the G-881 cesium sensor is necessary to insure that the best performance will be obtained for any given survey area. To accomplish this the sensor should always have the Earth's magnetic field lines (H field) well centered in its active zone. This position should also be such that the sensor will provide nearly equal performance in all four towing directions (forward and reverse of two orthogonal towing directions) to facilitate a methodical survey plan. To position the sensor, the Dip Angle of the field lines in the area of the intended survey must be known. This angle can be obtained from an INCLINATION map (see page 19). A TOTAL INTENSITY map is also provided to enable determination of the expected range of readings for the survey area(see page 18).

Since The G-881 has automatic hemisphere switching there are no different sensor positioning considerations for either the Northern or Southern hemispheres. Thus there are three regions in either hemisphere that are of interest with regards to positioning the G-881 cesium sensor. These regions are Dip angles of 0°-35°, 35°-67° and 67°-90° in either hemisphere.

Assembling the G-881 as pictured below provides the best operation in the 35°-67° region. See section 2.6 for assembly instructions. Note that in this picture the keel weight is attached to the tow fish such that the cesium sensor will be maintained in a position vertical to the Earth's surface while under tow. Figure 1 below also depicts this configuration of the TOW FISH and shows the Dip angle (45°) relative to the sensor. Then Figure 2 shows a graphic representation of the signal to noise ratio of the sensor at this orientation at this Dip angle. **The graphics shown in Figures 1 through 12 are derived using the CsAz software provided with this magnetometer. See section 2.5.2 of this manual for instruction in using CsAz.**

The G-881NT Nose Tow Magnetometer shown with the keel weight positioned such that the cesium sensor will tow in a position that is vertical to the surface of the earth.

The circumference of the graphic represents the compass directions in degrees i.e. the survey direction. The white portion of the graphic emanating from the center is proportional to the signal-to-noise ratio that would be obtained if the survey were run in that direction. In Figure 2 the graphic shows that in the sensor position of Figure 1 the sensor is omni-directional and will provide equal performance in any two orthogonal directions that might be selected for the survey. The black regions, when present (see Figure 4) represent survey directions (approximately a 30° wide region) in which the earth's magnetic field vector would be in the dead zone of the sensor. The region of the display that is white and outside of the ratio-15 circle represents survey directions in which the earth's magnetic field vector would be in the sensor's active zone and provide good data. The longer the white line, the higher the signal to noise ratio of the Magnetometer in that direction. Thus in Figure 4 a set of nearly equal performance orthogonal survey directions can be selected, but from a relatively small set when compared to Figure 2.

The magnetometer will still provide high quality data even when the sensor is not in the optimum orientation for the Dip angle in the survey area. However, the further the sensor is operated from optimal orientation, the more likely small changes in yaw, pitch or roll may result in spikes or miscounts. Note also that with the sensor in a much less than optimal orientation in addition to a speed that is less than 3 Knots, the tail of the fish may sag below the horizontal and produce the same type of erratic data. If the white line terminates inside the ratio-10 circle, then you will get no signal traveling in that direction. If it terminates just outside the 10° circle, then the installation will tolerate very little in the way of yaw, pitch or roll (depending on orientation, but most likely yaw) of the sensor before the earth's field vector goes into the sensor dead zone. The sensor position should be adjusted so that at least ±5° of signal (sensor motion) is available and preferably even more. This is easily achieved by selecting and setting the most optimal sensor orientation prior to initiation of the survey.

As can be seen in Figures 1 and 2 below, the position of the sensor is most optimal for the given dip angle. It provides equal performance of the sensor at any set of orthogonal angles that may be selected for survey, typically North-South survey lines and East-West tie lines. This facilitates a normal survey technique; primary, parallel survey lines and orthogonal, parallel tie lines. That is, the sensor's position in the tow fish does not require modification between orthogonal sets of survey lines.

The position of the sensor of the G-881 tow fish may be adjusted to other angles in relation to the earth's surface to accommodate the Dip angle of other regions of the earth. This is done by adjusting the position of the keel weight for the G-881NT (nose tow) or the center of gravity tow point clamp for the G-881CG (cg tow) in relation to the longitudinal axis of the cesium sensor. The graphic illustration below shows the relationships of the keel weight or CG tow point to the position of the sensor for three ranges of dip angles. The view is looking from the nose toward the ring fin.

Sensor

Keel

Dip Angle
\+ or -

35 – 67   67 – 90   0 – 35

CG Tow Point

Nose Tow

CG Tow
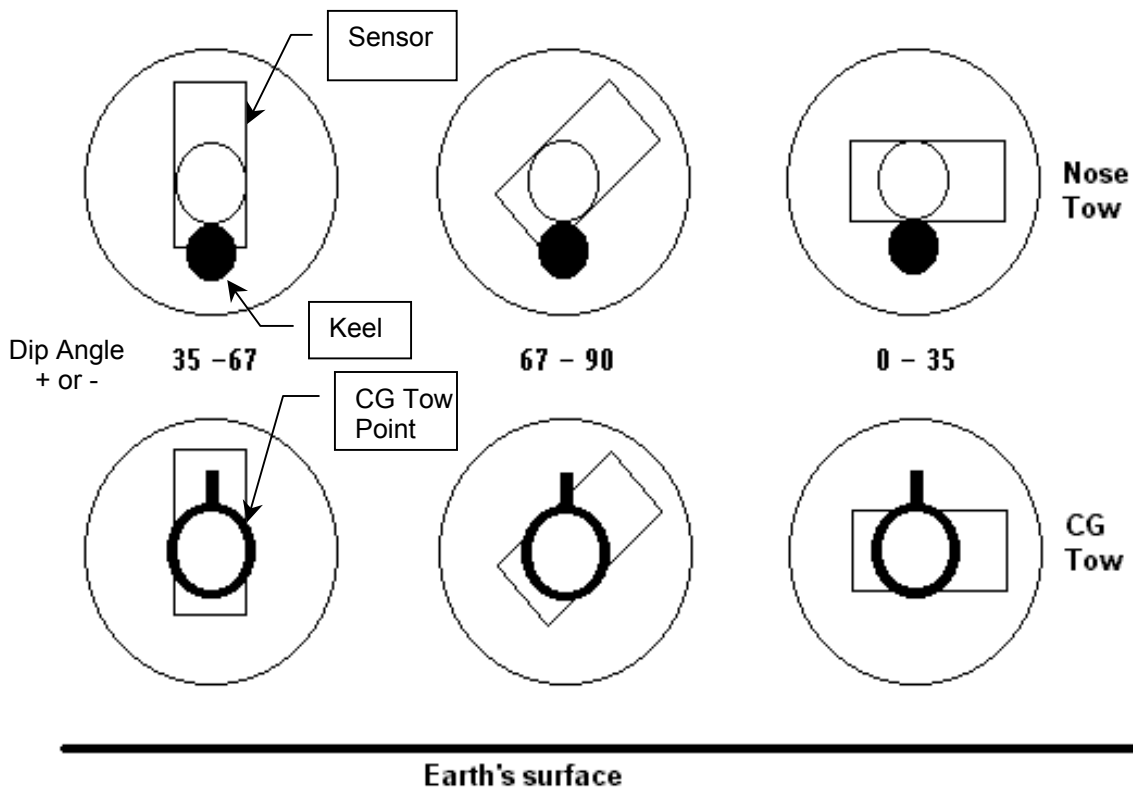
Earth's surface

For the 67°-90° Dip angle regions, roll the sensor to an angle of 45° with respect to the Earth's surface.

For the 0°-35° Dip angle regions, roll the sensor until it is horizontal with respect to the Earth's surface.

The optimal sensor configuration for one Dip angle region may be used in an adjacent region for a few degrees of overlap. Between the 35°-67° and 67°-90° regions only a 2° overlap is recommended. Between the 0°-35° and 35°-67° regions a 10° overlap will produce good data.

The figures below are derived from a software program, CSAZ, that is supplied as part of the Accessory software shipped with the G-881. The purpose of the figures below are to demonstrate that a only few configurations of sensor orientation are required to achieve good data acquisition anywhere on the earth's surface and to eliminate the need to use the CSAZ software.

Geometrics recommends that only the configurations depicted in Figures 1 through 12 be used. Roll angles other than 0°, 45°, and 90° tend to produce signal to noise ratio patterns that are asymmetrical. This could cause unequal instrument performance in the reverse and orthogonal directions of a typical survey.

Adjustment to the sensor roll angle can be made by loosening the two screws of either the keel collar or CG tow point as shown in the pictures below. Rotate the

sensor tow fish body as depicts in the graphic on the previous page. Then retighten the two screws. The keel weight on a CG towed fish could be rotated also, but this is not necessary because the position of the tow point controls the fish towing attitude. Finally, mount or move the deflector strap so that it will point toward the bottom of the survey area when under tow.

Keel collar.
Loosen these two screws, adjust keel position and re-tighten screws.

CG Tow-point.
Loosen these two screws, adjust position and re-tighten screws.
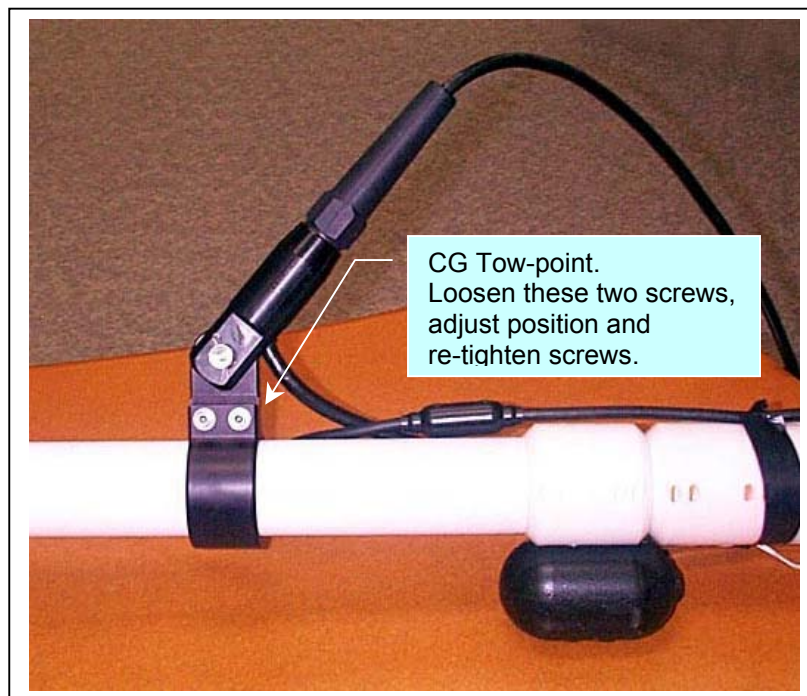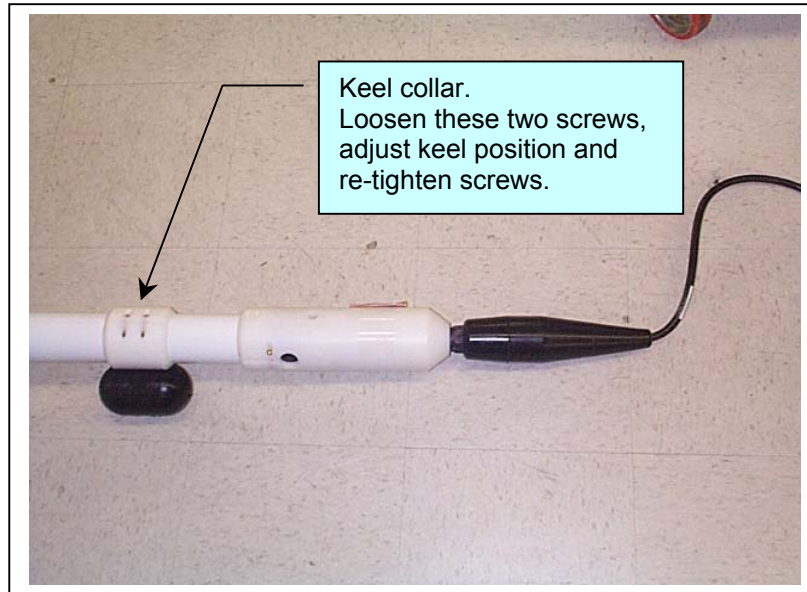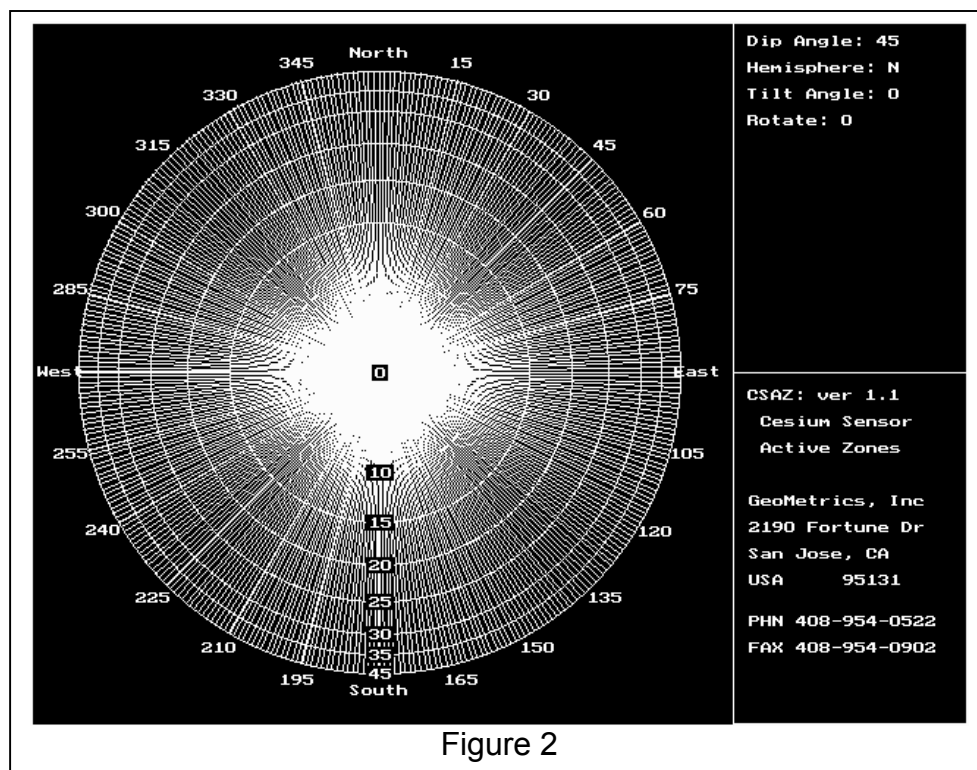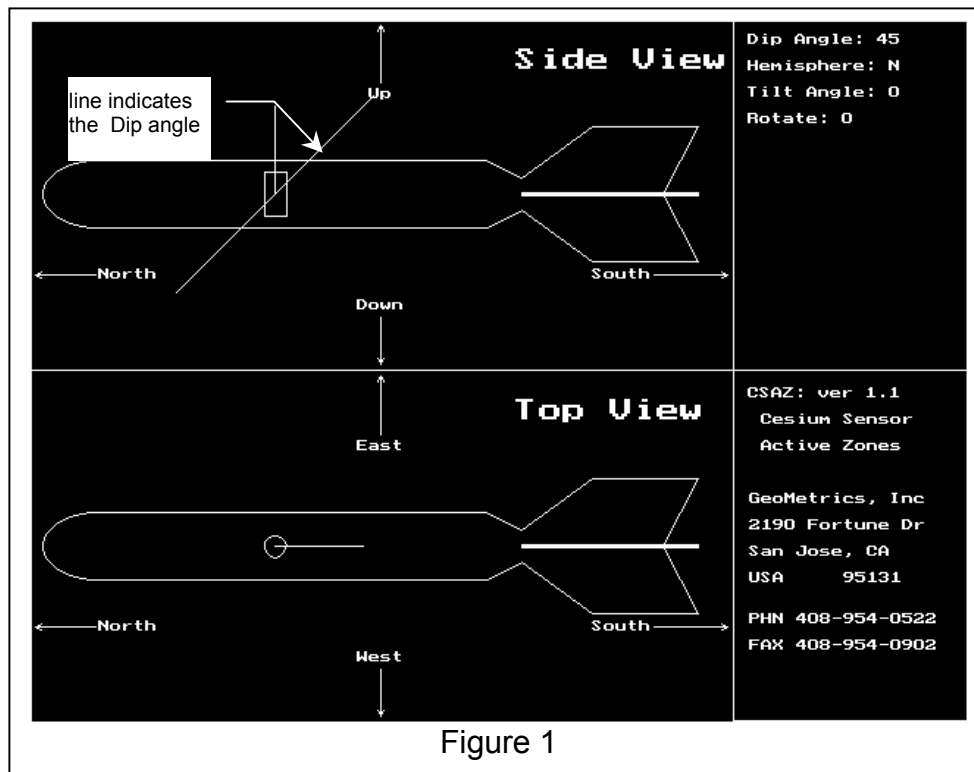
Figure 1

Figure 2

The configuration of Figure 1 above is the most optimal for the 35° to 67° Dip angle region. This is the "as shipped" configuration. This configuration provides omni-directional operation allowing any orthogonal set of directions to be selected for the survey grid.
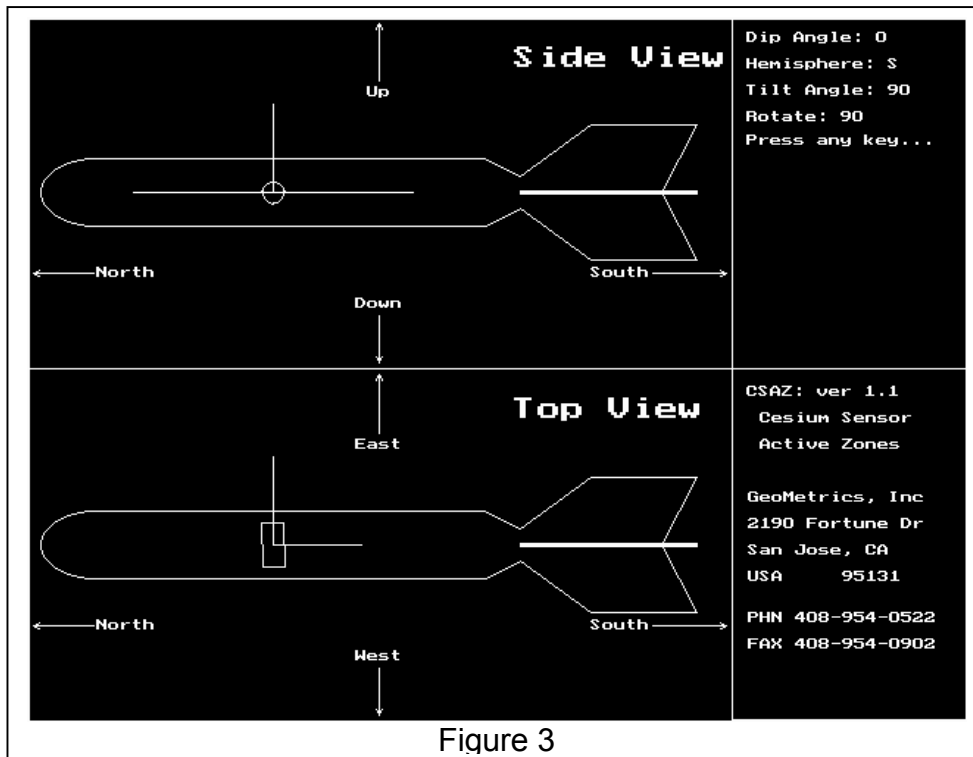
Figure 3
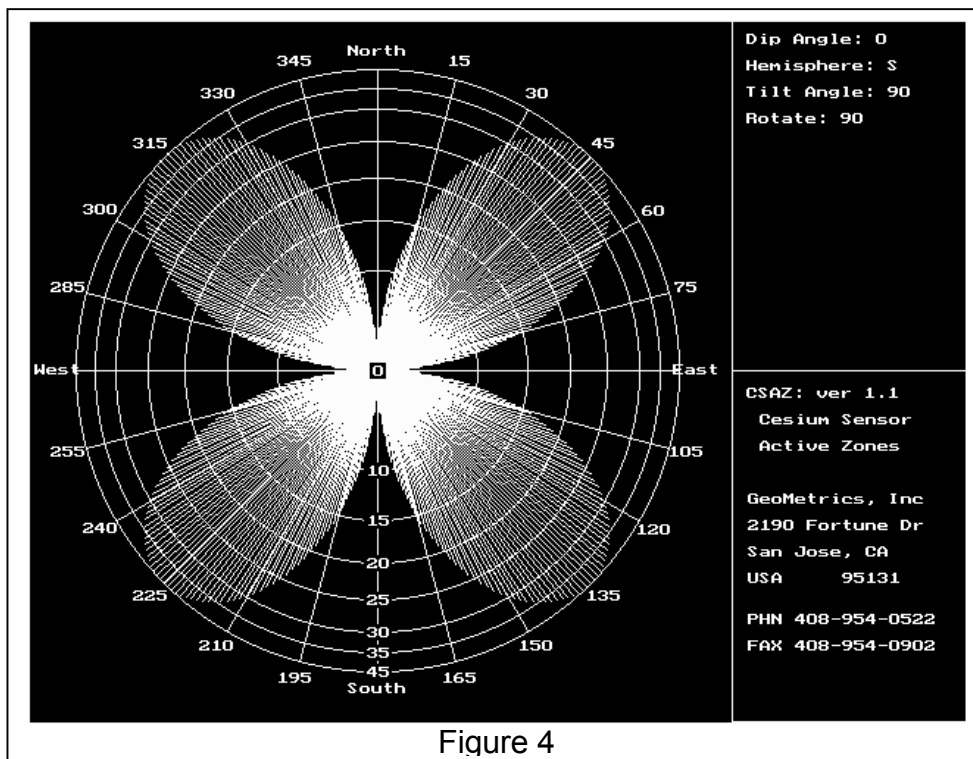
Figure 4

The configuration of Figure 3 above is one of the most optimal for the 0° to 35° Dip angle region. This configuration provides symmetrical performance for operation in a NW-SE and NE-SW orthogonal set of directions for survey use. To use this configuration roll the sensor 90° clockwise or counter-clockwise by rotating the sensor as described above.
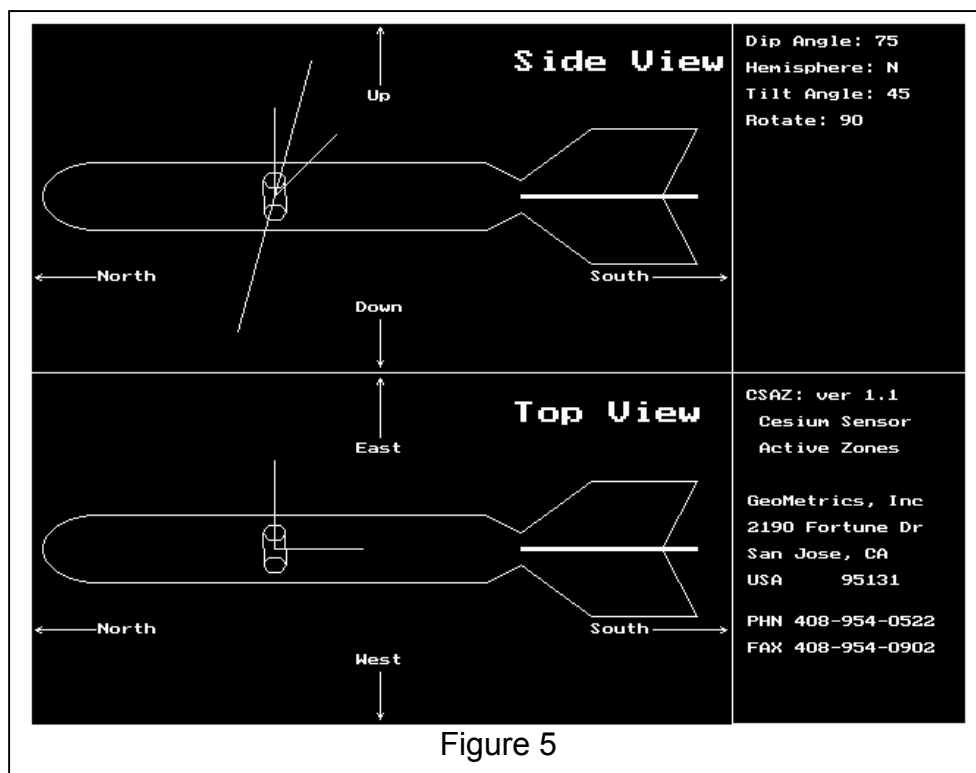
Figure 5
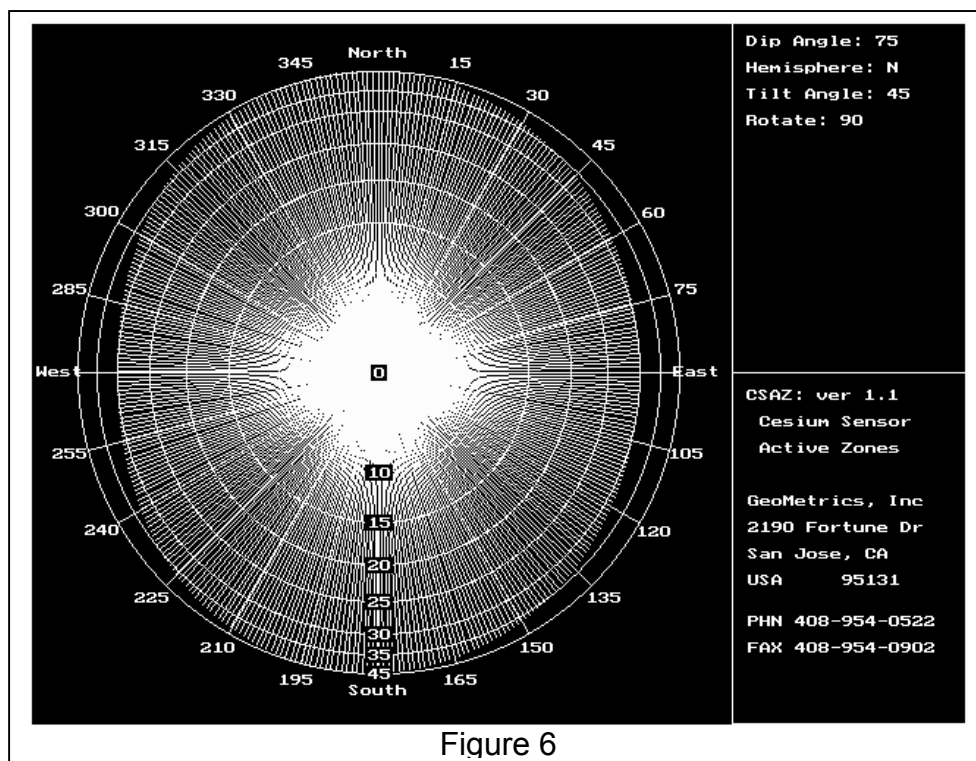
Figure 6

The configuration of Figure5 above is the most optimal for the 67° to 90° Dip angle region. This configuration provides omni-directional operation allowing any orthogonal set of directions to be selected for the survey grid. To use this configuration roll the sensor 45° clockwise or counter-clockwise by rotating the sensor as described above.
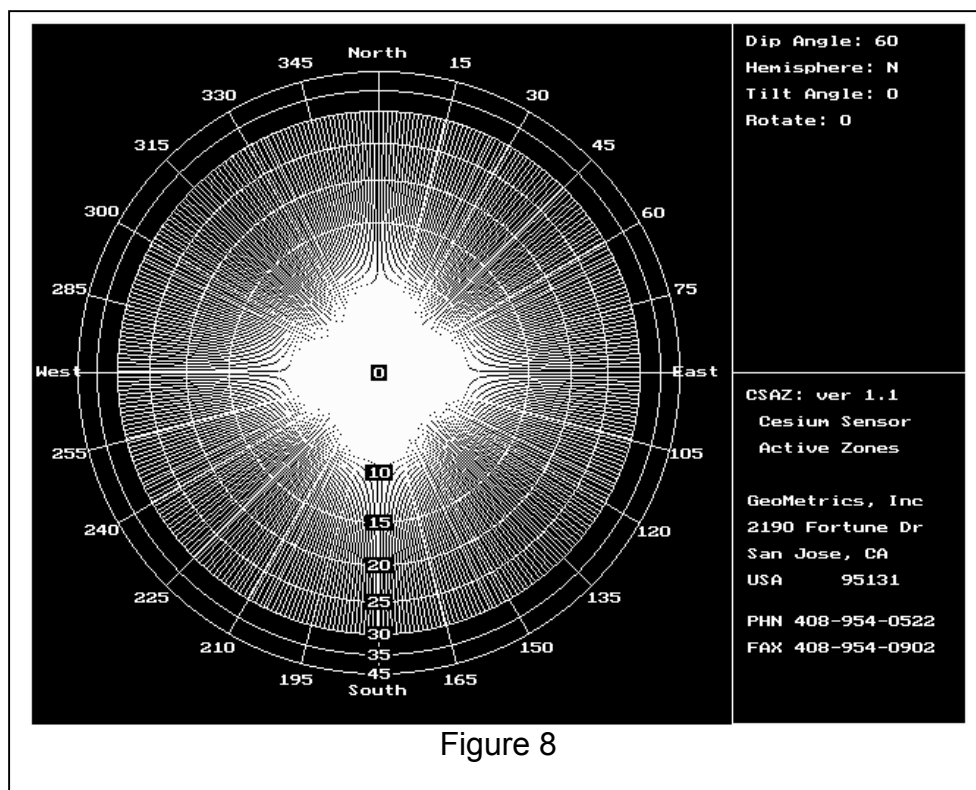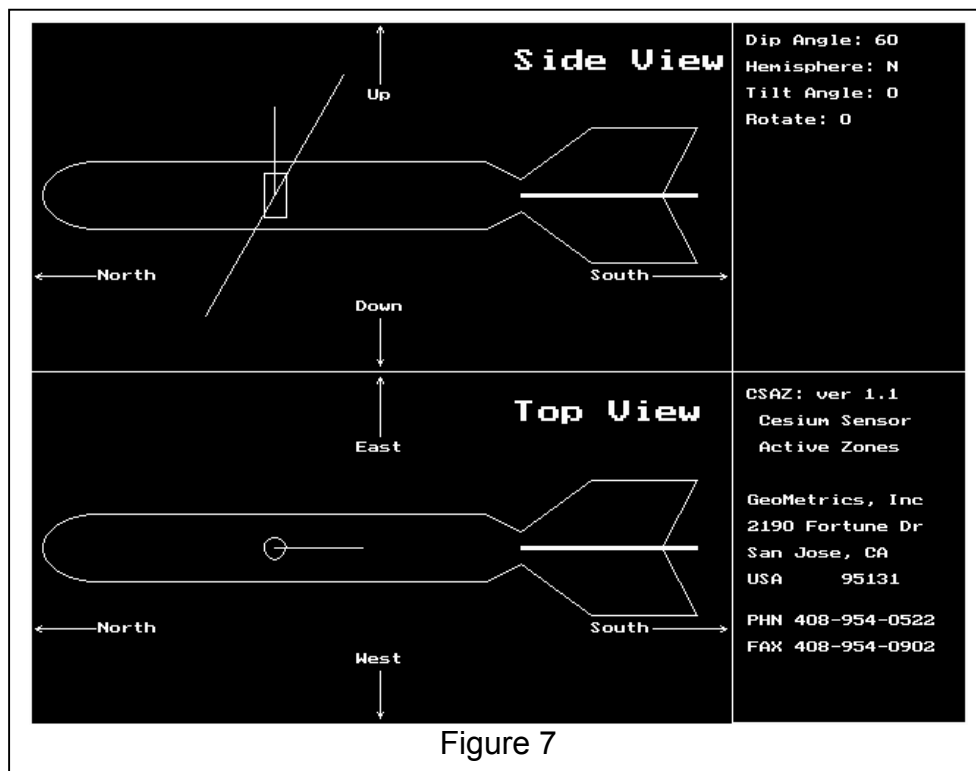
Figure 7

Figure 8

Figures 7, 8 above, 9, 10, 11, and 12 below depict cases where the optimal configuration for a region is operated near the region boundaries. Notice that the signal to noise ratios remain symmetrical and sufficient to produce excellent data.
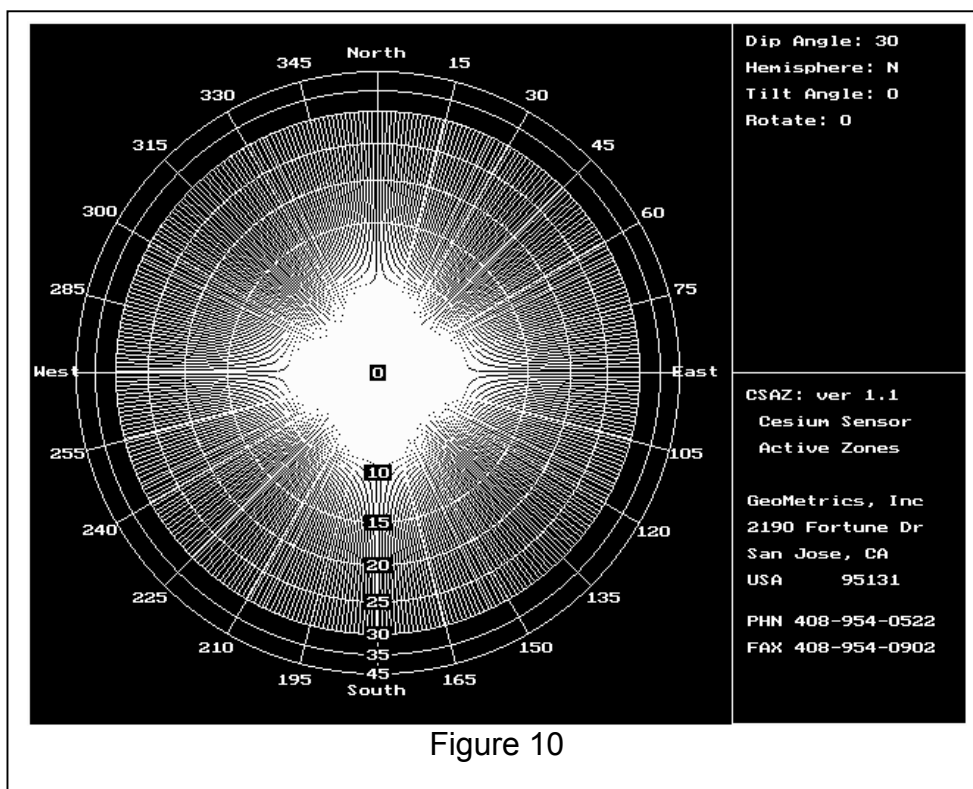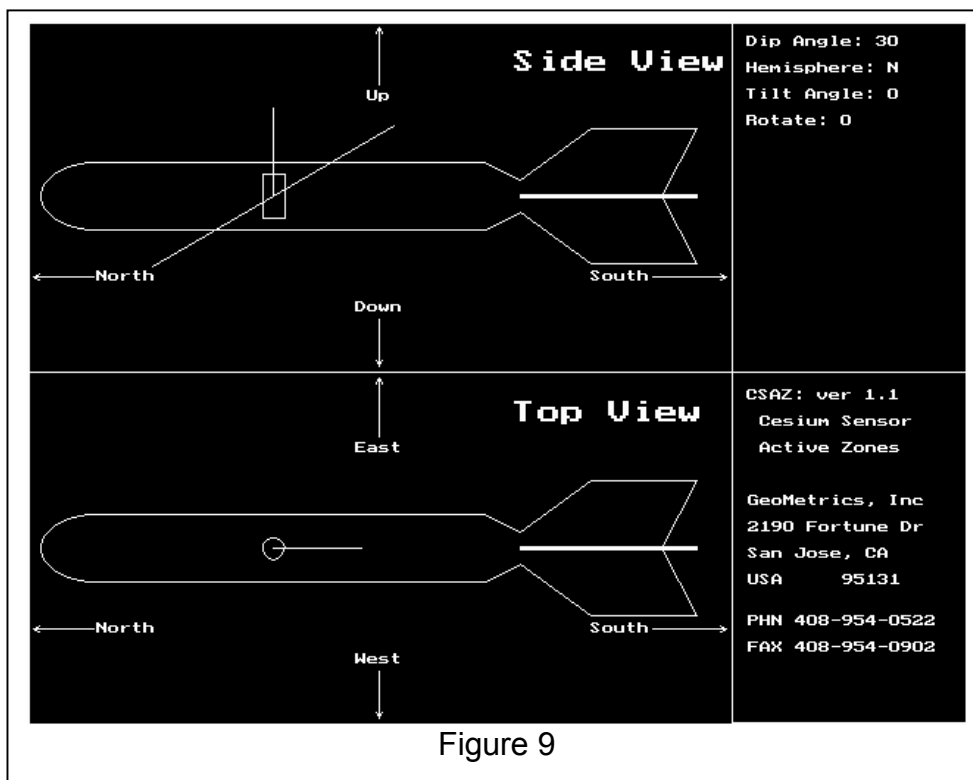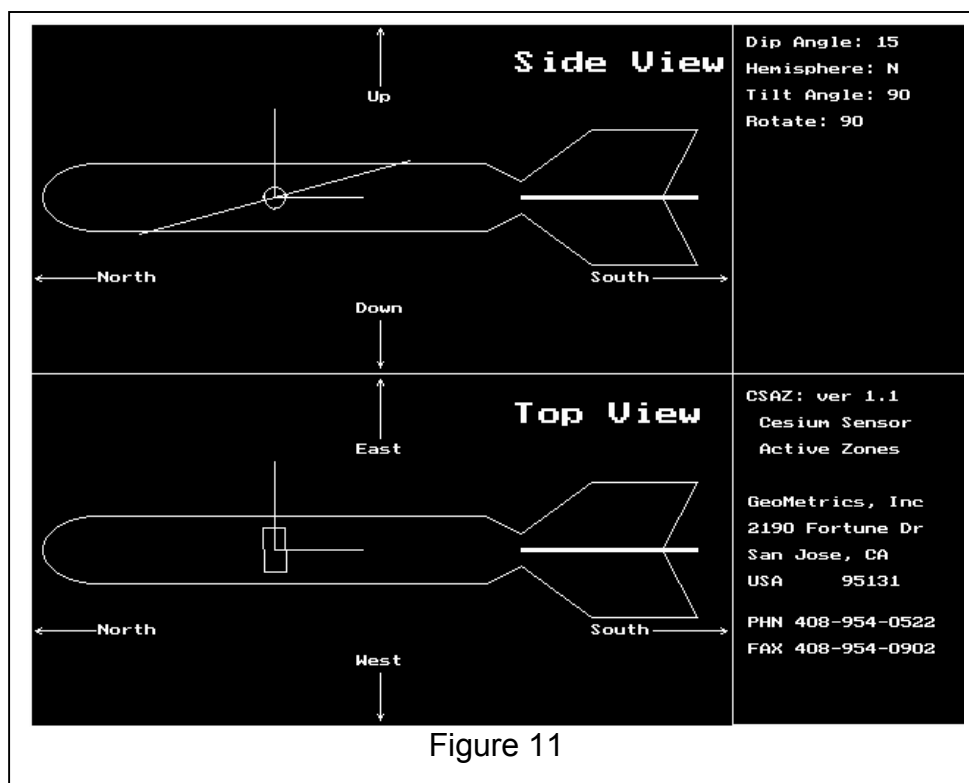
Figure 9
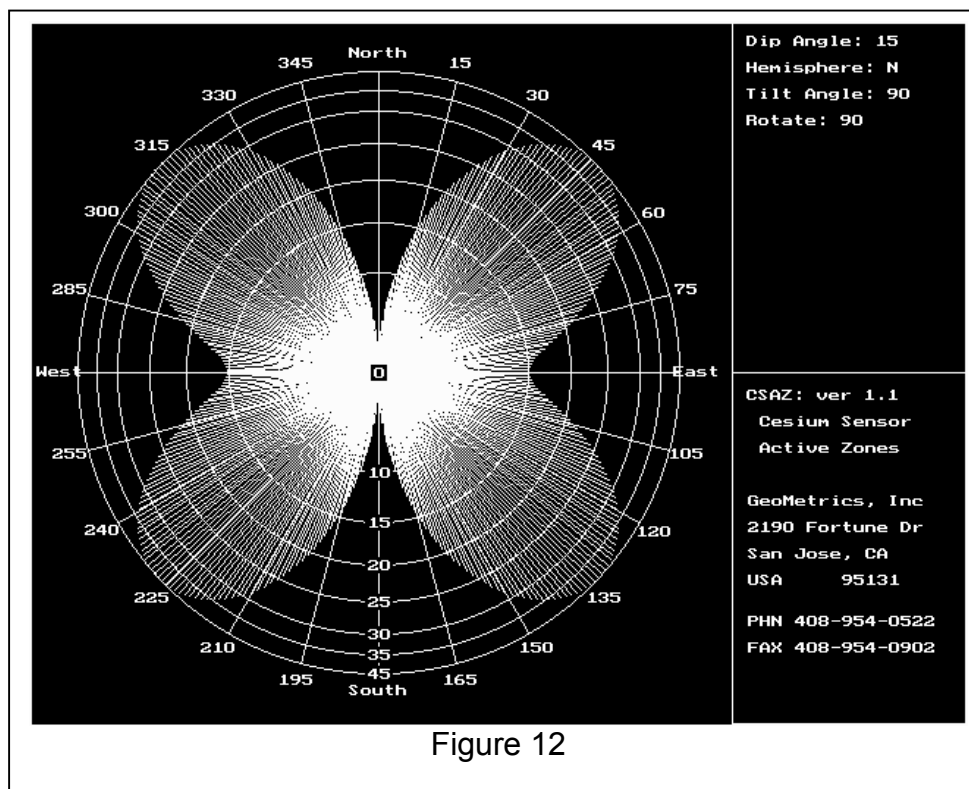
Figure 10

Figure 11

Figure 12

2.3.2 Main Field Inclination and Total Intensity Maps

The maps on the following two pages may be used to determine the inclination and total intensity of the Earth's magnetic field in the intended area of survey. The inclination information should be used to properly adjust the sensor position for the best performance in the intended area of survey. The Intensity information may be used as a check of the system operation, i.e., the readings appear to be in the range that is expected for the area of survey.

US/UK World Magnetic Chart -- Epoch 2000
Inclination - Main Field (I)
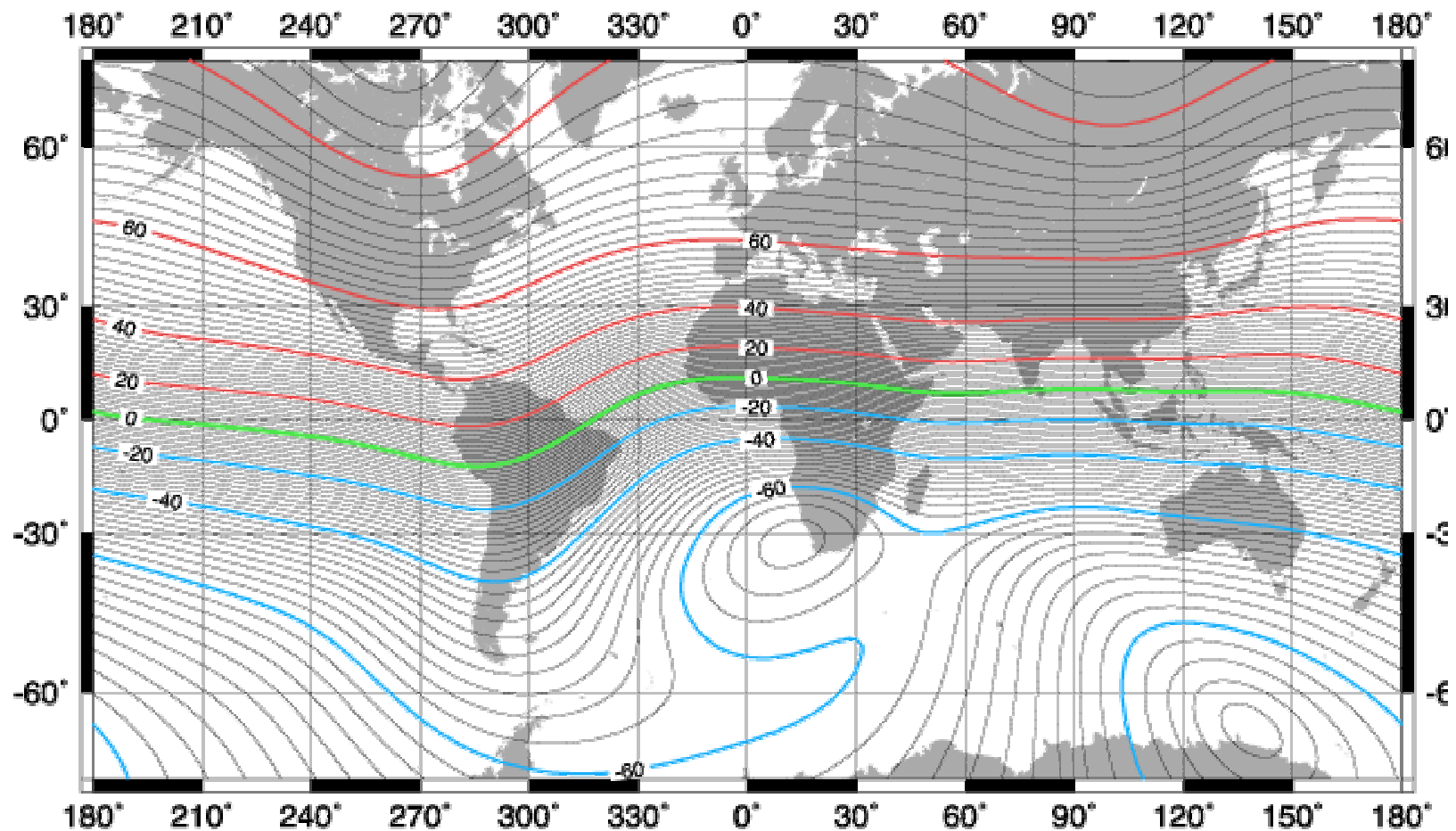
Units (Declination) : degrees
Contour Interval : 2 degrees

US/UK World Magnetic Chart -- Epoch 2000
Total Intensity - Main Field (F)
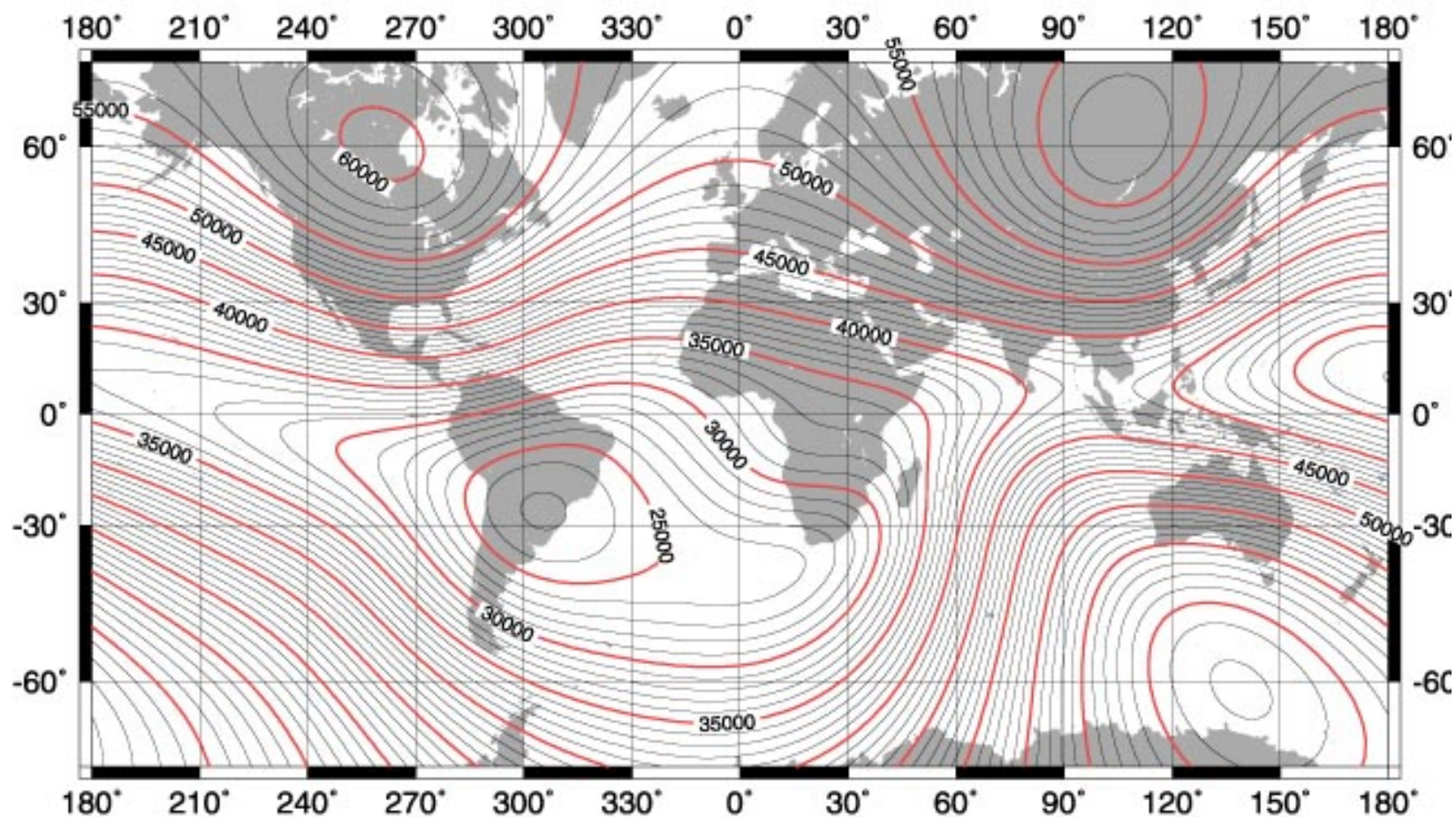
Units : nanoTeslas
Contour Interval : 1000 nanoTeslas

2.4 CM-221 Counter Data Format and Command Structure

The CM-221 counter module is a counting device that converts the cesium Larmor signal (70 kHz to 350 kHz) into magnetic field strength in nano-Teslas (20,000 nT to 100,000 nT). In addition there are 5 external 12 bit A/D channels and 1 internal A/D channel that can be digitized and appended to the output data. A Julian clock string can be enabled and added to the output data stream as well. Finally there is an External Event pin that can be used for external trigger or event marking.

The output data format is programmable. For example each of the A/D channels can be added/removed from the output data stream by sending the appropriate commands. There are several other commands that are discussed in detail later in this document.

2.4.1 Output Format

Figure 13 shows the standard single counter configuration. Commands from the PC are sent out the RS232 transmit pin (TxD) to the counter. Mag and other data return on the receive pin (RxD).
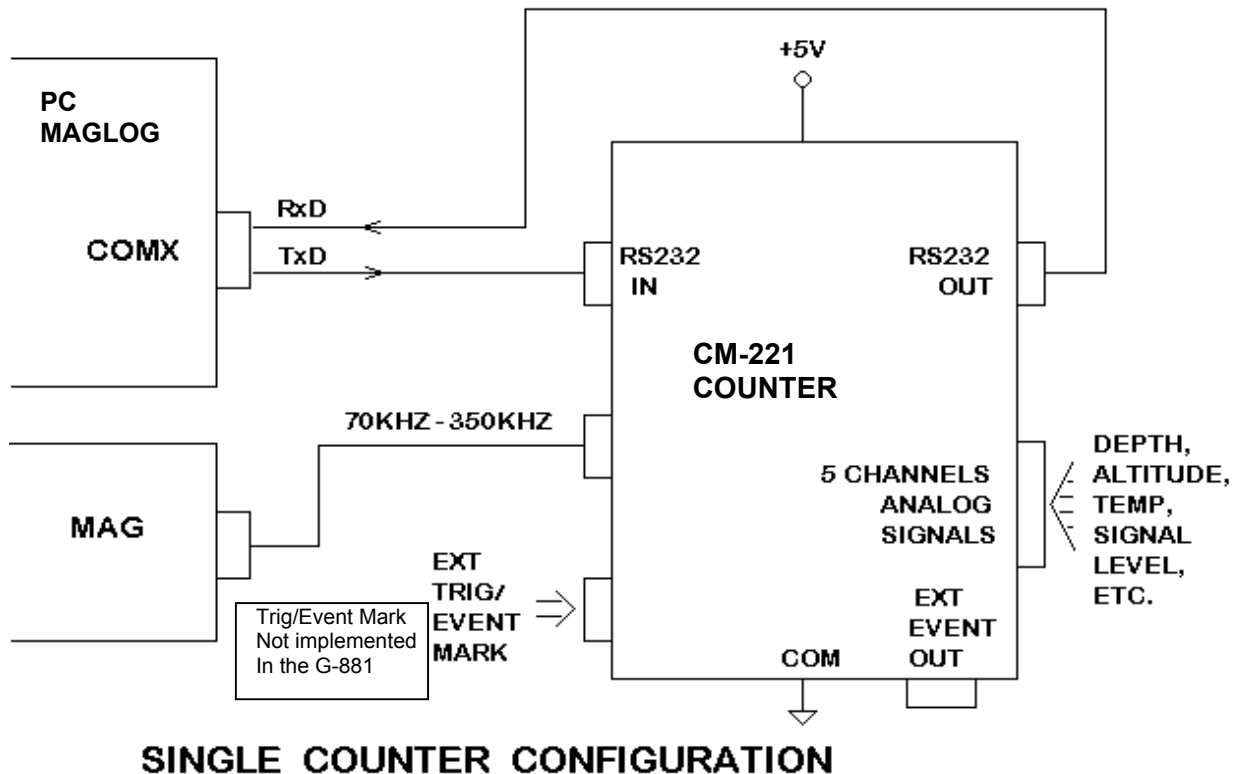
Fig. 13

Upon power on the counter module defaults to the following setup:

   Baud rate: 9600 baud, 8 data bits, no parity, 1 stop bit

   Cycle rate: 10 Hertz

   Analog channels: Channel 0 (Larmor signal level) enabled, depth and altitude
       Channels, when applicable, enabled, and channels 3-5 disabled.

   Julian Clock: Disabled

   Output Format: ASCII

The default output data stream contains all printable ASCII characters with each
sample terminated with a carriage return/ line feed sequence.   The following
example illustrates this format:

char #   description
-------   --------------------------------
 1   An ASCII '$' (marks first character of data stream)

 2   an ASCII '1' or a blank (depending on whether Mag reading is above or
          below _99999.999 nT).

 3-7   5 digits of Mag data

 8   an ASCII decimal point ['.']

 9-11   3 more digits of Mag data

 12   an ASCII comma [',']

 13-16   4 digits of A/D channel 0 (9999 full scale, 0 to +5 volts in). This channel is
internal
          and contains the signal level of the magnetometer.

 17   an ASCII carriage return

 18   an ASCII line feed

If the data were captured to a file and then copied to a line printer the printout would look something like this:

```
$ 99778.131,3749
$ 99890.376,3687
$ 99955.517,3545
$ 99998.293,3472
$100078.835,3329
$100032.071,3381
$ 99979.159,3498
$ 86778.508,3514
$ 78778.216,3645
$ 69978.347,3797
```

Counter modules can be daisy chained to form multiple sensor arrays as shown in Figure 14. Note that the output data from counter 0 goes into the input port of counter 1, and so on. This allows each counter module to append its output data onto the end of the data stream coming from the previous counter(s). As each counter receives data characters from previous counters they get echoed to the next. An exception to this is the carriage return/ line feed sequence. The carriage return is replaced by a comma and the line feed is ignored. Thus one long concatenated string from all counters is output from/through the last counter, and is terminated by a carriage return/ line feed sequence by the last counter only.

Note that only the first counter outputs a preamble character (the default character is '$').
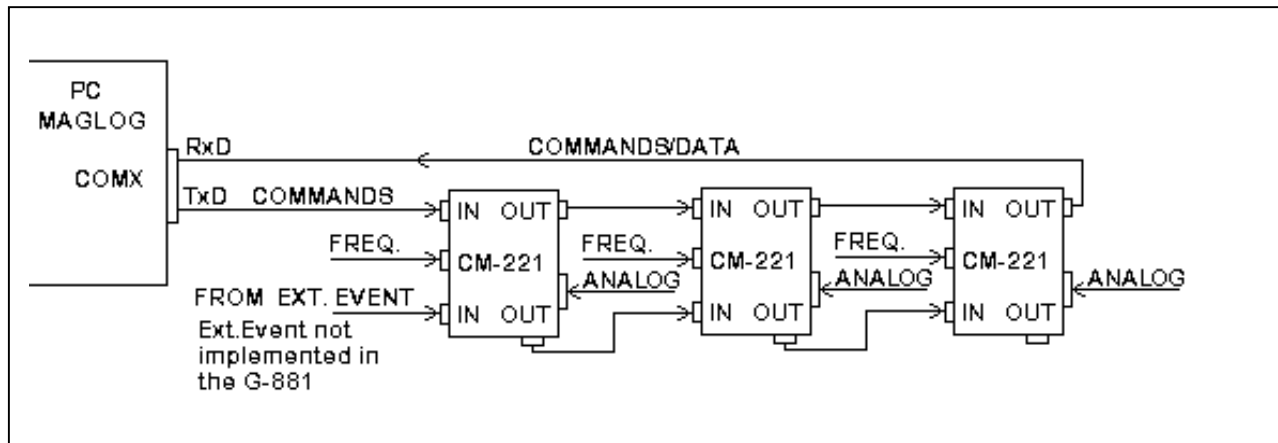
MULTI-COUNTER MODULE CONFIGURATION

Fig. 14

2.4.2 Commands

Commands are sent into the input port of the first counter. Note that commands are the only characters that enter the first counter. A command string is stored in an incoming buffer until terminated by a carriage return. The command will then be executed at the end of the current sample, immediately after the last 'data' byte has been sent out the output port. Then the command will be echoed to the next counter (or back to the logging computer if it is the last/only counter in the chain).

Subsequent counter modules in multiple counter arrays differentiate between output data and commands by assuming that all characters between the data preamble character ('$' is the default) and the next line feed are Data bytes from the previous counter(s). Commands only arrive at subsequent counters after the data transmission is complete. Each command is identified by the first character, followed by some number of operand characters and a carriage return.

Only one command can be sent at a time. After each command wait for the command echo before sending another.

All commands are terminated with a carriage return. A line feed may be sent as well, but it will be ignored by each counter module. However, at the end of every output data string there will be a carriage return and a line feed sent. This method insures that the final counter will have a carriage return/line feed sequence so that if the file is printed it will look correct on paper. By using the carriage return as the command terminator and stripping input line feeds insures that dumb terminals (and dumb terminal emulation software) can be used to control the counter output. (Dumb terminals do not normally transmit line feeds when <Enter> is pressed).

Here are the current list of commands and the format of each:

Command	Format:	Description:

Set Cycle time   Byte   1: 'C'   Set time in 0.01 sec increments
                                  2: x   MS digit of number ('0'-'9')
                                  3: x   3S digit of number
   4: x   2S digit of number
   5: x   LS digit of number
   x: x   5 MS optional char ('0' or '5')
   6/7: CR   carriage return

[Note: the 5 MS char is optional. It was added
to allow setting the cycle time to more precision
after the initial software release]

Set A/D ch's   Byte   1: 'A'   Enable/disable A/D channels
   2: x   '0' = turn off channel; '1' = turn on
   3: x   select channel #('0'-'5')('0'-'7' for CM-221)
   4: x   MS digit of counter # ('0' or '1')
   5: x   LS digit of counter # ('0' - '9')
   6: CR   carriage return

[Note: characters 4 and 5 can be omitted. If this is done the
 command will default to counter 0.]

Cycle Analog
Channels: Byte   1:'A'   Cycle analog channels command
   2:'C'   2nd character of command
   3: x   '0' = cycling disabled always
                 '1' = cycling enable on "break condition"
                 '2' = cycling always enabled at power-up
   4: x   MS digit or counter # ('0' or '1')
   5: x   LS digit of counter # ('0' - '9')
   6: CR   carriage return

[Note: characters 4 and 5 can be omitted. If this is done the
 command will default to counter 0.] Selection of cycling mode applies
 all counters unless specific counter selected with characters 4 & 5.

Command	Format:			Description:
-----------------	----------			--------------------------------
Number of Analog Channels to Cycle	Byte	1:	'A'	Channels to cycle
		2:	'N'	2nd character of command
		3:	x	Number of channels to cycle '2' thru '8'
		4:	x	MS digit or counter # ('0' or '1')
		5:	x	LS digit of counter # ('0' - '9')
		6:	CR	carriage return

[Note: characters 4 and 5 can be omitted. If this is done the
command will default to counter 0.] Selection of cycling mode applies
all counters unless specific counter selected with characters 4 & 5.

Change Baud Rate	Byte	1:	'B'	Baud rate change command
		2:	x	MS char (1,0,0,0,0,0,0)
		3:	x	S char (9,9,4,2,1,0,0)
		4:	x	3S char (2,6,8,4,2,6,3)
		5:	x	2S char (0,0,0,0,0,0,0)
		6:	x	LS char (0,0,0,0,0,0,0)
		7:	CR	carriage return

Output Format	Byte	1:	'O'	select output format
		2:	x	format select:
				'A'= ASCII (default)
				'E'= excess 3
				'P'= packed BCD
				'S'= Sandia G822A fmt
		x:	x	'0' = Sandia single Mag
				'1' = Sandia dual Mag
		3:	CR	carriage return

[Note: the '0' and '1' 3rd characters are valid only when selecting the
Sandia format]

Generate:	Byte	1:	'G'	Generate command
		2:	x	'0' = cycling disabled always
				'1' = cycling enable on "break condition"
				'2' = cycling always enabled at power-up
		3:	x	MS digit or counter # ('0' or '1')
		4:	x	LS digit of counter # ('0' - '9')
		5:	CR	carriage return

[Note: characters 3 and 4 can be omitted. If this is done the
command will default to counter 0.] Selection of Generate mode applies
all counters unless specific counter selected with characters 3 & 4.

Command	Format:		Description:
-----------------	-----------		--------------------------------
Julian Clock Format:	Byte	1: 'O'	select output format
		2: 'J'	format select:
		3: x	Day field: '1'= on ; '0' = off
		4: x	Hour field: '1'= on ; '0' = off
		5: x	Min field: '1'= on ; '0' = off
		6: x	Sec field: '1'= on ; '0' = off
		7: x	10mS field: '1'= on ; '0' = off
		8: x	MSB of counter # ('0' or '1')
		9: x	LSB of counter # ('0' thru '9')
		10: CR	carriage return

[Note: characters 8 and 9 can be omitted. If this is done the command
 will default to counter 0.]

Julian Time Enable:	Byte	1: 'J'	Enable/Disable Julian time output
		2: x	'0' = turn off; '1' = turn on
		3: x	MS digit of which counter ('0','1')
		4: x	LS digit of counter # ('0' - '9')
		5: CR	carriage return

[Note: characters 3 and 4 can be omitted. If
this is done the command will affect all
counters in the chain.]

Set Julian Day:	Byte	1: 'D'	Set the Julian day number
		2: x	MS digit of number ('0'-'3')
		3: x	2S digit of number ('0'-'9')
		4: x	LS digit of number ('0'-'9')
		5: CR	carriage return
Set Hour:	Byte	1: 'H'	Set the hour
		2: x	MS digit of number ('0'-'2')
		3: x	LS digit of number ('0'-'9')
		4: CR	carriage return
Set Minute:	Byte	1: 'M'	Set the minute
		2: x	MS digit of number ('0'-'5')
		3: x	LS digit of number ('0'-'9')
		4: CR	carriage return

Command	Format:		Description:
----------------	----------		--------------------------------
Set Second:	Byte	1: 'S'	Set the second
		2: x	MS digit of number ('0'-'5')
		3: x	LS digit of number ('0'-'9')
		4: CR	carriage return
Find counters:	Byte	1: 'F'	Find and assign counter numbers
		2: '0'	assign first counter as # 0 (MSB)
		3: '0'	LSB
		4: CR	carriage return
Set Preamble	Byte	1: 'P'	Set the preamble char ('$')
		2: x	The desired character
		3: CR	carriage return
Jump to debug	Byte	1: 'X'	first char of 'XBUG' string
		2: 'B'	2'cnd char
		3: 'U'	3'rd char
		4: 'G'	4'rth char
		5: CR	carriage return
Error echo	Byte	1: 'E'	Syntax err - echo 'ERR' + counter #
		2: 'R'	2'cnd char
		3: 'R'	3'rd char
		4: x	MS digit of counter number ('0'-'1')
		5: x	LS digit of counter number ('0'-'9')
		6: ':'	colon delimits error message cmd

[Note: xxx: bad command string is echoed in the
following characters, followed by a ...
x: CR carriage return]

Reset	Byte	1: 'R'	Reset the microprocessor
		2: 'E'	2'cnd char
		3: 'S'	3'rd char
		4: 'E'	4'th char
		5: 'T'	5'th char
		6: CR	carriage return

Command	Format:		Description:
-----------------	----------		-------------------------------
Interrogate Setup:	Byte	1: 'I'	Interrogate command
		2: x	item select:
			'A'= Analog output fields selected
			'J'= Julian Clock fields selected
			'V'= software version number.
		3: x	MS digit of counter number ('0'-'1')
		4: x	LS digit of counter number ('0'-'9)
		5: CR	carriage return

[Note: Characters 3 and 4 are optional. If they are omitted the command will return the output from counter 0.

Update	Byte	1: 'U'	Update operation parameters
		2: 'P'	2nd character
		3: 'D'	3rd character
		4: 'A'	4th character
		5: 'T'	5th character
		6: 'E'	6th character
		7: CR	carriage return

[Note: If it is desired to permanently save any changes to the operation parameters that may have been made, sending an UPDATE command before powering down will save them. The next time the system is powered-on the new, saved parameters will be used.]

The addressed counter will insert characters into the command string just before the carriage return before echoing to subsequent counters. See detailed command description for format and definition of these added characters.]

2.4.3 Detailed command descriptions:

Cycle Time Set:

Cycle time is set by transmitting the number of 0.01 second increments needed to make the desired output rate. The default rate is 10 hertz (C0010). To set the output rate to 1.2 seconds the command string would be "C0120".

After the initial software release another character was added to allow the cycle time to be set to 5 ms resolution. To maintain compatibility with older versions this character is optional. For an example on using this extra precision, the command "C00125" would set the cycle time to 8 hertz (125 ms).

A/D channel select/enable:

Three pieces of info are needed to select and turn on/off an A/D channel: The counter #, the channel number, and a flag indicating whether to enable or disable that channel. The enable/disable flag is sent first (after the 'A' command identifier). A '0' character will turn off the channel, a '1' turns it on. The next character specifies the channel number (0-5 for CM-201 or 0-7 for CM-221), followed by 2 characters indicating the counter number (00-19). If the counter number is not sent then it defaults to counter 0.

Cycle Analog Channels:

In some installations, the RS-232 channel is not fast enough to send all of the desired information. To reduce the number of characters that must be sent with each reading, the first analog channel can be put into the "Analog Cycling" mode.

In the "Analog Cycling" mode, each analog channel is displayed in turn. The first reading will be followed by the signal level. The next will be followed by the second analog channel. The next by the third and so on. After the last channel is done, the fixed value of 8888 is displayed and then the cycle starts again with the signal channel.

The setting of the "Analog Cycling" command is saved when the "UPDATE" command is used. The saved value can cause one of three actions the next time the power is applied.

If the saved value is two, the magnetometer will begin cycling the analogs when the power is applied.

If the saved value is one, the magnetometer will examine the state of the RS-232 command input when power is applied. If the command input is held at a voltage greater than 2V, the magnetometer will begin cycling the analogs. In the RS-232 standard, holding a signal high for a long time is referred to as a "break condition" or a "break character". The break condition must be asserted at the instant power is

applied and held for at least 1.5 seconds. Connecting the command input to power supply in the 2V to 25V range will also work.

If the saved value is zero, the cycling is disabled regardless of the state of the command input.

To set the state of the generate command use the command "AC0", "AC1", or "AC2". If there are multiple magnetometers all of them will be set to the desired mode. If only one of the magnetometers is to be set, the command can be followed by a two digit magnetometer number. "AC103" would set the forth magnetometer's mode to one.

Number of Analog Channels to Cycle:

The number of channels to be cycled through can be set to any value from 2 to 8 inclusive. This is done with the "AN" command. The command "AN3" would cause the first three channels to be cycled through.   If there are multiple magnetometers all of them will have the value set. If only one of the magnetometers is to be set, the command can be followed by a two digit magnetometer number. "AN503" would set the forth magnetometer's number to 5.

Baud Rate Change:

The baud rate can be commanded to change by giving a 'B' command character followed by 5 more number characters specifying the desired baud rate. Valid baud rate commands are: 'B19200', 'B09600', 'B04800', 'B02400', 'B01200', 'B00600', and 'B00300'. This command will not execute until the entire command has finished echoing out to the next counter/logging device. This allows the command to propagate through all counters and be implemented before output data arrives at a different rate.

Output Format Select:

The default (ASCII) output format is described in detail at the beginning of this document. This is the easiest format to view and import into various processing utilities. It is also very inefficient in terms of disk storage space and time required to transmit each cycle. There are three other output formats that can be used as well:

Packed BCD:

Packed BCD format throws away all commas, decimals, spaces, and the magnetometer most significant byte ('1' if more than 100,000 nT, or a blank is less than 100,000nT). The Preamble character is left alone. In addition all numeral characters (ASCII codes 30 hex through 39 hex) have the upper nibble (always a 3) discarded and two lower nibbles combined to form one byte. Finally, the carriage return, line feed sequence is replaced with a single terminating
character '*' (2A hex).

It is very difficult to show what these files would look like if displayed on a computer screen since each type of computer would display these binary characters differently. Many of these binary characters would be interpreted as screen commands which might ring the bell or clear the screen. Therefore it is necessary to convert ASCII printouts to hexadecimal numbers to show the Packed BCD format.

An ASCII counter output of:

'$ 54369.127,1234,5678,0000'(plus carriage return line feed)

converted to hexadecimal numbers would be:

 24 20 35 34 33 36 39 2E 31 32 37 2C 31 32 33 34
 2C 35 36 37 38 2C 30 30 30 30 0D 0A

['$'= 24, ' '= 20, '.'= 2E, ','= 2C, CR/LF = 0D 0A,
 '0'-'9'= 3x (where x = number 0-9)]

Using the above definition the same data in packed BCD
output format would be:

 24 54 36 91 27 12 34 56 78 00 00 2A
  \   \   \   \   \   ___Terminating character ('*')
   \   \   \   \   __analog channel #3 ('0000') (not available in G-881)
    \   \   \   __analog channel #2 ('5678') (not available in G-881)
     \   \   __analog channel #1 ('1234') (not available in G-881)
      \   __Mag reading ('54369.127')
       __Preamble Character ('$')

Note how easy it is to see the numbers if viewing a hex dump of the data. Remember though that it must be translated to printable characters before copying the raw data to printers or a CRT screen.

Commands that are echoed through the counter chain are received and sent as unmodified ASCII strings. Thus all commands will appear in the binary data set after the next '*' data terminating character and will be terminated itself by a carriage return line feed sequence. Binary transmission then resumes with the next sample.

Excess 3 format:

Excess three format is very similar to packed BCD. In fact the only difference is that each byte has 33 hex added to it after converting to Packed BCD. The reason for adding 33 hex to each packed BCD number is to avoid some difficult pitfalls with Packed BCD:

Packed BCD is a very common format but has many potential problems that can arise. ASCII digits are combined to form bytes with hexadecimal values in the control character range (less than 20 hex) which must be handled very carefully by the logging program. Examples of these characters include the Cntl-S and Cntl-Q software handshake controls (11 hex and 13 hex), the bell character (Cntl-G, 07 hex), and the ASCII null (Cntl-shift-@, 00H). Most terminal emulation programs can be configured to handle these characters as data instead of commands, but this is not the way the typical default configuration is set up.

Packed BCD eliminates this by shifting all numbers up by 33 hex. This moves all possible output values out of the control character range. It also makes them printable to a screen or printer without bells, beeps, screen clears, form feeds, etc. However they will still look like gibberish without translation.

Sandia/G822A format:

This is a printable ASCII format that mimics the output from a one or two channel G822A magnetometer. Its output is limited to one counter module, with the Mag and signal level values as the only data being sent out. The Mag reading is preceded with an 'A' followed by 10 characters of ASCII Mag data. The G822A format sometimes has a second Mag reading following the first which is preceded with an ASCII 'B'. If selected the CM-221 counter places the signal level in the first 4 significant characters of the second Mag data slot. The sample is terminated by a carriage return line feed sequence.

The purpose of this format is to allow customer with existing G822A Sandia logging software to be able to use the CM-221 without upgrading to new logging software.

The single channel Sandia format is selected with the command string "OS" or "OS0". The dual channel output is selected by the command string "OS1".

Example outputs:

This is the ASCII output example from earlier, but with 3 A/D channels:
- -

```
$ 99778.131,3749,0004,0005
$ 99890.376,3687,0003,0007
$ 99955.517,3545,0003,0006
$ 99998.293,3472,0005,0006
$100078.835,3329,0004,0005
$100032.071,3381,0006,0006
$ 99979.159,3498,0003,0007
$ 86778.508,3514,0004,0007
$ 78778.216,3645,0004,0004
$ 69978.347,3797,0003,0005
```

The same data displayed in hexadecimal:
- - - - - - - - - - - - - - - - - - -

```
24 20 39 39 37 37 38 2E 31 33 31 2C 33 37 34 39
2C 30 30 30 34 2C 30 30 30 35 0D 0A 24 20 39 39
38 39 30 2E 33 37 36 2C 33 36 38 37 2C 30 30 30
33 2C 30 30 30 37 0D 0A 24 20 39 39 39 35 35 2E
35 31 37 2C 33 35 34 35 2C 30 30 30 33 2C 30 30
30 36 0D 0A 24 20 39 39 39 39 38 2E 32 39 33 2C
33 34 37 32 2C 30 30 30 35 2C 30 30 30 36 0D 0A
24 31 30 30 30 37 38 2E 38 33 35 2C 33 33 32 39
2C 30 30 30 34 2C 30 30 30 35 0D 0A 24 31 30 30
30 33 32 2E 30 37 31 2C 33 33 38 31 2C 30 30 30
36 2C 30 30 30 36 0D 0A 24 20 39 39 39 37 39 2E
31 35 39 2C 33 34 39 38 2C 30 30 30 33 2C 30 30
30 37 0D 0A 24 20 38 36 37 37 38 2E 35 30 38 2C
33 35 31 34 2C 30 30 30 34 2C 30 30 30 37 0D 0A
24 20 37 38 37 37 38 2E 32 31 36 2C 33 36 34 35
2C 30 30 30 34 2C 30 30 30 34 0D 0A 24 20 36 39
39 37 38 2E 33 34 37 2C 33 37 39 37 2C 30 30 30
33 2C 30 30 30 35 0D 0A
```

The same data in Packed BCD format:
- - - - - - - - - - - - - - - - - -

```
 24 99 77 81 31 37 49 00 04 00 05 2A 24 99 89 03
 76 36 87 00 03 00 07 2A 24 99 95 55 17 35 45 00
 03 00 06 2A 24 99 99 82 93 34 72 00 05 00 06 2A
 24 00 07 88 35 33 29 00 04 00 05 2A 24 00 03 20
 71 33 81 00 06 00 06 2A 24 99 97 91 59 34 98 00
 03 00 07 2A 24 86 77 85 08 35 14 00 04 00 07 2A
 24 78 77 82 16 36 45 00 04 00 04 2A 24 69 97 83
 47 37 97 00 03 00 05 2A
```

The same data in Excess 3 format:
- - - - - - - - - - - - - - - - - -

```
 57 CC AA B4 64 6A 7C 33 37 33 38 5D 57 CC BC 36
 A9 69 BA 33 36 33 3A 5D 57 CC C8 88 4A 68 78 33
 36 33 39 5D 57 CC CC B5 C6 67 A5 33 38 33 39 5A
 57 33 3A BB 68 66 5C 33 37 33 38 5D 57 33 36 53
 A4 66 B4 33 39 33 39 5D 57 CC CA C4 8C 67 CB 33
 36 33 3A 5D 57 B9 AA B8 3B 68 47 33 37 33 3A 5A
 57 AB AA B5 49 69 78 33 37 33 37 5D 57 9C CA B6
 7A 6A CA 33 36 33 38 5D
```

The same data displayed in dual channel Sandia/G822A ASCII format:
- -

```
A9977813100B3749000000
A9989037600B3687000000
A9995551700B3545000000
A9999829300B3472000000
A0007883500B3329000000        (Note how the most significant '1'
A0003207100B3381000000         is truncated for readings greater
A9997915900B3498000000         than 100,000 nT).
A8677850800B3514000000
A7877821600B3645000000
A6997834700B3797000000
```

The same data in single channel Sandia format (ASCII):

A9977813100
A9989037600
A9995551700
A9999829300
A0007883500
A0003207100
A9997915900
A8677850800
A7877821600
A6997834700

Generate:

The "generate" command is useful for the testing of the recording and communications system. When enabled, it causes the field readings to gradually increase as a linear ramp. Each reading is 0.111nT greater than the one before.

The setting of the generate command is saved when the "UPDATE" command is used. The saved value can cause one of three actions the next time the power is applied.

If the saved value is two, the magnetometer will begin generating the test data when the power is applied.

If the saved value is one, the magnetometer will examine the state of the RS-232 command input when power is applied. If the command input is held at a voltage greater than 2V, the magnetometer will begin sending the test data. In the RS-232 standard, holding a signal high for a long time is referred to as a "break condition" or a "break character". The break condition must be asserted at the instant power is applied and held for at least 1.5 seconds. Connecting the command input to power supply in the 2V to 25V range will also work.

If the saved value is zero, the generation of test data is disabled regardless of the state of the command input.

To set the state of the generate command use the command "G0", "G1", or "G2". If there are multiple magnetometers all of them will be set to the desired mode. If only one of the magnetometers is to be set, the command can be followed by a two digit magnetometer number. "G103" would set the forth magnetometer's mode to one.

Julian Time Set:

The Set Time commands (D,H,M,S) will initialize the time in all counter modules. If a particular counter has all Julian clock fields enabled the output string will have the following inserted after the last A/D channel and before the CR/LF:

,DxxxHxxMxxSxx_xx

The x's would be ASCII characters (0-9) as required. The time registers are not incremented until enabled with the 'J1xx' command, so they can be set up then synchronized by sending the enable command at the correct time.

In Packed BCD and excess format the letters D,H,M,S, and _ are stripped and the data encoded as per the Mag data above. The Day info is put into 2 bytes with the most significant nibble of the most significant byte set to zero.

Julian Time Enable:

This command starts/stops the Julian clock. To start the clock on counter 0 the command would be "J100". "1" turns on the clock, while the "00" selects counter 0. To turn off the clock update on counter 2 the command would be "J002".

If the counter number information is omitted the command will affect all counter in the chain. Thus the command "J0" will turn off the update for every counter.

Note that the "Jxxx" command only affect whether the clock increments with time. It has no effect on whether or which clock fields are output. The "OJxxxxxyy" commands selects which field are output.

Julian Output format:

There are five clock output fields that can be turned on or off. These are the Julian Day, Hour, Minutes, Seconds, and Fractional seconds (to .01 seconds). These are selected with the "OJxxxxxyy" command. Each of the five x's corresponds to an output field, and can either be a '0' or a '1'. '1' turns the field on, '0' turns the field off. The yy characters is the counter number. Following is a diagram showing which character corresponds which each display field:

```
command:   "OJ0111103"
                   \ \ \ \ \ \ \__Counter number LSB
                    \ \ \ \ \ \__Counter number MSB
                     \ \ \ \ \__10 ms field
                      \ \ \ \__Seconds field
                       \ \ \__Minutes field
                        \ \__Hours field
                         \__Days field
```

In this example counter three would have all clock fields output except the Julian Day.

The counter number characters are optional. If not present the command would affect only counter 0 in the chain.

Find Counters:

This command is used to figure out how many counters there are in the daisy chain. An 'F00' is sent to the first counter which assigns it as counter 0. Before the command is echoed to the next counter the command is modified to 'F01'. The next counter modifies it to 'F02', and so on until the logging PC gets the command echo of 'Fxx' where xx is the number of counters in the chain.

Continuous data output can be inhibited by sending the command 'F01' to the first counter. In this mode there is no first counter (#00) which normally starts data transmission. Data output can be resumed by sending a new 'F00' command.

Set Preamble character:

By default the first character of each data stream is a '$'. If another character is desired the 'Px' command is used to change it to the character sent following the 'P'. All characters are allowed except control characters, digits (0-9), spaces, commas, decimal points, and the termination char ('*').

Echo Error command:

This is not really a command but a message. If a command string is incorrectly sent or garbled the counter receiving it will change it to 'ERRxx' before echoing it to the next counter. 'xx' specifies the counter number where the syntax error first occurred. This error message is interpreted as a command by subsequent counters which echoes the string unchanged.

Interrogate Setup command:

This command allows the operator or logging software to identify which analog channels and Julian clock fields are being output via the serial port. This information is used to verify output fields with their hardware channels, and to allow automated calculation of data field position within each sample being sent out. In addition the software revision number can be interrogated.

The first character 'I' designates the interrogate command, the second letter designates which item to interrogate. 'A' specifies interrogating the analog channels, 'J' specifies the Julian clock, and 'V' specifies the software revision number.

The next two characters specify the counter number '00' through '19'. If the counter number is omitted, counter 0 will respond.

The addressed counter will insert a response into the command string before sending echoing it out the serial port to the display terminal or subsequent counter modules. Subsequent counter modules will ignore these extra response characters and pass them unmodified down the chain. The response format for each of the three interrogate items are detailed in the examples below:

Analog channels:

The command "IA01" will command counter number one to output characters indicating which of the six analog channels have been selected for output. Counter 1 will modify the command string to "IA01:abcdef" where the letters a-f are either an ASCII '0' (channel off) or '1' (channel on) corresponding to channels 0-5 respectively. If analog channel 0,3, and 4 were selected on counter 1 the echoed command string would be "AI01:100110" followed with a carriage return line feed.

Julian Clock:

The command "IJ" will command counter 0 to output which Julian clock fields have been selected for output (note that the two digit counter number was not specified, so counter 0 responds by default). Counter 0 will modify the command string to "IJ:abcde" where the letters a-e would be replaced with an ASCII '0' (field off) or '1' (field on). The five output fields are:

a: Julian day
b: Hour
c: Minute
d: Second
e: Fractional Seconds (to 10 milliseconds)

If counter 0 had all clock fields selected for output except the Julian Day it would modify the command string to "IJ:01111" followed with a carriage return line feed.

Software Version Number:

The command "IV02" will command counter 2 to send its two character software version number. Counter 2 would change the command string to "IV02:xx" where xx is the version number of the software. If Counter 2 was software version "A4" then the echoed command string would be "IV02:A4" followed by a carriage return line feed.

Reset command:

If the command 'RESET' is sent to the counter a power up reset will occur initializing all parameters to default. The reset sequence will not start until the reset command has finished echoing out the RS232 port to the next counter/logging device. This allows each device down the chain to reset in sequence.

Update command:

If the command 'UPDATE' is sent to the counter, any parameters that were changed, will be saved and be the default parameters the next time the system is powered on. This command must be sent before powering down of the changes will be lost.

Jump to debug:

If the command string 'XBUG' is received the counter will do a one way jump to factory debug mode where a rudimentary operating system allows probing of registers, ports and memory for debugging purposes. It will only function properly with a single counter module (no daisy chained counters).

2.4.4 Power-up Initialization:

By default all counters will wake up thinking that they are counter #0 and begin to output data at the default 10 hertz rate. This data will appear as commands to any subsequent counters and will cause a brief period of chaos until each counter figures out where they stand in the daisy chain. Thus there will be some garbled transmissions to the logging PC upon power-up or reset.

2.5 Accessory Software

2.5.1 Cm201

Note: Cm201 and View201 software are compatible with CM-221 counters.

Cm201 is a program that facilitates sending a command start-up file to the G-881 counter(s) and initiating system operation. The program is executed by typing "cm201" at the DOS prompt and pressing return. Cm201 expects a counter command file that must be called Cm201go.cnf. This file is a list of counter commands, each followed by a carriage return that may be required to configure the counter to your application.

This software and all its necessary files may be installed on your system by placing the Install disk in either your a: or b: floppy drive, switching to that drive, typing "install" at the DOS prompt and pressing return. Install will ask a number of questions to which you should respond to configure the CM-221 counter to your system and create the Cm201go.cnf file.

If, after installing Cm201, if further commands are required (such as CLOCK) to configure CM-221 operation to your application, they may be added to the Cm201go.cnf file by editing this file with any suitable text editor.

The following describes Cm201 and the files that will be installed on your C: drive:

Install.bat

This is a batch file used to copy the contents of the floppy onto your hard disk. A directory called "GeoUtil" is created on the "C" drive, then all of the files are copied into that directory. After the files are copied, this batch file then runs Cm201set.bat

Cm201Set.bat

This batch asks the user questions and based on the answers to these questions creates a batch file called "Cm201.bat". The questions include such things as, to which COM port the CM-221 counter is connected.

Cm201.bat

This batch file is created by Cm201set.bat. It invokes Cm201go.exe to send any command lines necessary to correctly configure the CM-221 counter(s) for the users application.

Cm201go.exe

This program is intended to send any commands to correctly configure the CM-221 counter module(s). Normally the commands are taken from the file Cm201go.cnf, but this can be overridden if needed.

The calling syntax for this program is:

Cm201go FileName.cnf /b:BBBBB /p:P /i:I /d:D

Where:
BBBBB   Is the baud rate that the CM-221 starts at. Normally this is 9600.

P   The port number /p:1 would mean use COM1. This parameter is optional. If it not specified COM1 will be used.

I   The interrupt number to use. This parameter is optional. If it is not specified the normal interrupt for the COM port is used.

D   Any value other than zero will turn on the debugging display. This parameter is optional. If it is omitted the debugging display is disabled.

The contents of the Cm201go.cnf file are sent line by line to the CM-221 counter module(s). After each line is sent the CM201go program waits for the confirmation that the command was received correctly. If the confirmation is not received the line is repeated. For lines that change the CM-221's baud rate the Cm201go program changes its baud rate as required. If the input line has the special code "[CLOCK]" on it, the CM-221's clock will be set to match that of the PC.

A typical Cm201go.cnf would be:

[CLOCK]
c0010
oj11111

Commflip.exe

Given the port numbers of two COM ports this program will exchange their addresses. On some note book computers this is needed to be able to use some software.

batmenu.exe, drawbox.exe, gotoxy.exe, yymmdd.exe, foreach.exe, getkey.com

These programs are utility programs that allow the batch files to interact with the user.

2.5.2 Cesium Sensor Azimuth Program - CsAz

CsAz is a program written by Geometrics for users of Cesium magnetometers. The purpose of the program is to determine the proper orientation of the Cesium sensor at various earth's field dip angles. Az stands for azimuth.

The program is easy to operate. Begin by typing CsAz at the prompt followed by the Enter key. You will see a towed bird with the sensor mounted vertically. A lower graphic image displays the bird from a vertical perspective. If you are using the program for land or marine applications, the orientation of the bird can be taken to be the orientation of the wand or fish.

> Note: It would be beneficial to understanding to have CsAz running on a computer while studying the following material.

The first piece of information required is the earth's dip angle in your survey area. Refer to Geometrics' Application Manual for Portable Magnetometers, page 5, and select the angle from the map. For instance, the dip angle in San Francisco is 62 degrees North, Chicago is 72 degrees North, Sao Paolo is 30 degrees South and Singapore is 18 degrees South.

Next enter a N or S for the hemisphere (no enter key required here).

The first time, we recommend that you just press enter twice for no tilt and no rotation. After a few moments you will hear a beep when the computations are completed. Press any key to see the graphical display of the signal to noise ratio of the sensor in that orientation at that dip angle.

The circumference of the graphic represents the compass directions in degrees, i.e. the survey direction. The white portion of the graphic emanating from the center is the proportional signal-to-noise ratio that would be obtained if the survey were run in that direction. The black regions represent survey directions (approximately a 30 degree cone) in which the earth's magnetic field vector would be in the dead zone of the sensor. The region of the display that is white and outside of the 15 degree circle represents survey directions in which the earth's magnetic field vector would be in the sensor's active zone and provide good data. The longer the white line, the better the response of the Mag in that direction.

If the white line terminates inside the 15 degree circle, then you will get no signal traveling in that direction. If it terminates just outside the 15 degree circle, then

the installation will tolerate very little in the way of yaw, pitch or roll (depending on orientation, but most likely yaw) of the sensor before the earth's field vector goes into the sensor dead zone. Longer lines are better.

Next, press escape and reenter the dip angle and hemisphere information. Now you can tilt and rotate the sensor to see the effect on the signal versus survey direction. We have found that tilt angles of 0, 45 and 90 cover all realistic installations and dip angles. Rotating the sensor often has the effect of changing the optimum direction of survey.

Try a dip angle of 0 degrees with a tilt of 90 degrees. Try rotating 45 degrees. Even in a horizontal field, one can survey in both north-south and east-west directions. Geometrics sensors are fully automatic hemispheric switching allowing this versatility.

Try a dip angle of 70 degrees (Indiana) with a tilt of 45 degrees and a rotation of 90 degrees. In some areas, maximum signal cannot be achieved in all survey directions, but any signal-to-noise lines extending out to 20 and beyond will produce excellent data in those survey directions even in turbulent air.

With each entry of an angle of tilt and angle of rotation the sensor is depicted in the bird (fish) in the position that would be obtained if the sensor is first tilted aft from the depicted vertical axis by the specified angle and then rotated by the specified angle about the depicted vertical axis to its final position. Note the position of the sensor depicted in CsAz and make the appropriate mechanical adjustments to put the sensor in this same position as depicted by CsAz. In the G-881 only one adjustment is possible. It is rolling the sensor from vertical to horizontal by adjusting the keel weight position in relation the sensor.

> Note: The G-881 is shipped with the sensor and keel weights mounted such that the magnetometer fish would tow with the sensor in a position vertical to the earth's surface as initially depicted by CsAz.

As an example, in CsAz, the equivalent of rolling the G881's sensor to horizontal would be to enter a tilt angle of 90° and then a rotation of 90°. The CsAz map will then depict the corresponding tow path angles (in relation to North-South) that will provide acceptable data, if any, for the dip angle that was entered. To roll the sensor to an angle of 45°, enter a tilt angle of 45° and a rotation of 90°.

If you press F1 the program will identify your first available printer port and print out a laser printer compatible graphic of the screen. F2 is for Epson compatible printers. If you have both LPT1 and LPT2 operational and you want to go to LPT2, then add the following to the command line:

c:\csaz.exe /L=2   or /L=3   for LPT3

2.5.3 View201

View201 is a program that enables programming and viewing the magnetometer and analog data from one to three CM221 counter modules. It was written primarily as a factory debug/test utility and is provided as a tool to help installation and testing of the counter(s) in the field. The output can be viewed in both raw text and in graphics mode. In addition the output data can be logged to disk if desired. The program defaults to using Com port #1,although Com port #2 can be used be adding " /COM2" to the command line after "View201".

Upon startup the program listens to the output data stream from the counter(s) and synchronizes to the output baud rate. The raw output data is then displayed in a data text window. Along the top is a status bar showing the condition of the serial port and the serial input buffer.

View201 defaults to using COM port #1. COM port #2 can be selected by typing "View201 /COM2" and <ENTER> at the DOS prompt.

After the magnetometer has warmed up the first comma delimited field should be showing a stable magnetometer reading. The default counter output format includes the 4 character signal level in the next field (9999 full scale). Other data may be present as well depending on output configuration. If more than one magnetometer is daisy chained together there will be other magnetometer data field embedded in the output stream.

Commands can be sent to the counter module(s) at anytime. There are many commands that control the CM-221 which are detailed in the magnetometer manual. As an example, the command "A0000" followed by a carriage return turns off analog channel 0 (signal level) in counter 00: Each character is sent as it is typed and stored by the counter. When a carriage return is received by the counter the command is executed and then echoed down the daisy chain of counters until it is received back by the View201 program and displayed in the data window. A correctly echoed command string is a confirmation that the command was received and executed properly. Mis-typed or invalid commands will be turned into an error message and echoed through to the View201 display window. (Type A1000<return> to turn the signal level channel back on).

The magnetometer data can be viewed in graphics mode by pressing the <F5> function key. View201 defaults into displaying the magnetometer data from counter #0 at 10 nT full scale. Data from the second and third magnetometer can be displayed by pressing <F2> and <F3> respectively. If magnetometer 2 or 3 are not present the data fields are set to zero.

Data can be logged to disk at any time by pressing <F10>. A filename is created based on date and time and logged to disk. A logging message is displayed and a low frequency beeper plays to indicate that logging is taking place. Pressing <F10> again stops the logging process.

Currently, View201 only recognizes the ASCII output format. This is the default output format, but there is nothing preventing a change format command from being sent to the counter module. If the output format is changed the View201 program will cease to function correctly.

A list of function keys and their use can be viewed at anytime by typing a question mark (?).

Following is a description of each View201 function key. These are all functions that control the operation of the View201 program and should not be confused with commands that affect the counter module:

2.5.3.1 Function Keys

<F1>   =   Toggle graphics display of Mag1 on/off. Default setting is on. This key has effect in graphics mode only.

<F2>   =   Toggle graphics display of Mag2 on/off. Default setting is off. If turned on and no magnetometer#2 is present the magnetometer 2 data value is forced to zero. This key has effect in graphics mode only.

<F3>   =   Toggle graphics display of Mag3 on/off. Default setting is off. If turned on and no magnetometer#3 is present the Mag3 data value is forced to zero. This key has effect in graphics mode only.

<Alt F1> =   Toggle graphics display of Grad1 on/off. Gradient channel 1 is the difference between Mag1 and Mag2. This key has effect in graphics mode only.

<Alt F2> =   Same as <Alt F1> except it applies to Grad2 channel.

<Alt F3> =   Same as <Alt F1> except it applies to Grad3 channel.

<Shft F1>=   Change graphics display color for Mag1. Press this key several times to cycle through the 16 colors available for displaying mag1. Note that the display indicator for Mag 1 in the lower left hand corner of the graphics display changes as well, aiding in identifying which trace belongs to which variable. This key only has effect in graphics mode.

<Shft F2>=   Same as <Shft F1> except it applies to Mag2 channel.

<ShftF3> =   Same as <Shft F1> except it applies to Mag3 channel.

<Ctl F1> =   Change graphics display color for Grad1 trace. Press this key several times to cycle through the16 colors available for displaying Grad1. Note that the display indicator for Grad1 in the lower right

hand corner of the graphics display changes as well, aiding in identifying which trace belongs to which variable. This key only has effect in graphics mode.

<Ctl F2> = Same as <Ctl F1> except it applies to Grad2 channel.

<Ctl F3> = Same as <Ctl F1> except it applies to Grad3 channel.

<F4> = Toggle between true and normalized gradient display. When measuring gradients it often desirable to center the display trace to the center of the screen so that small variations do not cause screen wrapping. Pressing F4 will calculate and add an offset value to force the gradient display traces to the center. Pressing F4 again will toggle back to absolute display mode. Note that the Grad display indicators in the lower right hand corner of the graphics display screen change from "Gradx" to " "GradZx" indicating the current mode. Note that this normalizing only takes place on gradient channels.

<Alt F4> = Toggle true and normalized w. offset grad display. When measuring gradients with all three gradient channels turned on it is often desirable to move the three gradient traces close to the center of the display - but not place them right on top of each other. This key works the same as F4 above but leaves the traces slightly offset from one another.

<F5> = Toggle between graphics and text display mode.

<F6> = Lower the magnetometer full scale coefficient in the graphics display window. This key only affects the Mag channels (not gradient).

<F7> = Raise the magnetometer full scale coefficient in the graphics display window. This key only affects the Mag channels (not gradient).

<Alt F6> = Lower the Grad full scale coefficient in the graphics display window. This key only affects the Grad channels (not magnetometer).

<Alt F7> = Raise the Grad full scale coefficient in the graphics display window. This key only affects the Grad channels (not magnetometer).

<F8> = Clear next graphics screen and jump to it.

<F9> = Clear Break, Frame, and Parity errors in the Com port status bar (text display screen only).

<ALT F9>=   Auto adjust to incoming baud rate and clear errors.

<F10>   =   Toggle logging to disk.

<Esc>   =   Exit to text mode (if in graphics display mode). Exit to DOS (if text
              mode and not logging to disk).

2.5.3.2 Displaying Analog Channels

When in graphics display mode [F5] up to six analog channels may be enabled
by typing <CTRL A>. This will activate a series of questions to format the analog
data for display:

Display Channel Number [0-5]:

Selects one of six display channels. Any channel can be selected. The default
number is the first unused display channel. If a channel currently in use is
selected all subsequent menu items will have their default values set to the
current values. This makes it easy to modify the format of a channel currently
being plotted by simply pressing <enter> until the parameter to modify is
reached.

Display channel ON/OFF [0/1]:

Type '0' to turn a channel off. No further menu parameters will follow and the
channel will stop plotting. Type '1' to turn the display channel on or just
<ENTER>, which defaults to on.

Counter Number [0-2]:

Selects which counter the analog data will come from. Up to three daisy chained
counters may be logged by this program. The default is always counter 0 (the
first [or only] counter).

Analog Channel Number [0-5]:

Selects which A/D channel of the above counter is to be displayed.

    Note:

    1) Do not confuse "analog channel number" with "display channel
    number" above. They are not related in any way. Think of the
    display channels as 6 separate input channels to a 6 channel
    analog strip chart recorder. The counter channel numbers (along

with counter number information) specify a particular analog information channel. With three counters there could be 18 separate information channels - anyone of which could be configured to any display channel. In fact one analog channel could be assigned to two display channels with differing full scale coefficients - allowing a course and fine graphics display of the same channel.

2) This program does not know which analog channels are actually coming out of the counter. It is possible, for example, for the counter to be commanded to output channels 0, 4, and 5 only. This program sees only three analog channels in the counter's data stream and will refer to them as channels 0,1, and 2.

Unipolar/Bipolar [U/B]:

As described in the magnetometer/counter manual there are 4 unipolar (including the signal level) [0 to +4.096 volts], and 2 bipolar channels [ñ 2.048 volts]. This parameter is used to signify which type of analog channel this is.

Clip/Wrap [C/W]:

This parameter specifies what to do when the analog data exceeds the full scale setting (see next paragraph). Clip mode causes the data to be clipped at full scale so that the   channel traces the top of the display screen (or possibly the bottom of screen in bipolar mode). Wrap allows the trace to over-scale and wrap back around to the bottom or top of the screen.

Full Scale Set:

Set the full scale value of the display using the "+" and "-" keys. Note that a value of 10000 nT FS display as "0000" full scale. All other values display correctly in the allocated 4 digits.

Label:

This allows a 10 character label to be associated with the analog channel. These labels make it easy to identify what each trace is at a glance by looking at the label (which is   printed at the top of the screen) and correlating the label's color to the matching display trace color. To erase the default label of "channel n" use the backspace key, then enter   a new one.

Set trace color:

Use the "+" and '-' keys to cycle through all the possible trace colors using the label name entered above as a guide.

After the above data have been entered, the display channel will be plotting. At the top of the screen all of the activated display channels are documented in the same color as their associated trace color as in the following example:

Pitch
A13±1000C

The display channel in this case was labeled "Pitch". Underneath it is a shorthand display of all the setup parameters:

"A"   : signifies this is an analog channel.
"1"   : the counter number [0-2]
"3"   : the counter channel number [0-5]
"±"   : Bipolar mode, would have been set to "-" for unipolar
"1000" : Full scale value. If "0000" is displayed it mean "10000" full scale.
"C"   : Clipped display, would be a "W" for wrap mode.

At the right edge of the screen are two normalized scales for the analog data. One scale is for unipolar analog channels [0-100%],and the other is for bipolar channels [± 50%].

2.5.4 Depth Cal

This program is intended for use only if you purchased logging software other than **MagLog-Lite**™ or **Maglog NT**™ from Geometrics that might allow calibration of the depth sensor by determining a bias and scale factor. If you are using some other logging software, Geometrics does not warrant its use. See section 2.5.5 Depth Calibration using **MagLog-Lite**™ or **Maglog NT**™,below.

The Depthcal.exe program provides BIAS and SCALE values for entry into a logging software to calibrate the depth sensor. This program was installed in C:\GEOUTIL on your hard drive when you installed the ACCESSORY software.

DepthCal is an independent program (you may need to exit the logging software to use it) that will lead you through an experiment with your G-881 to derive the BIAS and SCALE values. To execute, at the DOS prompt in C:\GEOUTIL, type DEPTHCAL and press the Enter key. The questions that you answer will guide you through a simple experiment and then calculate the BIAS and SCALE values.

Bias and Scale Factors Explanation and Calculation:

The depth transducer provides full scale readings of '9999' regardless of whatever there range may be.

The DepthCal program may be used to calculate the bias and scale factors for the depth transducer as explained below.

The DepthCal program assumes that the logging software has initial settings of zero bias with a scale factor of 1.000. What this means is that the logging software should output zero meters when the serial data stream has "0000" in the appropriate analog channel and 128 meters when it has '0128', 5000 meters when '5000' and 9999 meters when '9999' (full scale).

The depth channel does not put out exactly zero volts at zero depth. Nor does a change of one digit '0001' equal one meter. And it varies from unit to unit due to differing sensor full scale values that may have been installed per the customer's system requirements. To correct for this, logging software may allow the user to input a bias (offset) value and a scale factor to transform the incoming device data such that the display readings that correspond to the device's actual reading. DepthCal can be used to avoid having to do the math required to obtain the bias and scale factors as shown in the example below.

NOTE: The depth transducer uses a strain gauge mechanism to measure the depth. Strain gauges as a rule are also greatly affected by temperature changes. The depth sensor used in the G-881 has been specially designed to compensate for temperature variations using calibration curves stored in a lookup table which is custom set for each device. None the less it is not perfect. For the best possible depth accuracy the depth bias and scale factors should be set at sea water operating temperatures. A magnetometer on the deck can get very warm from the sun and internal dissipation in contrast to the much cooler ocean even though both are technically at zero depth. The depth sensor is also mounted to a thermally massive aluminum pressure vessel which takes a while to stabilize at the local ambient temperature. Keeping these points in mind please observe the following:

Submerge the magnetometer before performing any of these procedures and wait 15 minutes for the magnetometer to warm up and allow the sensors to normalize to the water temperature.

Lets do an example with a typical depth sensor.

1)   First, in the logging software, set the bias and scale factors to their starting points.

2)   Adjust Units to meters (if not in meters already).

3)   While logging data tie off the magnetometer at the surface (zero depth) and write down the value that is reported for depth. You need not be logging to disk. Lets say it reads 112 meters.

4)   Lower the sensor down to a known depth (lets say 9 meters). Now, write down the values. You can watch the raw data coming in from the magnetometer. At this point, a one digit LSB change results in a 1 meter change in the depth value reported. Lets say the depth reads 917.0 meters.

5) Now run the Depth Cal program and enter the values written down above for the surface and at some known depth. DepthCal will return Bias and Scale Factors.

6)   (I got Bias = -1.2522, Scale = 0.0112). Write these values down for use when setting up your logging software. Restart your logging software and enter the bias and scale factors output from the DepthCal program. Depth should now be working correctly. See example below:

```
Depth calibration calculator    Version 1.2

Note:
     All depth values are assumed to be in meters.

With the sensor at the surface:
    What number is displayed for the depth? 112

With the sensor at a known depth:
    What depth did you place the sensor at ? 9
    What number is displayed for this depth ? 917

Enter a BIAS value of  : -1.2522
Enter a SCALE value of : 0.0112
```

NOTE: Some older versions of the DepthCal program instruct you to measure the "Zero Depth" value on the deck of the boat. Instead tie off the G-881 over the side at the surface but still submerged to do this measurement. See the discussion about temperature affects of the depth sensor in the paragraphs above.

Here is what the DepthCal numbers mean:

We entered a depth change of 9 meters and got a change of 805 meters (917 at depth minus the 112 at surface). To get your logging software to correctly display a change in depth for a given depth change we have to multiply the incoming data by (9/906) which equals 0.0112. This is the scale factor calculated by DepthCal above.

We read 112 meters out of your logging software when the magnetometer was at the surface. Its not really 112 meters though. Using the scale factor correction above we get an actual error of 1.2522 meters (0.0112 * 112). Thus to make it read correctly, we have to add a bias of –1.2522 meters which is the bias value calculated by
DepthCal.

Miscellaneous:

Note that once these values are entered, if your logging software remembers them, you will not have to enter them again. Of course, if a different instrument is connected at some later time, new values will be required corresponding to the new instrument.

Slope – Intercept Method

Here is a method for calculating the Scale Factor and Bias for depth calibration.

At the first depth, let the depth in meters be d1, and the raw reading r1.
At the second depth, let the depth in meters be d2, and the raw reading r2.

The formula for the Scale Factor is:
$$(d1-d2)/(r1-r2)$$
The formula for the Bias is:
$$(d2{\times}r1-d1{\times}r2)/(r1-r2)$$

You may also use Excel to calculate these values using linear regression. The advantage here is that you can use m ore that 2 depths and get a best fit for all the readings.

Put the actual depths in the first column. Put the raw readings in another column:

	A	B
1	True Depth	Raw Reading
2	1	30
3	5	34
4	30	46
5		
6	=INTERCEPT(A2:A4,B2:B4)	
7	=SLOPE(A2:A4,B2:B4)	

Use the INTERCEPT function to calculate the Bias. Use the SLOPE function to calculate the Scale Factor. Examples are shown in the table above. For this example, the Slope (Scale Factor) is 1.875, and the Intercept (Bias) is –56.75.

2.5.5 Depth Calibration Using MagLog-Lite™ or Maglog NT™

MagLog™ logging software from Geometrics provides capability to perform calibration of the depth sensor. It is preformed very much like the methods described above. Refer to the excerpt from the MagLog-Lite™/ Maglog NT™manual below.

Depth/Analog channel calibration

In order to get an accurate depth sensor reading, the pressure transducer sensor must be calibrated. This means that the depth sensor reading needs to be compared with a known depth to account for the variations occurring due to air pressure variations and to manufacturing variances.   Bias and linearity adjustment can be made in the program to empirically calibrate for depth. (You can read more about this method at the end of the section).

The depth reading from the magnetometer is an integer between 0 and 4095. This represents the full-scale range of the depth transducer. There may also be a certain offset that must be adjusted.

MagLog NT offers a few ways of calibrating the depth.

Note: These methods also work for calibrating other analog channels

Calibration Procedure:

The basic procedure for calibrating the depth sensor is as follows:

1) Place magnetometer in the water for at least 15 minutes at a known depth, say 3 meters. This will give the temperature of the sensor time to stabilize.
2) Write down the depth and reading that MagLog NT gives you.
3) Place magnetometer in the water at a DIFFERENT depth.
4) Write down the depth and reading that MagLog NT gives you.
5) Use either automatic calibration feature or manual calibration to apply results.

Note: If you use automatic depth/analog channel calibration, you can do this while in the calibration screen.

Automatic Depth/Analog Channel Calibration:

1) From your configuration screen, you should select the magnetometer. This should bring up the "*Settings*" screen that you originally used to input the number of sensors and analog channels. (You can get to this screen by going into your main list of devices, and then double clicking on the magnetometer description). You should see a screen similar to the one below:

2) In the section labeled "*Analog channel calibration setup*" select the sensor and channel number that you want to calibrate, e.g., to calibrate the depth of the first sensor in the earlier example, select
    Sensor #:   1
    Channel #: Depth

3) Select "A*uto calibration*. You should then see the following dialog box:

Calibration for sensor 1 channel Depth

Depth /altimeter calibration

Directions:

> Put array at a known depth and elevation above the ground. Let
> sensor's temperature stabilize (it can take about 15 min. in water).
> Then enter known depth for calibration of the depth sensor or
> elevation for altimeter and press "Add to list". Repeat at least at two

Add new calibration point

Value: `0`   [Add to the list]   [Reset av.]

Result of calibration:

Scale factor: none   Bias: none

Values for calibration

Current value: 1074.00   Current average: 1070.00

[Acceptable range...]   ☐ Use as depth for TrackPoint II

List of calibration points

#	Reading	Value	Predicted	

[OK (accept calibration)]   [Cancel (discard results)]

Note: At this time depth data is coming from the fish that is being analyzed by
the program to compute the bias and scale factor. You must place the fish
on at least two depths to get an accurate calculation. During Altimeter
Calibration discussed later, you must be over a hard bottom and the fish
must be held horizontally level.

You can add measured points to this menu and have it automatically calculate
your scale factor and bias. The depth sensor needs to be in the water for at least
15 minutes before you take your first measurement. This allows the temperature
of the electronics to stabilize.

To add a new point, place fish at known depth. Press *Reset av.* To discard
current average and wait for a few minutes to acquire a new one. Number after
text *Current average:* should stabilize. Then enter the depth that the device is at
under "*Value*" and press "*Add to the list*". This will take the average
measurement MagLog NT currently sees for the depth, and it will add it to a list of
calibration points.

It is important to remember to reset the average if you move the sensor. You can
do this by pressing "*Reset Av.*".

You can also specify an acceptable range of points to be used by pressing "*Acceptable Range*".   This will bring up a dialog box that will allow you to set a minimum and maximum allowed value. This is particularly important when you calibrate your altimeter because occasionally you might get a spiked reading (missed echo) that you don't want included in the calculation of your average.

After you have at least two points, MagLog NT will then try to calculate a scale factor and bias.   You need to make sure that you have at least two different depth points (e.g. it is advised to have one point near the surface, and the second point as close to the bottom as possible). Otherwise, the calibrations will not be accurate. It is advised to add more than two points to get improved accuracy.

You should also select "*Channel Represents Depth*". This option is important if you have an ORE device.

If you are satisfied with the calibration, select "*OK*".

4) You will then be given the opportunity to save your calibrations into a file. The file will keep track of the scale and bias calculated, and the readings used to make the calculation. It is advised to keep this for your records.

Manual Calibration

Manual calibration gives you the opportunity to enter the scale and bias directly without having MagLog NT calculate it for you.

You can find the scale and bias by hand, or use third party software.

To use MagLog NT's manual calibration feature, select "*Manual Calibration*" from your device settings menu. (Make sure that you have the correct sensor and channel selected as discussed in the section on "Auto Calibration".)

You will see a dialog box:
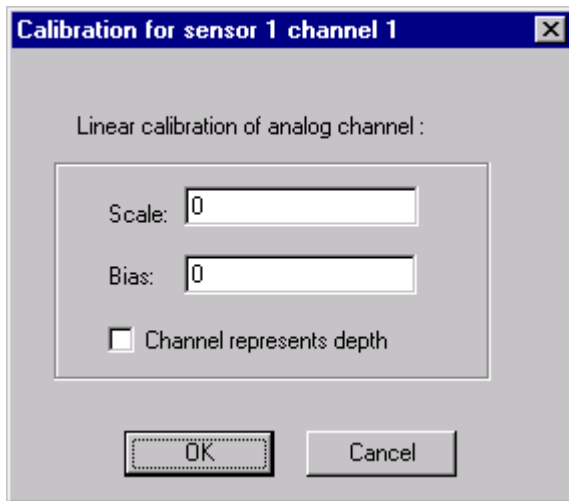
Enter your scale and bias values, and check "*Channel represents depth*" if this is a depth calibration. Then press "OK".

You will be given the opportunity to save these into a file.

Effects of Depth Calibration

After you have calibrated your depth sensor, you should see immediate changes in your data. The graphs and displays will use the new calibrated values.

However, the device file will have the uncalibrated values (.880).

If you need to store calibrated values, you should use the Interpolator device that will write calculated depths and altitudes in the interpolator file.

Why Should We Calibrate?

This is a brief discussion on how MagLog NT calculates scale and bias values and why this is needed.

The depth sensor is a pressure transducer. This means that for a given pressure, it will output a number proportional to the pressure measured. However, the number is meaningless until we solve for a few factors.

Assume that the depth reading is related to the pressure reading by the following:

Depth = A×Pressure + b

In this case, the two parameters A and b are the scale and bias values that we need to find.

We can solve for these two value if we have at least two sets of measurements. If we measure the following:

Depth	MagLog Reading (pressure)
Y1	X1
Y2	X2

I can then get two independent equations:

$$Y1 = A{\times}X1 + b \qquad Y2 = A{\times}X2 + b$$

Solving for A and b, I get:

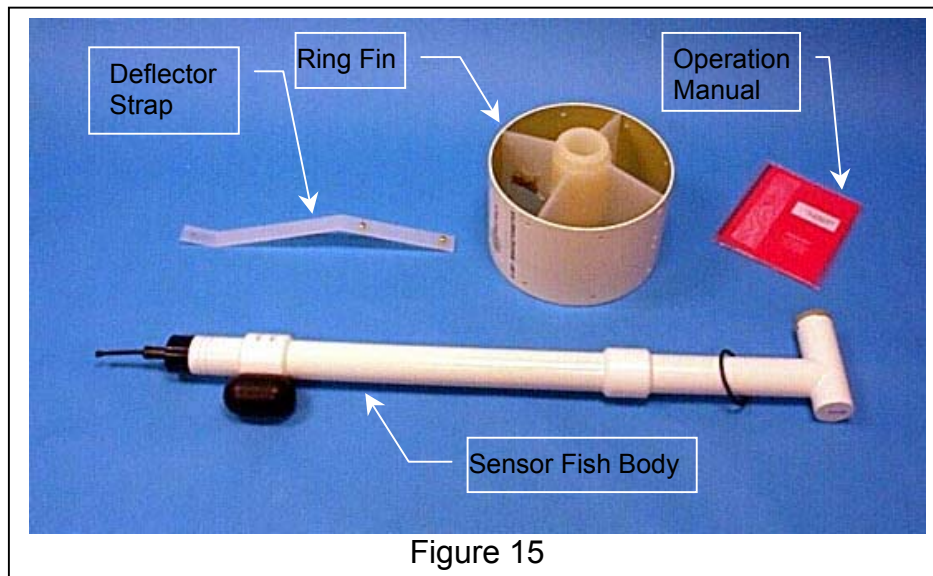$$A = (Y1 - Y2)/(X1 - X2) \qquad b = (Y2{\times}X1 - Y1{\times}X2)/(X1 - X2)$$

From here, we can now use these new values to calculate the correct depth, given only the pressure.

MagLog NT can then use these equations to automatically adjust all pressure readings to accurately reflect the depth measured.

2.6 Assembly, Installation and Use

2.6.1 Assembly of the Sensor Fish

Unpack the Sensor Fish Body, Ring Fin, Tow Cable, and Ship Kit from their shipping containers. Note the item in the pictures, Figures 15 and 16 below. These will be referred to later in this section, 2.6 (Tow Cable not shown).

Deflector Strap · Ring Fin · Operation Manual · Sensor Fish Body

Figure 15

Silicone grease for underwater connectors · AC/DC Supply & plug adapters · Cable Handle · Spare Hardware · Serial & Printer Cables Spare trimmer string · DC Power Cbl Ground Cable · Junction Box
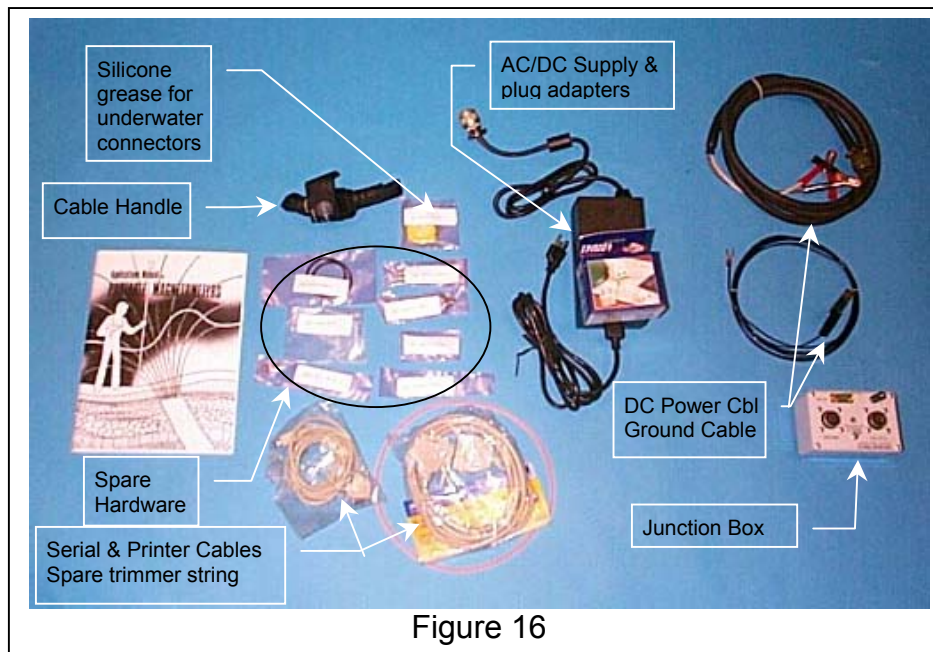
Figure 16

As can be seen, in Figures 15 and 16, some assembly is required. Proceed to assemble the Tow Fish.

Slide the fins out from of the Ring Fin. The fins will fall apart into two pieces. Note that the center portion of the fins is hollowed out to fit around the sensor end (tee end) of the Sensor Fish body.

Place the two halves of the fins around the sensor end of the Sensor Fish body and then stretch the large O-ring over the grooved end to retain these fin halves during the rest of the assembly process.

Deflector Strap anchor collar and cinching screws.
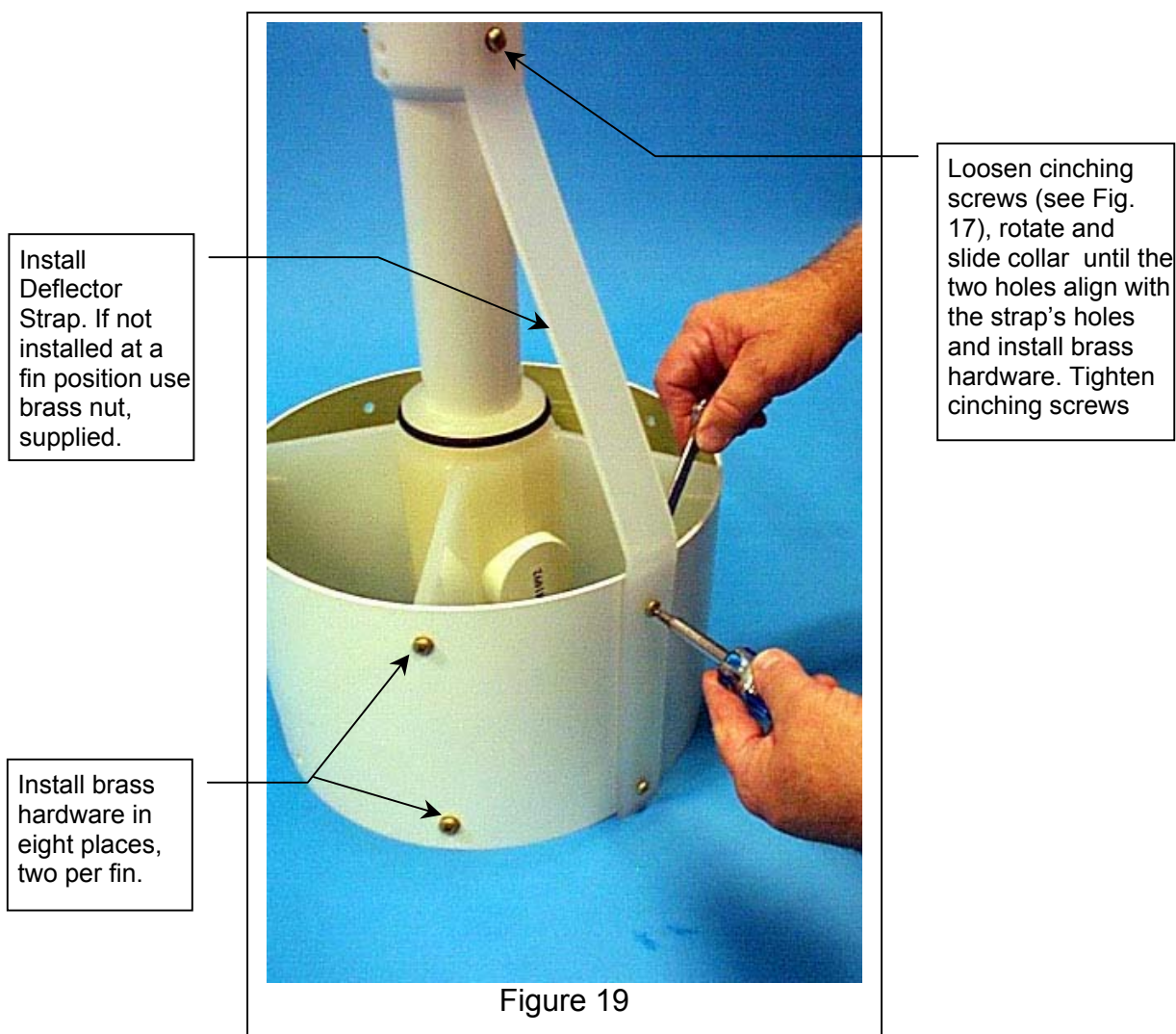
O-ring in groove of fin halves
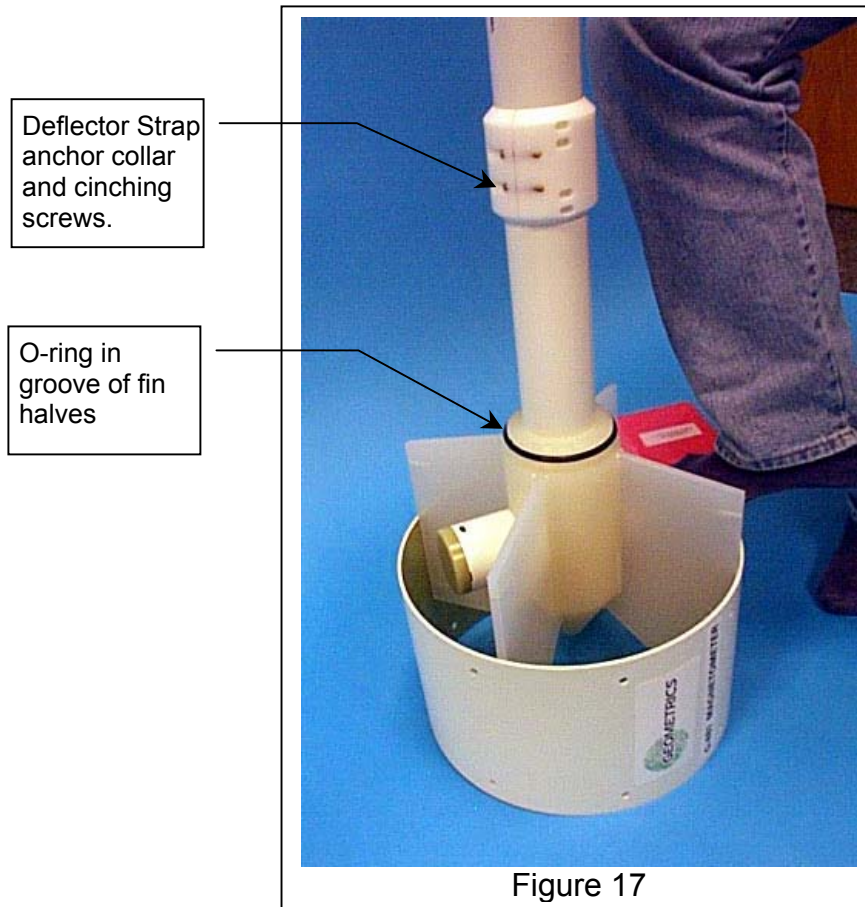
Figure 17

Now, slide the fins back into the ring-fin as shown in Figure 17 until they are completely inside the ring-fin as shown in Figure 18, below. Turn the fins as necessary to align the fins with the holes in the ring-fin. The brass hardware (screws and washers) that are used to fasten the fins inside the ring-fin are in a bag taped to one of the fins as shown in Figure 15. Remove this hardware from the bag.

DO NOT substitute any other hardware (steel, stainless steel, or anything that you may think is brass) here or anywhere else on the G-881 Magnetometer Fish. Spare hardware is supplied in the Ship Kit. All of the supplied hardware is magnetically tested to insure that it is clean (exhibits no magnetic signature). Failure to follow this caution could introduce heading errors into the data that is acquired making it useless or very difficult to interpret.

Holes aligned with fins.

Figure 18
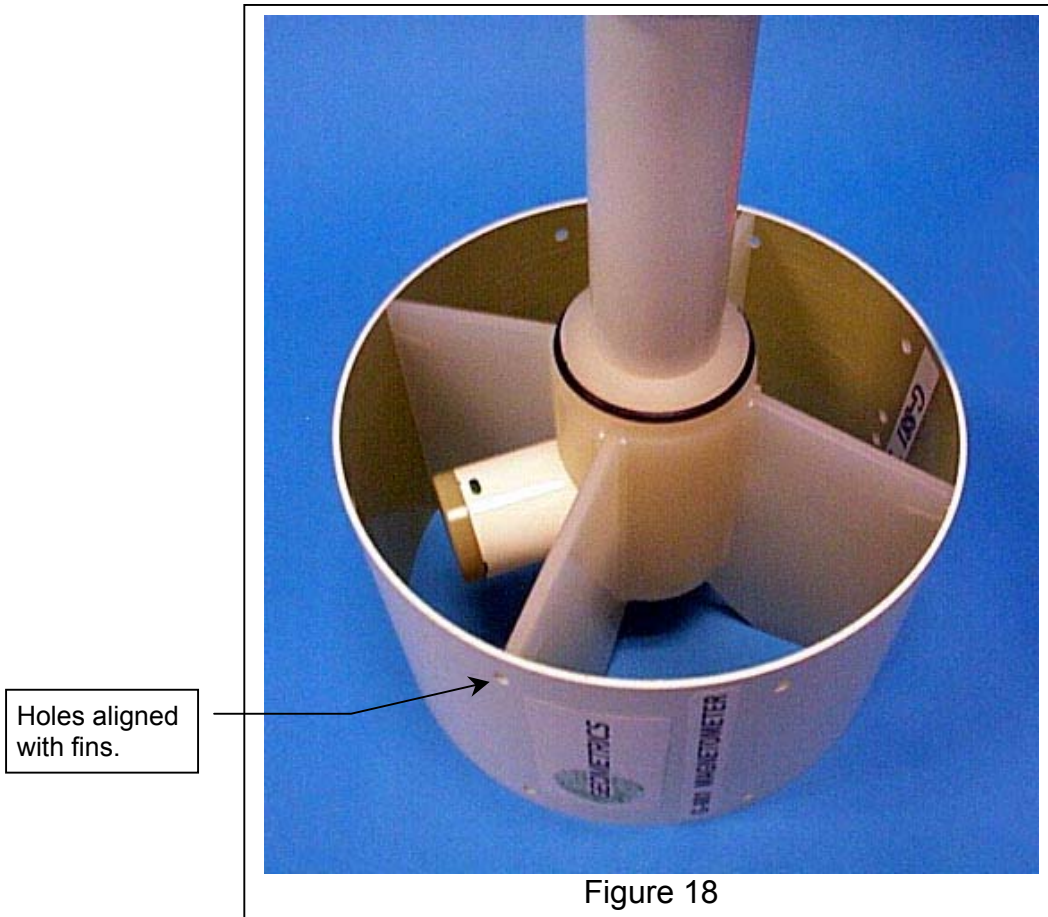
Install all eight ¼-20 x .75" brass screws and ¼ split lock bronze washers. Turn them in until they are just snug and then tighten them ¼ turn more. This should be sufficient to compress the lock washers. Next install the Deflector strap using the brass hard ware supplied (brass hardware found on the anchor collar and the Deflector Strap) as shown in Figure 19, below. This strap should be installed in a position such that it will point toward the survey area bottom when the Magnetometer Fish is adjusted as discussed is Section 2.3.1 to accommodate the magnetic dip angle of the survey area. The brass hardware on the strap may not be necessary if the Deflector Strap is installed over a fin.

Install Deflector Strap. If not installed at a fin position use brass nut, supplied.

Loosen cinching screws (see Fig. 17), rotate and slide collar until the two holes align with the strap's holes and install brass hardware. Tighten cinching screws

Install brass hardware in eight places, two per fin.

Figure 19

Next adjust the rotational position of the keel weight based on discussion of Section 2.3.1 to accommodate the magnetic dip angle of the survey area. Loosen the two cinching screws until the keel weight may be rotated. Position the keel weight as desired and tighten the cinching screws. Not pictured is the center of gravity tow point. If you purchased a CG towed fish, the CG tow point will already be installed behind the keel weight at the optimum position for best depth and tow characteristics(1/3 of the length of the tow fish from its nose). The CG Tow Point must be rotated to accommodate the magnetic dip angle of the survey area. Loosen the two cinching screws until the CG tow point may be rotated. Position the CG Tow Point as desired and tighten the cinching screws. While, for CG tow it is not necessary, Geometrics recommends that the keel weight also be rotated accordingly. See Figure 20, below.

Figure 20

2.6.2 Installation of the G-881 Magnetometer

While reading this section, refer to the System Connection Diagram in Appendix B.

Every G-881 is supplied with a Power/Data Junction Box (J-BOX). It functions as the center for all the items that need to be connected to have a functioning G-881 magnetometer system. The Data Logging Instrumentation; this J-BOX, the System Computer (Logging Computer), and the power source should be installed in a protected environment. These items are susceptible to water damage and most likely will cease to function if they become wet, particularly with salt water from a sea wave. Their installation could be in the cabin of the boat or the equipment room if there is one. In a very small boat, provide some protection by elevating this equipment from the deck and covering it with a tarp or provide a waterproof enclosure.

Safely secure the G-881 magnetometer fish at or near the stern of the vessel from which it will be deployed. Secure it in a manner that it will be easy to attach the tow cable, adjust the diving wing(if purchased), and adjust the keel weight to control the angle of the sensor tow as described in a previous section of this manual.

2.6.2.1 G-881NT Nose Tow Installation

Prepare the wet end of the tow cable for installation by insuring that the connectors on the tow cable and the magnetometer fish are clean and free of dirt. Using a finger, wipe a small amount of silicon grease across the face of the connector of the tow cable. If this is done properly, there will be a "half moon" of grease visible in each of the pin sockets of this connector. **Do Not** use too much grease. These water-tight connectors are rated to 10,000psi. If too much grease is used, under pressure, the female connector pins will permanently distort jeopardizing a sound electrical connection. The correct silicon grease is provided in a small circular container in the ship kit. Unless it is cleaned, once greased this connector may never require grease again. To keep these connectors clean, they are shipped with dummy plugs installed. Save these dummy plugs and re-install them for storage of the magnetometer system.

Press the wet end connector of the tow cable part way onto the connector of the tow fish and gently work it on and off a few times to spread the grease. **Do Not bend the connector side to side.** Then press the connector all the way on as far as it will go. Finally slide the locking shell down over the connector and screw it all the way on until it is finger tight and the tighten it 1/8 turn more. **DO NOT** wrench the locking shell; use only your fingers to tighten it. See Figure 21. below.

Figure 21

Locking backshell shown installed
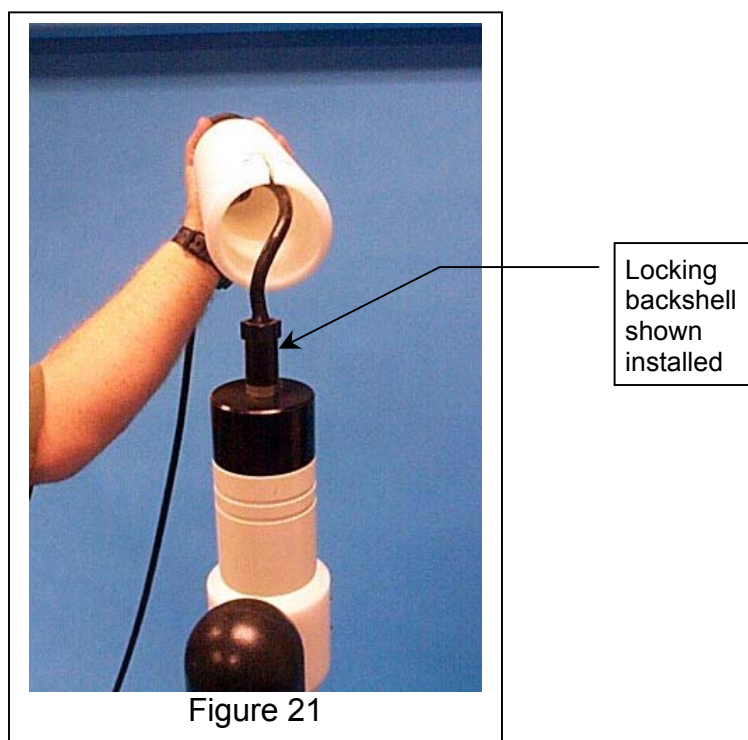
Slide the magnetometer nose onto the fish allowing the connector pigtail and cable splice to slide into the recess in the nose. Slide the nose all the way onto the fish until it hits the stop. At this point, observe that there are two grooves, one each, visible in the two oblong holes at the fish end of the nose.

Insert a piece of trimmer string into each of the two grooves. Push the strings as far as possible into each groove. Usually the end of the string will reappear in the hole after it has gone all the way around the fish. This locks the nose onto the fish. With both strings installed, tighten the cinching screw to prevent the nose from rotating and possibly ejecting the strings. See Figure 22, below.

Slide strings into grooves through oblong holes.

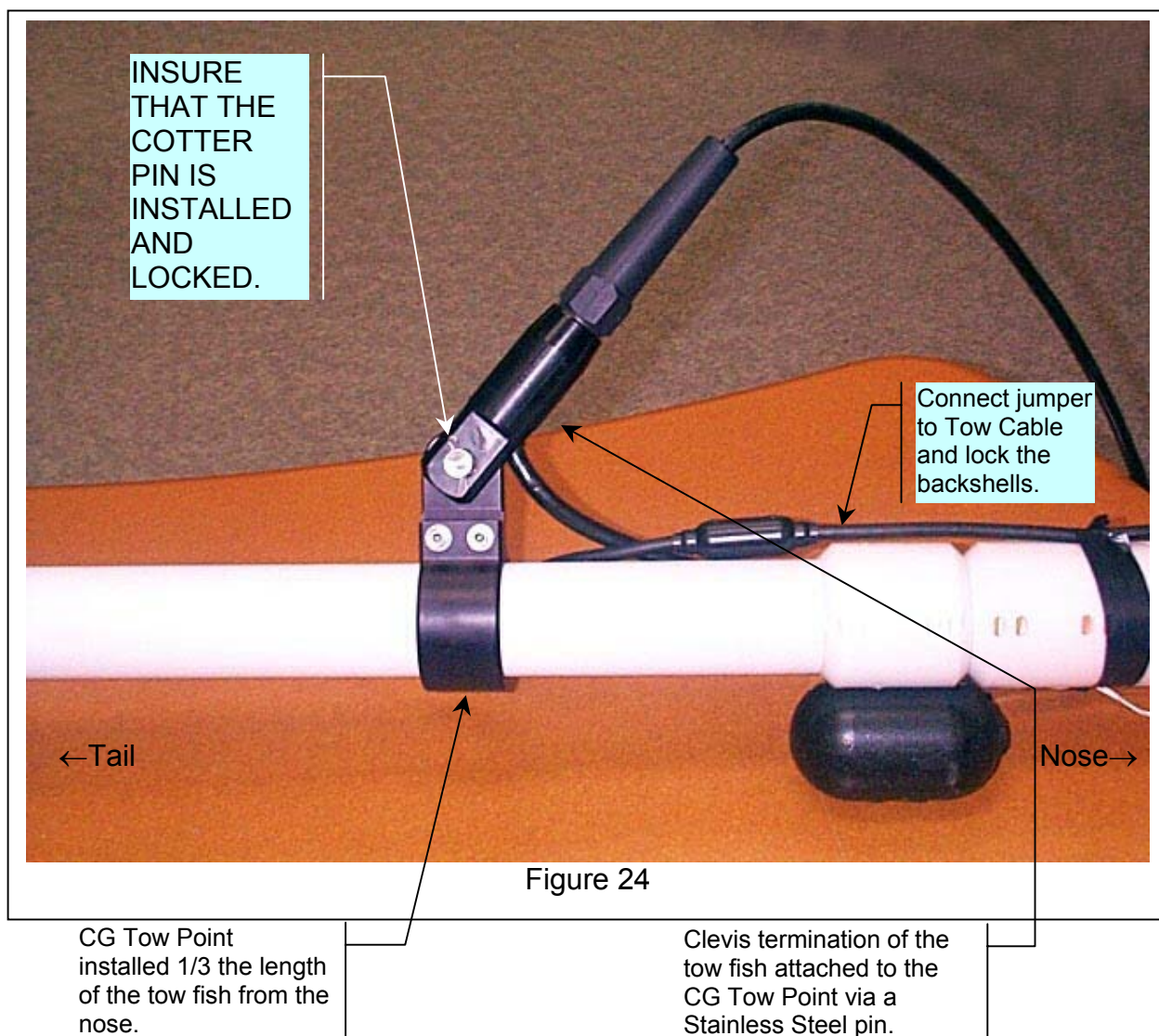Tighten cinching screw until nose does not rotate
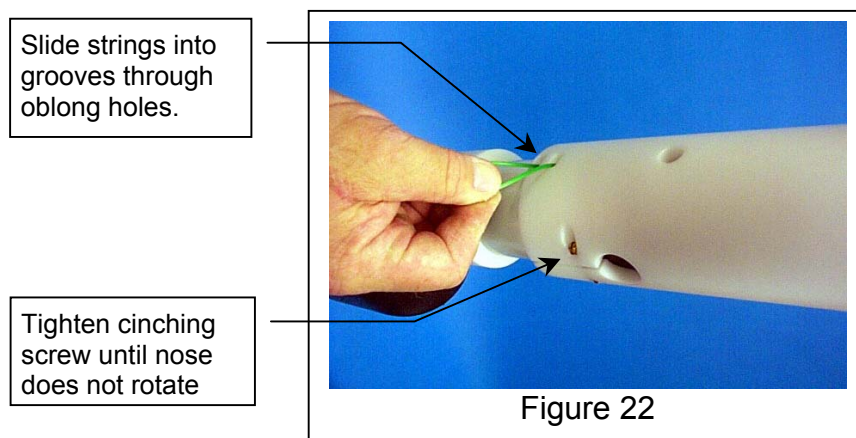
Figure 22

Below, Figure 23 shows how the G-881 Magnetometer nose towed sensor fish will look after it is assembled and ready to deploy in a survey region with a dip angle between 35°-67°.   If you are installing the nose of a Center of Gravity (CG) towed G-881, insert the jumper cable through the hole in the nose and proceed as above to install the nose leaving the jumper cable out the front of the nose for later attachment to the tow cable.

Figure 23

2.6.2.2 G-881CG Center of Gravity Tow Installation

The following picture, Figure 24, shows the tow cable connected to the G-881 for the CG tow configuration. The tow cable is terminated in a clevis. Slide this clevis over the fish mounted CG Tow point until the large holes in both are co-located. Then insert the stainless steel pin through both the clevis and tow point. The stainless steel pin is locked in place by inserting a stainless steel cotter pin through the hole in the end of the pin. Spread the split ends of the cotter pin to secure it in place. Connect the jumper cable to the tow cable as described below. The jumper cable should then be secured to the tow fish with tape or cable ties leaving a service loop to allow the clevis/tow point joint to move freely.

INSURE THAT THE COTTER PIN IS INSTALLED AND LOCKED.

Connect jumper to Tow Cable and lock the backshells.

←Tail

Nose→

Figure 24

CG Tow Point installed 1/3 the length of the tow fish from the nose.

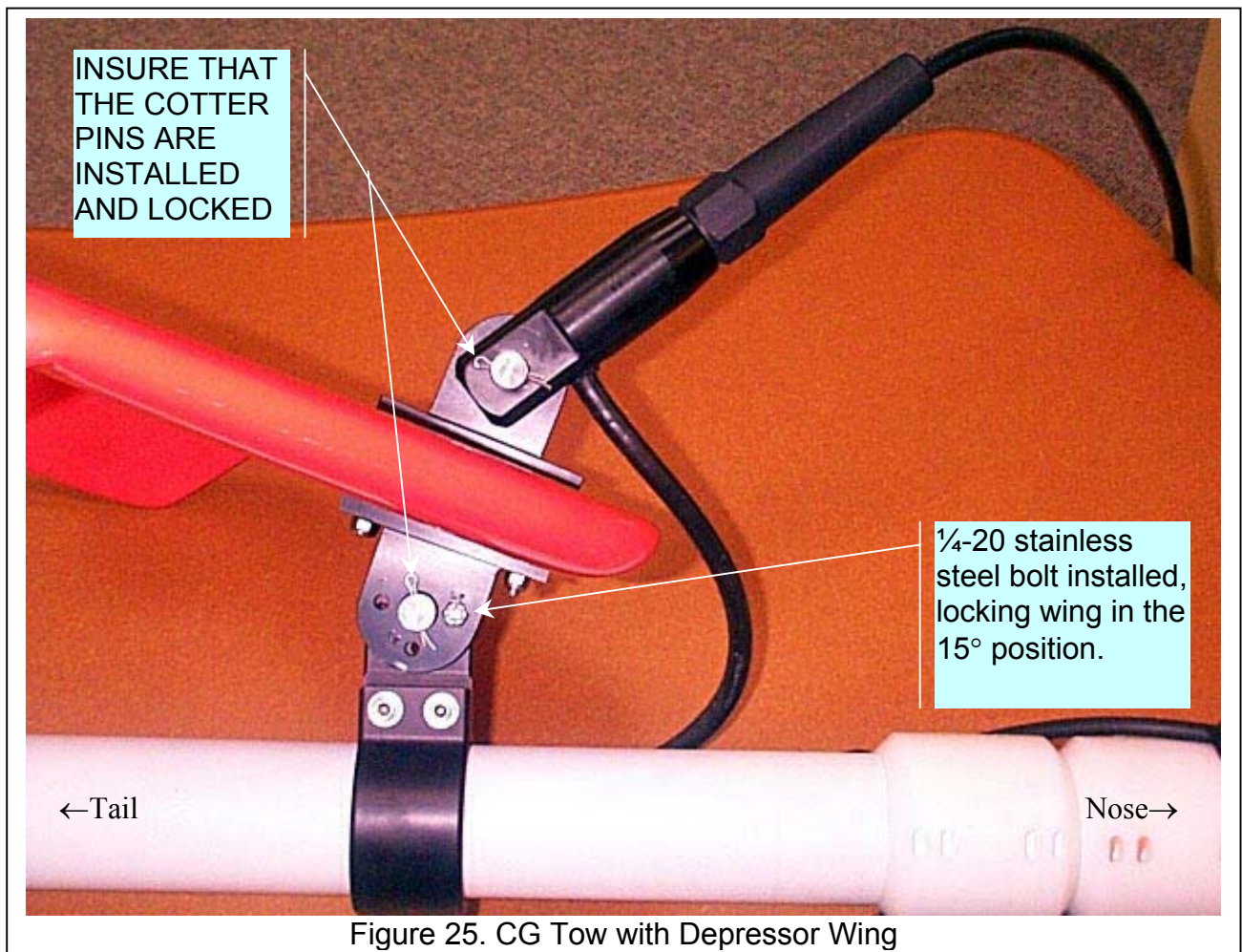Clevis termination of the tow fish attached to the CG Tow Point via a Stainless Steel pin.

With the tow cable attached to the CG Tow Point, mate the tow cable connector and the jumper cable connectors. Prepare the wet end of the tow cable for installation by insuring that the connectors on the tow cable and the jumper cable are clean and free of dirt. Using a finger, wipe a small amount of silicon grease across the face of the connector of the tow cable. If this is done properly, there will be a "half moon" of grease visible in each of the pin sockets of this connector.

Press the wet end connector of the tow cable part way onto the connector of the jumper cable and gently work it on and off a few times to spread the grease. **Do Not bend the connector side to side.** Then press the connector all the way on as far as it will go. Finally slide the locking shells down over the connectors and screw them all the way together until they are finger tight and the tighten them 1/8 turn more. DO NOT wrench the locking shells; use only your fingers to tighten them.

2.6.2.3 G-881CG Center of Gravity Tow Installation

The following picture, Figure 25, shows the tow cable connected to the G-881 for the CG tow configuration with a depressor wing. The depressor wing is mounted to the G-881 at the CG Tow Point. The bottom of the wing has a split tang that slips over the CG Tow Point just as the clevis of the tow cable in the CG tow only configuration. Slide the split tang around until the large holes are co-located and then insert the stainless steel pin. The stainless steel pin is locked in place by inserting a stainless steel cotter pin through the hole in the end of the pin. Spread the split ends of the cotter pin to secure it in place.

The wing is now attached to the G-881, but to function properly it must be locked at permanent angle in relation to the magnetometer tow fish. In Figure 25, the wing is shown mounted at a 15° angle. This is accomplished by tilting the wing forward until the hole marked with 15 is co-located with a hole in the CG Tow Point and then inserting a ¼-20 stainless steel bolt. With the bolt in place, apply the ¼-20 stainless steel locking nut and tighten until there is no play in the wing to tow fish joint.

INSURE THAT THE COTTER PINS ARE INSTALLED AND LOCKED

¼-20 stainless steel bolt installed, locking wing in the 15° position.

←Tail

Nose→

Figure 25. CG Tow with Depressor Wing

There are two other angles that may be selected, 10° and 5°, which should cause the tow fish to run at a more shallow depth than the 15° setting. Either of these may be selected by tilting the wing backward from the 15° setting until the desired holes are co-located and installing the stainless steel bolt. See Figure 26.
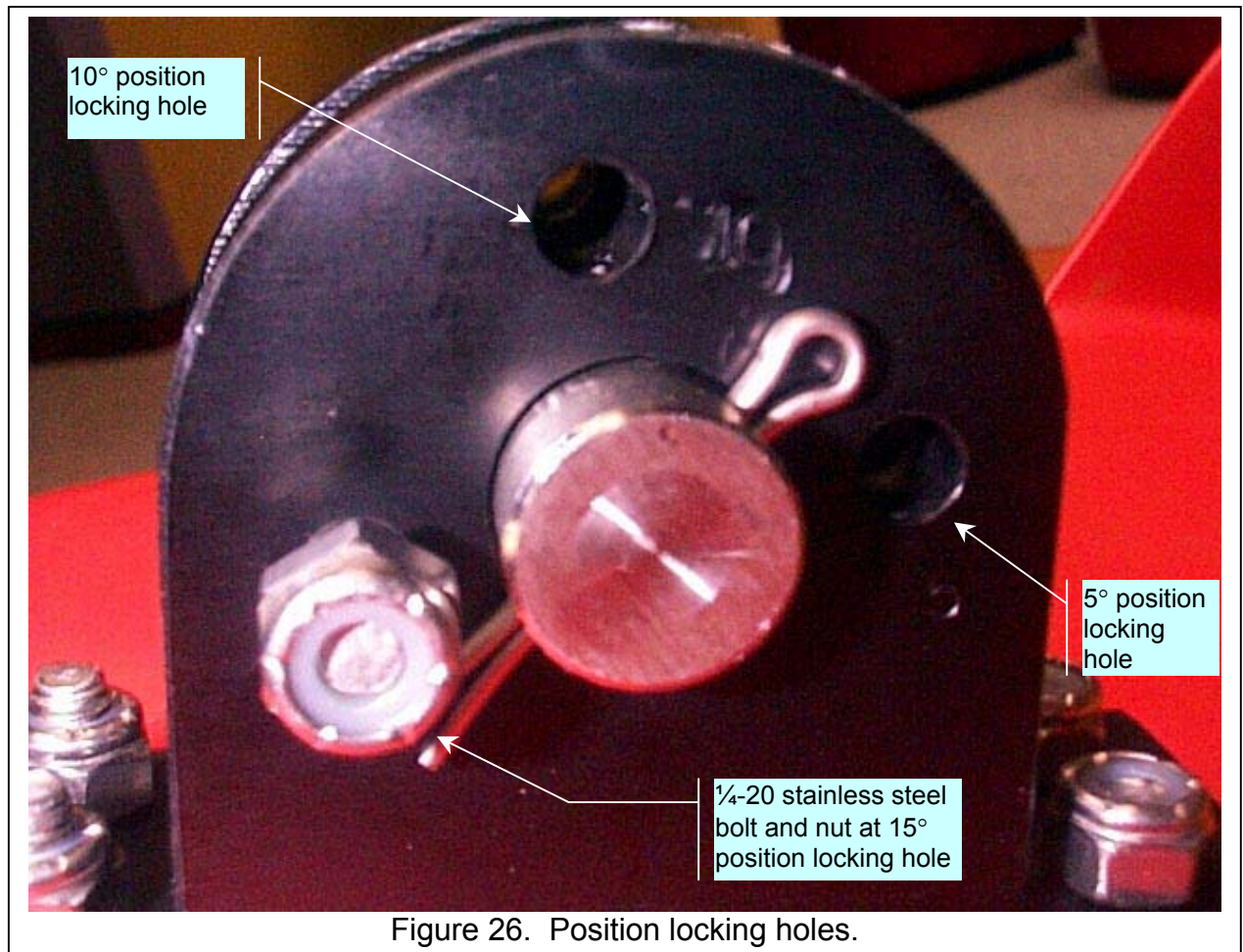

Figure 26. Position locking holes.

Figure 26, shows the tow cable connected to the depressor wing for the CG tow configuration. The tow cable clevis slides over the wing mounted CG Tow point until the large holes in both are co-located. Then insert the stainless steel pin through both the clevis and tow point. The stainless steel pin is locked in place by inserting a stainless steel cotter pin through the hole in the end of the pin. Spread the split ends of the cotter pin to secure it in place. Connect the jumper cable to the tow cable. The jumper cable should then be secured to the tow fish with tape or cable ties leaving a service loop to allow the clevis/tow point joint to move freely.

Again, while reading this section, refer to the System Connection Diagram in Appendix B.

With the tow cable now attached to the tow fish, drag the dry end of the tow cable to its connection point. This could be several places depending up your installation plan, as follows:

1. It could be a winch if you are using a substantial amount of tow cable. A winch in recommended if the length of the tow cable is to exceed 120 m (400 ft). An Onboard cable is then used to traverse the distance from the winch installation point the logging equipment installation place.

2. It could be at some tie off point on the aft deck if an onboard cable was purchased to traverse the distance from the aft deck to the logging equipment installation place.

3. It could be where the logging equipment is located. A short adapter cable is provided to connect the tow cable to the DC/Data Junction Box.

Connect the tow cable to the DC/Data Junction Box by one of the methods above.

Connect either the AC/DC Power Unit or a 24VDC minimum power source (such as two 12 VDC car batteries in series) to the DC/Data Junction Box. The DC Power Cable is provide to connect to batteries. If you are using the AC/DC Power Unit, connect it to the AC Mains. An AC adapter plug kit is provided.

If required, connect the ground lug on the DC/Data Junction Box to the ships hull using the ground cable provided. This connection could be required of the AC Mains is grounded to a steel hull.

Connect the Logging Computer to the DC/Data Junction Box using the Serial Data cable provided. See Figure 27, below.

Figure 27
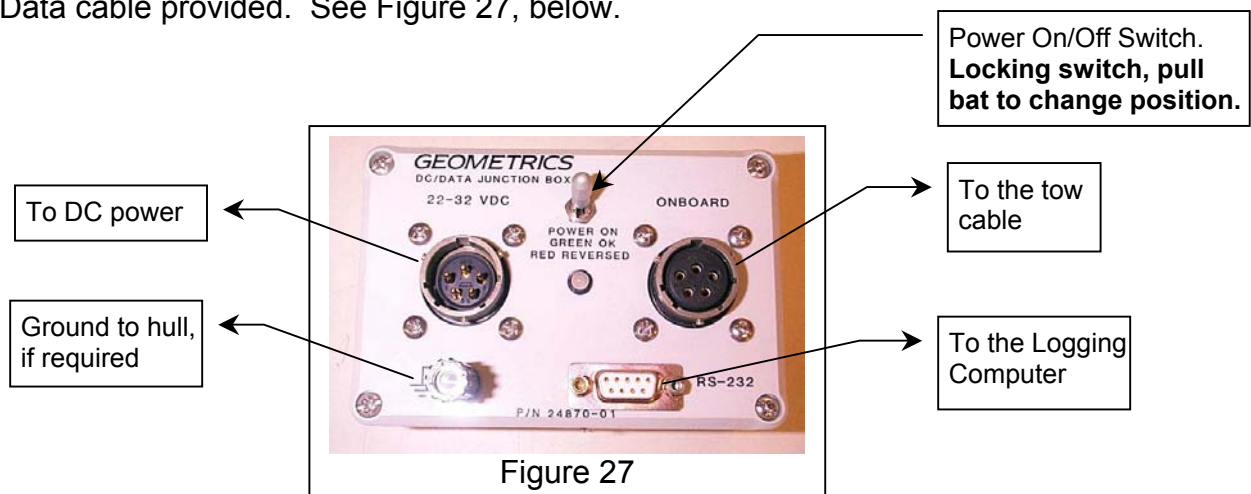
2.6.3 Deployment of the G-881 Magnetometer

If you are an "old salt", please do not be offended by the following section; please read it. We provide the following information in the hopes of insuring you have a successful survey.

Turn the power on the DC/Data Junction Box and the Logging Computer. After five minutes warm up for the magnetometer and boot up of the Logging Computer, start the logging software as described elsewhere in this manual or the MagLog™ manual. If the magnetometer is positioned horizontal on the deck away from any steel objects, you may begin to see readings that represent the intensity of the earth's field in the survey area. If you are on a steel hulled vessel, you may not see quiet data until you launch the magnetometer fish and it is about 30m (100ft) behind the vessel. With the system running you can proceed to perform the calibration of the depth sensor as described in Section 2.5.4 of this manual.

If the logging software is operating at power-on time, the following outlines what might be observed as the magnetometer is powered-on and warms up to operating temperature. **If the numbers observed are somewhat outside the ranges given below, the magnetometer is still, most probably, operating properly**. Extreme temperature conditions may cause some of these values to go significantly outside these ranges during normal operation.

1. Just after power-on and before the counter begins normal operation some garbage may be observe red for a brief period of time.

2. When the counter begins normal operation the following may be observed as the magnetometer begins to warm up:

    A. The magnetometer reading will be erratic as the sensor begins to warm up.
    B. Analog channel 0, the signal level, will be around 0010 and will increase during warm-up.
    C. Analog channel 1, the depth sensor, will exhibit a value near 0000 (unscaled) with the G-881 in air out of the water. If no depth sensor is installed in the G-881, the value could vary between 0000 and 0050.
    D. Analog channel 2, not used in the G-881, the value could vary between 0000 and 0050.

    If the additional analog channels are enabled, the following may be observed:

    E. Analog channel 3, the brightness, will exhibit numbers beginning low and will slowly rise towards a number around 5760 as the magnetometer warms up.

F. Analog channel 4, the RF, will exhibit numbers beginning low, fairly quickly ramping up to some high numbers and as the magnetometer warms up slowly settling down to a number around 2100.

G. Analog channel 5, the heater, will exhibit numbers beginning low, very quickly ramping up to some quite high numbers and then settling down to a number around 1740.

H. Analog channel 6, if not used, could vary between 0000 and 0050. As shipped, jumpered to an internal voltage, 28V, analog channel 6 could immediately exhibit numbers between 6200 and 6400. If used for an external input (this capability not currently implemented in the G-881), the values will depend upon the characteristics of the user device attached.

I. Analog channel 7, if not used, could vary between 0000 and 0050. As shipped, jumpered to an internal voltage, 21V, analog channel 7 could immediately exhibit numbers between 5000 and 5300. If used for an external input (this capability not currently implemented in the G-881), the values will depend upon the characteristics of the user device attached.

3. When the magnetometer is warmed up the following may be observed:

A. If the magnetometer is properly oriented to the ambient field and not near any large metal objects, a reading indicating the magnitude of the ambient field will be observed.

B. Analog channel 0, the signal level, depending on the field magnitude and sensor orientation, a normal signal could vary between 0900 and 1200.

C. Analog channel 1, the depth sensor, will exhibit a value near 0000 (unscaled) with the G-881 in air out of the water. If no depth sensor is installed in the G-881, the value could vary between 0000 and 0050. If the G-881 is in the water the value should vary with and be indicative of depth.

D. Analog channel 2, not used in the G-881, the value could vary between 0000 and 0050.

If the additional analog channels are enabled the following may be observed:

E. Analog channel 3, the brightness, will exhibit a value around 5760, but may vary between 5000 and 6000.

F. Analog channel 4, the RF, will exhibit a value around 2100, but vary between 2000 and 2400.

G. Analog channel 5, the heater, will exhibit value around 1740, but vary between 1700 and 1900.

H. Analog channel 6, if not used, could vary between 0000 and 0050. As shipped, jumpered to an internal voltage, 28V, analog channel 6 could exhibit a value around 6250, but vary between 6200 and 6400. If used for an external input (this capability not currently

implemented in the G-881), the values will depend upon the characteristics of the user device attached.

l. Analog channel 7, if not used, could vary between 0000 and 0050. As shipped, jumpered to an internal voltage, 21V, analog channel 7 could exhibit a value around 5130, but vary between 5000 and 5300. If used for an external input (this capability not currently implemented in the G-881), the values will depend upon the characteristics of the user device attached.

In either configuration above, nose or CG tow, the magnetometer can be one-man lifted over the side. However, the deployment will be much easier and smoother with two or more people handling the operation. Due to much lower levels of drag force, the nose towed magnetometer may be handled by one strong person. Cowhide work gloves provide the best protection and grip for handling the wet tow cable.

There are two methods to handle the cable on deck if a winch is not used:

1. Neatly fake (figure eight) the cable down on the deck beginning with the onboard end. As this is done remove any twists in the tow cable. The cable may be deployed from the figure eight without knots and kinks. One person should be assigned to tend the cable on and off of the figure eight. This method is better for cable up to 120m (400ft).

2. Neatly lay the cable out in long loops bow to stern on the deck beginning with the onboard end. As this is done remove any twists in the tow cable. The cable may be deployed from the loops on the deck without knots and kinks. One person should be assigned to walk the loops back on the deck during retrieval. This method works well with cables up to 60m (200 ft).

Tow cables longer than 90m to 120m (300ft to 400ft) should probably be handled with a winch.

Manual deployment, is best handled with two people, especially when a depressor wing is being used, a third person should manage the tow cable. The vessel should be making 1 to 1 ½ knots during deployment. It may be necessary to increase the vessel speed as more cable is deployed to prevent the magnetometer from striking the bottom. The more quickly the desired cable length can be deployed and the desired tow speed attained reduces the chances of the magnetometer going too deep striking the bottom or becoming hung. The recommended cable management mentioned above will aid in quick deployment. Another method is to stop playing out tow cable a few times during deployment while under tow. This will allow the tow fish to rise towards the surface. If a CG towed fish with a depressor wing is being deployed, it pulls with significant force. It may require two or three people to hold it during the play-out stops.

It is best if the tow cable is tied to the vessel before the vessel begins to acquire the desired tow speed. The magnetometer with the depressor wing produces strong pull forces under tow speed of 4 to 6 knots.

Determine the approximate length of tow cable to be deployed to achieve the required survey depth. Geometrics recommends that the Kellems grip provided on the tow cable be used to secure the tow cable to the towing vessel. Slide the Kellems grip (Figure 28) to length of tow cable desired to be deployed plus some additional cable to account for the distance from the ship to the tow cable water entry point. Secure the Kellems to the tow cable as shown in Figure 29. **DO NOT** tape along the whole length of the Kellems; this will prevent it from working properly. Attach the Kellems to the towing vessel using a strong line tied to the loop of the Kellems grip.

A Kellems grip is like a child's toy finger trap. The stronger the forces that pull on it, the tighter it grips the cable. If the Kellems grip needs to be moved to adjust the amount of tow cable deployed, remove the tape anchoring it to the tow cable. Compress each end to the Kellems towards the other along tow cable. This will expand the Kellems and allow it to slide easily along the cable to its new position. Release the ends of the Kellems, re-anchor the end towards the towfish as shown Figure 29 and then smooth it back down along the cable towards the vessel.
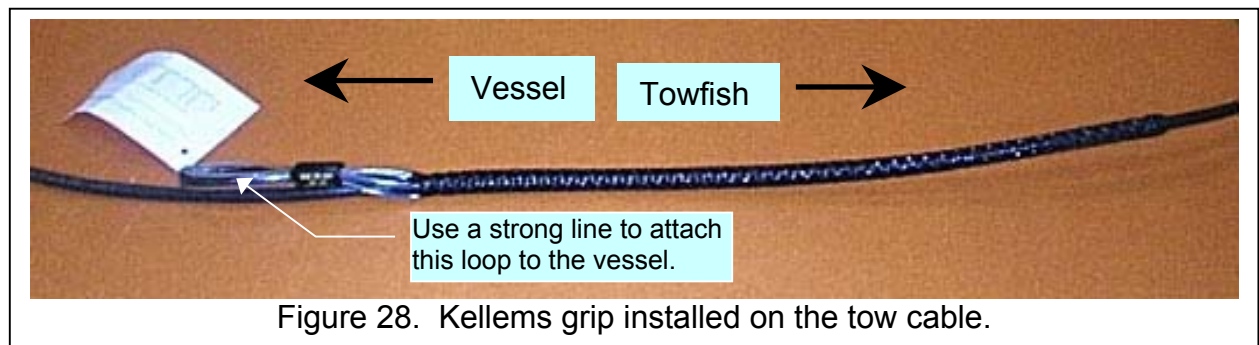

Figure 28. Kellems grip installed on the tow cable.

Towards the vessel

Towards the tow fish

Secure the Kellems grip to the tow cable by tightly wrapping electricians tape (or some other water-resistant tape) for approximately six inches from the end of the non-loop-end, as shown.
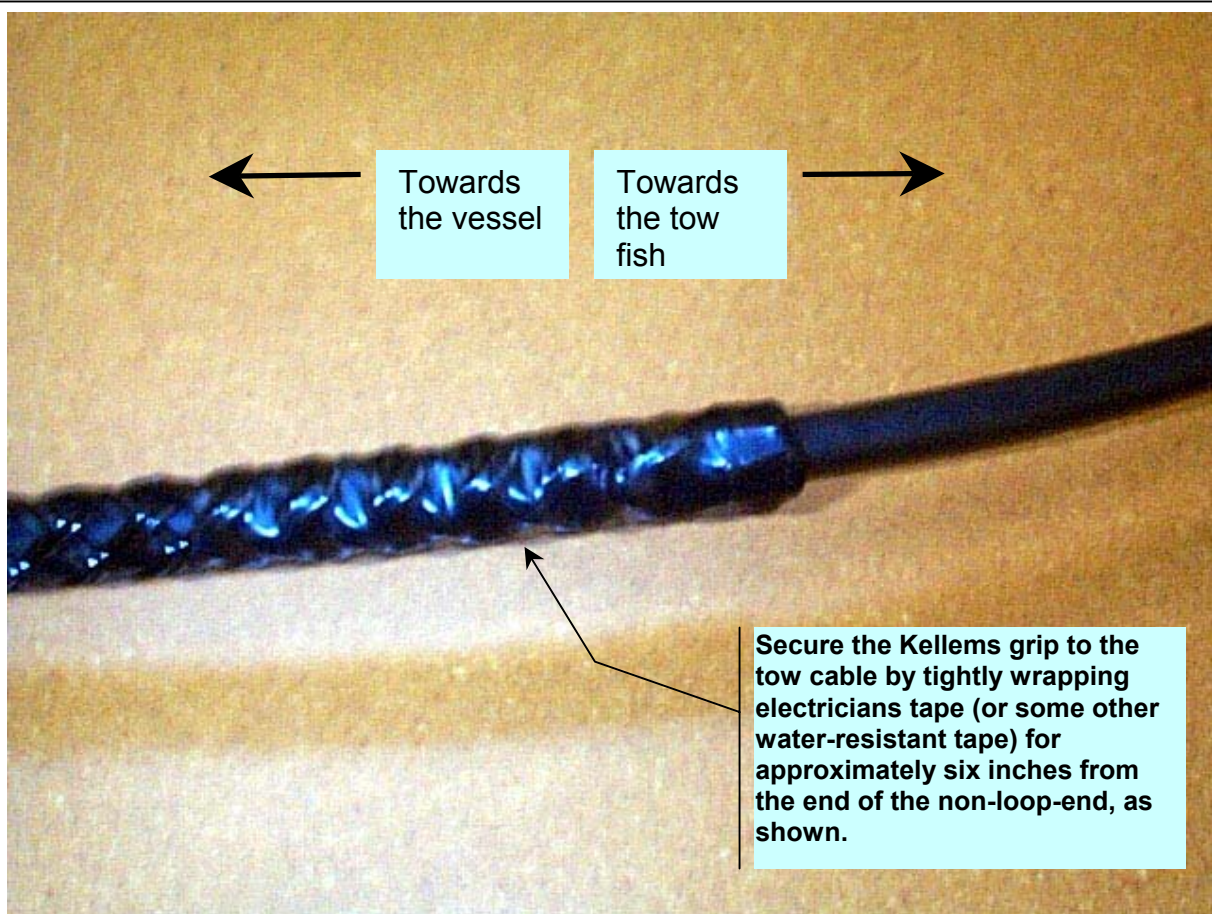
Figure 29

Retrieval is best performed with the vessel at full stop (propeller) not turning) or maintaining just enough headway to keep the cable from going under the vessel. The intent is to prevent the tow cable from becoming entangled in the propellers. Nothing destroys surveys and propeller shafts quicker than entangling the tow cable in the propellers.

Retrieve the cable as quickly as possible to help prevent the magnetometer from striking the bottom. Again, neat tow cable management as described above will greatly facilitate survey execution.

It is recommended that some form of quick communications be provided between the vessel captain and the magnetometer handlers. This will greatly ease handling and make the operation safer. Radios work well.

The tow cable length is generally determined by a number of factors. The most important factor is the desired depth of tow that must be achieved for the survey. The longer the cable the deeper the depth that can be achieved. The depth of tow may also be improved by the type of towing method selected for the magnetometer tow fish.

For shallow surveys on short tow cables (30 to 60 meters), the Nose Tow method works the best. One man can manage deployment and retrieval with a second man to manage the tow cable. The depth of tow graph below for a nose towed G-881 is derived from actual tests. However, it **DOES NOT** provide exact numbers. It is just intended to provide an indication of the tow depths that might be expected. The actual depth of tow can be affected by water current speed and turbulence. Also, turns to change course greatly slow the speed of tow increasing the tow depth. If you know you are towing in an area that may have potential snags upon which the tow fish may hang, retrieval of tow cable in the turns may be required to manage the tow fish depth guarding against snagging. This graph is provided as a suggestion of what tow depths might be expected using a nose towed G-881 magnetometer.

**G-881 Nose Tow Depth vs Speed on a 175 ft Cable Length**
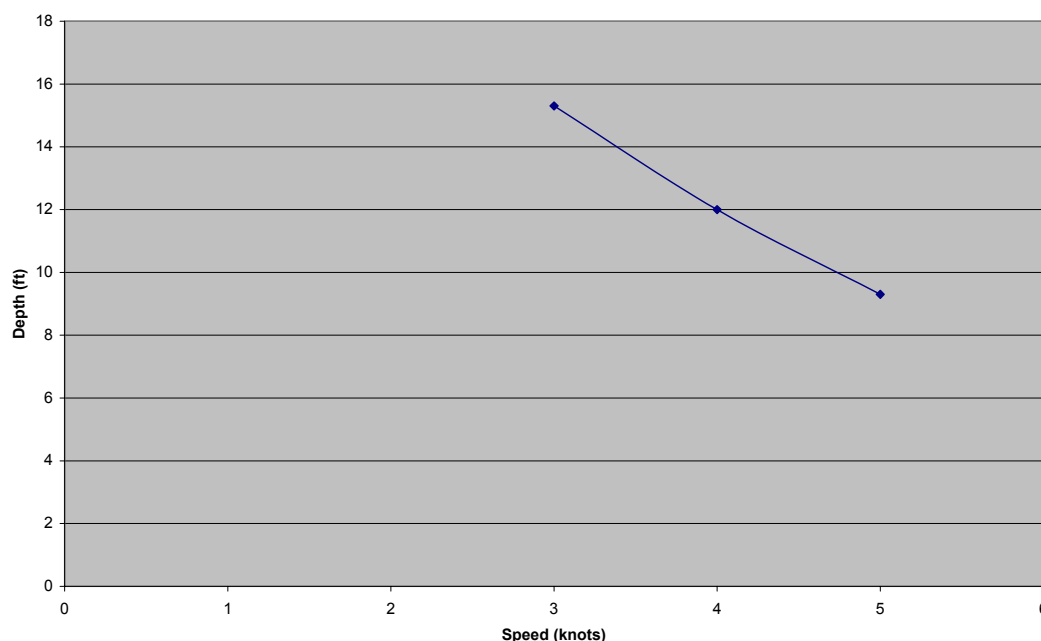
Towing a magnetometer fish from its center of gravity provides a method to allow the fish to be towed deeper, hence closer to the bottom for a better detection range. Generally, a CG towed G-881 will tow two to three times deeper than when nose towed. Adding a depressor wing to the CG tow point may double the depth again. Geometrics offer both options for the G-881. The following provide information regarding tow depths that may be expected and instructions for assembling.

The following graphs provide an approximate indication for tow depths that may be expected versus the cable length deployed versus the speed of tow. These graphs are derived from actual tests. However, they **DO NOT** provide exact numbers. The actual depth of tow can be affected by water current speed and turbulence. Also, turns greatly slow the speed of tow increasing the tow depth. If you know you are towing in an area that may have potential snags upon which the tow fish may hang, retrieval of tow cable in the turns may be required to manage the tow fish depth guarding against snagging.
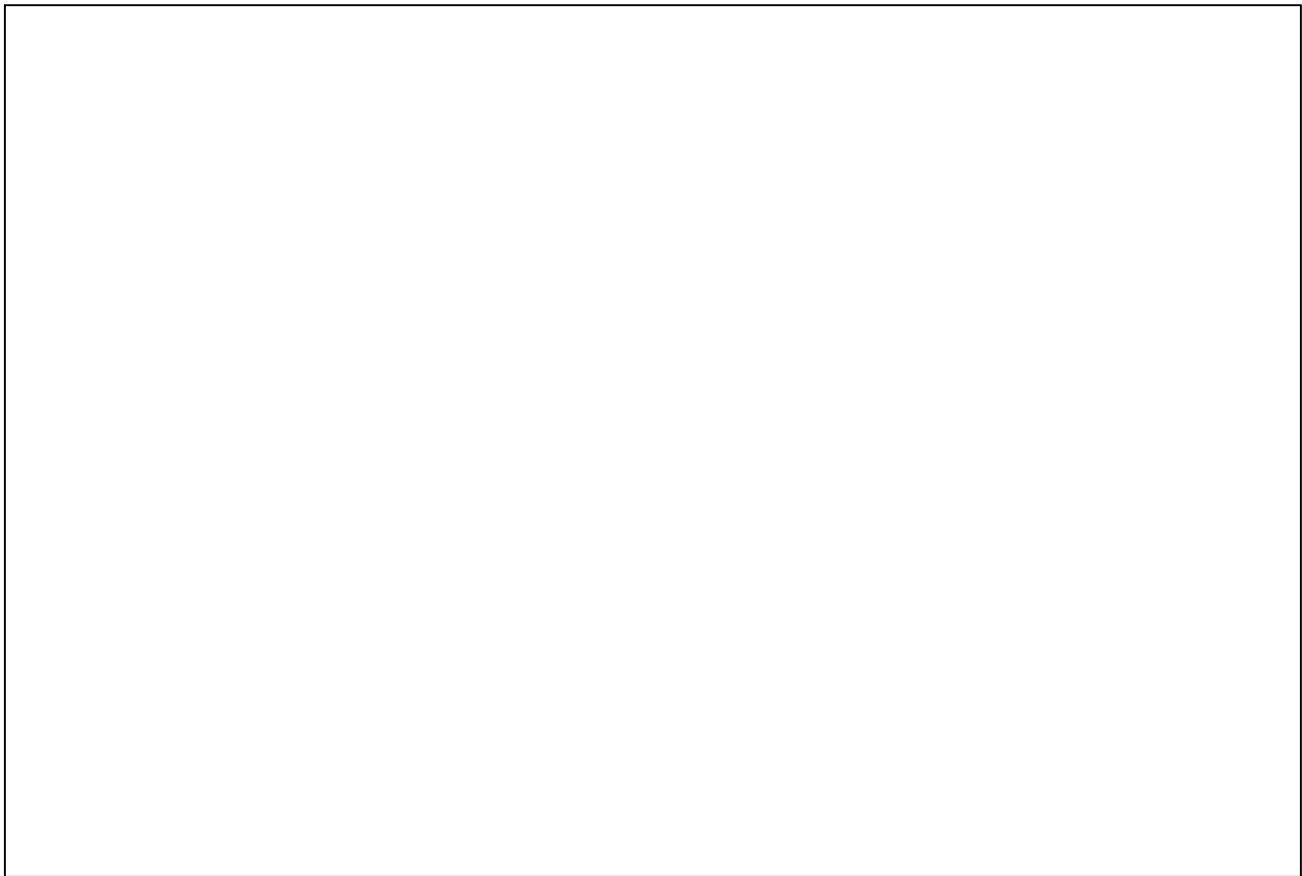
G-881 CG Tow Cable Length vs Depth with Depressor Wing
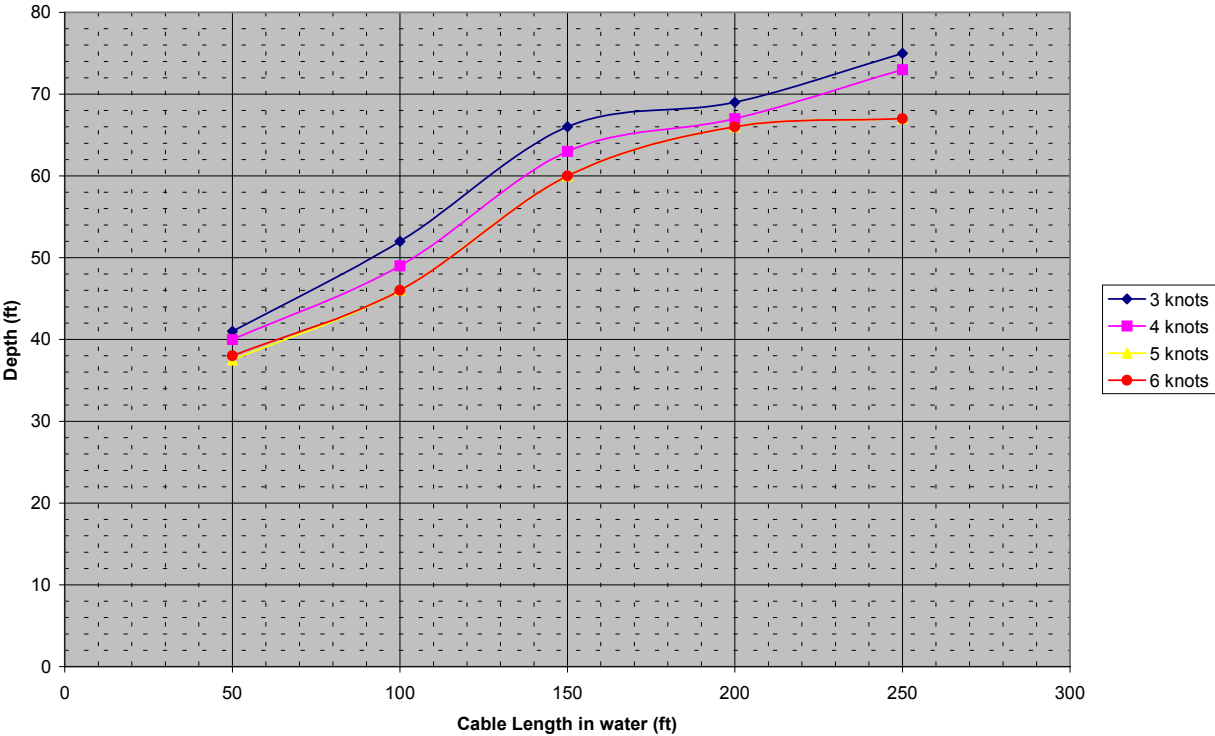
3.0 Service Information

It is possible to open the G-881 in the field, but is not recommended. There are no easily assessable parts that can be field serviced. It is recommended that if service is required, the G-881 be returned to the factory for service.

3.1 Connector Information

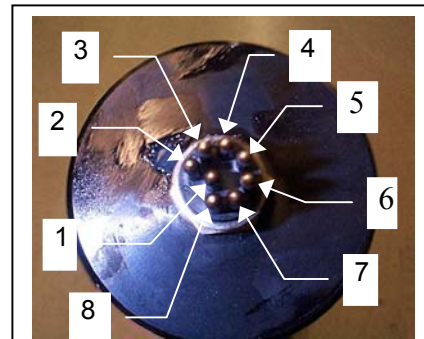The following Figures provide views of the connectors used on the G-881 tow cable.

Figure 30

Figure 31

Figures 30 and 31 show the male water tight connector on the nose bulkhead of the G-881 magnetometer. Figure 31 also shows the pin numbers for this connector. The Geometrics part number for this connector is 21-236-400.
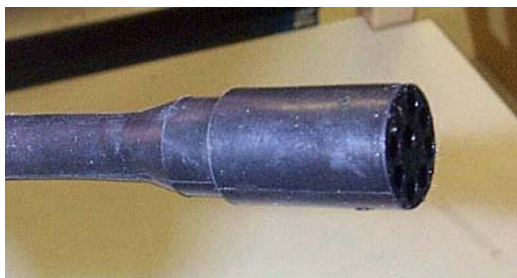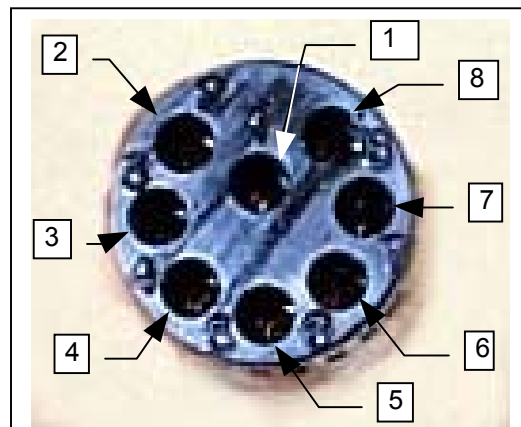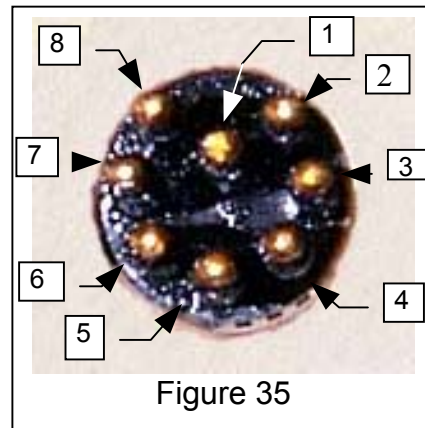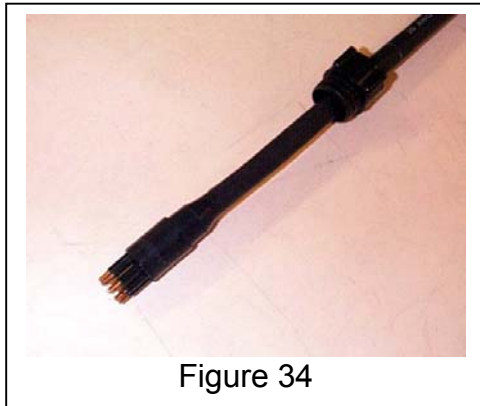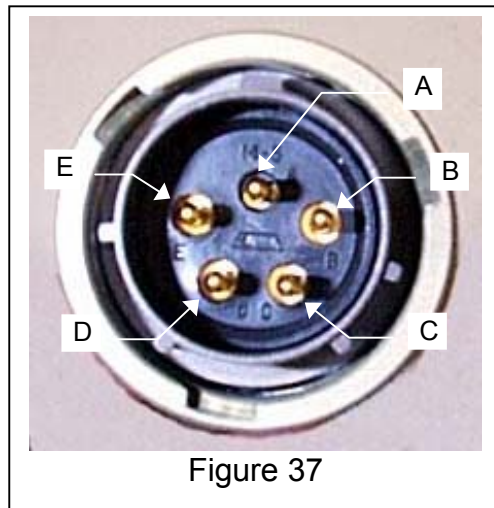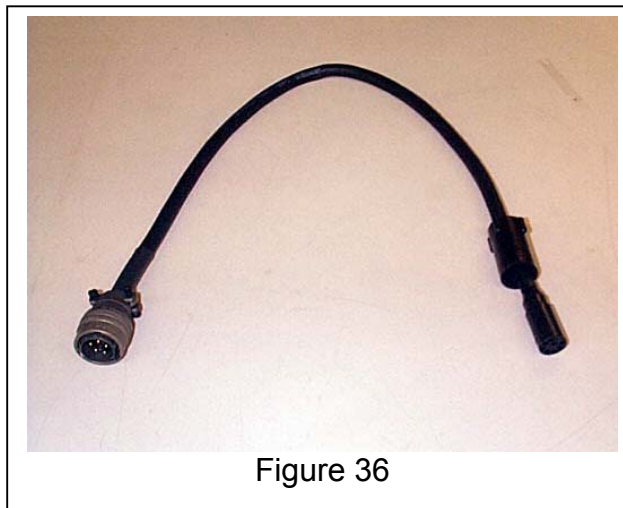

Figure 32

Figure 33

Figures 32 and 33 show the female water tight connector on the wet end of the tow cable. This connector mates with the connector of Figures 31 and 32. Figure 33 also shows the pin numbers for this connector. The Geometrics part number for this connector is 21-236-410.
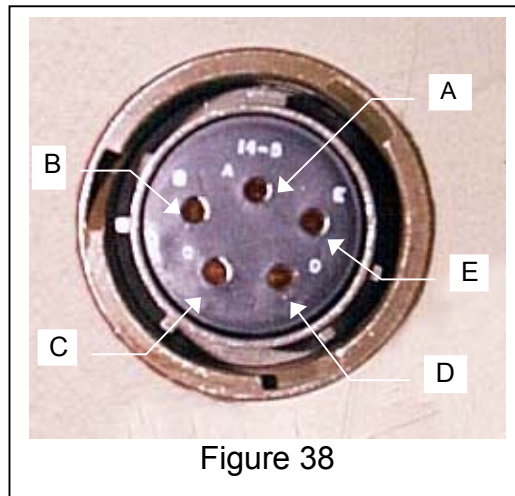

Figure 34

Figure 35

Figures 34 and 35 show the male water tight connector on the dry end of the tow cable. This connector mates either to the adapter cable shown below or to a winch if one is used. Figure 35 also shows the pin numbers for this connector. The Geometrics part number for this connector is 21-236-411.

Figure 36

Figure 37

If the tow cable purchased with your system is terminated as shown in above in Figure 34, an adapter cable as shown in Figure 36 is provided to allow connection the DC/Data Junction Box of Figure 27. The connector on the left in Figure 36 is a Bendix connector. It mates with the connector labeled ONBOARD on the DC/Data Junction Box. Figure 37 shows the pin numbers for the Bendix connector.

The connector that should be connected to the tow cable is the same as the wet end of the tow cable shown in Figures 32 and 33. This end should be mated with the dry end of the tow cable. Prepare these connectors for installation by insuring that the connectors on the tow cable and the adapter cable are clean and free of dirt. Using a finger, wipe a small amount of silicon grease across the face of the connector of the adapter cable. If this is done properly, there will be a "half moon" of grease visible in each of the pin sockets of this connector. The correct silicon grease is provided in a small circular, snap-lid container in the ship kit. Unless it is cleaned, once greased this connector may never require grease again.

Figure 38

The connector shown in Figure 38 is the DC power connector on the AC/DC power supply. The connector in Figure 38 is a Bendix connector. It mates with the connector labeled 22-32 VDC on the DC/Data Junction Box. Figure 38 shows the pin numbers for the Bendix connector.

3.2 O-ring Maintenance

The O-rings **do not** require maintenance. Unless the a bulkhead is removed from the magnetometer fish, the O-rings do not require maintenance. Geometrics does not recommend the customer open the magnetometer fish under any circumstances. There are not customer maintainable parts within.

Should the customer inadvertently remove a bulkhead or do so under instructions from Geometrics, the following procedure should be observed to re-install the bulkhead.

Remove the two O-rings from their grooves on the bulkhead. Using a clean towel, clean any contaminants that may be observed on the barrel of the bulkhead or in the O-ring grooves. Inspect the inside of the magnetometer fish from where the bulkhead was removed. Clean any contaminants that may be observed.

Take the two replacement O-rings provided in the ship kit and apply some silicon grease provided in a small circular, snap-lid container in the ship kit. Take a little grease between your thumb and index finger. Gently pull the circumference of the O-ring between your greased fingers to thoroughly apply a complete layer of grease to the O-ring.   Gently stretch the O-ring over the small end of the bulkhead and slide it into one of the O-ring grooves. Repeat this process with the second O-ring and place it in the other O-ring groove of the bulkhead. Take a little more grease on your index finger and wipe it on the circumference of the O-rings on the bulkhead.

Install the bulkhead into the magnetometer fish. Push the bulkhead straight in to insure proper installation.

3.3   Depth Sensor Ratings

There are four choices for a Depth Sensor that may be installed in a G-881.
They are: none
  100psi
  250psi
  500psi

These depth(pressure) sensor(s) will operate to 200% (for a 100psi sensor this would be 200psi) over pressure without damage or the calibration change. Exceeding 200% may cause a permanent change in the calibration as the sensor is permanently deformed.   Sensor failure to produce data may occur if 200% over pressure is exceeded.

These depth sensors are safe from bursting up to 400% over pressure with out bursting. The pressure sensor will be useless after this over pressure but it should not burst protecting the magnetometer from flooding. The pressure sensor will not burst at exactly 400% over pressure and may survive higher pressure without bursting. **However, if pressure is approaching 400%, every effort should be immediately undertaken to prevent the G-881 from going deeper to prevent bursting of the depth sensor.**

3.4 Tow Cable Strength Data

Recent design changes have made a stronger tow cable available. Data for both the "original" and the "new" cable are provided for those who may have the original cable with a magnetometer previously purchased from Geometrics.

Original Tow Cable

Color: black
Marking: GEOMETRICS, INC., P/N 60-453-095
Breaking Strength: 4000 lbs.
Maximum Working Load: 800 lbs.
Minimum Bend radius: 4.5 in.

New Tow Cable

Color: yellow
Marking: GEOMETRICS, INC., P/N 60-453-096
Breaking Strength: 4000 lbs.
Maximum Working Load: 800 lbs.
Minimum Bend Radius: 9 in.

The working loads exerted on the tow cable by the G-881 vary depending on the type of towing method used. The lowest amount of force exerted is the G-881NT nose tow version. Next is the CG towed version. Finally the highest force is exerted by the CG towed version with a depressor wing installed. Care should be taken to minimize the working load exerted on the tow cable. Exceeding the maximum working load, will, over time, cause the tow cable to fail electrically. The conductors may become work hardened and break. Following are some suggestions to minimize the work load:

1. Keep the tow speed to a maximum of six knots.

2. Slow the vessel down to 1-2 knots to retrieve tow cable.

3. Slow the tow speed in high seas to reduce the effect of heave on the tow cable, or cease the survey.

Should the tow fish become snagged, the much higher breaking strength may help insure that the tow fish is successfully retrieved. However, this will exert loads on the cable well in excess of the working load. Before the cable is used again it should be carefully inspected and tested. It may still be usable, but its life will have been shortened. How much, depends upon how close to the breaking strength the force induced by the snag was.

NOTES

Appendix A - Quick-start G-881 Operating Instructions

The information in this appendix is only provided as a quick way to turn the magnetometer on and determine that it functions. It is not intended to be used for normal survey work. It is highly recommended that this G-881 Manual be referred to as soon as possible, since this short description does not cover the full extent of what is available in the software package.

The G-881 magnetometer includes the CM-221 Larmor counter. The total field measurement is always available, as is the sensor signal amplitude. These two outputs do not require initializing.

The G-881 is shipped with a copy of "VIEW201" and other utilities. This software allows the operator to access the magnetometer field measurements.

The G-881 Magnetometer can be operated in the shop before installing it on board any vessel. A junction box is used to allow all communication and power connection to the tow cable and magnetometer. If the tow cable and power source are available, the system can be connected together. A source of DC power is required to operate the system. A mains power supply is supplied with the G-881 system. The mains power required can be any voltage from 90 to 230 volts ac at a frequency of 50 to 60 Hz. This "AC Power Supply" plugs directly into the "Power/Data Junction Box". There is also an RS-232 cable in the "Ship Kit" to connect the junction box to a computer.

With all of the components of a system connected, apply power by first turning the AC supply on. There is a switch next to the mains power entry connection. Now, turn the DC power on. There is a locking toggle switch on the junction box. The power indicator will light up green if the DC input polarity is correct. If the DC input is derived from a battery set, there is the possibility of accidental reverse connection of the power. If this should happen, the power indicator will light up red. In this case, recheck the DC power connections.

Note: A minimum of 24VDC must be presented to the Magnetometer. Therefore 26 to 28VDC may be required at the junction box.

If all of the above connections are correct and the power is on, the data from the CM-221 counter in the G-881 Magnetometer will be RS-232 at a 9600 Baud rate. After about 2 to 5 minutes, the output from the magnetometer will be stabilized and can be observed by using the program "VIEW201".

Install this program and the other utilities on the disc labeled "Cesium Magnetometer Accessory Software". Do the installation by inserting the disc in drive "A". Type "Install" [Enter]. Follow the instructions and answer the questions. After the installation is complete, type "Cm201"[Enter],"VIEW201" [Enter]. The

"VIEW201" program will start and test for the baud rate and display a screen with the ASCII data coming from the magnetometer.

The following description will help explain the output format from the CM-221.

The defaulted output from the CM-221 counter will have the following format:

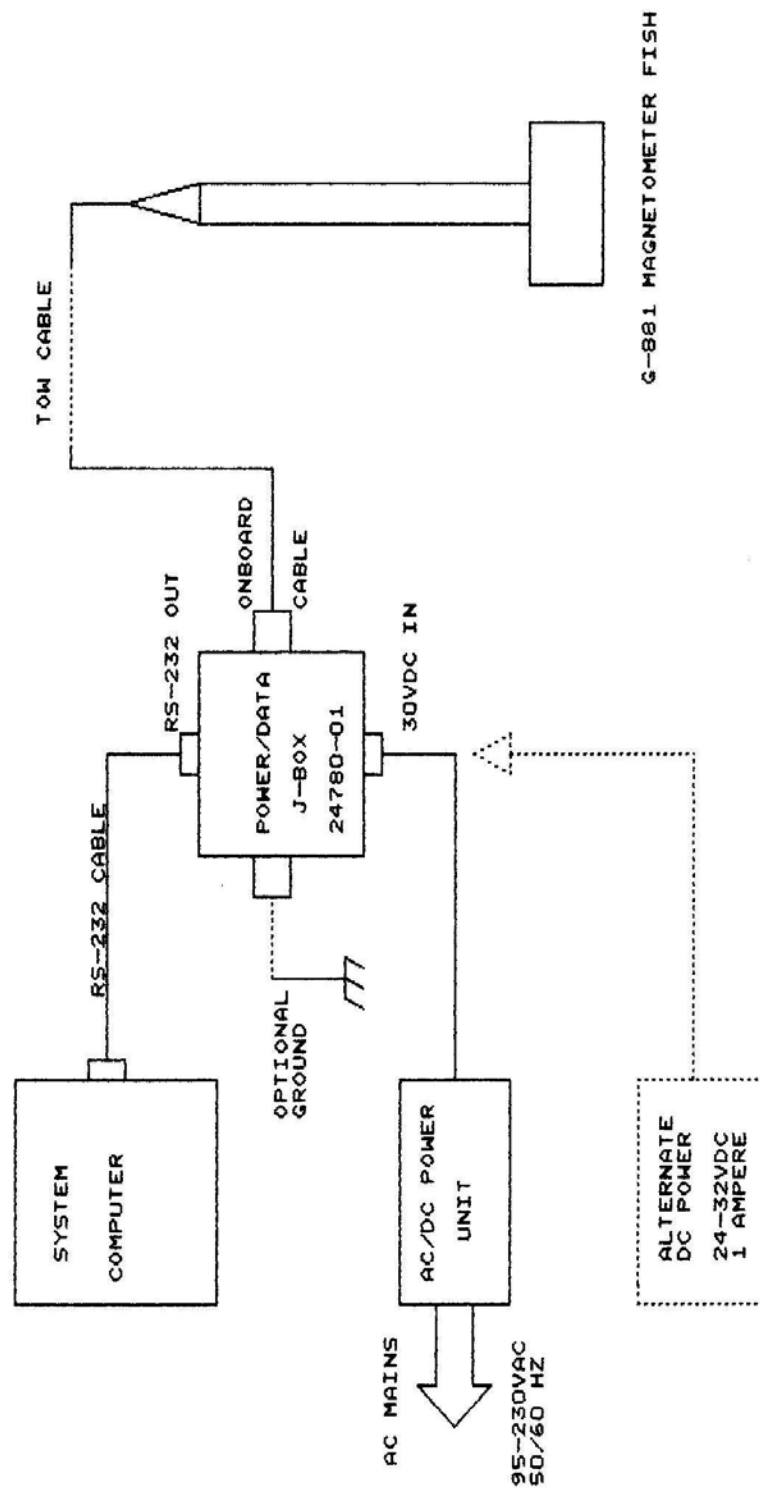| character #	description
1	An ASCII '$'
2	An ASCII '1' or blank (depending on whether the reading is above or below _999999.999nT)
3-7	5 digits of mag data
8	An ASCII decimal point
9-11	3 more digits of mag data
12	An ASCII comma
13-16	4 digits of A/D channel 0. This channel contains the signal level
17	an ASCII carriage return
18	an ASCII line feed

For example:

$ 99778.131,3749 where the first 9 digits past the $ are the total field reading in nanotesla. The next 4 digits are the sensor signal strength. The example reading is only given here to indicate the type of data which can be expected.
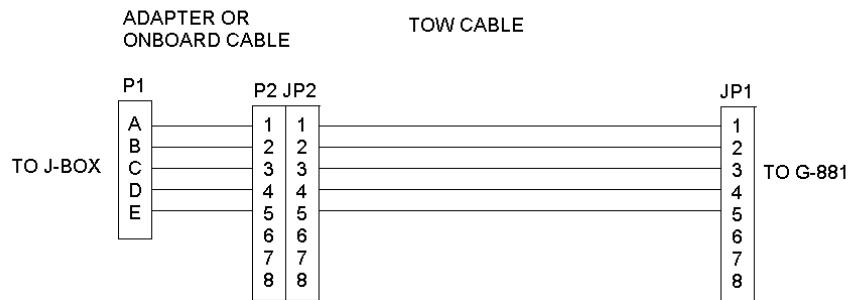
This Quick-start 880 is meant only to get the user started. It is highly recommended that the G-881 Manual be referred to as soon as possible, since this short description does not cover the full extent of what is available in the software package. This suite of software is meant to be run under DOS. It will not run properly under "Windows NT". If it is to be run in "Windows 95", the DOS window must be set to full screen.

Appendix B–System Connection Wiring Diagrams

NOTES

G-881 MAGNETOMETER FISH
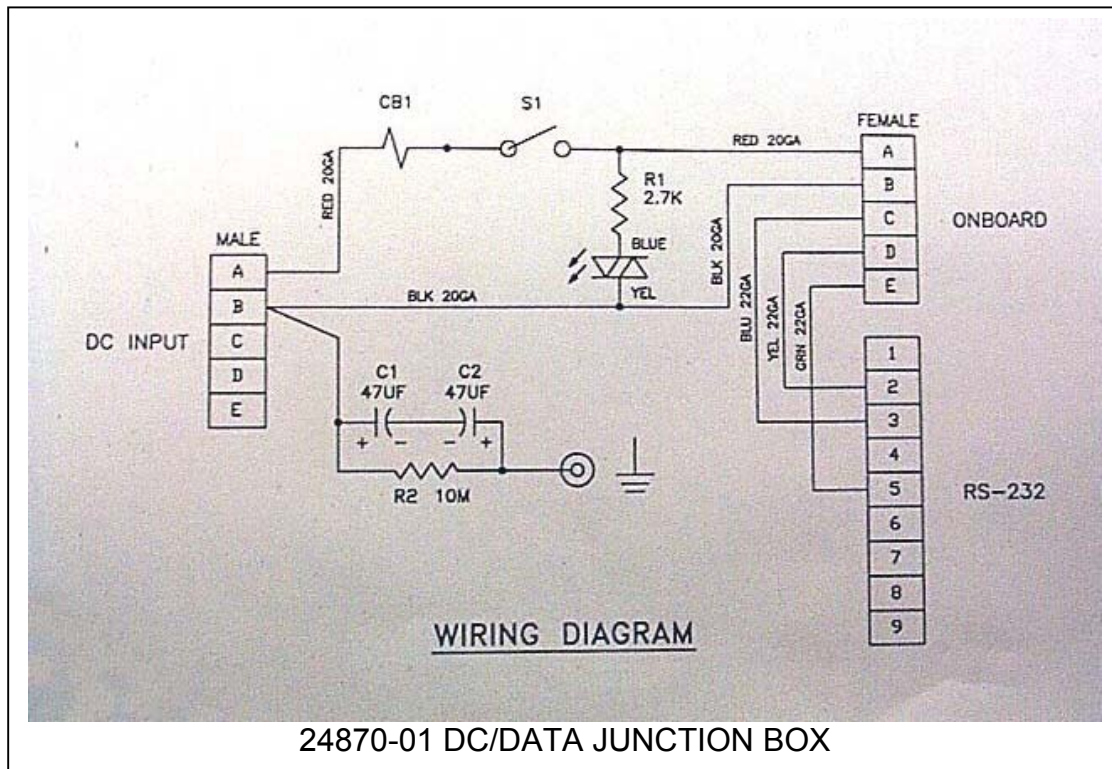
TOW CABLE

ONBOARD CABLE

RS-232 OUT

POWER/DATA
J-BOX
24780-01

30VDC IN

RS-232 CABLE

OPTIONAL GROUND

SYSTEM COMPUTER

AC/DC POWER UNIT

ALTERNATE DC POWER
24-32VDC
1 AMPERE

AC MAINS

95-230VAC
50/60 HZ

System Connection Diagram

ADAPTER OR
ONBOARD CABLE   TOW CABLE

P1   P2 JP2   JP1

TO J-BOX   TO G-881

A	1	1		1
B	2	2		2
C	3	3		3
D	4	4		4
E	5	5		5
	6	6		6
	7	7		7
	8	8		8

WIRE TABLE

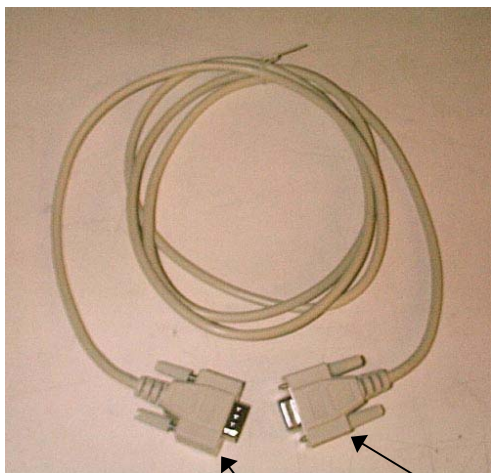| P1	P2,JP2,JP1	WIRE COLOR	FUNCTION
A	1	WHT 14GA	+30VDC
B	2	WHT/BLK 14GA	30 VRET
C	3	WHT	RX DATA
D	4	WHT/BRN	TX DATA
E	5	WHT/BLK	GND

PINS 6,7,8
NOT USED

NOTE:
If you have a tow cable
purchased before
March 2001, you may
not hav an adapter
cable. The pin out for
your tow cable would
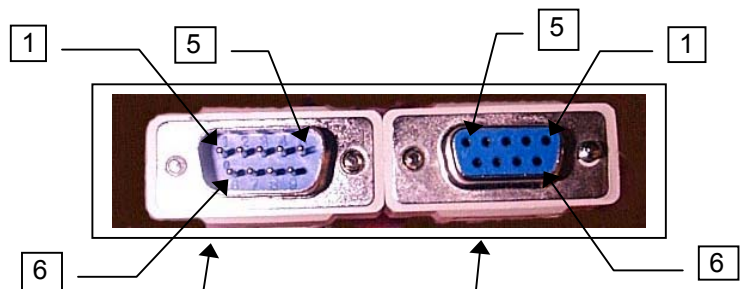be the same as the
Adapter Cable.

TOW CABLE WIRING DIAGRAM

24870-01 DC/DATA JUNCTION BOX

30 VDC + {
RED
BLK
YEL

WHT

RETURN – {
BLU
BRN

SHIELD

POWER SUPPLY

AC IN

A

B

C
D
E

DC OUTPUT
TO JUNCTION BOX
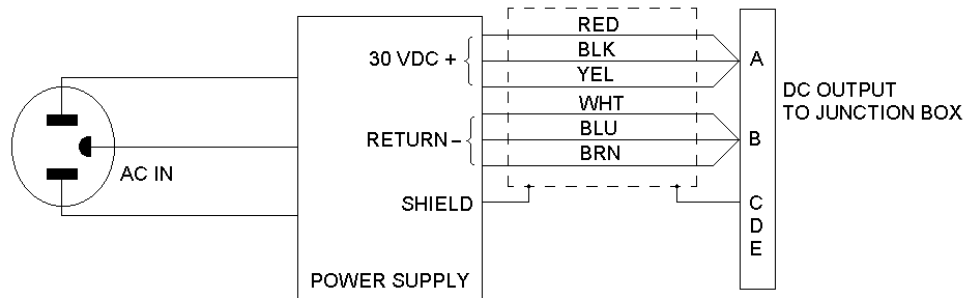
24810-01 or 24810-02

SERIAL CABLE
Wired pin to pin, 1 to 1, 2 to 2, ...

Logging Computer
Serial Connector
Pin Out
1 DCD
2 RX
3 TX
4 DTR
5 Sig Gnd
6 DSR
7 RTS
8 CTS
9 RI

Connect to
the J-Box

Connect to
the logging
computer

Computer Installation Service Bulletin

Fix for SocketIO cards in Windows 9X Computers

January 15, 2000

Sometimes a Windows 95 or Windows 98 computer with a SocketIO card will not recognize the card's serial port from a command prompt. Symptoms are that Hyperterminal and other Windows applications are able to use the SocketIO serial port, but DOS programs like View201 do not recognize the port or are unable to use it. The following procedure "tricks" the computer into thinking that the serial port is indeed installed.

1) Make sure the SocketIO serial port works from Windows. You can easily verify by using Hyperterminal.

2) Open the Control Panel and double click on System. Click the Device Manager tab of the System Properties window, then click the plus in the box to the left of the Ports(COM & LPT) item.

3) Click once on the Socket PCMCIA Serial Adapter, then click the Properties button near the bottom of the System Properties window.

4) Click the Resources tab of the resultant Properties window and write down the Setting for Input/Output Range.

5) Create a text file named, "fixcom.bat", in the C:\Bat directory. Make a new folder if necessary. Fixcom.bat should contain one line:

   C:\windows\command\debug < C:\bat\fixcom.txt

6) Create a text file named, "fixcom.txt", in the C:\bat directory. Fixcom.txt should contain four (4) lines:

   d 40:0
   e 40:02 f8 02   (*The last two entries are the first address from Port Settings*)
   d 40:0
   q

7) Edit C:\Autoexec.bat to add the following line:

   call c:\bat\fixcom.bat