MAG PRO II
Magnetic Gradiometer
Instruction Manual

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QUICK START INSTRUCTIONS

1. Make yourself magnetically clean.

2. Turn the Volume Switch clockwise to activate the instrument and set the volume to a comfortable level.

3. Set the Range Switch to 200 milligauss.

4. Sweep the unit back and forth in front of you as you walk along and search the area. With no magnetic (ferrous) targets present, the unit will idle at approximately 20 hertz. As you approach a ferrous target, the frequency will increase and peak directly over the target.

5. For strong or shallow targets, raise the unit about a foot above the ground or select the 2,000 milligauss range. Conversely, for weak or deep targets you may wish to increase the instrument sensitivity by selecting either the 20 milligauss or the 2.0 milligauss full-scale range.

6. If you intend to make a magnetic anomalies survey map of a target area, we suggest you procure a GPS unit and record both the magnitude and location of your magnetic peaks.

Always remember that the MAG PRO II is a precision instrument and should be treated accordingly.

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Introduction

Not only is the Mag Pro II a laboratory quality instrument designed for field use, but it is unequaled as a magnetic locator where it can be used to pinpoint buried iron or steel pipe, survey markers, water valves, water meters, unexploded ordinance, and any other ferrous object covered by dirt, asphalt, water, snow or ice.

The Mag Pro II has four full-scale operating ranges and they are: 2,000 milligauss, 200 milligauss, 20 milligauss and 2 milligauss. Normal surveys are conducted using the 200 milligauss range. The instrument audio output idles at a nominal 20 Hz when no magnetic objects are present and increases whenever the Mag Pro II approaches a ferromagnetic anomaly.

The state-of-the-art Mag Pro II Magnetic Gradiometer packs all of its sophisticated electronics in an incredibly light 2 pound package. The instrument is waterproof from the base of the electronics to the tip of the sensor, while the electronics housing is water resistant. When you wish to record the peak signal for a magnetic anomaly, rotate the instrument to the vertical position and use an "X" or crossing pattern to pinpoint the maximum vertical field.

If you hear a warble output from the instrument, BEWARE! A strong warble output from the instrument means you are probably over an energized power line, whereas a weak warble output often indicates the presence of a telephone or communications cable. The capabilities of this instrument are limitless and an experienced operator will find many uses for the Mag Pro II.

There is no need to worry about the instrument battery level since a built-in Low Battery indicator begins flashing whenever the operator has 2 to 3 hours of normal operation remaining. Typically the Mag Pro II will provide in excess of 40 hours of normal operation from a set of standard alkaline batteries.

The instrument of choice for any serious magnetic search is the Dunham & Morrow Mag Pro II. The first units were introduced in August of 2010. This latest update of the Mag Pro II design, adds a fourth range of 2.00 milligauss full scale.

Field Operation

For best results, begin by using your Mag Pro II on known targets; targets exactly like the ones you will be searching for in the field. Then once you have become comfortable with the Mag Pro II performance with known targets, you are ready for field work. During this initial stage, you may wish to note the magnitude of the target's magnetic field strength at several different depths. The presence of dirt, asphalt, water, snow and ice does not affect the magnetic field strength. It may even be helpful to make a chart of the target's magnetic field strength versus distance. Then once you go into the field, you can use this chart to estimate the target's depth.

Remember: It is not only inadvisable but in most areas illegal, to dig a hole without first contacting your local "Miss Utilities" contractor. They have trained individuals who can survey your area of interest and identify and mark all of your underground utilities before you dig.

If the nature of your target is unknown, the following chart may prove useful:

These are actual depths as reported by our customers. In almost every case, the magnetic locator operator knew how to get the maximum out of his instrument. He was magnetically clean and held his instrument in a vertical or near vertical position while operating the locator on the maximum sensitivity setting.

Depth chart information

Target	Depth
Survey Pin	Up to 15 feet, (4.6 meters)
Cast-Iron Pipe (4" Pipe)	Up to 15 feet, (4.6 meters)
Manhole Cover	Up to 15 feet, (4.6 meters)
Well Casing	Up to 20 feet, (6.1 meters)
Iron Valve	Up to 15 feet, (4.6 meters)
55 Gallon Drum	Up to 15 feet, (4.6 meters)
Septic Tank (Handles)	Up to 12 feet, (4.0 meters)
PK Nail	Up to 2.0 feet, (0.6 meters)

When operating in the field, always remember that the depth of any target is a function of that target's magnetic field orientation, the presence of any nearby magnetic anomalies and how long the target has been buried. The Mag Pro II is unique in its ability to measure the DC magnetic gradient of any ferrous target but it also has another unique ability; the ability to measure low frequency, AC magnetic fields. For more information about this and other uses for the Mag Pro II, contact Warren Dunham at 703-661-2144 or by email (warren@magneticlocator.com).

One of our customers sent the following picture:

"This is the shell I found with your locator. It is a seven inch Harding and weighs fifty pounds. It was made in Charleston during the civil war and only used in this area…..Gary

--The last time I checked with Gary, he had found three more shells all smaller.

Archeological uses for the Mag Pro II:

For years Archeologists have been using precision magnetic gradiometers like the Mag Pro II, to survey historical sites. By performing magnetic surveys of an historical area you can usually identify the location of old walls, fire pits and trash dumps. All of these produce low level surface magnetic anomalies that offer an insight into the area's past usage, and they are relatively easy to locate. The heat of the fire leaves its mark on the magnetic field of the surrounding material. Decaying walls can be outlined from the small iron targets that were once part of the wall or wall surface that after the wall decayed are now imbedded in the soil directly beneath. Similarly, the village trash dump frequently has a mixture of discarded magnetic material that remains and helps pinpoint the location. One other target that should not be overlooked is the magnetic field anomaly that man has created simply by digging holes in the Earth. At any specific location on the Earth, with the Mag Pro II you can usually detect an overall background magnetic field. At first you think this is an instrument calibration problem and your solution is to recalibrate the instrument. However, if you allow for the possibility that your search area has an overall magnetic offset or anomaly, then the World opens up for you. When man digs a hole he randomly distributes the minute magnetic particles that are part of the soil. This is done shovelful by shovelful. By holding your Mag Pro II in the vertical position, set on the most sensitive range and just walking around the area, you can detect these magnetic anomalies, these "magnetic holes", that were created by man even centuries ago. This is one way archeologist are able to locate entrances to tombs, water wells, caves, root cellars and other similar structures of antiquity.

Meteorite Detection:

Meteorites can be divided into three categories: Chondrites, Achondrites and Iron meteorites. The Iron meteorites make-up only 6% of all meteorites, however they are readily detectable by the Mag Pro II and they can be quite valuable. So grab your Mag Pro II and go searching. Have some fun and maybe make a few dollars while you are at it. Meteorites can be found all over the world. Central Canada and the high plateaus of our Western States are prime search areas because the meteorites impact the Earth before being entirely consumed while entering the Earth's atmosphere. Africa and Antarctica are also prime areas to search. Creek beds are also an area of interest, just watch your step and don't submerge the electronics

Hydrologist and Oil Companies:

The Mag Pro II has unequalled sensitivity for detection of deep wells. Both old water wells and abandoned or "Capped" oil wells. Old Wells that are now recognized as potentially valuable resources, wells that should be mapped and recorded for possible future resurrected.

CSI & EPA:

It may not be the most glamorous task, but since the Mag Pro II can be used to easily pinpoint discarded guns or knives, it can also be used to pinpoint illegally buried waste material.

Theory of Operation

The primary sensing elements used by the Mag Pro II Magnetic Gradiometer are fluxgate magnetometers. Fluxgate magnetometers are vector magnetic field sensors that measure the average magnetic field component along their sensitive axis, i.e. the magnetic field component along the longitudinal axis of the sensor tube.

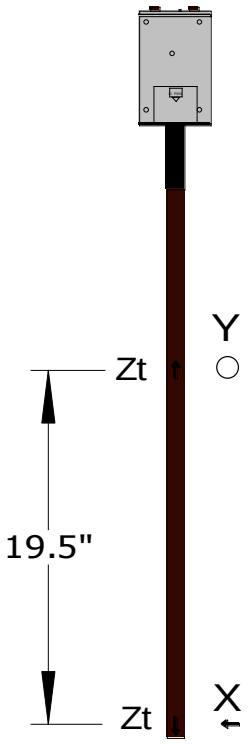

Figure 1, Sensor Location

For the magnetic gradiometer to work properly, the magnetometer sensors are aligned opposing so that the magnetic field measured by one sensor is the negative of the magnetic field measured by the other. The instrument then electrically sums the output of the two sensors. By summing the two output signals, you cancel any field common to both sensors, such as the Earth's Magnetic Field, and leave only the differential magnetic field. The differential magnetic field (the magnetic field detected by one sensor and not the other) is the magnetic field of interest and hopefully represents the magnetic field of your target and not the field of your pocketknife, your watch or the magnetic field of the steel toe protector in your shoes.

Magnetic Cleanliness

The importance of the operator's magnetic cleanliness prior to beginning a search cannot be over-emphasized. Some of the more common sources of local magnetic field interference are watches, the steel arch supports or toe protectors in shoes, key chains, belt buckles, pocketknives and cell phones.

Turn the gradiometer On and set the Volume Control to a comfortable setting. Then select the 20 Milligauss. Range on the Range Control Switch.

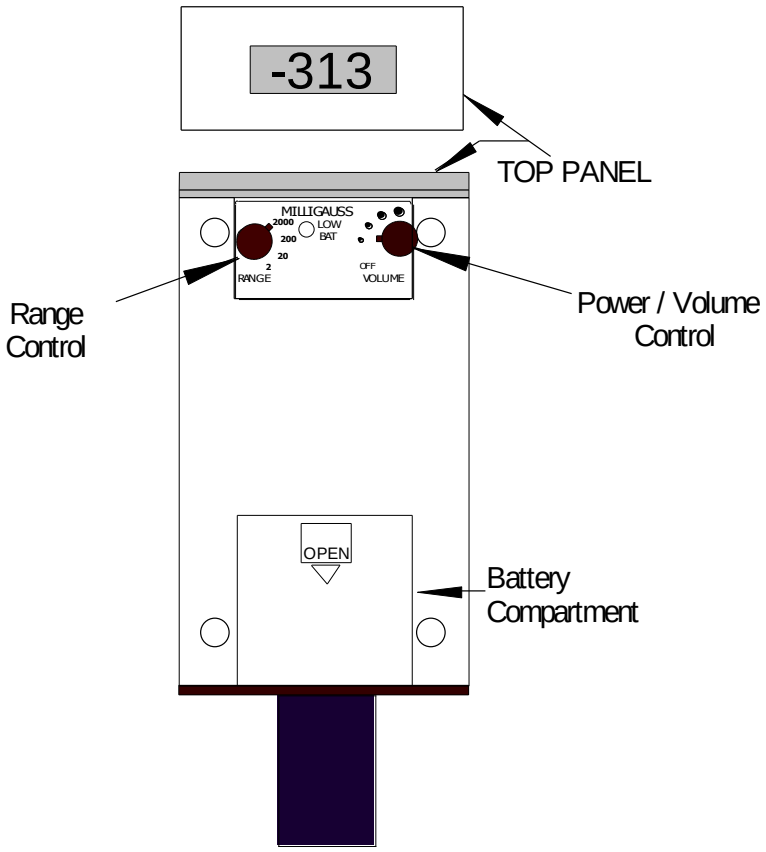

Figure 2, Instrument Controls

Range Settings
Most search operations work well with the Range Switch set to 200 milligauss full scale. For small and relatively weak magnetic targets, the 20 milligauss or even the 2 milligauss range may be more desirable. Conversely when the operator is searching for large, relatively strong magnetic targets, the 2,000 milligauss range may be desirable.

Audio Output
The instrument's audio output idles at approximately 20 Hertz when no magnetic objects are present. The speaker output tone then increases in frequency whenever the Mag Pro II approaches a magnetic object.

Pinpointing your Target
You may hold the instrument at an angle and swing it back and forth as you walk along to maximize your search area; however when you want to pinpoint your target's location, it is advisable to hold the gradiometer vertically and use an "X" or crossing pattern.

Panel Meter
The Mag Pro II magnetic gradiometer has an easily readable Liquid Crystal Display (LCD) panel meter. The 3½ digit (0 to ± 1999) Digital Panel Meter provides a resolution of 0.1 Nanotesla or 0.001 milligauss on the 2 milligauss range. The digital display provides an exact numeric readout of the local magnetic field gradient, and with a sensor separation of nearly 20 inches, the displayed field represents, in many cases, the total field of the target.

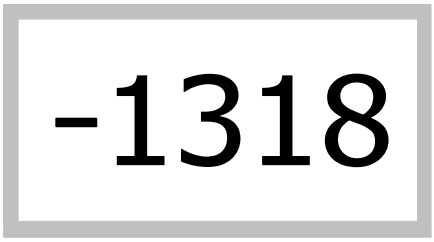

Figure 3, Panel Meter

The highly-visible LCD panel meter is also helpful if high background noise begins to overwhelm the speaker. At that time, the operator can frequently continue his search operation simply by referring to the LCD display. The LCD panel meter displays the strength of the local magnetic field while the audio output varies according to the output signal strength making it easy to precisely locate the source of this magnetic anomaly. If the polarity of the meter display is not what you prefer, there is a polarity select jumper inside the unit that can be repositioned to reverse the meter polarity.

Charting the Magnetic Field of a Target in the Lab

The best way to chart the magnetic field of any target is to place the Mag Pro II on a wooden or non-magnetic horizontal table or surface in an environment where the local magnetic anomalies are minimal. Select the Mag Pro II's most sensitive range and zero the instrument by moving nearby magnetic objects until the instrument audio output is idling. You now have created a **Magnetic Impurities Detector**. Feel free to check your gold and silver rings by placing them near the end sensor. Bring some samples of your target of interest close to the end sensor and record both the instrument meter output and the distance between your target and the end sensor of the Mag Pro II. By recording these readings you are establishing a representative "Depth Chart" for your target. For large targets or inaccessible targets, you can perform this same task in the field where the depth information is more easily attainable (i.e. new construction, an open trench, or a target that is just lying on the ground).

Figure 4, Performing Laboratory Measurements

Magnetic Signatures of common buried objects

Most common underground targets have a predictable magnetic pattern and consequently produce a predictable output frequency change in the magnetic locator. In the figures that follow, the bold line above ground indicates the relative output frequency level of the Mag Pro II as it moves across the indicated target: the higher the line; the higher the instrument output frequency.

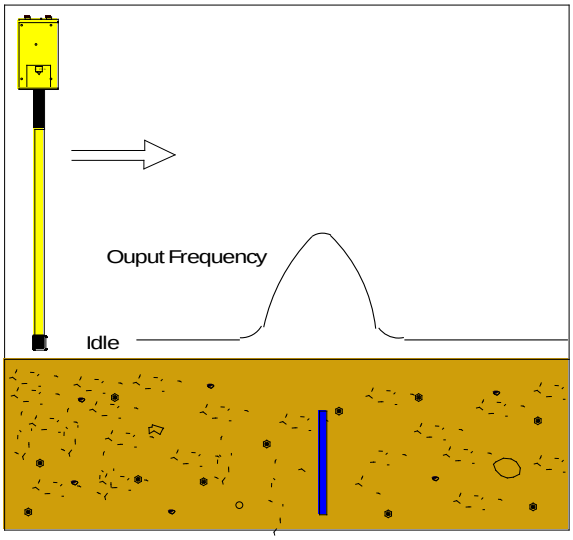

Figure 5, Survey Marker or Well Casing

The peaking of the Mag Pro II output frequency normally indicates that you are over the top center of a vertical dipole (survey marker or well casing).

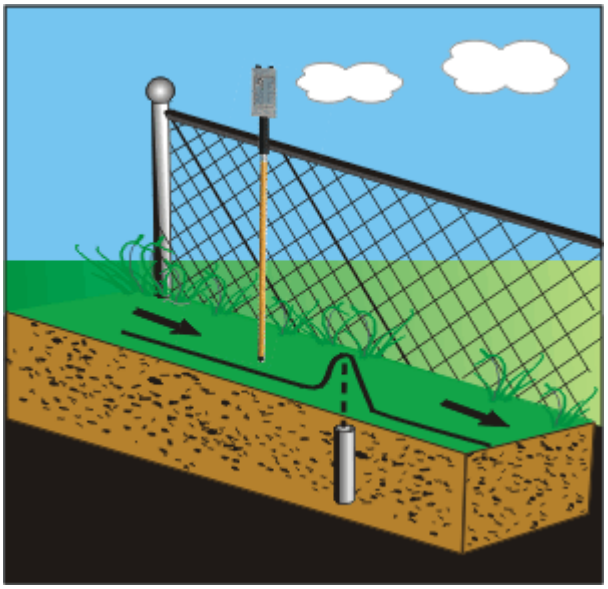

Figure 5, Chain-Link or "Cyclone" Fences

When working around chain-link fences, set the Range Switch to either 200 milligauss or 20 milligauss; whichever works best. Then hold the instrument vertically and walk along parallel to

the fence approximately 8 inches to 1 foot away. You will hear the magnetic field of the fence as you walk along, including the field from the posts. However; if your target is near to or under the fence, there will be a dramatic increase in the instrument frequency as you approach the target and you will have no difficulty distinguishing your target from the fence.

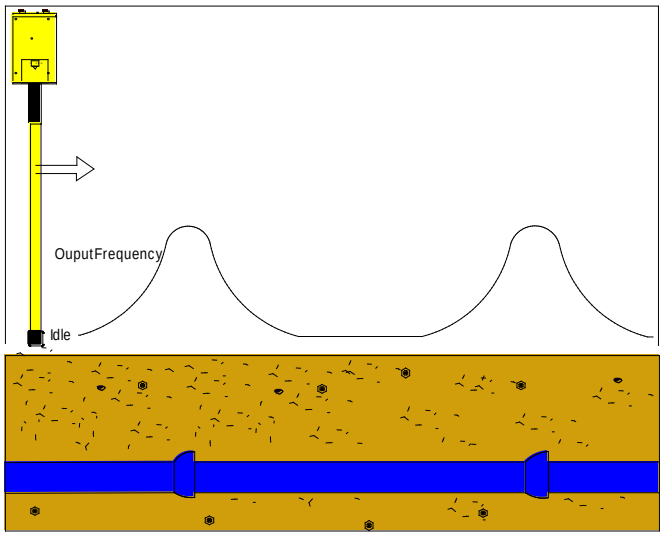

Figure 6, Horizontal Pipe

The peaking of the Mag Pro II output frequency indicates that you are over the end of that pipe section, which can be either a weld or a "Bell" joint, as shown above; or a pipe discontinuity such as an elbow, "T" section, meter or valve. When searching for horizontal gas and water lines, look for a polarity change on the panel meter. A polarity change that occurs when the output frequency is low means you are nominally over the midpoint of a pipe section; a polarity change that occurs when the output frequency is high typically indicates a pipe joint or weld.

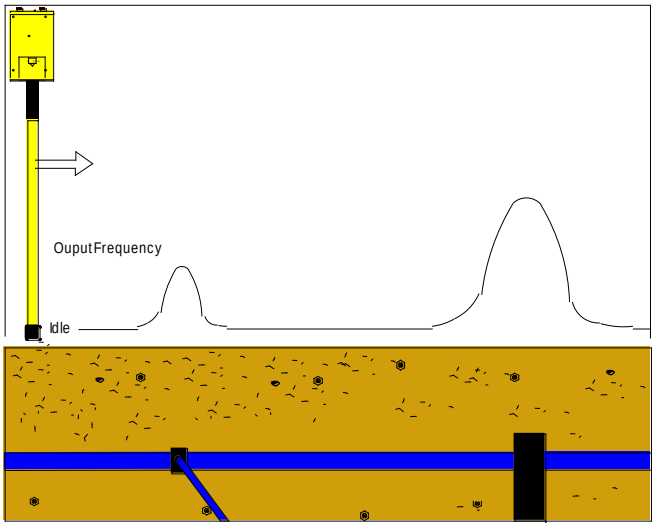

Figure 7, Service Connections and Valve boxes

Frequency peaking occurs over service connections and valve boxes: any place the pipe has been cut and a service connection or other magnetic anomaly inserted.

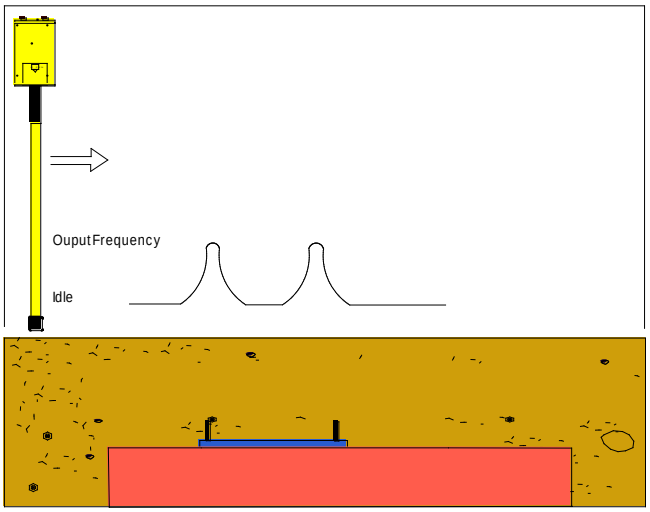

Figure 8, Septic Tank

Most concrete septic tanks have a cover with two handles. The handles are inverted U-shaped pieces of rebar which are highly magnetic. In most cases, the audio output of the Mag Pro II will reach its peak directly over the handles, which makes it easy for the operator to identify the correct place to dig. In other cases, the Mag Pro II will detect not only the handles on the cover, but the magnetic field of the wire mesh or rebar in the concrete. This allows you to not only pinpoint the location of the cover but to also outline the tank and determine precisely its orientation.

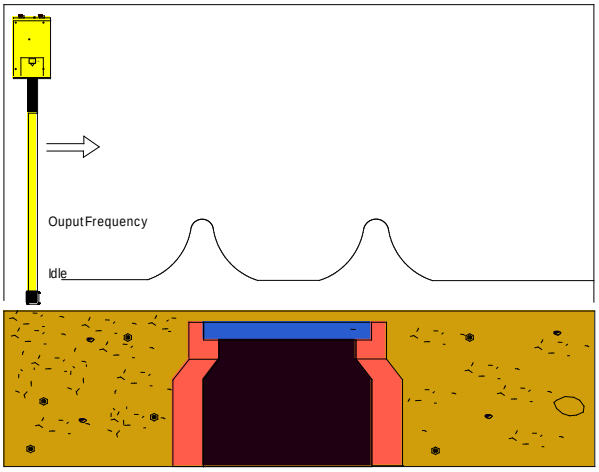

Figure 9, Manhole Cover

A typical manhole cover is highly magnetized and easily detected by the Mag Pro II magnetic locator. However, in some cases where the manhole cover has recently been removed and reinstalled but not in its original orientation, another situation can exist. The magnetic field of a manhole is a combination of two magnetic fields, the magnetic field of the cover itself and the magnetic field of the steel support ring. When both fields are aligned, they add and are easy to detect, this is the most common situation. However, when a manhole cover has been recently removed and the cover reinstalled but rotated 180°, then the two magnetic fields tend to cancel each other and detection becomes more difficult.

The instrument of choice for any serious magnetic search is the Dunham & Morrow Mag Pro II. The first units were introduced in August of 2010. The Mag Pro II now has four full-scale output ranges: 2,000 milligauss, 200.0 milligauss, 20.00 milligauss, finally 2.000 milligauss. It should be noted that on the 2,000 milligauss range, the maximum measurable magnetic field is limited to 1,400 milligauss or something just over twice the Earth's magnetic field.

MAGNETIC FIELD CONVERSION FACTORS:

The local magnetic field for the Washington DC area is **513 milligauss** at an angle of **67.6°**. A single-axis magnetometer with its sensor aligned along the axis of the Earth's magnetic field will therefore read **513** milligauss on the 2,000 milligauss range.

1 gamma (γ) = 1 nanotesla (nT)

0.01 milligauss (mG) = 1 gamma (γ) = 1 nanotesla (nT)

To convert from gamma or nanotesla to milligauss, multiply by 100

i.e. 513 milligauss = 51,300 nanotesla = 51,300 gamma

Historical Notes:

Some of the earliest work on Fluxgate magnetometer design took place at Bell Labs prior to and during World War II. Much of that work was later transferred to the Naval Ordinance Laboratory where they perfected the magnetic torpedo. The magnetometer sensors detected and measured the magnetic field of a target and detonated the torpedo when the signal polarity changed, just as it passed under the keel of the boat. The first practical use of two coaxial, fluxgate magnetometers arranged in the typical magnetic locator design occurred during the Vietnam War where they were used to detect Vietcong tunnels. Today, fluxgate magnetometers are used to monitor solar flare activity, control the attitude of satellites and guide cruise missiles to their target. They are also used in earthquake prediction instruments, in underwater Search & Salvage operations and in solid-state heading sensors on boats, cars and airplanes.

The engineers at Dunham & Morrow have been active in the US Space Program since the early 1970s. In addition, they have produced numerous specialty magnetometers for the US Military and the US intelligence community. Some of their more notable programs include: Hubble Space Telescope, the GOES series of weather satellites, the IRAS satellite for the European Space Administration, and magnetometers for the Italian San Marco series of satellites.

General Specifications

Meter: **3½ digit, LCD (0 to ± 1,999)**

Ranges (Full Scale): **2000 milligauss**
200 milligauss
20 milligauss
2 milligauss

Meter Resolution:

Range Full Scale Milligauss	Resolution (LSB) Milligauss	Resolution (LSB) NanoTesla
2000	1	100
200	0.1	10
20	0.01	1.0
2	0.001	0.1

Audio Output: **Variable frequency audio output proportional to the differential magnetic field**

Overall accuracy: **± 1 % of FS**

Low Battery Indicator: **RED flashing LED**

Temperature Range: **(32 – 90)°F, (0 – 33) °C**

Weight: **2.0 lbs. (0.9 kg)**

Dimensions: **42 ½" x 3 ¾" x 1 ¾, (108 cm x 9.5 cm x 4.4 cm)**

Waterproof: **36" (91.4 cm) base of electronics to tip of sensor**

Operating time: **40 hrs, 4-AA alkaline batteries**

MADE IN THE USA

Warranty

Lifetime Warranty – Your Mag Pro II Magnetic Gradiometer is warranted by Dunham & Morrow to be free from defects in material and workmanship. This warranty is extended to the owner of the product and is valid for the lifetime of the product; a period that extends no less than 25 years from the date of purchase. The batteries and meter are specifically excluded from this warranty as is exposure of the internal electronics to salt water or battery acid corrosion.

Calibration

Your Mag Pro II has been factory calibrated and with proper handling the calibration should remain unchanged. However, if at anytime re-calibration is required or desired, there will be a recalibration charge of $250 plus shipping.

Service

If your Mag Pro II ever needs service, please follow these simple procedures:

1. Return the instrument to :

   Dunham & Morrow, Inc.
   43676 Trade Center Place, Suite 145
   Dulles, VA 20166

2. Include a brief description of the defect and a daytime telephone number or email address, just in case our service technician needs some additional diagnostic information.

3. Warranty repairs will be completed at no charge. For non-warranty repairs a repair estimate will be prepared and emailed or faxed to you for approval before any work is initiated.

If the cause of the instrument failure is found to be misuse, abuse, or neglect the repairs will be billed at cost upon authorization from the customer. Under no circumstances will Dunham & Morrow's liability exceed the cost to repair or replace the defective parts.

The Mag Pro II

The top handles have since been changed to a protective ¼" thick Plexiglas plate.