

MAG PRO II ***Magnetic Gradiometer*** ***Instruction Manual***



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QUICK START INSTRUCTIONS

1. **Make yourself magnetically clean**
2. **HOLD** the instrument by the comfortable pistol grip positioned just below the **Electronics Box**, on the top of the instrument **Sensor Tube**.
3. Turn the **Volume Switch** clockwise to activate the instrument and set the volume to a comfortable level.
4. Set the **Range Switch** to 200 milligauss.
5. 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.
6. For strong or shallow targets, raise the unit about a foot above the ground or select the 2000 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.
7. 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: 2000 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 new range of 2 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.

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.



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 five 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 a 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 Detector:

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 should be mapped and recorded for possible future resurrection.

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.

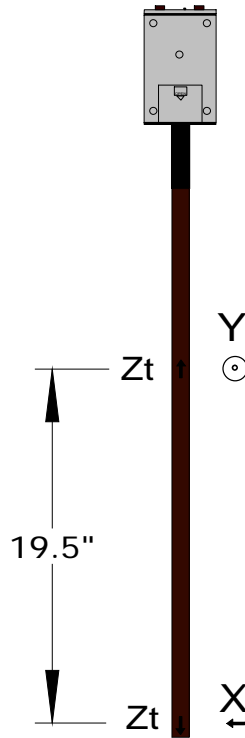


Figure 1, Sensor Location

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.

MAG PRO II - Target Depth Information

The instrument of choice for any serious magnetic search is the Dunham & Morrow, Mag Pro II Gradiometer.

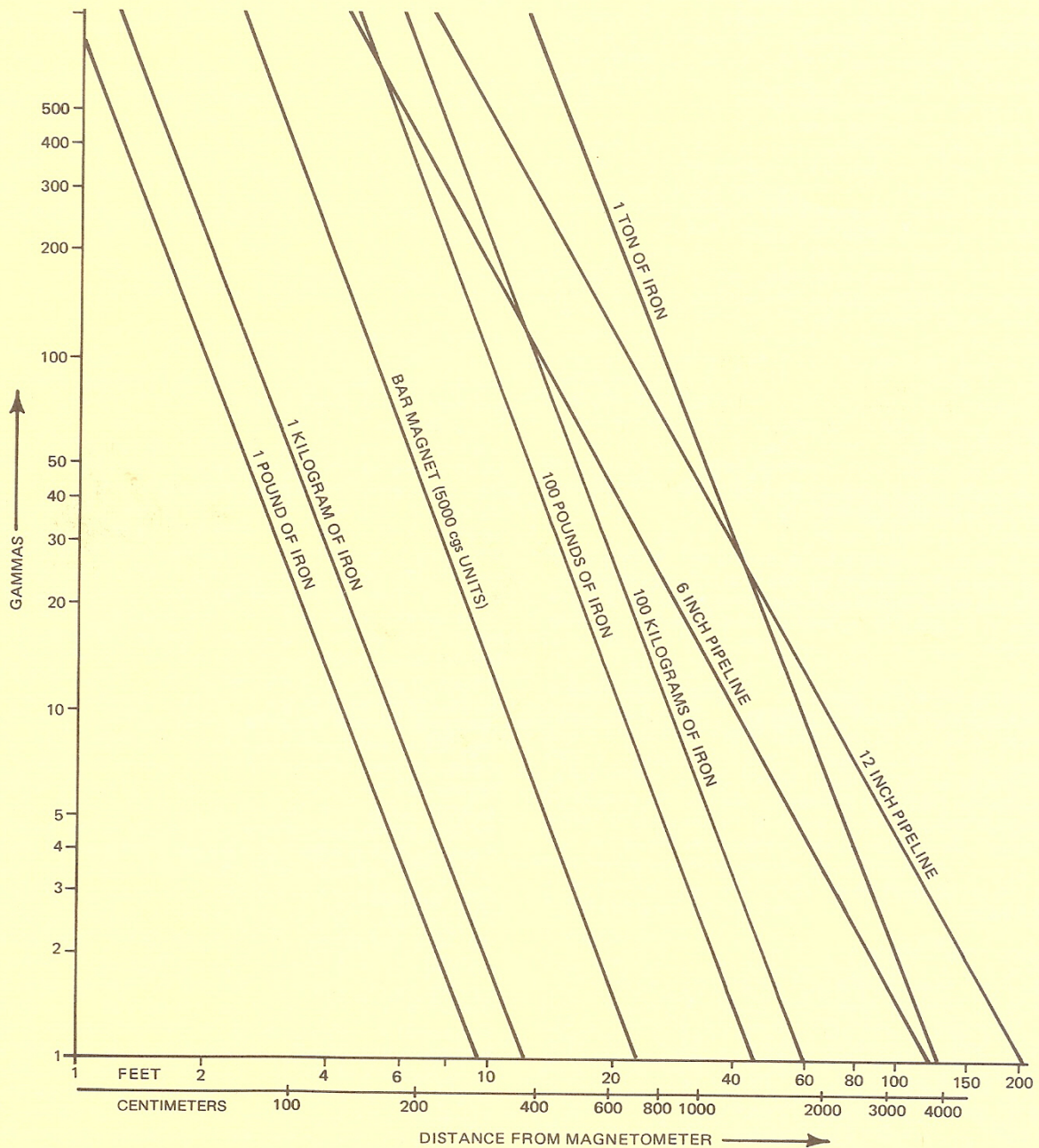
The Mag Pro II Gradiometer has four full-scale output ranges: 2,000 milligauss, 200 mG, 20 mG and 2 milligauss. The Mag Pro II output meter is a 3½ digit LCD panel meter. The corresponding instrument resolution for each range is therefore: 1mG, .1mG, .01mG and .001mG.

The best advice I can give you is to use your Mag Pro II gradiometer on known targets first. Once you are comfortable with how the instrument performs, then you can search for similar targets where the depth is unknown. Operating the Mag Pro II near ground level is inadvisable because of all the unknown magnetic anomalies that may be present. To avoid this problem we recommend that you hold the Mag Pro II so that the tip of the sensor probe is approximately 12 inches (1 foot) above ground level. You can then swing the gradiometer back and forth in front of you as you walk along. Then when you hear a change in the audio output, move the gradiometer into a vertical position to locate the peak magnetic field and measure that peak on the instrument meter.

Target depth determination has nothing to do with the soil content, or whether the target is buried under asphalt, water, ice or snow. The best way to determine the depth of any target is to locate or prepare a magnetic field strength chart for the type of target you are dealing with. Use the Mag Pro II gradiometer to measure the local magnetic field strength and then locate that same magnetic field strength on your chart. If your chart is a nomogram, then move your finger horizontally until it intersects with the graph of your target's magnetic field strength and then look down to note the depth.

On the next page is a nomogram copied from the 1973 Geometrics, Applications Manual for Portable Magnetometers”.

Figure 46. Nomogram for Estimating Anomalies from Typical Objects (assuming dipole moment $M = 5 \times 10^5$ cgs/ton, i.e., $k = 8$ cgs. Estimates valid only within order of magnitude)



INSTRUCTIONS FOR USE:

To use the nomogram, select a given weight or type of object from among the diagonal labeled lines. Then choose a distance along the bottom line (abscissa) of the graph and follow a vertical line upwards from that distance until it intersects the diagonal line of the selected object. At that point, move horizontally to the left to a value on the vertical axis (ordinate) of the graph and read the intensity in gammas.

At a given distance, the intensity is proportional to the weight of the object. Therefore, for an object whose weight is not precisely that of the labeled lines, simply multiply the intensity in gammas by the ratio of the desired weight to the labeled weight on the graph. If the distance desired does not appear on the graph, remember that for a typical object the intensity is inversely proportional to the cube of the distance and for a long pipeline the intensity is inversely proportional to the square of the distance between magnetometer sensor and object. Due to the many uncertainties described herein, the estimates derived from this nomogram may be larger or smaller by a factor of 2 to 5 or perhaps more.

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 would therefore read **513 milligauss** on the 2,000 milligauss range.

$$1 \text{ gamma } (\gamma) = 1 \text{ nanotesla (nT)}$$

$$0.01 \text{ milligauss (mG)} = 1 \text{ gamma } (\gamma) = 1 \text{ nanotesla (nT)}$$

To convert from gamma or nanotesla to milligauss, divide by 100.

For example 10 gamma = 0.10 milligauss

Conversely to convert from milligauss to gamma multiply by 100

For example 10 milligauss = 1000 gamma

Therefore the local magnetic field for the Washington DC area which is **513 mG** at an angle of **67.6°** can also be characterized as: 51,300 gamma or 51,300 nT at 67.6°.

ALWAYS 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 properly trained individuals who can survey your area of interest and properly identify and mark all of your underground utilities before you dig.

Table of Anomalies of Common Objects
Typical Maximum Anomaly

Object	Near Distance	Far Distance
Automobile (1 ton)	30 feet 40 gammas	100 feet 1 gamma
Ship (1000 tons)	100 feet 300 to 700 gammas	1000 feet 0.3 to 0.7 gammas
Light Aircraft	20 feet 10 to 30 gammas	50 feet 0.5 to 2 gammas
File (10 inch)	5 feet 50 to 100 gammas	10 feet 5 to 10 gammas
Screwdriver (5 inch)	5 feet 5 to 10 gammas	10 feet 0.5 to 1 gamma
Revolver (38 special or 45 automatic) (induced approximately equal to permanent, see text)	5 feet 10 to 20 gammas	10 feet 1 to 2 gammas
Rifle	5 feet 10 to 50 gammas	10 feet 2 to 10 gammas
Ball Bearing (2mm)	3 inches 4 gammas	6 inches (0.5 feet) 0.5 gamma
Fenceline	10 feet 15 gammas	25 feet 1 to 2 gammas
Pipeline (12 inch diameter)	25 feet 50 to 200 gammas	50 feet 12 to 50 gammas
DC Train	500 feet 5 to 200 gammas	1000 feet 1 to 50 gammas
'Cow' magnet (1/2" W, 3" L)	10 feet 20 gammas	20 feet 2 gammas
Well casing and wellhead	50 feet 200 to 500 gammas	500 feet 2 to 5 gammas

(Note: anomalies are only representative and may vary by a factor of 5 or even 10 depending upon the many factors described herein)



Figure 4, Sensor Location

The magnetic field test bench is oriented East → West, perpendicular to the Earth's magnetic field. With this test bench orientation, I can take any unknown ferrous target and plot the magnetic field strength of that target.

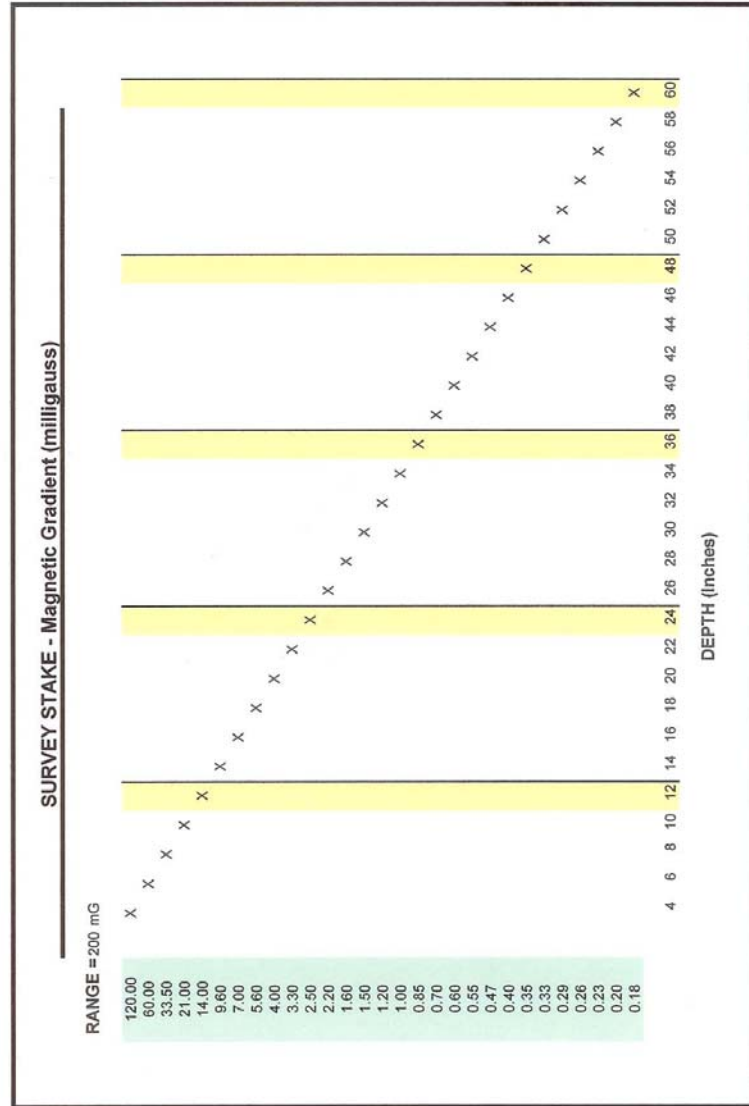
Take a typical property survey pin for example. Mount your target on a horizontal platform and approach the tip end of the Mag Pro II gradiometer. Record the magnitude of the target reading on the Mag Pro II meter and the distance between the Mag Pro II sensor and your target as you approach the sensor. Reverse the Property Survey pin on your horizontal platform and repeat these readings as you slowly back away from the sensor. If you like, you can turn your target 90° sideways to measure and diagram the horizontal magnetic field of your target. Repeat this type of test with other similar targets as often as necessary to build-up your numbers and confidence that you have developed a statistical average.

For large targets such a gas or water pipes, you will need to position a section of pipe horizontally on a magnetic-free section of ground, remove all potential magnetic anomalies from the immediate vicinity, then hold your Mag Pro II gradiometer horizontally at the height of your target and repeat the tests described above.

SURVEY STAKE - Magnetic Gradient (milligauss)
 Re-Bar (5/8Dia. X 18" L)

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

Prepared By: **Wrrren D. Dunham**
 Magnetic Gradient as measured by a Mag Pro II Gradiometer



Note: That this chart was generated with the instrument sensitivity switch set on 200 mG. Range, on the 2.0 mG Range the detection depth becomes more than 15 feet.

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.

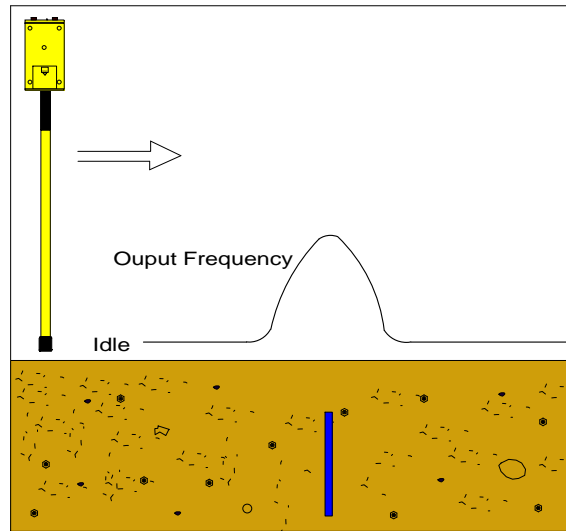


Figure 5, Survey Marker or Well Casing

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).

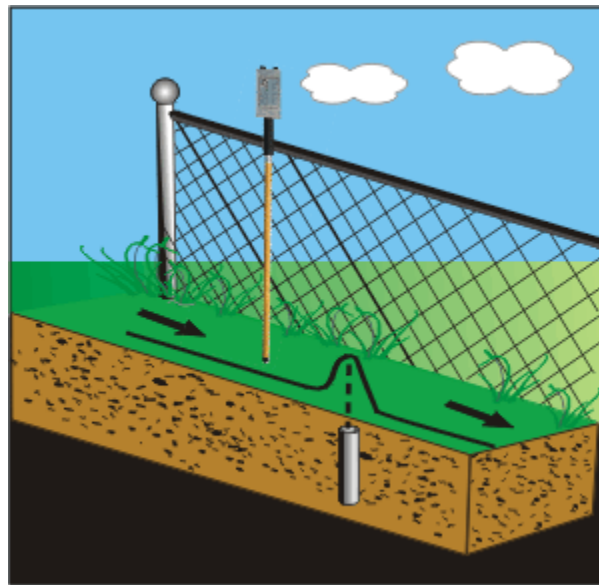


Figure 6, Chain-Link or “Cyclone” Fences

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.

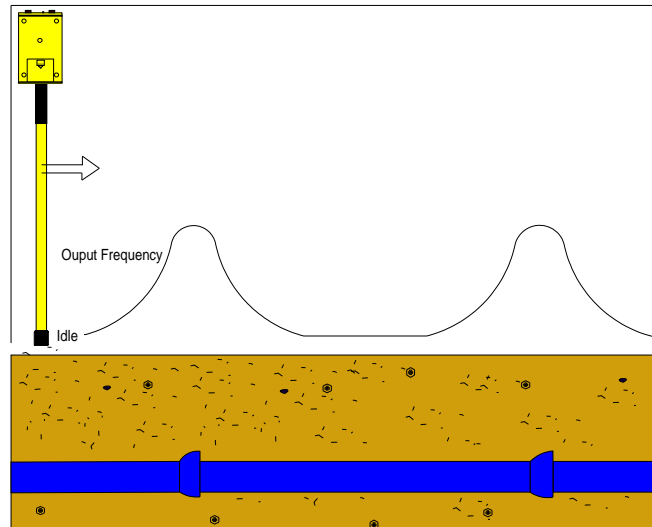


Figure 7, Horizontal Pipe

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.

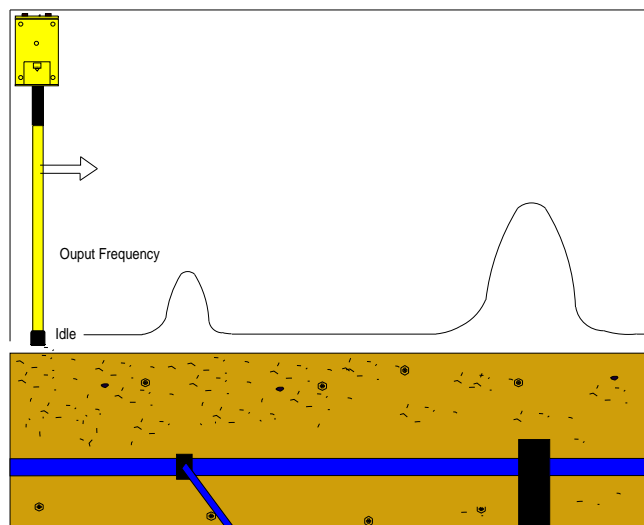


Figure 8, Service Connections and Valve boxes

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.

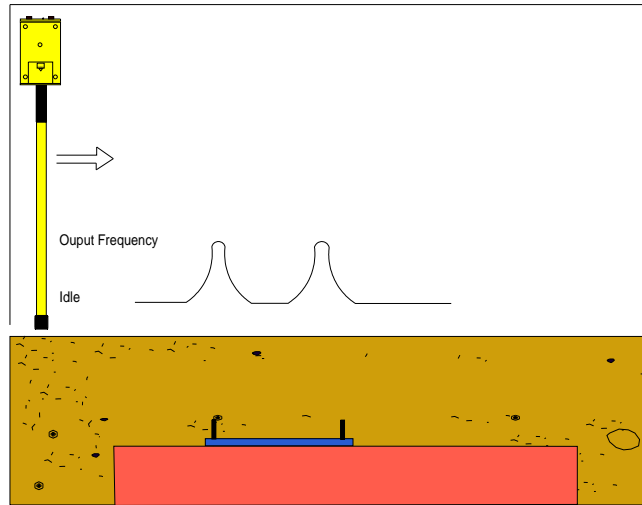


Figure 9, Septic Tank

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.

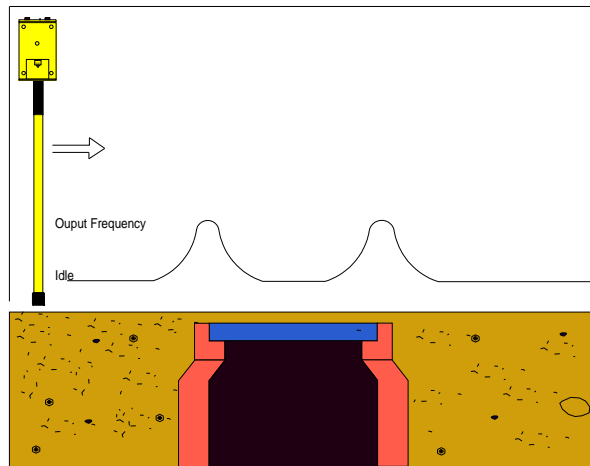


Figure 10, Manhole Cover

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.

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 Ordnance 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	1.0	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 minimum recalibration charge of \$250.

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.