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Strong Magnetic Field Detected Following a Sighting of an Unidentified Flying Object

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Abstract — Following the brief sighting of an unidentified flying object in Gulf Breeze, Florida in September 1992, investigators made an area search using a fluxgate gradient magnetometer and found a strong magnetic field gradient, indicative of a strong source of magnetic field, which appeared to be at or above the tops of some trees near a small pond. Three circles of depressed grass were found in the bottom of the shallow pond. This paper discusses the sighting, the area search, the circles and the field gradient measurements. An estimate of the field strength is presented and compared with magnetic effects associated with other sightings.

The Sighting

On Friday, Sept. 11, 1992, at approximately 6:20 pm, Mrs. **A** (name confidential) was entering the driveway at her home in Gulf Breeze, Florida, when she saw to the northeast, over the roof of her house, an unusual round object rise upward, move to the right a short distance while flipping over (see Figure 1) and disappear in the clear sky. During the subsequent interview with local representatives of the Mutual UFO Network (MUFON) she reported that the object was visible for 3 to 4 seconds. It appeared brownish-grey at the top and bottom with a pinkish-red line around its circumference. The center of the bottom seemed to be glowing. She could not determine how far away the object

WITNESS SKETCH OF SIGHTING

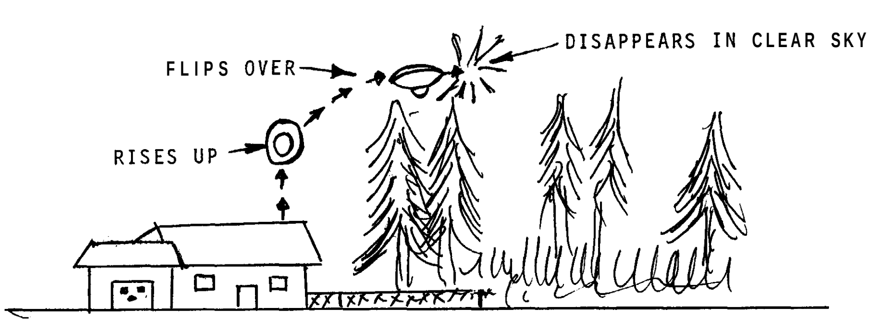

Fig. 1

was although it had clearly been at a distance greater than the distance to her house. She estimated that the apparent size of the object was about 4 times the diameter of the moon (i.e., about 2 degrees) and compared its size with that of a car (8-10 ft) at the same apparent distance (estimated several hundred feet).

Within an hour or so the witness told a very close acquaintance, J, about the sighting. He contacted Bland Pugh and Bruce Morrison, members of the Pensacola MUFON organization, several hours later and they decided to investigate the sighting during the afternoon of the next day. (Note: to avoid possibly negative effects of the association with UFO investigation on his rather high profile business J prefers to remain anonymous. However, he may be contacted through prior arrangement with the author providing that his name will be kept confidential.)

The Discovery of the Magnetic Field

There were thunderstorms in the area and it rained for a while late Friday night. The next morning J used a transit to determine Mrs. A's sighting line direction from her observation point in the driveway. He then decided to search the area behind the house to determine whether or not there was any trace of magnetism left by the UFO. He decided to search for a magnetic field because many years before (in 1973) he had had a UFO sighting which, in his opinion, involved a strong magnetic field. One night a bright UFO had passed over his car and afterward the gauges on the dashboard, including the non-electrically operated oil pressure gauge, all pointed roughly toward the steering column, a shaft of magnetizable iron. He believed at the time that a strong magnetic field associated with the UFO had magnetized the steering column causing the needles to point toward it. Unfortunately at that time he had no instrument to confirm that there was a magnetic field. But now he has a very sensitive device, a flux gradient magnetometer or "gradiometer" (model GA-52, manufactured by the Schoenstedt Instrument Corporation, Schoenstedt, which he has used during the last ten years to search for buried oil well casings (iron pipes) as part of his work. The gradiometer is a battery powered device which has a cylindrical rod (pipe) called a "wand" that is attached to a cylindrical case (see Figure 2). In the wand are two rigidly mounted fluxgate magnetometers (Primdahl, 1979) with their axes oriented along the rod and which are spaced about 51 cm apart. Each fluxgate is sensitive to the component of the magnetic field, B, along the axis of the wand. The electronic circuitry in the cylindrical case measures the magnitude of the difference in the component B values sensed by the two fluxgates. The circuitry does not determine which way the field is pointing along the axis, i.e., it does not distinguish between "forward or backward" along the axis of the gradiometer. This difference, divided by the spacing, is the gradient of the field along the direction of the wand. Hence the device is called a gradiometer. The electronic circuitry also generates an audio tone that drives a loudspeaker in the cylindrical case. The most important characteristic of the device for purposes of scientific research of magnetic

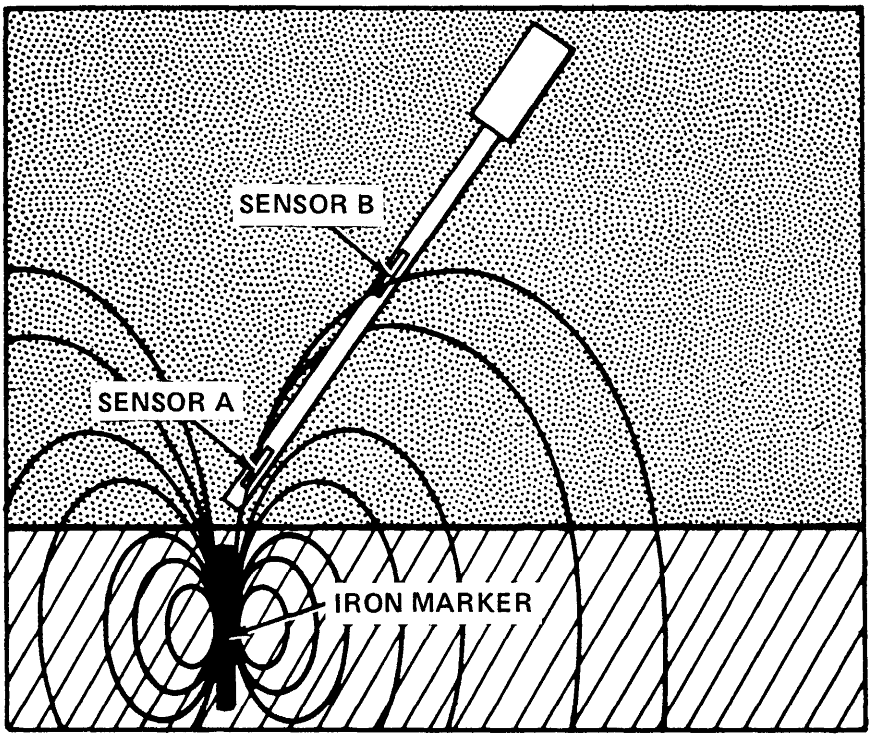

Fig. 2

fields is that the frequency, f, of the tone increases monotonically with the magnitude of the gradient. Furthermore, over a reasonably wide range the frequency is roughly proportional to the gradient: $f = K\,\Delta B/\Delta Z$ (magnitude of the gradient), where K is the calibration constant.

The gradiometer is a rugged field device that was designed for locating magnetic field "sources" such as buried iron objects. (Note: here the term "source" is applied to any object or material which either has its own magnetic field, such as a magnet, or which distorts the earth's field in the vicinity of the object, such as a piece of iron.) A field source could be a magnetized material or a ferrous (permeable) but non-magnetized material. It can detect non-magnetized ferrous materials because they distort the earth's field and the gradiometer detects the field gradient caused by the distortion. For example, a representative of the Schoenstedt company told me that at its most sensitive setting it could detect a piece of iron the size of a manhole cover at a distance of about seven feet.

The gradiometer is typically operated in the following manner: the operator holds the wand where it joins the cylindrical case and, while walking over the area to be searched, he "waves" it around, thus moving and rotating the fluxgates. At each location as he moves the operator searches for the location and direction of the wand where the frequency is the highest. When this is found the operator moves a short distance in the direction the wand is pointing and again waves it around to find the highest frequency. If the operator is now closer to the source the new maximum frequency should be higher than the previous maximum frequency. A large buried piece of metal can be found in this way because the wand points generally in the direction of the source of the field gradient, thereby leading the operator toward the metal. However, at many locations the gradient may actually point slightly away from the direction to the source. For example, at most locations in the field of a simple dipole source the maximum gradient points several degrees of arc away from the direction to the center of the dipole. The operator can compensate for this by doing enough of an area search to localize the area where the frequency is the highest. This localized area contains the source of the field. The same mode of operation can be used to locate any source of magnetic field, whether underground or not.

J began his search by following a footpath that leads around the west (left) end of the pond and then eastward on the north side the pond (see Figure **3** which is only approximately to scale). He was continually waving his gradiometer in various directions to the left and right while pointing it toward the ground and also upward. As he approached the east end of the pond he began to notice an increase in frequency. He subsequently determined that the frequency was highest when he stood on the shore of the pond, approximately at the location of the triangle in Figure 3, and pointed his instrument upward and over the pond. He believed that either he was detecting a "magnetic cloud" in the air over the pond or else his instrument was not operating correctly. He checked the operation of his instrument at a location a considerable distance away from the magnetic field and convinced himself that there was nothing wrong with the gradiometer. He then continued his search around the pond and discovered an area where he obtained the highest frequency when he pointed the wand straight upward or nearly so. This area, which seemed to him to be beneath the source of the field, was under some pine trees on the south side of the pond (see Figure 3), about 60 feet (18 m) from where he first detected the field. His impression was that the source was actually at or above the tops of the trees. He also noticed, while looking over the 4 to 5 foot deep pond, that there were three circular areas of depressed pond grass at the bottom (Figure 3; the circles are not to scale). He had been fishing there several days earlier and had not seen any circles. Subsequently, after plotting the locations of the circles and the strong magnetic field on a map of the area he found that they were roughly in the direction of the sighting line of the witness and about 200 feet (60 m) from her location in the driveway (Figure 3).

Several hours later the two MUFON investigators (Bruce Morrison and Bland Pugh) arrived with a video camera and a Geiger counter. Mr. Pugh made an area search with the Geiger counter and found no clearly elevated readings. J showed them the circles at the bottom of the pond and demonstrated the operation of the gradiometer. Mr. Morrison used a video camera to record the

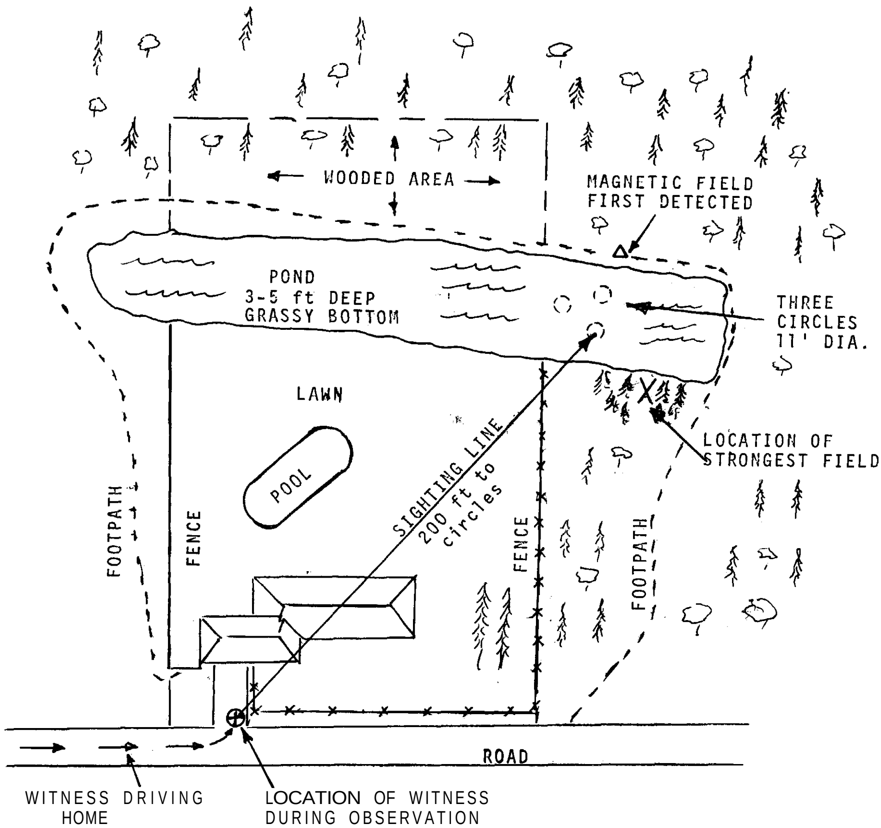

Fig. **3.** Map of the **Sighting Area**

way J operated the gradiometer as he searched the area for the presence of magnetic field sources. The video camera also recorded the audio pitch of the gradiometer as J waved it around at various locations. I subsequently determined from the videotape and from my own experiments with a nearly identical gradiometer that J operated it in a completely normal manner. A simple experiment carried out later by J at my request provided a calibration of the gradiometer and proved that it was operating normally.

Mr. Morrison first recorded J operating the gradiometer on the north side of the pond (triangle location, Figure 3) looking southward toward the clump of pine trees. As J moved the gradiometer from side to side the audio pitch was maximum when the wand was pointed somewhat upward (20-30 degrees of elevation) and generally in the direction of the trees which were about 60 feet (18 m) away across the pond. This suggested to J and the investigators that the source of the field was above the lake or perhaps at or above the treetops on the other side. As the gradiometer rod was turned away from the direction of maximum frequency (maximum gradient), i.e., rotated to the left, right, upward or downward, the frequency decreased considerably. The maximum pitch was at such a high frequency that J offered his opinion, based on using the gradiometer under many conditions for about ten years, that the response of the gradiometer was comparable to what one would get by putting the gradiometer very close to a large piece of iron or steel.

The investigators then walked to the clump of pines. There the videotape shows that the highest frequency recorded, higher than at the location across the pond, was obtained when the gradiometer was vertical or nearly vertical under the trees. As J walked away from the clump of trees in various directions the maximum frequency diminished indicating that he was moving away from the field source. (Note: there was no boat available at the time, so a search was not made over the water.) A search of the area failed to turn up any source of field other than the source which seemed to be at, or above, the treetops.

When J was across the pond from the trees and pointing the gradiometer toward the direction of maximum frequency the audio pitch of the gradiometer was not perfectly steady. Instead, it fluctuated rapidly by small amount in pitch ("warbled") at a roughly constant rate of about 8-22 Hz in a manner similar to a lightly modulated FM signal. (FM stands for frequency modulation in which a "carrier wave" of relatively high frequency is caused to change frequency slightly, usually a few percent, at a rate determined by a much lower modulating frequency.) This warbling was also apparent when the gradiometer was under the trees, where J called the attention of the investigators to this unusual effect. Subsequent experiments with a magnet (see below) created greater gradients and higher frequencies than were obtained under the trees, yet there was no "warbling" of the audio tone during the experiments. The warbling suggests that the magnetic field was pulsating slightly (changing in amplitude and/or direction) at a rate around 10 Hz.

While the investigators were under the trees Mr. Morrison pointed his camera upward and videotaped the treetops and the clear blue sky. Nothing unusual was seen in the sky or on the trees. (Recorded on the videotape is a discussion by investigators in which they speculate as to whether or not the source of the field, assumed to be the UFO, was still there but "cloaked" so as to be invisible.)

J repeated the area search the next day. He reported that the gradiometer had a slight response only under the trees, indicating a considerable decrease in the magnetic field gradient. On Sept. 14, three days after the sighting, the MUFON investigators returned to the area and videotaped the acquaintance with his gradiometer standing under the same trees where, two days before, the audio tone was very high. Now the pitch was at a value that corresponds to "no detectable gradient." On that same day the grass circles were measured and found to be about 11 ft (3.3 m) in diameter. A week or so later the investigators thought of checking the magnetic field in the area with compasses at several locations. All the compasses pointed north indicating that there was no large magnetic anomaly in the area. (It is unfortunate that they didn't think to use compasses on the day after sighting!)

Discussion of the Visual Sighting and the Circles

The sighting, although very brief, provided the witness with enough visual details to demonstrate that the UFO was no conventional aircraft, nor was it a bird, an insect or a piece of debris blowing in the breeze. Although the sighting did not provide much visual data for analysis, it did provide an angular size which can be compared to the size of the circles if the distance to the UFO is assumed. The witness estimated the angular size to be about four times the diameter of the moon which corresponds to roughly 2 degrees or about 0.035 radians. If one assumes that the UFO had actually risen upward from one of the circles just before the sighting and was therefore about 200 feet (about 60 m) away, then the actual diameter of the circular object was nearly 7 feet (2.1 m). This is four feet less than the measured diameter of the circles, but an acceptably small increase of 1.10 in the estimated angular size, making it about six times the diameter of the moon, would make the calculated size equal the circle diameter. It certainly is reasonable to assume that the witness could have underestimated the angular size by this small amount, and hence we may conclude that the visual sighting is consistent with the size and shape of the "circular evidence" at the bottom of the pond. Of course this does not prove that the observed UFO made the circles, nor does it explain the discrepancy in number: there were three circles but only one observed UFO.

The discovery of one or more circles in an area of a UFO sighting is not a rare occurrence, although generally such circles are found in grass or grain growing on dry land. However, "saucer nest" circles which were discovered after a UFO sighting on January 19, 1966 near Tully, Australia, were in a swampy area. The reeds were bent below water level (Phillips, 1975; Story, 1980; Delgado and Andrews, 1989). Phillips (1975) and Delgado and Andrews (1989) describe a considerable number of UFO sightings and associated circular traces that occurred in various countries including the USA, FSU (USSR), Canada, Australia, New Zealand and Britain.

Analysis of the Gradiometer Data

Although the UFO observation and the discovery of underwater circles are noteworthy by themselves, the aspect which really makes this case unique is the detection of the magnetic field gradient. This section presents an analysis of the field gradient data.

The gradiometer is designed so that it generates an audio tone with a pitch that is very nearly proportional to the magnetic field gradient. The sensitivity of the gradiometer is adjustable. In order to provide accurate gradient values corresponding to the frequencies that were recorded by Mr. Morrison during the investigation it was necessary to calibrate the gradiometer at the sensitivity level used during the investigation. At my request, J carried out an experiment which provided the data needed for calibration. I provided J with a small (1" long) bar magnet of known strength which had been calibrated with instruments at a Navy laboratory. J placed the gradiometer and magnet on a horizontal board far from any power lines or metal objects. He aligned the gradiometer in the east-west direction to eliminate the effect of the slight north-south gradient which is detectable with his instrument. He then aligned the axis of the magnet with the axis of the gradiometer. He placed the magnet at various measured distances from the end of the wand and tape recorded his verbal annotation of the measured distances and the resulting audio tones. The shortest distances used were 1" (2.5 cm) and 0" from the end of the rod or about 2.6" (6.6 cm) and 1.6" (4.1 cm) from the fluxgate sensor closest to the end. These produced frequencies which were much higher than those recorded under the trees near the pond. At distances of about 2 feet (about 60 cm) and beyond there was no detectable effect of the magnet.

Subsequently I calculated the magnetic field at each fluxgate sensor for each distance of the magnet's center using the standard equation for the field of a (small) bar magnet along its axis, $B = B_0/z^3$. In this equation B_0 is the effective pole strength which was determined from the magnet calibration (1040 nanoTesla (nT) at 30 cm from either end; see the Appendix) and z is the distance from the center of the magnet to the sensor. The difference in the field amplitudes at the two sensors for any given magnet location was divided by the sensor spacing, 0.51 m, to get the gradient as a function of distance. According to the manufacturer, when the gradient is below 1,000 nT per meter (nT/m) the frequency remains at a fixed minimum of about 65 Hz. I found that above 1,000 nT/m the relation between the audio frequency and the field gradient is nearly linear, as illustrated by the calibration graph shown in Figure 4. In the frequency range of interest to this investigation, 500-5000 Hz, the use of a calibration factor of 12 (nT/m)/Hz provides an accuracy of 5% or better.

(A note on units and conversion factors. The mks unit of magnetic flux is the Weber (Wb), which corresponds to the number of "lines" of magnetic force around a magnet or a loop of current. The field strength at any point is characterized by the induction B, which is the flux per unit area, Wb/m^2, called Tesla (T). Hence $1\ T = 1\ Wb/m^2$. In the cgs system the area flux density is in Gauss (G) where $1\ T = 10^4\ G$. For small fields a more typical unit is the $nT = 10^{-9}\ T$ which is also called "gamma." The magnitude of the earth's field at the surface is typically about 5×10^{-5}T or 50,000 nT or 0.5 G.)

It is important to realize that the gradiometer does not measure the actual value of the field induction at a point in space. To measure the magnitude of the field directly one needs a device such as a compass, a rotating coil of wire (with a voltmeter attached), a "Hall effect device" or a fluxgate magnetometer, using a single fluxgate rather than the difference of two fluxgates. However, the gradiometer is much more sensitive than the previously mentioned devices for measuring variations or "distortions" of the local (earth's) magnetic field caused by the presence of magnets or non-magnetized, but magnetizable, materials (e.g., iron). A magnet or a non-magnetized piece of magnetizable material will distort the local magnetic field over some distance from the piece of material, just as a rock in a river distorts the flow of a uniform stream of water. The presence of a magnet or a piece of magnetizable material in the earth's field creates a field gradient which the gradiometer can detect.

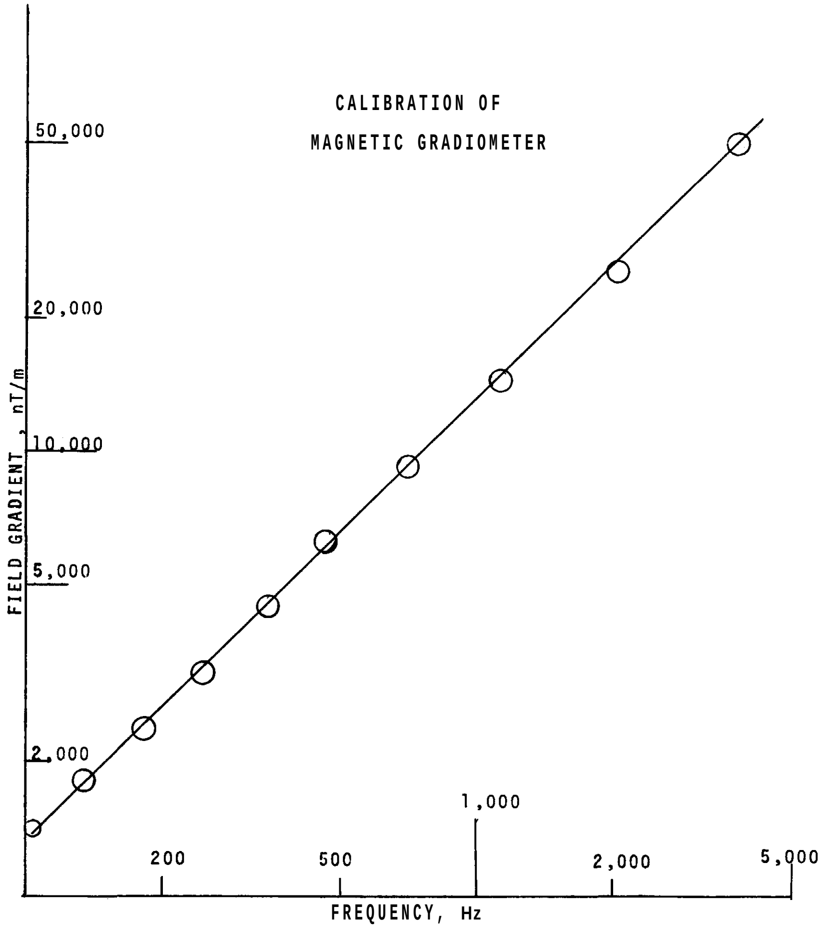

Fig. 4

A magnetic dipole consists effectively of positive (north) and negative (south) magnetic poles separated by a small distance. (Similarly, an electric dipole consists of opposite charges separated by a small distance.) Such a combination of poles creates a characteristic dipolar "shape" of the magnetic field as measured at distances from the dipole that are much greater than the separation of the poles. **A** small bar magnet creates such a field at distances that are large compared to the length of the magnet. A loop of wire carrying a current is also a source of magnetic field, a phenomenon which is used extensively in electromagnets, electric motors and generators. At distances considerably larger than the diameter of the loop the strength and direction of the magnetic field varies with position in the same way that it varies in strength and direction around a magnetic dipole provided that one imagines the axis of the loop (a line through the center which is perpendicular to the plane of the loop) is aligned with the axis of the analogous dipole. Hence it is common to refer to a circular loop carrying a current as a "current dipole." The similarity between a current dipole and a small bar magnet (dipole) provides a useful means for comparing the strengths of magnetic fields from different types of sources. This sort of comparison is made in this paper where calculated source strengths are given in terms of the equivalent current dipole strength which is the product of the area of the loop in square meters multiplied by the current flowing in it: amp-m^2. (Note: a single turn loop is assumed.) This is described more below and in the Appendix.

First, J waved the wand around while he was standing on the north side of the pond looking southward toward the clump of pine trees. The maximum recorded frequency was obtained when the gradiometer was pointed toward the trees and tilted upward at an angle of 20-30 degrees. The maximum frequency was about 1,500 Hz which, from Figure 4, corresponds to about 18,000 nT/m. As the gradiometer rod was turned away from the direction to the treetops the frequency decreased considerably. Next J walked to the clump of pine trees and again waved the wand around. The videotape shows that when the gradiometer was under the pine trees and pointed straight upward an even higher frequency, about 2,100 Hz, was obtained. This corresponds to about 25,000 nT/m. When the gradiometer was pointed away from the treetops the pitch was much lower, and, as J walked away from the pine trees the maximum pitch diminished. Hence it appears that he was closer to the source of the field when he was under the trees than when he was on the other side of the pond. The upward direction of the maximum gradient suggests that the source may have been at or above the tops the pine trees. However, as I have pointed out before, the gradiometer wand does not always point directly toward the source, so the source may not have been over the trees, but instead over the pond adjacent to the trees. (Note: the referee has pointed out that the gradiometer does not distinguish between "backwards and forwards" along the axis of the wand. Therefore, if J had made a measurement of the gradient at only a single location then one would have to allow for the possibility that the magnetic source was underground. However, the directions of the gradients were measured from two locations which are about 60 feet apart. These directions intersect above ground rather than below the ground. Hence I assume that the source was above the ground.)

Two days later J was recorded again standing under the trees pointing the gradiometer upward and this time the audio pitch was around 65 Hz, indicating that the field gradient had been reduced below 1,000 nT/m. (This does not mean that there was no field gradient, only that there was no gradient detectable by the instrument at the sensitivity used during the investigation.)

Discussion of the Field Gradient Data

In the Appendix I have presented the calculation of source strengths under the simplifying assumption that the source was a current dipole as described above. This must be considered an extreme simplification of the problem because a large (infinite) number of configurations of magnetic sources (dipole and multipole sources) could create any particular gradient at a particular location. The calculation also assumes that the size of the source is much smaller than the distance from it to the gradiometer (a "point" source), whereas the actual source could have been be quite large compared to the distance. Nevertheless. this sort of calculation allows us to compare field strength associated with the UFO sighting with field strengths of known sources such as electromagnets, permanent magnets and non-magnetized but magnetizable (permeable) materials.

For example, assume that the source was very nearly above the trees. If this were so, then the measured field gradient at the location across the pond, 18 m from the trees, could be generated by a current loop of strength 3.1 x 10^6 amp-m^2, providing that the axis of the current dipole was aligned with the axis of the gradiometer. This current dipole strength can be interpreted in the following way: a 1 m diameter loop, with an area of 0.78 m^2, could create the measured field gradient at a distance of 18 m if it were carrying a current of about 3.9 x 10^6 amp. Other size loops carrying other currents could also be assumed, as long as the product was the same. For example, a 2 m diameter loop has four times the area and needs only one quarter of the current to produce the same field. (If there were more "turns" in the loop the current could be divided by the number of turns.)

Assume, now, a 1 m diameter loop carrying the above current. At its center the field strength would be about 5 T. This field magnitude is about 100,000 times greater than that of the earth and is comparable to that inside the strongest magnetic materials (magnetic alloys such as ALNICO). Alternatively, one might imagine that the field gradient was created by the equivalent of a massive piece of magnetizable material. By comparison with the magnetic signatures of Navy ships it was determined that the field gradient measured at 18 m would be produced at a distance of about 18 m away from either end of a destroyer-sized battleship (the distance would be measured along the projected axis of the ship)!

A considerably different source strength can be calculated by assuming that the source was at the tops of the trees, about 3 m above the gradiometer when J operated it under the trees. Assuming again that the gradiometer was aligned with the axis of a hypothetical current dipole the source strength is now found to be about 3.4 x 10^3 amp-m^2. This dipole strength is three orders of magnitude less than the previously calculated value because of the z^4 distance dependence of the gradient (see Appendix) and the much shorter assumed distance (3 m vs 18 m). Such a small source strength could not create the field gradient that was measured on the far side of the pond. Therefore one might assume that the actual source was considerably higher than the trees and possibly somewhat over the lake. I have attempted to locate a unique position above the trees or above the lake at which a current dipole could create the measured gradients. However, numerous computer-aided calculations have shown that there appears to be no such unique location for a simple dipole source. Hence one may assume that the source of the gradient was not a simple small dipole but rather some complex distribution of sources. (Alternatively one could also make the less acceptable assumption that either magnetic source changed its strength between measurements or that it moved from one position to another between measurements.)

Unfortunately J and Bruce Morrison did not record gradient measurements at enough locations around the pond to provide sufficient information to specify the exact nature of the source of the field. Therefore the most significance one can attach to these measurements is that a large magnetic field was clearly present in an area where there should have been no such field. To further clarify this significance consider the following facts: (a) wood is not ferromagnetic (it cannot be magnetized); (b) while J was standing under the trees with his gradiometer pointed upward and generating a high pitch on Sept. 12, Bruce Morrison was videotaping the tops of the trees which were silhouetted against a clear blue sky–they could see nothing up there that could cause such a field gradient; (c) if, somehow, the wood had been made ferromagnetic by a UFO (an impossibility, according to the physics of magnetic materials), or if the UFO had deposited a massive amount (hundreds of pounds?) of some ferrous (i.e., containing iron) material on the trees (no deposit of material was seen on the trees, however), then the strength of the magnetic field should have been the same on the second day of the investigation because ferrous materials do not lose their magnetism at environmental temperatures (they do lose it at temperatures of many hundreds of degrees); (d) there had been rain the night after the sighting, yet there was no indication of magnetic sources on the ground, so no magnetic residue had washed off the trees. Hence we are left with a double mystery: (1) how did the field get there in the first place, and (2) once there, why did it disappear?

Although the gradient was large there was no observable effect on the videocamera. A calculation of the field strength at the videocamera when it was under the trees, assuming that the source was farther than about 10 ft (3 m) away (at or above the tops of the trees) shows that the field from a 3.4 x 10^3 amp-m^2 source would have been 0.00003 T or less, which is much too low to affect the videocamera mechanism or the videotape.

Discussion of Other UFO Sightings with Magnetic Effects

Anomalous magnetic effects have long been associated with UFOs. The earliest magnetic effect report on record is that of Fred Johnson who was prospecting near Mt. Adams on June 24, 1947. On that day, and only minutes before Johnson's sighting, Kenneth Arnold, a private pilot was flying a small plane about 20 miles west of Mt. Rainier in the state of Washington. Arnold saw nine flat, shiny crescent-like objects fly southward past Mt. Rainier (Maccabee, 1986; Story, 1980). Arnold last saw them as they vanished in the distance near Mt. Adams, about 50 miles south of Rainier. Arnold's sighting was widely reported in the press and gave rise to the term "flying saucers." (Although the Air Force called Arnold's sighting a "mirage," and others have offered similar suggestions, the fact is that Arnold's sighting could not have been caused by atmospheric phenomena. It has never been explained [Maccabee, 1986].) Several weeks after the sighting Johnson told the Air Force and then the FBI that he saw several of the objects fly overhead. He looked at them with a telescope and estimated their altitude as about 1,000 ft (about 300 m) above him and their diameter at about 30 ft (about 9 m). Of particular interest here, however, is Johnson's statement that, as the object passed over, his compass continually oscillated from side to side (Maccabee, 1986).

Assuming that the "saucers" were the source of the magnetic field that caused the compass to oscillate we can estimate the source strength in the following way. Assume that a magnetic field with a strength roughly 1/5 of the earth's field (i.e. about 10^{-5} T) that oscillates in direction or pulsates in amplitude (or both) could cause a noticeable oscillation of a compass needle. For simplicity also assume that a flying saucer is effectively a current dipole (9 m) in diameter and that the compass was, at least part of the time, at a distance of 300 m along the axis of the dipole as each saucer flew over. Since 300 m is much greater than the radius, 4.5 m, Eq. 2 in the Appendix can be approximated as $B = 2\,B_0/z^3$. Inverting this equation and solving for B_0 with $B = 10^{-5}$T and $z = 300$ m yields $B_0 = 135$ T-m^3 which corresponds to a source strength of 1.35 x 10^9 amp-m^2. This source strength can be created by a current of about 21 megamps flowing in a loop 9 m in diameter. The field strength at the center of the loop would be about 3 T. Of course, these very simplified calculations probably do not provide us with the actual effective source strength of the saucers, but they do demonstrate that the fields would have been very large to have affected Johnson's compass from a distance of 300 m.

In the years following 1947 there were reports of UFOs affecting iron items such as streetsigns and automobiles (Rodeghier, 1981). Researchers have long felt that car-stopping events were associated with the presence of large magnetic fields in the presence of UFOs, although evidence for this has been indirect at best. Experiments have shown (Rodeghier, 1981) that either a steady or a pulsating magnetic field can affect a spark coil in an automobile ignition system. A steady magnetic field can saturate the magnetic core of the coil and decrease the spark strength. A strong enough field could kill the spark completely. A somewhat weaker field which is pulsating at roughly the firing frequency of the automobile but is out of phase with the firing can cause the engine to stall. The demonstrations of the effects of magnetic fields on automobile ignition systems are interesting, but they do not provide conclusive evidence that magnetic fields associated with UFOs have stopped any cars.

Claude Poher, a French scientist formerly associated with the French National Space Agency (CNES), studied sightings in France that occurred during the October, 1954 "flap." He also studied magnetic field readings at a geophysical research station located at Chambon-la-Foret (Hendry, 1979). Poher claimed that the strength of the magnetic field tended to be larger during the flap, although Hendry (Hendry, 1979) has pointed out that this does not prove that the increase was caused by UFOs since the earth's magnetic field tends to fluctuate anyway. (The fluctuations are typically of a magnitude around 0.0001 to 0.001 of the earth's field and are a result of fluctuations in the "solar wind.") Poher also claimed to find a correlation between the distance of a reported object from the station and perturbations in the vertical component of the magnetic field at the station (Hendry, 1979; Hynek and Vallee, 1975). A graph of Poher's magnetic field data (Hynek and Vallee, 1975) has been magnified, slightly redrawn and reproduced in Figure 5 for convenience in the following discussion. Poher found that the strength of the perturbations seemed to decrease inversely with the distance of a UFO sighting from the station (the greater the distance, the smaller the effect). Unfortunately the closest distance was still 30 km away so the mathematical relation that he derived from the data was not well tested. Furthermore, although it was not pointed out in the publication, the line that he drew through the data points shows an inverse square decrease with increasing distance rather than the expected inverse cube which is associated with typical dipolar magnetic fields. If the data were really accurate, this could be considered to be evidence that UFOs are associated with monopolar magnetic fields. The idea that there might be magnetic monopoles is, so far as we know, only a theoretical construct which symmetrizes the Maxwell equations of electrodynamics by providing a monopolar source for magnetic fields which is analogous to the source (electron, proton) of the monopolar electric field. All sources of magnetic field of which we are experimentally aware are dipolar (or multipolar) in nature. Hence I have drawn another line, which corresponds to the inverse cube dipole field, through Poher's data. It is interesting to note that the inverse cube decrease with distance does not fit the data as well as the inverse square. However the better fit for the inverse square should not be considered as valid evidence that UFOs are sources of monopolar magnetic fields because range in distances is quite limited (one would like to see data from ranges 1-10 km) and because the data points are very scattered.

By projecting the inverse cube lines on Figure 5 "backward" to a distance of 1 m from an assumed source one can show that the equivalent dipole strength is about 1.5 x 10^{13} amp-m^2 which is many orders of magnitude greater than the previously calculated values. Since the magnitudes of these source strengths are crucially dependent upon the accuracy of the data points in Poher's graph, the numbers calculated here can be considered to be no more than indicative of very strong fields associated with UFOs, assuming that Poher was correct in associating these fluctuations with UFO sightings.

Many people have attempted to detect UFOs using simple magnetic field sensors in the past. A typical simple sensor is a compass with an optical system designed to detect any motion of the pointer from its normal north-south direction, and to set off an alarm. I am aware of no clear-cut successes of this approach to detecting UFOs. On the other hand, sensitive magnetic field detectors that might detect UFOs are not common items easily available to civilian

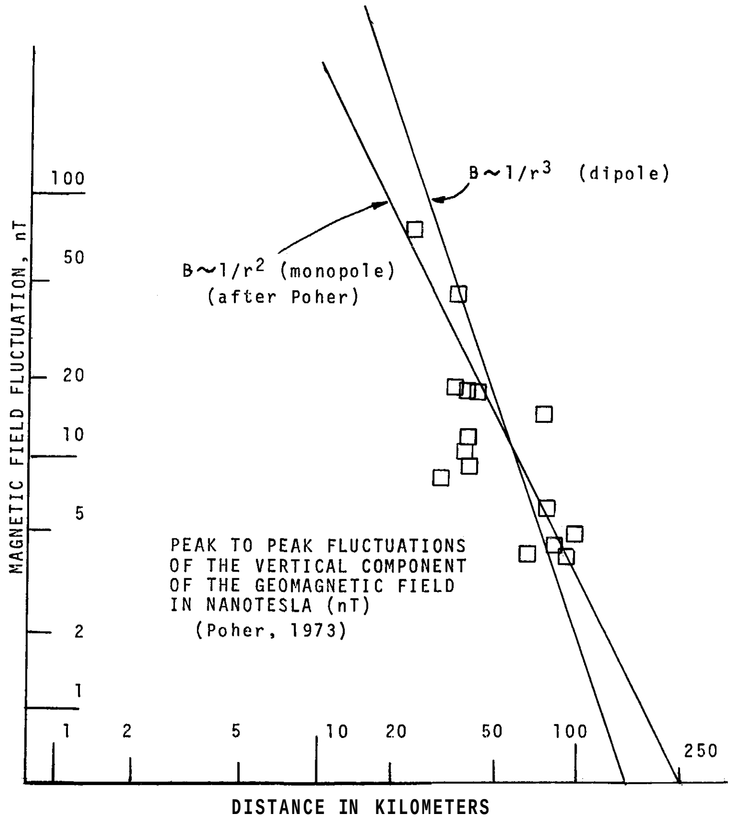

Fig. 5

UFO investigators and very few, if any, have them available for sighting investigations. I am aware of only one other magnetic site survey of an area of UFO activity that is similar to the one reported here (Cornet, 1993). The success in detecting a field after the sighting reported here and the past reports of apparent magnetic effects suggest that local UFO groups in areas of continued activity, perhaps with monetary aid from national UFO organizations, should consider purchasing these devices for use by trained field investigators along with the standard equipment (cameras, video cameras, sample taking devices, etc.).

Conclusion

Following a brief visual sighting of a disk shaped UFO an area search was made. In the bottom of a shallow pond three 11 ft circles of depressed pond grasses were discovered. An estimate of the size of the disk based on the visual apparent size and the distance to the circles agrees reasonably well with the size of the circles. An area search was made with a magnetic field gradiometer. The search discovered locations of anomalously high field gradient in the absence of known sources (large pieces of metal or electric current carrying wires). Estimates of the magnetic source strengths were made using the recorded gradiometer data (audio tones). The source strengths were found to be quite large in a manner that is consistent with estimates based on observed magnetic phenomena associated with other UFO sightings. One major difference between this magnetic field detection and other reported cases is that there was no UFO visually present during the detection of the field, which was only detected many hours after the sighting. This raises the question of whether or not a UFO actually was present during the measurements but in some way made itself invisible, or if the departing UFO in some way managed to leave a magnetic "trace" of its presence many hours before.

Appendix

A "field" is a volume in space throughout which some quantity (or quantities) varies in a consistent and measurable way. The magnetic field varies in both magnitude and direction (i.e., it is a vector field) in a volume of space around a magnet or around a loop of current. As virtually any textbook on electromagnetic theory (e.g., Scott, 1959) shows, the field of a magnetic dipole (or an electric dipole) can be represented in vector notation most simply by using cylindrical coordinates with the z axis along the axis of the magnet or perpendicular to the plane of the current loop. The other two axes, x and y, are replaced by new axes which are the radial distance, r, from the center of the dipole, and the angle, A, between r and the positive z axis. The equations for the vector components of B, B_r and B_A, are

$$(B_r,\ B_A) = \left(\frac{2B_0\cos(A)}{r^3},\ \frac{B_0\sin(A)}{r^3}\right) \tag{1}$$

where the magnitude of the field is given by $(B_r^2 + B_A^2)^{1/2}$ and r is assumed to be much larger than the dimensions of the source of the field (much greater than the length of a magnet or the diameter of a current loop). In this equation B_o in T-m^3 is given by $1 \times 10^{-7} MSL$ if the source is a bar magnet of magnetization per unit volume M (amp/m) with cross-sectional area, S (m$^{2)}$ and length, L (m), or B_0 is 1×10^{-7} IS if the source is a current loop (a single turn) of area S and current I (amp). Figure A1 illustrates the coordinate systems for the two types of sources. If the source is a current loop a more correct equation for the field along the z axis where $A = 0$ is

$$B_r = \frac{2B_0}{\left(z^2 + R^2\right)^{3/2}} \tag{2}$$

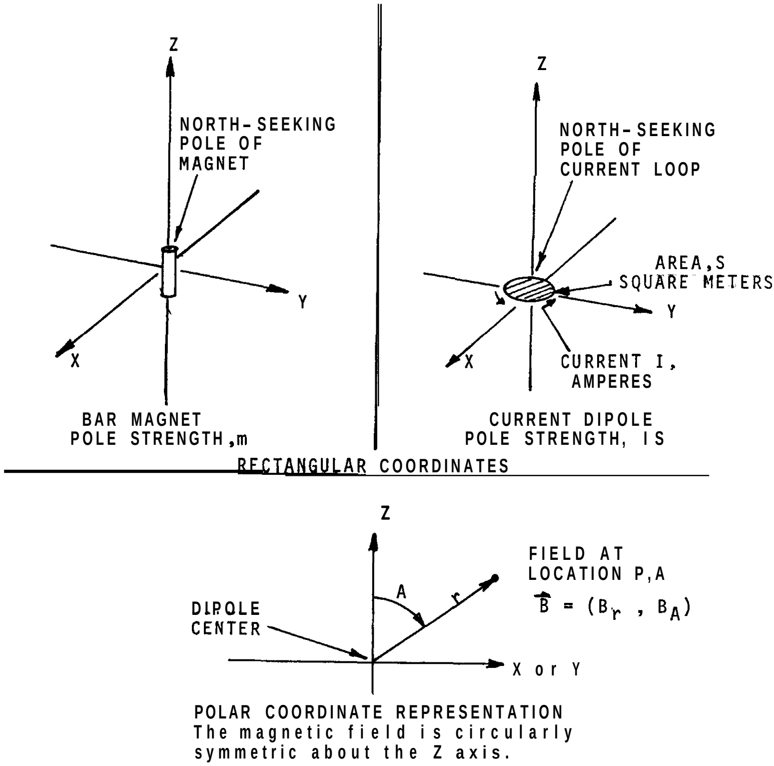

Fig. A1

where R is the radius of the loop and $B_0 = 1 \times 10^{-7} IS$. Along the z axis $\sin(A) = 0$ in Eq. 1 so there is no angular dependence of B; B points directly toward or away from the source at all z values. Comparing Eq. 1 with Eq. 2 we see that r has been replaced by z and when z is much greater than R the equations are essentially equal. The simple dipole model can be used to calculate the equivalent source strength, B„ from the gradient measured by J's instrument if the distance to the source is known or assumed. The measured gradient of the field is the derivative of B along the axis of the wand. In terms of the dipole model it can be shown that (by far!) the simplest direction to take is along the z axis (i.e., assume that the wand axis lies along the z axis). Also assume that the field gradient is measured at a distance far from the source ($z >> $ R) so that R can be ignored in Eq. 2. Then straightforward differentiation gives

$$\frac{dB}{dz} = \frac{6B_0}{z^4} \qquad (3)$$

This equation can be inverted and solved for B_0 as a function of the measured gradient:

$$B_0 = \frac{z^4}{6} \frac{dB}{dz} \tag{4}$$

When J was on the far side of the pond he was about 18 m from the trees. The measured gradient when J pointed the gradiometer toward the treetops was about 18,000 nT/m. If we assume that the source was a current loop at the distance of the trees with its axis pointing toward J when he stood on the far side of the pond, then the measured gradient multiplied by z^4 and divided by 6 gives $B_0 = 0.31$ T-m^3. Using the definition $B_0 = 10^{-7} IS$ the equivalent current dipole source is found to be IS = 3.1x10^6 amp-m'. With this dipole strength we can use Eq. 2 to calculate the field at the center of a loop. Assume that the loop has a radius of 0.5 m. Then, at $z = 0$, $B = 2$ x 0.3110.53 = 5 T. A field this strong is comparable to saturation field strengths inside the strongest magnets.

When J stood under the trees he obtained a frequency that corresponds to about 25,000 nT/m. Assuming that the source was at the treetops or just above, at a distance of 3 m, Eq. 4 yields B_0 = 3.5 x 10^{-4} T-m^3, which is much lower than the previously calculated value. This large decrease results from the assumption of a short distance (3 m vs 18 m) combined with the fourth power distance dependence of the gradient. In this case the current loop strength is 3.4 x 10^3 amp-m^2 which is still quite large. The implications of these calculations are discussed in the text.

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