BIOLOGICAL EFFECTS OF MAGNETIC FIELDS

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14. Brown, F.A., Jr., H.M. Webb, and W.J. Brett, "Magnetic Response of an Organism and Its Lunar Relationships," Biol. Bull. 118:382, 1960.
15. Terracini, E.D., and F.A. Brown, Jr., "Periodisms in Mouse 'Spontaneous' Activity Synchronized with Major Geophysical Cycles," Physiol. Zool. 35:27, 1962.

Chapter 2

Actions of a Very Weak Magnetic Gradient: The Reflex of the Dowser

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The way in which the dowser holds his divining rod (Figure 1) is common knowledge, although few people have tried it themselves. Whether the dowser really gets signals coincident with the presence of water is a very controversial question. In all events it appears undeniable that above-ground dowsers obtain, when certain physical conditions are present, a signal which is the involuntary upward or downward movement of the firmly held rod. It is independent of their will if they are employed solely in maintaining their grip. The interpretations of this signal in terms of water are very doubtful. Nevertheless, a correlation with the presence of water is manifested quite often.

If we let ten dowsers pass along a certain route, for example a quarter mile of road through a forest, and leave a mark wherever they get a signal, then experience shows that the marks of all the dowsers will coincide within 1 or 2 yards of the most frequent mark. Such verifications, made in a large number of cases,* lead one to believe that there exists a physical agent causing the reflex of the dowser above the ground.

THE MAGNETIC DOWSER

Through experiments described below and published in a recent book[1] we have established that:

1. The dowser, walking with uniform speed at his normal rate and with his rod in position, has his reflex started when he moves

*The controversy of the dowsers versus the scientific world is such that accounts of such experiences are practically excluded from scientific literature. To find them, one must have the courage to explore the so-called literature of the dowsers and attempt to read it with a critical mind. We cite in this regard: Sir William Barrett and Th. Besterman, "The Divining Rod," 1926; J. Cecil Maby and T. Bedford Franklin, "The Physics of the Divining Rod," 1939; Dr. Jules Regnault, "Baguettes et Pendules," 1948; Dr. Joseph Wust, cited by E. Hartmann, "Vorstoss in Biologisches Neuland," 1964; S. J. Tromp, "Psychical Physics."

Fig. 1. 1693 engraving showing how the divining rod is held.

through a region where the earth's magnetic field is not entirely uniform and an anomaly is present. If we characterize this anomaly by a "gradient" giving the variation of the field with respect to distance, we arrive at the following facts:

a. A gradient of 0.3 to 0.5 mOe/m can be detected, but with a time lag of the order of 1 sec.
b. If the gradient increases to 2 or 3 mOe/m, the detection is more accurate.

c. If the gradient falls below 0.1 mOe/m, the detection is wholly inaccurate. There is apparently a threshold below which the gradient cannot be accurately detected.

2. If many small anomalies are repeated in this way within a few meters, detection is improved in the sense that the signal becomes irresistible, i.e., no supplementary muscular contraction succeeds in restraining the rod. There is a slow integration (within seconds) of the causes contributing to the "signal."
3. If upon arriving at a gradient, one finds himself in a field which keeps increasing (within the interval), one witnesses a saturation: the human body adapts itself to the new value of the field; 20 to 50 mOe is large enough to cause this saturation. If one wishes to detect a signal despite this saturation, it is necessary to walk faster.
4. In a car or a plane one can detect a gradient $\Delta H/\Delta x$ weaker than that detectable while on foot, provided that the higher velocity $\Delta x/\Delta t$ of these vehicles produces a time variation of the field $\Delta H/\Delta t$ of the order necessary for detection when moving by foot, i.e., more than 0.3 mOe/sec.

THE ART OF THE DOWSER

We are not the first to have reported the sensitivity of a dowser to a magnetic field. According to a very old book,[2] when the Abbot of Vallemont—in reality the Reverend Father Le Lorrain, S. J., Professor of Physics at College Louis le Grand—places a lodestone before a well-known dowser, "the rod moves." S. J. Tromp ("Psychical Physics") causes the dowser to operate with artificial magnetic fields. Joseph Wust finds magnetic anomalies on the ground where the dowsers react. However, none of these authors connects these effects with the detection of water.

It appears to us that one may provisionally conclude that the dowser does not detect still water in a pond or running water in a river, but he can detect

a. water filtering through porous media, and
b. water in permeable layers adjacent to beds of clay,

since in these two cases water produces electric currents through electrofiltration potential and concentration batteries. If the medium is sufficiently conducting, and the current in the soil is sufficiently high, then there exists at the surface of the soil a small magnetic anomaly. The effects of electrofiltration and of clay potential are well known to geophysicists and can be calculated. We came to the conclusion that 1 mOe/m is very difficult to obtain, but one can obtain values of 0.1 mOe/m. On the ground, the magnetic dowser as we have described him is almost at the limit of his sensitivity when he attempts

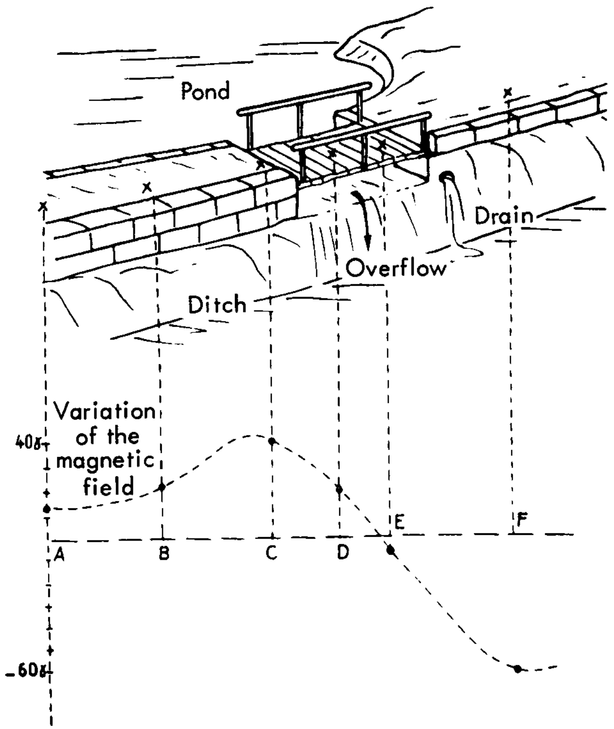

Fig. 2. Magnetic anomaly along an embankment bordering a pond which has various drains. The variations in the magnetic field are expressed in $\gamma = 10^{-5}$ Oe.

to detect water. In our opinion he detects it only if he experiences signals which change with time; considerable flood or drought causes disappearance of the signals, either by suppressing the stream of current or by distributing it uniformly. At the same time, these conditions limit considerably the chances of the dowser to find water close to the surface of the soil.

Figure 2 represents a site (a bank separating a pond from a ditch below) where a dowser will obtain strong signals, corresponding to a magnetic anomaly, as we have proven.

MAGNETIC TRAPS

The dowser can be made to err in cases where the magnetism in the ground is not due to water:

1. Objects encased in iron, unexploded shells, etc., give signals. One often finds that they cause a magnetic anomaly too large (2 to 3 mOe/m) to be attributed to water.

2. Certain rocks, basalt among others, become magnetized after being struck by lightning.

3. Ordinary humus contains a nonmagnetic iron oxide. But if it has been reduced in certain spots by organic decomposition or fire, then we have a magnetic variation: a camp fire in a forest often gives the dowser a signal. One often can detect tombs, either because of this mechanism or because of the deformation of a system of electric currents.

EXPERIMENTS WITHOUT AUTOSUGGESTION

In most scientific media, anything which is considered as not having a basis in physics is attributed to autosuggestion. Nevertheless, the fact that the dowser is sensitive to a magnetic field can be verified in practice by asking the dowser to indicate the presence or absence of a field controlled without his knowledge. This is possible if one employs the magnetic field of coils and the current is alternately turned on and off, with every precaution taken to prevent the dowser from knowing if the experimenter has turned the current on or off. Figure 3 indicates the field which is established around such a frame. We have described such experiments[3] and shall summarize them briefly:

1. It is necessary to find a site 12 to 15 m in length which does not give a magnetic signal.

2. Along the length of the rectilinear path which the operator follows, a frame is placed on an easel. The frame is about 50 cm by 100 cm, is wound about 100 times with fine wire, and is fed by a current of a few milliamperes. It produces a few millioersteds in its center and a few tenths of a millioersted at a distance of 1 m in front of it, the approximate distance at which the operator passes.

3. In following his path, the operator, walking at normal speed (1 to 1.20 m/sec), passes through an anomaly of a few tenths of a millioersted in $1\frac{1}{2}$ to 2 sec.

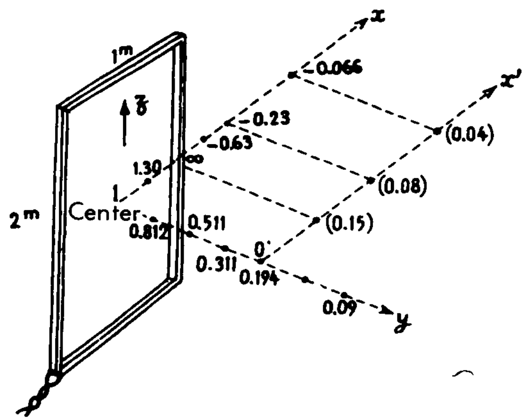

Fig. 3. Magnetic field of a 1 × 2 m rectangular coil. The field in the center is taken as unity.

4. After he is trained to hold his rod for 15 or 20 sec, he is made to pass back and forth and told that the current is now on. He shows that he detects it, and thus becomes accustomed to the field. A second run is made, and he is told this time that the current is off. He indicates that he does not sense anything. He is then made to go back and forth without knowing whether the current is on or off.

Under these conditions a good operator is never wrong, if he is not overworked. A series of 5 or 6 experiments comprising 30 to 36 passages is acceptable. However, in these experiments one never observes the irresistible signal often obtained on the ground. This irresistible effect is obtained if we place two frames in series about 3 m apart and allow the operator to pass before them in succession. This shows that the duration of the influence (1 or 2 sec) of a single frame is too short and that the effect is greatly increased by letting the forces integrate over a period of time.

CONSEQUENCES FOR BIOMAGNETISM

We consider it established that the dowser while walking reacts to a variation of 0.3 mOe/sec. We also carried out experiments in which the field was varied with time and the dowser remained immobile, but we do not wish to discuss them here. They are not absolutely equivalent.

One important point is that most persons are sensitive. It is necessary only that the person should be willing to learn how to hold the divining rod. Furthermore, when they are initiated, their first sensation must come from a good signal, with no possibility of autosuggestion. We found:

1. A good dowser is not sensitive to a much weaker gradient than a poor dowser, but he has a more rapid and accurate reflex.
2. One observes between the palms of the good dowser's hands an electrical resistance $\frac{1}{3}$ or $\frac{1}{4}$ that of the poor dowser. This is lessened if his hands are moist.
3. Certain very talented subjects can detect while standing still, observing a trembling of the divining rod.
4. These very talented subjects may perceive a small electric tingling in their palms during the signal.
5. It is much more difficult to determine the reality of the signal with a pendulum than with a rod. However, we think that the pendulum dowser detects approximately the same gradient as the rod dowser.

It appears that physiology has not yet attained a level at which explanation can go very far. However, we shall risk a few remarks from the point of view of physics.

a. Let μ be the magnetic moment of a molecule in the human body, and let H be the strength of the geomagnetic field (0.47 Oe). The energy μH is very small compared to kT ($k = 1.38 \times 10^{-16}$), the energy per degree of freedom in a molecule. It is impossible that sensitivity to a magnetic field would be caused by elemental effects. For example, a photon $h\nu$ causes a detectable photoelectric effect, with an energy much greater than kT. With regard to the sense of hearing, the kinetic or potential energy which can be detected by the tympan at the threshold of audibility is also considerably greater than kT.

b. The chest and arms of the dowser advancing in the magnetic anomaly will present living electrical circuits, which are the seat of an induced emf. One can calculate the emf; it is less than a microvolt. Moreover, this induction effect has a vector character. If the dowser were sensitive to it, he could act like a compass and find the direction of the field. This is absolutely not the case. The sensitivity of dowsers can therefore not depend on an induced emf.

c. On the other hand, nuclear magnetic resonance is an effect which would appear to have possibilities.

The nuclei of atoms are magnets on the one hand (magnetic moment μ) and gyroscopes on the other. The earth's magnetic field gives rise to precession of the nuclei; the precession rate is characteristic of the field, for example, 2000 rps for a proton and 0.48 Oe. Should the dowser be in a nonuniform field, some of the protons in his body will have a speed of 2000 rps, others 2001, corresponding to a variation of 0.25 mOe. These protons are fixed in the bones and muscles and mobile in the blood. They have, on the other hand, a relaxation time sometimes short, sometimes long (many seconds), depending on the molecules to which they belong. The circulation of the blood causes waves of mobile protons to come in contact with the fixed protons or other systems of molecules, beating at a frequency of $2001 - 2000 = 1$ cps. No matter how weak this is from one proton to another, it becomes evident when the volume is considerable.

If these vibrations (beats) play any role in living matter, for example in reducing muscle tone, this would suffice to cause a movement of the divining rod if it were in an initially unstable position.

The noticeably long hysteresis of the dowser's reflex could well be explained. Too strong a magnetic gradient could not be detected because it would produce too rapid a beat. It can also explain the fact that the movement of the dowser produces significant effects in a gradient. Even if the dowser is standing still in a magnetic gradient, the blood circulation may produce a beat which he can detect if he is very sensitive. On the other hand, the increased effect of a prolonged or repeated stimulus is explained equally well.

The consideration of a possible intervention of nuclear magnetic resonance is very attractive. In addition, it is not a vector effect, the speed of the nuclei depending on the absolute value of the magnetic field and not on its orientation. This agrees again with what we observe with the dowser.

Nevertheless, it is still not known how the physiological functions of the complex molecules of living matter, muscle contraction for example, are disturbed by a phase disorder in the rotation of the component nuclei under the action of a magnetic field.

Whatever it is, the curious phenomenon of the dowser's reflex, inasmuch as it is caused by a small magnetic variation, obliges us to consider wholly new possibilities for magnetic action on living matter.

REFERENCES

1. Rocard, Y., Le Signal du Sourcier, Dunod, ed., Paris, 1964.
2. Abbe de Vallemont, L. L., Occult Physics; or a Treatise on the Divining Rod, Paris, 1693.
3. Rocard, Y., Science Progrès–La Nature, No. 3343, pp. 468-472, November, 1963; (see also reference 1).

Chapter 3

Proposed Mechanisms for the Navigation of Migrating Birds

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The question of how migrating birds find their way when flying at night at great altitudes or in clouds, when no geographical landmarks can be seen, is an old puzzle. The hope of gaining new ideas for the guidance of intercontinental missiles has prompted the armed services to expend considerable research efforts on this quest. The number of papers dealing with this subject is quite impressive, but no final answer has yet been found.[1] In the following, two hypotheses are proposed. One of them is a new mechanism, the other a physical phenomenon so far not considered in relation to bird migration.

WING FLAPPING AS d-c TO a-c CONVERTER

In a conductor which moves in a magnetic field, electromotive forces are generated which are perpendicular to the direction of motion and to the field direction. Their strength in volts is given by emf $= Hv \cos \alpha / 10^8$, where H is the field strength in oersteds, v the velocity of the conductor in centimeters per second, and α the angle between the velocity and field vector. When a conductor of finite size is moving at constant speed in a homogeneous field whose direction does not change (that is, in a field with zero gradient and zero curl), as is the case for the geomagnetic field at a great height above the ground, these electromotive forces are compensated through the polarization of the conductor. A polarization current will flow whenever the emf changes due to a change in the direction of the velocity of the conductor relative to the magnetic vector. Intensity and duration of these polarization currents depend on the time derivate of the emf and on the electric resistance and capacitance of the conductor.

Living matter can be considered as a second-class conductor. The capacitance of a bird 5 in. long and 2 in. in diameter is about 10 $\mu\mu$F, and with a wingspan of 1 ft the capacitance of the wing ends could be