# Magnetic Hallucinations

by Maurice Townsend

**There is now so much laboratory evidence in favour of magnetically induced hallucinations that some paranormal researchers are taking it as read that they are the source of certain anomalous experiences, notably some kinds of ghost. However, the field evidence for such magnetic fields is slight at present. But that could soon change as equipment capable of detecting them is now being deployed at haunted locations. If these magnetic fields exist outside the laboratory, what exactly is causing them?**

There have been several articles in *Anomaly* recently concerning theories on the true nature of ghosts. In particular, there has been a lot about the possibility that they may be hallucinations induced in susceptible people by suitable ambient magnetic fields. While the results of lab experiments are impressive and compelling, there is still little evidence from the field to back this theory up. Initiatives like MADS (described in *Anomaly* 34) are designed to fill that gap. It will, at last, be simple to measure relevant magnetic fields in allegedly haunted locations.

An important question concerns the detailed nature of any such fields found at haunted locations for MADS to research. They are unlikely to be just like those produced artificially in the laboratory, so we need to investigate what they really 'look' like in the field. Once we know that, we can try to ascertain what aspects are absolutely necessary for strange experiences to occur.

Once such fields, and their principal components, have been identified then the next intriguing question becomes, 'where do they come from'. At first sight, there seem few obvious sources for such fields, perhaps explaining why ghosts are not common. I decided to research the possibilities so that the search could be narrowed down. I hope this will assist investigators when they are researching possible field sources in haunting cases.

## Defining the Fields

Before we can identify possible sources of relevant magnetic fields, we need to define exactly what we are looking for. I am indebted to Dr Jason Braithwaite for reviewing the relevant papers (from Persinger *et al*) concerning the laboratory experiments which have induced ghost-like hallucinations.

The best results have come from what could be broadly described as weak, complex, time-varying magnetic fields. Because the nature and potential sources of such fields are difficult to characterise at this stage, Braithwaite introduced the general term Experience-Inducing Fields, or EIFs for short (see the series of previous articles in *Anomaly*). This definition relates to all, or any, fields that could have experience-inducing properties. This distinction is helpful for a number of reasons. Firstly, while not all magnetic anomalies will have implications for experience, some will have the ability to influence equipment (which could be interpreted as paranormal) but will not alter the operation of the brain in any way. Those fields could be characterised as Event-Related Fields (ERFs) as they pertain to a tangible physical event. Secondly, it focuses the researcher theoretically on the potential relevance such fields might have.

There are three main aspects to EIFs that have been demonstrated experimentally to be of crucial importance. The following figures are by no means absolute limits: things might happen outside them. However, experiments within these bounds have produced reliable, strong results. So it makes sense to look for fields within these parameters first, at haunted locations.

At present, the evidence suggests that EIFs are varying magnetic fields with low frequency (approx 0.1 to 30 Hz, and certainly under 50Hz) and a moderate intensity (from 100 to 5000 nT) or amplitude (or, more correctly, flux density). For comparison, the average geomagnetic field, which is not generally considered strong and does not vary greatly over time, is around 50,000 nT. An important point to remember is that EIFs are most likely to overlay whatever ambient static magnetic field is present in the area. This would usually be the geomagnetic field itself. Confusion often arises here because the geomagnetic field is usually described as being 'static' (ie. does not change over time), whereas, in fact, it does change over time, but very slowly (over hours). There might also be other local permanent distortions to the local magnetic field, such as the presence of the mineral magnetite in the geological strata below the site. At present, such permanent static fields are NOT considered important to inducing hallucinations, however. Therefore, EIFs, if present, would most likely appear as fluctuations on top of the local static field (though see discussion below).

There is another important factor that greatly enhances the chance of hallucinations: field complexity. This is more difficult to characterise. As an example, a typical laboratory experiment may use a simple 30 Hz sine wave field but pulse it for, say, 1s every 3s for a period of 30mins (during this time the field may also vary in amplitude across the pulses as well). Thus, the field fluctuates overall, in addition to the fundamental sine wave. Such overall variance could involve any, or all, of the major field variables: amplitude, frequency and direction. Laboratory studies have used amplitude-modulated, frequency-modulated and complex pulse-patterned sequences with great success. Overall field variations might be repetitive, with the field eventually returning to its original state after a certain period, or they may be chaotic with no obvious repetition. The time period over which fields need to vary is probably (from experiments) in the millisecond to multiple minute region. Simple continuous waveforms, like sine waves, are not at all as effective. The reason for this is that such simple fields are considered not to ‘contain’ the complex information profile that a brain would accept as sensory information. Incidentally, the direction of a magnetic field (which is conventionally said to flow from the north pole of a bar magnet to the south pole) determines which way it will produce a force on another nearby magnetic object.

There are two other important issues concerned in producing magnetic hallucinations, not directly related to the field characteristics. The first is that not everyone is susceptible to hallucinating when subjected to the EIFs outlined above. Current estimates suggest that only around 20 - 30% of the population show a substantially increased susceptibility, due to increased neuronal instability in specific brain regions. Secondly, susceptible people need to be subjected continuously to the EIFs for a significant time, say 20 to 30 minutes, before hallucinations are reported. This applies if the person is static. I will mention people moving around in fields later on. There is, therefore, an important exposure component to EIFs – the effects are not instantaneous.

The hallucinatory phenomenon is thought to arise because the frequency of the external magnetic waves is similar to that used internally by the brain for cognition. This stimulates brain activity, through a process called neural entrainment, which can confuse the brain into producing hallucinations (see ‘Magnetic Fields and the Brain’, this issue).

The table below summarises the factors involved.

| Factor | Magnitude |
|---|---|
| Magnetic field frequency | 0.1 to 30 Hz |
| Magnetic field amplitude (flux density) | 100 to 5000 nT |
| Time varying 'complexity' | 1ms to 100s+ period |
| Brain susceptibility | Some 20 - 30% of the population |
| Length of exposure to EIFs | Over 20 minutes [if static] |

## Naturally Occurring EIFs

Could fields with the relevant characteristics occur naturally? The first obvious place to look is the geomagnetic field. This is the magnetic field that is constantly present at the Earth's surface and in which we are all immersed continuously. It is what makes a compass point north. It is caused by a dynamo effect in the molten core of our planet. Though this effect produces a highly stable field, like that of a bar magnet, the field is constantly changing, primarily due to the effects of the sun impinging on it. The sun is constantly bombarding the Earth with the solar wind, which consists of highly energetic, charged particles. These interact with the geomagnetic field and cause changes reflecting the sun's own activity. Features such as solar flares can have a major effect on the geomagnetic field. The most significant changes to the geomagnetic field take place over periods of hours. Thus, from a human perspective, the geomagnetic field appears relatively stable.

The geomagnetic field might appear, given its slow variations, an unlikely candidate for EIF, at first sight. Having said that, there have been some studies that have reported correlations between geomagnetic activity and the occurrence of spontaneous hauntings. These correlational studies did not involve field investigations and are considered controversial. As any statistician will tell you, a correlation does not always imply a causal link.

There are certain geomagnetic variables that change at frequencies required for EIFs. Unfortunately, it turns out that these variables, though they have relevant frequencies, are far too weak to produce EIFs, as shown in the table (Campbell, 2003).

| **Factor** | **Typical frequency** | **Typical Amplitude** | **Comments** |
|---|---|---|---|
| Pc1 pulsations | 0.2 - 5Hz | 0.1 nT | Pc = pulsation continuous, caused by magnetosphere processes |
| Schumann resonances | 7.8, 14, 20, 26Hz | 0.05 nT | Caused by lightning energy resonating between the earth and ionosphere. |
| Atmospherics | 5 - 100+ Hz | 0.05 nT | Caused by distant lightning |

Geomagnetic storms can bring larger amplitude changes in the geomagnetic field. A storm is defined as a period (usually of several days) when there is a large reduction in the horizontal component (parallel to the ground) of the geomagnetic field. On average, one big geomagnetic storm per year might bring a field reduction of around 250 nT, but most will be much less (maybe 10 per year bringing about 50 nT reduction). Therefore, only the largest, most infrequent storms have the sort of amplitudes we are looking for in

EIFs. However, these changes typically occur over hours, or minutes at the fastest. Even the Pc1 pulsation component of the geomagnetic field, which has the correct frequency, varies only by a maximum amplitude of a few tenths of one nT (Belyaev, 2003). In summary, there are no natural variations of the geomagnetic field that provide both the amplitude and frequency together to be classed as EIFs, even during geomagnetic storms. Indeed, as we will see later, most of us live in an environment where such natural magnetic variations are entirely swamped by more powerful local artificial sources. So the geomagnetic field can, effectively, be dismissed as a likely source of EIFs.

Another natural source of EIFs that has been suggested is tectonic strain. Essentially, the Tectonic Strain Theory (TST) states that stresses within the Earth's crust, less than those required to produce an earthquake, may result in highly localised surface electromagnetic disturbances through piezoelectricity in sub-surface rocks. Piezoelectricity is the phenomenon whereby certain crystals, notably quartz, produce an electric charge across opposite crystal faces when under physical pressure or strain.

The TST is the reason why many ghost researchers these days get excited if a geological fault lies near an allegedly haunted location. A fault is a crack in the Earth's crust. Like any crack in a solid object, it is an indicator of strain, or pressure for movement, in the local area. Strain generally builds up around a fault until it is released through a physical movement (usually) underground, resulting in an earthquake. Thankfully, the vast majority of earthquakes are, in fact, tremors and are so small they are only noticed by seismologists using sensitive equipment.

The TST looks attractive, in principle, but it does have its critics. I have always had problems understanding it, when considering the physical details of the processes involved. Quartz generally occurs underground within other rocks, like granite, where its crystals are separated by other minerals. If you crush granite, an electric charge will build up across individual quartz crystals. However, since the crystals are orientated randomly, the charges (on opposite sides of each crystal) do not align. Therefore, they tend to cancel each other out rather than combining to form a strong overall electric field. There is a tiny overall field where stressed granite (under strain from lateral stress near a fault) is exposed at the earth's surface, due to the fact that there are no crystals above the surface to completely cancel the field. But it is very small indeed.

Another problem that arises is that any electric field that might conceivably be produced by straining quartz underground will, in any case, be static. There is no movement (except for extremely slow tectonic movement, usually measured in mm per year) in the rocks and so no change in any field produced. This means there could be no magnetic field. In order to get a magnetic field you need to <u>move</u> electric charge through an electric field (such as when current flows down a wire). With no physical movement, there is no magnetic field.

Things change dramatically if the rock fractures, as has been demonstrated in granite crushing experiments (Zhu, 2001). Then, measurable electric (and magnetic) fields can be generated, through both the piezoelectric effect and something called seismoelectric conversion (caused by acoustic waves). The effect is amplified by the presence of water. While this process produces magnetic fields, you have to bear in mind that it involves the rock fracturing, not simply getting strained. There is little or no evidence for underground rock fracturing, even near faults, except during and immediately prior to an earthquake (Robb, 2005).

We do have some measurements of the kind of magnetic fields that might be produced by rock fracturing immediately prior to an earthquake. As a method of predicting earthquakes it is controversial, but the evidence does exist. One of the best known examples was the Loma Prieta earthquake in California in 1989. This was preceded by a weak (up to 60 nT) magnetic field with low frequency (0.01 to 10 Hz) up to 55 km away from the epicentre and three hours prior to the quake. However, even this field is not quite up to the strength required for an EIF and it took a 7.1 magnitude earthquake to generate it.

A further problem with TSTs is the very specific locality of the phenomena they set out to explain. In particular, the phenomena are often restricted not just to a single house but to particular rooms or even parts of rooms (sometimes in upper storeys). Houses nearby are seemingly unaffected. It seems unlikely that widespread tectonic strains could give rise to phenomena localised to just a couple of metres. However, it is possible that environmental factors within a house may amplify (or even attenuate) more widespread field disturbances. Also, a house may appear haunted, though next door does not, merely because an EIF-susceptible person lives in one and not the other.

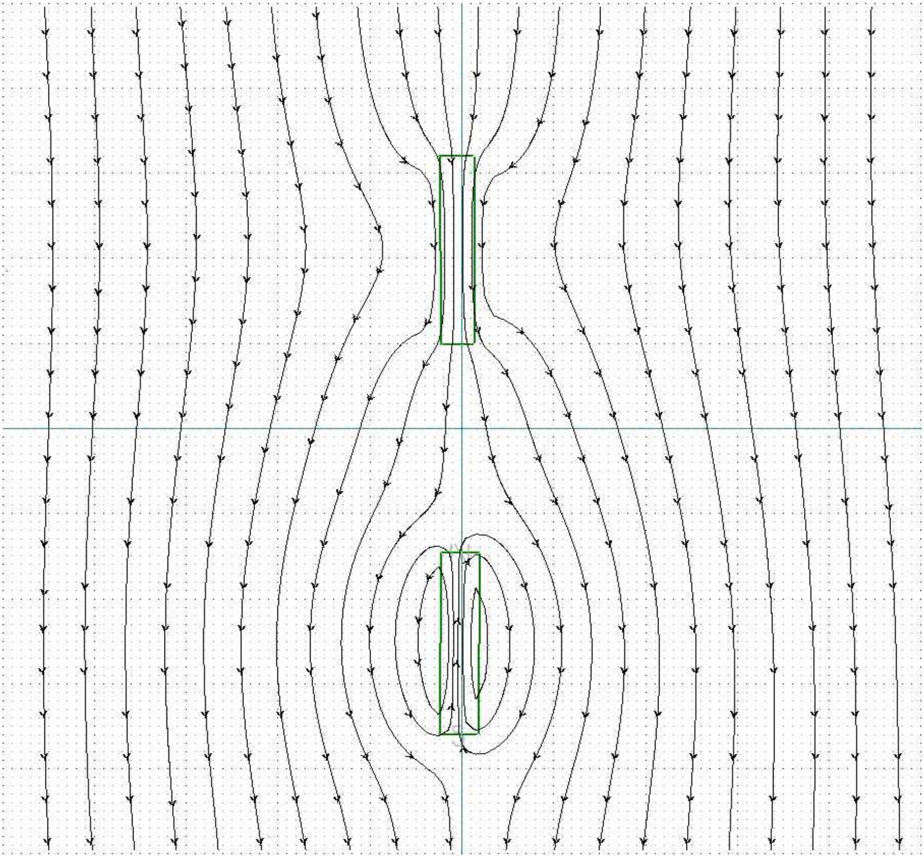
In spite of these problems, I will outline later a variation on the TST that might make it work better than the existing one.

## Artificially Occurring EIFs

In a paper on the electromagnetic environment around Moscow (Belyaev, 2003), it was found that the magnetic fields at frequencies around 1 Hz were around 10 times higher in the suburbs, and 100 times higher in the city centre, compared to the countryside. In the city centre fields up to 250 - 300 nT at a frequency of 0.5 Hz were measured. These are strong enough to constitute EIFs. The fields were attributed, unsurprisingly, to electrical equipment in the city. This indicates, quite eloquently, that we should probably look first for artificial sources of EIFs in investigations before looking for, generally weaker, natural alternatives.

Artificial sources contribute significantly to the magnetic fields in a domestic environment, as a quick survey with an EMF meter will show. However, the 0.1 to 30 Hz frequency range of varying fields is generally quiet. This is because most electrical and electronic devices operate using a mixture of DC (for motors, electronic power supplies, etc.), mains frequency (50/60 Hz) and higher. The DC (static) element is rarely pure, being derived from mains supply with rectifiers (often accompanied by transformers). The resultant DC current has a slight voltage ripple on it. However, due to the way rectifiers are designed, this ripple will typically be at mains frequency or above and so not contribute to EIFs. Similarly, the mains supply itself can be distorted by the electrical loads placed on it by various bits of electrical equipment. This gives rise to harmonics but these, too, have a higher frequency and lower amplitude than the mains fundamental frequency. So most domestic electrical appliances, as well as the mains supply itself, will not contribute to EIFs.

Probably the most important source of low frequency magnetic fields is the simple movement, or mechanical vibration, of magnetic materials. By magnetic materials I mean metals with a high magnetic permeability. This means that magnetic fields prefer to flow through them, rather than through the air. Common examples include objects made of iron and steel. The object itself does not have to be magnetised, so long as it has high permeability. You can



*An unmagnetised HMP (top) distorts the geomagnetic field nearly as well as a weak magnet*

test if an object is highly permeable by seeing if a magnet is attracted to it. It may, or may not, be able, in turn, to attract other bits of unmagnetised steel (eg. paper clips) to itself. All objects with high magnetic permeability (let's call them HMPs, for short), whether magnetised or not, distort the earth's magnetic field around them. In the accompanying figure you will see two objects, one weakly magnetic, the other merely highly permeable. Both distort the surrounding geomagnetic field dramatically. When such objects are vibrated, they drag the magnetic field distortion around with them.

To produce an EIF frequency disturbance in the ambient magnetic field, all we need to do is vibrate an HMP at a rate of between once every ten seconds (0.1 Hz) and thirty times a second (30 Hz). It doesn't need to be a constant frequency motion since, as we have seen, varying fields actually work better! The distortion to the ambient magnetic field will move in sympathy with the movement of the HMP, so inducing an EIF frequency change.

The possible examples of such moving HMPs in the domestic environment are almost endless. A sheet of corrugated iron vibrating in the wind, an iron bedstead shaken by nearby heavy traffic, a steel filing cabinet in a seaside office swayed gently by the crashing surf. Anything made of a suitable metal, whether magnetic or not, vibrated at a suitable frequency, will give us the EIF frequency disturbance. Whether it attains a suitable amplitude for an EIF depends on the degree of vibration of the object and the amount of distortion the HMP brings to the ambient field.

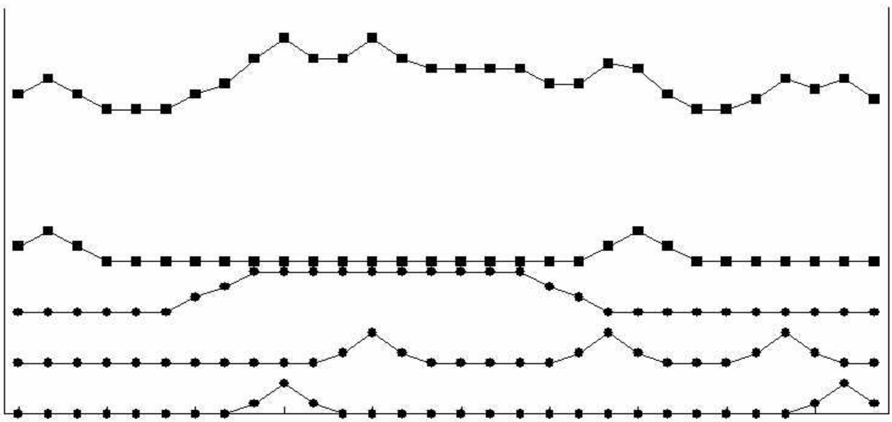
As well as bits of metal, there are also machines that can act as moving HMPs. An electric motor can be imagined as a permanent magnet being rotated, pole over pole, between the opposing poles of two other permanent magnets. In the real world, all the magnets are electromagnets but the effect is the same. A rotating magnetic field will be produced with a frequency reflecting the rotation rate of the motor's armature. Most motors in domestic use are likely to produce rotating fields at EIF frequencies. That's because few will go round faster than 1800 rpm, which equates to 30 Hz. In addition, DC motors may spark where brushes meet the commutator. This would introduce a sharply pulsed field, at twice the frequency of rotation, which might still be low enough to contribute to an EIF.

There are many motors used in the domestic environment. They commonly occur in such things as pumps (central heating, fridges, air-conditioning), fans (computers, air-conditioning, some ovens), washing machines, vacuum cleaners, even hi-fi equipment and hair dryers. Such appliances can produce quite powerful rotating magnetic fields.

Vibrating HMPs may produce the right frequencies, but will they give us the right amplitudes for people nearby? It comes down to your physical distance from the source of the field disturbance. Assuming the amplitudes exceed minimum EIF level at their source, there is bound to be some critical distance, or zone, away from the source where the field amplitude will be correct. All you have to do is stay in that critical area for long enough and, if you are susceptible and the field varies enough over time, you may well get hallucinations. It is difficult to predict how far such a zone would extend without doing experiments. Magnetic fields decline quickly away from their source, falling with the inverse square law. As a guess, I would say EIFs would probably extend no further than a metre or two from a source likely to be encountered in a domestic situation, assuming the average geomagnetic field as a background. If there was a higher than usual ambient magnetic field, the range would decrease. Conversely, in an area of lower than usual ambient field, the range would increase. One might reasonably ask, how can you live in an area of lower than normal geomagnetic field? HMPs can distort the local magnetic field, as we have seen, and create areas where the local magnetic field is actually lower than average. Such HMPs would, obviously, not need to be moving to produce such an effect. This is the principle behind magnetic shielding. The magnetic field is 'dragged' into the HMP, so attenuating the ambient field around it. A place where the ambient field is low could be particularly promising, as it would require less of a field distortion to produce an EIF.

Interestingly, the degree of distortion caused by HMPs to ambient fields depends on such things as the shape of the source and its angle to the field, as well as the permeability and magnetisation of the metal. Long thin HMPs (like sheet metal) and curved ones (think of a horshoe magnet) disrupt the local magnetic field more than short, fat ones. Also, HMPs aligned with the ambient field will produce a larger effect than those at right-angles to it. Note, also, that the presence of vibrating HMPs would mean that hallucinations would only be experienced in quite small areas inside a house. This would fit in with the often observed fact that only certain rooms, or even particular spots, regularly produce ghosts.

Another possible source of EIFs is combined magnetic transitions in mains frequency equipment. There are many pieces of electrical equipment that can produce such magnetic transitions. Though transitions are not EIFs in themselves, if you get enough of them in a small area, over a short period of time, they could have the same effect. By a transition, I mean a significant, slow (by electronic standards) change in the mains frequency magnetic field produced by electrical equipment. This would appear to a DC magnetometer (insensitive to mains-frequency) as a pulse. A transformer, for instance, though it operates at mains-frequency, takes time to become fully energised or drained (because the magnetic field induced is resisting the current change) when it is switched on or off. This produces a change in the magnetic field slow enough to be 'seen' by a DC magnetometer. Another example is a relay, which contains an electromagnet. When a relay is switched on or off, a static magnetic field will either rise or fall, producing a magnetic transition. Transformers and relays are common in the supply and switching sections of domestic electrical, and particularly electronic, equipment. Electrical house wiring may also show transitions (though not as powerfully) when equipment downstream is switched on or off or has a changing load.



*Transformers and a relay (middle curve) combine transitions to produce seemingly chaotic fluctuations (top curve)*

In the accompanying illustration you can see three imaginary transformers powering on and off, as well as a relay being operated once. The transformers only produce brief pulses, as explained above. The relay, by contrast, maintains a steady magnetic field, while on. The picture shows the way a DC magnetometer would ‘see’ the resultant magnetic fields. The top line shows the net fluctuations in the ambient static (DC) field. It looks, more or less, chaotic and could, with suitable frequency and amplitude, constitute an EIF.

In a house with lots of electrical equipment in use there may sometimes be enough pulses, close enough together, both in space and time, to constitute EIFs. If there are a few vibrating HMPs about as well, so much the better. It might seem unlikely that you would get enough pulses to constitute an EIF this way. But consider this, you only need one 100 nT pulse every ten seconds to qualify! As more and more electrical devices are operated in a house at once, the combined fluctuations will show a rise in amplitude and frequency as well as appearing increasingly chaotic.

Another important, though rarer, possible artificial source of EIFs is malfunctioning electrical equipment. This could include the mains supply itself. There are only a few ways most bits of electrical equipment can operate correctly, but any number in which they can malfunction. Therefore it is difficult to list particular examples of malfunctioning equipment producing EIFs. In general, though, accidental capacitances and inductances could possibly, in certain circumstances, give rise to low frequency currents (and hence magnetic fields). Fields can leak, unintentionally, from electrical equipment to nearby conductors (such as water pipes) through induction. Though these would be at the mains frequency, there might be resonances set up by the plumbing configuration that could be at a different frequency, possibly lower. Earthing problems are another possible source of unintentional fields. As I said before, it is difficult to come up with a concrete example, but it might happen and should be considered.

Of course, you may just happen to live in a magnetically dense area. As we saw with the unfortunate inhabitants of central Moscow, some places may be bathed perpetually in a sea of fields that qualify as EIFs. There may be nearby industrial users, such as factories, that could produce EIFs through HMPs and densely packed electrical equipment. So artificially produced EIFs may be outside the premises that are allegedly haunted. You should not assume EIFs are produced naturally just because they have no obvious source inside a house.

Another interesting source of EIFs is human movement! Although you may not have any moving fields within your home, you might move through reasonably strong, complex static fields sufficiently often to produce an EIF in your brain. If you think about it, walking between two areas of high magnetic field, with a low area in between, is no different from having a varying field pass through your head as you sit still. Given that you need to be exposed to such varying fields for some time, however, it might involve a lot of walking! It should be considered, however, particularly in a workplace that might well combine a lot of walking and a complex static magnetic environment.

## The Tectonic Strain Theory Revisited

A scientist called Friedemann Freund (of San José State University in California) has suggested that electric charges could be induced to flow by applying unusual pressure (through tectonic stress) to igneous rocks (normally insulators), turning them temporarily into semi-conductors (Enriquez, 2003). He has done experiments, crushing rocks, to demonstrate this effect. When the rocks are turned temporarily into semiconductors, holes (positively charged discontinuities) can flow rapidly through the rocks and might even reach the surface. The charges are conducted underground both by rocks, in their semi-conductor state, and by water.

Such moving charges would generate magnetic fields. It is thought these would be low-frequency fields, though there is no prediction, as yet, concerning exact intensity or frequency. The whole idea is still very new, but it could possibly result in natural EIFs near tectonically strained areas around geological faults. The strengths of the theory are that the electric charges are not cancelled out and that they move around (unlike the piezoelectric theory), so producing magnetic fields. The theory is still being developed, but it looks promising. Researchers should still, therefore, investigate local geology (particularly the presence of faults and igneous rocks, such as granite, diorite, gabbro, basalt, etc.) thoroughly in their investigations and see if any EIFs detected can be traced to an underground source.

## Detecting EIFs

Unfortunately, the equipment required to detect EIFs satisfactorily is not cheap. That explains the lack of convincing field evidence to date. To have a chance of detecting EIFs, you will need a sensitive magnetometer capable of giving a flat response to fields from 0 to 30 Hz. You will also need to be able to sample the field sufficiently frequently to capture waves up to 30 Hz (requiring 60 samples a second). In practice, it would be better to sample waves up to, say, 100 Hz to include mains frequency (50 Hz). So a sample rate of 200/s or better is required. You will need to sample for extended periods of time (hours) to capture any time variance in the field. The magnetometer should be sensitive to changes down to 50 nT (and preferably 1 nT) to capture waveforms accurately. In addition, it should measure over three axes simultaneously. This allows the whole field to be sampled accurately.

A suitable setup would be a tri-axial, fluxgate magnetometer linked directly to a computer recording device. Fluxgates are most suitable and typically operate from DC upwards and give a good, flat response at low frequencies. In fact, you'll need something very like the MADS system. Unfortunately, many of the cheaper EMF meters on the market are not suitable for scientific measurement of EIFs. Many are deliberately frequency-biassed towards mains frequency as they are designed to measure electromagnetic pollution. They rarely cover the sub-mains frequencies accurately. Some only register changes in the ambient magnetic field and so do not allow absolute amplitudes to be measured. In addition, few such meters respond quickly enough to field changes or allow attachment to a computer.

Once you have such a system, capable of making useful measurements, you can compare places where ghosts have been reported with others nearby where they have not. Assuming you find an EIF, you can then attempt to identify its, or their, source(s) by doing a survey, plotting readings obtained over a grid layout.

The detectors used on the MADS system may be within the financial reach of enthusiastic groups or individuals. In fact, the company that makes the MADS sensors also produce another suitable sensor at a considerably cheaper price with a slightly lower specification. Anyone obtaining such an instrument could greatly help in serious research in an, as yet, poorly explored area. Such field investigations are incredibly simple to set up (it's all done by computer) and non-technical researchers should not be put off, as ASSAP will provide support with these studies. If you are thinking of obtaining your own MADS system, please get in touch beforehand as each unit is custom-built and you will need details for appropriate settings. These settings are permanent to the sensor and cannot be altered after manufacture, so do get in touch beforehand. Please email the *Anomaly* editor for details.

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