9

Mysteries Before Earthquakes

The Behavior of Electric Appliances

Second hands of clocks were reported to have rotated rapidly before the Kobe, Izmit and Taiwan-921 earthquakes and also to have moved backwards. Obviously relativity theory is not a factor! Some have suggested that the *Alice in Wonderland Syndrome*—a vision disturbance disorder—might be responsible, but EM waves may account for the phenomenon. Above: An illustration of the Mad Tea Party by John Tenniel in *Alice's Adventure in Wonderland,* by Lewis Carroll.

9.1 Introduction

The electronic age has added a new category of earthquake precursor reports to the ancient legends.

They are accounts of odd behavior and noises from domestic electric appliances: TVs, radios, clocks, refrigerators, mobile phones, fluorescent lamps, car navigators, and possibly computers. The reports came in independently from Kobe, Izmit, and Taiwan before the large earthquakes of 1995, and 1999 and are described in more detail in Chapter 2.

Interestingly, exposure of some of these appliances to EM pulses in a laboratory reproduced the behaviors described in the reports: clocks stopped, or their hands rotated rapidly; fluorescent lamps lit up, radios went dead, or produced static; color shifts and speckle noise appeared on TV screens, or sets fluctuated between channels; refrigerator compressors switched on and off producing odd sounds; cellular phones illuminated and rang but no record of any call was left; the needle on a magnetic compass fluctuated.

Reports of malfunctioning devices that we did not attempt to replicate in the laboratory setting could just as easily be ascribed to EM wave interference: random self-operation of power windows in cars, spontaneous switching on of air conditioners and intercoms at midnight (five or six hours before the Kobe quake); the apparent sudden switching on of a tape-recorder in Izmit so that a unscheduled call to prayer resonated from a local mosque at 2 a.m.—one hour before the earthquake.

Several reports from slightly earlier than the electronic era are also investigated in this chapter: How was it that nails hanging for weeks from a permanent magnet dropped off two hours before the Ansei-Edo (Tokyo) Earthquake (M6.9) in 1855? Why did iron chains in a military factory begin to swing against each other two hours before the Eastern Nankai (M8) Earthquake in 1944? Why did arc discharges occur between iron bars lying on the ground a day or two before the Tangshan Earthquake in 1976? Why could a man no longer read the phosphorescent numbers on his watch 2-3 days before the Great Kanto Earthquake, but see them again one day later?

9.2 Magnetic earthquake precursors?

9.2.1 Nails falling from a magnet, not a magnetic anomaly!

In 1855 the *Ansei Chronicle* carried a report of 15 cm iron nails that dropped from a big natural magnet two hours before the Ansei-Edo Earthquake. They had been hanging end-to-end from the magnet in a spectacle store for some time as part of an advertisement. The magnet regained its iron-attachment properties after the earthquake.

Attempts have been made to link the anomaly to a change in the earth's magnetic field—but as discussed earlier, the variation in the earth's magnetic field before earthquakes is minuscule; the earth's magnetic field is 0.03 - 0.05 mT, and the change, a few nano-Tesla (nT) or about one ten thousandth of the field (Rikitake, 1986). The surface intensity of a ferrite magnet is tens of mT and that of the most intense permanent magnet made of Neomax (Nd-B-Fe alloy) is about 800 mT. The magnetic field of the natural magnet mentioned in the *Ansei Chronicle* may have been several mT at its surface. The only way to explain the phenomenon as a magnetic one was to argue that a large magnetic field variation had occurred before the earthquake. This was not credible, so the story came to be regarded by most geophysicists as a misleading anecdote, though there were two similar European reports (Rikitake, 2000).

Attempts to link the interrupted magnetic contact to the arrival of seismic P-waves does not stand up either, as they dropped off two hours before the quake. Had they fallen 20 seconds beforehand, the effect could plausibly have been argued to be a P-wave effect, since the epicenter was about 160 km away from the store. However, the story may be explicable as an electric effect.

Electric discharge experiment:

Several nails were attached to a magnet hung from a pole made of plastic LEGO blocks (See Figure 9.1). The floor under the LEGO construction was covered with aluminum foil, which was connected to the high voltage sphere of a Van de Graaff generator. When the high-voltage Van de Graaff sphere was electrically charged, the nails repelled each other. When the voltage was turned on and off (to simulate EM pulses of ULF waves) the iron nails began to swing increasingly, and finally dropped off.

Explanation:

Electric induction by EM pulses:

The iron magnet and nails acted as an electrode when the aluminum foil was charged up. Electrostatic induction generated a charge on the nails and an attractive force was formed between the ground and the nails. The nails, charged at their tips with the same electrical charge, repelled each other. When the charge was removed from the floor, the nails returned to their original position. When it was applied and removed several times, the nails began to swing, became unstable and dropped off.

So the nails that fell from the magnet at the spectacle store two hours before the Ansei Earthquake may have been responding to electric charge appearing on the ground, and not to changes in the Earth's magnetic field or to land tilting. This transforms the tale from a magnetic anomaly to an electrical one.

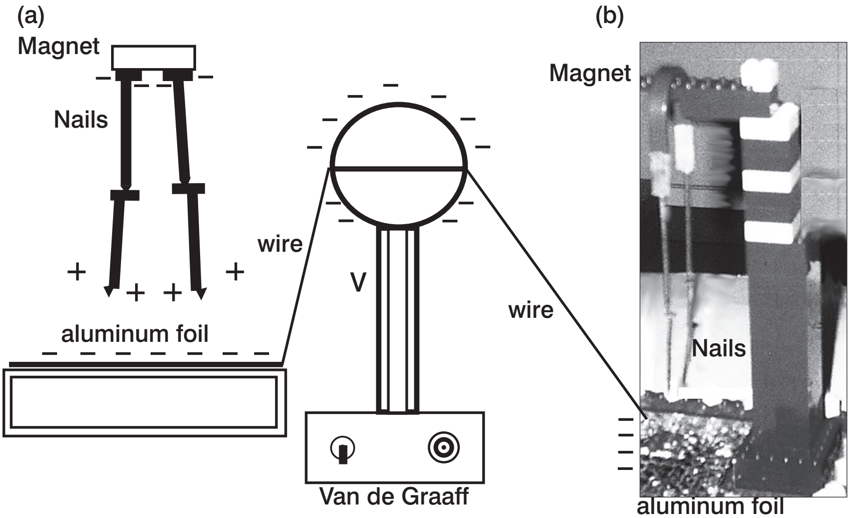

Figure 9.1 The induction of opposite charge at the nail tips made them drop off a magnet—as they did two hours before the Tokyo Earthquake (M6.9) in 1855. The opposite charge was induced by the appearance of negative charge on ground aluminum foil connected to the high voltage sphere of a Van de Graaff generator. (a) a diagram of the experiment (b) a photograph of the same experiment [See also front color plates and Figure 1.6 (a)].

Attempts have been made to attribute the story in the *Ansei Chronicle* to electrostatic charges produced on the nails by charged aerosol, as was done for a report from a watch repairman in Italy, who claimed a tiny watch mechanism jumped into the air just before an earthquake (Tributsch, 1982). Because the hypothesis of charged aerosol could also explain these results, such an effect was eliminated by placing the magnet and nails in a plastic box to shield them from any ion wind. The iron nails still swung and dropped during nearby electric discharges from the Van de Graaff generator, meaning that electric induction was sufficient explanation for the behavior of the nails.

9.2.2 Disturbed orientation of a magnetic compass

Statements:

Small compass magnets have been said to have fluctuated violently before the Eastern Nankai and other earthquakes. The anomaly has been rather dubiously attributed to cosmic radiation, explained thus:

> *The earth's magnetic field changed before the earthquake so that cosmic radiation penetrated to the non-polar area causing earthquake light similar*

to the auroral light caused by ionization by charged particles from solar flares…

It could be added that odd hypotheses like these appear because no serious attempt is being made to bring science to bear on unusual events before earthquakes. Although the author might also be accused of producing odd hypotheses, his efforts are at least a serious attempt at an objective scientific analysis of precursor reports.

Experiment:

A compass was placed near an antenna and a pulsed field applied. Naturally enough the compass needle moved with the interaction between the magnetic needle and the electric field. When systematically varying low frequency EM sine waves were applied, the needle spun round.

Explanations:

As discussed, changes in the earth's magnetic field before earthquakes are negligible: not enough to draw increased cosmic radiation into the earth's atmosphere, and certainly not in amounts intense enough to cause unusual animal behavior before earthquakes. If that were the case animals would have skin burns, as in overexposure to X-rays or intense UV light.

A change of a few nano-Tesla (nT) in the Earth's magnetic field before big earthquakes is about one ten-thousandth of the Earth's magnetic field. Given the frictional forces impeding rotation of the compass needle, such a small change would not be sufficient to move the needle. The fluctuation is much more explicable as an effect of charges induced by an electric field.

9.2.3 Car navigator: Fluctuating direction arrow

Statements:

Drivers claimed that their car navigators did not function—or malfunctioned—a day before the Kobe Earthquake. In one case the navigational arrow swung 180 degrees from the true in a car in the city of Kobe. Generally navigators did not function normally before and after the earthquake, but returned to normal a month or so later.

Experiment and Explanation:

Modern car navigators are set up to receive satellite signals coded as 0 and 1 to cut out background noise. Electric discharges were made using a Van de Graaff generator near such a modern navigator. Line noises caused by EM pulses were observed on the screen, but there was no fluctuation in the arrow.

When the author spoke to a woman who provided such a report she said that the navigator in the vehicle did not use the GPS system but an older system based on a magnetic compass. Hence, EM waves at low frequency may have been responsible for the change in the arrow's direction on the screen of the navigator, due to an induced electric field.

9.2.4 Mischief by an invisible man?

Swinging iron chains:

Two hours before the Eastern Nankai Earthquake in 1944, iron chains hanging from the ceiling in a military factory began to swing, knocking a nearby electric furnace and making clanging sounds. [This was not coincidental with the vigorous movement of the bubble in the surveying level (Chapter 8).] The phenomenon was reproduced in the laboratory by inducing charge on small iron chains hanging near the high voltage sphere of a Van der Graaff generator. The chains swung towards the sphere.

So it is possible that an intense electric field, presumably electric pulses, may have appeared before the earthquake inducing charges on metal objects so they were attracted to each other, causing swinging in the iron chains.

Arc discharges between iron bars:

A day or two before the 1976 Tangshan Earthquake (M8.2), China, arc discharges were observed between iron bars lying on the ground—as if an invisible man was using an arc-welding machine (Dai, 1996). (A small arc discharge caused by static electricity in a human body may be seen sometimes when one unlocks the car or touches a doorknob.)

An intense electric field is formed between iron bars (electric conductors) if charges appear on the ground. Opposite charges may appear at the ends of the bars producing sparks by atmospheric breakdown at 3 MV/m.

A charge appearing on the ground intense enough to swing iron nails and iron chains and move magnetic compass needles would also explain arc discharges between the iron bars. The charge density of less than one millionth of a Coulomb per square meter on the ground would be sufficient to cause discharges at the sharp edge of iron bars. (This is less one thousandth of the charge necessary to run a small piece of consumer electronic equipment for one second.)

9.3 Unusual behavior of electric home appliances

9.3.1 Faint glow of fluorescent lamp

Statements:

Fluorescent lamps glowed faintly before the Kobe Earthquake (Wadatsumi, 1995). They also lit up spontaneously before the Tangshan Earthquake (Dai, 1996). The author has also seen a faint glow from a fluorescent lamp in a room during a thunderstorm.

Experiment:

A fluorescent lamp held close to the charged sphere of a Van de Graaff generator in the dark, lit up because of the intense electric field. A plastic sheet charged by frictional electricity also produced a glow from a fluorescent lamp (surprising pupils in a lecture on earthquake precursor phenomena). Air-gap discharges between the high voltage sphere and an electrically grounded rod generated pulsed EM waves that also lit up the lamp in a darkened room (Figure 9.2). A fluorescent lamp exposed to EM waves at 1 MHz from a Tesla coil lit up as it also does in a microwave oven. (A Tesla Coil is a high voltage transformer that generates very high voltages at high frequency.)

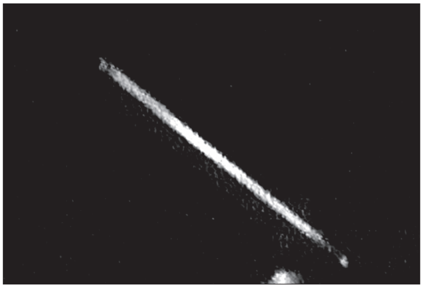

Figure 9.2 A fluorescent lamp in a laboratory lit up when it was exposed to EM pulses, as fluorescent lamps have been reported to do during thunderstorm lightning and before earthquakes.

Explanation:

In a suitable environment, EM waves from thunderstorms (produced by atmospheric lightning) light a fluorescent lamp. The faint light of a fluorescent lamp before earthquakes could similarly be due to an electric field of pulsed EM waves.

9.3.2 Radio interference

Incidents:

Truck drivers reported radio interference on a highway near the epicenter in Kobe about 5 a.m., 45 minutes before the Kobe Earthquake. Some were unable to get any reception at all. Before the Tangshan Earthquake factory workers manufacturing radios were unable to tune in any broadcast signals. The phenomenon seemed limited to that area, and reception returned to normal after the quake (Dai, 1996).

Experiments:

A transistor radio placed on the high voltage sphere of a Van de Graaff generator went dead at a high voltage but worked normally when the sphere was grounded. Air-gap discharges between the sphere and a grounded rod caused interference on another radio nearby (Ikeya and Matsumoto, 1998). FM broadcasts were not affected during these experiments. (A radio receiver is a good sensor of electromagnetic waves; a small radio placed near a computer will pick up EM interference from the computer.)

Explanation:

The air-gap discharges produced EM interference in the radio wave frequency range. Radio receivers tuned into AM bands are easily affected by EM noise; their longer, medium waves are more subject to interference than VHF FM waves. (Those seeking to use radio broadcasts for earthquake forecasting should obviously tune in to AM (rather than FM) broadcasts.)

Reported interference in FM broadcasts has been attributed to scattering of broadcast VHF waves according to a reasonable inference that the ionosphere descends locally from its usual height in response to the appearance of charges on the ground i.e. to an electric field of EM waves in the ULF range (Kushida and Kushida, 1998).

The reflection of FM waves might, rather, be caused by a change in the atmospheric conductivity around the epicenter due to charged aerosol. Whether the ionosphere is actually affected or not has yet to be established. For more on the apparent lithosphere-atmosphere-ionosphere (LAI) coupling, see Chapter 11.

9.3.3 "Barber-pole" color and speckle interference on TV screens

(a) Reproduction of barber-pole noise

Video films recording precursor noise: A video recording made 40 km away from the Kobe Earthquake epicenter of an NHK program broadcast at 11.18 p.m. (about six and half hours before the Kobe Earthquake), showed ghosting, "barber-pole" color and white speckle interference lasting for about 30 seconds. The broadcast and received images are shown respectively in Figure 9.3 (a) and (b). At this time hamsters were reported to be agitated and biting each other and mice were much more active than usual (Matsumoto *et al*., 1998) and Figure 5.5 (a).

A person living in Kyoto, about 80 km away from the Kobe epicenter, supplied another video film that recorded the same section of the program. In this case no "barber-pole" noise was recorded but flashing lines appeared across the screen at about 11:18 p.m. No seismic waves were detected at the time, so low frequency EM pulses (not detectable by seismographs) generated by local fractures in stressed rock close to the observation site might have been the cause.

However, the times did not exactly correspond, so a time difference needs to be accounted for. A speculative explanation might be that radiowave interference (generated by pre-seismic EM waves) was emitted either heterogeneously (in a focussed beam)—maybe because of some inexplicable polarization from a ferroelectric orientation of electric dipoles (Ikeya *et al*., 1998)—or the EM waves moved through the crust at an extraordinarily slow speed (Section 11.3.8, Table 11.2).

In any event, only the low frequency ULF component of EM pulses can be propagated from underground to the surface without attenuation (due to the large skin depth of these waves) and induce charges on the ground around fault planes. Appearance of this intense charge on the ground would cause electric discharges everywhere, generating EM noise in the high frequency (TV broadcast) range. They might also create disturbance in the ionosphere, creating high frequency EM waves by some unknown non-linear mechanism.

Analysis of videotapes:

Waveforms and signal spectra in both video recordings of the film were analyzed using a digital storage oscilloscope (DSO). An image on a TV screen is composed of 525 horizontal lines that are scanned from left to right in 0.063 ms by the NTSC system used in the USA and Japan. The luminosity signal (E_Y) and sub carrier color difference signals (E_I and E_Q) at a frequency of 3.58 MHz are related to components of the red, blue and green signals (E_R, E_B and E_G).

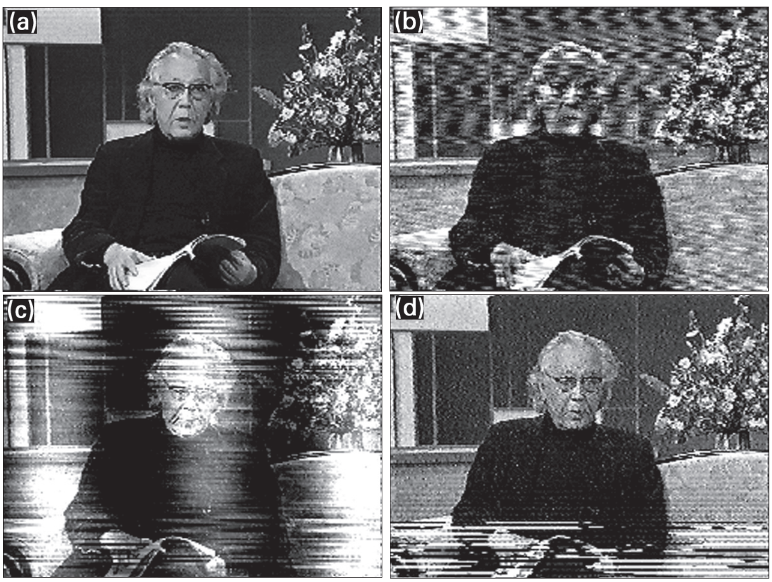

Figure 9.3 Screen distortion during a TV program broadcast by NHK at 11.18 p.m., January 16, 1995, about six and half hours before the Kobe Earthquake. (a) The image without distortion. (b) An image distorted by speckle noise and "barber-pole" interference. (c) Luminosity image E_Y isolated from (b) and showing speckle interference. (d) Image of color difference signal E_I, isolated from (b) and affected by "barber-pole" noise (Matsumoto *et al*, 1998). For a color view of "barber pole" noise, see the front color plates. (Videotape, Mr I. Kawakata.)

Figure 9.3 (c) and (d) respectively show the luminosity (brightness) and color difference signals isolated from the distorted image (b) recorded before the earthquake. Only speckle noises appear in (c); there is no effect on luminosity. Barber-pole noise appeared in the image showing color difference signals (d).

An attempt was made to reproduce barber-pole noise in a regular TV program broadcast by exposing the TV antenna to EM sine waves from a microwave synthesizer. A color shift appeared at 215 ± 5 MHz (within the TV broadcast frequency range).

It seems reasonable to conclude that EM pulses composed of EM waves at a wide range of frequencies before quakes can create interference on TV screens.

(b) Reproduction of speckle noise and channel fluctuation

There was a report of a faulty channel selection function in a TV remote for several days at the epicenter area before the Kobe Earthquake and we wondered if replication of channel-selection malfunction might be possible in a laboratory using EM waves. Speckle noise also seemed a likely candidate for an EM wave experiment given that the length of speckle interference in the video (based on the horizontal-scanning rate of 63 microseconds) was estimated to be of the order of microseconds, the same as pulsewidths observed during thunder, ten minutes before a local earthquake, and also during the granite compression experiment described in Chapter 5.

Experiments:

A TV antenna was exposed to EM waves produced by a microwave synthesizer and by air-gap discharge from a Van de Graaff generator. The discharges created speckle noise. A portable TV with a liquid crystal screen and a standard TV set were placed, respectively, on the sphere and also one meter from the sphere, during the air-gap discharge. Channel setting anomalies and noise were observed on the portable TV (Figure 9.4) on the sphere and in the standard set at a meter distant, during an arc discharge from the Van de Graaff generator.

Explanation:

Digital noise created by the EM waves scrambled the digital channel selection code in the TV and interfered with the broadcast frequency.

(c) Preseismic and coseismic EM pulses?

It is interesting to note that a small earthquake of M2.1 occurred at 11:49 p.m. on January 16 at the epicenter, apparently one of the four Kobe foreshocks. However, an episode of fluctuating channels at the epicenter area (above) occurred 30 minutes beforehand, meaning it can’t be linked to the foreshock itself. In addition no such interference had ever been reported in connection with frequent small earthquakes

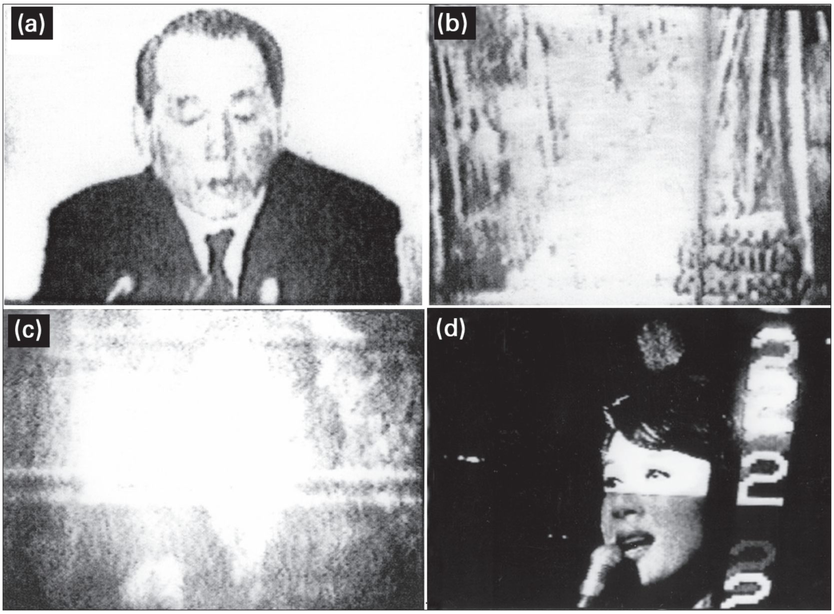

Figure 9.4 The effects of EM interference in an image on two color TV sets. (a) Normal image (b) Loss of image on the high voltage sphere of the Van de Graaff generator. (c) Horizontal line noise and "snow-like" speckle noise produced by arc discharges (d) Noise and an unstable channel setting (Channel 2).

in the area. So the incident is puzzling unless it was in response to presismic EM waves generated locally by increasing fault stress.

There was one report of distorted TV images a few seconds before the Kobe Earthquake affecting not just one but at least two channels, followed by earth sounds and then the tremor. This apparently indicates coseismic generation of EM waves producing interference, and then earth sounds, just before the arrival of S-waves (the quake).

Japan has just implemented a hi-tech digital broadcasting TV system that gives a high-resolution color picture, but the new technology will still remain susceptible to color changes and other interference from EM noise generated by earthquakes or lightning. Even cable TV will be susceptible.

9.3.4 Strange sounds from refrigerators, spontaneous on-and-off switching of appliances

Statements:

Reports of mysterious buzzes and alarm sounds over intercoms, and strange sounds from refrigerators and air conditioners are among precursor reports collected after the Kobe Earthquake (Wadatsumi, 1995). Kobe citizens were also surprised and puzzled by spontaneous switching of radios, TVs and air conditioners around 2 - 3 a.m. before the earthquake at 5:45 a.m.

Experiments:

Some of the electric appliances reported to have malfunctioned were exposed to EM pulses generated by arc discharges using a Van de Graaff generator or by 100 MHz EM waves from a Tesla coil.

A TV connected to a video recorder, which could be operated by remote control, switched on upon exposure to EM pulses.

A refrigerator was charged using the Van de Graaff generator. Electric discharges occurred in the circuitry affecting internal devices and the temperature sensors, creating malfunctions that switched the compressor off and then on again, creating sounds and vibrations in the refrigerator.

Explanation:

Modern electrical equipment employs a simple switching system using digital signals. Mains power is still connected to this quick switching apparatus even when the switch is off, meaning preseismic EM pulses could cause spontaneous switching of electric appliances before the Kobe Earthquake. (Malfunctioning caused by EM waves will not occur if the appliance is not connected to the mains socket. Only a fluorescent lamp operates differently.)

Buzzing sounds from intercoms and cellular phones may also be caused by EM interference. In fact, spontaneous switching and malfunctioning of nearby electric appliances in our laboratory surprised us sometimes during our experiments using a Van de Graaff generator and a Tesla coil e.g. a laboratory oven at room temperature began to warn us that it was overheating and a TV 2 m away switched on.

Intermittent short circuits within the refrigerators would have turned compressors off and on causing the sounds and vibrations reported before earthquakes and reducing cooling efficiency. This could explain reports of spoiled yogurt; certainly the direct effect of EM pulses on lactate cells is doubtful since the refrigerator would electrically shield the yogurt.

The reported malfunctioning of radios, TVs, air-conditioners and intercoms at midnight before the earthquake is consistent with preseismic discharges and effects of intense pulsed electric fields such as earthquake lightning. The unscheduled broadcast of the Koranic prayer from a local mosque one hour before the Izmit Earthquake in Turkey may have been due to spontaneous switching on of an electronic device. It should be noted that, at about the same time, budgerigars were very agitated, and frightened children woke people up according to reports (Section 2.3.3). These are consistent with the appearance of intense EM pulses in the epicenter area before the Izmit Earthquake, just as before the Kobe Earthquake.

9.3.5 Activated mobile phones with no call records

The big surge in popularity of mobile phones occurred only three to four years ago so there are not many reports of malfunctioning mobile phones before the Kobe Earthquake in 1995. However, there were reports from both Kobe and Izmit of mobile phones whose call indicators had activated but had received no calls. In other words, the display lit up and there may or may not have been a ringing tone, but there was no record of any caller (Figure 9.5).

Figure 9.5 Mobile phones exposed to electric discharges of EM waves lit up and rang but left no record of any caller.

Experiment: EM noise created by electric discharge

Ten mobile phones manufactured by different companies were placed on the Van de Graaff generator and the grounded sphere was placed close to the high voltage sphere. Electric discharges generated EM pulses. In two of the ten phones the display lit up and the phones rang. (The others may have been better shielded.) Again, lay reports of mobile phones receiving calls but leaving no record of a caller may be explained as an effect of preseismic EM pulses.

9.3.6 Assorted unusual reports

(a) Burglar-proof alarm

A car security alarm, which used an electrostatic field, sounded at 9.30 p.m., January 16, about 8 hours before the Kobe Earthquake—about 1hr 45 mins before the TV picture interference captured on video. The incident may be another case of spontaneous switching on of an electronic device.

(b) Cat disappears from locked car

A cat mysteriously escaped from a locked car before a large aftershock in Turkey (Ulusoy and Ikeya, 2002) while its owners were asleep inside the car. Woken by the tremor they found the cat outside the locked car. It is possible that the automatic power window, activated by intermittent EM pulses, opened briefly, letting the cat out, and closed again.

(c) More computer crashes?

There was a statement that personal computers were more troublesome than usual just before the Taiwan-921 earthquake. If pulsed noise affects only one bit in the digital code, a calculation result can be completely skewed, but usually there is sufficient redundancy built into system software to absorb these fluctuations. The author didn't notice anything unusual about the performance of his computer before the Kobe earthquake, but then again it crashed so frequently—with a high voltage line 30 m away and a bus station closer still—it would have been hard to know! (Data on the frequency of crashes would have to be kept if computers are to be used in earthquake forecasting.)

(d) Odd sounds from a power transformer

Two electric power transformers made strange "hoh-hoh-hoh" sounds from 13 to 6 hours before an earthquake (M5) in Canton, China in 1970 (Rikitake, 1979). Such sounds are produced from a transformer by coil vibration when there are minor voltage and amp instabilities in the power line, the instability having been induced in the power lines from outside.

Dr T. Higuchi (General Research Institute of the Kansai Electric Power Company) has detected noise before earthquakes by measuring current in the neutral line of three-phase power lines. Power lines are effectively huge antennae, or circuits, capable of measuring earth potential differences, and are therefore possible detectors of earth current and/or EM waves before earthquakes.

9.4 Mysterious clocks and the "Alice in Wonderland" Syndrome

9.4.1 Did time stop or speed up?

There was an anecdotal report that clocks in a local stock exchange did not show the correct time before the Kobe earthquake. Quartz clocks in Beijing, at a distance of 160 km from the epicenter were reported to have stopped eight hours before the Tangshan earthquake (M8.2) in 1976. The same clocks also stopped before large aftershocks (Dai, 1996).

A newspaper reported that a medical doctor in Osaka had a radio-clock which adjusted its time every hour in response to a 40 kHz radiowave signal from a Government telecommunications laboratory, close to Tokyo. His clock lost two seconds before the Kobe earthquake, but ran to time again after the earthquake.

A citizen of Ashiya City, 25 km away from the Kobe epicenter, telephoned the author and said that the hands of her quartz wall-clock stopped moving and then moved slightly backward for a few seconds a day before the Kobe earthquake. They resumed normal speed and function after the earthquake. She wondered if she had been "seeing things" because nobody believed her, and she sought a scientific explanation. A girl student who also claims she saw the hands of a clock move rapidly before the Kobe earthquake requested confidentiality in case people thought she was a little strange.

The "Alice in Wonderland" Syndrome?

According to the theory of relativity, time may pass faster or slower. One cosmological theory says time may even reverse if the universe starts to contract. Obviously erratic clock malfunction does not fall into the category of a real time anomaly, but to someone who hears reports of hands spinning forwards, backwards and jerking to and fro, it can sound like a case of 'Alice in Wonderland' syndrome (Burstein, 1998; Mizuno *et al*., 1998), in which symptoms of nausea and vision disturbance accompany a recurrent throbbing headache on one side of the head. Those with the syndrome have a disordered perception of time and space. The disorder can also be induced by drugs and gained its name from the book *Alice in Wonderland* by Lewis Carroll (1953).

In *Alice in Wonderland* (Chapter 7), the Hatter, who has become mad through exposure to toxic mercury used in tanning leathers to make hats, says to Alice at the Mad Teaparty,

> *Now if you only kept on good terms with him (Time), he'd do almost anything you liked with the clock. For instance, suppose it were nine o'clock in the morning, just time to begin lessons: you'd only have to whisper a hint to him (Time), and round goes the clock in a twinkling! Half-past one, time for dinner!*

There have been suggestions that people who claim to have seen clock hands jerk backwards and forwards or move at increased speed before earthquakes had some sort of psychological condition at the time. Did they?

Experiments:

A quartz clock was placed on the high voltage-sphere of a Van de Graaff generator (See Figure 9.6). No change in the movement of the hands was observed as the sphere was charged. However, the hands stopped moving when an air-gap discharge was made to a grounded rod close to the high voltage sphere. The alarm rang and then the second hand rotated at a speed eight times faster than normal when arc discharge occurred between the plastic case and the high voltage sphere.

Figure 9.6 The second hand of a quartz clock rotates at eight times normal speed on the high voltage metal sphere of the Van de Graaff generator.

An exposure to EM waves from an antenna at an emitting power of 10 W in a frequency range from 120 to 130 MHz stopped the clock. At the same time the automatic focusing motor of a video camera taking a picture of the clock at a distance of 2 m malfunctioned, blurring the image. The intensity of the EM waves was about 2 W/m^2 (30 V/m) assuming uniform radiation, a little higher than that causing unusual animal behavior in budgerigar and mice, as described in Chapter 4.

Explanation: Short circuits in a digital integrated circuit

The hands of a quartz clock are driven by a stepping motor, itself driven by electric pulses fed from a digital integrated circuit (IC) composed of flip-flop circuits in a state of either "0" or "1". The clock's plastic case was charged positively by collecting charges from the air and the clock's insulation was broken down by air-gap discharges. This discharge state generated electronic noise, which disturbed the digital circuit (essentially creating a short circuit by interfering with the digital code, and producing errors, thus affecting the generation of pulses, motor and hands).

Sometimes, discharges of accumulated charge in a printed circuit will also result in short-circuiting. Such short-circuiting would cause spontaneous ringing of a buzzer.

The eightfold increase in the speed of the clock in the present experiment suggests that three flip-flop circuits in the digital IC were short-circuited giving eight times the number of electric pulses to the pulse motor, resulting in the faster movement of the second hand (the loss of each flip-flop doubling the speed of the second hand).

Thus, the statements about rapidly moving clock hands before the Kobe earthquake appear to have nothing to do with the "Alice in Wonderland" Syndrome (Ikeya *et al*., 1998a), but were probably real.

It should also be repeated that preseismic EM waves are not 120-130 MHz or any particular frequency but are pulses composed of many different frequencies, so having a much higher probability of affecting circuits than if they were one specific frequency.

So, the reports of aberrant clocks before the Kobe, Izmit and Taiwan earthquakes could have been real natural phenomena.

9.4.2 Dead phosphors on a wristwatch

A man passing through a tunnel near Izu (close to Tokyo) in a train looked at his wristwatch. He was unable to read the phosphorescent markers and concluded the phosphors had failed. This happened on August 29, 1923 and the Great Kanto earthquake occurred two days later on September 1. On September 2 the man found that the phosphorescence had reappeared (Kamei, 1976).

Experiment:

When a light emitting phosphor was placed under an intense electric field generated by the Van de Graaff generator, in a dark room, the phosphorescence faded and then disappeared. It took hours for it to be restored.

Explanation:

In the 1920s phosphors in wristwatches were excited by alpha rays emitted by radium. Alpha rays have a strongly ionizing effect, creating electrons and holes (Figure 7.4). The slow recombination of electrons and holes in the phosphor was responsible for the phosphorescence. An electric field removes ionized electrons so reducing the efficiency of the electron-hole recombination in the phosphor. Hence, phosphorescence may be degraded under an intense electric field before an earthquake. When the field disappeared the distribution of the electrons would return to normal in time.

9.5 Earthquake forecasting using electric appliances?

By exposing radios, TVs and air conditioners to EM noise at about 10 W/m^2 or 60 V/m in many laboratory experiments we have reproduced the spontaneous switching of these devices and appliances that have been reported before earthquakes. Essentially, the phenomenon of malfunctioning modern electric home appliances before earthquakes (Figure 9.7) may be explained largely in terms of short circuits

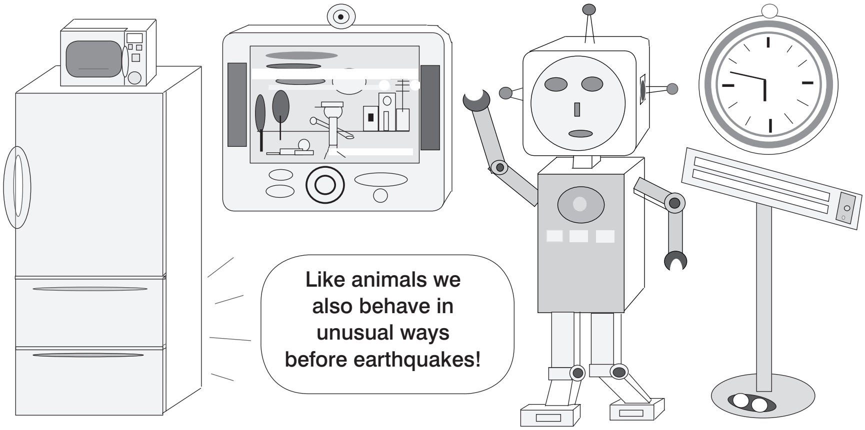

Figure 9.7 Electric home appliances—present and future—that can be expected to malfunction on exposure to EM waves.

from digital data errors produced by electronic interference from intense EM pulses, though some exaggeration or invention of reports cannot be excluded.

However it is risky to use electronic devices in earthquake forecasting. There are too many other factors producing interference to make them reliable indicators of an imminent large quake e.g. a sporadic E layer in the ionosphere formed by solar flares (and maybe also by the apparent bending of the ionosphere towards intense ground charges in epicenter areas), globally disturbs the transmission of EM waves creating interference in radio and TV reception.

Radio and TV transmitters and receivers are not always maintained well, nor is the power supply universally stable, and modern environments are noisy with sudden EM discharges, so malfunctioning electric appliances are a fact of life for many people. PC crashes are too frequent and commonplace to be used in prediction. Consumer demand for better-performing appliances might eventually make them more reliable indicators of imminent earthquakes, but electrical shielding of circuitry will no doubt also improve.

In any event, if greater efforts are not made scientifically to predict earthquakes, lay people may be able to get enough warning from sudden malfunctions in a group of ordinarily well-performing electronic appliances to make sure life-saving and property-protecting precautions are in place in case of a quake.

9.6 Care needed to avoid interference in data measurements

Many university geophysicists have tended to do their field work with cheap recorders and electrometers that are not made for regular outdoor use i.e. the manufacturer's specifications stipulate use in air-conditioned rooms only. This introduces a risk of electronic noise and errors. Perhaps the best-known example of interference was the illusory discovery of "cold fusion." In the late 1980s, scientists thought they had found a way to produce energy by nuclear fusion at very low cost by putting a current through heavy water at room temperature using special palladium and platinum electrodes. But they were apparently misled by electronic interference created partly by moisture precipitation on the circuit from the bubbling humidifying action of the heavy-water cells. When they gained grants because of their "discovery" and moved the operation into dehumidified rooms their cold fusion discovery burst like the bubbles. They were unable to reproduce their result.

These cases are warnings to researchers, especially non-professionals, working in short term forecasting that the greatest care needs to be taken in measuring seismo-electromagnetic signals (SEMS) because their equipment could be subject to electronic interference—not least from EM waves themselves—and misleading associations made.

Necessary caution is one side of the story in EM/earthquake research. The other side is an unwillingness or inability to see past an entrenched point of view. When the laboratory response of a quartz clock to EM waves was described at a conference of the International Geophysical Union (IGU) at Birmingham, England in 1999, a leading geophysicist simply said "Rubbish! If a quartz clock in my more than three hundred seismographs in California were to have malfunctioned, the earthquake focus could not have been determined. We have not had an event like that in the last twenty years!" The man dismissed the evidence outright because he leapt to the defence of the clocks in his system (presumably well-shielded expensive quartz clocks used in precise scientific instruments) and failed to see that cheap quartz clocks in plastic casing fell into a different category altogether. In so doing he failed to hear a legitimate case for EM effects on electronic objects.

In another, but much smaller, symposium a leading geophysicist said he had considered certain seismograph clock data to be electronic error and omitted the data from his results because no other local stations gave similar data. The author upset him by suggesting the omitted data might have been a meaningful EM pulse signal before the Northridge Earthquake and that the settings of their instruments (viz. their low sampling frequency and the time window of their A-D converter) meant the probability of two instruments picking up the same pulse would have been very small. A skeptical referee also argued that electronic error might have been the cause of the high activity levels reported in mice before the Kobe Earthquake (Chapter 5).

Strange data should not necessarily be blamed on electronic error; they could be caused by preseismic EM interference.

9.7 Summary

Malfunctions in a range of modern electronic appliances, reported before four large earthquakes in 1995 and 1999, have been reproduced in laboratory settings by exposing them to EM waves, giving support to the emission of EM waves both before and at the time of earthquakes.

Though EM interference can be produced from many sources, lay people should be alert if they notice in a number of domestic electric appliances, over a short period of time, odd functions of the kinds that have been described in this chapter. An earthquake may follow, it may not, but it would be a good time to make sure that precautions have been taken to save life and property in earthquake-prone areas.