Something in the Cellar

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Abstract

An investigation into the link between infrasound and the perception of apparitions was performed in the 14th Century cellar beneath the Tourist Information Centre in Coventry. Based on the effect described in The Ghost in the Machine (Tandy and Lawrence 1998) details of individuals experiences were recorded and an analysis performed to test for any infrasound present in the cellar. Infrasound was found to be present at the point at which individuals had reported apparitional experiences at exactly the same frequency as that predicted in the original paper.

Introduction

This paper describes an investigation into the phenomena described in the Ghost in the Machine (Tandy and Lawrence 1998) which proposes that low frequency sound can cause individuals to experience what may appear to be an apparition. In the original paper, a frequency of 18.9 Hz was found to be present in a laboratory where several people experienced what could reasonably be described as an encounter with an apparition. While measuring low frequency sound is not technically difficult, it does require specialist equipment that is expensive. An opportunity arose recently to explore a 14th Century cellar where hauntings had been reported. Situated near to Coventry University, the cellar is very conveniently placed and has electrical power available to drive the instrumentation. The expectation was that a correlation would be found between infrasound and the experiences of individuals who had visited the site. While it had been found that 18.9 Hz was responsible for one apparent haunting

(Tandy and Lawrence 1998) it was thought that a range of frequencies in this area might well give the same results. The actual measurements were so astonishing that they were repeated several times by the members of the research team, Vic Tandy and Sam Maunder of the School of International Studies and Law and Bill Dunn of the School of Engineering at Coventry University.

The 14th Century Cellar

The cellar is adjacent to Coventry University beneath the Tourist Information Centre, which is built on the site of a 14th century house, 38/39 Bayley Lane. The house was originally owned by the Benedictine Priory that stood opposite, where Coventry Cathedral now stands. A plan of the cellar is included in appendix1 to this paper. Initially an undercroft it would have been open to the road on one side, however, as the area developed it was buried completely leaving access only available from the house above. At the time the cellar was built, Coventry was a centre for the wool and cloth trade and it would most likely have been used to store merchandise (Tourist Information Centre 2000). Niches in the walls would have contained valuable goods such as spices and would have had lockable doors attached. The cellar is built of local red sandstone and is of such quality that it has survived many new houses being built above it. The final house was destroyed, along with the Cathedral, during the Coventry Blitz of 1940. This blocked the cellar's remaining entrance and its presence was forgotten for a time. Rediscovered during the excavation for the foundations of the Tourist Information Centre, the cellar now serves this new building. Accessed by well-lit modern steps and underground passageway it is open to the public and has a steady flow of visitors.

Apparitions

It is the strange experiences of some visitors to the cellar that prompted this investigation. A number of stories began to emerge form several witnesses as follows. In 1997 Coventry Tourguide, Colin Cook accompanied a Canadian journalist touring Britain into the cellar, he noticed that the journalist gave the appearance of being taken ill as he crossed the threshold of the room. "The gentleman was frozen to the spot and the colour drained from his face, the hairs on his arms rose up and goose pimples formed". Concerned for the man's health, Mr Cook asked him if he could be of assistance. The journalist described a feeling as if a balloon was being pushed between his shoulder blades and an intense feeling of a presence. Eventually he reported that the face of a woman seemed to be peering over his right shoulder. Mr Cook was unable to feel or see anything but the visitor had become "ashen" and looked very unwell. Mr Cook became seriously concerned for the health of his visitor and suggested they return to the Information Centre. The journalist recounted his experience to staff in the centre and exhibited the physical symptoms for some time before recovering. Mr Cook also gave details of a Latvian Gentleman who experienced a strange feeling upon entering the room, he described feeling a presence, a cold chill, as if there was a ghost in the room but there was no physical manifestation. A husband and wife visiting from the USA were also accompanied by Mr Cook and entered the cellar together but the woman suddenly stopped on the threshold of the room, she claimed to be experiencing a very strong feeling of presence and described it as barring her way. Neither her husband nor Mr Cook experienced any phenomena at all. However the woman became pale and refused to enter the cellar however much her husband encouraged her. On returning to the

Information Centre, staff noted the very pale complexion of the woman. However they did make the point that they had not seen her prior to the experience, so although she struck them as unusually pale it was not known whether this was her natural complexion. Staff at the Information Centre were interviewed and confirmed that a significant number of visitors do report a presence in the cellar but generally give few details, some are just noticed to leave rather hastily. Staff did however remember two white witches visiting the cellar to "make contact". They announced that there was the spirit of a woman in the cellar but it was friendly and there was no need for any concern. Another white witch also visited, according to Carole Jung, assistant manager of the centre at the time. However, she was greeted with less charity by the presence and "frightened to death" by the experience, left rather rapidly. Mrs Jung, who also acted as a tour guide, had first hand experience of the apparition, she said she hated going down into the cellar, "there was a very strong sense of presence as if she were intruding, disturbing something, there was a strange chill to the atmosphere." While no physical apparitions appeared to her the presence felt so strong that she said she found herself talking to it. A fluent German speaker, Mrs Jung often accompanied German visitors into the cellar, who also remarked on the feeling of intruding. It is particularly interesting that so many foreign visitors have experienced the apparition, because they would be less likely to know of the cellar's growing reputation.

Infrasound

In The Ghost in the Machine (Tandy & Lawrence 1998) apparitional experiences of several people were traced to a low frequency standing wave within the building. The wave was detected accidentally by its effect on a foil blade (fencing weapon), which the author was attempting to cut a screw thread on, in preparation for fitting a new handle. This five-minute job resulted in several hours of research when the blade began to vibrate. The blade was clearly receiving energy and calculations showed that a standing wave of approximately 18.9 Hz was present in the laboratory. The equipment was not available to measure amplitude but to excite the foil blade in the way described it must have been substantial. There are a number of recorded events in which infrasound has been shown to affect humans in strange ways, the original paper cites work by which describes workers feeling uneasy or dizzy as a result of exposure to infrasound. A French research team under the direction of Dr Gavreau also experienced strange results from exposure to infrasound in 1957(Vassilatos,G). A disconcerting feeling of nausea mystified Dr Gavreau and his team and frequently caused them substantial discomfort. Originally, put down to airborne toxins no trace was found of any agents that could cause the symptoms. Scientist brought in to investigate also experienced the phenomena. Finally, a researcher found that the sickness ceased when certain laboratory windows were closed. The nausea was caused by a low frequency sound wave which resonated with the structure of the laboratory, closing the windows altered the resonant frequency and made the situation for the occupants either better or worse. This discovery lead to experiments in infrasound weapons that continue in several countries (Dunning 1968) (Lewer 1997).

The Test

The cellar was a prime opportunity to test the theory that infrasound could cause humans to experience hallucinations suggestive of an apparition. Located next door to

Coventry University it was easy to move measuring equipment in and even had a mains voltage power supply. A Bruel & Kjaer precision sound level meter Type 2209 fitted with a microphone sensitive to frequencies down to 1Hz was attached to a Zonic AND Type 3525 Dual Channel FFT analyser. The microphone was placed in the centre of the cellar and connected to the analyser in the corridor leading in. The hypothesis was that the structure might have the potential to support resonance in the infrasound area. The longest dimension of the cellar was 7.7m which, if treated as a simple mathematical model, would resonate at about 22Hz by the calculation below.

$$f = v / \lambda$$

where= 2 x frequency of sound velocityof sound (343 m

$$\lambda =$$

$$= =$$

$$\lambda =$$

$$=$$

While it is theoretically possible to treat the cellar as a collection of boxes that would resonate in any plane, reference to the layout of the cellar as shown in appendix 1 gives an idea of the complexity, which this would involve. It would be extremely difficult to create a theoretical model of all the possible interactions of the various steps, corridors and shafts attached to the room, which itself has complex shapes in the roof and walls The instrumentation enables us to analyse the resonances directly using a simple stamp test. This is a fairly straightforward experiment where someone stamps his or her foot causing a loud bang. Impacts produce a wide spectrum of sound that will interact with any resonances in the structure and enables them to be seen as peaks on the spectrum analyser. Another approach, often used by audio engineers is to burst a balloon, however in the absence of such sophistication a stamp test was considered adequate. Prior to the "stamp" it is normal practice to take a background reading and it was during this that an astonishing result was recorded.

The experimenters withdrew from the cellar and left the instrumentation to sample and average any ambient sounds present for 20 seconds. A Fast Fourier Transform (see appendix 2) was then performed providing a spectrum of the sounds present in the cellar. The trace was printed out and can be seen as figure1.

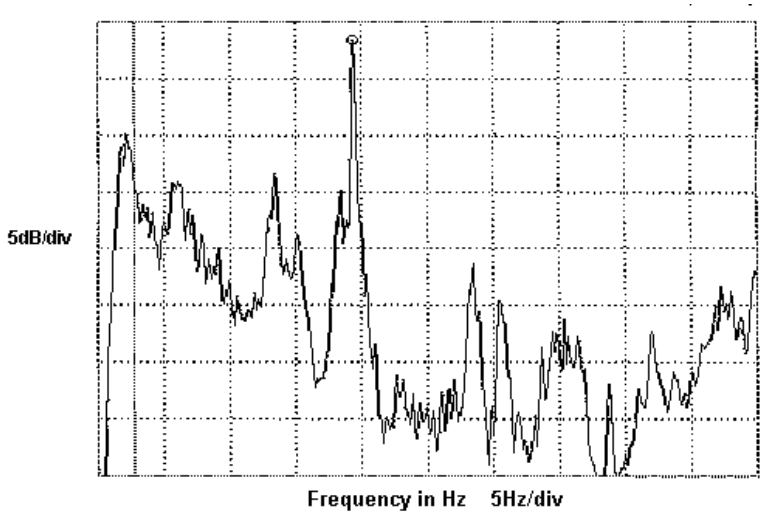

fig 1. **FFT analysis of ambient noise level in cellar dB scale**

Each division along the horizontal (X) axis represents 5Hz. The vertical (Y) axis provides a measure of amplitude, each division representing 5dB. The trace therefore provides a picture of the frequencies present and their amplitude. Appendix 2 has a very brief introduction to the use of these units for the uninitiated.

There is a clear peak at 19 Hz, exactly the frequency predicted in The Ghost in the Machine paper. The amplitude of the signal is about 38dB and is substantially above any of the other background noise. Decibels are a logarithmic scale used to make the measurement of the ratios of one sound to another practical because there is often to big a difference between levels to plot successfully. However this can sometimes mask the true scale of a signal and it is useful to view our infrasound on a linear scale just to place it in context, see figure2.

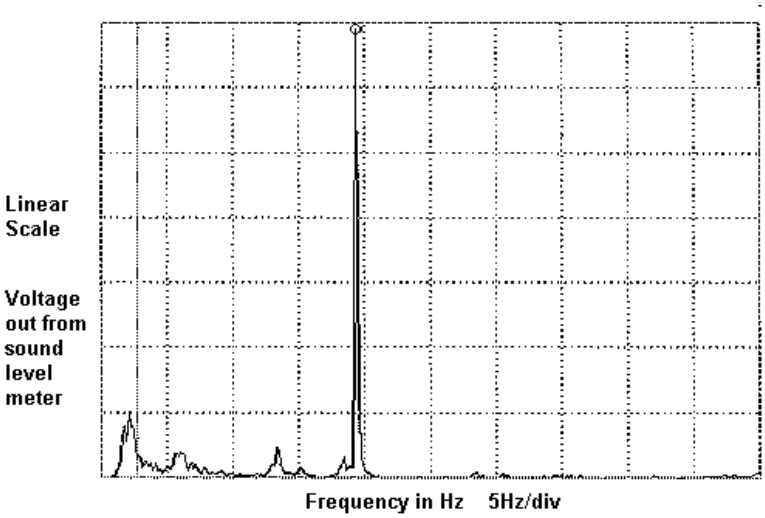

fig 2. **FFT analysis of ambient noise level in cellar linear scale**

The amplitude measurement is simply the voltage output of the sound level meter and is only valid for this comparison. The amplitude of the 19Hz signal and the background noise is now very apparent. This test for background level was repeated

several times over a period of three hours and no measurable difference was observed. For the signal level to be so consistent was in itself, rather surprising and the instrumentation was used to isolate the actual signal, which was almost sinusoidal, see figure 3.

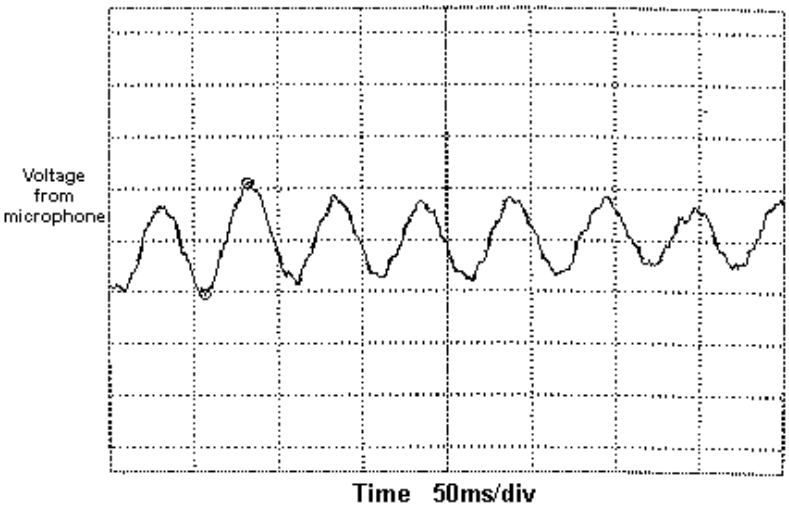

fig 3. **19Hz signal present in the cellar (X axis = 50mS/div)**

It can be seen that the level of the signal varies in amplitude during the measurement and it was suspected that the sound might be modulated (appendix 2). Therefore, another trace was made over a longer period with results shown in figure 4.

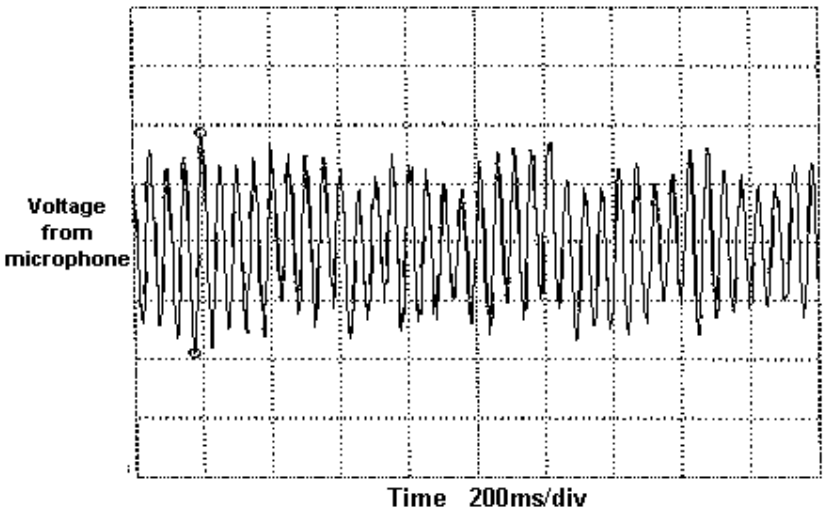

fig 4. **19Hz signal modulated by 2-3Hz signal present in the cellar (X axis = 200mS/div)**

It is clear from this trace that the signal is, indeed, modulated by another frequency, which itself is complex in nature, estimated to be varying between 2 to 4Hz. This is consistent with the spectrum shown in figure 1, where closer inspection shows a peak at 3-4 Hz. It is most probable that this signal is influencing the 19 Hz signal. The results of the stamp test, which we eventually got around to doing, are also supportive of this assertion. Inspection of figure 5 does show a peak at 2 to 3 Hz and another has now appeared at about 23Hz (23Hz is the resonance of the cellar about its length). The unmarked peak at around 50Hz is the resonance about the cellar's width, which is

probably too high a frequency to influence the current findings significantly. The level of the 19Hz signal is enhanced by about 3dB (see appendix 2) which, in linear terms, corresponds to an increase of 1.41 in its sound pressure level and points to the conclusion that it is not just a passing sound but a local resonance, a standing wave. Further investigation found that the corridor leading to the cellar is 10.95m in length, which would resonate at about 16.3 Hz following the calculation above. However, the corridor is not straight and it is suggested that the door opening would reduce this effective length in the same way that a finger hole in a wind instrument would behave. When this is taken into account the effective length is more like 9.5 m, which would resonate at 18 Hz. The relationship is not simple but at the moment, this looks to be the most likely resonator. The witnesses also refer to the feeling of presence being strongest at the threshold of the cellar, which would be consistent with this explanation.

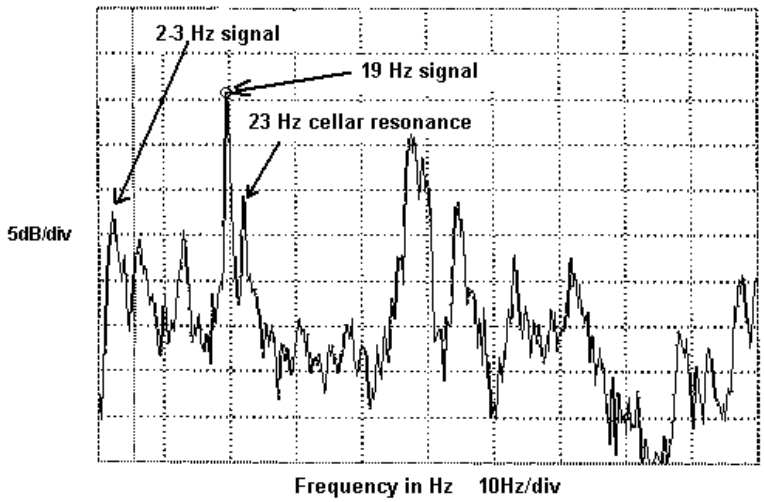

fig 5. **19Hz Stamp test showing resonances in the cellar complex**

The other peaks on the trace, figure 5, represent other resonances in the cellar complex.

Discussion

There are two significant points, which come from these results. The first is to question the low amplitude of the signal present and the second is the effect of the modulation. There is no proof as to the exact amplitude of the infrasound wave at the time of the apparitional experiences. Of course, there is no absolute proof that it was there at all at the time. However, the fact that the corridor has the correct physical proportions to resonate at 19Hz combined with the fact that the experimenters measured it doing so, consistently for several hours, seems sufficient circumstantial evidence to pursue. If the signal were present at around 38dB, it would be completely inaudible. Sources such as Tempest (1976) describe physiological responses to infrasound at levels well above the threshold of hearing. However, Mr Cook (tour guide) reported that he was not aware of any sound during the incidents he described. Experiments reported in the New Scientist (Brown1973) suggest lower levels may have effects. The experiments described found that a frequency of 12 Hz at levels as low as 85dB could cause "sudden and violent nausea". This is still substantially higher than the level measured in the cellar but the effect is also rather less spectacular.

A paper by Green J, (1968) suggests a more subtle connection between infrasound and human behaviour. It draws a correlation between naturally occurring infrasound and selected human behaviour. A test was carried out to see what effect natural infrasound from a storm some 1,500 miles away would have on the population of an area enjoying "innocuous local weather conditions". Infrasound can travel enormous distances without appreciable attenuation so the only evidence of the storm was inaudible infrasound monitored by instrumentation. The results of the test show an increase in automobile accident rate and a higher rate of absenteeism among school children when the storm infrasound was present, compared to the normal state. It may be that the effects of infrasound at low level are underestimated and may only affect a small part of the population. The whole area of infrasound and its effects has seen little experimentation over the past 10-20 years and it would seem these findings could well justify more work in the area.

Modulation of the infrasonic signal is considered, by those engaged in the design of infrasound weapons as an important property if the weapon is to be effective. An article in the New Scientist (1999) suggests that experiments in the use of pure, airborne infrasound as a weapon have been ineffective whereas direct coupling of the energy in the form of vibration has been shown to cause physiological effects. The problem is the coupling of the energy to the body. It will come as no surprise that little is written about this area of research. However, Dr Kalus-Dieter Thiel of the Fraunhofer Instiut für Chemische Technologie (ICT), a colleague working in this area, has stated that current research into infrasound weapons places emphasis on the use of modulation to enhance their effectiveness. In his recent book, Future War, Colonel John Alexander (2000) refers to experiments with Pulsed Periodic Stimuli (PPS) an extreme form of modulation.

> "The technique.. [PPS] .. can be applied to situations where it is desirable to cause perceptual disorientation in targeted individuals. This is important, as it is the first acoustic weapon that does not rely on high intensity to cause the desired effects. Rather low-intensity, pulsed, acoustic energy can induce fairly strong effects in humans."
> (Alexander 2000)

The weapon designers are, of course looking for something which will reliably disable its target whereas the effects considered in this paper clearly only effect a small part of the population and, even then in a very subtle way. Dr David Swanson (1999) makes the point that a small part of the population is "hypersensitive" to the effects of infrasound. These individuals have been known to become physically ill living near the seashore (a source of natural infrasound) or near airports. It would seem reasonable to suggest that sensitivity combined with a "spooky" atmosphere are significant components in the apparitional experience and that in other surroundings different interpretations might be made.

The source of energy to create the standing wave remains a mystery. Most visitors come to the centre in the summer and the events described by Mr Cook took place in pleasant weather conditions. The heating system at the Tourist Centre was eliminated as a potential source by simply being shut off at the request of the investigators. Coventry is still a centre for industry and there are industrial plants all over the City.

Vehicle noise is possible but it is unlikely to be so consistent. It is hoped that further trials will be carried out with the permission of the owners and more clues to the source will be gained.

Conclusion

The findings of this investigation would seem to support the effects described in the Ghost in the Machine (Tandy and Lawrence 1998). To find exactly the predicted frequency was astonishing and the experiment was repeated several times to ensure that it was not an anomaly of the equipment. While reluctant to rule out other frequencies in the infrasound band, clearly 19 Hz must be of particular interest. The dimensions of the corridor leading to the cellar fit well with the assertion that it is resonating at this frequency and contains a standing wave.

Acknowledgements

I would like to thank the staff at the Tourist Information Centre for their patience and help in providing access to the cellar.
The following colleagues from Coventry University. Bill Dunn of the School of Engineering both for his help with the technical aspects and for carrying out the actual measurements. Graeme Vanner of the School of Art and Design, Martin Simons of the School of the Built Environment, Ian Baker, Sam Maunder of the School of International Studies and Law and all the technical staff who have given so freely of their time to discuss and support the research.

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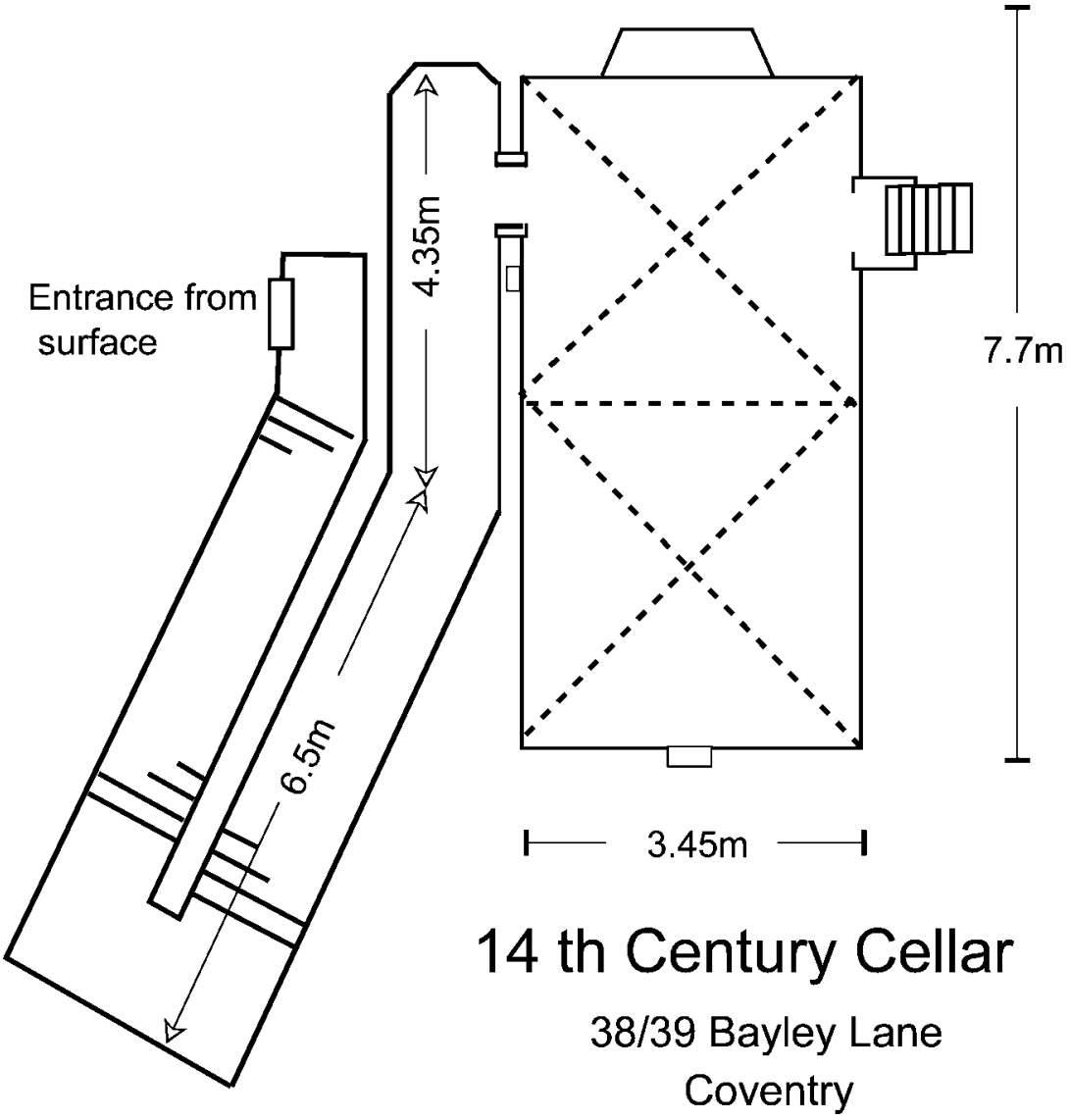
Appendix 1

Plan of the 14th Century Cellar



Appendix 2

Frequency, Amplitude, FFT and Modulation Explained

The purpose of this paper is to communicate with as wide an audience as possible so it was felt that this quick explanation of some of the technical concepts introduced might be appropriate.

Sound has two major parameters, frequency (pitch) and amplitude (humans perceive this as loudness). The frequency is the number of cycles per second in the sound signal and is measured in Hertz (Hz) so 20 cycles per second is the same as 20Hz. The piano keyboard has low frequencies at the left-hand end and high frequencies at the right. If the piano keyboard were extended to the left, it could include the infrasound frequencies referred to in this paper. Clearly, it would be hard to find a market for such an instrument because the audience would simply not hear it unless it was made very loud. Some church organs do produce these frequencies and their effect is to modulate the audible sound rather than stand as notes in their own right.

Pressure waves of particular frequencies in the atmosphere create a sensation which humans describe as sound. Our ears and the microphone in the monitoring equipment are sensitive to the level of this sound pressure. We would describe a low sound pressure as quiet and a high one as loud. The ratio of the quietest sound a human can hear to the loudest sound, which can be heard without immediate damage to the ear, is a ratio of ten million to one (10^7) in pressure terms. However, human hearing is non-linear. For a human to perceive a slight change in loudness the actual sound pressure level will have increased by a factor of up to around two times its original level. There is a very good reason for this property of our hearing. Early survival depended on our ability to detect predators so, at one end of the scale, the further away we could hear the foot falls of a hunting sabre tooth tiger the greater the chance of escape. At the other end of the scale, the same ears have to cope with a clap of thunder, with sound pressure level of anything up to a ten million times higher, without permanent damage.

When measurement of sound was in its infancy there was a clear need for a logarithmic unit of measurement that had similar properties to the way we hear. The decibel (dB) was already in use by electronic engineers and was adopted to simplify the representation of the massively variable signal levels. An example of the use of decibels is well illustrated in the early stages of this paper. A linear scale is used in figure 2 to show the peak at 19Hz but the other information, in the lower level signals, has been lost. Figure 1 shows exactly the same signal on a logarithmic scale measured in dB. It may take a while to become comfortable with this, but it is important for us to retain the other signals for comparison.

Without a logarithmic scale, plotting signal levels can become impractical. As an extreme example, if we were to draw a linear bar graph that represented the sound pressure level of the quietest noise a human ear can detect as a bar1meter high. Then tried to plot the thunderstorm on the same scale, the bar representing the sound pressure level of that signal would need to be ten million meters high, the piece of graph paper would be a hazard to space satellites!

While it is possible to quote the formula for conversion of linear changes in amplitude to dB, in practice the following examples are easier to remember and may help interpret actual results. A rise or fall of 6dB in sound pressure level represents a linear doubling or halving of the signal amplitude. A rise or fall of 20 dB represents a multiplication or division of 10 times the signal amplitude. So a rise of 40dB would be 10x10 = 100 times increase in signal amplitude. We need to remember this when we discuss two signals that only vary in sound pressure level by 6dB, in linear terms, one is actually twice the size of the other.

Fast Fourier Transform

Most sound that we are familiar with is complex, a single note on a pipe organ can produce a reasonably pure tone and if viewed on an oscilloscope it could well look like a sine wave. However, humans rarely encounter simple sinusoidal waves in the wild. A French mathematician by the name of Joseph Fourier stated that the complexity of a complex sound wave depended on the number and specific dimensional values (amplitude, frequency and phase) of it's sinusoidal components. The Fast Fourier Transform Analyser is a device that breaks a complex wave into component parts, which enables us to see the frequencies that give rise to it. The graphs shown in figure 1, figure 2 and figure 5 of this paper therefore represent the spectrum of frequencies present in the cellar. Frequency is plotted on the horizontal, X axis while amplitude, either as a linear or logarithmic scale, is on the vertical, Y axis.

Modulation

In the case of the signal in figure 4 the amplitude of the signal is being influenced by another signal of much lower frequency. This is described as amplitude modulation. In this case the signal of lower frequency is not simple itself and represents a complex interaction of several frequencies. As a result, we do not see a smoothly varying signal but a pattern that repeats with time. We know from this that it is the influence of another waveform and the FFT analysis in figure 5 provides us with possible culprits in the region of 2-3 Hz.