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HOME OFFICE

Detection Devices for Hidden or Buried Casualties

Catherine Reynolds

FIRE RESEARCH & DEVELOPMENT GROUP

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ABSTRACT

The task of finding hidden or buried casualties is a difficult one and different types of equipment cope better or worse with the conditions of, for example, a building collapse.

This report summarises a study of the type of equipment used by the Fire Service for the detection of hidden or buried casualties. The study was undertaken as part of a wider study of the equipment used by the Fire Service. A questionnaire was sent by FRDG, through the Fire Service Inspectorate, to all Brigades, requesting details of detection devices used operationally, on loan or for trial purposes. A brief evaluation of the types of equipment has been included, although no field trials were undertaken.

The types of equipment in general use are thermal imaging cameras and noise detection apparatus such as Vibraphones and Life Detectors. Several Brigades have specialised equipment such as fibrescopes and digital thermometers. Noise detection equipment requires strict operating procedures at the incident site to be effective, but has been found useful operationally. Thermal imaging cameras are in use in many Brigades but have limitations for detection of buried casualties. Alternative methods of detection, such as tracker dogs, are also in use but have limitations.

MANAGEMENT SUMMARY

Objectives of Project

The detection and location of hidden or buried casualties is a difficult task. The need to detect casualties in situations such as collapsed buildings, dense undergrowth and thick smoke is becoming more common and consequently British Fire Brigades have been acquiring specialised equipment to deal with the problems involved. The project was initiated to determine the types of detection equipment currently in use, or available to the Fire Service for the detection of casualties.

The objectives of the project were:

1. To determine what equipment was in use by fire brigades in the UK.

2. To establish how often the equipment was used.

3. To determine how effective the equipment was found to be.

4. To discover any special training or mobilising requirements.

The Questionnaire

A questionnaire was issued to Brigades requesting information on the types of equipment in use and how useful such equipment had been found. The questionnaire also asked for details on training and mobilisation of these tools.

Several Brigades were visited to gain insight into the operational experiences of firefighters who have used detection devices, and manufacturers' literature was used to provide details such as operating conditions, dimensions and weight.

Results of Survey

The majority of Brigades (66%) have thermal imaging cameras which can locate casualties in dense undergrowth or thick smoke. The cameras, however, have limitations in that they can not 'see' through glass or water. Also, any solid objects of more than minimal thickness (say, a few millimetres), which cover a body will obscure it from detection. Temperatures are represented visually as shades of grey (for equipment in use in brigades), which means that comparison of temperatures is relatively easy but small changes in temperature are difficult to monitor.

More specialised pieces of equipment for detection of vibrations are in use in thirteen Brigades. These work by using sensitive microphones to detect sounds made by trapped victims. The vibrations picked up from rubble or earth are transformed into audible frequencies and sometimes visual displays. The vibrations detected can be caused by the trapped person tapping on the structure around them, calling out or even just breathing. These pieces of equipment have been proved useful in a number of situations such as the

Armenian earthquake, terrorists bombings and gas explosions. Any success of the equipment is not certain and is dependant upon the skill and technique of the operator in interpreting the readings and maintaining good command procedures at the incident.

Three Brigades also have other equipment, such as fibrescopes, which could be used in a search situation. Fibrescopes allow operators to see into cavities within structures by using a thin optical fibre. To be of use in search situations, the casualty must be located fairly accurately first, probably by other means, as the optical fibre can only be used where a clear path to the victim is available or has been made. The fibrescope will allow the operator to visually check on the condition of the trapped person and possibly to determine the safety of the structure around them. This type of equipment tends to be expensive but does have other uses within the Brigade environment.

Other pieces of equipment being used include an 'Infratrace', which is a non-contact (does not need to touch the surface for which a temperature is measured) digital thermometer. It gives a visual readout of the temperature of a remote surface to within a one degree Celsius accuracy. This equipment has not been tested for use in a search and rescue exercise, but it is unlikely to have significant potential for locating hidden casualties.

Each Brigade has different techniques for training and mobilising. Some Brigades are able to offer ongoing training for search teams, others provide hands-on training at station level and the majority distribute technical information on the equipment available within the Brigade. Mobilisation of thermal imaging cameras is generally done on emergency tenders, whilst listening devices are usually mobilised to appropriate incidents on call from the officer in charge.

Other methods and techniques, such as using search and rescue dogs, are not regularly used operationally, but do have some potential.

Conclusions

1. Equipment in Use

Fifty brigades (75%) said that they had purchased or used a detection device. Forty four Brigades had thermal imaging cameras, twenty Brigades had sound detection equipment and three Brigades had other types of equipment such as fibrescopes. Seventeen brigades had no such equipment or had not used any.

2. Operational Use and Effectiveness

Sound detection devices have been used operationally by seven brigades. Of these, three brigades have successfully used the equipment to locate persons trapped or hidden.

Devices which register vibrations or sounds which would otherwise go undetected have been found to be the most effective equipment for the location of buried casualties. The better models of this type of equipment have filtering systems so that background noise can be reduced, making it easier to detect sounds made by trapped casualties.

Thermal imaging cameras have been used frequently operationally to detect casualties, but with limited success when the victim has been obscured by dense material, water or glass. The cameras have been successfully used to search for casualties lost in thick smoke, dense undergrowth or darkness. The cameras have only limited potential for detection of victims buried in collapsed buildings because they cannot 'see' through glass or dense objects such as brick rubble. Their use in such circumstances is almost certain to be unsuccessful.

Search and rescue dogs have the potential to be useful for detecting and locating hidden or buried casualties, but as yet this potential has not been realised in this country. Several overseas organisations use dogs to locate missing people, but this tends to be mountain rescue type incidents where the dogs have few scents to follow and less to distract them.

3. Training and Mobilising

Whatever type of equipment is used to detect trapped casualties, the overriding requirement for a search is that it is carried out methodically and with good control of resources by the officer in charge.

The effectiveness of all items of equipment is increased by training of operators in good search techniques and the abilities and limitations of the equipment being used.

Twenty eight Brigades mobilised their equipment on request from the officer in charge at an incident. Of these, twelve generally kept their equipment at a central location and the remaining stored the equipment either on front line appliances, emergency tenders or rescue tenders which could be mobilised on request.

4. Summary of Conclusions

Sound detection devices have been found to be most useful for detection and location of casualties buried in collapsed buildings or other similar situations. Thermal imaging cameras have been used successfully to detect victims in dense undergrowth, darkness and thick smoke. Other specialised equipment has been used in a small number of incidents with varying success.

CONTENTS

DETECTION DEVICES FOR HIDDEN OR BURIED CASUALTIES

1. INTRODUCTION

As part of a larger investigation by the Fire Research and Development Group (FRDG) into rescue tools used by the Fire Service, a study was undertaken of the equipment in use for detecting hidden or buried casualties in circumstances such as collapsed buildings.

The objectives of the project were:

1. To determine what equipment was in use by fire brigades in the UK.

2. To establish how often the equipment was used.

3. To determine how effective the equipment was found to be.

4. To discover any special training or mobilising requirements.

A questionnaire was sent by FRDG, through the Fire Service Inspectorate, to all Brigades, requesting details of detection devices used operationally, on loan or for trial purposes. A copy of the questionnaire can be found in Appendix 1. The questionnaire requested information about the types of equipment in use, whether the equipment had been found useful operationally, and any special mobilising or training procedures.

A brief evaluation of the most common equipment is included, although no practical field trials were undertaken. A number of Brigades were visited to obtain insight into the operational experiences of the various devices. Manufacturers literature has been used to obtain specifications such as size and power consumption.

2. RESULTS OF QUESTIONNAIRE SURVEY

This chapter lists the questions FRDG asked Brigades on the questionnaire and summarises their responses. Sixty five Brigades (97%) returned the questionnaire, and the remaining two responded verbally.

2.1 Question 1

Does your brigade have any equipment for the detection of hidden or buried casualties, or has it used any ?

Fifty brigades (75%) said that they had purchased or used a detection device. Seventeen brigades had no such equipment or had not used any.

2.2 Question 2

What is the equipment ?

This question requested details on the name, make and model of each piece of equipment.

The numbers of Brigades with each type of equipment is shown in Figure 1. The answers to this question and question 3 are summarised in Table 1, page 29.

2.3 Question 3

What method of detection does this equipment use ?

Answers to this question were generally straightforward with two main methods of detection: thermal imaging or sound/seismic detection. One or two specialised pieces of equipment did, however, employ different methods of detection.

One Brigade also had access to SONDE (sound detection) sets, endoscopic probe equipment and an optical fibre endoscope, within 1 - 2 hours of a request, through members of International Rescue and an agreement with Eastern Electricity Board.

Table 2, page 30, provides a list of Brigades and the types of detection equipment they own or use.

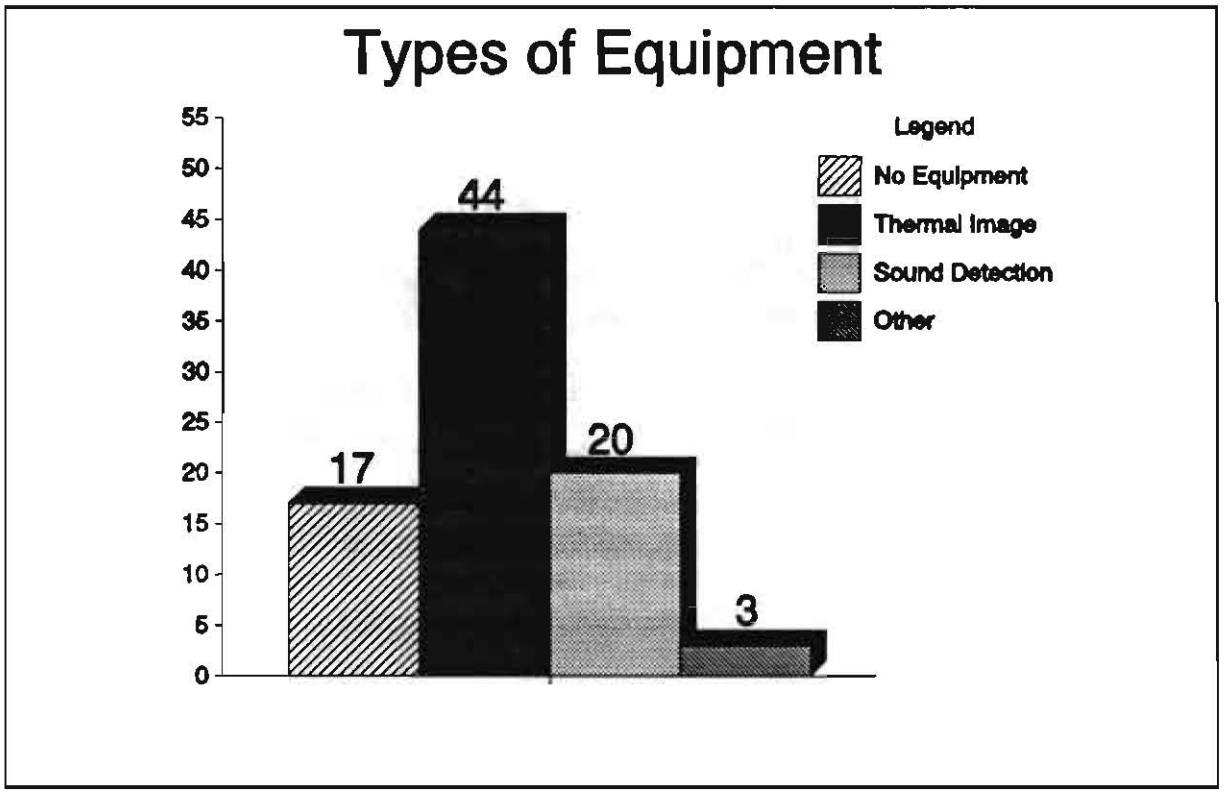

Figure 1: Numbers of Brigades with Each Type of Equipment

2.4 Question 4

How often has it been used and briefly describe in what circumstances ?

Thermal Imaging Cameras

Forty four Brigades owned thermal imaging cameras. They were used frequently by Brigades, mainly for

* identifying 'hot spots', for example during damping down operations or fires in trunking.
* finding hidden seats of fires.
* locating overheating chokes on fluorescent lights.
* determining the extent of large or partially hidden fires.

Twenty five Brigades said that they had used a thermal imaging camera to locate missing persons or animals. The number of times the equipment was used for this purpose in each Brigade was generally very small (less than five per year).

The cameras had been used in a variety of 'missing person' situations such as;

* at RTAs for locating persons who may have been thrown clear or wandered away from the scene.
* searching smoke filled buildings for missing persons.
* searching canals and rivers for locating persons missing feared drowned.
* searching underground cellars for missing persons.
* searching dense undergrowth for missing persons.
* recovery of a body following an explosion at a factory.
* animal rescue, i.e. locating trapped dogs, badgers etc.

Ten Brigades reported that a camera had been used to search buildings which had collapsed, as a result of gas explosions or terrorist bombs. They have also been used to search collapsed trenches.

One Brigade stated that it mobilised a thermal imaging camera to all 'persons reported' incidents.

Sound Detection Devices

Twenty Brigades had some type of sound detection equipment, and of these, thirteen had not used their equipment operationally. Of the remaining seven, three Brigades had attended incidents and used the equipment but subsequently discovered that no-one had been trapped (Figure 2). One Brigade had used the equipment successfully to detect trapped animals in rabbit warrens and badger sets. Three Brigades had used equipment operationally during building collapse due to bombings, explosions and the Armenian earthquake.

Other Equipment

The Infratrace infrared thermometer had been used on several occasions in conjunction with a thermal imaging camera, to ensure the temperatures of hot spots were being reduced during firefighting operations. The equipment had not been used for the purpose of locating hidden casualties.

Fibrescopes were not regularly used but had been used in such situations as cavity wall fires and collapsed structures.

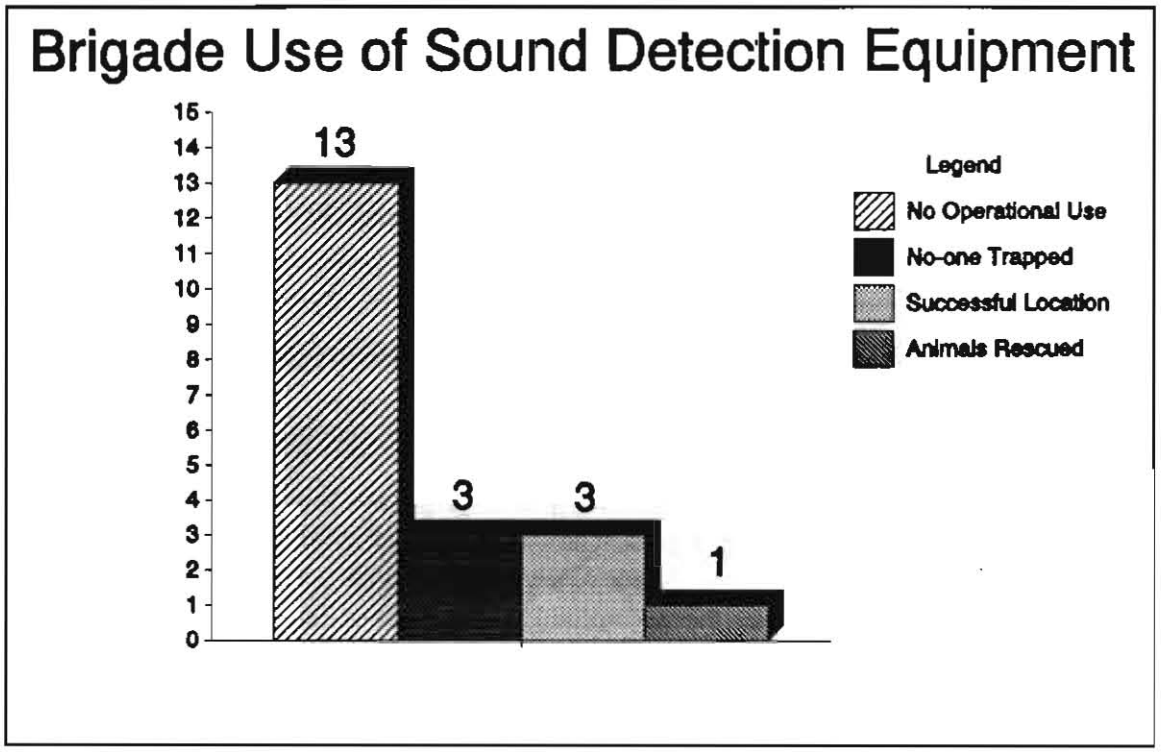

Figure 2: Number of Brigades for Each Usage Category

2.5 Question 5

Has the equipment been found useful ?

Thermal Imaging Cameras

Brigades stated that they had found the thermal imaging cameras very useful for locating hidden hot spots and assessing the success of firefighting operations. However, monitoring changes in temperature over a period of time was reported to be difficult as the camera displayed temperatures in shades of grey, which were not easily remembered to be compared with later images.

The equipment was found to be of use for locating persons hidden from sight by smoke or undergrowth, or in the dark. The usefulness of the camera was, however, limited if the casualty was completely buried by rubble from a collapsed building or, for example, slurry from a coal pit. The camera could only detect temperature gradients, and heat from a body was not sufficient to be detectable through dense media.

Limited success had been achieved with cameras during rescue operations in water. The usefulness or otherwise of the thermal imaging cameras in these situations most likely depended upon the conditions at the particular incident, but it is extremely unlikely that a body submerged in any appreciable depth of water could be detected.

Sound Detection Equipment

For the limited number of occasions that the equipment had been used, it had been found very useful. Live casualties were rescued in Armenia using the Vibraphone ASB6 and sound detection equipment was successfully used in Kent during the Deal bombing emergency.

Other Equipment

The Infratrace equipment had been found very useful for accurately determining the temperature of surfaces. The equipment was sensitive to very small changes in radiated heat and could, in theory, be used to detect hidden bodies, although this had not been tried in training or operationally.

Fibrescopes had been found useful for viewing the extent of hidden fires and for judging the safety of collapsed structures.

2.6 Question 6

What methods of special training do you employ ?

Thermal Imaging Cameras

In Brigades where special training in the use of thermal imaging cameras took place, it was usually allied to BA training at station level, and backed up with Brigade technical bulletins. Sixteen Brigades employed only 'hands-on' training with a minimum of extra theoretical training or specific exercises. At least eight Brigades mounted ongoing regular training in both theoretical and practical operation of the equipment.

Sound Detection Equipment

The majority of Brigades (thirteen out of twenty) with this type of equipment trained a small team of operators in its use. This training is both theoretical, via Brigade technical bulletins, and practical, via special training exercises. Brigade bulletins are also available to all firefighters, who can then learn about the operation of equipment as necessary.

The training for the sound detection equipment tended to be more specialised because the equipment is more difficult to operate than the thermal imaging cameras. Instruction on filtering of background noise was considered necessary. Three Brigades commented that command and control of the search team and the site was

the most difficult and important part of using the equipment.

Other Equipment

Infratrace - all officers in the Brigade were given training involving practical use of the equipment.

Fibrescope - initial training of operators was carried out by the Brigade training department, followed by regular refresher training by station staff.

2.7 Question 7

How is the equipment mobilised ?

Twenty eight Brigades said that their equipment was mobilised on request by the Officer-in-Charge at an incident. Of these, twelve Brigades generally kept their equipment at Headquarters or a central location and from there it was mobilised by car by an officer. The remaining Brigades kept equipment either on front line appliances, emergency tenders or rescue tenders which could be mobilised on request.

Sixteen Brigades usually carried equipment on appliances that could be mobilised as part of a Pre-Determined Attendance. One Brigade routinely mobilised casualty detection equipment to all off-shore fires and another to all house fire and larger incidents.

In general, Brigades own more thermal imaging cameras than any other type of detection equipment, and these tend to be the pieces of equipment that are likely to be mobilised as a Pre-Determined Attendance.

3. THERMAL IMAGING CAMERAS

This chapter provides details on thermal imaging cameras, which are used by brigades in a variety of circumstances, in particular, to locate casualties at incidents. Section 3.1 provides a general description of the cameras. Section 3.2 lists the technical specifications of the two types of camera in general use in brigades. Section 3.3 details the operational use of the cameras and Section 3.4 concludes the chapter with a discussion of the applicability of thermal imaging cameras to casualty location.

Table 3, page 33, lists the types of thermal imaging camera currently in use in each Brigade.

3.1 General Description

Thermal imaging cameras are in use in the majority of brigades. They work on the principle of converting radiated heat energy (infrared) into a visible image, where different temperatures are represented by varying shades of grey on a monitor.

Infrared is a non-penetrating radiation (in the 8-14 μm band) which means that the cameras can not "see" through normally transparent objects such as glass or plastic or water. Similarly, any layer of rubble or dense material will effectively obscure a casualty from the operator's view. Infrared can be reflected and focused in the same way as visible light. Consequently, any smooth surface, even surfaces not normally considered reflective, can act as a mirror for infrared radiation and give misleading indications of the location of heat sources. Thermal shadows may also be apparent where hot or cold objects have been in contact with a surface and then removed.

3.2 Specifications

The two main types of thermal imaging camera in use are models P4228 and the P4428, manufactured by the English Electric Valve Company.

Model P4228

Dimensions:	262mm x 243mm excluding eyepiece
Weight:	4kg excluding batteries
Batteries:	10 x 'AA' size 1.5v disposable alkaline cells
Operating time:	1.5 to 2 hours

This model has the battery cartridge container in the body of the camera.

Model P4428

This model has an external voltage stabiliser unit connected to the thermal camera by a cable concealed in the harness.

Camera

Dimensions:	255mm x 155mm excluding eyepiece and handle
Weight:	3kg

Voltage Stabiliser Unit

Dimensions:	215mm x 85mm
Weight:	0.5kg excluding batteries
Batteries:	10 x 'AA' size 1.5v disposable alkaline cells
Operating time:	1 to 1.5 hours

The P4430 model is a later version of the P4428, but had no significant differences from the description above.

3.3 Operational Use

Thermal imaging cameras are in use in most brigades but generally for firefighting rather than rescue purposes. The thermal imaging technique is limited in its usefulness in the rescue situation in that it can only give an indication of temperature at a surface. This means that a casualty that is hidden or buried under rubble, or some other dense medium, cannot be detected using a thermal imaging camera. The cameras can, however, be used to locate missing persons in the dark, in dense undergrowth and in smoke and therefore are a useful aid to a rescuer.

The camera can be used in two different modes.

Pan Mode

Infrared radiation received by the camera produces photo-electric excitation of the sensing element in the vidicon tube. The excitation dies away to the ground state over a period of approximately 10 seconds. This means that the image produced will, therefore, fade to a uniform grey until such time as the sensing element is re-excited by an increase (or decrease) of infrared radiation, or infrared radiation falls on a different part of the sensor.

In this mode the camera will only produce a permanent image if the instrument is kept in motion, ie panned.

If the camera remains stationary, signals will only be produced if the intensity of infrared radiation varies or if radiation falls on a different part of the sensor. This facility may be used to monitor temperature changes or hot spot movement and has a resolution of 0.5°C.

Chop mode

In chop mode, a rotating shutter in front of the vidicon tube interrupts the radiation received at the sensor momentarily. The resulting display is a continuous thermal image with a resolution of 1°C.

3.4 Discussion

Thermal imaging cameras are of limited use for locating hidden or buried casualties in a building collapse situation. Their limitation is that some part of the body must be visible to the naked eye, or if hidden, in contact with a thin obscuring material such as a partition, for the camera to be able to detect its presence. The display of standard cameras is limited to shades of grey to depict different temperatures. This means that unless the operator is very skilled, it is difficult to give an accurate interpretation of temperature, and it is also very difficult to detect small changes in temperature over time.

These cameras are very useful for finding hotspots during firefighting and for locating the seat of fires in situations where it may be hidden or obscured. However, their use for detecting buried casualties during building collapse is minimal, to the point of being virtually irrelevant.

4. SOUND DETECTION EQUIPMENT

There are several different types of sound detection equipment available specifically for the purpose of locating trapped casualties. This chapter summarises the details of the equipment and its use. Section 4.1 is a general description of the equipment available and how it works. Section 4.2 provides details of individual models and makes of equipment. Section 4.3 explains operational methods for using the equipment and section 4.4 concludes the chapter with a discussion of relevant points.

Table 4, page 36, lists the sound detection equipment in use in each Brigade.

4.1 General Description

Sound detection equipment generally consists of two or more sensitive microphones with an amplifier. The amplifier allows each sensor in turn to be monitored both aurally (the operator listening to headphones) and visually (usually a needle gauge or LED display). The better amplifiers will allow certain bandwidths to be filtered from detected sound so that background noise can be reduced.

Some types of equipment also include seismic sensors (sensitive microphones for listening to noises transmitted through solids) and facilities for voice communication between rescue teams and victims who have been located.

In general, there is no dedicated facility for recording any sound detected, for example, as a paper trace or data file. However, this is possible by using additional equipment such as an oscilloscope with the standard output of the equipment.

The operating procedures are relatively simple. However, the expertise required to interpret the sounds picked up by the seismic sensors can only be achieved by experience and regular use of the equipment in training.

Search patterns must be conducted in a methodical manner in order to cover the entire area to be searched.

4.2 Specifications

4.2.1 TPL 310

The "Trapped Person Locator" is produced in Israel and has been introduced into this country by Conjay Firearms & Ammunition Ltd. This equipment is designed primarily to detect sound transmission through solid material, with a secondary facility of an atmospheric listening sensor.

The unit consists of:

An amplifier
Two sets of headphones, mono.
Right and left seismic sensors
One atmospheric listening (acoustic) sensor
Two cable drums and cable
A test kit
Integral amplifier container

The unit and accessories are stowed complete in one metal case, approx 24" high x 18" x 10", which is provided with a carrying handle on either side. This container is quite heavy (18.5 Kg) and therefore awkward when working on any surface other than a flat surface.

The amplifier has a LED sound level display which displays the levels detected by both the left and right seismic sensor on separate sections. This display has a "freeze" facility which records the highest sound level at any given time by a touch button.

The unit can be powered by:

* one alkaline 12v battery (operating time 30 hours at room temperature) or
* ten D type alkaline batteries at 1.5v each (operating time 80 hours approximately) held in a battery holder, or
* for extreme cold environment (less than -20°C) four lithium batteries at 3.3v each, or
* external 12v car battery using the external battery cable provided.

The Atmospheric Listening Sensor detects voice transmissions from a trapped person. It is, however, only a one way system i.e. the operator can listen to the trapped person's voice but cannot communicate with him, although the later model the TPL 310B has a two way facility. The sensor may be of use where a victim has limited movement and cannot attract attention other than by calling out. In this case, the ALS must be placed in the vicinity of the trapped person for use, which means that both the sensor and its cable must be fed through a suitable channel in the rubble and debris. Hence the system is of minimal use unless there is a clear passage to the trapped person, e.g. a vertical shaft.

Costs
The basic unit costs approximately £2,000 depending upon the exact equipment required.

4.2.2 TRIPHONE 2000

The "Triphone Detector" is produced by Socam, a French company with a subsidiary in Staffordshire. This equipment is designed to detect sound transmissions which vibrate through solid material, particularly sounds made by conscious persons trapped under building rubble.

The unit consists of a carrying case containing:-

An amplifier
Two sets of headphones, switchable between mono and stereo, with individual volume controls
Right and left seismic sensors with cable
Extension cable
Tape recorder cable
Sensor extension rods

The unit and accessories are stowed complete in one canvas carrying case. It is light weight (6.5Kg) and reasonably comfortable to wear.

The Triphone is supplied with seismic sensor extension rods whose purpose is to increase the surface area contact of the seismic sensor when working on very loose, small size material. The extensions increase the sensitivity of the equipment and are useful in circumstances where contact with the ground would normally be difficult.

The amplifier has a meter gauge which is switchable between the two seismic sensors. Additional earphones are supplied so that two operators can listen at the same time. The T-piece for the additional earphones also provides the capability of attaching external equipment, such as an oscilloscope, to visually monitor detected sounds over a period of time.

Costs
The basic unit cost price is approximately £800.

4.2.3 LIFE DETECTOR

This equipment is produced in Germany by Wandel and Goltermann Ltd, who have a subsidiary in the UK. It is designed primarily to detect sound transmissions through solid material and has a secondary facility of a two way speech system.

The basic unit consists of:

An amplifier
1 seismic sensor
5 metre cable
1 headphone
Battery charger
Carrybag for amplifier
Metal case for storage (complete unit).

Additional equipment which may be required includes a further seismic sensor, additional 5m cable and a set of earphones.

The unit and accessories are stored in one or two metal containers, depending on the number of accessories purchased. These metal containers are both heavy and bulky (approximately 15kg in total). For operational use a canvas carrybag is supplied to carry the amplifier (7.2Kg), slung round the operator's neck.

Signal strength is displayed on the amplifier by means of a series of LEDs. The amplifier also has a variable filter facility which allows background noise to be filtered from the amplified sound so that particular frequencies can be focused upon by the operator.

The seismic sensors are painted in high visibility orange, with a large numeral corresponding to a seismic sensor identification on the amplifier. This provides immediate identification of individual seismic sensors making operation of the equipment simpler.

An optional extra for the "Life Detector" is an intercom system providing two way communication facility between the rescuer and the trapped person. It is, however, dependant upon there being a suitable channel for the microphone and cable to reach the victim. In situations where this is possible, the two-way communication would allow the victim to be calmed and reassured that help is on the way, and might allow a medic to make an estimate of the state of health of the trapped person.

The seismic sensors can be attached by means of a screw thread to magnetic bases. This facility would be useful when using the equipment against metal structures, such as ships, as it removes the necessity to have a man holding the sensor against the structure, which would inevitably lead to some background noise due to movement of the sensor.

Costs

The basic unit as detailed	£2,455
Additional equipment	
1 seismic sensor	£ 209
1 x 5m cable	£ 30
1 set earphones	£ 73
Intercom system	£ 250
Total	£3,017

4.2.4 VIBRAPHONE ASB6

The Vibraphone ASB6 is the most common sound detection device in use in brigades. The basic unit consists of:

a) electronic control module (with carrying strap)
b) detachable headphones
c) two captors (sensitive microphones)
d) watertight case

The complete unit has a weight of approximately 13Kg.

The control module consists of:

a) on/off switch
b) volume control dial
c) headphone connection
d) left and right captor connections
e) left and right viewmeters

The equipment is supplied with a carrybag which is light enough to be slung around the operators neck (4.7Kg).

The amplifier runs on 9v batteries which allow approximately 100 hours use. There is a battery condition indicator on the control module, to warn when the batteries are low. The viewmeters are rotating graduated cylinders which provide visual reference of the response from the captors.

The captor leads are colour coded for easy identification and so that left and right captor sound is directed to the appropriate headphone.

The ASB7 is a slightly more recent version of the equipment with a few additional features, but the same basic make-up as the ASB6.

4.3 Operational Use

Brigade experience has provided some useful notes for working with sound detection devices. For all these pieces of equipment, pinpointing the casualty depends on:-

a) the casualty being conscious and capable of movement (in some cases, voice sounds can be picked up), and

b) the materials involved; metal will transmit sound much more readily than concrete. This means that a casualty tapping on a metal pipe is likely to be detected most strongly at the point where the pipe is closest to the surface. This means that the digging search may not begin closest to the victim, however the transmitted sound will give a rough location and direction for search. Most sounds can be pin-pointed to within one metre square surface area but the depth is unidentifiable.

4.3.1 Search Procedures

For all these types of sound detection equipment, strict search procedures must be enforced at the site so that the equipment can be used effectively.
These procedures include:

a) Complete silence on the search area whilst the operator of the equipment is listening for sounds from possible casualties. This is essential as the devices are very sensitive and any external noise will drown sounds from possible casualties and deafen the operator.

b) Strict procedures for moving the microphones are necessary. Generally an operator will work with two assistants, who move the sensors in the direction of any sound detected by the operator. The assistants must take care not to move the sensors until the operator has indicated both where he wishes the sensor to be placed and that he is ready for the sensor to be moved.

c) Some method for marking areas which have been searched is necessary. This can generally be fulfilled by partitioning off each sector searched using incident marker tape. However it is necessary to ensure that all of the site location is searched thoroughly and methodically.

4.3.2 Search Patterns

For the majority of the equipment, a sectoring search pattern is the most appropriate ie. progressing in quarter circles around a central point. The starting point for the search will generally be dictated by:

a) the circumstances found at the incident, and
b) information obtained from persons or crew members already in attendance.

If there is no obvious sound from a casualty, then the operator must make a decision upon which direction to take. This decision will be based on:

a) The state and condition of the ground and materials at the incident in relation to the safety of the search team.

b) Defining a route which will cover the entire site, preferably without covering ground already covered.

For additional searches covering the same area, the sensors should be placed in different locations, if possible, to maximise the chances of detection of a trapped person and to minimise the effects of high density materials reducing noise levels.

The following diagram details a typical pattern for a sound detected on the first quartering sweep and loudest in sensor A at position A2.

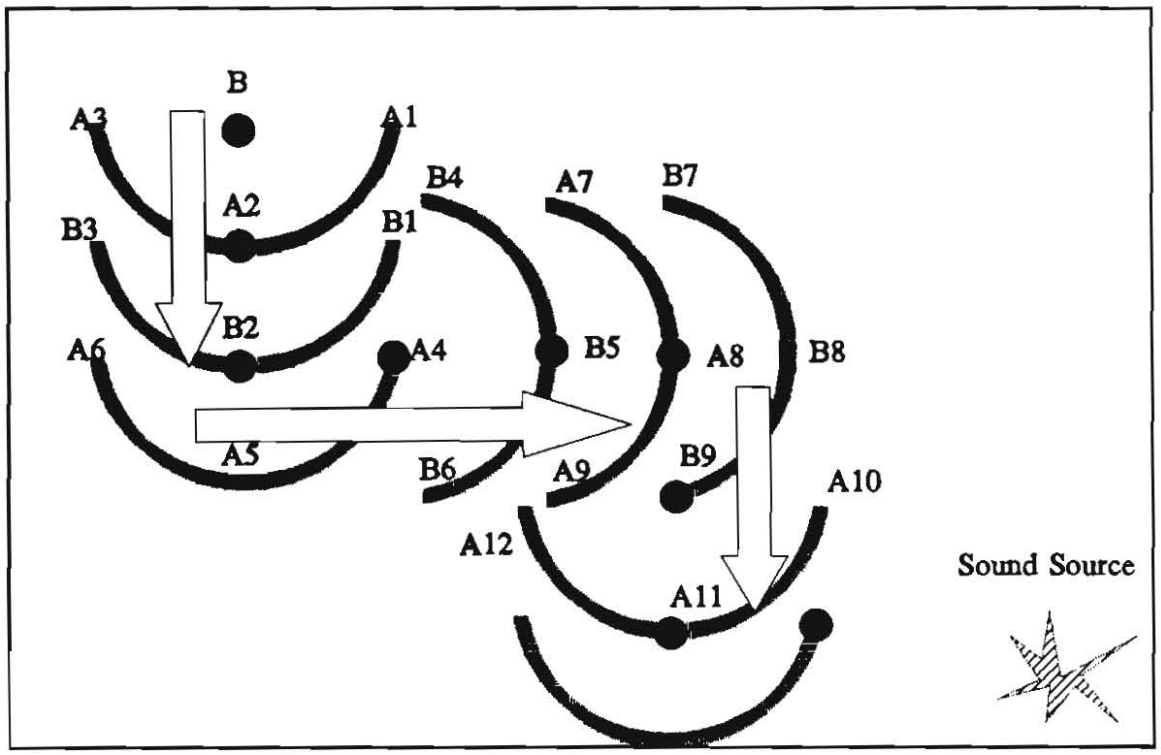

Figure 3: Search Pattern for Location of Trapped Casualties

The search should commence in a methodical pattern, so that no area of the ground is missed and as little as possible is covered more than once.

For the above diagram, the positions of the sensors are marked by the letters A*n* and B*n*. To begin the search, one sensor remains stationary at point B, whilst the other is placed at intervals around it, positions A1, A2 and A3.

The operator would work so that sensor B is kept stationary and sensor A is swept around sensor B in a circle approximately 6ft in diameter (depending upon conditions on site). If a sound is detected and is loudest in sensor A, at position A2, then sensor A should be kept stationary and sensor B swept around it in a similar pattern. For the next sweep, the detected sound is loudest in sensor B at position B2 and so sensor B is kept stationary. The next sweep has the loudest sound in sensor A at position A4, so the direction of the search is changed. In this way, progress should be made in the direction of the sound, as the arrows indicate.

When the detected sound is loudest in the central, stationary sensor, then the diameter of the sweeps should be reduced until the origin of the sound is pinpointed.

4.3.3 Special Conditions

The operational use of listening devices can be hampered by conditions at the incident. (1). (Numbers in parenthesis refer to the references on page 29).

1. Wind can cause background noise from sensors. The sensors should be covered and placed inside a structure if possible. They should not be attached to beams extending out from a rubble pile. The cables should be weighed down to prevent their movement.

2. Rain, sleet or hail will appear to the operator to be an increase in noise similar to an engine running. The sensors should be protected from the direct impact of the raindrops by a cloth or non-contacting wood. The distance between the sensors should be reduced to compensate for the conditions.

3. Running water may sound similar to rain or vibrations.

4. Airborne sound does not usually cause severe interference, but some attenuated sound may be picked up from the structure.

5. Vibrations from, for example machinery or engines can mask signals from the victim depending upon the amplitude and the location of the source. If the equipment has filtering systems, then cutting off the low frequencies reduces the interference.*

6. Diamond saws used to cut concrete produce signals of higher frequencies which can be filtered out. Knocking by the victim should still be detected.*

7. Jackhammers create interference which is very difficult to filter out and will almost certainly drown the sound of a victim. Operations using this type of equipment should be ceased for the duration of the search.

8. Work on neighbouring sites should not present a problem unless the sites are physically connected to the structure being searched.

*(Except for the very sharp line frequency notch filters, all listening should be done first in the unfiltered, wideband mode so that no signals such as scratching or crying are overlooked. This will mean that silence will be necessary on the site for the initial search period).

4.3.4 Useful Techniques

In general, vibrations transmitted through solid material are easier to detect than audible sound from a victim. This means that the victim should be encouraged to tap on the structure rather than call out. If the searchers tap three times on the structure,

a similar response will usually come from a trapped victim.

The more solid the material, the better it will carry sound and the less attenuation it will suffer. Excellent conductors are steel, unbroken concrete, solid brick and glass. Good conductors are loose concrete, rubble brick, gravel and wood. Wet soil and compacted soil are fair conductors whilst dry sand, snow, acoustic tile, carpet and fibreglass are poor sound conductors. The mechanical contact of the sensors with the conducting medium is also important. For example, attaching the sensors to spikes driven into soft ground or crevices will make the search easier. Magnetic holders to attach the sensors to metal will improve the contact to the structure.

4.4 Discussion

Sound detection equipment is designed specifically for the location of hidden or buried casualties at incidents such as collapsed buildings. The equipment is generally simple to use and effective operationally, although operator skill is of benefit for speedy and accurate location of a casualty. The equipment is very specialised and its cost, usually in the range £2000 to £8000 makes it quite expensive for the small number of incidents where it can be of benefit. However, when used operationally it can save considerable time in locating and rescuing casualties, thus not only saving brigade time but also increasing the chances of finding victims alive.

5. OTHER EQUIPMENT

This chapter describes equipment in use in brigades which does not employ thermal imaging or sound detection, but which could be used for the detection of buried casualties.

Table 5, page 39, lists other equipment in use in Brigades.

5.1 Kane May Infratrace

5.1.1 General Description

The INFRATRACE equipment is a non-contact digital thermometer which measures radiated energy from an object or surface and translates it to a visual LCD display in degrees Celsius. Any surface at a temperature above absolute zero emits heat in the form of radiated energy. At temperatures above 600°C some of this energy is visible, but much of it is of longer wavelength than visible light (ie infra red), although it behaves in the same manner as visible light. It travels in straight lines, can be reflected by mirrors and focused by lenses. The radiated flux from a surface is directly proportional to its temperature. Thus the Infratrace can provide an accurate surface temperature by measuring the flux emitted from a surface.

5.1.2 Specifications

INFRATRACE 1000

Applications: General industry use, energy conservation, measures glass temperature.
Readout: 12.7mm Digital Liquid Crystal Display
Full Scale Measurement Range: 0-1000°C (temperatures outside this range are displayed at reduced accuracy)
Resolution: 1°C
Accuracy: ±0.7% of reading, ±0.4% of full scale
Repeatability: ±0.3% of full scale
Emissivity Compensation: 0.2 to 1.0
Spectral Range: 8-14μm
Speed of Response: 3 readings per second < 100ms at recorder output
Minimum Target Size: 20mm diameter at 1 metre range
Field of View: 25 milliradians (1.5°)
Distance/Target Diameter: 40:1
Optical Sight: Integral, parallax corrected
Ambient Temperature: operating 0°C to 45°C, storage -20°C to 60°C
Battery Type: 9 volt PP3, TR146X, 6FF (Heavy duty type recommended)
Battery Life: 30 hours, representing 3 months typical use
Dimensions (excluding handle): 235 x 90mm (9¼ x 3½")
Weight: 980gms (2lb 2½oz)

INFRATRACE 2000

Applications: High Temperature Processes, Metal Foundry, Measures through glass
Readout: 12.7mm Digital Liquid Crystal Display
Full Scale Measurement Range: 600-2000°C (Automatic out of range indication)
Resolution: 1°C
Accuracy: ±1% of reading, ±0.4% of full scale
Repeatability: ±0.3% of full scale
Emissivity Compensation: 0.2 to 1.0
Spectral Range: 2-2.5μm
Speed of Response: 3 readings per second < 100ms at recorder output
Minimum Target Size: 20mm diameter at 1 metre range
Field of View: 25 milliradians (1.5°)
Distance/Target Diameter: 40:1
Optical Sight: Integral, parallax corrected
Ambient Temperature: operating 0°C to 45°C, storage -20°C to 60°C
Battery Type: 9 volt PP3, TR146X, 6FF (Heavy duty type recommended)
Battery Life: 30 hours, representing 3 months typical use
Dimensions (excluding handle): 235 x 90mm (9¼ x 3½")
Weight: 980gms (2lb 2½oz)

5.1.3 Operational Use

The Infratrace is a useful tool for determining the surface temperature of objects. The accuracy of the readout is operator dependant as the emissivity of the object must be judged and accounted for by the operator. The Infratrace is easy to use and can provide useful information on whether objects are cooling down or heating up and the rate at which this is taking place. Maintenance of the equipment is minimal but can be carried out in the UK by the distributor.

The ability of the equipment to detect casualties has not been tested either in training or operationally. It is sensitive to very small changes in temperature of a surface but whether the heat from a body could be detected through solid objects would depend upon the circumstances at the incident such as the depth of rubble and the coverage of the body. The expectation of success with the use of this equipment would be no more than for the thermal imaging equipment.

5.2 Fibrescope/Endoscope

5.2.1 General Description

This equipment consists mainly of a bright light source which is transmitted through thin optical fibre cable so that inaccessible places can be viewed.

The equipment described below is a particular make of fibrescope which is in operational use in a brigade. It may differ in some small details from other makes of equipment of the same type, but the general descriptions and operating procedures will remain the same.

5.2.2 Specifications

The full fibrescope kit consists of:

Olympus IF 11D4-20 Fibrescope
Olympus KLS - 301L Light Source
KMI Nickel Cadmium Battery Belt

The battery belt is the mobile power source for the light generator and allows the use of the fibrescope in 'silent' environments such as when using sound detection equipment. The belt houses 10 1.2v nickel-cadmium cells, each fully sealed in a stainless steel case with a safety vent. The battery is protected by a 15A anti-surge fuse located near the connector to the light source. An integral battery charger is contained within the belt. The fully charged battery belt will give a working duration of 1 hour, and will take approximately 15 hours to recharge.

The light source can alternatively be powered from either a 230v or 115v AC supply or by a DC supply of 10-15v. The unit has an internal relay to automatically switch the unit between AC and DC supplies, if both are connected the unit will run from AC to conserve the battery supply. A 150W quartz halogen lamp is mounted into a one-piece lamp holder inside the unit. The light unit is approximately 14 inches long, 10 inches high, eight inches wide and weighs 8.5 Kg. Light output from the unit can be controlled by means of a shutter.

The fibrescope can be considered in five main parts: distal end, bending section, insertion tube, control/ocular section and light guide cable.

Distal end
This is the working end of the fibrescope and contains an optical adaptor - two adaptors are provided with the equipment, one forward viewing and one side viewing at 90°.

Bending section
This is the final 55mm of the fibrescope, which has an angulation range of 120° up, 120° down, 100° left and 100° right. The movement of the section is directed from the control section of the fibrescope.

Insertion tube
The insertion tube has a braided metal outer sleeve which is 11.3mm in diameter. It has a total length of 2020mm of which the working length is 1700mm.

Control/Ocular Section
The following controls are fitted:

i). Ocular This is the eyepiece and includes an index mark in the view field, which indicates 'up' in the direction of bending, in relation to the controls.

ii). Dioptre Adjustment Ring Adjusts the eyepiece to suit the operator's vision. Four colour coded indexes are provided for quick setting of the ring.

iii). Focusing Ring Adjusts the objective to suit different lens to object distances. It is mounted below and at right angles to the Dioptre Adjustment Ring.

iv). Angle Free Knob Locks the bending section of the fibrescope in position when rotated anti-clockwise, frees the bending section when rotated clockwise.

v). Angle Knobs These control the movement of the bending section of the fibrescope.

Light Guide Cable
Contains the bundle of optical fibres encased in a flexible metal sheath 2m in length, terminating in a push fit connector for connection to the light source. The connector gets hot from the light source during operations and should be removed with care.

Costs
The basic unit consisting of light source, optical cable and battery pack costs approximately £7,000. Additional equipment for CCTV use and video imaging is considerably more expensive.

5.2.3 Operational Use

The fibrescope can also be attached to CCTV for external monitoring. This may be useful where a number of experts are gathered to advise on, for example, medical aspects or building construction.

Operational use for search and rescue purposes is limited by the length of the cable and the availability of a suitable passageway for the optical fibre cable to be inserted through. A channel may be provided by crews drilling through rubble or concrete debris, however this must be carried out carefully where casualties are expected to be located.

The equipment is simple to use and robust but has a very small search area for the location of buried casualties. Once a casualty is pinpointed the fibrescope could be used to determine the exact condition of the casualty and to determine the best method of rescue.

Maintenance of the equipment should be minimal, but can be carried out in the UK by the distributor/manufacturer.

5.3 Search and Rescue Dogs

5.3.1 General Discussion

Trained dogs are used for many search and rescue applications. The dogs are trained to follow a human scent and to alert the trainer when the source is found. The dogs cannot, however, distinguish between scents from different people, between live casualties or dead ones, or from scents that remain on articles of clothing. Thus the dog will track the first human scent it comes across until the source is found, whether this be a live casualty or an overcoat. In the same vein, strong smells, for example smoke, may confuse dogs, although the degree to which they are affected will depend very much upon the individual animal. The dogs follow airborne scents, so tracking across water is possible.

5.3.2 Organisations

There are a number of organisations which train dogs for search and rescue purposes. These include the Search and Rescue Dog Association, and the Cave Rescue Organisation in England. Most of the organisations are voluntary and therefore have little financial provision for training exercises, or evaluation regimes.

5.3.3 Overseas Experience

A number of organisations exist overseas, mainly in mountainous areas of Europe where rescue teams endeavour to find those lost in hazardous conditions on the mountains.

An exercise mounted by the Virginia Beach Fire Department in America in 1989 involved two dog teams from:

Virginia Department of
Emergency Services
c/o Ralph Wilphong
Operations Division,
7700 Midlothian Turnpike,
Richmond
Virginia, 232556

US Disaster Search Dog Team
c/o Bill Dotson
Coordinator/Trainer
Route 2 Box 122
Ruckersville,
Virginia, 22968

The exercise was mounted by Chase Sargent who is a Battalion Chief and Paramedic with the Virginia Beach Fire Department. The following is an extract from his summary of the exercise:

"SEARCH DOG TEAMS AND OTHER COMPONENTS

If heavy rescue team personnel are unable to locate and pinpoint the victims of a building collapse their skills have been wasted. With the main emphasis to find, treat and remove victims, locating them quickly and timely is essential. Search dogs and their handlers provide the edge needed to gain maximum live extrications from building collapses. Dog teams have proven effective time and time again in building search and rescue functions across the world. These personnel should be of a reputable and highly trained organisation. Personnel and dogs should have an excellent understanding of search patterns, building construction, managing the search function and knowledge and ability to work within the incident command system. Medical skills are almost a necessity for handlers as they may be called to assist in the primary treatment of partially covered victims. In a drill situation a search component must be incorporated into the plan. Another must for the search dog-handlers is a well-rounded understanding of building construction principles. This coupled with the fact that a dog handler will always have a heavy rescue team member with them for safety and collapse evaluation will allow them to safely work their dogs in an unstable environment.

Additional search functions such as infra-red cameras, listening devices, bore hole cameras and other electronic sensing equipment are interesting if you have them in your area. But in this author's opinion it will never replace a dogs nose and a knowledgeable handler!"

5.3.4 Discussion

Search dogs provide an additional resource to rescue services in that they utilise scent rather than sight or sound, as with the man-made equipment, to locate casualties. The use of dogs therefore has good potential for locating trapped victims, although the potential may not always be realised due to circumstances at the incident.

6. CONCLUSIONS

This chapter provides summarised conclusions from the questionnaire responses from brigades, from technical evaluation of equipment and from operational experiences of a number of fire brigades which own or use such equipment.

Equipment in Use

1. Fifty brigades (75%) said that they had purchased or used a detection device. Forty four Brigades had thermal imaging cameras, twenty Brigades had sound detection equipment and three Brigades had other types of equipment such as fibrescopes. Seventeen brigades had no such equipment or had not used any.

Operational Use and Effectiveness

2. Sound detection devices have been used operationally by seven brigades. Of these, three brigades have successfully used the equipment to locate persons trapped or hidden.

3. Devices which detect vibrations or sounds which would otherwise go undetected has been found to be the most effective equipment for the location of buried casualties. The better models of this type of equipment have filtering systems so that background noise can be reduced, making it easier to detect sounds made by trapped casualties.

4. Thermal imaging cameras have been used frequently operationally to detect casualties, but with limited success when the victim has been obscured by dense material, water or glass. The cameras have no appreciable potential for detection of victims buried in collapsed buildings, or similar situations, because they cannot 'see' through dense objects such as brick, rubble or even through glass.

5. Search and rescue dogs have the potential to be useful for detecting and locating hidden or buried casualties, but as yet this potential has not been realised in this country. Several overseas organisations use dogs to locate missing people, but this tends to be mountain rescue type incidents where the dogs have few scents to follow and less to distract them.

Training and Mobilising

6. Whatever type of equipment is used to detect trapped casualties, the overriding requirement for a search is that it is carried out methodically and with good control of resources by the officer in charge.

7. The effectiveness of all items of equipment is increased by training of operators in good search techniques and the abilities and limitations of the equipment being used.

8. Twenty eight Brigades mobilised their equipment on request from the officer in charge at an incident. Of these, twelve generally kept their equipment at a central location and the remaining stored the equipment either on front line appliances, emergency tenders or rescue tenders which could be mobilised on request.

Summary of Conclusions

9. Sound detection devices have been found to be most useful for detection and location of casualties buried in collapsed buildings or other similar situations. Thermal imaging cameras have been used successfully to detect victims in dense undergrowth, darkness and thick smoke. Other specialised equipment has been used in a small number of incidents with varying success.

ACKNOWLEDGMENTS

The author would like to thank:

Devon Fire and Rescue Service
Dorset Fire Brigade
Grampian Fire Brigade
London Fire and Civil Defence Authority
Tyne & Wear Metropolitan Fire Brigade
Search and Rescue Dogs Association

REFERENCES

1. Fire Engineering, July 1991, p87-90
2. Grampian Fire Brigade Training Note: Vibraphone ASB6
3. Devon Fire & Rescue Service Evaluation of Seismic Detection Equipment

TABLE 1: TYPES OF EQUIPMENT

Name of Equipment	Method of Detection	Suppliers	Model	Number of brigades
Thermal Imaging Camera	Thermal Imaging	English Electric Valve Company, Waterhouse Lane, Chelmsford, Essex CM1 2QU	P4428	31
			P4228	9
			P4430	1
			Unknown	3
Life Detection System	Seismic probes & directional microphone	Wandel & Goltermann Ltd., Progress Ho. 412, Greenford Road, Greenford, Middlesex UB6 9AH	BN 2097/01	2
Vibraphone	Sound detection	Electronic Service, 244 Rue de Plaimpalias, St. Alban-Leysse, France	ASB6	11
			ASB7	1
Infratrace	Infra-red thermometer	Kane-May, Burrowfield, Welwyn Garden City, Hertfordshire, AL7 4TU	801/1501	1
Triphone secours	Sound detection	Socam Meters plc Chemain de Chantelle F-31000 Toulouse Haute Garonne, France	T2000s	1
Fibrescope - Visual Inspection Equipment	Visual inspection through flexible probe	Olympus Distribution Ltd, 18 Gravelly Park Ind. Estate, Tyburn Road, Birmingham, B24 8HZ	IF-11D4-20	1
Trapped Person Locator	Seismic & acoustic sensors	Elpam Electronics Ltd., Conjay Firearms & Ammunition, PO Box 582, Unit 4, 765 Narrow Road, London NW1 0NZ	TPL 310B	3

TABLE 2: TYPES OF EQUIPMENT IN EACH BRIGADE

Brigade	Casualty Detection Equipment			
	No equipment	Thermal imaging camera	Sound Detection Equipment	Other
Avon		✓		
Bedfordshire		✓		
Berkshire		✓		
Buckinghamshire	✓			
Cambridgeshire			✓	
Cheshire		✓		
Cleveland		✓	✓	
Clywd	✓			
Cornwall	✓			
Cumbria		✓		
Derbyshire		✓		
Devon		✓		
Dorset		✓	✓	✓
Durham	✓			
Dyfed		✓		
Essex			✓	
Glamorgan Mid		✓		
Glamorgan South	✓			
Glamorgan West		✓		
Gloucestershire		✓		
Guernsey	✓			
Gwent		✓		
Gwynedd	✓			
Hampshire		✓	✓	

Brigade	Casualty Detection Equipment			
	No equipment	Thermal imaging camera	Sound Detection Equipment	Other
Hereford & Worcester		✓		
Hertfordshire		✓	✓	
Humberside		✓	✓	
Isle of Man		✓		
Isle of Wight		✓		
Isles of Scilly	✓			
Jersey		✓		
Kent		✓	✓	
Lancashire	✓			
Leicestershire		✓		
Lincolnshire	✓			
London		✓	✓	
Manchester		✓		
Merseyside		✓		
West Midlands			✓	
Norfolk		✓		✓(on call)
Northamptonshire			✓	
Northumberland	✓			
Nottinghamshire		✓		
Oxfordshire		✓	✓	
Powys	✓			
Shropshire		✓		
Somerset		✓		
Staffordshire		✓	✓	

Brigade	Casualty Detection Equipment			
	No equipment	Thermal imaging camera	Sound Detection Equipment	Other
Suffolk		✓		
Surrey		✓		
Sussex East	✓			
Sussex West		✓	✓	
Tyne & Wear		✓	✓	✓
Warwickshire		✓		
Wiltshire	✓			
Yorkshire North		✓		
Yorkshire South		✓		
Yorkshire West			✓	
Central Region		✓	✓	
Dumfries	✓			
Fife			✓	
Grampian		✓	✓	
Highlands & Islands	✓			
Lothian & Borders	✓			
Strathclyde		✓	✓	
Tayside		✓		
N Ireland		✓		

TABLE 3: TYPES OF THERMAL IMAGING EQUIPMENT BY BRIGADE

Brigade	Thermal imaging cameras			
	P4228	P4428	P4430	Other
Avon				
Bedfordshire		✓		
Berkshire				
Buckinghamshire				
Cambridgeshire				
Cheshire		✓		
Cleveland		✓		
Clywd				
Cornwall				
Cumbria			✓	
Derbyshire		✓		
Devon	✓			
Dorset		✓		
Durham				
Dyfed		✓		
Essex				
Glamorgan Mid		✓		
Glamorgan South				
Glamorgan West		✓		
Gloucestershire		✓		
Guernsey				
Gwent		✓		
Gwynedd				
Hampshire		✓		
Hereford & Worcester		✓		

Brigade	Thermal imaging cameras			
	P4228	P4428	P4430	Other
Hertfordshire		✓		
Humberside	✓	✓		
Isle of Man				
Isle of Wight		✓		
Isles of Scilly				
Jersey				
Kent	✓			
Lancashire				
Leicestershire				
Lincolnshire				
London	✓			
Manchester	✓	✓		
Merseyside		✓		
West Midlands				
Norfolk		✓		
Northamptonshire				
Northumberland				
Nottinghamshire				
Oxfordshire		✓		
Powys				
Shropshire		✓		
Somerset		✓		
Staffordshire		✓		
Suffolk		✓		
Surrey		✓		
Sussex East				
Sussex West		✓		

Brigade	Thermal imaging cameras			
	P4228	P4428	P4430	Other
Tyne & Wear				
Warwickshire	✓			
Wiltshire				
Yorkshire North		✓		
Yorkshire South	✓			
Yorkshire West				
Central Region				✓
Dumfries				
Fife				
Grampian	✓	✓		
Highlands & Islands				
Lothian & Borders				
Strathclyde	✓			
Tayside		✓		
N Ireland				

TABLE 4: TYPES OF SOUND DETECTION EQUIPMENT BY BRIGADE

Brigade	Sound Detection Equipment				
	Vibra-phone ASB6	Vibra-phone ASB7	Trapped Person Locator TPL310	Triphone Secours TS2000S	Life Detection System BN 2097/01
Avon					
Bedfordshire					
Berkshire					
Buckinghamshire					
Cambridgeshire	✓				
Cheshire					
Cleveland	✓				
Clywd					
Cornwall					
Cumbria					
Derbyshire					
Devon					
Dorset				✓	
Durham					
Dyfed					
Essex	✓				
Glamorgan Mid					
Glamorgan South					
Glamorgan West					
Gloucestershire					
Guernsey					
Gwent					
Gwynedd					

Brigade	Sound Detection Equipment				
	Vibra-phone ASB6	Vibra-phone ASB7	Trapped Person Locator TPL310	Triphone Secours TS2000S	Life Detection System BN 2097/01
Hampshire	(one piece of equipment, unknown make, on loan from another brigade)				
Hereford & Worcester	✓				
Hertfordshire		✓			
Humberside	✓				
Isle of Man					
Isle of Wight					
Isles of Scilly					
Jersey					
Kent	✓				
Lancashire					
Leicestershire					
Lincolnshire					
London	✓		✓		
Manchester					
Merseyside					
West Midlands			✓		
Norfolk					
Northamptonshire			✓		
Northumberland					
Nottinghamshire					
Oxfordshire	✓				
Powys					
Shropshire					

Brigade	Sound Detection Equipment				
	Vibra-phone ASB6	Vibra-phone ASB7	Trapped Person Locator TPL310	Triphone Secours TS2000S	Life Detection System BN 2097/01
Somerset					
Staffordshire	✓				
Suffolk					
Surrey					
Sussex East					
Sussex West	✓				
Tyne & Wear	✓				
Warwickshire					
Wiltshire					
Yorkshire North					
Yorkshire South					
Yorkshire West					
Central Region					✓
Dumfries					
Fife					✓
Grampian	✓				
Highlands & Islands					
Lothian & Borders					
Strathclyde	✓				
Tayside					
N Ireland					

TABLE 5: OTHER EQUIPMENT BY BRIGADE

Brigade	Other Equipment			
	Kane-May Infratrace	Endoscope Probe	Fibrescope - Visual inspection equipment	Optic Fibre Endoscope
Avon				
Bedfordshire				
Berkshire				
Buckinghamshire				
Cambridgeshire				
Cheshire				
Cleveland				
Clywd				
Cornwall				
Cumbria				
Derbyshire				
Devon				
Dorset	✓			
Durham				
Dyfed				
Essex				
Glamorgan Mid				
Glamorgan South				
Glamorgan West				
Gloucestershire				
Guernsey				
Gwent				
Gwynedd				

Brigade	Other Equipment			
	Kane-May Infratrace	Endoscope Probe	Fibrescope - Visual inspection equipment	Optic Fibre Endoscope
Hampshire				
Hereford & Worcester				
Hertfordshire				
Humberside				
Isle of Man				
Isle of Wight				
Isles of Scilly				
Jersey				
Kent				
Lancashire				
Leicestershire				
Lincolnshire				
London				
Manchester				
Merseyside				
West Midlands				
Norfolk				
Northamptonshire		available on loan		available on loan
Northumberland				
Nottinghamshire				
Oxfordshire				
Powys				
Shropshire				

Brigade	Other Equipment			
	Kane-May Infratrace	Endoscope Probe	Fibrescope - Visual inspection equipment	Optic Fibre Endoscope
Somerset				
Staffordshire				
Suffolk				
Surrey				
Sussex East				
Sussex West				
Tyne & Wear			✓	
Warwickshire				
Wiltshire				
Yorkshire North				
Yorkshire South				
Yorkshire West				
Central Region				
Dumfries				
Fife				
Grampian				
Highlands & Islands				
Lothian & Borders				
Strathclyde				
Tayside				
N Ireland				

Appendix A: Questionnaire issued by FRDG to Brigades requesting information on the detection devices.

HOME OFFICE FIRE RESEARCH AND DEVELOPMENT GROUP

SURVEY OF DETECTION DEVICES FOR HIDDEN OR BURIED CASUALTIES

Name of Officer completing the form:

Telephone number for enquiries:

Brigade:

Question

1. Does your brigade have any equipment for the detection of hidden or buried casualties, or has it used any ?

   Please tick the appropriate box:

   Yes ☐ Please complete Questions 2 - 7

   No ☐ Please return the Questionnaire in the envelope provided

2. What is the equipment ? (If your brigade uses several types of equipment, please answer for each separately, using extra sheets of paper).

   Name:

   Make:

   Model:

3. What method of detection does this equipment use ? (eg. thermal imaging, sound detection).

4. How often has it been used operationally and briefly describe in what circumstances?

5. Has the equipment been found useful?

6. What methods or special training for the equipment do you employ?

7. How is the equipment mobilised to the incident?

Please return this questionnaire in the envelope provided to Miss C A Reynolds, Fire Research and Development Group, Home Office, Room 443, Horseferry House, Dean Ryle Street, London, SW1P 2AW.

Appendix B: An extract from a report by Devon Fire Brigade, evaluating seismic detection devices.

APPENDIX B: EXTRACT FROM EVALUATION OF SEISMIC DETECTION EQUIPMENT BY DEVON FIRE BRIGADE

The following is a brief description of a few of the successful tests:-

a) Tests on a mound of building rubble approx 30ft x 20ft x 15ft.

The test start point was on top of the mound in the centre. The sound source was identified immediately and a search pattern conducted. It was not necessary to search the whole mound as a direction became immediately apparent. Many other noises were picked up, including traffic, aircraft flying by and other unidentified noises, all of which were sufficiently filtered out to make the noise source of the "trapped person" a prominent noise.

b) Tests on a number of scrap cars.

A number of cars, stock piled and bumper to bumper were tested. The only contact between cars piled one on top of the other was through the rubber tyres. This test was successful in that the noise source was picked up immediately and the direction was clear. Some confusion occurred when the seismic sensors were placed on a car body which was separated from the noise source by the tyres. The level of noise was reduced. It is for this reason that it is essential that regular training is carried out to permit operators to recognise the possibility of misreading the situation due to the ability of different materials to transmit sound.

c) A Royal Marine training tunnel.

An underground tunnel for Royal Marine training on Woodburgh Common was trialled several times. In every test, the seismic sensors located the noise source to within 1 metre (surface area). The construction of the tunnel was packed with earth, stones and rubble.

d) A Royal Marine barrier 4ft high x 20ft long.

This test was to simulate depth. Although the results can not be accurately taken to represent depth due to the fact that the surrounding material was air, it did indicate that the readable sound is capable of travelling a distance of at least 10ft through compacted sand and stone.

e) A Storm Drain

This test was conducted with White watch, Exeter as 2 combined test and exercise.

The test site was a storm drain approx 40 yards long, at a depth of between 8 x 10 ft.

One man was detailed to locate himself anywhere within the 40 yard section to act as a conscious casualty. Safety men were detailed and two teams of two B.A. wearers were told to stand by. Silence was called for and the test commenced. The drain was in three sections, separated by manholes. The effect this had on the test was no sound picked up in the first section, even when close to the first manhole. Immediately after passing the first manhole, the casualty's tapping noise was picked up and the B.A. teams were informed. Further soundings with the seismic sensors declared the casualty to be approx halfway between the first and second manhole. This proved to be an accurate identification.

One B.A. team entered the "down" manhole and the other team entered the "up".

The progress being made by a B.A. team was clearly detected by the seismic sensor right up until they made contact with the casualty.

Once contact was made, the conversation between the B.A. teams and the casualty were clearly audible. This meant that O.I.C. knew the B.A. team requirements and acted on them before their message reached the surface, via the safety men at each manhole.

This was an impressive test and one which the watch concerned enjoyed participating in.

Conclusion

As far as the tests went, this equipment is capable of detecting the type of noise a trapped person may be expected to make.

There is one point which must not be overlooked. All the above tests were carried out during the hot dry summer of 1989; no wet or saturated ground tests were conducted. This may have an effect on the capabilities of this equipment due to any dampness defusing or subduing sound transmissions.

No equipment at present in this Brigade (other than a fireman's ear placed on the ground) is capable of detecting sound underground. This type of equipment would be of immense value at an incident involving building collapse and other incidents as detailed above.

Even though collapsed building incidents are few in this Brigade, as has been seen on the national news lately, terrorist bombings are becoming more common almost anywhere in mainland Britain, in particular in 'soft targets', of which there are many in this Brigade area. Therefore, the threat is increasing where major collapse of heavily occupied premises are likely to occur.

As may be deduced from the above tests, the use of this equipment is not restricted to collapsed buildings. Other incidents where it may be of use are ships, underground passages and cellars, including Hi-ex foam filled cellars.

The make of set to be purchased to be decided after completion of evaluation of the other makes available.

Appendix B 3

Appendix C: Extract from training literature issued by Grampian Fire Brigade on the Vibraphone ASB6

GRAMPIAN FIRE BRIGADE OPERATIONAL TRAINING NOTE
VIBRAPHONE ASB 6

GENERAL

The Vibraphone ASB 6 is a device used for detecting sounds transmitted through solids and is anticipated being used to search for casualties buried alive or trapped in collapsed buildings. It will be held in the Special Equipment Store at Station 77.

DESCRIPTION

The Vibraphone consists of the Vibraphone unit, headphones and two captors (sound detection devices), all kept in carrying case.

The captors are used to pick up vibrations or sounds being transmitted through ground or rubble, and transmit them to the unit. The unit has amplifiers set to receive such sounds. Signals transmitted to the unit can then be received by the operator through the headphones and on the gauges on the unit. The signal from the left captor registers on the left gauge and the left hand side of the headphones, the signal from the right captor on the right.

USING THE VIBRAPHONE

Connect the headphones and captors to the appropriate plugs (all plugs are marked). Switch the unit on with the on/off switch and turn the gain control fully clockwise. Put the headphones on, ensuring that the headphones are on the correct way round (marked left and right). Sounds being transmitted can be heard through the headphones or observed visually on the gauges. The stronger the signal, the louder the noise through the headphones and the higher the gauge reading will be.

METHOD OF SEARCHING

Three people are needed for a quick and efficient search pattern, one with the unit and one person with each of the captors.

The area to be searched, should be searched in a square pattern, the left captor working to the left of the operator, the right captor to the right. The captors should be operated at approximately 6ft on either side from the unit operator. Move one captor forward 6ft and listen, if no noise is heard, move the other captor forward 6ft and listen, and so on until a noise is heard.

On hearing a noise that could be a trapped person, ascertain by using the gauges which captor is picking up the stronger signal. Move the other captor around until the signal in both captors is the same strength. Move the captor which first picked up the signal around until the strongest signal is heard and follow that line to find the point at which the noise is loudest. Using this method should quickly determine the area in which the casualties are trapped.

Note: If the casualties are conscious, searching will be made easier if the casualties are incited to make tapping noises.

If searching on soft ground ie sand or earth, it may be advisable to push a crowbar into the ground and rest the captor on it. This will pick up sounds more efficiently.

TESTING

The Vibraphone should be tested on acceptance, quarterly and whenever deemed necessary.

To test the Vibraphone, set it up as described in "Using the Vibraphone". Don the headphones and place the captors on the ground. Using a hard object, tap the ground approximately 6ft distance from each captor in turn and make sure both captors are picking up signals.

Check both sides of the headphones transmit sounds and that both gauges register the signals.

Give the unit and accessories a thorough visual examination. Log results.

Any faults or damage should be reported to the Technical Services.

CHANGING THE BATTERIES

The batteries should be changed whenever the unit shows signs of wearing down. To change the batteries, unscrew the lid and lift out the battery carrier. The unit requires 6 x HP7, 1.5 volt batteries.