Protecting the Fabric and Content of Historic Cathedrals against Fire

by

VINCENT SHACKLOCK and ALEXANDER COPPING

Cathedral fabric requires continuous monitoring and repair by skilled professionals but although adequate attention is generally given to the issue of gradual decay, the risk of fire is probably the most significant single threat and it is one which, it may be argued, has not received the attention it deserves. Historically, there have been numerous cathedral fires and it remains the most difficult event to anticipate, even with sophisticated technologies and carefully-devised safety procedures. The devastating fire at York Minster in 1984 may be uppermost in our minds but there have been numerous minor fires with at least twenty-three incidents reported in Anglican cathedrals during the period 1988-94.

Statutory controls applying to safety in cathedrals are limited and no legislation exists to safeguard building content and fabric from fire. In the relative vacuum caused by lack of clear legislation, cathedral insurers, principally the Ecclesiastical Insurance Group which covers forty-five Anglican Cathedrals, have been a source of advice on higher standards of safety and a recent English Heritage draft report on fire-safety in cathedrals is focusing attention on the technical, practical and financial issues. A cathedrals fabric survey conducted in 1991, the most substantial up-to-date review of the condition of cathedral fabric, provides only limited coverage of fire safety. Quinquennial surveys vary widely in their coverage of the issue and reports of fire safety facilities or improvements in the technical press are usually brief and concerned only with the larger cathedrals.

Even the partial destruction of a large cathedral would represent an irreplaceable loss but the complete safety of cathedrals from fire cannot be achieved no matter what technologies and management systems are employed. The highest orders of protection would require sophisticated detection and suppression systems and such rigid adherence to patterns of safety-conscious building

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management that the cost in terms of capital outlay and loss of flexible operation would be unacceptable.

This article looks at the causes and effects of fire and at systems and procedures which will minimise risk, using information drawn from various cathedrals and agencies. Experiences at York Minster and Norwich Anglican Cathedral, both leaders in certain respects in the adoption of fire safety measures, is given special attention. The aesthetic impact of physical interventions is also considered.

INTRODUCTION

A major cathedral is one of the mightiest, most sublime works of man. Collectively, the country's cathedrals amount to the greatest single contribution to the national heritage and, individually, some are of international architectural and historical significance. Pevsner and Metcalf wrote that:

> a cathedral is more than 'a building'. More too than a work of art, very much more than a museum of works of art... more than a setting for ritual observance and religious experience, more than a seat of administration... Ministered to by centuries of clergy and craftsmen, the mediaeval fabrics are mosaics of communal memory, memorials to English men and women's own past.[1]

Cathedrals have broad symbolic roles reaching beyond Christian ceremony to encompass many other groups and communities. Churchill recognised this in 1941, instructing fire authorities to focus maximum attention on St Paul's. The enormous effort involved in protecting this symbol of the capital city diverted water and manpower from the suppression of numerous fires affecting housing, trade and industry in nearby areas which would have had more tangible value for the local community and made a practical contribution to economic production and fighting capacity.

There are sixty-two Anglican and Catholic cathedrals in England, thirty-six of which are significantly or principally of medieval construction. The remainder include one seventeenth-century building (St Paul's), two eighteenth-century (Birmingham and Derby), fourteen parish-scale buildings of the nineteenth and early twentieth centuries, and nine generally larger-scale buildings of the last 100 years. Only twenty-six cathedrals might reasonably be called large, with a gross internal area of 3000 square metres or more.

Even a small fire can do irreparable damage, caused not only by the fire itself but by smoke, falling debris, and the huge volume of water which may be employed to quench the flames. After the fire a building may be structurally unstable and open to wind, rain and vandalism. Currently, statutory control applying to safety in cathedrals is very limited and no legislation exists to safeguard the building content and fabric from fire.[2] To date, most fire safety improvements have been funded by the individual cathedral with overall progress clearly skewed towards the financially more fortunate. At a number of cathedrals, despite awareness of inadequate fire-safety facilities, there has been a reluctance to divert limited funds from other programmes of conservation and repair. With no statutory duty to upgrade and where there may be no particular threat of fire outbreak, it is difficult to be critical of those who have directed resources to seemingly more urgent tasks. It is ironic, however, that when a catastrophe occurs the level of public sympathy generated may yield gifts of money sufficient to install *after the event* all the features which would have identified, controlled or even prevented the occurrence in the first place.

HISTORICAL REVIEW OF FIRE IN CATHEDRALS

That there have been so many serious fires in cathedrals and major churches over the centuries should not cause any surprise. Torchlights, candlelit shrines, wooden roofs, towers and spires, flammable fixtures and contents, and numerous domestic and other buildings cheek-by-jowl amounted to an environment rich in fire sources. Among the most severe losses are Peterborough (gutted in 1116), Gloucester ('calamitous' losses in 1122), Canterbury (loss of choir in 1174), Southwark (gutted in 1212), old St Paul's (almost total loss in the Great Fire of 1666) and York (partial or substantial destructions in 1080, 1137 and 1463; loss of the south aisle roof in 1753; loss of the choir in 1829; loss of the nave roof in 1840; and severe damage to the south transept in 1984). To this list may be added the destruction of Coventry Cathedral by aerial bombardment in 1940.[3]

The three most recent fires at York make a useful study of the varied causes, problems of fire fighting, and the scale of loss.

1. On 1st February 1829 an act of arson by Jonathan Martin destroyed the choir roof, the organ, the medieval stalls and all the furnishings of the eastern section of the building (Figs. 1 & 2). Born in 1782, Martin served in the Royal Navy for

Fig. 1
Sketch by T. Inchbold of the 1829 York Minster fire
York Minster Library

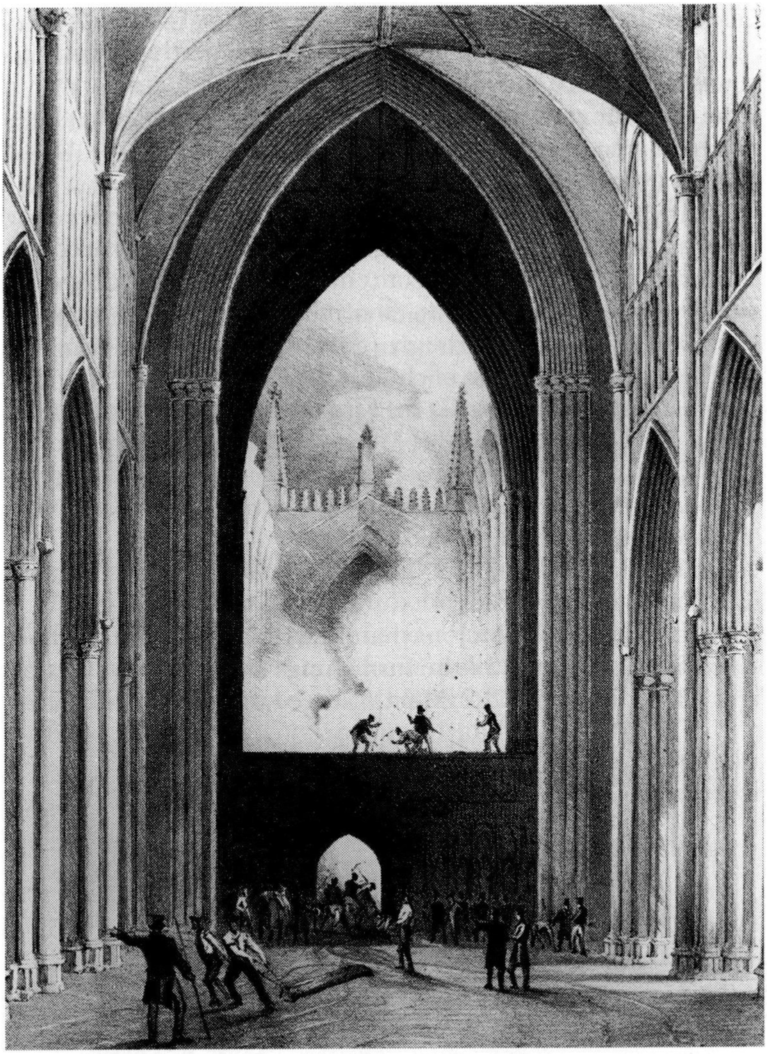
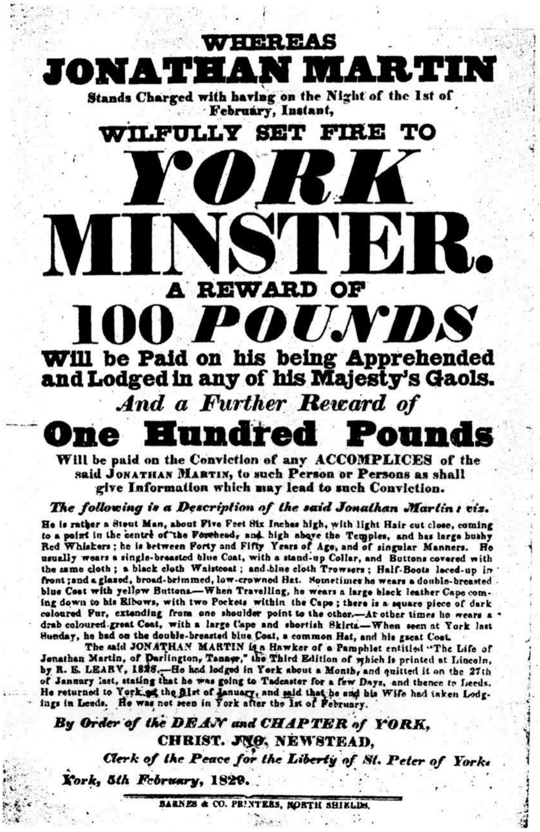


Fig. 2
Engraving by J. Browne showing the fire brigade and volunteers tackling the York Minster blaze on the morning of 2nd February 1829
York Minster Library

six years before becoming an itinerant hawker of his autobiography. He nursed a particular grievance against Anglican clergymen through much of his adult life. A series of extreme acts designed to annoy or embarrass clergy included hiding in the pulpit of his parish church before a service and rising unexpectedly after psalms to address the congregation. In December 1828 he arrived in York and during the following weeks made frequent visits to the Minster leaving messages pinned to the choir denouncing the Dean and Chapter. On 1st February he hid behind a tomb until the Minster was locked and then set two bonfires of books and cushions on the floor of the choir. The fires were slow to take hold but began to spread rapidly after about six hours as the flames came into contact with the organ and within hours the east end was ablaze and the roof collapsed. The crossing tower, fortunately, prevented the spread of fire to other parts of the roof. It did not take long for a committee of clergy and magistrates to be convinced of Martin's probable guilt and on 5th February an advertisement was circulated to all the principal newspapers offering a reward for his arrest (Fig. 3). He was apprehended a few days later near Hexham, Northumberland. In finding him not guilty, the jury was influenced by Paul Glenton, a surgeon of Newcastle-upon-Tyne, who gave evidence that Martin was '...undoubtedly a monomaniac on the subject of the clergy. ...when he was on this subject his eyes became glassy and his pupils much dilated'.[4] It was a verdict the Dean and Chapter had hoped for, as they did not wish to see him hanged. The public of York, however, are recorded as being far less charitable.[5]



WHEREAS
JONATHAN MARTIN
Stands Charged with having on the Night of the 1st of February, Instant,
WILFULLY SET FIRE TO
YORK
MINSTER.
A REWARD OF
100 POUNDS
Will be Paid on his being Apprehended and Lodged in any of his Majesty's Gaols.
And a Further Reward of
One Hundred Pounds
Will be paid on the Conviction of any ACCOMPLICES of the said JONATHAN MARTIN, to such Person or Persons as shall give Information which may lead to such Conviction.

The following is a Description of the said Jonathan Martin: viz.

He is rather a Stout Man, about Five Feet Six Inches high, with light Hair cut close, coming to a point in the centre of the Forehead, and high above the Temples, and has large bushy Red Whiskers; he is between Forty and Fifty Years of Age, and of singular Manners. He usually wears a single-breasted blue Coat, with a stand-up Collar, and Buttons covered with the same cloth; a black cloth Waistcoat; and blue cloth Trowsers; Half-Boots laced-up in front; and a glazed, broad-brimmed, low-crowned Hat. Sometimes he wears a double-breasted blue Coat with yellow Buttons.—When Travelling, he wears a large black leather Cape coming down to his Elbows, with two Pockets within the Cape; there is a square piece of dark coloured Fur, extending from one shoulder point to the other.—At other times he wears a drab coloured great Coat, with a large Cape and shortish Skirts.—When seen at York last Sunday, he had on the double-breasted blue Coat, a common Hat, and his great Coat.

The said JONATHAN MARTIN is a Hawker of a Pamphlet entitled "The Life of Jonathan Martin, of Darlington, Tanner," the Third Edition of which is printed at Lincoln, by R. E. LEARY, 1828.—He had lodged in York about a Month, and quitted it on the 27th of January last, stating that he was going to Tadcaster for a few Days, and thence to Leeds. He returned to York on the 31st of January, and said that he and his Wife had taken Lodgings in Leeds. He was not seen in York after the 1st of February.

By Order of the DEAN and CHAPTER of YORK,
CHRIST. JNO. NEWSTEAD,
Clerk of the Peace for the Liberty of St. Peter of York.
York, 5th February, 1829.

BARNES & CO. PRINTERS, NORTH SHIELDS.

Fig. 3
Jonathan Martin wanted poster circulated to all the principal newspapers of the region
Macmillan

2. At the end of his working day on the 20th May 1840 a craftsman accidentally left a candle burning in the chamber beneath the bells in the south-west tower. The fire was spotted at a quarter-to-nine that evening and within one hour local fire services were on the scene. By eleven o'clock that evening, when the fire was believed to be under control, smoke was seen coming from the nave roof and within a short period the roof timbers were engulfed in flames. At this stage people believed the entire building may burn down and a salvage operation was put into action to remove under military escort the ancient muniments of the Dean and Chapter and records of the Diocesan Registry.[6] Fortunately the fire was halted by the bulk of the central tower, but the nave roof and the south-west tower were destroyed (Fig. 4).
3. In the early hours of 9th July 1984 the south transept was devastated by fire. The Minster security officer was on duty in the north transept when the fire alarm was raised and the first two pumps were in attendance within minutes. After a short delay in finding the key to the door leading into the south transept

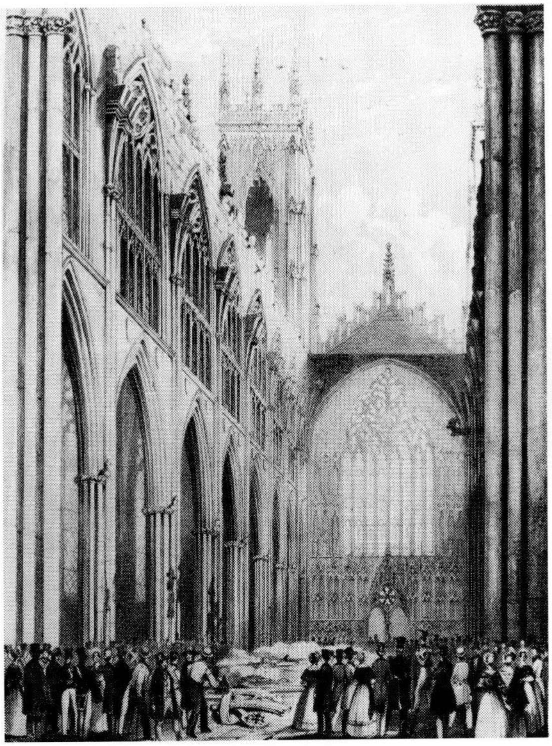


Fig. 4
Engraving by F.H. Abrahams of the aftermath of the 1840 York Minster fire
York Minster Library

Fig. 5
York Minster south transept fire 9th July 1984. Working from a 30 metre ladder a fireman attempts to cool the Rose Window by spraying the stonework above
Yorkshire Evening Post

tower, the firemen gained access to discover a severe conflagration involving the entire south transept roof (Fig. 5). The fire damage was restricted to this area because two powerful water jets set up inside the Minster prevented flames spreading up into the central tower. Although the entire south transept roof was lost, the famous Rose Window survived. The fire is believed to have been started by a lightning strike generating a phenomenon known as a 'side-flash' which causes an electrical discharge to jump from one conductor to another nearby. This flash occurred within the roof space, splintering and igniting timbers and allowing fire to gain a hold without the knowledge of security staff on duty.

THE ANATOMY OF FIRE

Before considering how fire may behave in cathedrals it is useful to clarify the physics of fire. Fuel, oxygen and heat are needed to initiate and sustain a fire but two further elements must be understood. First, the buoyancy of hot air carries the exhaust products away from the fire. Without such movement all the combustible gases would remain in the heart of the fire and there would be no spread. Second, it is the flammable gases given off from the heated-up solid material that burns rather than the solid material itself. These gases produce more heat which feeds back to the fuel, causing greater intensity and leading to the production of more flammable gas.[7] All fires, regardless of their severity, undergo the following five stages (Fig. 6):

1. *Initiation.* Heat is brought in contact with flammable material which acts as kindling.
2. *Accelerating growth.* Flames raise any potential fuel in the vicinity to the point at which it starts to release combustible gases (pyrolysis) which feed the flames, generating more heat, creating a chain-reaction effect.

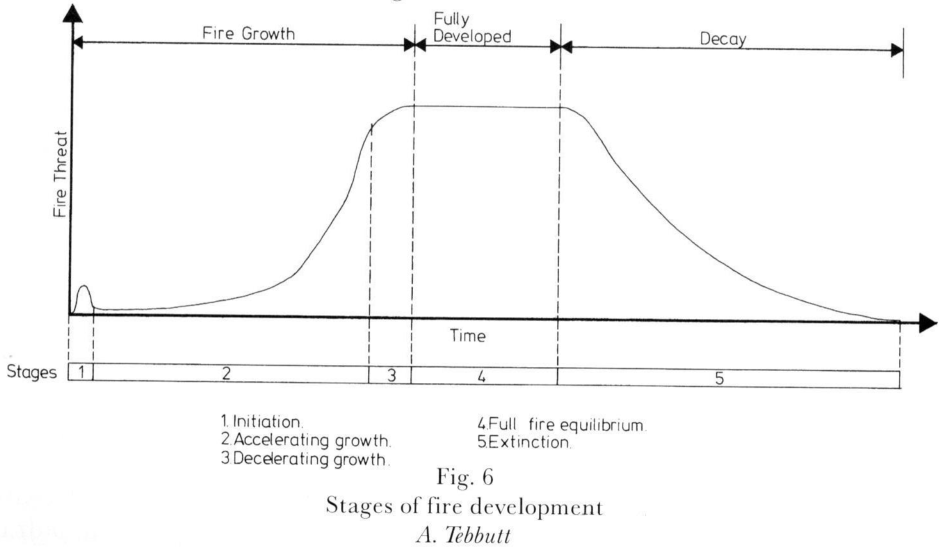


Fig. 6
Stages of fire development
A. Tebbutt

3. *Decelerating growth*. The rate of growth declines as the concentration of oxygen in the air becomes depleted and the supply of fresh air to the fire zone is constrained by the capacity of the ventilation system. As the temperature rises, the rate at which heat is lost from the fire zone by convection and radiation increases sharply, limiting the rate of pyrolysis. Although the pyrolysis-effect reduces temperatures, extremes of heat may be transferred to adjoining areas and structures by convection and radiation.
4. *Full fire equilibrium*. The fire atmosphere reaches an equilibrium temperature that fluctuates about a mean of 1000^{0}C as a result of the processes described in the third stage. The energy output of the fire remains relatively constant so long as fuel and air supplies to the fire zone are maintained.
5. *Extinction*. This will be caused by the action of fire suppression systems or exhaustion of available fuel.[8]

Fire taking hold on a horizontal surface will spread slowly, the flames and gas rising and lateral transmission depending on the gradual heating of adjacent areas. This is an inefficient arrangement for flame spread and was the reason Jonathan Martin's fire at York made little progress in the first six hours. Had it been tackled by an efficient means within this period, it is likely that it would have been extinguished without major loss. From the moment the flames took hold of the vertical structure of the organ, the fire adopted entirely different dynamics, moving quickly to engulf the choir and roof. Fire spreads far more quickly on a combustible vertical surface with air drawn from beneath fanning the flames. It can be further accelerated if the flame then hits a ceiling as happened at the Bradford Football Stadium fire in 1985, where the spread quite suddenly increased to a rate which out-paced the fleeing spectators. In certain respects, such as roof height and volume of air available, the stadium at Bradford may be compared to a cathedral. Flammable vertical surfaces including wooden choir stalls, organ, panelling, screens and tapestries or flags draped from walls are the main vertical elements which may transmit flame quickly. In the case of a cathedral, a fire in its later stages may be assisted by towers and other high level vents acting as flues to provide a fierce draught.

FIRE RISK IN CATHEDRALS

It should be clear that the common understanding of cathedrals as low-risk buildings is mistaken and twenty-three fire incidents in Anglican cathedrals in the period 1988-94 are testimony to the need to be sensitive to the risk.[9] The nave, by itself, may warrant a 'low risk' classification but a cathedral must be seen as a closely integrated complex of spaces and structures with each part posing particular problems of fire risk and management. Furthermore, cathedrals are not just used for Sunday worship but might be open twelve hours each day of the year (making them, arguably, the most accessible public buildings in the country) and host a wide range of secular activities including lectures, degree congregations, concerts and exhibitions (Fig. 7). The grander cathedrals attract huge numbers of visitors, prompting the need for a wide range of supporting facilities in the cathedral or attached buildings. In the modern era, the use of electric light may have lessened some risks, but the character of uses has changed, bringing new problems: heating is now common; public events and performances require complex lighting; kitchens, restaurants and giftshops increasingly are considered necessary. All these add to the risk already associated with offices, meeting rooms, libraries and, in some cases, sleeping accommodation. Cathedrals contain abundant combustible material and ignition sources. Structural timbers in roofs, timber ceilings and vaults, wooden screens, wall panelling, pews and choir stalls are ready fuel for a fire. The organ is often one of the most expensive pieces of equipment in the building and also one of the most combustible in which fire will spread rapidly.

Fig. 7
The north transept at Ely Cathedral is used as a permanent exhibition area
A. Copping

Poor housekeeping can exacerbate fire danger through the accumulation of rubbish or loose combustible materials. Boiler rooms frequently are used as a convenient place for storage of cleaning materials and other equipment. Many cleaning liquids are highly inflammable and may ignite spontaneously if subject to high temperature. Wax polish can encourage woodwork to burn more rapidly. The accumulation of nests, bird droppings and dust in roof spaces can be an unnoticed hazard. Radiant heaters, whether electric, gas or oil are capable of igniting material up to a metre away. Faulty wiring, overloaded circuits and badly maintained or carelessly-used equipment can present an unnoticed risk. Even properly installed electrical circuits and equipment may become hazardous if not subject to periodic inspection, maintenance and repair. Cables running close to combustible material or through inaccessible spaces are common.

Building or repair work can increase the risk of fire through carelessness or through unfamiliarity with protocols for fire-risk control. The Windsor Castle fire of 1992 is a recent reminder of this danger, but all cathedrals now have stringent work specifications to ensure precautions are in place when blowlamps, flame cutting and welding equipment or flammable liquids are being used. Lightning remains a threat to any church although techniques for bonding electrical and structural elements and catering for side-flash are now better understood and applied. A full protection system involves a number of circuits and earthing points and most casual observers would be surprised to discover the length of conductor cable and the number of lightning rods employed (Fig. 8).

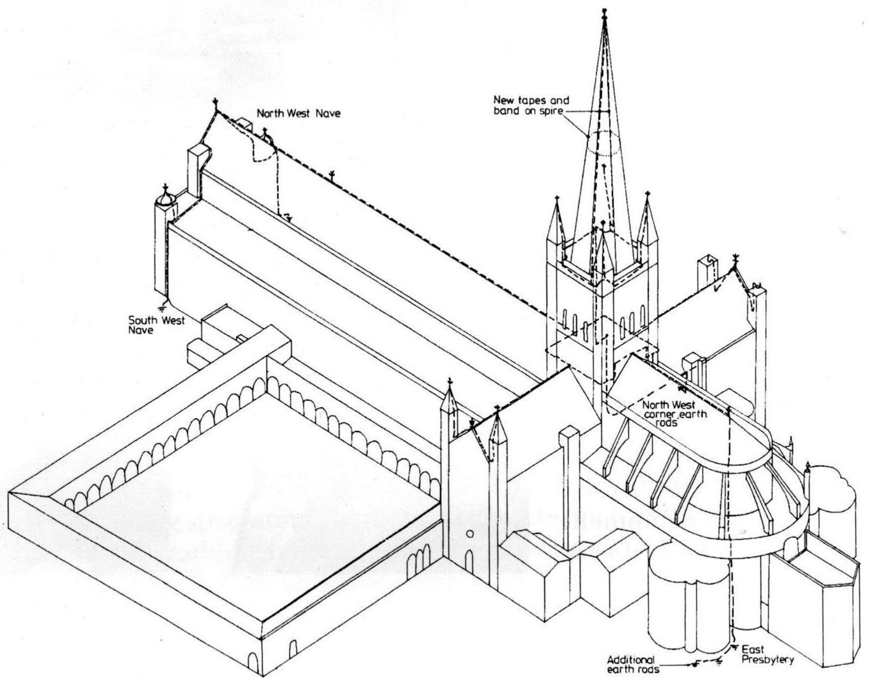


Fig. 8
Norwich Anglican Cathedral lightning protection system. All the pinnacles and other high points are protected
A. Tebbutt, by permission of the Dean and Chapter of Norwich Anglican Cathedral

An open-door policy in cathedrals and churches allows access to those who are bent on wilful damage and arson. Such people have already forced many parish churches to close their doors to casual access, arson having been identified as being the cause of three out of four church fires.[10] Guarding against this threat requires cathedral administrators to consider the installation of security systems, discreet supervision of popular and remote areas, and thorough end-of-day checks. Scaffolding erected on the exterior of cathedrals presents a ready route for an arsonist to enter roof voids and other high level areas and robust low level screens and scaffold sensor devices are justified in some circumstances.

UNDERSTANDING RISK

'Complete fire safety' can be described as the absence of any threat of loss and 'no fire safety' can be described as the risk of total loss. Absolute safety is desirable but it is not attainable, while total loss is never likely to be acceptable. Between these extremes an acceptable level of loss must be established.[11] In the context of fire safety, there are three elements that need to be protected against injury or damage caused by fire: occupants, contents, and building fabric.

For the cathedral, like any other public building, it may be expected that the safety of occupants would be uppermost in the minds of those with management responsibility. However, statutory requirements for public safety in relation to cathedrals are limited, with much of the legislation relevant to other places of assembly (such as concert halls and theatres) being unclear in its application to ecclesiastical buildings.[12] The basis for insurance of fabric and contents can also be quite different. In some commercial contexts, the total loss of tangible assets could be beneficial to trade, allowing outdated premises, equipment and methods to be reviewed and replaced with more up-to-date means of production, providing better or cheaper goods to the advantage of company and customer. The insurance, in a sense, relates to the success of the business enterprise with the buildings and contents forming a device for framing the insurance agreement. In the case of cathedrals, however, the emotional and cultural value of the fabric and contents may be seen as an intrinsic part of the institution of the Church which, some might believe, could not be modernised or up-dated without great loss to the clergy and laity.

In order to establish an acceptable level of fire safety the risk or threat of fire must be analysed. Historic buildings, specifically cathedrals, carry a multitude of aesthetic, economic and practical constraints on the use of available methods of fire safety provision. An assessment of the risk of fire represents the first step in achieving an appropriate level of safety. From the results of the assessment, suitable systems for protection may be introduced but these must then be managed efficiently and continuously monitored for effectiveness. It is critical to understand that any installation of safety equipment will be geared to the particular circumstances of each place of worship, taking account of its materials, structure and contents *and* its activities, seasonal characteristics, management regimes, and personnel. Once installed, the systems will only have value where they form part of a committed management regime which understands risk and acts in a co-ordinated fashion. Risk assessment in cathedrals is not a precise science and a uniform approach will be difficult to achieve since all cathedrals are unique in structure, configuration and operation. The current practice for assessment of risk is through a collaboration involving the cathedral architect, insurance surveyor, local fire officer (with a specific concern for life safety) and any appointed consultants. The assessment of the fire risk depends on identifying hazards, estimating risk, evaluating the significance of those risks, and setting in place suitable threat-reducing procedures and protocols.[13] Each stage relies upon intuition and opinion informed by expert judgement.

Hazard identification begins with a full survey of the building, identifying fuel for a fire, potential ignition sources and patterns of use. The size and inter-relationship of spaces within the cathedral will also be recorded, together with the means of escape, exit points and safety measures which are already in place.

Risk estimation quantifies the probability of a specific outcome from each cause, but this work depends upon the availability of documented case studies and fire statistics of each building type and with relatively few large scale fires in the last fifty years (though there have been many smaller fires), risk estimation is not exact and it is peppered with informed guesswork. For major or complex fires or fire ignitions, insurance companies dealing with cathedrals share a problem of lack of case study experience upon which to draw. They have several principal concerns, based around the need to understand the total likely or conceivable physical loss caused by fire and the cost of the resultant building or repair works. It is now broadly agreed that the dense stone walls of a cathedral would resist flames and the central crossing tower act as a fire-break, leaving a substantial amount of the building standing even after a major fire. The major exceptions are St Paul's and Ely which, although they have a central crossing tower, do not have massive masonry construction from ground to roof. Work which recently has been carried out at Ely, examining the effect of stone vault pockets filling with water in the event of a roof fire, has concluded that even half-filling brings the danger of collapse if the wooden roof should fall in.[14] This danger is being addressed by installing drains at the base of each pocket. The Ecclesiastical Insurance Group now considers the worst probable loss would be the burning and collapse of the cathedral nave, the accompanying aisle roofs and the vaults. With regard to reinstatement, valuation appears to be based on historic figures and broad estimates of repair costs rather than on hard, factual studies. At York it was found that insurance cover was sufficient for the south transept (11% of the total roof area) but would not have been sufficient if the fire had spread to the nave or choir. In response to this discovery, the insurance of cathedrals now tends to be based upon internal volume and latest estimates assume rebuild costs of £400 per cubic metre giving overall rebuild insurance values of £50-£120 million.[15]

Risk evaluation begins with some form of understanding of the level or limit of loss which the cathedral authority is prepared to accept. The risks concerned relate to persons within the building, the building's contents, and the building fabric. Although the application of health and safety legislation to cathedrals is not as clear as in other building types, there is little doubt that cathedral managers hold this responsibility to be their most important duty. In respect to fabric and contents, it is doubtful whether the serious issues of the amount of fabric which may be repaired, restored from salvaged fragments, replaced in modern idiom, or rebuilt in facsimile have been properly acknowledged. The variation in costs of these different approaches is huge and there must be concern that a fire-damaged cathedral might not be fully covered by insurance if the philosophy of repair demands especially costly methods.

Risk reduction depends upon removing unnecessary hazards, avoiding risks by altering the pattern of use to eliminate high-risk processes and activities or upgrading safety facilities and management. Removal of unnecessary hazards is something over which cathedral managers have control. Of course, there are some hazards that must be catered for. Every cathedral needs an organ, electrical power, boiler room and so on but precautions must be taken to reduce risks in their operation. Proper awareness by senior staff of the workings of the cathedral is important and even voluntary helpers must understand the need to follow procedures. At one cathedral a hazard identification survey revealed that a fire-proof cupboard for candles, installed in the nave, was empty since vergers found the oak cupboard in the choir more convenient. It was pointed out that the candles themselves had a substantial fire capacity (as did the cupboard, choir stalls and screen) and the practice was ceased immediately with the full agreement of the staff concerned.

RECORDING NEEDS

Wherever possible we should have the fullest record of our great churches and cathedrals. Given the immense size and complexity of these buildings, their richness of ornament and range of contents, this is a tall order. Nevertheless, the importance of making a proper record cannot be overstated since no amount of good intentions or financial resources will lead to proper reinstatement if records are inadequate. The archive of recorded information, including whatever original drawings may have survived, modern records of work, measured surveys and photographs, should be kept in a secure location and copies of as much of the record as possible made for safe-keeping at a second repository. The *Care of Cathedrals Measure* of 1990 stipulates that all cathedrals should have a detailed inventory of their contents, but progress on achieving this goal is varied. In relation to fire, the vital importance of survey goes further. Immediately after any serious fire, a full and careful record of remains, both standing and amid the debris, must be put into operation and strict attention given to the need to leave these areas undisturbed until such work is complete. Without this action, the evidence will not exist if it is decided that re-creation is the right course.

ACTIVE FIRE PROTECTION

Portable fire extinguishers are the initial line of defence against the majority of small fires. The types of extinguishers and their locations in the building should be identified by the local fire service. In the interest of life safety some extinguishers must be located in conspicuous positions on brackets or stands in public areas where they can be rapidly seen by persons following escape routes. If an adequate water supply to the building is available, fixed hose reels can provide an instant and more effective defence against larger fires.

Automatic sprinkler systems will usually control a fire in the early stages and are particularly valuable where initial attendance by the fire service may take time. Many cathedral architects and administrators have reservations about the practicality of installing sprinklers in historic cathedrals because of the physical damage and visual intrusion on the fabric of the building of pipework and fixings.[16]

A further worry is water damage caused to fabric or contents by fire-related or accidental discharge, but this has to be seen in the context of the thousands of gallons of water released by the fire service during recent fires in historic buildings and the damaging effects of smoke.[17] Currently only a handful of cathedrals have sprinkler systems and in each case they are confined to the tower or spire. A number of the large cathedrals are now assessing the value of automatic water sprinklers for selected areas of the building where material, activities or heat sources are most likely to initiate or assist a fire. Halon gas systems are installed in the electrical plant rooms and organ-blower lofts or chambers of a number of the larger cathedrals, but the use of halon is being restricted by the Montreal Protocol of 1987 because of its effect on the earth's ozone layer.[18] Various replacement systems are being developed, including high-pressure water mist.

Automatic fire detection and alarm systems provide a means of continuous and accurate detection and are regarded by most as an essential component of the measures required to protect a property. The development of such equipment has become increasingly sophisticated and cathedral architects and administrators are presented with an array of combinations and options. A typical system adopted by cathedrals consists of a series of sensors detecting smoke, heat or flames, connected to a control panel. Sensors trigger the control panel which lights up to show the zone of the building or the particular sensors where the incident is occurring. In addition, many systems also have break-glass points located in suitable areas. When the control panel is activated, a signal is transmitted either by digital communicators straight to the local fire station or by way of British Telecom's 'RedCare' system to a commercial central alarm station. Although the majority of the major cathedrals of both Anglican and Roman Catholic denominations now have a full automatic detection and alarm system, the smaller cathedrals generally have not. Cathedrals, because of their size, structure and architectural sensitivity, provide a considerable challenge to designers to achieve an effective detection and alarm installation. An acceptable solution can, however, nearly always be found where time is available and careful thought is applied. Radio-based detection systems avoid extensive wiring by using compact radio transceivers in the detectors and offer great advantages in terms of ease of installation and lack of interference with historic fabric. There is currently considerable interest among cathedral managers, professional practitioners and historic building owners to know of the performance of such systems with regard to reliability, battery life, and interference from other radio and electrical sources. Norwich Anglican Cathedral installed a radio-based fire detection system in the late 1980s and remains the only cathedral to have done so. The cathedral complex contains an array of interior spaces ranging from the vast medieval nave to the underground boiler house and a network of rooms which are used as a shop, refreshment area, visitors centre, exhibition space, library and offices. The system uses various types of detector, each equipped to signal its zone, detector number, head type and exact location. Each is placed where it will meet the full requirements of detection without presenting difficulty of access for battery replacement. For fire detection purposes, the cathedral is divided into fifty zones

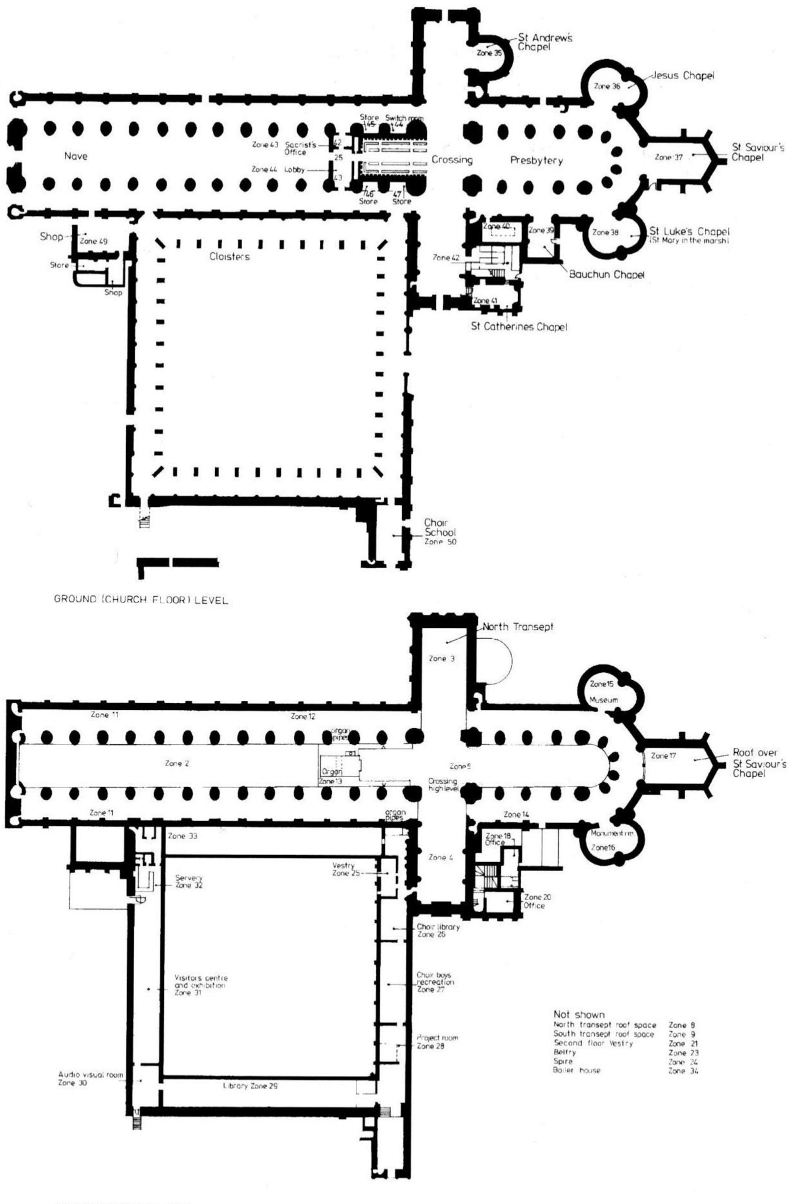


Fig. 9
Norwich Anglican Cathedral radio-based fire detection system. The complex nature of the cathedral's spaces and uses is evident from the fifty fire zones which have been created, each fitted with appropriate detectors.
A. Tebbutt, by permission of the Dean and Chapter of Norwich Anglican Cathedral

(Fig. 9). Ionisation smoke detectors which detect visible and non-visible smoke are deployed in the roof spaces, spire and triforium. Optical smoke detectors which react to the refraction of an infra-red light pulse in the presence of smoke are located over the organ blowers, switchgear and the library. In the visitors' centre, rate of rise detectors are used which work on the principle of two sensing semi-conductors which have differing thermal time constants, so that a sudden source of heat will cause an imbalance, signalling an alarm condition. Fixed temperature detectors which signal an alarm if the temperature rises above a set point are also deployed in the north cloister roof-space. In addition, beam detectors are set diagonally across both transepts and the choir at triforium level. Finally, a number of manual break-glass call-points complete the arrangement. In the several years since the system was installed, problems relating to batteries have been successfully overcome and the investment justified by the detection of two small fires in their early stages.

Cathedral security is an essential component of active fire prevention. Vigilant employees are the first line of defence in all cathedrals when the building is open to the public. Responsibility for security can rest with a single verger or be the task of an organised internal 'police' force as at York Minster. At present, twenty-four-hour surveillance is employed at a handful of cathedrals, most others depending on intruder alarms.

PASSIVE FIRE PROTECTION

Fig. 10
Insulation being installed under the bell tower floor at Winchester Cathedral
Rockwool Ltd

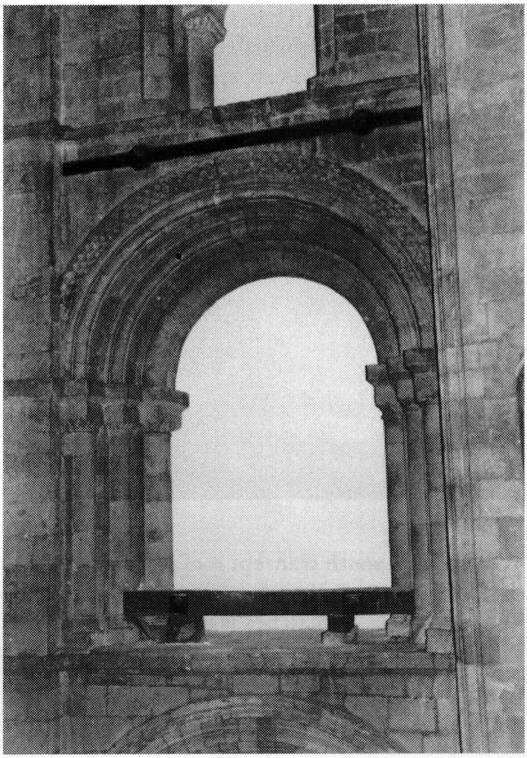
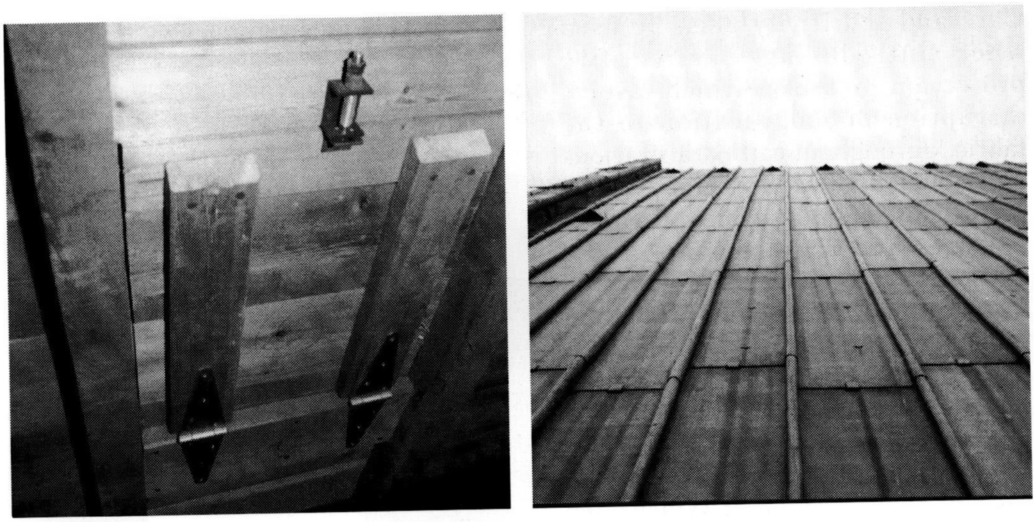


Fig. 11
On the advice of the local fire service, the triforium and clerestory arches open to the west towers at Southwell Minster have been infilled with one-hour fire-resisting board
A. Copping

Care and sensitivity must be used when introducing passive fire protection measures which involve disruption or modification to the fabric. Throughout cathedrals various types of structural protection can be installed, depending on individual features and requirements. Most cathedrals are now budgeting for installation of passive fire protection in their long-term maintenance programmes. Recent examples include the unusual installation of a fire barrier in the horizontal position which protects the entire underside of the bell-chamber floor at Winchester Cathedral (Fig. 10). At Southwell Minster, upon the advice of the local fire service, the west tower triforium arches have been infilled with one-hour fire-resisting plasterboard, secured to the back of the arches to ensure that the mouldings are not disturbed (Fig. 11). Compartmentation is recommended as a key passive fire defence for the large, unrestricted roof spaces of cathedrals. The installation of partitions on stone-vaulted ceilings is relatively straightforward, but establishing an efficient fire break over timber and plaster vaults may be more demanding. Some resistance to compartmentation is based on the fear that it may reduce ventilation and increase the risk of timber decay, wood-boring insect attack and lead corrosion. In the large roof voids it can also destroy the sense of space of these areas and harm the experience of the person seeking to enjoy, or learn from medieval tradition and method.

Air-venting to allow the escape of smoke also helps to control fires. On the new south transept roof at York Minster, cleverly disguised bottom-hung trapdoors have been installed. In the event of fire the fusible-link catches are designed to give way and the trap to fall open, allowing the lead roof at this point to melt and the smoke and heat to escape. The hatches are identified on the outside of the roof by lead dots, allowing fire-fighters to locate them (Figs. 12a & b).

In response to concern at the potential for the collapse of vaults owing to water retention in the pockets, some cathedral authorities have installed scuppers which



Figs. 12 a & b
On the new south transept roof of York Minster, cleverly disguised bottom-hung trapdoors have been installed to allow the escape of smoke and heat in the event of fire. The location of the fire hatches is identified on the outside of the roof by lead dots.
A. Copping

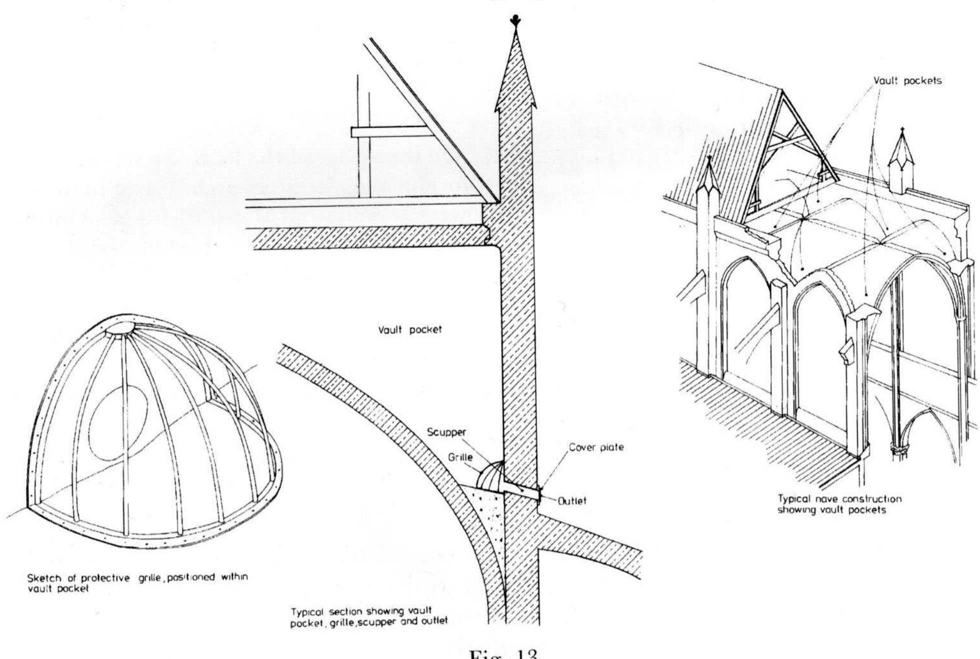


Fig. 13
Removal of water from vault pockets. Scuppers allow drainage to ensure that vaults are not threatened by a water load in the event of a roof fire.
A. Tebbutt

will allow water to drain away. These are holes drilled from the bottom of vault pockets to the exterior of the building or into an interior drainage facility, covered with grilles to prevent blockage by debris. Scupper outlets may be disguised by a variety of means including top-hinged plates, loose-fitting stone blocks which are pushed out through pressure of water or new gargoyles (Fig. 13). St Paul's has a similar potential for large amounts of water to be caught at high level because of its complex construction, consisting of an inner dome, a brick cone which supports the lantern and an outer dome, which is really a trussed roof, covered in lead. Subdivision of the outer space into eight compartments has been completed to slow the progress of any fire in this dry and frequently very hot space. Difficulties of access have been addressed in part by the insertion of an elevator in the south-west corner to enable four firemen, in full equipment, to be taken up the first thirty metres; a second elevator to the base of the dome remains to be completed.[19] The problem of retention of water used to fight a fire in the dome remains to be addressed. Two substantial reservoirs exist which, if filled might prove heavy enough to bring about a collapse (Fig. 14).

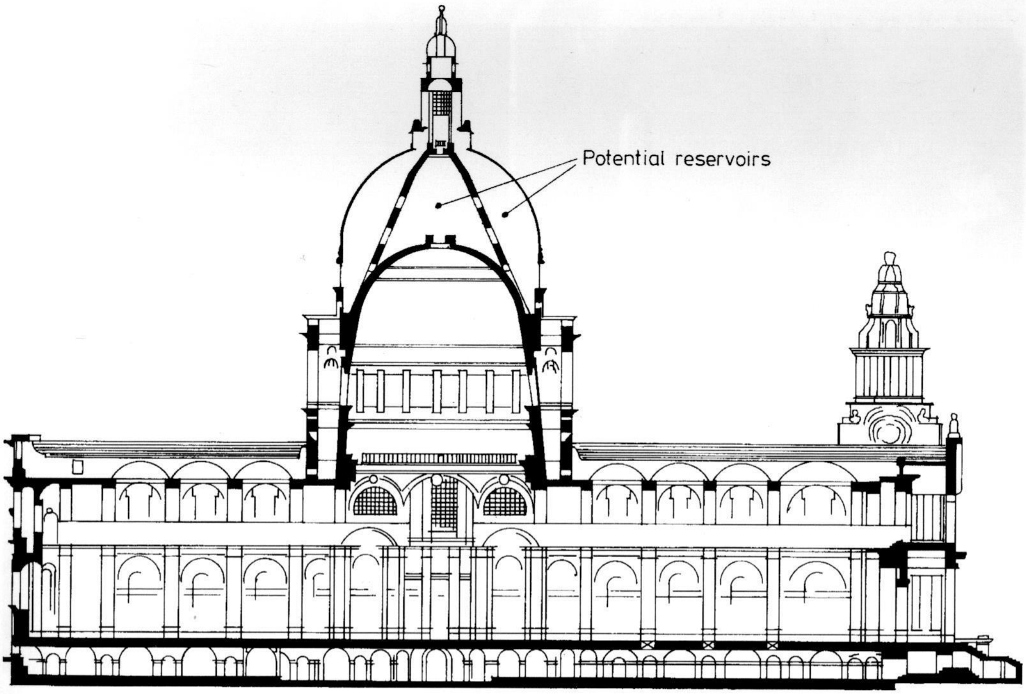


Fig. 14
St Paul's Cathedral. The dome's construction has created spaces with the potential to hold dangerously large quantities of water.
A. Tebbutt

MEANS OF ESCAPE

With many cathedrals attracting large congregations for certain services, holding frequent secular functions, and drawing large numbers of tourists and visitors, it is vital that effective means of escape is available throughout the building. Means of escape which satisfy the local fire service can often be difficult to achieve from high level areas and isolated rooms but a satisfactory compromise is generally achieved. On the recommendation of the local fire service, Southwell Minster recently has upgraded its fire safety on the high-level walkway used for conducting visitor tours. This includes installing toeboards and handrails across the clerestory openings, positioning half-hour fire doors along the walkways and white-lining the edges of the spiral stone stairs (Figs. 15a & b). At Carlisle Cathedral, the request of the local fire service for a secondary escape route from the bell ringing room in the tower has led to a proposal for an external stair case which has, not surprisingly, caused concern in some circles. A comprehensive system of emergency lighting is desirable on all escape route corridors and stairways, supplemented by illuminated notices identifying exits powered either from a central battery supply or self-contained units. The installation of such systems in historic cathedrals is expensive

Figs. 15 a & b

Recently installed solid oak fire doors at Southwell Minster provide additional safety for tour parties, while emergency lighting, white-lined stair-treads, toeboards and handrails improve ease of escape in the event of fire.

A. Copping

and creates many aesthetic problems. Most large cathedrals have emergency lighting installations but provision for means of escape varies significantly.

FIRE FIGHTING

Establishing a close relationship between the local fire service and individual cathedrals is essential to ensure a high level of fire safety and since the York fire relationships appear to have improved. Although a local fire service is obliged under Section 1 of the Fire Service Act of 1947 to give advice on fire prevention and fire-fighting facilities, the level of service provided is, in part, dependent on the nature and success of the relationship. Local fire services should ideally have a detailed cathedral fire plan prepared in consultation with the cathedral staff which should comprise a structured document with details of the building's layout, fire-fighting facilities available and the operational procedures to be adopted in the event of a fire.

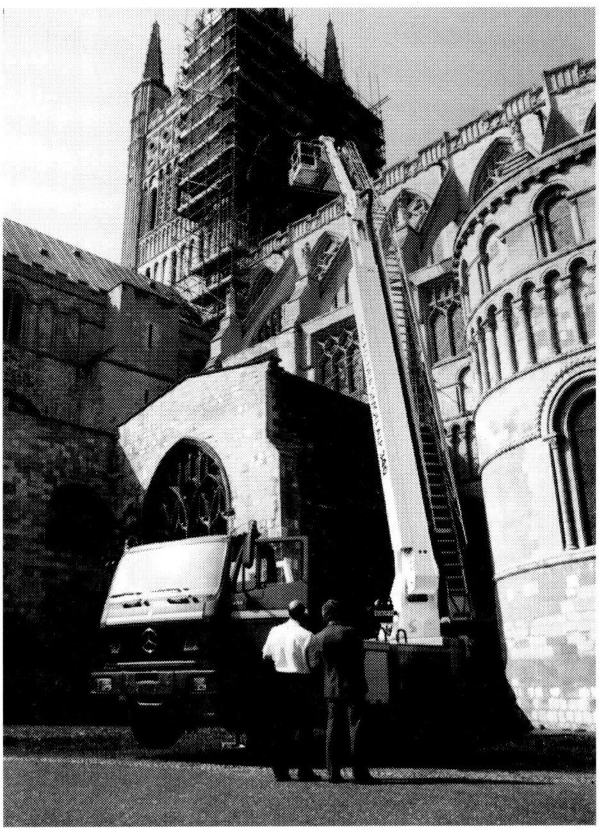


Fig. 16
At Norwich Anglican Cathedral the fire brigade practise regularly, so that each fireman is familiar with the cathedral layout and the procedures to be followed in an emergency.
A. Copping

Fire services will frequently regard a cathedral as the single most important structure in the area, carrying out training exercises as frequently as every two months, but this is not always the case (Fig. 16). In the event of a fire, it is vital that there is suitable access for fire appliances and equipment but many cathedrals present problems. Access to Wells, for example, requires appliances to have tyres part-deflated to get through a medieval gate to the precinct, while at Canterbury the Christchurch Gate, the single access for the brigade, allows only 75mm clearance to either side of the vehicle which has to be very carefully aligned before entry is attempted (Fig. 17). Elsewhere, there are various examples of graveyards and monuments, burial voids and unconsolidated ground presenting obvious problems

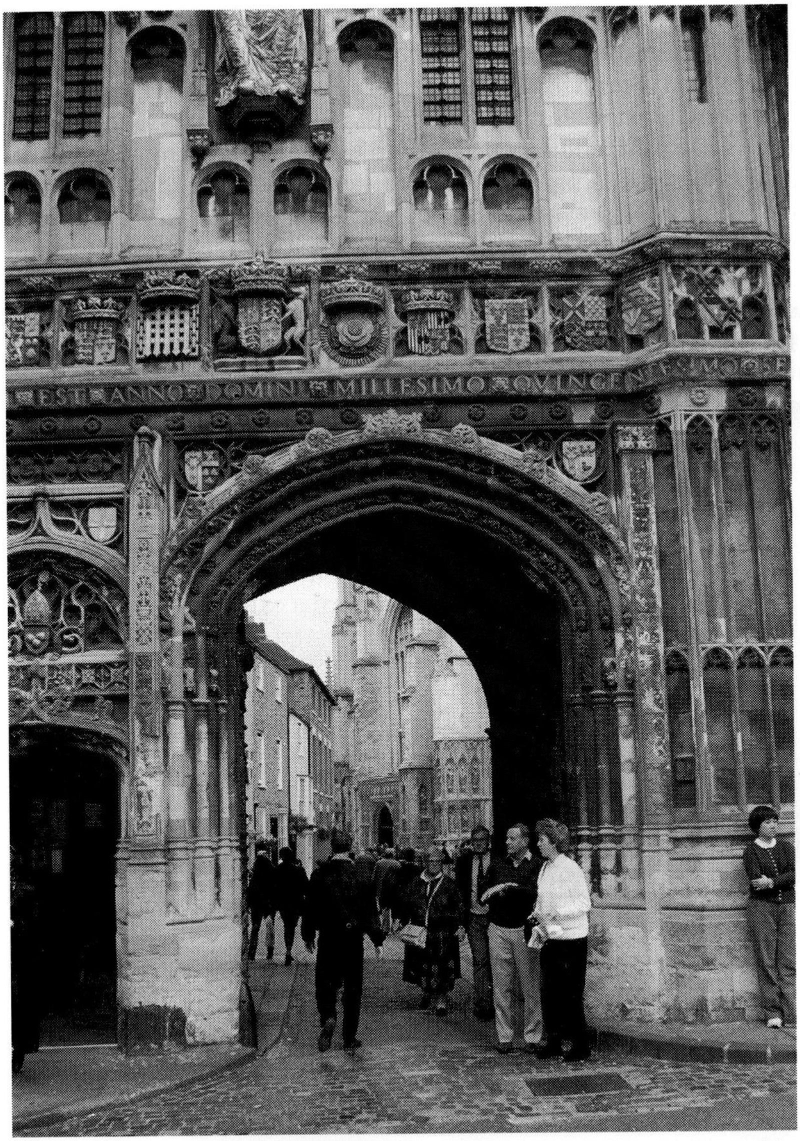
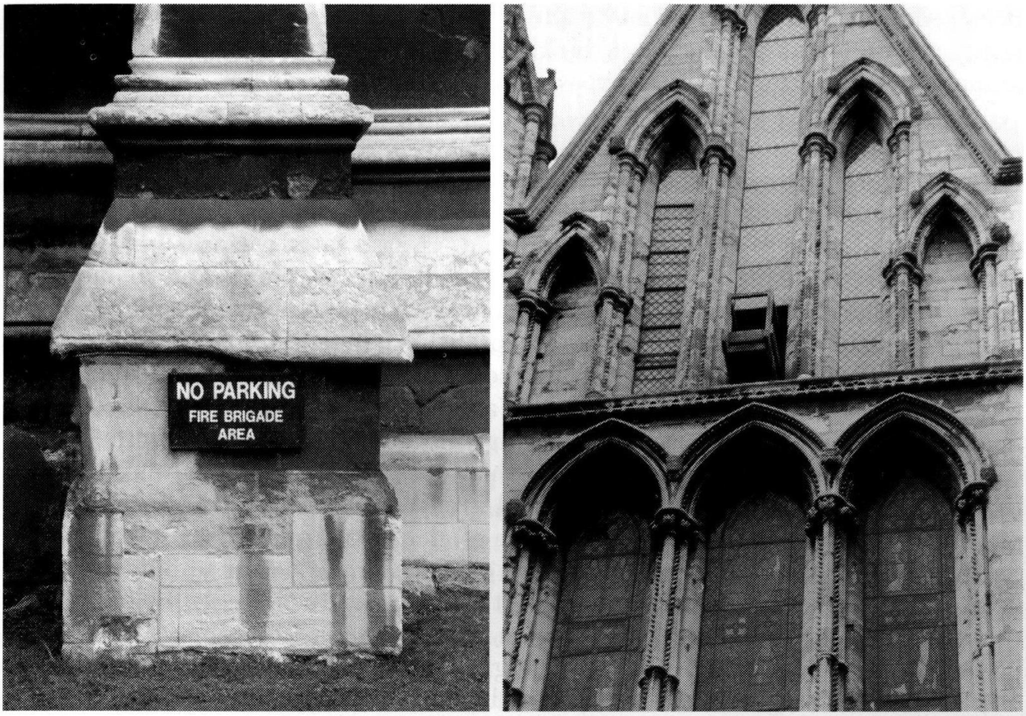


Fig. 17
The Christchurch Gate at Canterbury Cathedral provides the only vehicle access. Clearance on either side of the fire appliance is less than 75mm.
A. Copping

for large heavy machinery. A hardstanding capable of carrying 12.5 tonnes is required for the engines and one of 16.25 tonnes needed for high-reach equipment[20] (Figs. 18a & b). Wet and dry risers are a vital tool in enabling water to be pumped rapidly into the building. Most systems are interconnected and provide internal outlets at ground level, within roof spaces and at other high-risk areas within the cathedrals. In addition, foam inlets to protect the boilers and oil tanks are used. Although risers are a visual scar on the exterior, their importance in ensuring fire safety seems to be recognised by all parties.



Figs. 18 a & b
Lincoln Cathedral. A grass covered concrete hardstanding for a brigade vehicle with an access walkway above leading directly into a roof space in the south transept.
V. Shacklock

FIRE-CONSCIOUS CATHEDRAL MANAGEMENT

A specific recommendation of the inquiry report into the Windsor Castle fire (the 'Bailey Inquiry') was that every historic building should have a clear statement of fire safety policy. This should be unique and should take account of all activities. It should be a clear statement of the aims and objectives of the organisation in its determination to ensure that fire is treated seriously.[21] Bailey further recommended that each building should have an accompanying fire-safety manual which should contain not only records of the established policy but all other details relating to the fire safety of the building which may include details of such matters as overall strategy, management policies for fire safety, risk management, fire safety auditing, alterations to assist means of escape and inhibit fire and smoke spread, fire brigade access and facilities, salvage and damage control, and staff training programmes.[22] Currently, no cathedral is in such a position, but it is anticipated that most of the larger cathedrals will move towards the approach to fire safety management recommended by Sir Alan Bailey within the next few years. York Minster has made more progress than most cathedrals in identifying a member of staff as the fire officer and assigning related responsibilities to others. An emergency plan has been produced and circulated and training sessions, equipment tests and drills are regularly undertaken. Although lacking defined policies and procedures, the management system is comprehensive in its content.

AESTHETIC ISSUES

It is considered by some that the architectural integrity and historic value of a building can be harmed considerably by the installation of a full system of fire detection and control. Smoke and heat detectors, associated wiring, signage, safety doors, handrails, rising mains, hardstandings, roof access points and so on are all potentially harmful to appearance, fabric and archaeology, but assessing when the impact of such measures becomes unacceptable is a matter for consideration on a case-by-case basis. It is the responsibility of cathedral fabric advisory committees to assess the particular impacts and make a judgement on the safety value and the appearance or physical impact of the fitting. It has been suggested that the Gothic cathedral can be more accommodating than others in accepting alterations and that the rules and discipline of classical architecture present a more difficult problem.[23] This is certainly so in the case of electrical and electronic equipment related to fire safety which in the Gothic church may be easier to hide amid the great complexity of detail and mouldings. It is in the nature of fire detection systems that the detecting devices must be in open positions and will frequently, therefore, be visible to the cathedral user. Although, the detector heads are not large or obtrusive, the wiring on which the system depends may be extensive, amounting to thousands of metres of cabling connecting each fire detection point and zone and carrying signals to a central panel, which must necessarily be at a point convenient to those responsible for safety and security.

Concern about fire-safety fittings should be seen in the context of the paraphernalia of light fittings, artificial lighting effects, sound amplification equipment, notices, display literature and all the other incremental additions which are common in cathedrals. For the most part, safety fittings are things which we accept in the knowledge that they are transitory. Such level of acquiescence depends upon the fittings being treated as honest, reversible additions intended to provide a modern level of convenience, safety or comfort. Where the contractor attempts to hide the wiring by letting it into joints or creating channels in brick, stone or plaster the deception brings the risk of criticism that the action is permanent, and, worse, that it is harmful to the fabric of the cathedral. The preference, in most cases, should be for the wires to be mounted on the surface and run in positions where little physical damage through fixing will occur and the impact upon our enjoyment of the architecture is minimised.

The rapid improvements being made in fire protection technology are also making a major contribution to the preservation of medieval fabric. Probably the most significant advance is the radio transmitter fire detection system, pioneered at Norwich, saving thousands of metres of wiring between detectors and the control panel and preventing the need for the historic fabric to be punctured to allow wire access from one space to the next.

CONCLUSIONS

There has been considerable progress in responding to the threat of fire in cathedrals in the last ten years. The risk of fire has been compared to such other events as floods, subsidence and storms, which all share the lack of a reliable method to assess the likelihood of occurrence. With only one major fire in a cathedral in the last fifty years it is easy to understand limited fabric funds being assigned to seemingly more urgent tasks such as roof repairs. Two factors, however, set fire apart: the potential for sudden and catastrophic damage places the fire hazard in a category of its own; and the capacity for cathedral managers to reduce risk might, in certain cases, lie more in the management of the cathedral than in the installation of sophisticated equipment. The identification of hazards, evaluation of risks and introduction of risk-minimising patterns of behaviour need not be costly and should be given the highest priority.

Cathedral architects, fire consultants, fire authority personnel, insurance assessors and suppliers of fire safety equipment have worked together closely at various cathedrals to identify strategies and principles which will form a basis upon which other cathedrals, and many larger parish churches, might build. Although there is evidence of initial conflicts within these interdisciplinary groups over particular measures to be adopted, the final outcomes, in most cases, have been acceptable to all sides. New technologies, such as radio-based systems, miniaturisation of detectors and so on, will offer less intrusive systems and will reduce concerns over the extent of the visual and actual damage to fabric.

Among the conclusions which may be drawn from pioneer cathedrals is that it is a responsibility of the Dean and Chapter to set (or approve) fire safety policy and issue clear directions and responsibilities. Safety manuals, damage control contingencies, salvage plans and other policy positions should have the highest authority and be circulated and understood. The cathedral architect has an important role but may not have the necessary knowledge or experience to take technical decisions, nor might he or she have the authority to instruct change from one operational practice to another which is safer. It seems inevitable that quinquennial surveys will come to cover fire safety issues more carefully than in the past.

The Bailey Inquiry conclusions and a forthcoming English Heritage publication[24] are likely to provide clear guidance on the standard of fire safety expected in the future, and those cathedrals seeking financial support for fire protection measures are likely to find these documents forming a basis for consideration of their case. The time lag between surveying cathedrals for risks and introducing fire safety measures means that many cathedrals are now close to taking positive steps of implementation. It is conceivable that progress in carrying out comprehensive fire safety measures in cathedrals over the next five years will exceed that made in the last twenty-five years, leaving admirers of these important architectural monuments far more confident of their survival by the end of the millennium.

REFERENCES

1. Pevsner, N., and Metcalf, P., *The Cathedrals of England* (London, 1985), 13.
2. Copping, A., and Swallow, P., 'Fire Safety in Cathedrals: The Influence of Legislation', *Building Engineer* (May 1994), 26.
3. The two volumes of *The Cathedrals of England* (1985) by Pevsner and Metcalf identify numerous fires resulting in loss of life, damage to fabric and subsequent changes in structure of the cathedral. A brief summary of major cathedral fires appears in a paper presented by Peter Burman (then Secretary to the Cathedrals Advisory Commission for England) to an international conference in York in 1989. The conference papers were published as *Cathedrals and Fire Risks* by the Cathedral Architects Association (York, 1989).
4. Balston, T., *The Life of Jonathan Martin: Incendiary of York Minster* (London, 1945), 93.
5. *The Fires of York Minster from AD 741 to 9 July 1984* (London, 1985), 6.
6. *Ibid*, 7.
7. Burry, P., (The Fire Research Station, Borehamwood), 'Development in Fire Protection', *Cathedrals and Fire Risks* (York, 1989).
8. These principles are clearly illustrated in a fire development model devised by the British Research Establishment published by Phillips, W., 'The Development of a Fire Risk Assessment Model', *BRE Information Paper IP8/92*, British Research Establishment (May 1992), 4.
9. Shacklock, V., and Copping, A., 'The Protection of Anglican Cathedrals from Damage by Fire: A Review Based Upon Insurance Data', *Structural Survey*, Vol. 12, No. 5 (1993/4), 4.
10. Lee, C., 'The Insurers' Viewpoint', *Cathedrals and Fire Risks* (York, 1989), 49.
11. Marchant, E., 'Preventing Fire in Historic Buildings: The Acceptable Risk', *Fire Technology* (May 1989). Marchant provides a review of judgements associated with our understanding of risks.
12. See Copping, A., and Swallow, P., *op.cit*, for an account of the legislative implications of cathedrals being used as places of public entertainment.
13. Marchant, E., 'Fire Engineering Strategies', *Fire Science and Technology*, Vol.11, No.1, 2 (1991), 14.
14. Lee, C., *op.cit*, 50.
15. Lee, C. *op.cit*, provides an overview of how insurance cover for cathedrals is derived. The up-dated figures are arrived at after discussion with a number of insurers and cathedral administrators.
16. In discussion with several cathedral architects the authors observed a reluctance to accept the physical and visual damage that might be associated with sprinkler system installations.
17. The case for sprinkler systems is put in Ackland, A., 'Automatic Sprinkler Systems: Their Role in Historic Buildings', (paper to the Fire '93 Conference, Fire Prevention Association, Glasgow, September 1993).
18. U.K. Working Party on Fire Safety in Historic Buildings, *Heritage Under Fire - A Guide to the Protection of Historic Buildings*, Second Edition, Fire Protection Association (1995), 44.
19. Whitfield, W., 'Aesthetic Considerations', *Cathedrals and Fire Risks* (York, 1989), 62-3.
20. U.K. Working Party on Fire Safety in Historic Buildings, *op.cit*, 49.
21. Bailey, A., *Fire Protection Measures for the Royal Palaces* (London), 37.
22. Bailey, A., *ibid*, Appendix D.
23. Whitfield, W., *op.cit*, 60.
24. During the final stages of production of this paper a draft report from English Heritage, 'Fire Safety in Cathedrals', has been published for distribution to cathedrals and their advisers. The final document is expected to set out guidance on higher standards of fire safety.