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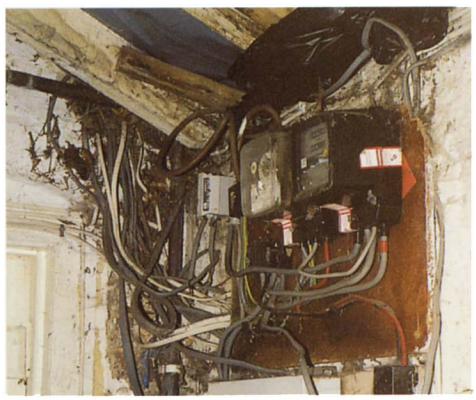
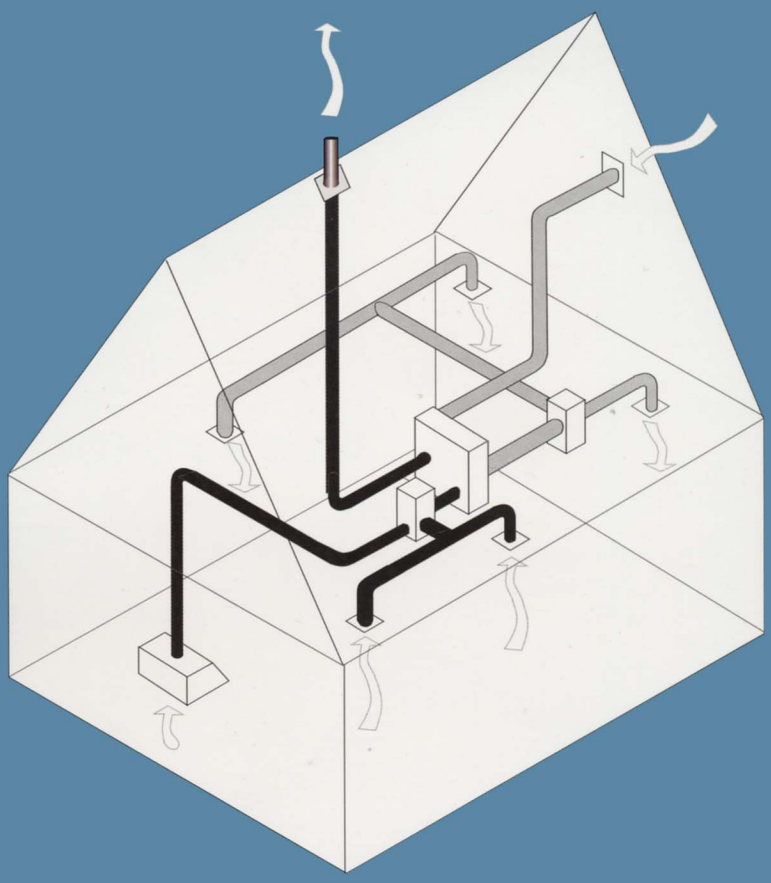
BRE Building Elements

Building services



H W Harrison
and
P M Trotman

Performance, diagnosis, maintenance, repair and the avoidance of defects



BRE

BRE Building Elements

Building services

Performance, diagnosis, maintenance, repair and the avoidance of defects

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Contents

Preface

This book is about building services: the gamut of fuelled, piped, ducted, wired and mechanical facilities which extend over the whole age range of the UK's building stock. In essence, it is the quality of heating, artificial lighting and other services, such as refuse disposal, which makes an otherwise bare carcass habitable – even efficient and enjoyable. However, things do go wrong from time to time – the boiler ceases to function, the television aerial corrodes, the pipes in hard water areas fill with calcium deposits, and, sadly, there is the occasional disaster and tragedy from carbon monoxide poisoning or electrical fault.

Sir John Egan, in his report, *Rethinking construction*[1], has drawn attention to the need, amongst other things, to improve productivity, reduce construction times and cut accidents in the UK construction industry, and he also called for a 20% cut in the number of defects. This book may be seen as a contribution to some of the aims identified in the report, and is drawn from the collective experience of the Building Research Station and its successors, the Building Research Establishment and BRE Ltd, over the years since its foundation in 1921.

Information on faults in buildings of all types shows that a substantial number relate to building services, and some of those are rather elementary in nature. An analysis of the information available to BRE is given in Chapter 0.

Readership

Building services is addressed primarily to building surveyors and other professionals performing similar functions – such as architects and builders – who maintain, repair, extend and renew the national building stock. During the course of routine surveys of existing buildings by surveyors and architects, there will be a need to identify items relating to the services: deficiencies in performance resulting from outdated installations, or breakdown through wear and tear, which demand attention. Bearing in mind the increasing complexity of building services, and of the old adage that a little knowledge can be a dangerous thing, there is still a need for sufficient information to be available to enable building owners to be advised on when to call in specialist consultants to rectify, enhance or replace existing installations. *Building services* is certainly not aimed at the mechanical and electrical engineer nor indeed at the building services engineer, though it will perhaps find application in the education field.

The descriptions and advice given in the pages which follow concentrate on practical details. But there also needs to be sufficient discussion of principles to impart understanding of the reason for certain practices, and some of this information of a general nature is given in Chapter 1.

Scope of the book

All kinds of building services, including space heating and cooling, ventilation systems, piped services of water and gas, refuse disposal, wired services for electricity, telephone and television, and mechanical handling systems such as lifts and escalators are, in principle, covered in the book. It will immediately be apparent that in a production of this limited size the coverage on any particular topic can only be brief. The text therefore concentrates on those aspects with which BRE has been most heavily involved, whether in laboratory research, site investigation or the development of legislation and Standards.

Although lightning protection might possibly be considered as a building service, this topic has already been dealt with in *Roofs and roofing*, Chapter 1.6, and *Walls, windows and doors*, Chapter 1.8; the risk of lightning strikes and detailed discussion of the necessary provision against strikes is not included in this book, though a case study drawing attention to the extent of damage which can occur to a chimney is included in Chapter 2.1. However, since these other volumes were written BRE has issued a new Digest which deals with lightning protection[2].

Building services does not deal with industrial plant engineering, nor in any detail with the design and installation (and faults) of the large scale installations necessary to service larger buildings. Nor can it deal with specialised buildings such as cold stores. There is an almost incredible variety of practices, with corresponding potential for error and breakdown. The saving grace is, of

course, the degree of specialisation, competence and professional skills of the larger firms of consultants and contractors in the building services industry who are more usually involved in these larger schemes. It is in the smaller schemes that corners are sometimes cut.

In principle, all types of buildings are included. However, it is inevitable that the nature of installations becomes very sophisticated in some building types such as factories and health buildings, and these installations do not make it easy to provide simple guidance for use of non-specialists on site. The topics differ somewhat in this respect from those which have been covered in the other books in the BRE Building Elements series. However, even the relatively simple systems used in the majority of domestic construction provide adequate potential for improvement.

Both good and bad features of building services are described, and sources of further information and advice are offered. The drawings are not working drawings but merely show either those aspects to which the particular attention of readers needs to be drawn or provide typical details to support text. The discussion is deliberately neutral on matters of style and aesthetics and is wary of suggesting that there is ever a unique optimum solution.

As with the other books in this series, the text concentrates on those aspects of building services which, in the experience of BRE, lead to the greatest number of problems or greatest potential expense, if carried out unsatisfactorily. It follows that these problems will be picked up most frequently by maintenance surveyors and others specifying and carrying out remedial work on building services. Occasionally there is information relating to an item, perhaps a fault, which is infrequently encountered, and about which it may in consequence be difficult to locate information. Although most of the information relates to older buildings, material concerning observations by BRE investigators
of new buildings under construction in the period from 1985 to 1995 is also included.

The case studies provided in some of the chapters are selected from the files of the BRE Advisory Service, the Building Research Energy Conservation Support Unit, and the former BRE Defects Prevention Unit, and represent the most frequent kinds of problems on which BRE has been consulted.

An attempt has been made within the chapters to follow the standard order of section headings adopted for the other books in the series. These standard headings are repeated only where there is a need to refer the reader to earlier statements or where there is something relevant to add to what has gone before.

In the United Kingdom, there are three different sets of building regulations: the Building Regulations 1991 which apply to England and Wales; the Building Standards (Scotland) Regulations 1990; and the Building Regulations (Northern Ireland) 1994. There are many common provisions between the three sets, but there are also major differences. The book has been written against the background of the building regulations for England and Wales, since, although there has been an active Advisory Service for Scotland and Northern Ireland, the highest proportion of site inspections has been carried out in England and Wales. The fact that the majority of references to building regulations are to those for England and Wales should not make the book less applicable to Scotland and Northern Ireland.

In addition to the building regulations, there is also other legislation such as the Electricity at Work Regulations 1989, the Electricity Supply Regulations 1989, the Regulations of the Institution of Electrical Engineers, now published by BSI as Requirements for electrical installations, BS 7671[3], the Gas Safety (Installation and Use) Regulations 1998, and the Water Byelaws[4] which were succeeded by the Water Regulations in 1999[5].

Although practically all building services are encompassed in the Construction (Design and Management) Regulations 1994, the ramifications for each of the services covered in this book are considerable. It is not practical to spell them out in this book, beyond noting that there must be a Health and Safety Plan and File for buildings constructed after this date which should include information on how to manage health and safety issues after the installation is completed and throughout its life until demolition[6].

Some important definitions

The broad term 'services' usually includes those provisions for meeting the internal environmental requirements that – like heating, lighting and ventilating systems – depend on the consumption of energy and materials. The most common requirements today are for consumable water for life support and for sanitation, for consumable energy (for heating, lighting, ventilation and other purposes), and for means of transportation and telecommunication. All services, of course, require further space for their accommodation within the building, and most, but not all, also require support and enclosure.

For the purposes of this book the word 'chimney' means a structure consisting of a wall or walls containing a flue or flues. This definition includes any part of the fabric of a building or a part separate from it; that is to say, either masonry carcass or metal sheath. The 'flue' is the continuous void which actually carries the products of combustion from the appliance to the terminal. The term 'duct' means an enclosed void which carries one or more pipes from one part of the building to another part. Chimney can also apply to the structure which encloses a vertical ventilation duct. The term duct can also apply to the (usually) sheet metal enclosed void which carries fresh air into the building, or vitiated or exhausted air out of the building.

Since *Building services* is mainly about the problems that occur in building services, two words, 'fault' and 'defect', need precise definition. Fault describes a departure from good practice in design or execution of design; it is used for any departure from requirements specified in

building regulations, British Standards and Codes of practice, and the published recommendations of authoritative organisations. A defect – a shortfall in performance – is the product of a fault, but while such a consequence cannot always be predicted with certainty, all faults have the potential for leading to defects. The word 'failure' has occasionally been used to signify the more serious defects (and catastrophes!). The word fault as used here is not synonymous with electrical fault as defined in BS 7671, and defects and unsafe conditions take on a special significance in gas utilisation as controlled by the Gas Safety (Installation and Use) Regulations.

A general requirement for 'safety' arises because many of the means adopted to satisfy the primary user requirements create potential or actual hazards. BRE has been greatly concerned with safety over the years. The most important aspects in the past history of building have been structural collapse and fire. Hazards to health probably come next, though they tend to be more insidious, and less easily recognised and defined. Other aspects include explosion (closely related to fire), and a variety of possible contributory causes of human accidents such as falls. Safety means the reduction of these hazards and risks of accident to tolerable levels since absolute safety is virtually unattainable. A number of accident rates are quoted in this book for various building services. As noted in the companion book *Roofs and roofing*, it is a matter for the collective judgement of society, operating through building regulations and British Standards, whether these accident rates are acceptable, for it could be very expensive to uprate all Standards to provide for better protection.

Where the term 'investigator' has been used, it covers a variety of roles including a member of BRE's Advisory Service, a BRE researcher or a consultant working under contract to BRE.

Particular terms used in connection with energy, central heating and air conditioning will be found listed in later chapters.

So far as water terms are concerned, there has been a significant change in usage since the 1980s. The term 'potable' water to describe water of a quality suitable for drinking is now no longer popular, though it is still contained in current Standards: the terms 'drinking water' or 'wholesome water' are preferred. 'Grey water' is defined as waste water not containing faecal matter or urine, and 'black water' is defined as waste water which contains faecal matter or urine.

Acknowledgements

Photographs which do not bear an attribution have been provided from our own collections or from the BRE Photographic Archive, a unique collection dating from the early 1920s.

We are particularly grateful to Peter Mapp (Peter Mapp and Associates) who drafted Chapter 5.4, and to Geoff Dunstan (GDK Associates), who provided information and comments on parts of Chapter 2.

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H W H
P M T
July 2000

Chapter 1 Building physics (services)

This first chapter deals in simplified form with some of the basic underlying scientific and engineering principles which tend to affect the internal environment of the building as a whole. It also concentrates on those uses of energy which seem to be of most consequence to the occupants and which have a direct effect on their comfort, both thermal and visual.

As noted in the introductory chapter, the oldest buildings in the UK building stock have relatively little in the way of building services. In the days when these buildings were built, their occupants had to make do with the crudity of what was currently available. The application of scientific principles to the design of buildings, although receiving some impetus with the technological developments of the Industrial Revolution, did not take off until the 1920s and did not really form a significant part of the education of architects until the middle years of the twentieth century.

'The highest available knowledge of pure science and the most effective methods of research are needed in building as in any other field of research. Building research as a whole, however, is concerned with the principles of an exceptionally wide range of science. Results of past scientific research are not at present fully utilised in building because there is no suitable bridge between the research worker and the architect or designer.' (The Department of Scientific and Industrial Research, 1919).

Although the principles underlying design for user satisfaction might not have changed significantly during the interwar years, the 1920s and 1930s, the application of scientific principles to the design and construction of buildings received a boost when the first volume of the book *Principles of modern building* was published in 1938 (see Chapter 1.1).

There is not the slightest doubt that since that time the increasing sophistication and consequent demands of users for improved standards in all kinds of buildings are driving an accelerating rate of change in the technological development of building services. In consequence, building services plant is getting more and more sophisticated (Figure 1.1), and services are taking an ever-increasing share of the total costs of a building project.

Figure 1.1
Part of the plant room for a small office building. The rate of change of technological development is increasing, and plant rooms can become congested

Chapter 1.1 The building as a whole

At the time that the Building Research Station (BRS) was first established, relatively few houses had bathrooms and water closets, relying instead on outside 'privies'. Central heating was rare, even in non-domestic buildings. Washday for many households began by lighting a gas or coal fire under the 'copper', stirring the clothes with a 'dolly', and 'mangling' them by hand to a semi-dry state. Standards since then have risen out of all recognition.

When the first edition of *Principles of modern building* [13] was published in 1938, it was possible to discuss in physical terms the functions and performances of the types of construction that were then being built, to indicate ways of predicting some of the performances, and to distinguish between good and bad practices. In the revised and expanded editions of 1959–61 this approach was further developed and extended to floors and roofs as well as to walls. But the focus on the building element – the wall, floor, or roof – remained.

This concentration on building elements had the merit that it directly reflected the main interests of the designer at the detailed design stage. On the other hand it offered little general guidance on, for instance, the design of a complete spatial enclosure, the performance of which was of more interest to the user; and, for this reason, it could lead to overemphasis on some features and the relative neglect of others of equal or greater importance. There was a need to think more in terms of the whole system, at least when contemplating any major departure from already proven practice.

Part 1 of the third edition of *Principles of modern building* was entitled 'The building as a whole'. The text dealt with a number of important aspects of the performance of the whole building such as stability, ventilation, thermal and sound insulation, fire protection and daylighting, but there was little examination of the role of building services and the part they played in establishing comfortable conditions for the occupants. Since the 1960s, BRE has put much effort into examining the influence of one services subsystem upon another; for example, the inter-relationship of different forms of heating systems with thermal capacity, thermal insulation and ventilation provision, and the effects of extraneous air leakage. The performance of the whole building ought to be viewed as a complex interaction of all its parts and all its subsystems, and what is in balance for one set of circumstances may not be the same for another. Although the carcass of the building can provide the occupants with some protection from extremes of climate, both winter and summer, it is the servicing subsystems which now provide the fine tuning and correction of any imbalances in comfort levels (Figure 1.2).

The UK Climate Change Impacts Review Group have published estimates of the changes to the British climate that are expected to result from global warming over the next 60 years. Climate change has particular relevance to buildings because they last a long time. Buildings now being

Figure 1.2
Simple protection from the weather, which might have sufficed in years gone by, is no longer enough. When this substantial dwelling was built in the nineteenth century, the many chimneys now surviving indicate that the main rooms were heated by open fires; even so, some rooms were unheated. Used since the early 1920s as offices, the servicing systems have needed to change out of all recognition

designed or extensively refurbished are expected to last well beyond the time when significant climate change is expected, and many aspects of buildings are sensitive to climate. Current design procedures rely on historical climate data for the assessment of risk, but, if climate is to change, risk needs to be reassessed. Given the high degree of uncertainty about future climate, the first requirement is to determine the extent to which aspects of buildings are sensitive to climate change. The results form a basis for deciding where changes to design conditions are required. For building services, the greatest changes are likely to be in heating and cooling requirements. In the short term, the most important effects are likely to derive from initiatives to limit global warming by improving energy efficiency, rather than from the direct effects of climate change[30].

BREEAM – the BRE Environmental Assessment Method for buildings – was launched in July 1990. It remains the main working method worldwide for assessing environmental performance, and indeed has become a *de facto* standard for environmental performance[29].

Integration of building services into the overall design process

Although it might be thought that services would always be fully integrated into the carcasses of buildings from the start of the design process, with coordination proceeding through to the site assembly, it is only within recent years that significant progress has been made. When buildings were simple, and had few services other than provision for space heating, a hand pump in the kitchen, and bell wires to summon the servants, coordination of the installations was relatively unimportant, and could be accommodated piecemeal. Some were left exposed in any case.

BRS became more heavily involved in the rationalisation and integration of building services in the late 1950s following the discovery that it was common on site inspections to find that no such planning had taken place. Each specialised contractor would do his own thing. The first one on site had a clear run, and all the others following on had to fit their pipe runs and cables around what was already there. A mechanical and electrical engineer of a brand new hospital under construction in 1960 was asked by a BRE investigator if he could show a drawing of the services at one pinch point in the structure, an underground duct joining two buildings. The engineer produced 24 separate drawings, each showing different installations passing through the same location! No one had thought to coordinate them, and a veritable cat's cradle had resulted on site. The legacy lingers on in many of the buildings of those days, with a few honourable exceptions.

This lamentable state of affairs prompted BRE to include the integration of building services in the series of books aimed at the educational field, and entitled *Designing for production*[31].

In these publications, building services are categorised into three types:

- large self-contained elements with few connections to other services, such as lift installations
- utility services, such as sanitary accommodation, usually grouped into fairly well defined areas of the building, with connections with hot and cold water systems, and to drainage
- environmental services, which by their nature extend on a significant scale throughout a building; these include heating, ventilation, lighting and communications subsystems (Figure 1.3)

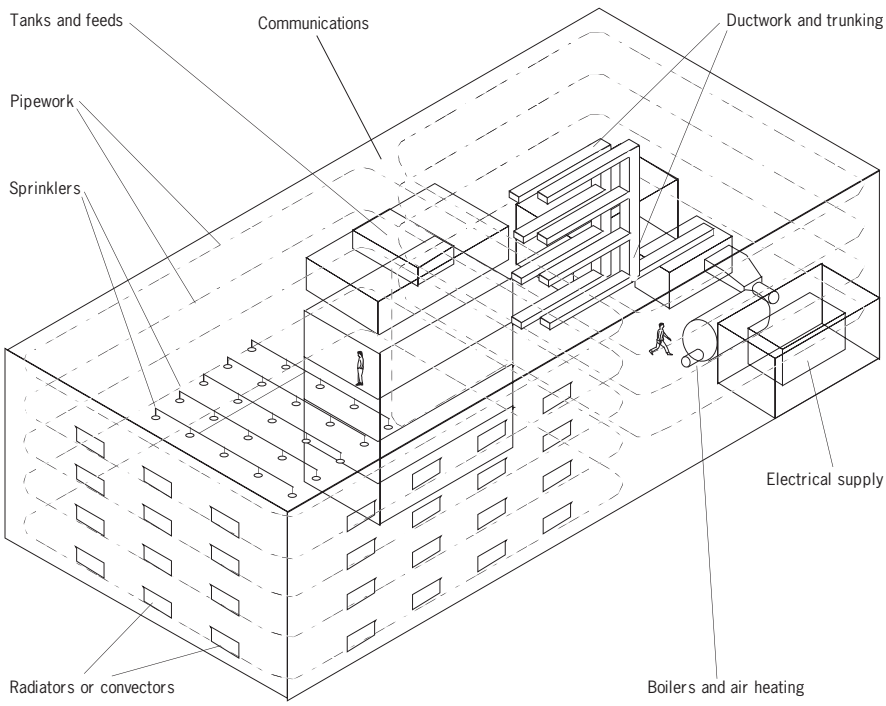

Figure 1.3
A schematic illustration adapted from Designing for production[31] showing some of the environmental services for a large building