Building Services Engineering

A Review of Its Development

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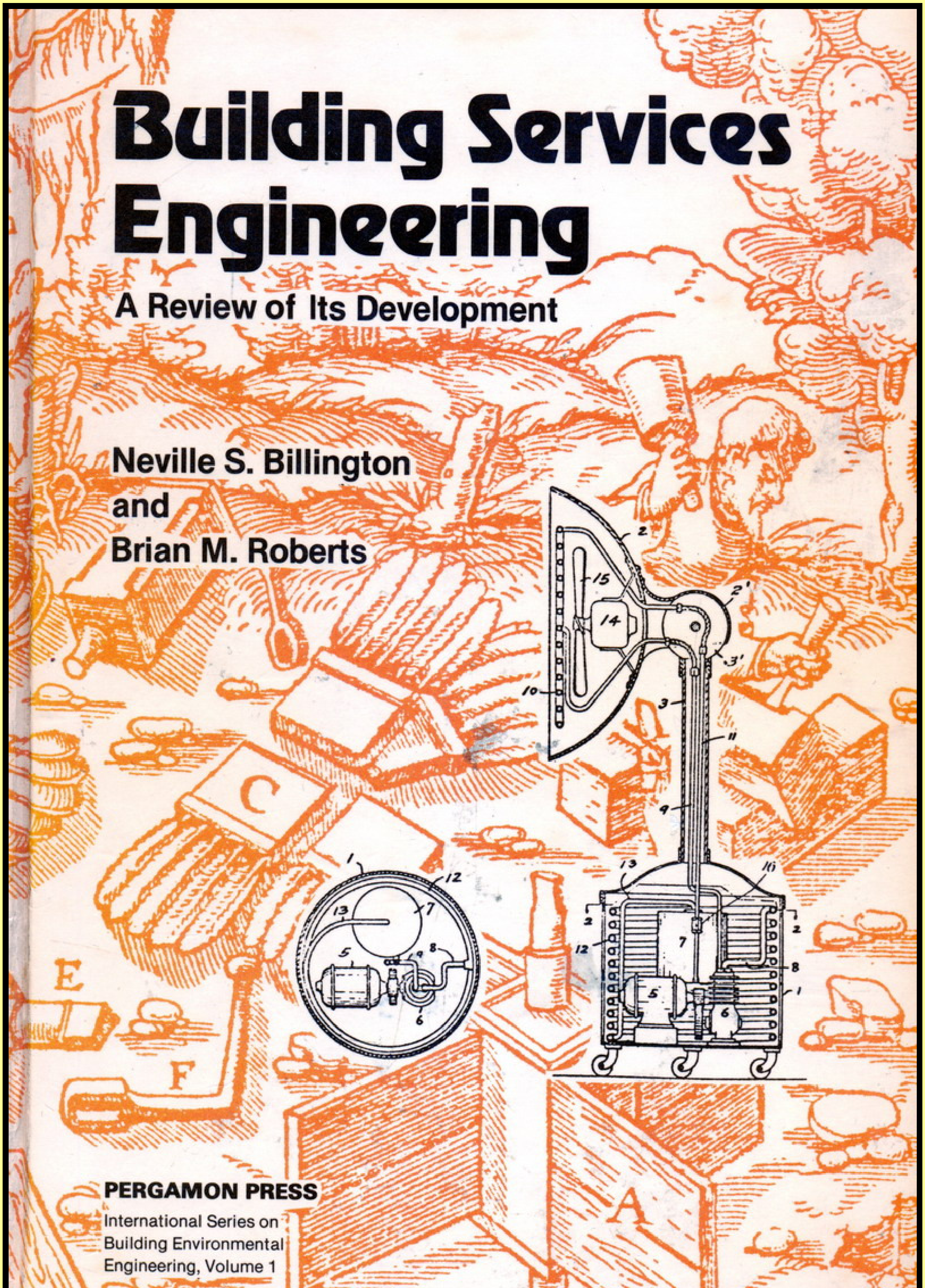

PERGAMON PRESS

International Series on
Building Environmental
Engineering, Volume 1

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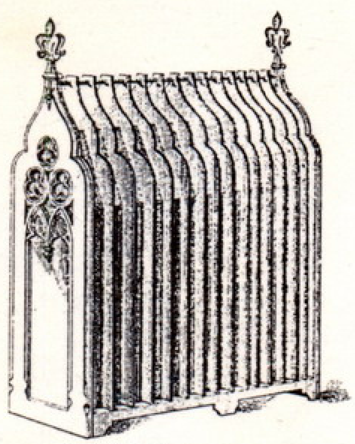

COTHIC HOT WATER OR STEAM STOVE.

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PREFACE

In attempting to deal in a single volume with the development of those disciplines which we now call building services engineering, we have been faced with difficult choices. We have felt it desirable to sacrifice minute and exhaustive detail in order to stress the significant technical advances and their social and economic consequences. Pressure of space has prevented us from dealing with applications to transport or to general industrial problems; we have for the same reason reluctantly excluded any discussion of cooking equipment, although it is an important domestic service.

The literature on heating and ventilation is certainly older, and probably more extensive, than that on any other discipline within building services engineering, yet, curiously, the development of heating and ventilating engineering over the past century has not previously been traced, whereas the story of refrigeration and of lighting in the same period has been recorded. We make no apology for having treated the progress of heating and ventilation at relatively great length, for its stages encompass the whole growth of civilisation and the development of modern modes of thought. We see in it the trial and error and the empiricism of the early days, even the re-discovery of older ideas, before the growth of knowledge in the physical, medical and psychological sciences paved the way for numerate design. The effects of sociological change in moving from a feudal (and monastic) system to an industrialised urban existence, and of the broadening of the educational base, freed from the restrictions of monasticism, the birth of an industry and the emergence of the consulting engineer, are generally more easily seen via the advances in heating and ventilating engineering. Technologies of more recent origin (such as refrigeration) have developed in a different and more direct way. They were essentially based on the discoveries of contemporary science, and by availing themselves of these, they were able largely to bypass the empirical stages. They were established in a period of industrial growth, and in consequence gave rise to the modern concept of industrial research and development.

We are indebted to a great many friends and colleagues, both at home and abroad, who have helped us in many ways. In particular, we should mention F. Clain, M. Gartside, Barrie Graham, Professor Inoue, F. Meszaros, G. Rooley and Dr F. M. H. Taylor, for private talks and correspondence, and the staff of the BSRIA Library for unstinted assistance with difficult enquiries.

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"Those who cannot remember the past are condemned to repeat it" (Santayana).

"In attempts to improve, it is always desirable to know exactly what progress has been made — to be able to measure the distance we have laid behind us in our advances, and also that which remains between us and the object in view. The ground which has been gone over is easily measured, but to estimate that which still lies before us is frequently much more difficult" (Rumford).

"Technology covers as wide a field as history, and has of necessity history's slowness and ambiguities. Technology is explained by history, and in its turn, explains history" (Braudel)(1).

Bronowski has observed that man, almost alone of all the animals, does not accept his (natural) environment, but seeks to change and modify it to suit his own needs and purposes. The present work is an outline of the history of man's efforts to make this change; but in compiling it, the force of Braudel's statement became evident. It clearly became impossible to treat the advance of technology in isolation: the social causes of the advance, and the social consequences of the advance, are so significant that to omit mention of them would have been misleading, if not an actual dereliction.

Architecture and building services engineering together constitute man's attempts at environmental control. Together they seek to provide the most suitable environments in which people can work, play and have their being. They seek to minimise the physiological and psychological stresses imposed by the natural ambience. They free man from at least some of the constraints imposed by climate and geography. They have been essential elements in the advance of every civilisation; they may perhaps have contributed to their fall also.

Architecture is the passive element, engineering the active element of the combination. This is not in any sense derogatory: neither one can succeed without the other. Traditional styles of architecture have been developed to give the best possible protection in any one climate, short of engineering control. The thick-walled buildings of the Sahara are particularly efficacious in maintaining equable temperatures inside. The white exteriors reflect sunlight; the narrow streets give maximum shade; the small windows exclude solar heat. Rather similar characteristics typify the architecture of the European countries which border the Mediterranean. In the more humid tropics, where diurnal temperature changes are slight, native architecture uses light buildings with opportunity for copious ventilation.

Architecture, however, gives only limited protection against the climate. It cannot change the temperature; it cannot give light where none exists; it cannot supply water or remove waste. These are the province of engineering.

The originators of early inventions are rarely known, particularly where these are gradual developments of pre-existing techniques. These inventions were however born of need. We have seen how methods of water supply were gradually improved as a consequence of the increasing demands of a growing and more urbanised population. The same forces, less successfully, were operative in sanitation. Heating and ventilation were hardly necessary in the early civilisations which grew up in the warm sub-tropical regions, as Markham has pointed out. It is perhaps significant that the Romans, the first to attempt to colonise the temperate areas of central and Western Europe, were also the people who were pre-eminent in the development of heating and ventilation.

The decline of the early civilisations led to an abandonment, if not a loss, of Greek and Roman technologies, at least in Western Europe, where there was a reversion to an earlier peasant existence. The monasteries of France and Germany survived and retained a core of knowledge which was later exported to Britain with the Norman Conquest.

Islamic and Eastern cultures were unaffected, but apparently made little progress in environmental control. (In Islam, the need to do so was slight.) When travel between Europe and the Near East became possible in times of peace, Islamic methods were reported (e.g. by Ogilvie) and Father Gramont recorded Eastern technology. These had some influence on the Western culture of the Middle Ages and after.

Between the Conquest and the 15th century the monasteries were the repositories of knowledge: it is small wonder that the arts of civilisation were developed in them. In the latter part of this period, the growth of trade enabled knowledge to spread: technologies developed in one part of Europe were translated and adopted in other parts, though this was often a slow process, dependent on the availability of local resources and needs. The last factor became less and less important as the trading patterns enlarged, but it never entirely disappeared, since to import all the necessary resources would be uneconomic.

In the 15th and 16th centuries, we see a revival of experimental science and philosophy, based on observation, and the application of knowledge to practical problems. Large-scale mining was the source of much technological progress from the 15th century on, especially in Germany. The problems involved in pumping, hauling and ventilation stimulated research in allied fields. It was the beginning of the age when genius could flower (Galileo, da Vinci), but those who could indulge their enquiring bent were necessarily of the educated and rich few. In the two centuries which followed, scientific discoveries were made by dilettantes, seekers after knowledge for its own sake. They had no recognised profession. But in the 18th century, members of universities began to contribute. It is probably no accident that many of them were physicians — a discipline which had at least some observational and experimental basis. It was at this time, too, that the basic sciences of physics and chemistry, and the art of mathematics, were being developed in the universities.

A. G. R. Smith has said[3]

> "A basic need if scientific discoveries are to have a significant practical effect on the conditions of life of the average man, is a close prolonged and large-scale alliance between science and technology. It was not to exist before the later eighteenth century at the earliest."

Tredgold was one of those who attempted to forge this alliance.

The Industrial Revolution was a turning point. Its inception was due to the steam engine which provided a new source of power. Once this was available, power-driven machines displaced manually-operated devices; workshops and factories superseded cottage industry; urbanisation spread rapidly. New skills were required, not only by the workpeople, but by the makers of tools. Inventions were then largely due to the manufacturers, like Boulton, Watt and Murdoch, who were also able to exploit these inventions. This may be said to be the beginning of the heating industry. A number of engineering firms included the installation of heating systems in their business; consultants, like Tredgold, arose.

The experiences of the Industrial Revolution awakened the social conscience, and people became ever less willing to accept the squalid and unhealthy conditions of the 18th and early 19th centuries.

The 19th century was the period of the great social reformers. In the context of this history, Duchâtelet and Villermé in France contributed greatly during the first decade to the ideas on public health; in the middle of the century Arnott, Kay and Southwood Smith, Galton and Chadwick urged the necessity for improved water supplies, drainage, sanitation and ventilation of dwellings in Britain; and Pettenkofer established the Munich School of Hygiene in 1865. Other reforms included the prohibition of chimney boys, and there was the introduction both of factory legislation and of important attempts by private individuals (cf. Chadwick's report) to ameliorate the conditions of factory and other workers. Neither was heating neglected. The 1857 Board of Health Commissioners made significant steps in setting down, probably for the first time, the requirements for satisfactory warming — a statement which, apart from the temperature level, has been accepted ever since.

One notices the involvement of eminent scientists in this work — Lavoisier, Gay-Lussac, Leblanc; Wheatstone, Campbell-Stokes and Roscoe. This was a significant step towards the development of a science of Building Services engineering. Previously, almost without exception, work in this field had been the result of efforts by individual savants and dilettante inventors. In the 20th century, there were (and are) many who have devoted their whole life to such matters (Bedford, the ASHRAE teams, Hopkinson, Sabine, Morse, Parkin, Rietschel, Carpenter and others).

An important factor in the development of techniques for heating and ventilation was the increasing number of public buildings in the early and middle years of the 19th century, erected to cater for an urban population. The new municipal authorities then being set up not only required their schools, their town halls and administrative offices, but they were anxious to build prestige buildings as places of public assembly. Asa Briggs mentions Bradford Town Hall as one; St George's Hall, Liverpool, is perhaps another. To these "patrons", cost was of less significance, and they were prepared to experiment (or rather, to allow experiment) in their buildings. The Government itself was no mean sponsor, as witness the many schemes used at various times in the Houses of Parliament. It must be admitted that the desire for improvement, or the desire to take advantage of the most modern knowledge, lay at the back of every attempt, whether occasioned by simple dissatisfaction, or by disaster (e.g. the fire of 1834, or bombing in World War II).

Possibly "lobbying" of members of committees was partly responsible for this attitude, for obviously an inventor (as many after Sutton) would endeavour to secure a trial at public expense. A few, like Winsor, arranged their own public demonstrations; but he was probably alone in setting up a public utility company, the Chartered Gas Light and Coke Company.

From this point on, development and invention were the result of interplay between scientific studies, new materials and methods of manufacture and economic or social needs. No one of these can be said to have been fundamental: need led to study,

study to new techniques; but new techniques also led to study and to new needs.

Some of the original discoveries were accidental, and were useless until a need for them existed. In other cases, and gas is a prime example, from an accidental observation, followed by a number of unrelated *ad hoc* experiments, the need was created by percipient entrepreneurs.

Amongst the academics, the British scientists seem to have been "purer" than the French and German counterparts. Meissner in Vienna, Lavoisier, Péclet and Pettenkofer, applied their scientific results to practical problems (or was it that the practical problems inspired their scientific inquiries?).

By 1900, the newest technological devices were for the most part not of British origin, and what was of even greater importance, they were being more energetically developed in countries which did not have vast capital locked up in well-tried methods of production. Electric power and the internal combustion engine, for instance, were making rapid progress elsewhere, while Britain with her superb equipment based on steam power, was slowly learning that the good is the enemy of the best.(2)

Auer von Welsbach, Edison and Swan combined inventive genius with commercial acumen. So too did Linde in Germany and Hellyer in Britain. They perhaps mark the beginning of modern industrial research, geared to identifying needs and finding the means of satisfying them on a commercial basis. The Carrier Company in USA was a prime mover in this direction, followed by DSIR in Britain. (Pettenkofer's School of Hygiene in Munich was not an industrial research laboratory. And although Rietschel at Charlottenburg had an organised research school, this too was divorced from commerce.)

Modern R & D is divided between universities and similar academic bodies, autonomous research organisations and the R & D departments of large companies. There is little scope for the private individual. Discoveries and inventions are largely the result of purposeful, directed effort by teams of investigators, though nothing can replace the inspiration or intuition of the individual, whether leader or member of the team – this last is an essential element in any successful invention.

The explosion of research in the last 50 years has had surprisingly little impact on the technologies of building services. Most of the basic principles were laid down during the previous century, and few significant changes have taken place, save in detail or refinement, and of these, energy economy and automatic control have been the most important. Of greater significance has been the application of the available techniques to a wider range of industries and to the development of the tropical and arctic areas of the globe.

The increasing importance of environmental engineering led to the founding of specialist professional institutions. ASHVE in America and IHVE in Britain were founded in the closing years of the 19th century; the illuminating engineering societies at the beginning of the 20th. The report of the first meeting of the IHVE is amusing:

> After the Presidential Address at 5 pm, and some discussion, the meeting was adjourned and dinner was served. The menu was (according to the Report) "most elaborate, and the dinner very satisfactory."
>
> "After dinner was served, the toast master, President Jones, called the members to order, and the following programme was gone through, and evidently much enjoyed by all present:

Pianoforte solo, Mr S. Levey
Toast "The Institution of Heating and Ventilating Engineers" proposed by the President and responded to by Vice-Presidents Nesbit and Russell.
Songs "The Longshoreman" (Mr Crispin)
"Whisper and I shall hear" (Mr Miller)
"The Diver" (Mr Taylor)
"Village Blacksmith" (Mr Brown)
A few yarns by Mr Taylor
Songs "Topical song" (Mr Levey)
"Queen of the earth" (Mr Crispin)
"The World went very well then" (Mr Taylor)
"Mona" (Mr J. Taylor)
"Three beggars" (Mr Miller)
"To my watch" (Mr Brown)
"The powder monkey" (Mr Crispin)
Votes of thanks to President, Secretary and Master of Ceremonies."

How very different from the present day – either at a technical meeting or a formal dinner!

What was probably the first technical journal in the field was the *Rohrleger* – now *Gesundheits-Ingenieur* – established in 1878. In its first years, it drew largely on foreign contributions; but gradually these gave way to original German work. The historian now finds the extremely voluminous journals and proceedings of the professional institutions rich sources of information on progress during the last 50 to 70 years.

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