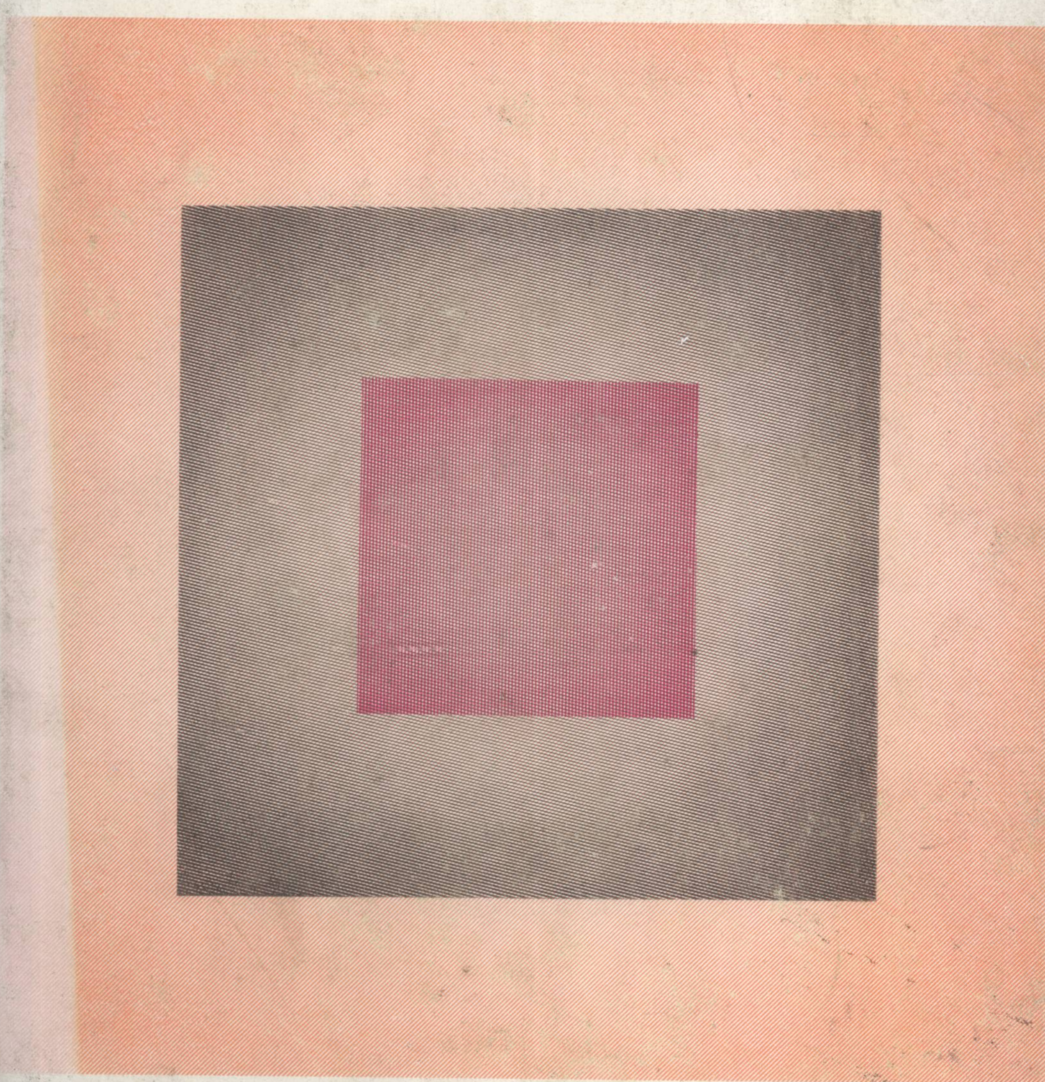
Warm Air Heating

David Kut



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WARM AIR HEATING

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HEATING, VENTILATION AND REFRIGERATION

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VOLUME 7

WARM AIR HEATING

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PREFACE

During 1968/9 the *Steam & Heating Engineer* published a series of thirteen articles written by me relating to the various aspects of heating by warm air. In the course of their preparation I became aware of the then lack of published comprehensive information on the subject and decided to write this book. I trust that it will materially assist the student, designer, and installer of warm air heating systems.

In warm air heating, the warming effect within a space is achieved predominantly by the introduction of warm air into that space. The warm air may be the sole means of heating or it may be supplemented by other sources of warmth such as radiators, convectors, or skirting heaters. A comprehensive warm air heating system offers the following major advantages:

- A dry heating medium which is not vulnerable to frost damage and given to water leaks.
- The facility to combine space heating with ventilation.
- The ability to raise rapidly the temperature within the space to be heated.
- The control of temperature, air movement, and relative humidity within the heated space.
- The exclusion of airborne dirt and dust.
- Elimination of odours, staleness, and tobacco smoke.
- The regulated intake of fresh air and the exhaust of vitiated air.
- Convenience of measuring heat consumption in simple schemes.

The above features ensure an increasing interest in warm air heating installations; these range in type from the simple brick-set gravity air flow domestic heater to the large sophisticated comprehensive industrial air heating plant.

In this book I have described the underlying principles of heating by warm air and have shown how these are carried into practice. Whilst I have drawn freely on published information, I have refrained from extensive copying and repetition. The available information has been pin-pointed and the references to my sources presented together at the end of each chapter. Where a reference does not specify a section or page number, it is recommended for general reading and study.

Numerous illustrations are included with the text and these should greatly contribute towards a better understanding of the subject matter.

Much effort has been channelled into Chapter 14: Duct Design, and I express my thanks to my Associate, Mr. G. Cannon, for his contribution to this work.

Many of the photographs have been provided by manufacturers of heating and ventilating equipment and I am grateful for this assistance. The diagrams and general illustrations were drawn by members of my staff.

METRICATION

At the time of completing the final draft of this book, the changeover from British units to metric units was approaching the fringes of the heating and ventilating industry. Whilst the Institution of Heating and Ventilating Engineers have recommended the adoption of the SI unit for metrication, it is too early to predict when the majority of the industry will be able to proceed on a metric base and, also, whether the SI unit will be universally adopted; there is some evidence that there will be certain exceptions where the SI unit is likely to prove very unpopular or, possibly, unworkable.

It appears to the author that British units will remain in use by the Heating and Ventilating Engineers for some considerable time and that, prior to complete metrication, there will be a period when both British and metric units will be employed side by side (though one can only hope that such a period of confusion will be mercifully short). In view of these considerations, it has been decided to present this book in both British and metric units, though with certain inevitable exceptions: in respect of subject matter for which information is not currently available in metric form or where the use of two sets of units would be greatly confusing (this refers particularly to the chapter on Duct Design, which is dealt with on the basis of British units); where it has become uncertain whether the SI unit is to be adopted (such as for the rating of boiler); where metric units are predominantly in current use and where little purpose would be served by converting to British units (this applies particularly to the chapters on Humidity Control and Sound Attenuation).

It appears that the Fahrenheit scale of temperature will remain in common use for some time, with the Centigrade scale slowly making ground. To assist the reader, each temperature has been set down in both Centigrade and Fahrenheit.

COSTS

I have considered adding information on the capital and operating costs of the various systems described herein, but have decided not to do so. Costs are at present in a state of great flux and under inflationary pressure; in particular, it is impossible to forecast the effects of North Sea gas on the fuel situation.

DAVID KUT

EDITORS' PREFACE

MODERN industrial civilization depends for its existence on man's control of his environment. Simple comfort requires that in most parts of the world buildings must be artificially heated or cooled during some part of the year. Rising standards of living have made people intolerant of the conditions of yesteryear in factories, offices and the home, and manufacturing processes themselves are requiring ever closer control of environment. Present-day air travel would be impossible without the air conditioning of aircraft.

Heating and air conditioning, then, have an essential contribution to make to the life of everyone—in the home, at work, while travelling or during recreation. These engineering services can account for between one-tenth and one half of the total cost of a building, depending on their complexity and sophistication. They require expert design; and the number of skilled personnel is, almost everywhere, too small.

These, then, are the justifications for a series of textbooks dealing with the design of heating and air conditioning plant and equipment. The series is planned to include the following subjects:

Basic principles of heating and ventilating
Heating and cooling load calculation
Heating and hot-water supply
Ventilation and air conditioning of buildings
Industrial ventilation
Fuels and boilerhouse practice
Heat and mass transfer
Fans
Dust and air cleaning
Refrigeration technology

Each volume in the series is complete and self-contained in so far as the technical and practical engineering applications of its main theme are concerned, but for a more detailed discussion of the underlying principles of certain subsidiary subjects and for derivation of the formulae and equations, quoted reference to the other volumes may be necessary. For example, heat transfer formulae must be quoted and used in more than one of the books but their derivation is given in all necessary detail in the specialist volume on heat transfer. Similarly for heating and cooling load calculations which concern not only ventilation and heating but also refrigeration. This treatment has allowed more detailed consideration of the subject than is possible in an omnibus volume of manageable size.

Another book that should be consulted when more detail is required is *The Measurement of Air Flow* by Ower and Pankhurst (Pergamon Press, 1966), which does not form part of the series because it covers a considerably wider area.

The authors have taken as their starting-point a basic training in general engineering such as may be acquired during the first years of apprenticeship. On this foundation, the specialist treatment is built and carried to a level approximating to that of a first degree. The graduate engineer or physicist who wishes to enter this field will also find the series useful, since he is introduced to new disciplines (for example, human physiology or climatology) and new applications of his fundamental knowledge, while some parts of his undergraduate course work are taken to much greater depth. Throughout the whole series, the practical applications are stressed.

The volumes do not pretend to cover the whole range of problems encountered in design, though a student who has mastered the basic principles embodied therein should be a competent engineer capable of handling a majority of the tasks he will meet. For the test, practical experience backed by further study of more advanced texts will be essential.

N.S.B.
E.O.

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CONTENTS

CHAPTER 1

THERMAL COMFORT AND HEAT TRANSFER

VARIOUS research programmes and studies have investigated the reactions of men and women to their thermal environment. The publications by Thomas Bedford, who worked at the Medical Research Council's Environmental Hygiene Research Unit at London, are of particular importance. Dr. Bedford stated that the basic requirements for a pleasant thermal environment are:

(a) The room should be as cool as is compatible with comfort.

(b) There should be adequate air movement without local draughts. At the room temperatures customarily maintained in winter in the United Kingdom, the optimum velocity at which the air moves across the room lies between 0.1 and 0.15 m/s (20 and 30 ft/min). At lower velocities there will be feelings of stuffiness; at higher velocities complaints of objectionable draughts are likely. During the summer months generally, and particularly in the presence of high heat gain, greater rates of air movement are desirable and at times necessary.

(c) The human body is stimulated by ceaseless changes in the environment; the air movement should therefore be variable rather than uniform and monotonous.

(d) Relative humidity should not exceed 70 per cent; a much lower relative humidity is preferable.

(e) The average temperature of the walls and other solid surroundings should not be appreciably lower than that of the ambient air; preferably, it should be higher. Where such "warm wall" environment cannot be achieved, the combination of cold walls and warm air tends to cause feelings of stuffiness.

(f) The air at head-level should not be noticeably warmer than that near the floor; i.e. a high temperature gradient between floor and ceiling should be avoided.