



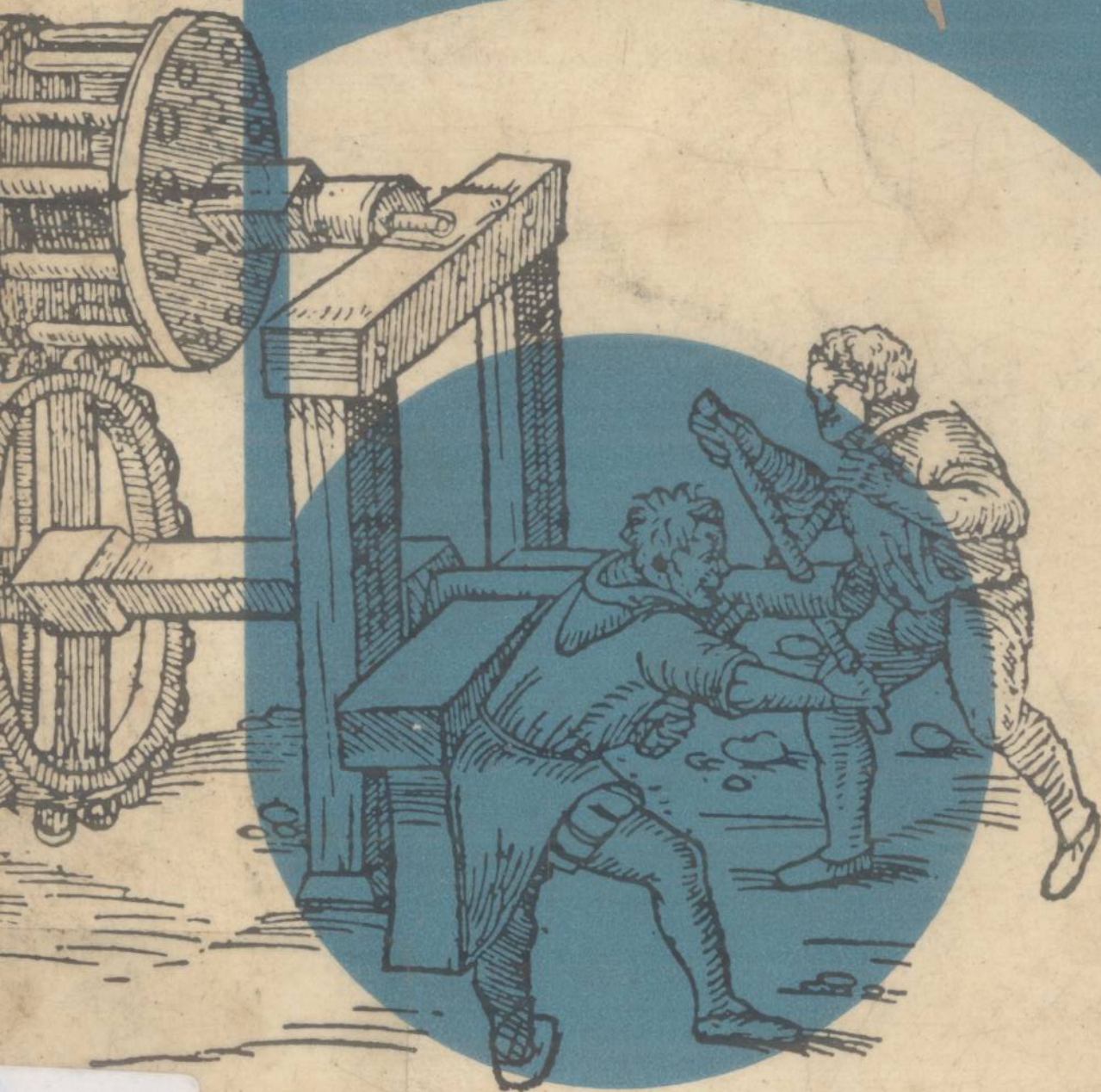
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历史

# Man and Energy

A. R. Ubbelohde



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## PREFACE TO THE FIRST EDITION

POWER and knowledge are twin prizes that have been sought after as far back as human records can be traced. In modern times, for good or ill, the predominant emphasis is on material power and on knowledge obtained by scientific methods. These have led to striking advances in certain ways of living. But scientific power and knowledge also form the background to some very uneasy situations in the modern world. This makes it desirable to attempt a survey.

The bulk of scientific progress is now so large that a balanced survey of the whole tends to become lost in mere encyclopaedism. However, one central theme which ties much effort together is the development of the various relationships between man and physical energy. This book surveys the astonishing growth of human power over energy from the prehistoric domestication of slaves and draught animals to the modern control of the atomic bomb. Some description is also given of the growth of knowledge about energy, with special reference to the Laws of Thermodynamics. While such developments of knowledge are less spectacular and less well known than the growth of scientific power in the modern world, their contributions to an integrated interpretation of experience are quite as important.

This book germinated out of talks on the BBC Third Programme. Thanks are due for willing help from various correspondents, enumerated in more detail under 'Acknowledgements' or 'References'. Grateful acknowledgement is also made of valuable cooperation from members of the library, secretarial, and technical staff of Queen's University, and of Messrs Hutchinsons.

A.R.U.





## PREFACE TO THE PELICAN EDITION

ONLY seven years have elapsed since the first edition; many quantitative assessments of present energy uses and future energy demands by mankind have undergone striking changes even during this short period. Where appropriate, facts about present energy uses have been added, to give some perspective about the tempo of change. Estimates about future demands over the next three or four decades can only be made within wide margins of uncertainty; figures quoted in the first edition have only been modified where there seemed to be a real gain of reliability.

A major change in the second edition deals with uses of nuclear energy. Since 1954 much additional information has been made public, especially with regard to the peaceful uses of atomic energy which formed the subject of a famous international Symposium in 1955. Nuclear power stations are contributing to the national electricity grid in Britain since the opening of Calder Hall in 1956. This has made it desirable to collect information about nuclear energy into a separate chapter (Chapter 5).

The sun continues to pour energy onto the earth's surface in totals that dwarf even current rates of use of fossil fuels, including nuclear fuels. All present information suggests that the supply of solar energy is too diffuse to permit its direct harnessing so as to give real relief of the load for the more densely populated cities of Tektopia. Nevertheless, the totals are so large that continued research on solar energy seems warranted. Chapter 4 has been expanded to give a somewhat fuller account of the present position, than in the first edition.

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PART I

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GROWTH OF POWER





## CHAPTER I

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### *Dominion over Matter through Energy*

THE growth of man's dominion over matter through control of energy was, and is likely to be, a long-drawn-out process. It extends back through history and prehistory, to the very beginnings of humanity. Every important technical advance in the past has involved some new phase in the control of energy. Steps forward such as the use of tools to redirect human effort to better advantage, control over fire, or control over the energy of horses and other power animals are extremely ancient. Probably these advances were quite unobtrusive when first introduced. Although they have turned out to be epoch-making in their outcome, because of their antiquity it is difficult now to reconstruct all the original features of such discoveries. What does persist as obvious, even now, is the need to control energy. This need to achieve dominion over matter inspired these advances and remains perennial. A Robinson Crusoe suddenly abandoned now on a desert island would experience much the same sequence of ideas about how to subjugate the world around him as did the original. In fact, the vocation to control energy in its various manifestations is absolutely basic to human nature.

A brief view of incidents in the life of a business man travelling daily to his work will illustrate in another way the perennial human dependence on energy control. When modern man wakes and gets up, electric power is switched on to supply light and (perhaps less excusably) heat. Possibly the man shaves with an electric razor. While he dresses in clothes to which innumerable machines have contributed their work, his breakfast is being cooked by the heat energy liberated by burning coal-gas. Modern man sits down to eat his breakfast with a battery of knives, forks, and spoons – instruments and apparatus all based on machines. Then the newspaper which has been produced by yet other machines is hurriedly snatched up, and he runs to the station –

## MAN AND ENERGY

a relic of primitive life, and often as keenly felt such – and sits down (if he is lucky) in a machine capable of moving itself by its own power under human guidance. Modern man strikes a match to liberate the heat energy in the match-head, starts up a pipe . . . and so it goes on. It might well be made a modern supplement to an old family game to give forty examples in ten minutes of the energy-dependence of modern man.



*Fig. 1. 'Man and Energy.'* Even in his cradle, infant man shows his vocation to dominate matter by the control of energy.

Human experience of babyhood illustrates man's vocation to control energy in yet another way. In many ways, babyhood telescopes into a very few years the centuries' long-drawn-out growth of man's dominion over matter achieved through control of energy. By its very earliest efforts, a new-born infant strives to achieve control of its own body, which is the very special packet of matter with which the baby is endowed on entering this world. Next, baby seeks to extend its control to inanimate matter around itself. By more subtle devices, efforts are soon made to obtain dominion over the packets of matter really belonging to other individuals – relatives, pets, and indeed the whole of the animal world that is prepared to do fealty to infant man. A healthy baby's growth leaves no doubt about one of the most deep-seated instincts of mankind, to control and dominate its

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environment. Though this instinct of dominion receives less publicity than others, such as hunger, or sex, in many ways it is much the most universal manifestation of the spirit of man at odds with matter.

This same urge to master the world of matter provides the driving force for all the tremendous developments of modern technology. Dominion over matter through control of energy is a permanent ambition in human nature.

Much of this book deals with a critical change in the development of mankind, which can be recognized as having begun around 1700. Before that time, control of energy nearly always implied control of animal energy. This meant command over the energy of one's own body, or the driving of human slaves and other animals under the lash. As is well known, since about 1700 new methods have been brought in for releasing and harnessing the inanimate energy stored within certain forms of matter, such as coal, oil, or more recently atomic nuclei. A New Era has begun. Two hundred and fifty years is only a short run in world history. But time has moved fast in the New Era. Already it can be argued that the arrival of the New Era is as remarkable as the transition from the age of reptiles to the age of mammals in the past history of this earth.

Furthermore, so far as mere technological factors will determine the future, all the signs are that this 'New Era of Inanimate Energy in the Service of Man' is still very near its beginnings. Coal and oil, as reservoirs of inanimate energy, and hydro-electric installations, have been exploited long enough to allow reasonable forecasts of the future for these sources of power. Possible applications of nuclear energy are, however, only just being explored. In this age of atomic energy great promise of grandiose developments is joined with more than a hint of uneasiness about the future.

Immediate practical implications of the 'New Era of Inanimate Energy in the Service of Man' are so weighty that it is mere common sense to attempt a survey. But in the course of a review such as is made in the first part of this book less obvious aspects of the science of energy – 'Thermodynamics' – which have also proved to be of extreme general importance are dealt with. To

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balance the more immediate practical implications of modern relations between Man and Energy, later parts of this book describe how the wider concepts of thermodynamics continue to influence ideas and conclusions in other branches of knowledge.

### THE MACHINE AGE

It is a widespread mistake to describe our present age as the Machine Age. Admittedly machines of great power and helpfulness are active daily in town and country. Each member of a household uses and depends on a great diversity of machines throughout every day. This utter dependence on machines is a really striking feature of our present mode of life. Many people even consider it a very alarming feature. Yet what really marks out our civilization from all previous experience in the history of mankind is the nature of the power used for driving the machines. It is common knowledge that in those parts of the world which are most advanced technologically the overwhelming proportion of machines are driven by inanimate energy. As will be described in Chapter 7, the yearly consumption of various forms of inanimate energy per head of population provides an important index of the technological development of a country.

Before means of applying inanimate energy as a driving force were developed at all extensively, motive power for more primitive machinery was practically always obtained by harnessing the animate energy belonging to horses, oxen, or human slaves. These sources of driving-power are still applied in less developed parts of the world, which are only just beginning to move into the New Era. Much clarification of ideas about our modern technological civilization can be reached by exploring the relationships between man and energy in the pre-metrical age, from which some countries are still emerging. It may be explained that the term 'pre-metrical' is a compact way of describing bygone applications of animate driving-power, since no exact quantitative measures of energy were practised in connexion with such primitive uses. There are also more subtle reasons why an emphasis on the metrical nature of our contemporary approach to energy is appropriate in the New Era. These will be discussed