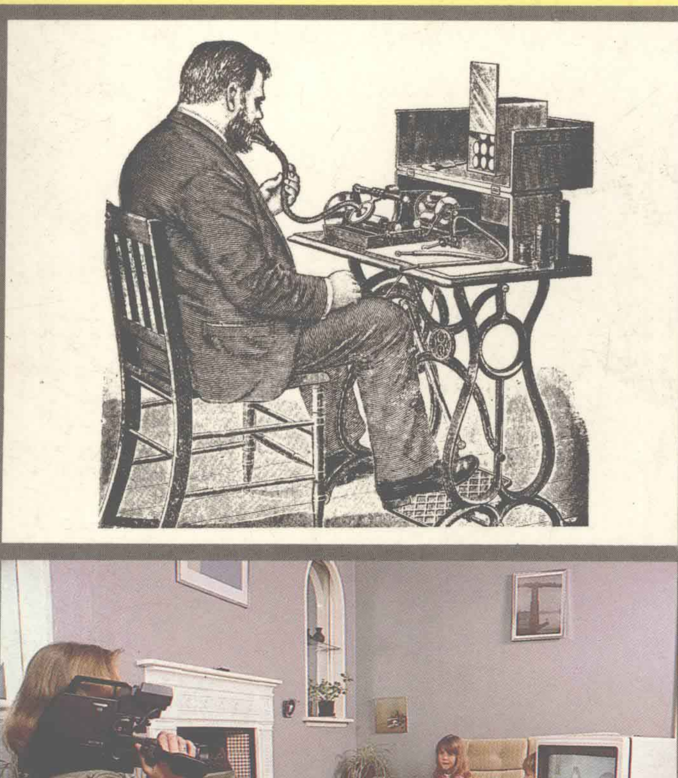
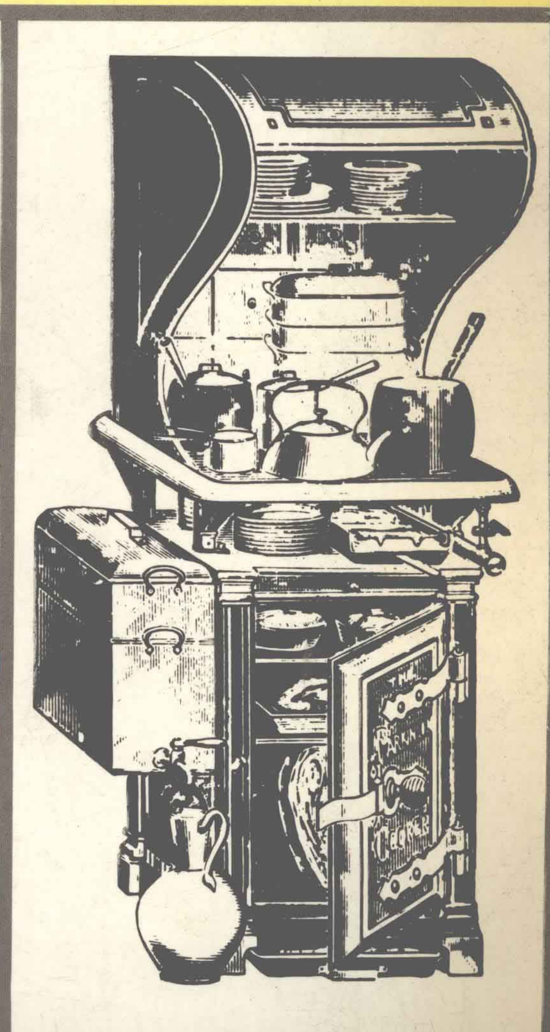
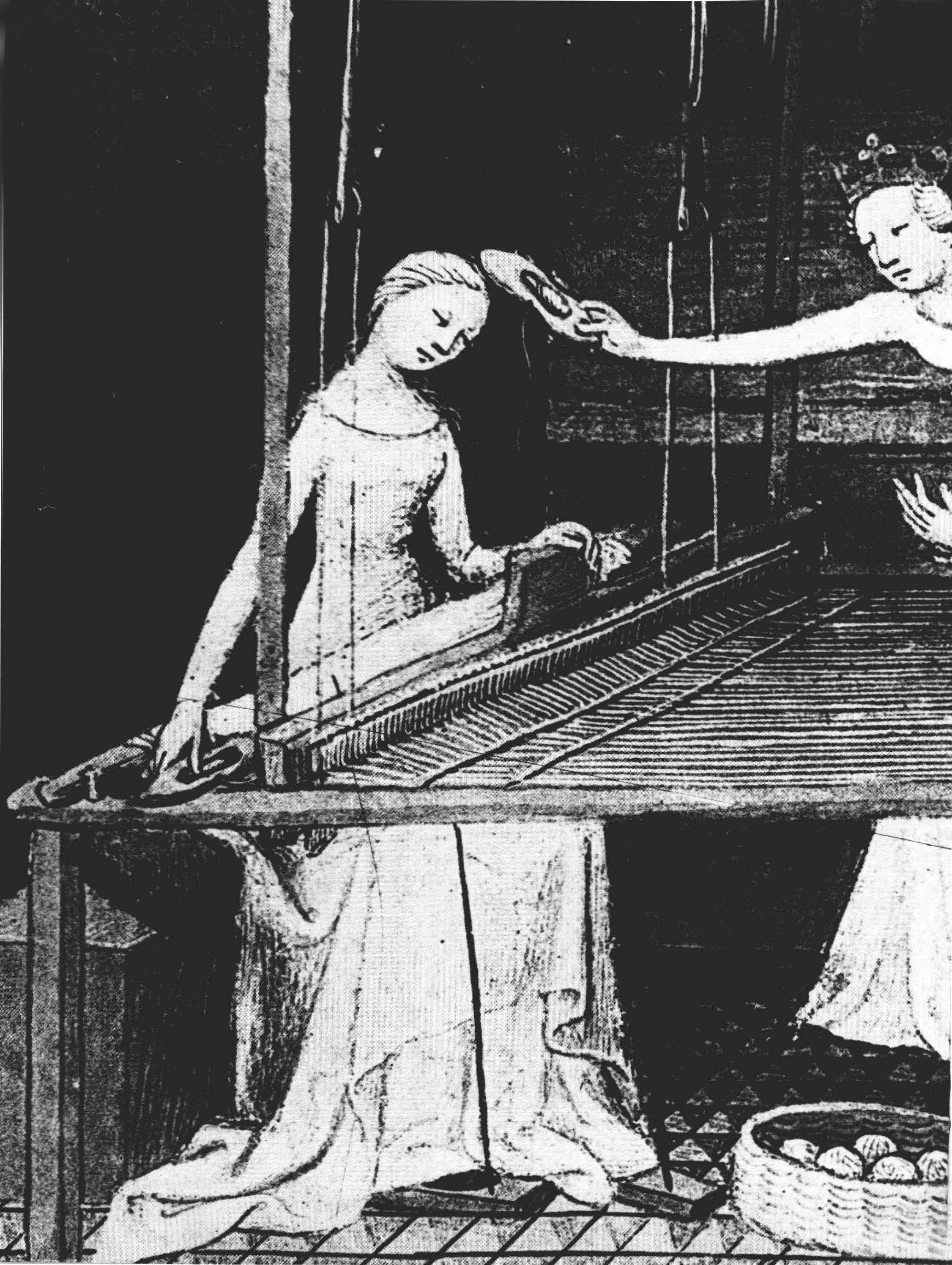
SCIENCE AND THE HOME

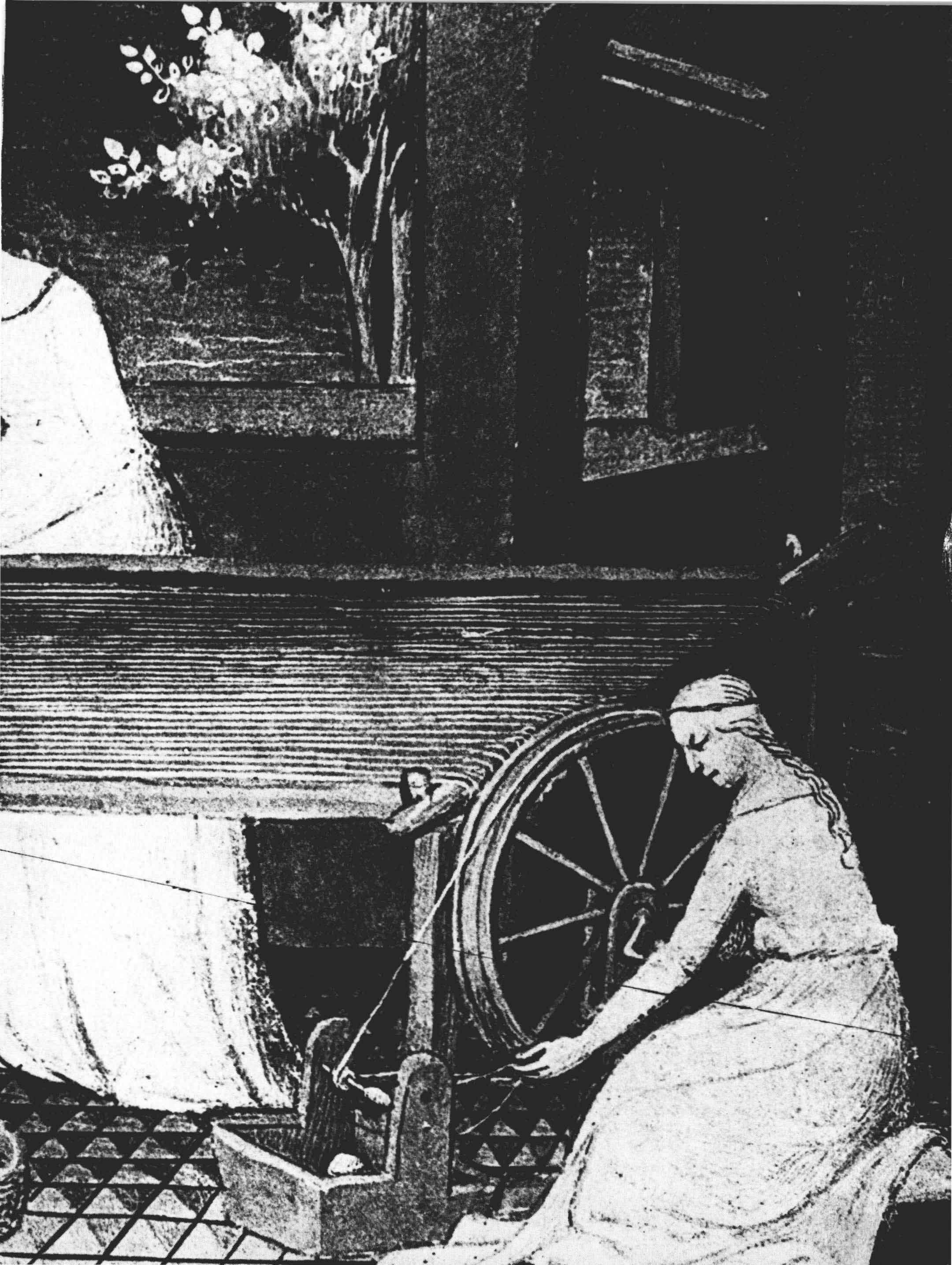
500 Years of technical advance

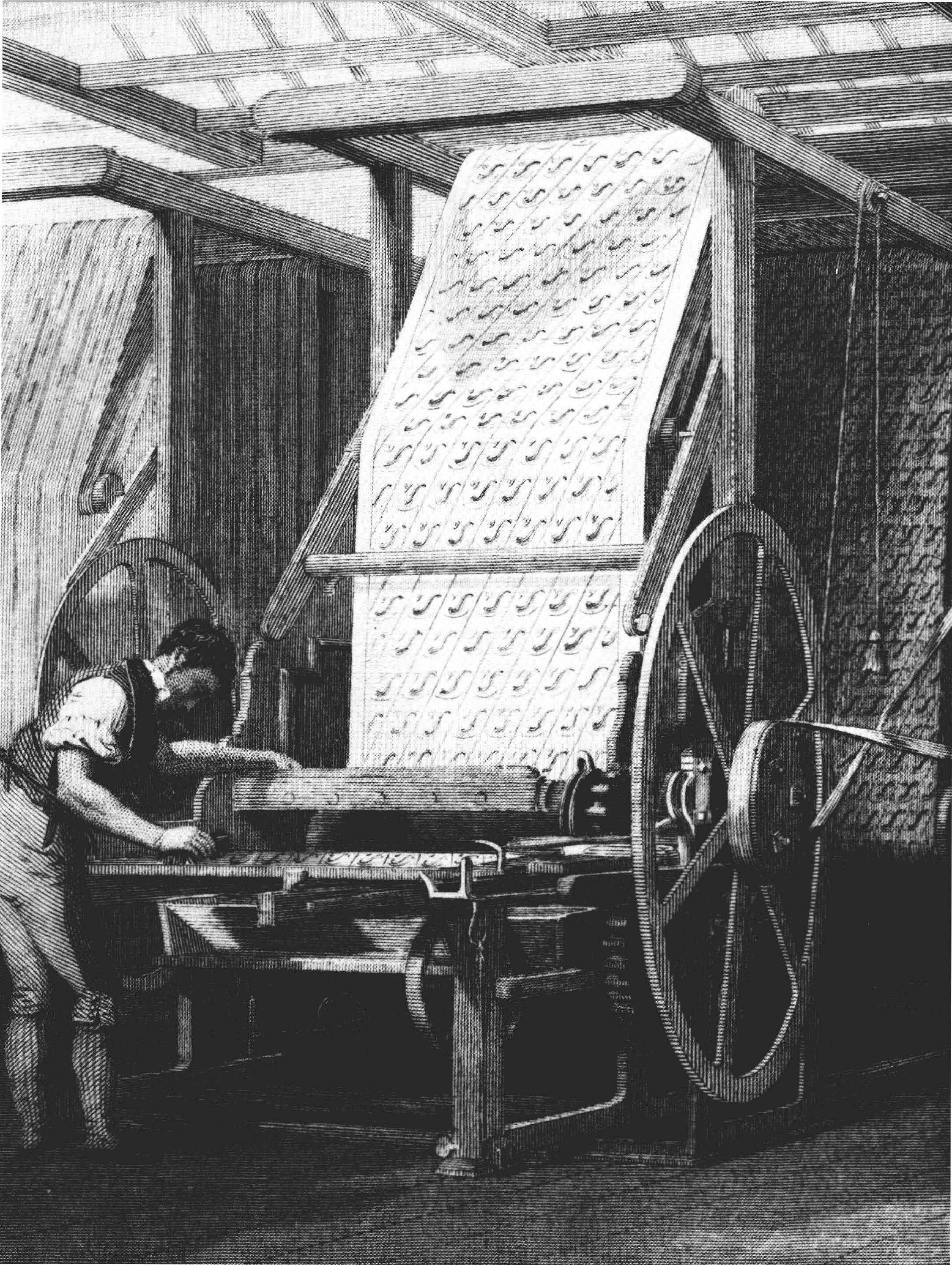


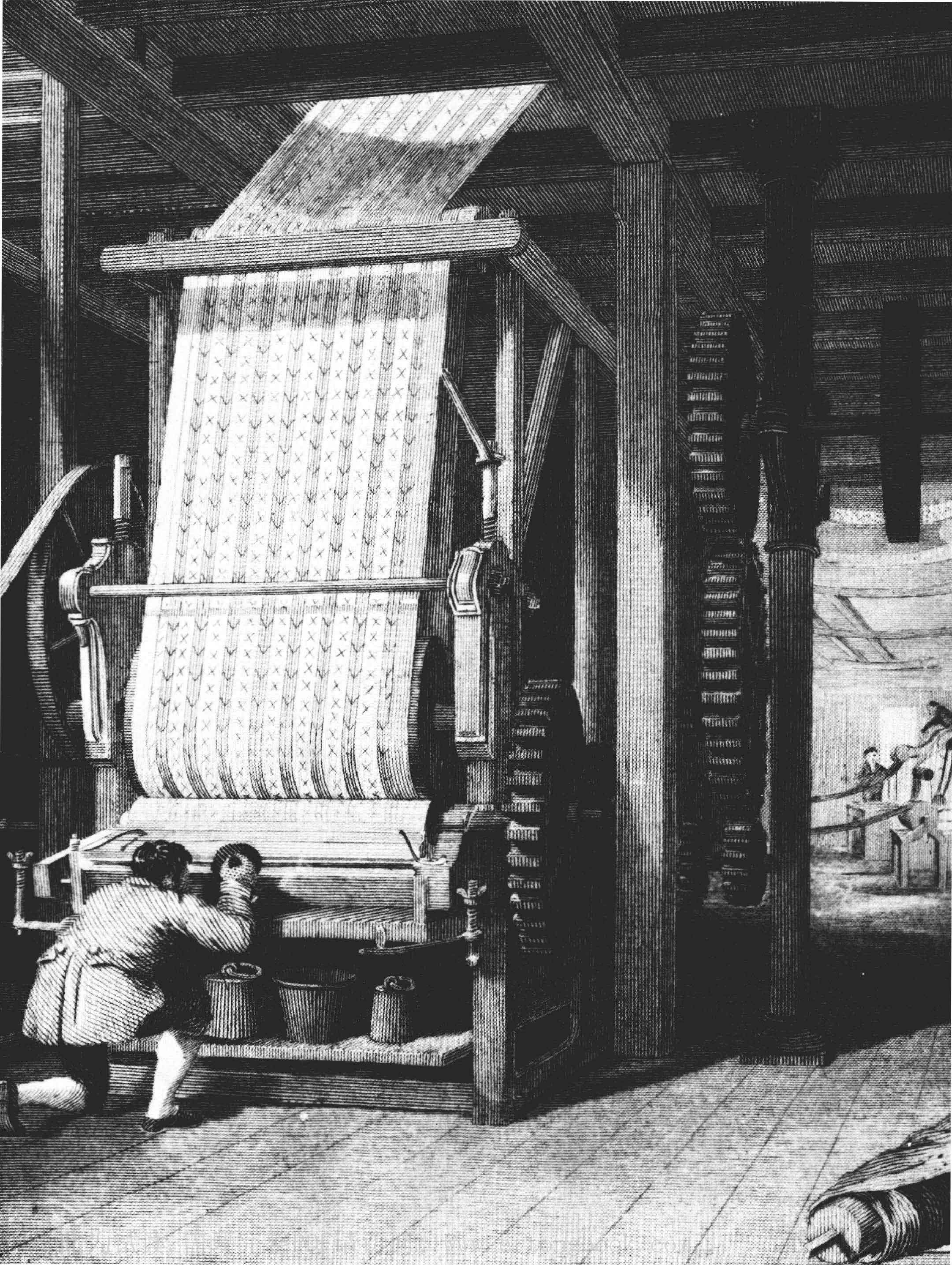


DOREEN YARWOOD









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DOREEN YARWOOD

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Preface

Since the Second World War it has been accepted in both school and college education that students studying science should also acquire a background knowledge of arts and language: such supplementary courses are generally described as 'liberal studies'. More recently the view has been put forward that students of history and allied subjects should be given some help in understanding the vital part which science and technology have played, and are increasingly playing, in determining the course of events which have shaped people's lives. This view is now expressed in the syllabuses for a number of the examinations set for the General Certificate of Education. Students taking subjects such as Social and Economic History and Home Economics are expected, for example, to study the effects of the Industrial Revolution and its modern technological counterpart, the development of new sources of power, the emergence of forms of transport and communication, of food science, synthetic materials, the rise of the chemical industry and mass entertainment by radio and television.

The idea of teaching an understanding of such subjects to students of history and domestic science is not new, but its implementation has been long delayed chiefly because it is not easy to explain much of the development of scientific and technological achievement to students who possess little if any scientific knowledge or mathematical ability. There are now available several popular books on science and television programmes for schools have pointed the way towards methods of explaining simply in words and pictures many of these concepts and happenings.

This book is an attempt to trace the way in which science and technology have changed domestic life since about AD 1500. It is written by an art historian for students studying Social and Economic History as well as Home Economics at 'O'-level standard. The close co-operation and generous assistance given to me by my husband John Yarwood have ensured its scientific accuracy. The introductory chapter discusses the outline effects of science and technology over these years and relates the contribution of each. The second chapter is also introductory; it deals chronologically with the emergence of sources of power (upon which all other technological development has depended) from slave labour to nuclear power stations. There are then five chapters on the basics of home life – food, shelter, clothes – three on the home itself, its structure, materials and interior, one on food and one on textiles. To these fundamentals I have added a chapter on home communication and entertainment. Finally there is a glance at the present microelectronics revolution and its possible meaning for the immediate domestic future. A selected bibliography is provided for students who wish to extend their studies beyond this brief introduction to the subject.

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Doreen Yarwood
East Grinstead 1982

CHAPTER ONE

Science and Society

Both science and technology have been vital factors in moulding human society. Until comparatively recent times they have performed different, separate functions, the progress of one, more often than not, unrelated to that of the other. The English word science derives from the Latin *scientia*, meaning knowledge. In its modern sense it may be more closely defined as knowledge gained by observation, tested by experimentation, of the workings of nature. This concept of science, both intellectual and practical in approach, stems, in Britain, from the ideas of a small group of men in the seventeenth century who attempted to investigate the natural laws which govern the behaviour of matter. They studied the natural sciences, that is, biology, chemistry, physics.

Whereas science is knowledge of how and of what the world, indeed the universe, is made and operates, technology is, or should be, a method adopted by mankind to make life in this world easier, more comfortable and more pleasant by improving the quality of satisfying basic material needs such as shelter, food and clothing. The term technology derives from the Greek word *tekhnologia*, its usual dictionary definition being 'science of the industrial arts'. The modern interpretation tends to be rather wider than this.

For much of man's history since prehistoric times the improvements in his way of life resulted from an empirical approach, that is, a process of trial and error, by which means simple ways were developed of lifting or moving things, harnessing natural forces to aid this and making equipment and tools to satisfy important needs. From such empirical methods technology has evolved. With each step forward further invention and mechanization has resulted.

The scientific revolution of the seventeenth century led, over 100 years later, to a technology which began to rely upon science. The growing wealth of scientific knowledge was not yet a replacement for the empirical system but it helped the technical innovator to see which path of experimentation might be more fruitful for his purpose. With the industrialization of the nineteenth century the bond between science and technology strengthened. In our own time the mutual reliance of one discipline upon the other has greatly increased. For example, technology is in debt to scientific research for knowledge of materials and energy resources, and also for the perception of new fields for study. Science appeals to technology to produce the instruments and equipment which it needs for research as well as for the handling and dissemination of data.

Yet, over the last 300 years technological innovation and scientific discovery have, most often, not marched in step. In some cases scientific research brought new knowledge but it was a long time, often more than a century, before it became possible to apply such knowledge technologically to produce something useful. For instance, Michael Faraday discovered electromagnetic induction in his laboratory experiments in 1831 but it was the 1880s before this understanding was translated into efficient electric generators and motors (page 39). An example for more recent times is the laser (where the delay between the scientific discovery and the techonological application is getting much shorter). Its action was first observed by Schawlow and Townes in 1958 but there was at that time no specific plan for its use; indeed, it was on occasion referred to as 'a solution looking for a problem'. Within a short while, however, its possibilities were perceived and utilized. It is now extensively employed in various fields, from opthalmic surgery to printing (page 173).

On the other hand innovatory ideas have been put forward and mechanisms manufactured to work perfectly well without the scientific principles behind such equipment being understood. This was particularly so prior to the seventeenth and eighteenth centuries (but to some extent is still true today) when men developed and designed artefacts on a trial and error basis. An example is the water-wheel, used as an instrument of power (page 24) in Britain from the early Middle Ages but not developed to its most efficient potential until John Smeaton carried out his scientific experiments in the eighteenth century to demonstrate the superior efficacy of the overshot design. Also, over the years, technological ideas have been advanced but, due to the inadequate state of current scientific knowledge, were stillborn. In some instances such ideas have been put into cold storage, then resuscitated at a later time when conditions were more favourable. A number of proposals were put forward early for uses to which semiconductors might be put. Also, the first radio receiver made use of a crystal (page 162). Yet it was not until the 1950s that chemical and metallurgical techniques, among others, had been developed to such a sophisticated level that the semiconductor diode and the transistor were commercially realized (pages 164, 169).

It is sometimes suggested that many scientific discoveries are accidental and that a number of the outstanding technological ideas were chanced upon. It is true that some innovations derived from lines of research which were not in the mainstream of the work upon which the scientist or inventor was currently engaged and that an element of chance or coincidence was present. A notable recent example is the discovery of penicillin by Alexander Fleming in 1928. But the majority of discoveries and vital developments were due to repeated study and trial and error and only a notable, analytical mind, ready to interpret and grasp each new factor, would be critically aware and so take advantage of such chance. Louis Pasteur's comment that 'Chance favours only the mind which is prepared' is apt.

In science, as in the arts, new discoveries and conclusions were, in many instances, reached almost simultaneously by people of different nationalities working independently and often unknown to one another. It seems as if knowledge in any particular sphere reaches a certain stage of gestation so that the time is ripe for the next venture to be made. Of the numerous instances of this may be mentioned the various contenders put forward for the invention in the fifteenth century of typographical printing: Gutenberg. Fust, Schoeffer, Laurens Coster (page 154), or the nineteenth-century development of the incandescent filament electric lamp by the American Thomas Edison and the Englishman Sir Joseph Swan (page 119).

Over the centuries scientific knowledge has played a comparatively small part in the development of some industries: steel, for example, and the early stages of photography. In others, particularly those of the nineteenth and twentieth centuries, its contribution has been vital and extensive as it was in the chemical and electrical industries. In our own century the time lag between scientific discovery and technical development has become steadily shorter and the dependence of one discipline upon the other greater. This is particularly so in communications (for instance, television) and electronics.

THE EARLY YEARS: EMPIRICISM

From the earliest times until the Renaissance all advances were made by empirical means, that is, by way of experimentation. The word empiric derives from the Greek *empeirikos*, meaning experience. Fundamental discoveries, such as that by primitive man of how to make fire were followed in the third millennium BC by the development of the wheel. After solving the means to cook food, the greatest problem in early centuries was the creation of power (Chapter Two) and the means of transportation.

The first stages in developing these functions was man's ability to domesticate cattle. It was soon appreciated that a castrated animal became biddable and the breeding of heavy draught animals was undertaken. Such animals were trained to pull heavy wooden carts with solid wheels. It was natural that this development should take place in areas where the land was flat, the earth firm yet where timber was readily available for construction purposes. Several parts of Europe and Asia were suitable and such wheeled transport appeared in Mesopotamia, southern Russia, Armenia, Georgia and along the Baltic coastal regions from Holland to Poland.

The classical world of Greece and Rome developed all kinds of tools and equipment as well as acquiring engineering and building skills. Slaves provided a basic source of power but the Christian populations of the Middle Ages had no such means available to them and much of their energies were devoted to developing ways of providing power for pumping, hauling and grinding. They harnessed water and air to turn water-wheels and windmills for their basic needs of food, shelter and clothes and dug shallowly in the earth to mine metals and chemicals.

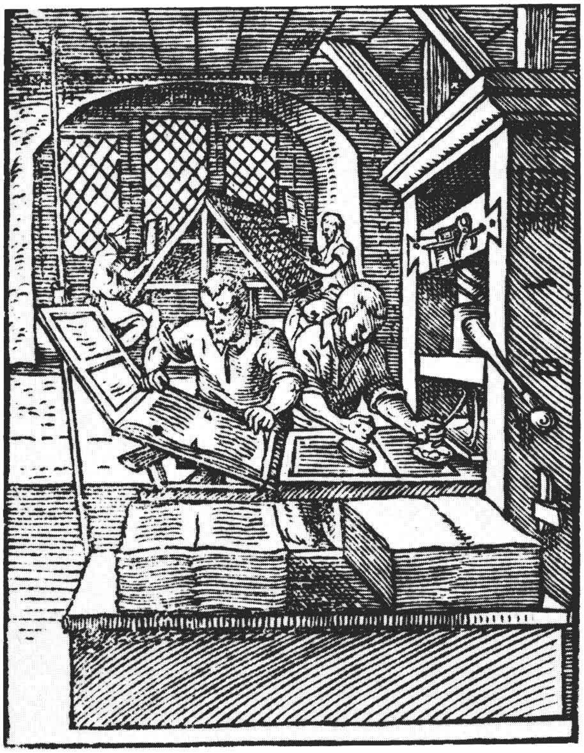
THE SCIENTIFIC REVOLUTION

In the two centuries between 1500 and 1700 the basis of life was irrevocably altered for everyone in Europe, though at first this was only perceived by the small educated minority who were able to read and understand the exciting new ideas about the known world which were being circulated. The Scientific Revolution, as it is now termed, was essentially related to and a part of the wider Renaissance movement which had begun in literary form in fourteenth-century Italy with the writings of Petrarch, Boccaccio and Dante, then gradually gaining momentum with its extension into the media of the visual arts and architecture. The concepts of the Renaissance spread westward and northward until, by the sixteenth century, they dominated the thinking of artists and writers in the whole of western Europe. It was then that the new methods of thinking, of approach, began to extend to science.

A number of different reasons have been put forward why the Scientific Revolution should have taken place in the sixteenth and seventeenth centuries in Europe. These include the extension of the world known to Europeans by means of geographical exploration, economic advances leading to greater wealth and higher standard of living, the advent of printing which enabled new knowledge to be disseminated and, not least, the existence, at that time, of a few men of outstanding genius living contemporaneously in several European countries. Certainly all these factors contributed to the establishment then of the new scientific thought but without the invention of typographical printing it would have been a markedly slower process (page 154).

In the Middle Ages knowledge was disseminated with difficulty by means of manuscript copies. By 1500 printing presses were available in nearly every European country, better papermaking methods were being experimented with and a flood of books and papers, scientific works among them, were published and read; the printing industry expanded rapidly during both sixteenth and seventeenth centuries (1). The revived interest in the ancient classical world applied to science as well as literature and architecture and the works and ideas of philosophers and scientists, for example, Aristotle and Archimedes, were studied by a wider public. At the same time the Greek theories were being challenged; Aristotle's concept of the universe and, in particular, his view of the laws of motion, were replaced as a result of the modern scientific method of observation and experimentation taken up by scientists such as Galileo and Newton.

The global exploration which had been widely undertaken in the fifteenth and sixteenth centuries had extended the scientific understanding of the world. It also demanded more advanced navigational techniques (e.g. the magnetic compass resulting from the pioneer work of the Elizabethan scientist, Gilbert) and improved maps and charts. Their exploration also brought wealth to the European countries of origin and



1 *Printing in 1574 (page 154)*

this, together with advances in agricultural methods, led to an improvement in economic standards.

All these factors – printing, exploration, improved economic levels – brought about a climate suitable for the creation of a new intellectual approach to science. It was the genius of the individual scientists who established a novel tradition and made the experiments and observations leading to the fundamental discoveries which laid the foundations of nineteenth- and twentieth-century science and technology. This was the work of such men as Galileo and Leonardo in Italy, Descartes in France, Copernicus in Poland, Tycho Brahe in Denmark, Kepler in Germany and Newton in England.

The scientific method of investigation developed in the seventeeth century was found to require a more reliable and sophisticated system of mathematics as well as a greater variety of instruments of improved accuracy. Impressive advances were made during the century in both these areas, by and large mainly by the scientists who themselves were engaged upon the important discoveries of the day in the fields of astronomy and mechanics. By the end of the century, for instance, the simple mathematical symbols for addition, subtraction, multiplication and division had come into general use and logarithms had been invented by the Scottish mathematician John Napier (1550–1617). This technique saved time and effort in calculation by reducing the need to multiply and divide to addition and subtraction. More important still was the invention of the calculus, one type by Isaac Newton (1642–1727) in England and another by Gottfried von Leibniz (1646–1716) in Germany, each working independently of the other. Of considerable usefulness as a calculating device was the introduction of the graduated rule (the sector); this was followed later in the century by the slide rule.

Demand for scientific instruments of quality and accuracy grew rapidly during the seventeenth century as the new knowledge was more widely disseminated. A number of scientists, chiefly astronomers such as Tycho Brahe (1546–1601) had designed and made the instruments which they needed. Craftsmen were then trained to copy and make numbers of such instruments. As the craft of instrument-making grew, the demand increased further with the printing of yet more books (page 154). Instruments included navigational aids such as the quadrant and magnetic compass, measuring devices such as the thermometer and barometer and optical instruments, for example, the telescope and microscope.

In 1500 engineering techniques were still entirely empirical, but during the sixteenth and seventeenth centuries a closer relationship developed between the scientific investigation of mechanics and dynamics and an engineering method more closely founded upon the results of such investigations. Precursor of this trend was that unique Renaissance genius Leonardo da Vinci (1452–1519), artist, philosopher, scientist and engineer, who filled so many notebooks with drawings which antedated a tremendous variety of concepts and mechanisms from spinning wheels and screw-cutting lathes to tanks and flying machines. A century before Francis Bacon