Chapter XX (amended 15.xi.99)

THE INDUSTRIAL REVOLUTION

What we know as the 'industrial revolution' (the name was first applied to it in France during the 1830's) is usually assigned to the end of the eighteenth and beginning of the nineteenth centuries. The 'scientific revolution', although it acquired the name more recently, belongs, we are taught, to the seventeenth century.

Neither 'revolution' has any precise date of birth. The scientific revolution was largely European: Poland, Germany, the Netherlands, France, England and other countries had some part in it. The industrial revolution was wholly British until well into the nineteenth century.

This confronts us with a double, perhaps triple, conundrum. The first concerns the singular role played by Britain in the industrial revolution. Its origins are easily traceable through the two or three previous generations, but the industrial revolution had certainly established itself there by the 1780's, and it seems to have taken France, Germany and the new United States at least one generation to 'catch on' to what was happening, and another to begin trying to catch up.

Yet the crafts which made the major contribution to the industrial revolution in Britain were common to most Western European countries; indeed, patent rights in new inventions were available in France well before England. Yet again, the natural sciences, now familiar as an intrinsic part of modern industry, and regarded as assuming their modern form during the seventeenth century, played virtually no part in the industrial revolution until the beginning of the nineteenth century. The industrial revolution seems to have come from quite different sources and developed according to a quite different pattern from what obtained in the case of the 'scientific revolution' or, for that matter, from the 'commercial revolution', the 'consumer revolution' and other near-contemporary movements. Yet it is impossible not to believe that all these developments were somehow connected with the growth of industry - which happened to occur first, and by a long way, in England. The question is, how?

Most of the craft skills which helped create the industrial revolution date back to prehistory. Even power-operated machinery has a much longer history than most people nowadays seem to think. Water-power for operating mills for grinding corn was certainly familiar to the Romans, and water mills harnessed to operate hammers and bellows were in use early in the Middle Ages. Shipbuilding developed from its prehistoric origins throughout the whole period. The windmill, compass and rudder, paper, silk, paper and
glazed pottery all came into use, knowledge having been imported from Arab or Byzantine sources; many of them originated in India and China. Printing certainly came from China, although the invention of the movable type essential for printing books occurred in fifteenth-century Germany.

Much the same perspective of antecedent history holds good for the scientific revolution as for the industrial. While the great names of the scientific revolution - Galileo, Kepler, Descartes, Newton - belong to the seventeenth century, Copernicus and Vesalius made their reputation in the previous century, and their reconstruction of the Aristotelian-Ptolemaic-Galenian universe had begun in medieval times. Scientific enquiry was initiated, so far as Europe is concerned, by the Greeks, but the Chinese and - possibly - the Indians preceded them by hundreds of years. The science and medicine known to the Greeks and Romans make their appearance during the Middle Ages partly through translation into Latin from Greek sources, but mostly from Arabic.

From the very beginning, any connection between the scientific enquiries pursued or industrial enterprises attempted, the kind of person making the attempt, the perception of relevance, and what kind of institutional support was available, were significantly different at different times - and almost negligible at all times. Skilled craftsmen were peripatetic in the Middle Ages, but rarely encountered by scholars and others interested in scientific enquiry.

The lack of connection between scientific study and the craftsmanship applied to innovation for practical purposes is probably responsible for the late start of the scientific and industrial revolutions - long after the Renaissance and Reformation and even the political upheavals which ended in the establishment of monarchist states in Europe. The only exception is the application of astronomical knowledge (or doctrine) to navigation late in the fifteenth century - and this came mostly from medieval Arab sources.

Even during the sixteenth, seventeenth and eighteenth centuries, there is a sense not so much of growing interconnection between science and technology as of each side blundering along its separate path and encountering the other by chance. In the sixteenth century, individual astronomers, mathematicians, and physicians tended to be themselves peripatetic, dependent on universities, especially those of Padua, Bologna and Naples, or on royal or noble patronage. Later on, leading natural philosophers formed groups in London, Paris, and other major centres, and corresponded actively with their fellows all over Europe. This is commonly taken to be the setting of the 'new philosophy' of Galileo and Kepler, Bacon and Descartes, which 'liberated the science of nature from old bonds, from the ontology of qualitatively irreducible Aristotelian "natures" and the perfection of circular motion, and brought about a submission to fact, however untidy, and eventually a greater scruple over actual, observational, as distinct from theoretical, accuracy. In consequence it brought about an increasing emphasis on precision in calculation, on closer observation and measurement, and especially, in the latter case, on augmenting the senses by "a supplying of their infirmities with Instruments, and, as it were, the adding of
artificial Organs to the natural."¹ To all appearances, scientific enquiry was being led by craftsmanship.

II

The interconnections are matters which have been energetically debated over the past few decades,² but for the most part the debate has to do with whether - or to what extent - 'science', 'technology', 'the economic factor', or the prevailing ethos or culture of society is to be credited with what was an unprecedented surge in the number and importance of inventions which were of direct application to industrial production.

There are several variations on each theme. According to one school of thought, it was science - or the scientific attitude - or scientific method - that invented the machines and engines which harnessed the forces of nature to the task of industrial production.³

For the title of what is the best book on the industrial revolution since Mantoux's, D.S.Landes used the image of Prometheus Unbound to represent the extraordinary outburst of inventions and innovations which made it possible.⁴ While the image is taken from Shelley, the idea of man's (western man's) release from bondage which it is meant to represent is distinctly Weberian. Modern science, like modern capitalism and modern industrialism, in Weber's view, originated in the release of the innate rationality of western man, hitherto pinned down and restricted by tradition and by the Church's teaching. For Weber, the Reformation acted as a 'releaser', not a generator: it was the counterpart, in terms of science, of Burckhardt's Renaissance, through which western man was culturally and intellectually re-born.

The scientific revolution of the seventeenth century fits the schema very aptly; there is even the confrontation between Galileo and the Church to epitomise the new Prometheus contending with the bonds of obscurantism and the forces of reaction. And, throughout the seventeenth century, men of science - to clinch the connection with the industrial revolution implied by Landes' title - urged repeatedly that science could and should be made use of as a resource, which would assuredly prove of immense value to society. There are repeated references, and not only in England, to Bacon's manifesto: "The true and lawful goal of the sciences is none other than this, that human life be endowed with new discoveries and powers."

Yet the scientific revolution began long after the final years of the Renaissance and the Reformation. And the very same cause had been urged as long ago as the thirteenth century - by Roger Bacon, among others. Roger Bacon's idea of how the 'true and lawful goal' was to be achieved was to pursue the quest for the philosopher's stone as persistently and diligently as he could.

'Knowledge is power' was the creed of Faustian as well as, perhaps even rather than, Promethean man. Up to the end of the sixteenth century, and even beyond, in so far as men cultivated science, it was in order to penetrate and dominate the mysterious forces of nature or to transcend the barriers of the visible world; the acknowledged scientific advances made by men like Copernicus (a Rosicrucian) and John Dee (a Ramist) were incidental to their main quest. And even in the next century, the two images, Promethean and Faustian, were confused with each other, rather than amalgamated: "The hope that there was some single omnipotent key to the treasury of nature, some primary methodological discovery or technique of thinking with whose aid patient industry alone would suffice to give complete knowledge of, and power over, the natural world was fondly cherished by many of the great scientific reformers, by Bacon and Descartes, perhaps even by Newton." Alchemy was the preferred path of most of them.

Despite all this, the inventions which led to the rapidly increasing flow of innovations during the eighteenth century were almost exclusively the work of craftsmen rather than scientists. So some put more weight on technology than science. As A.R.Hall puts it, "the history of the industrial revolution seems rather to reveal the frailty of science's claim to change the world, than its strength of which contemporaries boasted......The logic of science has no place for 'accidental', unpredictable discoveries (though these have often occurred in practice), yet the most 'scientific' inventions of the industrial revolution possessed this fortuitous character - they were made, but they could not be understood."

But to replace the word 'science' by the word 'technology' does not dispose of the problem of the origin of new ways of thinking about how to make the commonplace artefacts of everyday life, about how to expand or multiply human energies. Technology, a word which has entered popular usage in the last fifty years, has come to stand for the practical arts collectively, and nowadays suggests a unity of theory and method which is in some respects a counterpart to natural science. (It was first used to describe the study of the practical arts). Yet the omnibus label 'technology' covers several sets of ideas and practices which were, in the past, clearly separate from each other. Indeed, they still are; one set relates to engines and the controlled use of power to move quantities of water, earth, material goods, and people beyond the capacity of human or animal strength; a second to replicating operations, skilled or unskilled, ordinarily performed by a manual worker; a third to chemical and metallurgical reactions and processes; a fourth to structures and materials; a fifth to agriculture; and there are more.

The point is that the interaction between the two sets of knowledge, theoretical and empirical, which we take for granted as all-important, is not all that demonstrably the

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case for the seventeenth and eighteenth centuries. Why, then, should there have been advances more or less concurrently in all these different fields - some, like chemical processes, with a sizeable direct contribution from scientists, others, like the earliest textile machines, owing practically nothing to science, or to scientists?

What both science (or the natural sciences) and technology (or the various branches of technology) now share is a certain attitude to problems and a certain methodical procedure in going about solving them, an attitude and a method now labelled 'scientific'. The attitude consists in a combination of scepticism about received wisdom (from whatever source) and curiosity, along with a procedure involving controlled experiment, careful observation, accurate measurement and mathematical calculation.

But, to begin with, the procedure in many respects was on the lines of 'best practice' - what Michael Polanyi called 'personal knowledge' - acquired by craftsmen, who included the kind of people who produced the gold and silver ware, the miniatures, jewellery, instruments and clocks now housed in museums. Seventeenth-century scientists themselves seemed to acknowledge that, as things stood, the traditional 'know-how' and practical experience of the ordinary craftsman gave him a closer acquaintance with the physical world and a clearer understanding of how things worked than did their own scientific learning.

"The engineer and the metal-worker were daily proving the value of techniques which the philosopher could not explain, encountering new phenomena of which he had remained ignorant, and making useful innovations to which he had contributed nothing. As Galileo put it, speaking of the skilled workmen in the arsenal at Venice, 'Conference with them has often helped me in the investigation of certain effects including not only those which are striking but also others which are recondite and almost incredible.'" 

Yet even if scientists, from Tycho Brahe and Kepler on, became experimental, their best endeavours were still directed to the solution of problems very far removed from the world of common human needs and entrepreneurial ambitions. On the other hand, craftsmen still went on refining and adapting machines and instruments, making them stronger or more powerful, and even inventing new ones. And there were plenty of machines, engines, instruments and chemical processes in existence for them to work on.

As time went on, the scientific attitude and the scientific method claimed more and more people for their own. But what this often amounted to in reality was that the scientist learned - or learned about, or used by proxy - the craftsman's manual skills, the dexterity and empirical knowledge ('know-how') and systematised them. 'Capitalised on them' would perhaps put it better, since what the craftsman had learned by instruction by a master, imitation, years of practice, and put to everyday use, was accumulated and ordered into a stock of knowledge. Even beyond this, the new science could in many respects be regarded as a consequence of improvements in craftsmanship; many of the discoveries of the natural philosophers of the seventeenth century were made possible

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only by the vastly improved optical apparatus at their disposal. At the same time, more and more craftsmen became acquainted with the new scientific attitude of curiosity and experiment, and the new scientific methods of observation, meticulous measurement and recording.

The lead in industrial innovation was taken by craftsmen who had acquired something of the new 'scientific attitude'. For the stock of scientific knowledge in the possession of scientists was not, it seems, of much direct practical use or application. Wren, a competent mathematician and Fellow of the Royal Society, did not use any structural engineering principles in his architectural designs which were unknown to the cathedral builders of the Middle Ages; Newcomen was a blacksmith, innocent of any scientific knowledge - at least, until after he designed his engine. Three score years later, Watt built his condenser, in all probability, without reference to the principle of latent heat which Black had worked out at Glasgow University while Watt was employed as a laboratory technician there. Still less was he indebted to any stock, or even item, of scientific knowledge about cybernetics for his invention of the governor - which was almost certainly suggested to him by its use in windmills: and Watt is the classic example of the linkage of science and industrial innovation during the industrial revolution. Pragmatic craftsmanship, again, has been shown to have been the principal resource of the men who revolutionised the textile industry: Kay, Paul, Wyatt, Hargreaves, Crompton and Cartwright.

Yet these can hardly be ranked with the anonymous artisans of earlier centuries, and the science-or-technology question is merely shifted to one concerning the new-found creativity and inventiveness of seventeenth and eighteenth century craftsmen.

The third viewpoint is one which is fairly neutral in respect of the claims made for science or for technology, since it holds that whether science or technology is the mother of invention, finance is the father. More generally, the critical factors in industrial innovation are said to be economic, and this applies as much to the eighteenth century as to the twentieth; after all, economics was born along with the industrial revolution itself. There are several variants on the theme: at one extreme, it is suggested (rather than argued) that the rather mysterious primal force or combination of forces working through 'the economy' which manifests itself statistically in Kondratieff cycles (or waves), and generates, at certain points in any cycle, pressures which result in economic depression, followed by a surge of innovations.

At the other extreme, there is the more substantive and specific Marxist argument. The greatly increased demand for consumer goods promoted by rising European prosperity, it is argued, was channelled into demand for manufactured articles of the kind being made on a rapidly increasing scale in Britain. This was supplemented by an equally accelerating demand for commodities of the kind most easily obtainable through Britain. A number of successful ventures in imperialism, both military and economic, turned the country, already a major exporter of coal and iron to Europe and a leader in the slave trade to North and South America, into a vast staple for textiles, tobacco, tea and other products.
Britain's aggressive imperialism was evidenced by the expansion, by conquest and 'alliance', on the model of ancient Rome, of the East India Company in India, in the ousting of Dutch and French colonial settlements along the Atlantic seaboard of North America and the aggressive westward movement of English settlers there, and in the acquisition, by one peace treaty after another, of islands and trading posts and settlements in Africa, Asia and most lucrative of all, to begin with - the West Indies. Economic imperialism followed the mercantilist principles shared by most European countries at the time, but even so was prosecuted more strenuously, more persistently (and more successfully) than by other countries through the Navigation Acts and the supplementary embargoes on manufacturing in dependencies, especially Ireland and India.

One can go outside all these explanatory theses and invoke the extraordinary, and almost inexplicable, change in the fortunes of western man which began towards the end of the seventeenth century. Famine and plague still killed off large fractions of the population of whole countries (more than a quarter of the population of Finland was wiped out by famine in 1696-7, and plague is said to have halved the population of Marseilles in 1720), but the tide had already turned in England; dearth was still frequent, people still starved to death and died by the thousand in epidemics, but after the 'little ice-age' of the seventeenth century, conditions did improve. England, together with Holland, was the first to benefit from the 'vital revolution', which seemingly involved major structural changes in living conditions rather more fundamental, and also more indefinable, than the improvements in farming methods of the 'agricultural revolution'.

The principal indicator of the 'vital revolution' is in fact its principal consequence: the startling, and unprecedented, acceleration in population growth which took place in the eighteenth century, an acceleration which was especially well-marked in England but was in fact world-wide.

Lastly, there is the explanation still offered by many economic historians of how and why the Industrial Revolution started in Britain long before it affected other countries. It lies in what has been called the comparative 'openness' of English and Scottish society at the time. Yet, while the openness applied not only to the way in which the upper tiers of society were permeable by new political, economic, moral and scientific ideas, for this applied equally - perhaps even more strongly - to French society, it also applied, and with special pertinence, to the facility with which the English formed associations and partnerships in religious, political and commercial undertakings outside the safe confines of the family network, the Court, and the neighbourhood.

Even more pertinently, the notion applies to the freedom with which men could dispose of themselves as resources of information, skill and labour. The buying and selling of labour as a commodity, an absolute prerequisite for modern industrialism, was already fully institutionalised in England, where by 1700 more than half the occupied adults were wage-earners. In continental Europe, it was well over a hundred years before the satisfaction and even the possibility of controlling one's own labour and the rewards of producing independently were sufficiently reduced to render wage labour preferable.
Ease of travel was just as important. There was, to begin with, the simple geographical fact of Britain's being an island, which simplified and cheapened the transport of heavy goods, especially coal: almost every coastal county had a reasonably sizeable port. Distances between major areas of economic activity were relatively short, and roads were somewhat better than they were on the continent. But even more important was the absence of internal customs barriers to the movement of goods - a fact which distinguished Britain from all continental countries.

The same freedom from institutional and physical constraint is reflected in the comparative freedom with which many Englishmen could dispose of themselves as resources of skill and labour. (The Scots were not so well off - hence Dr.Johnson's barbed remark about the high road to England being 'the noblest prospect a Scotchman ever sees.') According to Hobsbawm, it was the prevalence of both the assumption and the experience of labour mobility in this sense which distinguishes the historical experience of early industrialisation in England from contemporary developments in France and Germany.\(^8\)

In the next century, during the reigns of the first two Georges, the Court became, relatively speaking, socially rather isolated and insignificant. Politically, the Court was still supreme, since it was still for the King to appoint or dismiss ministers, and they were still, in theory and to some extent in practice, his advisers only. In all other respects - economic, social, cultural, intellectual - it was London which was the centre, and political action was dominated by Parliament in a Westminster which, by 1700, had been engulfed by London, now, with a population of 600,000, by far the largest city in Europe.

What this adds up to is that the societal core (or apex, or epicentre) of social action shifted critically from the Court, in which aspiration, rivalry, ambition, self-interest was locked on to the kind of achievement likely to gain recognition - ultimately - by the king, to much more diffuse and varied sources of fame and fortune, one which was dominated by wealthy merchants and financiers, by territorial magnates and by leading politicians, themselves dominated by the ruling passion of the eighteenth century: making money.

It is this dislocation of Society (the capital 'S' now becomes significant) from its traditional dependency on the royal court which combined with its comparative 'openness' to distinguish the social order prevailing in England and Scotland from what obtained elsewhere. It is not so much social mobility, even though it was a more prominent feature of English society than elsewhere, or any greater readiness of the rich and powerful to make money in trade. The significance in Britain of the attribute of 'openness' was felt in different ways from what was manifest in Europe. Voltaire, who spent three years of exile in England, was especially struck by the contrast - and said as much in his Letters on the English, which he published on his return to France.

Of course, the permeability of the aristocracy and bourgeoisie to the new was as true of France and much of the rest of western Europe as it was to England and Scotland. The difference was that there, in Europe, where the court was the centre of political gravity and the destiny of absolutism the central political issue, the central concerns were political and cultural. Scientific, legal, even religious discussion and controversy were either secondary or tributary to debate about the nature of political power, the way in which it was exercised, about the true nature of society, and about the possibility and the desirability of change. Hence the prominence later writers have given to the political consequences of the 'Enlightenment' and the role of Offentlichkeit in causal explanations of the French Revolution.

In the main, English 'Society' regarded such political issues as having been settled quite satisfactorily in 1688; they were now things of the past, or of academic interest, or the concerns of foreigners in which their own interest was mainly that of the spectator. (Boswell was not alone in sympathising - at a distance, of course - with the Corsican revolt, but Shelburne was, in his attempt - which was futile, of course - to get Britain to intervene.) What they did find of absorbing interest was money, and ways of getting it.

There were too, of course, other factors, like the growth of 'consumerism', the increase in wealth, the growth in overseas trade which was fed by the territorial acquisitions which came from successful participation in war, but some of these were matched in other countries. What counted most, though, was the characteristic openness of British social life and institutions. There is a similarity running through British institutional forms in the eighteenth century which exhibits a common outlook ('circumstantial postulate'), along with a tendency for social organisation to adapt to new kinds of alliance and to desert older ones. And this is something one cannot leave with phrases such as the prevailing temper of British social institutions. Both circumstantial postulate and the new directions of movement taken by social organisation may be seen as exhibiting the increasingly wide acceptance of a general theory of society formulated (in a specifically political guise) in the seventeenth century. This general theory, to which C.B. Macpherson gave the label "possessive individualism", is not attributable to any one person, although Macpherson claims that its outlines are clearest in Hobbes. It developed by approximation to what, at the hands of Locke, could serve as a compendium from which could be drawn any manifesto designed to substantiate the claims of men of property to political power.

There is no point in discussing here how much of Locke's liberal democracy is a gloss put by later theorists and polemicists on his work. What is important is the well of concepts and axioms from which literate Englishmen of the eighteenth century drew their versions of individual rights and of sovereignty. These axioms and concepts became sufficiently articulated to amount to a model of 'possessive market society':

'By possessive market society I mean one which, in contrast to a society based on custom and status, there is no authoritative allocation of work and rewards, and in which, in

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contrast to a society of independent producers who exchange only their products in the market, there is a market in labour as well as in products. If a single criterion of the possessive market society is wanted it is that a man's labour is a commodity, i.e., that a man's energy and skill are his own, yet are regarded not as integral parts of his personality, but as possessions, and the use and disposal of which he is free to hand over to others for a price. It is to emphasise this characteristic of the fully market society that I have called it the possessive market society.\footnote{C.B.Macpherson, The Theory of Possessive Individualism, p.48.}

The claim is that it was because of the prevalence of this kind of thinking about the situation of the individual in society and the distinctive character of social institutions relating to economic life in England that the scientific revolution and the craft revolution gave birth to the Industrial Revolution. If one substitutes for Hobbes' sardonic rendering of man as driven by rivalry for power, by fear, and the desire to be conspicuous, Locke's 'uneasiness' or 'desire for some absent good', the transition to a morally sanctioned market society is almost complete. The buying and selling of labour as a commodity, an absolute prerequisite for capitalist industry, was fully institutionalised in early eighteenth-century England. In the latter half of the eighteenth century, the supply of labour was expanded not only by a population increase a good deal beyond that of any other European country but by the enclosure of common land which deprived thousands of poorer independent farmers of grazing for what cattle they kept, and drove them off the land altogether. The effect was enlarged by the withdrawal by the state of any legal protection for combinations of workers, and eventually, by the end of the eighteenth century, the prohibition of all such combinations; as Mathias remarked (see above) markets have to be established by law, which means that they are essentially political creations.

Within the confines of these new conditions and the newly institutionalised forms of economic activity, the life of the country became permeated with the value system and the characteristic patterns of action of a market society.

The development of the spinning machine illustrates the extent to which inventions and technical ideas were themselves alienable and marketable commodities. John Wyatt is probably the inventor of the first patented device, even though his name is not mentioned in the patent which Lewis Paul took out for it in 1738. Again, Wyatt's 'first invention seems to have been a machine for turning and boring metals, which was purchased by a Birmingham armourer called Richard Heeley. This man got into difficulties, and finding himself, apparently, unable to fulfil his engagements he finally made over his rights to a third party.\footnote{P.Mantoux, The Industrial Revolution in the Eighteenth Century, 13th. edn., Methuen, 1961, p. 210.}

Arkwright's whole life is testimony to the freedom with which inventions and improvements could be bartered and become the subject of contracts - and to the success of one who, like Arkwright, 'was anxious to better himself,' who 'had fertile brains for devising means of rising in the world, and ... knew how to drive a good bargain, the sort
of diplomacy in which he had been trained being akin to that of the pedlar or horse-dealer.  

It is the same world, in short, which accepted the traffic in electoral votes and Parliamentary seats as part of the machinery of politics; politicians might be condemned as venal, but the system of purchase was as defensible in that respect as any other. Votes, inventive ideas, a capacity for business enterprise, were saleable resources, as were literary and artistic effort. The system of patronage which supported the writer, the painter, and the musician was succeeded by commercial publishing, the Academy market, and the subscription concert. The change was due much more to the pervasiveness and increasing familiarity of the market society model than to the spirit of individual independence which was its ideological counterpart. Perhaps the most telling example of the extent to which paradigm of the market society took hold lies in the commercial exploitation of aesthetic design - traditionally the product of an act of creation uniquely personal and inalienable: 'The great names of Chippendale, Hepplewhite and Sheraton are known to everyone not for what they made but for the books of design and styles which they published, and which in time affected the work of the humblest market-town furniture carver.'

There are difficulties about this, and some historians have looked elsewhere. J.H. Plumb, for example, does so by picking his way through horse-breeding and plant-breeding, the craze for 'improvement', new 'scientific' toys for children, and the like: "During the eighteenth century extraordinary economic and social changes swept through Britain and brought into being the first society dedicated to ever-increasing consumption based on industrial production. For this to happen required men and women to believe in growth, in change, in modernity; to believe that the future was bright, far brighter than the past.....

"This change cannot be explained by the scientific revolution of the seventeenth century or the discovery, before that, of the new world of flora and fauna in America which so stimulated Europe's imagination, although they were strong contributory streams.... It is my belief that quite humble activities played their part in the acceptance of modernity and of science: growing auriculas or cucumbers, crossing greyhounds with bulldogs, giving a child a microscope or a pack of geographical playing cards, taking it to look at the first kangaroo seen in England or to watch a balloon rise in the skies did much to create one of the greatest revolutions in human life. They were the tiny channels by which the main stream of elitist thought reached the mass of the people."  

Naturally, the 'scientific revolution' of the seventeenth century exerted its influence on the readiness of people - and not merely those who professed an interest in 'natural philosophy' - to adopt new methods and to experiment themselves. Naturally, too, the conjunction between trade and industry furthered, as well as being furthered by, new

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mechanical inventions. It is, however, possible to make a start at a less peripheral point than Professor Plumb has chosen.

III

So one returns, not much the wiser, to the starting point: why Britain? Why did the industrial revolution not only begin in England but establish a lead of at least two generations before other countries followed suit? Even if we discount the twenty-odd years of the Revolutionary and Napoleonic wars which engaged the attention of almost every country in Europe, the time-gap between is enormous.

What is almost always left out of account, and is special to England, is the English Revolution - the one major difference between the structure of society in seventeenth and eighteenth century England and that of every other European country. The reign of the first two Stuart kings broke the Protestant-patriotic unity established during Elizabeth's reign; the 'political nation' that emerged during the 1620's produced a House of Commons in 1629 that showed itself as so clearly opposed to the monarch and the Court as well as to the new church establishment created by Laud that Charles I dissolved Parliament and held off calling for elections for a new one for ten years. During the twenty years of civil war and Protectorate that followed, the world was indeed 'turned upside down' in many ways.

The English Revolution lasted from 1639 to 1660, twenty-one years of critical importance for the development of that 'attitude to problems and methodical procedure in going about solving them, an attitude and a method now labelled "scientific"' (see above). For most historians, however, the 'English Revolution' is a period of political history which begins with the civil war fought between the armed forces recruited by the King, on one side, and by Parliament on the other and ends with the recall of the king's son and his restoration to the throne by Parliament.

This is something of an oddity, even if the explanation lies mostly in the even odder separation between 'political history' and 'economic history'. Part of the trouble seems to lie in the fact that, as Christopher Hill points out, there were in fact "two revolutions in mid-seventeenth-century England. The one which succeeded established the sacred rights of property (abolition of feudal tenures, no arbitrary taxation), gave political power to the propertied (sovereignty of Parliament and common law, abolition of prerogative courts), and removed all impediments to the triumph of the ideology of men of property - the protestant ethic." The second is the one missing from the list of revolutions - scientific, commercial, financial, consumer - accumulated by economic historians as contributory to the Industrial Revolution itself. It has to do with the confused flood of radical ideas thrown up by what has, until the last fifty years or so, been "arrogantly and snobbishly dismissed as 'the lunatic fringe'"15

The 'lunatic fringe' seems to have comprised rather more than half the population of England. They included tenants evicted or bought out from their holdings by landlords expanding their estates by clearing woodland, draining marshes, or enclosing common land over the previous hundred years. Most of them were forced to join the lowest order of 'masterless men': rogues, vagabonds and beggars, who roamed the countryside or sought anonymous refuge in London, whose population in 1650 was probably eight times what it had been in 1500.

The years from 1620 to 1650 have been described as economically the most terrible in English history. Enclosures were part of it, but the government was responsible for serious economic mismanagement (sale of monopolies was only one of a series of mistimed or simply misconceived fiscal devices). And all this happened during the 'little ice age' of the first half of the seventeenth century.

The level of physical disorder dropped when the New Model Army was mobilised, but intellectual turbulence remained, and this was by no means confined to the dispossessed and poor. Radical army chaplains, joined by an increasing number of common soldiers, preached to civilian congregations in order to teach the poor to 'understand liberty', and 'thanks to freedom of organization and discussion, the Army became a hothouse of political ideas.'

It did not stop there. Men with radical ideas found support in the new mechanical philosophy. 'Human curiosity', it was said, now 'played freely upon the works of creation'. The affinity may strike us nowadays as something of a oddity, but it was real enough at the time. 'Bacon's influence was spread wide in England after 1640, thanks especially to the exertions of Samuel Hartlib, and to the invitation to Comenius' (a disciple of Bacon) 'to come to England.... The Comenians appealed especially to craftsmen, who formed the bulk of the religious sects, by their call for a wide extension of educational opportunity, for new teaching methods (using the vernacular, not Latin; emphasizing things, not words; experience, not books.\(^\text{16}\) More to the point, they were fired by the new 'antinomian' ethos which, outside religious sectarians, encouraged self-improvement and enterprise. Antinomian ideas in general - religious, philosophical, social, political - permeated the 'mechanical classes' in England during the revolutionary years. These ideas may have been religious in origin (the multiplicity of sects and the hostility to the established church is proof enough), but clearly infected political and social attitudes and challenged belief in systems of ideas whose authority derived from tradition, the teaching of established churches (Catholic or Protestant), or classical writings. Interestingly, antinomian ideas (which went along with anti-hegemony, although stopping short of the kind of democratic ideology credited to the Levellers) were held by a number of sects and by individuals, especially in the Parliamentary armed forces during the civil wars and among the growing number of itinerant craftsmen, traders and literate 'masterless men'.

There is no suggestion that any of them made any contribution to the 'scientific revolution', but the intellectual radicalism which prevailed among English craftsmen in

\(^{16}\) Christopher Hill, The World Turned Upside Down, p.288.
the middle of the seventeenth century seems to have survived in some strength and to have persisted throughout the eighteenth century.17

Intellectual radicalism made its own contribution to the currency of scientific, technical and innovative attitudes and ideas and quickened the speed with which they circulated. Yet again, it has to be remembered that neither scientific knowledge nor the scientific attitude or method was the stock-in-trade of teachers of scientific subjects in schools and universities, as it is now. "The disposition of modern writers to regard nineteenth [and eighteenth] century inventors as uneducated and empirical in their methods is a direct outcome of the difficulty which academically educated people often have in understanding the possibilities of self-education."18

Schooling may still have been the prerogative of the comparatively well-to-do (although the numbers of schools increased vastly during the century) but most men above the level of the labouring classes, and a sizeable proportion of women, were literate; and attendance at a school was by no means the only avenue to literacy. "Most eighteenth-century learning went on outside officially designated systems of instruction," Roy Porter remarks19: "The broad basis of literacy and learning came not from school but from self-help, the family, or the community."20 This applied not merely to acquiring the ability to read and write but to ideas, natural curiosities, speculation - and 'natural philosophy'.

IV

After the twenty years when English society was permeated with antinomian ideas which challenged traditional authority and traditional ideas, it is difficult to take the foundation of the Royal Society in 1662 as an accident of history. For England, it counts as the 'Year 1789' of the scientific revolution. It was inaugurated at the instigation of a group of intellectuals meeting at Oxford throughout the Interregnum and of the earlier Gresham Club in London Its royal charter signalled public support by the state for scientific enterprise. France's Academie des Sciences, interestingly, followed a few years later.

The foundation of the Royal Society marked the formulation of the code of practice which professional scientists came to adopt - a code which clearly resembles that which prevailed among master craftsmen. The account of the Royal Society's early years compiled by Thomas Sprat contains a sharp and informed appreciation of the kind of qualities needed if scientific enterprise was to be turned to practical use. He criticises previous (and contemporary) 'natural philosophers' for either looking for quick profits, or in 'rendering causes barren', in that 'when they have been found out, they have been suffered to lie idle; and have been only used, to increase thoughts, and not words', and

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attacks the tradition by which 'Masters' were too domineering over their 'Scholars' - 'some imposing and all others submitting; and not as equal observers without dependence.'

The Royal Society's interest - and initiative - in science and manufacturing technology tended to lapse early in the eighteenth century, when more of its members tended to be wealthy landowners rather than professional men like Wren and Newton. Nevertheless, the impulse given by the founding members carried far enough to provide backing for the first manifestation of the 'new technology': the steam engine.

Water-flooding had become a major problem in mining, and although methods of raising water by watermill and windmill had been used for centuries, (apart from manpower and horse - or donkey - power) neither could cope with underground water; and mines were getting deeper. Throughout the seventeenth century there were attempts in France and England to design an 'atmospheric' steam engine efficient enough to drive a pump. 'Wind was cheap but unreliable; water was limited by local conditions, but steam suffers neither disadvantage. The invention of the steam-engine is the central fact in the industrial revolution.' In 1698, Thomas Savery, a military engineer, demonstrated a water pump driven by steam power first to William III and, the next year, to the Royal Society. The patent he was awarded was so phrased that Thomas Newcomen, who produced a much better steam-powered pump some years later, was able to profit by it only by associating with Savery. The first Savery-Newcomen steam engine was demonstrated in 1712. It soon proved indispensable, when harnessed to a water-pump, for feeding canal reservoirs and for town water supplies as well as for mining.

Not all the credit for this major step forward should attach to Savery or Newcomen. Both depended very much on the increased knowledge and skill of ordinary artificers and instrument makers. Crude and unreliable as they were, by today's standards, with breakdowns all too frequent because of unsound joints and ill-fitting moving parts, the skills which went into the making of the first steam engines were far in advance of what they had been in previous centuries. The industrial revolution in fact owed just as much to what could well be entitled a 'craft revolution' as to the scientific revolution.

The revolutionary improvement in craft skills is reckoned to have started up just before the seventeenth century, originating in the rapidly-growing demand for clocks and for optical and navigational instruments. Neither the demand nor the craft revolution itself was confined to Britain. The demand for clocks, gauges, spectacles, magnifying glasses, fine cutting-tools and scientific instruments was growing almost as fast in Holland and France. But the importance of the craft revolution for economic historians lies, after Newcomen, in the central position it occupies in the Industrial Revolution proper. The growth in Britain of a large and very profitable market for instrument-making throughout the following century included the development of machine-tools like screw-cutting lathes and, by the end of the eighteenth century, Maudsley's mass-production of blocks for naval vessels. Nor was its relevance exclusive to scientific enquiry and manufacturing.

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industry; improvements in agricultural tools and implements were made throughout the eighteenth century, from the earliest experiments with seed-drills at the very beginning to Ransome's new ploughs at the end.

V

There is about eighteenth century Britain the impression of wholesale changes in agriculture, commerce and industry and a growing prosperity, based on a new-found political stability after the settlement of 1689, on greatly increased world trade and, with the rapid growth of its maritime power, a growing share of it - at the expense of the Dutch, the French and the Spanish, who were embroiled in one war after another, wars which brought the English more profit in trade and new possessions than they cost in taxes. Even the American War of Independence, in which they were on the winning side, worked out more costly for the French than it did for the British.

There is one distinction that can be made when it comes to disentangling the different strands which went into the transformation. By and large, many of the changes in the social and economic scenery brought with them, or were, their own instruments of change. Changes of this kind introduced or demanded kinds of commodities, activities and transactions which were new in themselves, and opened up new fields of enterprise. They presented new problems for solution, too, but in an important sense the strategies of change were often patently obvious in the demand itself, as in the case of the new 'consumerism'. Any problems that arose were incidental, matters of tactical contrivance and of opportunities to grasp rather than of strategic choice and planning.

On the other hand, there were serial processes of change which were inherently problematical. This is especially true of technological innovation. The essence of successful innovation lies in first defining the problem and then searching for solutions: a strategy has to be worked out, action over a relatively long period has to be planned, and contingencies allowed for. True, the craze for clocks and watches (as potent a factor in the new consumerism as muslins and lace) allied with popular fascination with instruments of all kinds, and backed by the exercises in 'haute vulgarisation' which began to percolate through magazines and booksellers' shops, can be seen as testimony to the widespread interest in the promise of 'natural philosophy'. Widespread interest, however, can of itself do no more than multiply the number of interested parties. This may, in favourable circumstances, increase the number of people seeking solutions, but does little more than does increased demand to help formulate the technical problems, any more than it provides the answers.

In parallel fashion, the organisation of industrial production on a scale commensurate with expanded demand and the opportunities offered by new technology, and now made feasible by easier access to capital, made itself apparent from the end of the seventeenth century on as a set of new and unprecedented problems.

If the commercialisation of the police function by consumer associations bent on dealing with 'nuisances' in their own way did not launch the 'consumer revolution' of the
eighteenth century, it certainly plotted its path beforehand, right through to the employment of cheap labour. The chief historian of the 'consumer revolution', has rightly drawn attention to the "insufficient justice" paid by previous historians to "an event of such dramatic importance in English life." All the same, it would seem that the rise in demand for consumer goods occurred after the earlier, and even more neglected, revolutionary transformation had started. Some significance attaches to the fact that it was in the 1660's - after the English Resolution had ended and the Royal Society had been founded - that people began in the 1660's to form 'associations of consumers' in order to buy for themselves improvements in public hygiene, better streets, and protection from crime and 'nuisances' - all those matters which had been everybody's responsibility and were now becoming, seemingly, nobody's.

The turning-point for the consumer revolution in commodities, as against what are now called 'services', seems to have been the 1690's. It was then that "the taste for cheap, colourful fabrics imported by the East India Company reached 'epidemic proportions', with 'the craze over printed calicoes.' "The potential market power of previously unfelt wants came clearly into view. Under the sway of new consuming tastes, people had spent more, and in spending more the elasticity of demand had become apparent. In this elasticity, the defenders of domestic spending discovered the propulsive power (and the economic advantages to the nation) of envy, love of luxury, vanity and vaulting ambition."24

Yet in this later 'consumer revolution', England was following the lead of French fashion. And the 'consumer revolution' in France can hardly be regarded as a force propelling that country towards higher levels of economic prosperity. For the principal source of the money so freely spent by the aristocracy and bourgeoisie of France on their new houses, furniture and clothes was peasant agriculture:

"The landed proprietors [of France] did not seek to return capital to the land..... The great means through which [they] flood the French economy is consumer goods.....furnishing, rugs, and fabrics; they increase their household staffs, improve their daily menus, enrich their wine cellars and, in particular, have things built. Few profitable investments, much expenditure for luxury items." 25

The 'consumerism' that may well have helped start off the Industrial Revolution in England hastened French economic decline. It acted on economic life (as in fact mounting consumer demand always may, in the absence of corresponding economic development on the 'supply' side) rather in the manner that, in Shaw's play, Sir Colenso Ridgeon explained that 'phagocytes' act. Stimulated in the wrong circumstances, the patient gets worse rather than better.

The cotton which acted as Sir Colenso's 'opsonin' on the 'phagocytes' of consumer taste was not unknown to earlier generations. Its use in European textile manufactures seems to have begun in the latter part of the sixteenth century. 'Seems' is the appropriate word, because it was first introduced as a cheap substitute for wool, 'cotton' being a word used interchangeably with 'cotton wool' or, simply, 'wool'. It was meant, at first, to refer to cloth with a raised, fluffy, nap, and this was the universal treatment given to cloth made from cotton and wool, or flax and cotton, or wool and flax mixtures, made up as 'fustian', a cheap substitute for woollen cloth and an English speciality. But it was the cotton fabrics which the East India Company began to import from India, so much more colourful and less expensive than silk, which stimulated demand and accelerated the pace of fashion changes. And the embargo slapped on the import of silk and cotton fabrics early in the eighteenth century saw to it that, eventually, such fabrics would be manufactured in Britain.

Having led off with its Indian 'calicoes', and been quickly (though only partially) frustrated by the embargo laid on them by Parliament, the Company turned to other profitable imports. Coffee and tea, exotic commodities to begin with, were quickly in fashionable (and in the case of tea, mass) demand. Even so, as the century grew older, they began to be outmatched in bulk or value by the quantities of tobacco, rum, chocolate and, especially, sugar and fish which were being brought across the Atlantic from the now established settlements on the north-east coast of North America (by 1760, their combined population of settlers was almost half that of England), and from the West Indian islands. One peace treaty after another saw both kinds of colony grow in number and prosperity. And the Navigation Acts were at least as successful in keeping all the commerce generated in this way in the hands of English and Scottish merchants as were the embargoes on the import of Asian manufactures in promoting the manufacture of textiles.

The multiple revolution - fiscal, commercial, consumer, and, in the long run, industrial - of the eighteenth century could not have happened without the political stability (a novel experience for England) which was built up somehow after the settlement of 1689, helped by a series of successful military campaigns in Europe, an equally unfamiliar experience. New-found confidence coincided with an expansion in world trade and England took a growing share of it, at the expense of the French and the Spanish, hopelessly embroiled as they were in seemingly endless wars (which brought the English far more profit in trade and possessions than they cost in taxes). And, for the first half of the century, at least, the sources of England's rapidly growing prosperity lay in exploitation and plunder, as well as commerce.

The ability to profit from opportunities and temporary advantages - and, more important, the direction which the search for profit actually took - was guided by a new ethos. And whatever other qualities entered into it, that ethos was unashamedly acquisitive, mercenary and spendthrift.
It was Mandeville, a Dutchman by birth, who pointed the moral of the 'consumerism' born of this new prosperity. The Fable of the Bees was first published in 1705, with society likened to a hive, in which...

"...every part was full of Vice,
Yet the whole Mass a Paradise;
Flattered in Peace, and fear'd in Wars,
They were th'Esteem of Foreigners,
And lavish of their Wealth and Lives,
The Balance of all other Hives...
The Root of Evil, Avarice,
That damn'd ill-natur'd baneful Vice,
Was Slave to Prodigality,
That noble Sin, whilst Luxury
Employ'd a million of the Poor,
And odious Pride a hundred more.
Envy itself, and Vanity
Were Ministers of Industry;
Their darling Folly, Fickleness,
In Diet, Furniture and Dress,
That strange ridic'lous Vice, was made
The very Wheel, that turned the Trade."26

Mandeville's Fable, when it was republished in 1715, was prefaced by the earlier verse squib, The Grumbling Hive, from which these lines are quoted. It was denounced as energetically as it was widely read. But fifty years later, Adam Smith incorporated the same perception of 'Luxury' employing 'a million of the poor/ And odious Pride a hundred more' into his lectures on moral philosophy at Glasgow, this time transmuted into the public benefit wrought by an 'invisible hand' (or, rather, by that 'trickle-down' notion which has latterly captured the imagination of right-wing politicians, glossing over the reality of the 'trickle' of luxury consumption ending up nowadays in rather distant places):

"The produce of the soil maintains at all times nearly that number of inhabitants which it is capable of maintaining. The rich only select from the soil what is most precious and agreeable. They consume little more than the poor, and in spite of their natural selfishness and rapacity, though they mean only their own conveniency, though the sole end which they propose from the labour of all the thousands whom they employ, be the gratification of their own vain and insatiable desires, they divide with the poor the produce of all their improvements. They are led by an invisible hand to make nearly the same distribution of the necessaries of life which would have been made, had the earth been divided into equal portions, among all its inhabitants."27

27 Adam Smith, The Theory of Moral Sentiments, (IV.i.1.10).
From the earliest years of the century, lavish expenditure on great houses, landscaping, paintings, sculpture, the decorative arts, coaches and clothes fostered their own new breeds of professional architects, designers, coachmakers, joiners, milliners and other craftsmen. Their creations came to be imitated by the thousands who profited most from the extravagance of the rich or who themselves found a more modest place at the same trough. As the century grew older, satisfying this secondary, 'down-market', demand developed its own momentum. One clear sign of the advent of the 'market society' ethos is the commercial exploitation of aesthetic design itself, traditionally the product of an act of creation uniquely personal and inalienable: "Boulton studied classical designs until he picked a favourite and then impressed it on all his buttons in an attempt to produce a uniform popular line for a world market. The very similar action of Wedgwood in fixing upon a best-selling pattern is even better known.... The great names of Chippendale, Hepplewhite and Sheraton are known to everyone not for what they made but for the books of designs and styles which they published, and which in time affected the work of the humblest furniture carver."

All the evidence points to an accelerating growth in demand for manufactures in England. It was this, rather than exports, which first stoked the fires of the industrial revolution, although the export boom of which followed on the successful imperialist exploits of the Seven Years War undoubtedly added a forced draught of its own. In Professor McKendrick's words - "If we accept that industrial output trebled in the course of the eighteenth century, if...export of manufacture goods account for only a small proportion of the total, and if the bulk of manufactured products were of the mass consumption type, then the acceptance of substantially larger market is difficult to avoid. The rich simply cannot have drunk all the beer, worn all the cheap cottons, bought all the cheap pottery, buckles, buttons and so on......"

This does not mean that the eighteenth century consumer revolution affected the poorer half of the population, even if the products of the new manufacture were of the 'mass production type'. What it does mean is that the merchant, shopkeeper and entrepreneurial class who constituted the "socially anonymous, unfashionable and provincial markets" McKendrick refers to, had grown prodigiously by the end of the century (the passage just quoted refers to 1780 - 1800) and that their appetite for beer, pottery, buttons and so on had grown with it.

This puts innovation in manufacturing techniques and industrial organisation into a category of its own. It is also distinguished by the direct effect it had on the working life, the everyday social activity and relationships and the sense of autonomy in these matters that working people had, however precarious, limited, or even unfounded that feeling may have been. Of course, the innovations in material and social technology that went into creating the factory were only the more immediate and obvious elements of the combination of forces that were at work - something which working people themselves came to perceive over the years.

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29 N.McKendrick, op. cit., p.29.
30 N.McKendrick, op. cit., p.77.
The development of new institutional systems and of what amounted to a new economic and political ethos around the year 1700 quickened the pace of industrialisation in England until, a hundred years later, it was on an irreversible path to becoming the first industrial nation. The modern factory, which for Mantoux symbolised industrial capitalism, had arrived.

What had been no more than a thin trickle of innovations in mechanical engineering and chemical processes at the beginning of the eighteenth century were becoming a significant flow by the end, beginning to effect dramatic and fundamental changes in economic, social and, eventually, political life. They started off a continuous process of technological development which has been integral since then to the whole process of modern industrialisation and, eventually, to the course of world history.

Later in the eighteenth century came the new mechanical inventions which were to revolutionise the textile industry, beginning with Kay's flying shuttle and ending with Watt's steam engine, Crompton's spinning mule and Cartwright's power loom. And while the history of each of the technical inventions of the eighteenth century, and the lives of their inventors, have their catalogue of failure as well as success, however one rates inventions in the long list of 'historical causes' of the industrial revolution, they certainly figure as an essential element of what may properly be regarded as the primary instrument of modern industrialism, as well as its symbol: the factory.

VII

Industrialism is usually equated with factory production. A country in which a large fraction of the commodities it produces consists of finished articles, parts, or semi-finished materials made in factories is regarded as industrialised. So, despite the lead taken early on by the Crowleys and others, and the fact that iron and steel machinery, rather than textile production, is often regarded as the prime mover of the Industrial Revolution, to most people 'industrialism' spells 'factories'. In Paul Mantoux's words, "the characteristic monument containing within its walls the raw material of modern production, and embodying in a visible form its very principle, is the factory."31 And the factory has remained the universal symbol of industrialism.

Factories are workplaces in which a sizeable number of workers are employed; but also, and this is more important, they are employed to use, manipulate, tend, or service machines. Recently, in fact, machinery has become the dominant element, so much so that where farming is heavily mechanised, agriculture is spoken of as 'industrialised'. Even so, the core meaning holds good for what are known as 'factory farms'; these are highly organised food-producing units and not necessarily farms where mechanical aids are extensively used.

There is no one definition of the factory, from Dr. Andrew Ure's on, which satisfies everybody. One difficulty is that some writers include within the scope of the definition the large medieval workshops mentioned in an earlier chapter and others the state factories, the manufactures royales and the manufacture privilegiees of eighteenth century France which, says Mantoux, "only lived on protection and privilege", and, "left to themselves......would have disappeared at once."

A definition of the modern factory which seems to fit the requirements is that it is a system of industrial production which combines labour force, power plant (or power supply), and machines, into a single organised unit. More precisely, it is a manufacturing plant made up of a number of specialised machines, driven by an independent power-plant, set up in a single building (or an integrated collection of buildings), and tended by a disciplined labour force. All three elements are equally essential, even though it is the 'specialised machines' and the 'power plant' which occupy the foreground of the picture which the words 'Industrial Revolution' conjure up, rather than the 'disciplined labour force'. They have, even now, the vivid, dramatic, quality of new forces being let loose in the world - even though specialised textile machines were nothing new, and water power for driving mills and machines was centuries old, and even though the independent power supply Wyatt and Paul used in Birmingham in 1740 for their new spinning machine was a pair of donkeys.

But, as Mantoux was careful to insist, the factory was, and is, primarily a mode of organising production. It is the system of organisation, rather than the building or the equipment, which is important.

The creation of the modern factory is traditionally tied in closely with cotton-spinning and the phenomenal expansion of the cotton industry. For many years, the alternative label for the new-style factory was 'the Arkwright system', an attribution which placed it firmly alongside the steam-engine and the newly invented cotton-spinning machines as evidence of the kind of enterprise and inventiveness which made Britain the first industrial nation. But the first truly modern factory in Britain was given over to the production of silk thread. It was, so the story goes, the outcome of a feat of industrial espionage.

Silk fabrics had been imported into Europe from China since Roman times but, since the Middle Ages, the stronghold of silk production in Europe was Italy. By 1700 the silk industry had spread to northern and western countries, but Italy still retained a virtual monopoly of the spinning ('throwing') of organsin, the stronger silk thread used for the warp in silk weaving. The monopoly was in fact a technical one, founded on fairly complex machinery powered by a watermill. In 1716, it seems, one John Lombe succeeded in getting inside an organsin mill and, at great risk - if caught, he would have suffered, at the very least, a long prison sentence - got drawings made of the machinery. On his return to England, he proved himself possessed of as much impudence as audacity

32 ibid., p. 31.
33 ibid., p.25.
by patenting the drawings. In partnership with his brother, who supplied the capital, he built a silk-throwing mill near Derby.

It is this mill which has some claim to be the first modern factory in Britain; the spinning was done automatically by machinery, the workers' task being merely to join the threads whenever they broke, and the power for the machines came from a water-mill driven by the River Derwent; it employed some three hundred workers - mostly women and children. Thomas Lombe, the brother (John having died a year or two after his successful exploit), made a fortune.\(^{34}\)

Later silk-spinning factories, most of them in the Midlands, employed even more workers. Yet the spread of the factory system to other industries hung fire until after the acceleration in economic growth after the middle of the century. It was with this further, and spectacular, expansion in the demand for cotton goods in Britain and abroad, which actually led to prizes being offered in the 1760's for inventions which would improve the volume and quality of output, that the first factory for cotton-spinning was projected.

It was the Lombes' factory, built near Derby, which is said to have served as the model for Arkwright's first water-powered cotton-spinning mill built in 1771, over fifty years later, at Crompton, in Derbyshire. The Lombes' factory apart, there were, in the early decades of the eighteenth century, a number of different patterns according to which industrial production might be organised. They ranged, as we have seen, from joint-stock companies (until 1720), through the smaller mining and ironworking partnerships, hosiery workshops with wage-earning employees or groups of tied homeworkers using knitting frames owned by hosiers, larger numbers, especially in the south, of semi-dependent domestic manufacturers in linen, wool and cotton who contracted their output to clothiers, down to the independent craftsmen and domestic manufacturers typical of Yorkshire.

The very first major moves towards the new industrialism were made in hosiery. While they may not have been wholly responsible, there were some special, and interrelated, features of the hosiery industry which must have helped give it a flying start. The first is the shortness of the series of production processes involved, compared with other textile industries. Hosiers produced finished articles in a single process straight from woollen, cotton or silk yarn without the intervention of weavers, finishers, printers, tailors or dressmakers. Secondly, the relatively integrated hosiery industry of the early eighteenth century was also relatively mechanised, although it was still, basically, William Lee's sixteenth century stocking frame that served as machinery. Lastly, the Lombes and their imitators were producing organzin for the warp of woven cloth, as well as for knitwear.

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\(^{34}\) Later historians have done what they can to spoil what was quite a good story. It seems that detailed drawings of the machine were reproduced in a treatise published as early as 1621, a copy of which was in the Bodleian. While it is not at all unlikely that Lombe's interest in textile machines would have led to his discovery of Zonca's *Nuovo Teatro di Macchine ed Edifice* while he was in Italy, it is doubtful whether he would have had either the confidence in the efficiency of the machinery or the effrontery to patent the drawings he had obtained without closer and more practical acquaintance with its operational effectiveness.
decades before the more clumsy 'twist-mills' were developed for the strong thread needed for the warp of fustian and cotton cloth.

Given this centuries-old connection between hosiery and machinery, and the more recent, but still traditional, arrangement by which hosiers employed frame-knitters in their own workshops and leased frames to domestic workers, it is not surprising to find the first steps towards factory production being taken in the hosiery industry. A London hosier, Samuel Fellows, moved to Nottingham (so as to be out of reach of the regulations of the London Company of Framework Knitters; he is said to have been one of the targets of the 1705 riots because of the large number of apprentices he employed). Once there, he set up a workshop, boarding a large number of apprentices to work his frames. These 'apprentices' were pauper boys, the frames being simple enough for older children to work. Since he would have been paid £5 a head by the parish authorities for taking them off their hands, and their wages would have been up to three shillings a week less than the 10s. or 12s. he would have had to pay journeymen, Samuel Fellows prospered, as did the other Nottingham hosiers who followed his lead.

Even so, Fellows' enterprise would not have amounted to much more than a workshop, bigger than most other hosiers' establishments, but consisting of a large room with two or three dozen knitting frames, all manually operated, in it. It was later, in the late 1750's, that frames began to appear which incorporated adaptations which led to the production of new kinds of knitwear: "The initial stimulus was provided by the success of Jedediah Strutt's 'Derby rib' hose (1756). The continuous experiments of framework knitters during the next generation extended the use of the frame from stockings to underwear, breeches, gloves, handkerchiefs, waistcoats and elasticated knitwear, and various imitations of cushion-lace. In 1812, some forty distinct fabrics were being knitted on the frame, despite some contraction due to the war."\(^3\)

Strutt, a wheelwright and farmer, seems to have acquired the new frame (or rather, a new attachment to the old frame) which made his fortune (and led to Arkwright's) by buying up 'the rude and imperfect idea' worked out by 'a common workman, called Roper'\(^3\) and, assisted by Roper, developing it into a workable and effective piece of equipment. Mindful, perhaps, of the reputed origin of the Lombe's fortune, he installed his new machinery in a windowless 'safe-box' - a security measure all too easily penetrated: the locals merely climbed on to the roof and inspected the machines through the skylights.

When his turn came, Fellows bought a device for another, and more elaborate, kind of knitted fabric from the two artisans who had devised it, and built a 'a large factory' (really meant as a much safer 'safe box') in Nottingham. "The idea was taken up by successive hosiers who sponsored innovation so that, by the time Arkwright came to Nottingham, the factory could be recognised as a location of production commonly used by innovators."\(^3\)

\(^3\) S.D.Chapman, The Early Factory Masters, p.19.
\(^3\) S.D.Chapman, op. cit., p.39.
By the 1760’s, association with innovation would alone have made the word 'factory' attractive to entrepreneurs. Yet there was nothing about them to distinguish them from the large workrooms which still housed most of the central production units of hosiers and clothiers. And such larger units represented a small fraction of the total manufacturing capacity in textiles, even in the case of the bigger merchant-industrialists. Most production was still by outworkers, domestic manufacturers who worked for hosiers or merchants, and were single workers or, more commonly, families or sub-contractors with rooms large enough to accommodate a few spinning wheels or frames. The main variation was in the size of room, and hence the number of workers they could accommodate. In Nottingham, the rooms of terrace houses could hold no more than two or three hosiery workers and their frames; elsewhere, in the villages, there was often room for more, or even for an extension or extra building.

The success of the Nottingham workshops in the hosiery industry was largely the consequence of the ability of merchant hosiers (abetted by the local magistrates) to cut their costs by employing labour at lower rates, ignoring regulations about the employment of apprentices as against journeymen, and so underselling their London rivals. In the early 1760’s, though, the east Midlands hosiers themselves began to be undersold by hosiers in the Tewkesbury area, where "it was discovered that their country spinsters could readily accommodate themselves to spinning cotton because they were used to handling short-staple Spanish wool."38 Nottingham hosiers had to rely on Indian cotton yarn which, superior as it was, was indistinguishable from the home product when it was made up, and was much more expensive.

With the screw tightened in this way, the search for innovation as a way out was especially intense in the Nottingham area, and especially intense concerning cotton spinning. The need was met in the Midlands by two migrants (refugees, rather, from the 'jenny riots' in Blackburn) who arrived in Nottingham to look for backers; neither had any difficulty in finding them.

Hargreaves was first, with his new spinning-jenny, which could duplicate the work of the traditional spinning wheel. Hargreaves' first jenny was a hand machine, simple to operate, and much better suited to domestic manufacture than to the mill. Cheap as the machines were to buy (and easy to copy, patent or no patent), it was, as before, people who had money or could get credit who bought them, to hire out to homeworkers, at the usual rates and with the usual penalties. As in earlier times, the masters turned the screw as tight as they dared, to the point of provoking the 'jenny riots', when homeworkers, as in earlier times, vented their resentment on the masters' property - the machines in their own homes.

As Mantoux observes, "Long before machinery made its appearance it had been a common thing in disorderly strikes for tools to be destroyed. But when the stocking-knitters revolted against their employers and broke their knitting frames, it was not done to stop the frames being used. They bore no malice against the frames but against the

38 ibid., p.47.
owners, and they only broke them up as being the property of greedy employers who were levying the cruel frame rent on them.....But the riots against machinery, which began in the second half of the eighteenth century, had a quite different meaning........it was to fight the factories."  

The initial success in Nottingham of Hargreaves and his patron, Thomas James, was short-lived, partly because the invention was not protected by patent until 1770, but more because of the superior quality of yarn turned out by Arkwright's 'water frame'. Arkwright, had worked up, in company with John Kay (a Warrington clockmaker, not the inventor of the flying shuttle) a new spinning device using rollers. The yarn it produced was not only of better quality (or finer denier, which comes to the same thing) than came off the jenny, but, much more important, it could be operated by an independent power supply - horses, in the first instance (a workshop in Nottingham). But it was by a water-mill at Crompton, in Derbyshire, that he built the first of the Arkwright factories, to house the spinning machines he now called his 'water-frames'.

Arkwright found little difficulty in finding patrons prepared to invest capital in return for a partnership. The first was Samuel Need, the wealthiest hosier in Nottingham and the second, who bought into partnership by finding the money for the Crompton factory, Jedediah Strutt himself. After that, Arkwright was unstoppable. He even survived the disastrous action he brought, and lost, in 1781, against spinners who had 'invented around' his patent. Apart from founding a dozen or more factories himself, mostly in his native Lancashire, he leased the design to others under licence. In 1792, when he died, he left nearly two million pounds.

Arkwright was no engineer - nor, apparently, much of a mechanic. His 'water-frame', like Hargreaves' jenny, bore a close resemblance to Wyatt's invention of 1733, the basis of the unsuccessful Birmingham venture of 1740. He was hardly "one of the enigmas of the eighteenth century", as Chapman calls him. Even Mantoux's grudging admission that his "real claim to fame lies in the fact that he was successful," because "he was the first who knew how to make something out of other men's inventions, and who built them up into an industrial system," overstates the case. Others were there before him; what was special about Arkwright was that it was in cotton manufacture that he made his mark. And, after decades of debate, economic historians seem now to have settled with themselves that it was cotton which was indeed mainly responsible for the surge in British economic growth with which the Industrial Revolution is normally associated.

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39 P.Mantoux, The Industrial Revolution, pp.400-1
40 ibid., p. 62.
41 P.Mantoux, op. cit., p.233.
The way in which production in a multiplicity of one-person operations and small units came to be organised into large, integrated, plants can be broken down into component elements according to several quite different analytical categories, but, without becoming too entangled in definitional problems, these four elements will serve our present purposes:

1. Division of labour i.e., dividing and subdividing the work so as to allow of its execution either by machines or by workers who, by specialising, may attain higher speeds, greater dexterity - or a better quality of product, together with Labour Intensification, i.e., extracting a segment of manufacturing work from execution by individuals or small groups of people working according to methods and a tempo they themselves choose, and using traditional manual skills, and converting it into routine, repetitive, performances in which speed and dexterity could be improved.

2. Labour discipline i.e., engaging an adequate labour force and ensuring that the work of manufacturing and all the necessary ancillary work was carried out efficiently (i.e., economically), effectively, and at prescribed times.

3. Planned sequence and progress of operations i.e., arranging the progress of work through all the stages of production so as to reduce or eliminate the time and labour involved in moving it between stages.

4. Conversion of externalities into internal organisation i.e., excising a coherent set of transactions from the 'external' organisation of industrial activity and encapsulating them in a single enterprise, within which direction, cooperation and transactions were planned and supervised by the owner or his agent.

All four elements were featured in the new spinning mills, and more prominently still in the later textile factories; they are indeed commonly regarded as the direct consequence of 'the Arkwright system', the term which was commonly applied to the factory system. The introduction of machines itself imposed a division of labour between combing, carding, spinning and weaving. All these processes were mechanized by 1800 or soon after, with women employed on the non-mechanised work of piecing (mending breaks in the spun yarn), and children to fetch and carry. Labour intensification and discipline came in as 'natural' or 'rational' corollaries to the division of labour, as Adam Smith had noted. The effective exploitation of a planned sequence of operations and of the absorption of external market costs by effective organisation, both of which depended directly on the managerial competence of the factory-owner or his agent, were rather more chancy.

In fact, though, while it was the cotton factory that saw the most widespread and publicised - and therefore critically important - synthesis of all the features of the new technology of industrial organization, it was in mining, metal-working, brewing, pottery
and engineering that the organisational techniques of the new industrialism were first tried out, even before Arkwright built his first textile factory in 1769.

In these other industries, where the relevant organisational technology had not been imposed, or prompted, by the replacement of manual dexterity or craft skill by a machine, the craft of particular artisans had to be analysed, separated into sub-skills and fractional operations, and allocated to different processes and workers. It was here that Wedgwood and Boulton made their mark, taking specifically organisational technology well beyond what Crowley and Darby had achieved before them.

One of the most energetic, and successful, innovators of this kind was Josiah Wedgwood. In his Etruria works, while it was not a factory, and little or no machinery was used in the manufacturing process itself the factory system was established as completely as ever it was in the textile mills. The absence of machinery in fact makes it easier to discriminate and point out how all five elements of the organizational transformation were worked out in practice.

Things were already on the move in the Potteries, as they were elsewhere, when he broke new ground in 1763 by patenting his 'Queen's Ware'. Wedgwood, as master potter, had already ousted the individual craftsman and his family, recruiting the best journeymen and apprentices he could afford, but he too was finding the growing complexity of new glazes, new clays, new shapes and new methods too much to handle. Wedgwood, once he had decided to exploit the craze for porcelain that had swept Europe and go 'up-market' (his articles sold at twice the price and more that others charged), went to extreme lengths to partition the whole process into tiny fractions - which he determined. "The analysis of workers drawn up by Alexander Chisholm, Wedgwood's secretary and amanuensis, in the early 1790's, shows to what extent the division of labour had been developed. It reveals a fixed hierarchy ranging from a famous modeller like William Hackwood earning 42s. a week to Fanny Lowds, a 'painter of pins' on a 1s. per week... Each workshop had its specialists: in coloured ware there were painters, grinders, printers, liners, borderers, burnishers and scourers; in jasper there were ornamenters....."\(^43\) Altogether, McKendrick names thirty-seven distinct specialisms, in each of which men, women and children would be trained and thereafter employed exclusively.

Wedgwood's declared purpose was twofold. In his own words, they were first, to make Artists of mere Men, and, secondly, to make such machines of the Men as cannot err. To these ends, virtually all his employees were set to work at one particular fraction and kept constantly employed in it. "His workmen were not allowed to wander at will from one task to another as the workmen did in the pre-Wedgwood potteries. They were trained to one particular task and they had to stick to it.\(^44\)

Wedgwood, with no machinery to do it for him, had to design an effective lay-out himself. What he aimed at was to eliminate all the moving about of work in progress which was not strictly necessary: "the kiln room succeeded the painting room, the

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\(^{44}\)N.Mckendrick, "Josiah Wedgwood and Factory Discipline," , p.32.
account room the kiln room, and the ware room the account room, so that there was a smooth progression from the ware being painted, to being fired, to being entered in the books, to being stored. Yet each process remained quite separate.  

All these developments had to be contrived within the commercial functions which the entrepreneur had to continue to discharge in the market situation external to his enterprise: buying materials and plant and hiring labour, and selling the products. The new industrialist, manufacturer though he might be, had nevertheless to keep constantly aware of the dependence of his business on successful trading; first and last, he was a merchant.

But many of the transactions which had formerly been part and parcel of the institutional system external to the merchant's or master's own establishment now had to be incorporated within the new factory system. An enormous number of matters had customarily been handled by agreement, contract, and bargains. Since these were usually made on the spot and commonly without written agreements, they had depended almost entirely on trust, for however often they were broken, it was out of the question to resort to law for the remedy of essentially trivial delinquencies. These now became the subject of managerial control.

The measures instituted by Wedgwood included a clocking-in system and the appointment of overseers for each workshop and then for each stage of the process: "Wedgwood had solved his problem by dividing the responsibility and reintroducing the unit of the old pot-bank, with 'one steady man' to each process. They were reinforced by the 'Clerk of the Manufactory', the 'Clerk of Weights and Measures', the Porter [who ran the clocking-in system], and general inspectors to look after the men & wages."  

At the same time as developing the essentials of the factory system, Wedgwood, along with his contemporary, Matthew Boulton, was extending the definition of industrial entrepreneurship by marketing, distributing and selling his products with immense enthusiasm and energy - and with a great variety of entirely novel ideas. Wedgwood, indeed, accomplished almost single-handed a revolution in salesmanship, advertising, and marketing, as well as in design: "The Industrial Revolution in the potteries..... called for new methods of salesmanship and new centres for display. To succeed, the potter needed merchant partners, foreign agents, salerooms, warehouses, travelling salesmen, catalogues and trained linguists to deal with the increasingly technical problems of foreign trade. He also needed improved transport and more favourable commercial agreements. It was Wedgwood who provided them, and gave the lead to others."  

He also went beyond the bounds of the requirements of his own manufacturing concern. Like several of the new manufacturing magnates, he found he had to build an infrastructure in support of the industrial complex he, and other potters, had created.

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46 ibid., p.40.
There was nothing new in this; Crowley and Darby, who had done the same thing before them, were following established tradition; harbour-works or staithes, roads and bridges, houses and even churches and schools were as familiar a part of initial capital outlay as were warehouses and ships, and raised its deterrent significance accordingly. What was new, in the eighteenth century, were the sheer number of such capital works and the scale of them. It was all part of the entrepreneurial - or managerial - task. "In the canal era, the duke of Bridgewater's agent had to supervise the building of the premier canal as part of his duties of running the Worsley collieries, besides managing an extensive agricultural estate, draining marshes, dovetailing a tree planting programme and generally supervising the erratic innovating genius of Brindley."48 Wedgwood took the lead in road improvements and in the construction of the Mersey-Trent canal; he is generally acknowledged as the principal engineer of the transformation by which the Potteries became as famous for its manifest prosperity and the well-being of its inhabitants as Manchester was to become notorious for its poverty, misery and squalor.

As for Boulton, his Soho factory employed over 600 workers when it opened in 1762, seven years before Watt joined him in partnership. "Soho had its own central motive power which drove all the little lathes, drills and polishers within the works, in the form of a water-wheel, the inadequacy of which was one of the reasons for taking an interest in Watt's improved steam engine, but in the main Boulton sought the sort of organizational advantages which were summarized so brilliantly by Adam Smith as the 'division of labour', illustrated by a pin factory. Boulton's works, and very soon there were others in Birmingham which copied him and the larger works of John Taylor, used the large scale of production first to divide and subdivide the work, secondly to replace the thus simplified tasks by primitive machinery, such as stamps or dies or lathes, and thirdly to make use of skilled artists and designers of the kind which smaller firms could not afford at all."49

Apart from Boulton, Taylor, and one or two others, mechanical engineering, which was to become the most important source of industrial development in the early nineteenth century, bore all the marks of the traditional style of industrial organization before 1800. It was carried on in quite small concerns. Bramah, a superlative inventor, employed fewer than a hundred. His most famous apprentice, Maudslay, who at the height of the war with France supplied Portsmouth dockyards with well over 100,000 ship's blocks and whips a year on machines designed by Brunel50 - the first ever mass production engineering job - had no more than eighty. Their small size was in conformity with the essentially craft nature of engineering; small as they were, their workshops nevertheless housed several separate workgroups, each with its own benches and each engaged on different kinds of article. It was not until the next, post-1800, generation that innovation in the technology of organising production began to match the engineering innovations they were trying to exploit.

Even the specialised undertaking of Boulton and Watt, which began building Watt's improved steam engine in 1774, depended on subcontracting and outworking for a number of years; indeed, as Erich Roll says, "for the first twenty years of their connection Boulton and Watt were not manufacturers of steam engines. A more appropriate description would be 'consulting engineers'"\(^\text{51}\). A great deal of their own engine-construction work was sub-contracted out; Wilkinson, the ironmaster who had developed a new and better method of boring castings to produce gun-barrels, made most of the cylinders needed for the Watt engines. It was in fact eighteen years before the enterprise - which was kept well apart from Boulton's own hardware factory - was firmly established. The improvements in factory organization, after the Soho foundry was built in 1795, which Erich Roll claimed anticipated 'scientific management' by a century,\(^\text{52}\) was the work of the next generation, M.R. Boulton and James Watt the younger.

**IX**

While to identify the textile factory with the new industrialism overstates the case, and to regard it as the birthplace of what I suppose must be called the managerial revolution is misleading, it was in the textile factory that all four elements of the organizational transformation to modern industrialism were most commonly and most fully worked out.

Apart from anything else, many of the four elements listed were, as I have already suggested, incorporated almost of necessity in the new cotton-mills. Those manual tasks which required an element of skill were separated out in terms of the strict division of labour and the work intensified - by being speeded up and kept going for long hours - simply because they were mechanised. The task of labour - women and children, mostly - was reduced to the simple job of fetching and carrying. Dexterity was still needed for piecing broken thread on the machines - as was skill for repairing the machines themselves, but this latter task was something which could be left to the few overseers. By 1775, textiles had developed its own factory system, with all the successive operations of the industry, save the last and most difficult, that of weaving, performed consecutively.\(^\text{53}\)

This meant, too, that those essentially market transactions between individuals and small firms engaged in carding and combing on the one side, and spinning on the other were not so much incorporated in the factory system as eliminated. And the third element, the planned sequence and progress of operation, was, as Mantoux's remark implies, incorporated in the mechanical process itself.

There remained the task of dealing with suppliers of wool and with weavers and merchants. This type of transaction had in fact been incorporated by Wedgwood in his own sales and marketing organization, but, on the whole, textile manufacturers kept clear of the kind of vertical organisation by which earlier merchants - and eighteenth-century

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52 ibid., pp.184-188.
ironfounders and metalworkers - had expanded their business; the elder Peel set up his twenty-three spinning mills without venturing into later manufacturing processes. Vertical integration in textiles was left, even by the biggest concerns, until the advent of Cartwright's powered loom, which extended still further the process of mechanisation.

They needed more capital for such expansion, but this, as the cotton boom continued into a period of price-inflation, was not too difficult to obtain. To begin with, capital had been the prospective manufacturer's most useful equipment, and acquiring moneyed partners the most useful skill. The merchants who turned merchant-manufacturer had the advantage at first, therefore. But in the northern textile districts, the transition from merchant and domestic industry to manufacturer and factory industry was much more abrupt, and here it was being able to drive a hard bargain and keeping afloat on the shifting tides of debits and credits that counted most. Even so, the price inflation that began in 1790 and continued throughout the French wars and coincided with the cotton boom brought immense advantages to the new men. The price of wheat tripled in ten years, and other prices kept pace; wages stayed low, rising a mere ten per cent.

One fundamental change - in one sense, the most fundamental of all changes wrought by the Industrial Revolution - was achieved in piecemeal fashion. This was the conversion of the batch production method traditional to all industry to flow production. As we have seen, this was almost an implicit consequence of the way the textile industry grew, but it is just as apparent in the methods adopted by Josiah Wedgwood in the manufacture of pottery, even though mechanical devices entered into no stage of the process of manufacture.

X

For the fifty years or so after the 1770's, the part played by factories in manufacturing industries was comparatively small. The factories themselves were small, too; even by 1860, the largest in Britain employed no more than six hundred. But their significance is not to be measured by their number or size. For those who went into the new factories to work, and for their families, the conditions of work they faced called for changes in their everyday life which amount altogether to perhaps the most far-reaching consequence of the Industrial Revolution. As Sidney Pollard put it, "The worker who left the background of his domestic workshop or peasant holding for the factory, entered a new culture."54

Factory-work can, of course, be seen as the terminal stage of a centuries-old process by which manufacture was progressively displaced from the individual family's home and subjected to disciplines of time and behaviour imposed by others. As early as the fourteenth century, bells rang out in the cities of the Netherlands to signal the start and the end of the working day. Over the centuries, the process of change had moved from what was essentially subsistence work through successive stages: 'pieces' being made at home for travelling factors, 'putting-out' especially skilled or time-consuming work to be

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done by people using their own tools and equipment, and 'outworking', when more expensive equipment would be rented out to workers by merchants and master clothiers or smiths. Countless laws had been passed and ordinances issued to control workers' pay, conditions of work, and training.

But while it makes sense to have regard to an essential continuity, the difference is there. The whole process, which had been piecemeal as well as slow, speeded up immensely after 1750. More important, whereas working time, pay, and conditions had been subject to regulations passed into law by the government of a country or by city authorities, they were now instituted and administered by individual employers of labour. In other words, what had been formerly a matter of legal authority, politically enacted by government and - at least to some extent - socially sanctioned, was now something for the individual employer to determine; it became, as we say now, 'privatised'. Not until the middle of the nineteenth century did hours and conditions of work for men, women and children, even begin to be subjected once again to public, legal, control.

In this and other ways, treating the experience as 'entering a new culture' misses the point. It can even be misleading; the same phrase covers experiences which are liberating, or energising, or educative. In cultural terms, what the factory meant for the first generation who went to work in them has to be reckoned in its entirety as loss and deprivation.

The first factory workers took the full brunt of the exploitation of labour which came in with a new "master-class without traditional authority or obligations." Factory-work "forced on them the growing distance between master and man: the transparency of the exploitation at the source of their new wealth and power: the loss of status and above all of independence for the worker, his reduction to total dependence on the master's instruments of production: the partiality of the law: the disruption of the traditional family economy: the discipline, monotony, hours and conditions of work: loss of leisure and amenities: the reduction of man to the status of an 'instrument'".\(^{55}\)

For a start, the new factories were built in places where there were ample and constant supplies of water power to drive the mills. This, almost invariably, meant that they were located in remote country places. Their former surroundings, social life, and familiar round of activity were now lost to them. Deficient as the world of everyday life may have been, there were at least no walls or equally impenetrable boundaries of time and distance separating them from opportunities for action and interaction, of participation in the events and the changes taking place in the larger society outside. Life in the world of the factory meant that, eventually, the motivations, reactions, and feelings connected with what had been ordinary social life were worn away by attrition or overcome by obsolescence. With them went the kind of self-conception belonging to independent existence, however impoverished, unstable or disorganised that may have been. The new life brought with it a sort of training in unfitness for the world outside, an unfitness that showed itself in the drunkenness and brutality which became so prominent a feature of working class life in the factory towns later on.

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For the entrepreneur, the isolation of the new factories of itself multiplied the tasks confronting him. He had to create his own 'infrastructure' of transport (roads as well as vehicles), engineering (for building machines as well as maintenance and repair), housing, and services (shops, always, but sometimes schools, churches, medical services, and policing, too).

Of course, ironmasters and mine-owners, and manufacturing entrepreneurs like Crowley and Wedgwood, had shown the way earlier, building their own canals and port facilities, and developing and managing large-scale farms. In all cases, the capital outlay called for was almost unprecedented, as was the need for organisational ability and effort. One consequence was to reinforce their determination to get a satisfactory return on the whole undertaking.

But the first and foremost need was for housing. Pollard lists a sample of 48 factory villages, which, he says, reads "like a roll-call of the giants of the industrial revolution." Ten of the 48 were in connection with ironworks; there is a scattering villages built for woollen mills, copper, lead, tinplate, and slate workings. Wedgwood's pottery works at Etruria ends the list. But fully half the total number were built for cotton mills.

They were a mixed lot. Robert Owen added a second storey to the houses he acquired at New Lanark, and set up a cleaning service; others in Scotland were regarded as model villages, as were a few in England, especially Thomas Aston's at Hyde. Elsewhere, they could be, like the large block built at Anderston in Glasgow, worse than the workhouses and prisons which had served as the preferred model for the mills themselves. This was not all: "At Merthyr Tydvil, a company town in many respects, though dominated by four iron companies rather than one, Crawshay, having monopolized all the likely building land around his works, leased it out to others, with disastrous results for the health and amenities of the area."

Merthyr was a company town in more respects than this. Crawshay and other ironmasters saw to it that they were also the magistrates, and were thus able to deal with trade-unionists as well as with applicants for licences. "In Whitehaven, again, the Lowthers were kings. The first earl of Lonsdale, losing a case over subsidence in 1791, simply decided to close all the town's collieries." Twelve years later, his manager reported to his master his outrage at the local coroner's daring to hold an inquest on a woman killed in a mine accident - "'a thing never practiced here in my memory, such enquiry being supposed only calculated to frighten the ignorant and discourage them from going into the Pits; on this account the workmen were always forbid to even talk about any accidents which happened in the Pits.'"58

The sheer number of workers to be supervised seemed, to all employers, good and bad, to demand strict measures. They felt justified, in most cases, because factory hands soon

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acquired a reputation for drunkenness, thieving, quarrelling, immorality and general misconduct - not surprisingly, because factory work was, until well into the nineteenth century, detested and feared; almost any other kind of work was preferred. They also felt free to act as they did, because, as F.M.Eden, a professed disciple of Adam Smith, wrote, in 1797, "The man who has only the unsubstantial property of labour to offer in exchange for the real visible produce of landed property, and whose daily wants require daily exertion, must, it may be said, from the very nature of his situation, be almost entirely at the mercy of his employer." As Mantoux comments, "In this, the heroic age of great undertakings, ... the absolute and uncontrolled power of the capitalist... was acknowledged, admitted, and even proclaimed with brutal candour. It was the employer's own business, he did as he chose and did not consider that any other justification of his conduct was necessary."

To achieve these ends with a labour force numbering hundreds, employers resorted to disciplinary measures of a kind and a severity previously unknown. There were, as one might expect, a whole range of carrot and stick methods, with plenty of famous and notorious names and cases at each end of the range.

Early on, before the cotton factories became an established part of the industrial scene, some employers had experimented with efforts to attach their workers' interests and loyalty by making use of "feasts and holidays typical of the old order in cementing personal relationships and breaking the monotony of the working year." Matthew Boulton's grand feast for 700 at his son's coming-of-age, Wedgwood's for 120 to celebrate the move to Etruria, Heathcote's outing for 2,300 from Tiverton matched the Duke of Bridgewater's paying for a roasted ox and plenty to drink to celebrate the opening of his canal. "But within a generation," Pollard ends, "it was the shareholders that were being feasted, not the workers, whose relationship with the employers had taken on an entirely different character."

Later on, employers adapted the contract relationship which had predominated for skilled and heavy manual work like iron-smelting, metalworking and mining and paid by results. Piece-work payments had often been made to groups, though, and their effectiveness was reduced when they were made individually, reduced further when they were poorly constructed and badly administered, as they often were, and self-defeating eventually when rate-cutting and speed-up were tied to them.

Among the factory-owners, Robert Owen and others, for all that some of the measures they adopted now seem either simple-minded or rather odd, did try to divert some of the benefits the new industrialism had brought them to their workpeople and their families. They were, however, outnumbered by the 'flogging-masters'.

Physical violence was reserved, usually, for children; sanctions for adults took the form of fines and, of course, dismissal, but even by 1816 adult males made up only 18 per cent of the labour force in cotton. Employment for men lay mostly outside of textile factories. Earlier on, Wedgwood had employed adults, mostly, and his blows were reserved for

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60 S.Pollard, "Factory Discipline in the Industrial Revolution", p.257.
badly made pots. He is usually presented as an exemplary employer, and indeed he was; he built a school and a hospital for his workers and their families, as well as houses, but his scale of fines included sums of more than a day's pay for throwing anything inside the walls of his plant, writing up graffiti, playing fives or bringing in beer. Striking or abusing an overseer meant dismissal.

The sub-contracting tradition survived in factories in one important respect. It was widespread practice in the first generation of factories for the entrepreneur to free himself from the personal supervision of his workers, the most time-consuming of his responsibilities.

Some employers earned a special notoriety by engaging sub-contractors who felt free to use whatever slave-driving methods they chose in order to speed up output and improve their own piece-rate payments.61

While there were also plenty of masters who did their own flogging, there were still others who, though not necessarily 'humanitarian', if by that is meant a special inclination towards benevolence and Christian charity, were decent, sensible, men who drew the line at expanding the profits by brutalizing their workers. Nevertheless, as Neil Smelser has pointed out, "From the point of view of controlling labour,... both types of factory management display a concern with the enforcement of discipline."62

The new industrial regime imposed new attitudes, a new structure of relationships, even new beliefs on entrepreneurs and their agents as well as on their workpeople. It brought into being a new master class which did not possess, or know of, the kind of authority or the obligations which by tradition had attached to employers. It seemed to see itself as committed to the exploitation of labour in much the same sense as it was committed to the exploitation of the machines they had bought and housed in the new mills, side by side with the workers whom they had also had to house.

Employers, on their side, could point to the absolute necessity of suppressing the go-as-you-please attitude traditional among independent workpeople, their 'distaste' for regular hours, their predilection for drinking in the early afternoon and for taking holidays when they felt like it. Observing 'Saint Monday' was a widespread practice, often protracted so as to include Tuesday and Wednesday. In Birmingham, it persisted as a major problem for employers until the 1850's, when it was surrendered in exchange for the Saturday half-holiday.63

To create, maintain, and expand the new industrial system required the widespread acceptance of an ordered array of values by which people in different positions in the system set their aims in life and guided their day-to-day actions, and these values were inculcated in a variety of ways. For the new factories to operate at all, there had to be specified a set of entirely new work-roles, each with its own set of entitlements and

constraints; there had also to be disciplinary codes, in order to confine admissible conduct within the new constraints. In all these senses, the new industrialism marked the host society with its own special imprint. The people who became subject to the system were, so to speak, processed by industry into human resources.

Ultimately, factory discipline rests on workers being there to be disciplined. Obvious as this is, it proved to be immensely difficult to ensure with a work force brought up to believe that they were their own masters. "I found the utmost distaste," said one hosier who gave evidence to a Parliamentary Committee in 1806, "on the part of the men, to any regular hours or regular habits.... The men themselves were considerably dissatisfied, because they could not go in and out as they pleased, and have what holidays they pleased, and go on just as they had been used to do." What 'they had been used to do' might also mean that, on their return, they would 'work desperately, day and night'; this, however, also met with disapproval, since - clearly - they did so only to pay off their score for drink and to get more money for dissipation.

Others found that their employees went off at harvest time, or go back to agricultural work entirely. This was especially complained of by those factory-owners and other employers who could not guarantee regular work - an interesting instance of the dual code for manual workers and for employers and managers that was to become so durable a feature of conditions of work in British industry.

Late timekeeping met with heavy fines, and it was common practice to lock the factory gates and shut out those who were a couple of minutes late.

It was in fact machinery that created the need for discipline. To justify the capital outlay they needed, goods had to be produced on time, of a quality and in quantities which would pay for it. Destroying any freedom the ordinary worker had in the past to use his time as he wished was a necessary first step in disciplining his working practices. For Dr. Andrew Ure, the outstanding apologist of the factory system, it was this that made Arkwright the greatest of the pioneers of the new industrialism: 'To devise and administer a successful code of factory discipline, suited to the necessities of factory diligence, was the Herculean enterprise, the noble achievement of Arkwright.'

Punishment for infringements ranged from beatings and fines to dismissal and blacklisting. According to Pollard, dismissal and the threat of dismissal were the main instruments of deterrence, but fines were widely used, and much more frequent. "Their general level was high and was meant to hurt"; typically, they amounted to from two hours' to two days' wages. Blacklisting is an obvious measure for groups of neighbouring employers to take against persistently ill-disciplined workers, but it came into its own (and has stayed ever since) as a means of penalising 'trouble-makers' - i.e., those who

64 Quoted S. Pollard, "Factory Discipline...", p.255.
65 S. Pollard, "Factory Discipline...", p.256.
opposed discipline and control, and especially those who were in the forefront of wage demands and protests against conditions of work:

"The law could usually be assumed to be at the service of the employer, and was called into service for two types of offence, breaches of contract and trade-union organization and rioting. Workmen's combinations were widely treated as criminal offences in employers' circles, even before the law made them explicitly such, and, in turn, the legal disabilities turned trade disputes easily towards violence, particularly before the 1790's. In the Scottish mines, serfdom was only just being eradicated, and in the North-East the one-year contract, coupled with the character note, could also be used to impose conditions akin to serfdom; opposition, including the inevitable rioting, was met by transportation and the death penalty not only in the mines, but even in such advanced areas as Etruria as late as 1783.

"Where their powers permitted, employers met organization with immediate dismissal.... More widespread, however, was the use of blacklists against those who had aroused the employer's disfavour.... as more evidence is becoming available, it is increasingly obvious that they were a most important prop of that reign of terror which in so many works did duty for factory discipline."68

The factory not only swallowed up the day; for common people, the very nature and meaning of time underwent wholesale reconstruction, as E.P.Thompson has spelled out at some length,69 and it is this which has made the deepest and longest-lived impression.

Work under the new factory regime meant a six-day week and up to sixteen hours a day - and sometimes more. The first attempts to limit hours of work by legislation to twelve hours a day applied only to 'pauper children', then to children between the ages of nine and sixteen. But the latest of these Acts, passed in 1819, could still be, and was, evaded by employers. Nor was there any attempt by Parliament to restrict the working hours of men or women, or of children other than those working in cotton mills.

Over four-fifths of the workforce in cotton-mills were women and children. There were more children under eighteen than women in the industry as a whole. Some of the bigger firms had more; in 1816, 73 per cent of Horrocks, Miller and Co.'s workers were under eighteen, 13 per cent under ten.

So it was on women, and, still more, children, that the new methods of factory discipline were tried out. As we are repeatedly told, child-labour was nothing new. But traditionally, it was their parents who directed and controlled their children's work. Mass employment "removed the incentive of learning a craft, alienated the children by its monotony and did this just at the moment when it undermined the authority of the family, and of the father in particular." Instead, they were supervised by "untrained people whose incentive for

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68 S.Pollard, "Factory Discipline...", p.262.
driving the children was their own piece-rate payments."\textsuperscript{70} Not surprisingly, beatings figured largely in the evidence given to the series of Factory Commissions after the turn of the century.

\textsuperscript{70} S. Pollard, "Factory Discipline...", p. 259.