Some British Artists and the Industrial Revolution

—— Interaction between the Arts and Eighteenth-Century Science and Industry ——

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Abstract : Like all great social movements, the Industrial Revolution influenced the arts. In Britain, as elsewhere, these influences led to changes in the ways writers and artists perceived and presented their world and also to the techniques they used. Some of these influences are obvious ; others are more subtle and their full importance is only now beginning to be realised. This paper will discuss these matters, concentrating mainly on the visual arts but with some reference to music and 'useful arts' such as architecture and ceramics as well. We begin with a short analysis of the Industrial Revolution in Britain, and go on to an overview of the direct and indirect changes which it brought about in the art world in Britain. After an outline of the fine and useful arts as they were regarded in the eighteenth century, there will be more detailed study of specific artists, in a wide sense, in various fields, especially Joseph Wright of Derby, de Loutherbourg and John Martin (painting), Josiah Wedgwood (ceramics), Thomas Telford (bridge design and building) and John Harrison (horology).

Introduction

There is a sense in which the Industrial Revolution has always been with us. When the first hominid chipped a stone into a better shape for use as a hand-axe, a step towards technological civilisation was taken. When the wheel was invented, when the first windmill was made, when Richard of Wallingford made his clock at St Albans (FB 27), when Gutenberg printed the Bible, all these events were steps along the road to an industrial society. But the critical requirement for what we now call the Industrial Revolution was the birth of a new frame of mind in which precise observation and experiment, not rules-of-thumb, guesswork and recourse to divination and sortilege, were to be the norm for acquiring knowledge and praxis. Already in the fifteenth century Leonardo da Vinci had grasped the principles of scientific analysis, as his sketches of human anatomy show. Galileo's experiments and, perhaps most important for England, the work of Francis Bacon, Lord Verulam, culminating in his advocacy of scientific method and deduction from observation and experiment in the *Novum Organum*, published in 1620, began a new era for knowledge. It is a question how far the opposition of the Roman Catholic Church to rational scientific enquiry held back progress in western Europe, but there can be no doubt that the growth of such enquiry in England, leading to the Industrial Revolution, was due to a more liberal intellectual climate.

There are several ways in which England was peculiarly suited to the development of industry and science in the seventeenth and eighteenth centuries. In addition to the intellectual foundations laid by Bacon and developed by such figures as Newton and Boyle, there were other factors to encourage the birth of a new type of society based on scientific progress. In spite of widespread inequalities in social class, there was in some respects a more relaxed social climate which may be traced back to the Peasants' Revolt of 1381. In seventeenth century France, as the comments of La Bruyere show (LB 37), the gap between nobles and peasants was perceived as so great that they might almost be regarded as different species. But as G. M. Trevelyan points out (GT 340), in England the outcome of the Peasants' Revolt, in spite of its apparent failure at the time, had been a broader consensus over social rank and an atmosphere in which co-operation between socially disparate elements was possible. There were obvious exceptions to this ; the steady enclosure of land, for example, which began in the sixteenth century and went on for over two hundred years, gradually caused the true landowning peasantry to dwindle in numbers while landless labourers increased (GT 375). This facilitated the drift to the towns and to the mushrooming mills of the new industrial world (DG 101), where, at least to begin with, the lot of the ordinary workers, and especially children, was miserable indeed. However, in general the working classes were less dissatisfied and better fed than elsewhere, as pointed out by Dorothy George (DG 25–28). A related element in both the development of the Industrial Revolution and harmony in British society was the growth of the British Empire, itself the product of several factors, notably the cementing of ties between England and Scotland, culminating in the Union of 1707, and the impetus given to aggressive colonisation and exploration by the success of the British army and navy in a series of wars with France. Seen in this context, the psychological effect of the victory of John Churchill, Duke of Marlborough, over the army of Louis XIV at Blenheim in 1704, can hardly be overestimated. Such victories not only helped the British people to feel united in triumph, they also paved the way for the adventures in India and North America and the growth of trade between the colonies and England, leading to a need for factories to process the raw colonial materials, such as cotton, and to make iron and steel for the machines for such factories, all of which the new industrial scene was able to satisfy. By slow degrees, these developments altered the whole face of society ; Britain changed from a rural and fishing society to an urban, manufacturing one and, after a long period in which the workers suffered much privation at the hands of powerful and unprincipled mill-owners and entrepreneurs, a more generally prosperous and healthy scene emerged. In a sense, it is only now, at the turn of the twenty-first century, that the benefits of the Industrial Revolution are apparent and despite persistent inequalities a society of fair shares and equal opportunities for all is, in theory at least, attainable where, three hundred years ago, it was not.

How did all this affect the arts? It affected them in both direct and indirect ways. In the first place, the Industrial Revolution produced new techniques in fields related to the arts. The visual arts profited from the development of optics and techniques of theatrical lighting and staging to make possible such things as the Eidophusikon of de Loutherbourg, and, in the mid-nineteenth century, photography, leading ultimately to the cinema and television. New engraving techniques, notably the mezzotint, made it possible to make high-quality pictures in metal for printing. Mass-production of printed material helped to develop popular novels in the nineteenth century ; it is a question whether the great English novelists of the time would have been so successful without the technological advances which backed up their work. Ceramics and related arts took benefit from new methods, both in materials and manufacture, including the birth of mass-produced quality pieces, and this is one reason for the contemporary and lasting fame of the work of Josiah Wedgwood. Improvements in smelting iron led to larger and stronger pieces of metal becoming available which revolutionised the building of bridges and led to a new set of artistic criteria for large structures, such as the suspension bridges of Thomas Telford. The new machines, great and small, of the new era gave their makers new ways of combining usefulness with beauty, as anyone can say who has considered the mechanical charm of John Harrison's chronometer H 4, which set new standards of timekeeping by its voyage to Jamaica in 1761 (RGC 55), or the elegant power of Daniel Gooch's broad-gauge locomotives for the Great Western Railway in the 1840s (LRB 206). It is also not too much to say that better types of metalwork changed music by making possible, through stronger framing, the modern pianoforte (RB). In England, Muzio Clementi facilitated the composition of music with his new and improved pianos (RB), which could not have been made without the technological advances of the preceding century.

Indirectly — and here perhaps is the greatest and most obvious gift of the Industrial Revolution to the fine arts — the progress of the eighteenth century provided artists and their patrons with new ideas and ideals. Painters like de Loutherbourg and Joseph Wright of Derby responded enthusiastically to the energy and fierce colours of industry, the flames of the great furnaces and the power of machines, and after the start of the Railway Age, the locomotive figured in some important works. This response continues right down through the work of Turner and the French Impressionists like Monet. Response was not entirely favourable, however, and here, in a way, a negative reaction gave rise to highly positive productions like the poems of William Blake and William Wordsworth, who saw in the Industrial Revolution dangers which were then often ignored, but which we now feel more concerned about in our own age of massive environmental degradation.

A sometimes neglected influence of the Industrial Revolution on the arts lies in the development of wider patronage for artists. In earlier times, British patrons were chiefly kings and nobles, who had provided work for such painters as Holbein, Van Dyck, Kneller and Lely. Country landowners in the early eighteenth century gave their support to painters, as we can see in one of the most famous portrait-landscapes of the time, Gainsborough's *Mr and Mrs Andrews.* But in due course the rising industrialists wished to have their status confirmed through works of art. Josiah Wedgwood performed a dual role, as artist in the design and creation of decorative and useful wares and as a patron of art, notably of Stubbs and Wright of Derby (SD 53). By the mid-nineteenth century the captains of industry were giving full support to artistic endeavour and industrial cities like Leeds and Oldham added to the artistic scene by opening museums and galleries where their cultural aspirations could be reflected in the works of British painters. A late, and impressive, example of the patronage of commerce is the collection of mainly nineteenth century British paintings in the private gallery of Thomas Holloway, proprietor of a well-known type of medicine, which was finally installed in the college he founded in the University of London, Royal Holloway (JC 9). None of this would have come about without the impetus of industrial development.

All in all, the Industrial Revolution was also an Artistic Revolution, and in the following pages we shall look at some of the key figures and artworks of the eighteenth and early nineteenth centuries in Britain and see how they reflect the direct and indirect influences of the Industrial Revolution.

Fine Arts and Useful Arts in the Eighteenth Century

As a first stage, we must decide just what were considered arts in the eighteenth century. It has been observed that in earlier times no clear demarcation existed between art and science, or between that which is mainly beautiful and that which is mainly useful. In mediaeval times, such science as existed was inextricably mixed with poetry, for example in the 'music of the spheres' so charmingly referred to in Lorenzo's explanation of the stars to Jessica in Act V of *The Merchant of Venice.* The Royal Society, officially the Royal Society of London for Promoting Natural Knowledge, was given its charter by King Charles II in 1662. Its early members included not only Robert Boyle, who developed Boyle's Law, and Sir Isaac Newton, but also Pepys and Evelyn, the diarists, and Sir Christopher Wren, who collaborated as an architect with John Flamsteed, the Astronomer Royal, and Thomas Tompion, the horologist, in the creation of the aesthetically magnificent Royal Observatory at Greenwich which was to house apparatus for precisely measuring time to help astronomical observations (AH VII i 24). Science, or 'natural philosophy' was seen at this time as part of a continuum of human knowledge and skill, which stretched from observation and measurement to imagination and beauty, and there was no clear consciousness of any gulf fixed between them. The relevance of both arts and the business world to contemporary culture was recognised by the foundation of the Society (later Royal Society) for the Encouragement of the Arts, Manufactures and Commerce, in 1754. It was only by a gradual process that art and science, imagination and measurement, came to be compartmentalised, and by the mid-nineteenth century the men of science had come to dominate the Royal Society (the RSA was not so quick to sever connections between fields of human endeavour and has been a leader in the development of such things as industrial design). Now there are signs of a return to a more eclectic approach, though we still tend to divide university studies into 'arts' and 'sciences', and it was a far-sighted move when the University College of North Staffordshire, later to become Keele University, decided in 1949 to require arts students to take a science subject as one element of their course, and science students to do *vice versa.*

The early eighteenth century was poised at the delicate point where science was beginning to be seen as a distinct world from art, but contact between art and science quite reasonable and desirable. In the same way that art and science were seen as a cline, we can see within the arts a cline from those which are purely decorative to those which are predominantly for use. Indeed, the word 'artist' could sometimes be applied to what we would now call a craftsman ; the French composer Couperin's harpsichord piece 'l'Artiste' (Book 3 of the *Ordres pour Clavecin,* 1722) has been held to depict such a person (PB), and we find also Pope's *Iliad* referring to the armourer Hephaestus as 'the lame artist' (see note 1 at end). The accepted arts in eighteenth century Britain ranged from music and painting through sculpture, architecture and ceramics to the design of more severely practical objects like bridges and machinery great and small, the early stationary steam engines, the beginnings of the locomotive and the chronometers which were to change the face of marine navigation help explorers and empire-builders.

Although this present study will not specifically concern itself with the written arts, they too are intricately involved in both aesthetic and functional considerations ; a poem like Erasmus Darwin's *The Botanic Garden* is both an exercise in metrical self-expression and a treatise on science, while certain of Wordsworth's poems, and his introduction to the *Lyrical Ballads,* are not only of aesthetic importance but also a commentary on some of the anxieties felt over the development of technology. Blake — a special case — is involved both as artist and writer.

Painting

Joseph Wright of Derby

There are two painters who can be considered of vital importance to our understanding of the relationship between the Industrial Revolution and the arts in Britain. The one now esteemed as the greater, and of increased popularity today, is Joseph Wright (1734–97), commonly called 'Wright of Derby'. His association with that town is important for two reasons : one is that his residence there led to some of his most important works being in the town's art museum ; the other is that Derby was at the heart of the early Industrial Revolution because of its coalfields and the development of many kinds of industry, and the home of a number of figures who were influential in both the art and scientific worlds of the time, all of whom were in contact with Wright and who affected his work in various ways.

Joseph Wright was born in 1734 ; his father John was an attorney and also Town Clerk of Derby. Young Joseph's first attempts at artwork came at the age of fourteen ; his formal training began three years later when he was bound apprentice for two years to Thomas Hudson, a London portrait painter. This was the time when 'face-painting' was highly fashionable among the rich and in his lifetime Joseph Wright was at least as highly esteemed for his portraits as for his landscapes and other works. Hudson was one of the most prestigious (and expensive) teachers of the art of portrait-painting, and Wright made good use of his time as an apprentice. Returning to Derby, he associated with a number of distinguished figures in local society, including Brooke Boothby, a literary figure of importance for his editing of Rousseau, Peter Perez Burdett, the cartographer, and John Whitehurst, a member of the Royal Society, a man of varied talents, famous not only for his skill and originality as a clock-maker but also as a geologist. The Derby area, with its unusual and at times dramatic rock-formations, was an ideal place for geological investigation and Wright's portrait of Whitehurst (1772–3) shows him working on a sketch of a section of Matlock Tor (Wright himself made some sketches of Derbyshire rock-formations). Perhaps through Whitehurst, Wright came to know some members of the Lunar Society (of which, however, he never himself became a member). These included Josiah Wedgwood and Erasmus Darwin, who both lived at Stoke-on-Trent, no great distance from Derby. In the 1760s Wright began the famous series of science-and-industry-related pictures which are now so well known, including *A Lecture on the Orrery* (see note 2 at end) and *An Experiment with a Bird in the Air Pump.* In the 1770s to these were added his paintings of iron forges and *The Alchymist.* Following his marriage in 1773, Wright made an extended trip to Italy, where he did his spectacular paintings of Mount Vesuvius, in which the fires of nature replaced those of industry as a source of illumination, handled with a skill which stands comparison with Claude Lorrain and Rembrandt. Wright then remained in Derby for most of his life, suffering with increasing frequency from bouts of depression and ill-health which often interrupted his painting activities. His later works include, however, some of his best portraits (including the celebrated one of Richard Arkwright) and, shortly before his death in 1797, some fine pictures of the Lake District.

From the point of view of the influence of the Industrial Revolution, two paintings by Wright are of outstanding importance. These are *An Experiment with a Bird in the Air Pump* (1768) and *An Iron Forge* (1772). The first of these paintings is the more profound, but both of them show the impact of industry and science on society and some of the attitudes evoked and moral problems presented.

These paintings are of the type known as 'candlelight pictures' in which a group of persons is shown 'concentrating on some object in darkened interiors, their faces and expressions brilliantly illuminated by a candle flame' (SD 32). This type of painting was exploited with great success by Wright, not only for homely subjects, but also for scenes showing the growing vogue for scientific experiment. In *The Air Pump,* some people are gathered round a table on which stands a contraption with a glass vessel at the top, in which lies a white cockatoo, in great distress from the vacuum which has been produced by the action of an air-pump. The lecturer, behind the pump, is on the point of releasing the valve so as to readmit air to the vessel, and presumably save the life of the unfortunate cockatoo. On the left of the picture stand two young people, a man and a woman, who appear at first sight to be more interested in one another than in the experiment which is going forward. In front of them, a man and a young boy are watching the experiment with fascination. On the right is a pathetic group. Two little girls, presumably the owners of the cockatoo, show great anxiety : the elder of them is hiding her eyes with her hand as if she cannot bear to watch. Behind them, an older man has one hand comfortingly round the elder girl, while with the other he points to the cockatoo as if to indicate that the lecturer is about to open the valve and save their pet's life. Near the girls, another older man is sitting with a serious expression on his face ; he appears to be looking at a piece of human skull in a glass filled with a liquid, perhaps related to another part of the lecture (see note 3 at end). The group is completed by a small boy on the right, who is pulling on a cord to raise or lower the cage in which the bird had apparently been kept until the experiment. Near him, a ghostly moonlight seeps in through a small window.

The more one looks at this painting, the more one is intrigued not only by its consummate technique but by the ambiguities expressed in the figures and their actions. In the first place, the light source is plainly some sort of candle or lamp, but just where is it? It appears to be behind the glass containing the skull fragment, which is thrown into sharp relief, and one wonders whether this fact is supposed to have some kind of symbolic significance. The old man : is he indeed looking at the skull, or does his pensive look relate to reflection on what good can really come out of experiments like these? The young couple on the left : are they engrossed in one another, or is it perhaps that the young woman is commenting to her companion on the cruelty being inflicted on the cockatoo? Her expression might suggest this, and the young man's rather abstracted gaze could reveal a mental conflict between distaste for the cruelty and enthusiasm for the scientific value of the experiment. The world's first comment on vivisection, perhaps? Is the other older man with the girls showing optimism over the bird's eventual fate, or trying to say that one must make sacrifices for the sake of progress (suggested by Kenneth Clark, KC 257)? Lastly, there is the figure of the lecturer himself, a wild, dishevelled visionary, an 'enigmatic magus-like figure, with one of the most haunting expressions in eighteenth-century art' (SD 41), whose eyes look, not at his audience or at us, but as if staring at the Future of Science.

This picture might be said to sum up the enigma of the era of the Industrial Revolution and its scientific foundations ; how far is it good, is this really progress, what can we think about it, how differently are different people affected by it? A significant point is that we cannot tell, from the picture, whether the bird will survive or not. At our present position in time, with a wider view of all that science has achieved, including the atomic bomb, we do not know whether science will allow the human race to survive or not. Joseph Wright's painting says more to us today than its creator may have dreamt of.

The other painting by Wright which we shall consider in detail is *An Iron Forge* (1772), sometimes called *An Iron Forge Viewed from Within* to distinguish it from *An*

Iron Forge Viewed from Without (1773), which shows what appears to be the same place, but looking in through a demolished side-wall. The earlier picture has more cogency from the fact that we are viewing the scene and its actors from close to. The outer margins of the scene vanish into darkness, but the centre is lighted by the glow of a white-hot ingot, held by a worker who crouches down with his back to us in the foreground of the picture. The ingot is being shaped by the action of a huge hammer operated by a cam driven by water-power. In the middle of the picture, seen over the crouching form of the worker, the young and well-dressed forge-master stands with folded arms, looking with rather stolid affection at his wife, who stands nearby on the right, holding their baby daughter, while the elder daughter has her arm round them. On the left, in silhouette like the worker, is an old man, evidently the forge-master's father, who sits gazing at the glowing ingot, though we cannot see his expression because it is covered with his hand. The family dog, walking behind the elder daughter. completes the scene. The message of the picture is simple, though also with some intriguing ambiguities. In a sense the real hero of the scene is the water-wheel, the mechanical device which does most of the work ; the forge-master can afford to stand there in his fine clothes because the use of water-power spares him from having to help his man with the work. He is prosperous and can be proud of his elegant wife and fine daughters. But what are the workman and the father thinking? The forge-master is content with his lot, but is the workman, whose back is turned towards us, wondering when his own will improve? Does the father's concealed face show his wonder at the development in his craft, or is he thinking that his son is more fortunate than he had been? Or does he feel that young people are now spoilt by the new inventions that simplify their labour? We are left to interpret for ourselves.

Before we leave Joseph Wright, we can consider some other ways in which he exemplifies the influence of the Industrial Revolution. One is in his treatment of landscapes. Not only did he make paintings of industrial landscapes, such as the highly atmospheric moonlight scene of Arkwright's cotton mill at Cromford (1783), but also highly charged expressions of the 'sublime' in his dramatic views of a firework display in Naples (1775) and of Vesuvius in eruption (a series of thirty paintings between 1776 and 1780, mainly from sketches made in Italy and then worked up in England after his return). These are not only full of the same energy and sense of power that we find in his industrial paintings, but also the product of his interest in geology and vulcanology as a result of his friendship, already mentioned, with John Whitehurst (SD 65).

The other group of paintings connected with industry, and they are important *per se* as well as providing a record, consists of works painted for, or portraits of, friends and clients who were leading figures of science or industry. These include the famous paintings of Sir Richard Arkwright (1789–90), Jedediah Strutt, a textile magnate (1790) and Erasmus Darwin (1792), all now in the Derby Museum and Art Gallery, and an earlier one of Peter Perez Burdett and his wife (1765). There is also the painting already mentioned of John Whitehurst (c. 1782–3), and Whitehurst is said to have been the model for the imposing lecturer in Wright's painting of *A Lecture on the Orrery* (c. 1766). His association with Josiah Wedgwood led to a commission for a painting on a classical theme, *The Corinthian Maid* (c. 1782–5), based on a legend about the origin of ceramic portraiture, and intended by Wedgwood to be used as an advertisement for his work.

Some space has been devoted to Wright in this paper because his work is central to the contact between art and the sciences and industry in eighteenth century Britain. His importance both as an artist and as a historical figure is only now becoming apparent, evaluation having been effectively begun by Francis Klingender in the 1940s.

Philip James de Loutherbourg

A native of Alsace, de Loutherbourg (1740–1812) is of interest to the student of art and the Industrial Revolution not only because some of his paintings are of industrial subjects, in which role he is often spectacular, but also because of his technically innovatory experiments which brought revolutionary ideas to art and give him a claim to be the father of the cinema and of the colour reproduction of paintings. In his youth he worked in Paris under Van Loo and Francesco Casanova and was admitted to the French Royal Academy of Painting and Sculpture, where he was warmly supported and admired by the *encyclopédiste* Denis Diderot. He came to England with an introduction to David Garrick, and then began his long association with theatre-connected art. Indeed, many of his paintings are theatrical in their feeling and inspiration, such as the celebrated *Coalbrookdale by Night* (1801), which shows the buildings on the side of the river valley silhouetted against a background of gigantic flames. This can be seen both as a commentary on the energy of the Industrial Revolution and as a criticism of its destruction of the environment. But it is above all a theatrical statement, a glorified version of the stage backdrops for which he became famous while working under Garrick. He invented the act drop, an intermediate curtain with scenery painted on it which could be lowered so that scene-shifters could change the set behind it while the actors continued their performance in front.

> De Loutherbourg's stage innovations were ambitious and hugely imaginative. These were all intended to further illusion and to encourage the audience to suspend disbelief. He utilised spectacular new devices, such as the introduction of mechanical scene drops, which prevented interruptions from stage hands, and subtle lighting which could be changed by the use of silk screens and transparencies (AC 4).

His most original activity, however, was the extraordinary entertainment called the Eidophusikon ('image of nature'). This has been variously described as 'a mechanical theatre, a miniature stage, a diorama, a panorama or a physiorama' (AC 6). Originally set up in de Loutherbourg's own house, it was later moved to the Exhibition Rooms in the Strand. It seems to have resembled a *camera obscura* (see note 4 at end), but with an aperture about 6 feet square through which viewers saw pictures skilfully illuminated and enhanced with reflecting mirrors. 'Tiny mechanical actors' performed dramas to the accompaniment of vivid lighting and sound effects (AC 5). One of the handbills still extant, shown here (from AC, 1, reproduced from Altick's *The Shows of London*), mentions the most popular and spectacular of the scenes presented, the *Grand Scene from Milton,* in which Satan harangues his troops on the Fiery Lake (Paradise Lost, Book 1). The Eidophusikon was enormously successful following its appearance in 1781, and although eventually sold by de Loutherbourg, went on into the early years of the next century, when it was burned down (FK 87).

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In later life, de Loutherbourg seems to have become for a time less interested in painting and devoted his attention to faith-healing, which resulted in his house being attacked by a mob (JA). He then reverted to painting, mainly of religious and historical scenes for publication, and some large marine canvases (John Sutherland in DB 151). Subsequently he worked on a new technique for reproducing the colours of paintings for mass-produced copies. All in all, he pioneered the mechanical advances of the Industrial Revolution for artistic purposes as well as painting scenes in which its energy — and its environmental disruption — were shown.

John Martin

Before we leave painting, it seems appropriate to mention an artist who belongs to the nineteenth century but is a bridge between the early artists of the Industrial Revolution and the development of the Romantic Movement. John Martin (1789–1854) astonished his contemporaries with his immense paintings of cataclysmal events. Martin, 'it has recently become clear. . . . . like Loutherbourg and Blake, was influenced by popular millenarianism, which claimed that the materialism and war which characterized the age heralded the immediate destruction of man, as prophesied in the Bible' (David Bindman in DB 156). The lurid colours and displays of violent fiery energy remind one of Wright's paintings of Vesuvius as well as de Loutherbourg's paintings of industrial landscapes. In one of his earliest canvases, *Sadak in Search of the Waters of Oblivion,* we see in the background a vast range of high mountains, glowing red as if by intense heat, while in front of them lies a wide lake which spills over in the left foreground into a seemingly bottomless abyss. To the right, we barely notice the tiny nude figure of Sadak, displayed with his back to us, as he heaves himself in utter exhaustion over the top of a cliff in order to throw himself into the lake. One of Martin's most admired pieces, *The Fall of Babylon* (1819) also shows a huge expanse of water in the middle distance, while in the background stretches an immense city, with ziggurat-like buildings wreathed in fiery clouds and struck by lightning-bolts, while in the foreground women stretch out their arms in attitudes of despair while, on the terraces below them, countless numbers of tiny people dash about in panic. Perhaps the most remarkable of Martin's works, and the one most highly esteemed in his lifetime, is *The Great Day of His Wrath* (1852), part of a trilogy representing the end of the world and the Last Judgment. On either side of the canvas the ground rears up and explodes in huge pieces, while in the distance molten rock and shafts of lightning combine in a colossal fireball; in the foreground dozens of naked figures, their faces hidden in their hands or turned away in despair, fall over one another as they are sucked down into a vast chasm opening beneath them. The scene is perhaps more convincing from the fact that Martin was a trained geologist and saw the end of the world as a geological event(WV 237). The three great eschatological paintings were immensely successful and went all over Britain and America as a travelling exhibition for twenty years. Martin lost favour with the critics, however; his scenes came to be perceived as vulgar and sensational and the trilogy sank from view and was finally sold in the 1930s for the derisory sum of £9.00 (WV 237). Martin himself seems to have been a very complex figure who combined metaphysical despair over the fate of humans in the wake of their misuse of Nature with a great eagerness to improve them, shown by his interest in various urban improvement schemes and designs for ships and railways. David Bindman suggests that he may have wished to help humans to avert disaster by creating the New Jerusalem mentioned in Biblical prophecies (DB 156). He certainly seems to have been something of an outsider, quarrelling with the Royal Academy and at one time being known as Mad Martin, though this seems to have been less for his paintings than from the circumstance of his brother having tried to burn down York Minster(SW). As an artist whose subjects are drawn from epic and Biblical sources combined with a strongly romantic approach and with elements from the art of the early Industrial Revolution, John Martin is a curiosity of the highest interest.

Etchings and Caricatures

The eighteenth century showed a great increase in the quantity of pictures and other materials reproduced for publication. A favourite medium was the etching, made by printing from a plate, usually of copper, in which a design had been made by the corrosive effect of acid. The first artist known to have used this technique was the Swiss Urs Graf in 1513, and it was used outstandingly in the following century by Rembrandt, at the same time that it was being developed in England by the Czech Wenceslaus Hollar. In 1771 the invention of aquatint made it possible for etchings to imitate watercolour.

Etchings were widely circulated and many of them had a topical content. Inevitably, many of them were connected with the Industrial Revolution. The arrival of gas-lighting in London in 1820 was greeted by satirical commentary like the Rowlandson etching in Dorothy George's *England in Transition* (DG Plate 12); passers-by in Pall Mall talk about the new invention, and a prostitute and her ponce are shown having the following conversation: "If this light is not put a stop to we must give up our business. We may as well shut up shop." "True, my dear, not a dark corner to be had for love or money."

Klingender's *Art and the Industrial Revolution* reproduces many line drawings, etchings and aquatints showing motifs from industrial life. Some of these are in effect technical drawings of industrial machines, such as stationary steam engines. The idea of technical drawing progressed quite quickly from more or less naturalistic sketches, showing surrounding countryside and people, such as *The Engine for Raising Water by Fire,* 1717, through the perspective drawing of *A Steam Engine of 20 Horse-power by Fenton and Co, Leeds* to precise elevations and plans, made to exact measurements, like the coloured line engraving of *A Locomotive Engine,* published in 1848 in the book *Diagrams of the Steam Engine,* though earlier examples of this kind of exact mechanical drawing can be found (see AB 48, fig. 12). The best of both the naturalistic and precise types of drawing show a high degree of artistic skill, but the general superseding of the former by the latter might be seen as paralleling the growing divide between art and science described near the beginning of this paper.

Caricature, the art of exaggerating the features of people for humorous and (frequently) satirical effect, greatly increased in incidence and scope in the eighteenth century. James Gillray (1756–1815) is probably the greatest English artist working in the medium of the caricature, which became a staple feature both of broadsheets and more serious satirical publications, or just individual reproductions. His fierce political satires, aimed at many people, especially Whigs and supporters of reform, and also the Royal Family, do not concern us here, but he also satirised the contemporary interest in scientific experiments. His etching *Scientific Researches . . . an Experimental Lecture on the Powers of Air* (1802), in which several figures from the London scientific world are caricatured, can be seen as a hilarious low-life contrast to Joseph Wright's high-minded *An Experiment with a Bird in the Air-pump.* One wonders if Gillray could have seen this painting, or at least heard a description of it. Like the painting, Gillray's etching shows a group of fashionable people gathered round a table laden with scientific apparatus relating to pneumatics, and like the Wright, it indicates that research sometimes has its unpleasant side. Gillray's comment, however, is less than high-minded. The lecturer, identified by Klingender as Dr Thomas Garnett of the Royal Institution, has been pumping air into the mouth of Sir John Coxe Hippisley, who stands at one side of the table (FK 188). Unfortunately, this has caused Sir John to let fly a tremendous fart, destroying his breeches and subjecting the spectators behind him to malodorous fumes, as their expressions make clear. In their high and low ways, both Wright and Gillray might be said to justify Kenneth Clark's comment that at this time in history, at least among the middle classes, 'science was . . . an after-dinner occupation, like playing the piano in the next century' (KC 257). It was perhaps only when science both changed our daily life and showed itself a threat to religion, that people began to take it seriously.

Music

Leaving the visual arts altogether, when we look at music it is at first hard to find any obvious influence from the Industrial Revolution beyond a Handel aria in which the organ is addressed as 'harmonious Machine!' However, it can be said that various developments in the world of industry produced not only new machines for helping in daily life but also mechanical contrivances which helped music. One area already touched on is that of improvements in stagecraft which affected not only regular plays, but also opera. Paradoxically, this had little effect in England at first, because opera, so successful after its introduction to England by Henry Purcell, suffered an eclipse in Handelian days as people flocked to the great German immigrant's successful oratorios. However, it can hardly be a coincidence that the century which saw a rise in the importance of the machine saw much interest in new musical instruments and what were seen as improvements in old ones. Towards the end of the eighteenth century the Baroque violin and bow changed (shorter, more angled fingerboard ; heavier, differently-shaped bow) in ways which encouraged a more mellow, but less incisive sound, which accorded well with the changes in the style of music away from the contrapuntal style of the Baroque and Rococo towards the larger orchestras and fuller, more overtly emotional uses of sound of the Romantic era (EM-BBC). To put it simply, there is a world of difference between the technique and the sound of a Bach suite and a Beethoven quartet, quite apart from the actual written music, and this difference is even more marked if (as increasingly happens) the music is played on instruments of contemporary pattern.

As music changed towards the end of the eighteenth century away from interest in pure form and from a dynamic in which *piano* and *forte* were contrasted in blocks of sound, as had been more usual in Renaissance and Baroque music, towards a dynamic in which frequent *crescendo* and *diminuendo* became more important, so certain instruments were changed to conform to this requirement.

In the case of the organ, an early type of swell-box was invented in 1712 by Abraham Jordan (NG vol. 18 607) but no eighteenth-century music really requires it, and swell techniques only appeared in organ music in the mid-nineteenth century. It is a very different story with the harpsichord.

It is a curious fact that while there is fine music for the harpsichord from J. S. Bach, Handel, Louis and Francois Couperin, Rameau, Domenico Scarlatti and many other composers, no English native after the time of King Charles I wrote first-rate music for the harpsichord. In fact, there is little post-virginalist English harpsichord music of any kind apart from a few modest suites for teaching purposes by Purcell and his imitators and those of Handel. This did not stop the harpsichord, and its small, country-cottage version the spinet, from becoming a very popular instrument in England (if expensive ; according to John Brewer (JB 535) a good harpsichord in 1770 might cost fifty guineas, £52.5, compared with £3.5 for a violin). It would have been used as an accompaniment to singing and for continuo in consort music, for solo performance of music by Handel and continental composers, as far as such music was ever available, and for playing the numerous run-of-the-mill keyboard teaching manuals mentioned above. It is interesting to find that the greatest technical innovations in harpsichord construction were made in English instruments. Jacob Kirckman, a German, and Burckardt Tschudi, a Swiss who later Anglicised his name to Burkat Shudi, settled in London in the mid-eighteenth century and started companies for the making of harpsichords and, later, pianos. After about 1760, their harpsichords began to use new kinds of stops, especially the so-called 'machine' stop, which made it possible to change combinations of other stops, usually by depressing or raising a pedal, and the 'Venetian swell', which could vary the volume of the instrument by opening or shutting a series of shutters placed over the strings. There can be no doubt that these expressive devices were an attempt to imitate the flexibility of the piano, which was at this time growing in popularity, and also to make it possible to play early piano music more easily on the harpsichord (see note 5 at end). It is perhaps natural that such innovations, of a mechanical character, should have appeared in the country which had been so central in the development of 'machines' of every type. However, they failed to prolong the fading popularity of the harpsichord, and after 1800 both Kirckman and Shudi (and his partner and successor John Broadwood) concentrated more and more on making pianos until soon afterwards harpsichord manufacture finished altogether.

The piano, which began very tentatively about 1700 in Italy with the 'gravicembalo (harpsichord) con piano e forte' of Bartolomeo Cristofori, is a struck keyboard instrument using an escapement which will allow the striking hammer to fall back and leave the string still vibrating until a damper is applied. This allows far more volume and contrast than the earlier clavichord, in which the hammer remains in contact with the string until the key is released. The piano developed through the eighteenth century, and towards the end of that period the escapement was improved in England by John Broadwood and others to what came to be called 'the English action'. While Continental pianos developed numerous pedals, operating devices to produce buzzing or cymbal effects for such pieces as Mozart's 'Turkish March' in the Sonata in A, K. 331 (see note 5 at end), English pianos concentrated instead on producing a fuller amd more mellow sound. It has been observed that their tone is more harpsichord-like than German pianos of the time, suggesting an attempt to make the piano into a sort of more expressive harpsichord.

The final development of the piano was in America in the mid-nineteenth century, when metal framing and overstringing made for a much heavier and more sonorous instrument with up to eight and a half octaves. This lies outside our terms of reference ; however, it is worth mentioning that the move to a longer compass was much encouraged by the business acumen of Muzio Clementi (1752–1832), an Italian who settled in London and became famous at first as a composer and performer on the piano, and then as a manufacturer of pianos, the compass of which made them the only available instruments on which some of his very popular music could be played. He thus enriched himself and encouraged the development of his chosen instrument. Clementi's *Gradus ad Parnassum* is still a widely used piano-teaching book.

The Useful Arts

Josiah Wedgwood, Potter

Josiah Wedgwood (1730–1795) distinguished between 'ornamental wares' and 'useful wares', and we can do something similar with the arts, making a rather arbitrary distinction between the 'ornamental arts', such as painting, music and fine writing and the 'useful arts' like ceramics and architecture. Arbitrary, because all art can be considered, as Dr Johnson observed, as 'that which enables a man the better to enjoy life, or the better to endure it' and a well-made cup, a beautiful piece of music, an attractive residence, a perceptive novel or poem and a fine painting all help in their way to lift the human spirit.

Wedgwood himself is an interesting and ambivalent figure. Was he more of an artist, or more of a business man? His tomb, in front of his factory at Etruria, near Stoke, bears at his request the inscription JOSIAH WEDGWOOD, POTTER, but there is no doubt that this simple definition is not the whole story. He was driven by a desire to achieve perfection — the well-known story of his touring his factory daily and smashing imperfect work with his wooden leg, exclaiming "That's not good enough for Josiah Wedgwood!" may not be verifiable, but what we know of him suggests a strongly perfectionist urge. However, this extended to a wish for perfection in marketing his products as successfully as possible, and to this end he recruited all the new techniques of the Industrial Revolution. Helped from the beginning by his habit of recording in an 'experiment book' anything useful that he learned or invented about pottery, he successively devised an improved green glaze, the cream earthenware which came to be called 'Queen's ware', the black stoneware known as basaltes, the famous coloured jasperware, the pyrometer and the use of steam power to operate machinery in his factory, thus facilitating mass-production. He also made good use of ideas and products developed by others, probably the most important being his buying from Saddler and Green of Liverpool permission to use their invention of transfer printing for his classic style jasperwares. This greatly increased the speed with which his wares could be manufactured. His business skill also extended to advertisement ; he commissioned Joseph Wright to paint a picture (*The Corinthian Maid*) on a classical motif relating to the supposed origin of pottery sculpture, and also had George Stubbs, chiefly famous today as a painter of animals, paint a picture of himself and his wife with one of Wedgwood's vases prominently displayed. Stubbs later used plaques made by Wedgwood in his experimental paintings using enamels (DB 261).

Nobody who knows the classical vases and other vessels designed by Wedgwood (and his great employed worker in sculpture, John Flaxman), and his decision to make a jasperware recreation of the celebrated Roman glass Portland Vase can doubt that Wedgwood was far more than a talented mass-producer ; he was also a man of discernment who achieved the then undreamed-of feat of combining creative art and mass-production. Today many of his original elegant jasperware designs, and others of similar style designed more recently, are a continuing popular testimony to his taste and skill. Wedgwood must surely share with Joseph Wright — and, as we shall see, Thomas Telford — the distinction of having pre-eminently blended the contemporary influences of the Industrial Revolution and the individual genius of the artist to make things of beauty and usefulness.

Thomas Telford, Bridge-builder

The eighteenth century saw the creation of many fine buildings in Britain, and the men who built them — Sir John Vanbrugh, William Kent, Nicholas Hawksmoor, Robert Adam — are justly remembered. One class of architecture, however, owes a special debt to the Industrial Revolution and its chief exponent was as much an artist as an industrial engineer. He was Thomas Telford, son of a Scots shepherd, who gave Britain not only bridges but also fine roads of a quality not seen since the Romans, fifteen hundred years earlier. William Southey the poet dubbed him 'the Colossus of Roads', but for others he was 'Pontifex Maximus', the supreme builder of bridges (LRT 13).

Born in 1757, Telford never knew his father, for he died a few months after his son's birth. After a childhood of poverty, he went south to London, on foot, in 1781, to learn more about his chosen craft of stonemasonry. After working as an apprentice in London and Portsmouth, he began to interest himself in architecture and in particular with the construction of roads and bridges, and by the time he was twenty-nine he had become a surveyor of public works in the county of Shropshire, where he built a number of bridges, one in cast iron. In doing this, he was helping to pioneer a new era in bridge building, following the creation of the great cast iron bridge at Ironbridge in Coalbrookdale, in the same county. The iron bridge still stands, near the early factories of the infant Industrial Revolution, which are now a memorial museum to what many see as the beginning of that movement, though in fact it is impossible to point exactly to any one place or time as that of its origin.

What strikes one immediately on looking at the iron bridge in Coalbrookdale is how much its shape resembles that of the old stone bridges which had been put up in Britain, and indeed all over Europe, for over a thousand years. Using the simple smelting and refining procedures of the day, Thomas Pritchard, who had designed the bridge and then died, and Abraham Darby, who had built it, had used relatively short pieces of iron bolted together, having no notion of how to make a bridge apart from the traditional pattern. In any case, techniques at that time made it impossible to forge large pieces of iron. Telford was to show the world how to adapt the technology of iron to make stronger and longer bridges on so far unimagined patterns.

His early works, though spectacular, gave little hint of what was to come. In fact Telford's first famous work was 'the stream in the sky', an aqueduct on the Ellesmere Canal, running from Shropshire into North Wales, and one of the many canals which had revolutionised transport in Britain since the Duke of Bridgwater's early venture in the North of England in 1761. The Ellesmere Canal had to pass over the River Dee at Pontcysyllte, in the Vale of Llangollen. Telford's plan was for an aqueduct of nineteen arches, with the canal carried in a set of troughs of cast-iron resting on the arches. Nothing of the kind had ever been attempted before, but it was successfully completed in 1805, after many difficulties, including the threatened bankruptcy of the company. The result was a bridge such as nobody had seen in Britain, though perhaps not unlike such great Roman aqueducts as the one at Segovia in Spain. Still, far more than the Roman constructions, Telford's aqueduct has an etherial quality which, combined with the sight of boats passing along it silently as if suspended in the heavens, inspired awe in the viewers. This work of art prompted a different sort of artist, John Sell Cotman, to make 'a beautiful watercolour . . . (which) demonstrates how profoundly his classical sense of design was stirred by the massive simplicity of that great engineering work' (FK 81).

It has been observed by L. T. C. Rolt that Telford's designs tended to be severely functional except where special considerations indicated to him that some kind of decoration was required. Such was the case with the suspension bridge at Conwy in North Wales, which incorporated crenellated towers to match the mediaeval castle next to it. This has been the subject of controversy, but Rolt comments :

> There is truth in the functional argument, but it is limited and like all limited truths it can easily be carried to excess. The evidence of this is painfully apparent in too much of the architecture and civil engineering work of today. Such uncompromising functionalism repels us by its arrogant contempt for its surroundings, and if it be said that Telford went to the opposite extreme of false compromise, at least he displayed an intelligent respect for the past which is sadly lacking today. Many would say that he did succeed in his intention of welding bridge and castle into one harmonious composition (LRT 139).

The Conwy bridge was planned and undertaken at the same time as a far greater and more ambitious work, which was in effect the first important suspension bridge in the world, the bridge which Telford made as part of his enormous project of modernising the road for the mail coaches between London and Holyhead. This had up to then suffered a break at the Menai Straits between the Welsh mainland and the island of Anglesey, necessitating the use of a ferry. Telford's bridge, opened in January, 1826, fulfilled an ancient Welsh prophecy, quoted by George Borrow at the head of Chapter 28 of his *Wild Wales* :

Af i dir Mon, cr dŵr Menai
Tros y traeth, ond aros trai.

This can be translated : 'I will go to Mona (Anglesey), across the waters of Menai, over the strand, without waiting for the ebbtide'. L. T. C. Rolt describes imaginatively but convincingly the moment when the prophecy came true :

> It was after midnight on 30 January, a pitch dark night and blowing hard, when the Down Royal London and Holyhead Mail came over the Nant Ffrancon Pass. . . . . Round the bend of the road the lights of the bridge, special sperm oil lanterns made by James De Ville of London, starred the darkness over Anglesey and threw serpentine reflections on the storm-tossed water far below. So, at 1.35 a. m. on that winter morning while the great chains overhead stirred uneasily and the wind howled through the suspension rods, the first coach rolled over the Menai and the bridge was opened (LRT 140).

The 'great chains' and suspension rods did their duty for one hundred and twelve years ; then in 1938–40 they, and the bridge deck itself, were replaced by stronger ones to cope with the growing numbers of heavy lorries and other vehicles seeking to use the Menai Bridge. But the great towers, proudly bearing the name of Thomas Telford and the date of opening, still remain as a witness to the soundness of planning and imaginative foresight of the man who first bridged the Menai. So also remains the beauty of the bridge, which, like Pontcysyllte, has inspired many artists, starting with Thomas Dibdin and Henry Gastineau, to try and capture the blend of natural and manmade elements in this great product of the Industrial Revolution. Telford's great bridges can be considered as works of art in their own right which also inspired other works of art ; perhaps the most interesting of his designs, and one which might have had the greatest artistic appeal, is one which was never built. This is the planned single-span cast-iron arch with which he proposed to replace old London Bridge. A picture representing this amazing bridge exists ; of it Rolt says 'Were it not dated by the shipping on the river, Telford's picture of his mighty bridge would still appear, even today, as some apocalyptic vision of the future' (LRT 154). In the end, the committee appointed to examine the proposal were unable to accept it on the grounds of cost, and later a design by John Rennie was adopted.

In his lifetime, Telford achieved popular fame and also official recognition by being appointed a Fellow of the Royal Societies of London and Edinburgh. Soon after his time, the railway seemed to dull the edge of his achievements as roads took second place to rails ; it is interesting to recall that one of the first great railway bridges was also over the Menai Strait, the Britannia Tubular Bridge of Robert Stephenson. But the eventual triumph of the motor car and the revival of Britain's canals as a valued source of recreational space and a new way for people to explore the countryside has begun to renew interest and appreciation of this shy, rather lonely man who had 'many friends but no intimates' (LRT 203). It was a fine stroke of kindly justice when a New Town built in Shropshire, at the heart of the early Industrial Revolution, was named Telford. Close by is that Iron Bridge whose style he had transformed into the suspension bridge at Menai, ancestor of the beautiful bridges of the Seto and Akashi Straits.

John Harrison, horologist : the man who discovered The Longitude

A poor carpenter's son from Yorkshire, never able to express himself clearly in speech or writing and without formal training in his eventual craft, may seem an unlikely person to become a central figure in the interplay between arts, sciences, commerce and empire in the eighteenth century. In reality, in every single one of these aspects of life, Harrison exercised some influence, at least indirectly. His most famous creation, the silver coach-watch style chronometer known as H 4, is both a rigorously accurate timekeeper and a beautiful contribution to art, elaborately engraved and chased in places which would normally not be seen ; his discovery of how to find longitude with exactness led to safer sea-travel and helped commerce and the pursuit of naval warfare by the British in the eighteenth and early nineteenth century, but all nations in the end profited from his work. As a poor man he suffered from the prejudice of those in positions of power, who were unwilling to admit that a 'mere mechanick' could solve a problem that had eluded the greatest minds of the century ; the record of how he was saved from being cheated of his reward by the intervention of a King is both a sociological document and a romantic episode in our history and the restoration of his chronometers by Rupert Gould in the early twentieth century a hardly less romantic story. The lives of the two men are the subject of a highly esteemed film, *Longitude,* directed by Charles Sturridge.

Born in 1693 at the small village of Foulby, near Pontefract in West Yorkshire, Harrison moved with his family to Barrow-on-Humber in Lincolnshire when quite young, and at first helped his father as a carpenter. However, he became interested in mechanisms and was helped in this by one of his brothers and by the local clergyman, who lent him books. He then started making clocks, at first conventional in layout except for the extraordinary fact that nearly all the wheels were made of wood. He also invented an escapement known as the 'grasshopper' from its appearance when working, which was virtually frictionless and made it possible to dispense with oil. Some of Harrison's wooden clocks (one of which is in the Science Museum) are known to have gone for long periods without needing any attention ; by his own account, one of them worked for fourteen years without ever varying by more than one second a month (RGC 42). Other youthful horological inventions were the 'gridiron' pendulum, in which the use of brass and steel rods balanced out the coefficients of expansion of the two metals and produced a pendulum of constant length and periodicity, and Harrison's Maintaining Power, a device for keeping a clock or watch going while power is taken off during winding (this is the only one of his numerous inventions to have been generally adopted). He also experimented with the remontoire, a device which evens out the transmission of power from the main driving force of a clock or watch to the balance or pendulum.

In 1707 a fleet commanded by Sir Cloudesley Shovell was wrecked, with the loss of 2000 lives, including the Admiral's, as a result of a mistake over the calculation of their exact position at sea. At that time, although latitude could be calculated from observations of the heavenly bodies, there was no way of being certain about longitude. This could only be done by taking observations to find the exact time at the point where the ship was sailing and comparing it with the time at a known point, such as London. This would make it possible to work out how many degrees the ship was to the east or west of the known point. But no timepiece existed of sufficient accuracy to make such calculations available. The accuracy required was very high, as even a small error could give rise to a mistaken calculation of several miles, and this could be fatal if the ship was near a lee shore in bad weather. Although fixed clocks with a pendulum could keep time to the necessary precision, they were useless on a ship at sea because of the motion to which they were subjected, and also due to variations in rate affecting the pendulum by reason of the different pull of gravity at different latitudes. Spring-driven watches were capable of keeping time to a minute or so a day in the pocket, but this was inadequate and in any case they lacked any device to allow for changes in the rate of going due to variations in temperature. Accordingly in 1714 the British Government established the Board of Longitude, which offered a prize of £20,000, an enormous sum, to anyone who could make a timepiece reliable enough to plot a ship's position to within forty miles after a six weeks' voyage. John Harrison decided in 1728 to make such a timepiece and apply for the prize. He was recommended by Edmund Halley, the Astronomer Royal, to make his instrument before approaching the Board, who had suffered from numerous applications from charlatans or plain lunatics, including one who advised the use of a sundial and another who claimed to have discovered the secret of perpetual motion (RGC 15). Accordingly Harrison set to work, helped by a gift of about £200 from George Graham, the eminent horologist, who admired Harrison's skill as a clockmaker. In 1734 Harrison completed his first sea-clock, now called H 1. It is a huge instrument of frankly grotesque appearance, having most of the wheels of wood and a modified grasshopper escapement. There are two huge balances, set vertically and composed of long bars with weights at the ends. They revolve in opposite directions to compensate for irregularities due to the motion of the ship. Despite its appearance, the standard of workmanship is of the highest and on a trial voyage to Lisbon in 1738 it performed well. However, as Lisbon and London are not very far apart in longitude further trials were needed. The Board allowed Harrison £500 to fund the construction of a second machine, H 2. This was ready in 1739, but Harrison told the Board he was now working on a third sea-clock, H 3, which would be far more accurate than the first two.

Harrison's third instrument took the astonishing period of seventeen years to complete, but for various reasons it was never tested at sea. All three of these instruments were similar in size and general design, and very heavy ;

H 1 weighed 72 lbs (32.7 kilos). But by 1761 Harrison had made H 4, a quite different kind of timekeeper, resembling a large watch in a pair (double) case of silver. It was — and is — as beautiful as the earlier machines were ungainly, as if Harrison's inspiration had told him that this was to be the best design and worthy of artistic as well as scientific consideration. In essence it is similar to the simplest type of common pocket-watch of the time, but with critical changes to the design of the escapement and with sophisticated temperature compensation, consisting of a bimetallic strip which moved the curb pins on the balance spring, effectively lengthening or shortening it according to temperature and thus correcting the rate of the watch. There is a remontoire, the function of which has been explained above, which Rupert Gould has described :

> This mechanism, in action, is most fascinating to watch. The mechanical intelligence with which the claw unerringly selects the right spring, disengages itself, and returns to meet the next is, as the Marquis of Worcester said of his perpetual motion, 'A thing most incredible, if not seen' (RGC 52).

As a final touch, the balance cock, the circular table which supports the bearing of the balance, and the cover to the third wheel are exquisitely pierced and decorated with foliate and arabesque designs, and the whole of the top plate profusely engraved in a similar manner, the whole being of course gilded. This style of decoration was usual in watches at that time, but in this case has been carried to a very high order of artistry. Gould surmises that Harrison may have had help with this decoration, but the fact that it was done to this standard says much about Harrison's feeling for this, his masterpiece.

In performance, H 4 exceeded all expectations. In 1762, it was accompanied by Harrison's son William to Jamaica, and on arrival at Port Royal was found to have lost only five seconds after eighty-one days at sea. This amounted to an error of only 1¼ minutes of longitude, well within the requirements for the award of £20,000. At this point the Board of Longitude became more critical of Harrison. They insisted on a further trial, a voyage to Barbados, before paying the full reward. This may have been because they did not want to see a man without formal education or social standing win the prize, and this is actually suggested in the film *Longitude*. Comparisons have been made between the Board and the Royal Society as satirised by Swift in Book III of *Gulliver's Travels* (DVD). A further reason, however, was the attitude of Rev Nevil Maskelyne, the new Astronomer Royal, who favoured the use of 'Lunar Tables' for finding the longitude. This documentary method is now known to be useful theoretically, but is in practice inferior to the chronometer. Gould, in *The Marine Chronometer,* is of the opinion that he was an honourable man but that his interest in his own scheme, and in claiming the reward for himself, made it impossible for him to deal with impartiality. Objections made by William Harrison to Maskelyne's acting as an observer on the second voyage stiffened his determination to find fault with Harrison's instrument and to insist that its success, even when confirmed by its performance on the second voyage, could not be regarded as conclusive.

The Board now set additional conditions for the payment of the reward. Harrison was told to write a detailed explanation of his instrument and to make two more copies of H 4. This he could not and would not do ; in the first place he was now seventy and his eyesight failing, in the second place he was not capable of putting down technical discourse on paper. In Gould's words, 'he could do, but not describe' (RGH 13). All his known attempts to write on horology are unreadable. But above all, he was a justly proud man, who knew he was being unfairly treated and refused to bend. In the end, he and his son made one copy, known as H 5, which performed even better than H 4, and a second copy, known as K 1, was made and tested with equal success by Larcum Kendall, to be used by Captain James Cook on two of his voyages. Cook, a man sparing of praise, was enthusiastic about its performance (RGH 12). But all these extra works did nothing to get the Board of Longitude to pay Harrison the full reward.

The end of the story is well known. Granted an audience with King George III (who was greatly interested in horology), Harrison and his son explained their grievances. The King was heard to say to himself 'These people have been cruelly wronged' and then, aloud, 'By God, Harrison, I'll see you righted!' (RGH 12). He forthwith arranged his own trials (at Kew Observatory) of H 5, which showed that it was if anything superior to H 4. When the Board of Longitude refused to take notice of the results, Harrison, supported by no less a political figure than Charles James Fox, made a petition direct to Parliament in 1772, and the Prime Minister, Lord North, announced that the King 'recommended it to the Consideration of the House'. At last, the Board yielded and Harrison was paid. He died, justified in the eyes of the world and, long before, in his own eyes, in 1776.

One last word remains to be said about — and by — Harrison, and it shows his status as a craftsman, artist and scientist. It was said above that he could do, but not describe. However, in one (unpublished) writing, an attempt to describe H 4, one lucid sentence stands out :

> I think I may make bold to say, that there is neither any other Mechanical or Mathematical thing in the world that is more beautiful or curious in texture than this my watch or Timekeeper for the Longitude . . . . . and I heartily thank Almighty God that I have lived so long, as in some measure to complete it (quoted in RGH 11).

This earnest utterance makes four points : that his 'watch' is a scientific instrument, that it is also a thing of beauty, that it is a marvel ('curious in texture') and that it is not an end in itself, but a single step towards perfection ('I have lived so long . . . as in some measure to complete it'). Here is that mixture of pride and humility which the artist and scientist need in order to achieve 'some measure' of success. It marks Harrison as one like Wedgwood or Telford, whose words are here appropriate : 'I hold that the end and aim of all ought not to be a mere bag of money, but something far higher and far better' (LRT 205). Harrison fought long and hard for his money, but his true reward had become his long before the Board paid him.

Conclusion

The eighteenth century was a time of great change, and the developments of science and industry were, as we have seen, reflected in the arts, both those for pure enjoyment and those where skill and accuracy can join with aesthetic considerations to make something which is beautiful as well as useful. Then, as now, it was all too easy for commercial considerations to dictate an easy course, with gain uppermost in the mind, but the people described in this paper managed without compromising their integrity to combine the new ideas and methods of the Industrial Revolution with their creative skills. In this way, they were empowered to produce works which, like all works of art, claim our thought, admiration and delight.

Notes

1) **Art and Artists** In this study these words are used in their widest sense, bearing in mind that it is only in recent times that we have tended to limit the word 'arts' to the ornamental arts while paying less attention to the useful ones. To the Romans, *ars* meant anything requiring skill, and the practitioner of an art was an *artifex*. Thus Ovid wrote his *Ars Amatoria* and the Emperor Nero, as he died from a self-inflicted wound, is said to have exclaimed 'Qualis artifex pereo!', 'What an artist dies in me!' — apparently in allusion to his self-imagined gifts not only as an actor, charioteer and lyre-player, but also as an architect. In the Middle Ages, the word *ars* was often used to mean a philosophical idea or system, as in Carano's great exposition of algebra, the *Ars Magna,* and the style of music known as the *Ars Antiqua*. Later still, the English word *artificial* sometimes meant 'not natural, man-made' as in William Derham's 1696 treatise *The Artificial Clockmaker,* which contrasts 'artificial' clocks (made by people) with 'natural' clocks (made by God ; the sun and moon). It was a few years earlier, that King James II had shown his approval of the new St Paul's Cathedral by exclaiming 'How amusing! How awful! How artificial! (fascinating, awe-inspiring, made with art)'.

2) **The Orrery** was named after Charles Boyle, 4th Earl of Orrery in Ireland, who had one made for him. It was probably first designed by George Graham, the clockmaker mentioned in the last part of this study as a supporter of John Harrison. An orrery is a simple type of planetarium, in which models of the planets revolve by clockwork around a model sun at the correct relative speeds, though distances are not to scale. There is an orrery on display at the Derby Museum and Art Gallery, which also contains Joseph Wright's painting of *A Lecture on the Orrery.*

3) **The Skull in the Wright Painting** It is worth mentioning that the mysterious and indeed hardly recognisable object in the glass is in the same relative position in the painting — at the bottom centre — as the anamorphic skull in Holbein's *Ambassadors*. Did Wright know that painting, and put his own version of the *memento mori* into his own painting to indicate its importance for him as as a solemn utterance, worth considering on a similar level to the Holbein? The nature of the strange shape in the older painting was only publicly acknowledged in the nineteenth century, but that is not

to say that Wright was unaware of what it was.

4) **The Camera Obscura** The idea of the *camera obscura* is very old, far earlier than the Industrial Revolution. Leonardo da Vinci made drawings of it (as he made drawings about almost everything else). Early versions simply consisted of a box with a pinhole which admitted light and threw an inverted, reversed image of the view outside. Later the idea was refined, with lenses, and a large room fitted with lenses, in essence a simple photographic camera without any film, was built at Greenwich Observatory some time prior to de Loutherbourg's Eidophusikon. In this darkened room, visitors could watch what was going on outside reflected on to a table. Today the best known extant *camera obscura* of this kind is in Edinburgh, in the Royal Mile near the Castle. It is of the mid-nineteenth century, and still provides a curiously entertaining experience.

5) **Harpsichords and Pianos with Machine Stops** The lecture-recitals given at Finchcocks, a country house in Kent, by Richard Burnett, who keeps a fine collection of historic keyboard instruments there, demonstrate the development of the clavichord, harpsichord and piano. Examples are given of music played on English harpsichords with machine and swell pedals, and on a Viennese piano with a number of percussion devices which give a completely new perspective on the Mozart Turkish March described. Perhaps this was really how Mozart intended his music to be heard.

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