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Inventing the Future

Why should we look to the past in order to prepare for the future? Because there is nowhere else to look. The real question is whether the past contains clues to the future. Either history is a series of individual and unrepeated acts which bear no relation to anything other than their immediate and unique temporal environment, or it is a series of events triggered by recurring factors which manifest themselves as a product of human behaviour at all times. If the latter is the case, it may be that the past illustrates a number of cause and effect sequences which may take place again, given similar circumstances. If it is not, then, as Henry Ford put it, 'history is bunk', and there is no profit to be had from its study, or from anything not immediately and only concerned with the unchanging laws of nature.

Clearly, a preference for the cause and effect argument governs the approach to history expressed in this book. The process of innovation is shown to be influenced by several factors recurring at different times and places; although these may not be repeated exactly each time, the observer becomes aware that they may recur in his own future, and is therefore more able to recognize them should they do so. The structural device used here is to examine an event in the past which bears similarity to one in the present in order to see where such an event led. Thus we return from the modern ballistic missile to the development of cannon-balls, from the telephone to medieval church postal services, from the atomic bomb to the stirrup, and so on. The purpose of this approach is to attempt to question the adequacy of the standard modern schoolbook treatment, in which history is represented in terms of heroes, themes or periods.

In the heroic treatment, historical change is shown to have been generated by the genius of individuals, conveniently labelled 'inventors'. In such a treatment, Edison invented the electric light, Bell the telephone, Gutenberg the printing press, Watt the steam engine, and so on. But no individual is responsible for producing an invention *ex nihilo*. The elevation of the single inventor to the position of sole creator at best exaggerates his influence over events, and at worst denies the involvement of those humbler members of society without whose work his task might have been impossible.

The thematic approach attempts to divide the past into subjects such as Transport, Communications, Sail, Steam, Warfare, Metallurgy and others, but this implies a degree of foreknowledge where none exists. Thus Bouchon's use of perforated paper in 1725 to automate the Lyons silk looms had nothing to do with the development of calculation or data transmission, and yet it was an integral part of the development of the computer. The Venturi principle, basic to the structure and operation of the jet engine or the carburettor, was originally produced in an attempt to measure the flow of water through pumps. Gutenberg's movable typeface belonged as much to metallurgy or textiles as it did to the development of literacy.

In the periodic treatment the past is seen as a series of sub-units bounded by specific dates such as the beginning of a new royal dynasty, the fall of an imperial capital city, the arrival of a new mode of transport, and these sub-units are conveniently labelled the Dark Ages, Middle Ages, Renaissance, Age of Enlightenment, and so forth. As this book has shown, such a view of the past is over-simplified, for to give any period a specific label is to ignore the overlapping nature of the passage of events. Elements of efficient Roman administration techniques continued to operate throughout the so-called Dark Ages. The fall of Constantinople meant little or nothing to the vast majority of the European population, if indeed they knew of it at all. There was no sudden and radical alteration in English life when the Tudors gave way to the Stuarts.

These approaches to the study of history tend to leave the layman with a linear view of the way change occurs, and this in turn affects the way he sees the future. Most people, if asked how the telephone is likely to develop during their lifetime, will consider merely the ways in which the instrument itself may change. If such changes include a reduction in size and cost and an increase in operating capability, it is easy to assume that the user will be encouraged to communicate more frequently than he does at present. But the major influence of the telephone on his life might come from an interaction between communications technology and other factors which have nothing to do with technology.

Consider, for instance, a point in the future at which depletion of energy resources makes Draconian governmental action necessary in order to enforce severe energy rationing. In such a situation the government might decide to tap telephones on a random national basis as part of a campaign to discourage profiteering and, in a more subtle manner, dissent. In these circumstances the telephone would become an instrument which would act as a brake rather than a stimulus to communication. This is typical of the way things happen. The triggering factor is more often than not operating in an area entirely unconnected with the situation which is about to undergo change. A linear view of the past would, for instance, place the arrival of the chimney in a sequence of developments relating to change in domestic living. Yet the alteration of life-style brought about by the chimney included year-round administration and increased intellectual activity, which in turn contributed to a general increase in the economic welfare of the community to a point where the increase in the construction of houses brought about a shortage of wood. The consequent need for alternative sources of energy spurred the development of a furnace which would operate efficiently on coal, and this led to the production of molten iron in large quantities, permitting the casting of the cylinders which were used in the early steam engines. Their use of air pressure led first to the investigation of gases and then petroleum as a fuel for the modern automobile engine, without which, in turn, powered flight would have been impossible.

Within this apparently haphazard structure of events we have seen that there are certain recurring factors at work in the process of change. The first is what one would expect: that an innovation occurs as the result of deliberate attempts to develop it. Napoleon presented the nation with clearly defined goals when he established the Society for the Encouragement of National Industry. One of those goals was the development of a means of preserving food, and it was reached by Appert's bottling process. When Edison began work on the development of the incandescent light bulb, he did so in response to the inadequacy of the arc light. All the means were available: a vacuum pump to evacuate the bulb, electric current, the filament concept which the arc light itself used, the use of carbon for the filament. The idea of serial motion in Muybridge's early photographs of the trotting horse led, through Edison's friendship with Muybridge, to the deliberate development of the kinetoscope as a money-making proposition. Von Linde perfected the domestic refrigeration system in answer to a specific request from the Munich beer brewers for a way of making and keeping beer in their cellars all year round.

A second factor which recurs frequently is that the attempt to find one thing leads to the discovery of another. William Perkin was in search of an artificial form of quinine, using some of the molecular combinations available in coal tar, when the black sludge with which one of his experiments ended turned out to be the first artificial aniline dye. Oersted's attempt to illustrate that a compass needle was not affected by electric current showed that in fact it was, and the electromagnet was the result of that surprise discovery. Henri Moissan, attempting to make artificial diamonds by subjecting common carbon to very high temperatures, failed to do so, but trying his luck with other materials at hand he produced calcium carbide, the basis for acetylene and fertilizer.

Another factor is one in which unrelated developments have a decisive effect on the main event. The existence of a pegged cylinder as a control mechanism for automated organs gave Bouchon the idea of using perforated paper for use in the silk loom. The medieval textile-revolution, which was based on the use of the spinning wheel in conjunction with the horizontal loom, lowered the price of linen to the point where enough of it became available in rag form to revolutionize the production of paper. C.T.R. Wilson's cloud chamber gave the physicists the tool they needed to work on the splitting of the atom.

Motives such as war and religion may also act as major stimulants to innovation. The use of the cannon in the fourteenth and fifteenth centuries led to defensive architectural developments which made use of astronomical instruments that became the basic tools of map-making. The introduction of the stirrup, and through it, the medieval armoured shock-troop, helped to change the social and economic structure of Europe. The need to pray at predetermined times during the night and to know when feast days would occur aroused interest in Arab knowledge of astronomy. The water-powered alarm clock and the verge and foliot were the direct result of this interest.

Accident and unforeseen circumstances play a leading role in innovation. It was only when the bottom dropped out of the acetylene gas market that attempts were made to find a use for the vast amounts of calcium carbide in Europe and America: cheap fertilizer was the result. When the Earl of Dundonald's coal distillation kiln exploded and the vapours ignited, investigation into the gases resulted in the production of coal gas. The sudden arrival in Europe of the compass needle from China led to work on the phenomenon of magnetic attraction, and this in turn led to the discovery of electricity. A similarly unexpected Chinese invention, gunpowder, stimulated mining for metals to make cannon, and the money to pay for them. The flooding of these mines and the subsequent failure of the pumps brought about the development of the barometer.

Physical and climatic conditions play their part. As the European communities recovered after the withdrawal of the Roman legions and the centuries of invasion and war that had followed, reclamation of the land depended for its success on the development of a plough that would clear the forests and till some of the toughest bottom land in the world. These conditions helped to structure the mouldboard and coulter, implements that formed the basis for the radically new plough design that emerged in Europe in the ninth century, and thus helped to move the centre of economic power north of the Alps. The change in the weather which struck northern Europe like a sledgehammer in the twelfth and thirteenth centuries provided urgent need for more efficient heating. The chimney answered that need, and in doing so had the most profound effect on the economic and cultural life of the continent. In the early nineteenth century the prevalence of malaria in Florida, spread by the mosquitoes breeding in the swamps surrounding the town of Apalachicola, spurred John Gorrie to develop the ice-making machine and air-conditioning system in an attempt to cure his patients, in the mistaken belief that the disease was related directly to summer temperatures and miasma rising from rotting vegetation.

Two points arise from this way of looking at the process of change and innovation. One is that, as we have seen, no inventor works alone. The myth of the lonely genius, filled with vision and driven to exhaustion by his dream, may have been deliberately fostered by Edison, but even he did not invent without help from his colleagues and predecessors. The automobile, for example, was assembled from parts which included Volta's electric pistol, using the electric spark to ignite gases. Its basic piston and cylinder drive was Newcomen's. The carburettor owed its operation to Venturi's jet principle and its scent spray derivative. Its gears were descendants of the waterwheel. The elevation of the lonely inventor to a position of ivory-tower isolation does more than deny such debts; it makes more difficult the bridging of the gap between the technologist and the man in the street.

The second point is that the ease with which information can be spread is critical to the rate at which change occurs. The inventive output of Western technology can be said to have occurred in three major surges. The first – the Medieval Industrial Revolution – came after the establishment of safe lines of communication between the communities of Europe as order was re-established in the wake of the invasions of the tenth century. The second occurred in the seventeenth century when the scientific community began to make use of printing to exchange ideas on a major scale. The third followed the nineteenth-century development of telecommunications.

It was with the second of these stages that the age of specialization began, when scientists began to talk to each other in language that only their fellows could understand. The more the knowledge in a certain field increased, the more esoteric became the language. The reason for this is simply that ordinary everyday language has proved incapable of encompassing scientific subject matter. As the amount of knowledge in each field increased, the percentage of language shared only by others in the same field also grew. Today, the man in the street is often prevented from sharing in scientific and technological discussions not by mental inadequacy, but because he lacks certain key words and an understanding of their meaning. Has the rate of change become so high that it is impossible for the layman to do more than keep up to date with the *shape* of things around him? It has been said that if you understand something today it must by definition be obsolete. And yet the rate at which change now occurs is an integral part of the way our society functions. The avalanche of ephemera that arrives in our homes every day has to continue to flow if the economy is to operate to the general advantage. Our industries are geared to high turnover, planned obsolescence, novelty. The basic components of the modern automobile have not changed in a generation, but minor modifications such as fuel-injection systems, suspension, lighting, seat cover material, body styling, have done so. Without these modifications the consumer would have no desire to change a machine which can operate efficiently, if well looked after, for a decade or more. Thus change is good for the economy because it keeps the money going round and workers employed. The interdependence of such a society, however, renders it vulnerable to component failure. A small factory making one part of an automobile can bring the entire industry to a halt if its workers go on strike. The New York blackout of 1965 occurred because of the action of a single relay at Niagara Falls.

The production-line style of manufacture has increasingly affected our way of life, in some cases creating problems of alienation and dissatisfaction among wide sectors of the work force. But such difficulties go hand in hand with a higher standard of living engendered by these very production processes. As the pace quickens, and the diffusion of innovative ideas in the technological community is made easier by technological advance itself, the rate of change accelerates. At an obvious level this increases the avalanche of material goods and services provided, and makes life more comfortable – if also more complicated. But the amount of innovation increases also at an 'invisible' level – that at which a high degree of specialist knowledge is necessary to understand what is happening. Unfortunately, it is at this level that many of the advances most critically important to our future occur: developments in the field of genetic engineering, radioactive fuels, drugs, urban planning, and so on. It is in these areas of innovation that the average citizen feels disfranchized. He knows that they are happening, but does not know enough to be involved in decisions relating to them. Indeed, in some cases, he is actively discouraged from being so.

Thus the intelligent layman realizes that he is surrounded by man-made objects – the products of innovation – that constantly serve as a reminder of his ignorance. It may be this contradiction, coupled with the possibility of resolving it provided by technology itself, which has led to a growing desire in the community to assess the likely future effects of the present high rate of change.

Attitudes have tended to fall into four groups. The first maintains that we should give up the present system oriented towards high technology and return to an 'intermediate' technology, making use of resources which cannot be depleted, such as wind, wave and solar power–in effect, that we should return to the land. The attraction of this idea is that it might draw society closer together by reducing the present gulf between the technologist and the layman, thus encouraging participation on the part of the electorate in decision-making which would relate to simpler, more fundamental matters – a theory which has obvious appeal for the developing world, too. The question is whether such an alternative is possible for other than the simplest communities. Are we not in our advanced society already too dependent on technological life-support systems to make the switch?

The second attitude held is that we should assess scientific and technological research strictly according to its worth for society, and curtail all other forms of research. This presents more difficult problems. In selecting which areas of research to encourage and which to curtail, to what extent are we depriving ourselves of the benefits of serendipity, which, as this book shows, is at the heart of the process of change? Without Apollo, would we have had minicomputers? Without Moissan's search for artificial diamonds, would cyanamide fertilizer have been discovered? Without the atomic bomb, would fusion be feasible?

The third alternative is that we should allow technology to continue to solve the problems as it always has done. The result of this would be a continued rise in the standard of living, fuelled by cheaper consumer goods produced from cheaper power sources. Even if it worked, this option would still leave the community with two major concerns. The first is the effect on the environment of the vast amounts of virtually free energy created by the fusion process. While undoubtedly attractive in its stimulating effect on manufacture, the use of energy on such a scale might create a major planet-wide problem of heat. The waste heat created by the prolific use of this energy would have to go somewhere, and if it were not to have profound and long-term effects on the ecosphere, rationing measures might have to be taken. The next consideration is the inevitable frustration of the citizen should such rationing be enforced. This would surely increase, with potentially disruptive consequences.

The final alternative is that research and development should be directed towards producing more durable goods and less planned obsolescence. We should seek continued economic health in the markets as yet unsaturated by consumer products – in other words, 'spread the wealth'. This offers a utopian concept of the future. Sharing the present level of advance on a world-wide scale would present the manufacturing industries with decades of opportunity. The gap between the haves and have-nots would narrow, eventually to disappear, and with it would go the divisions that endanger the survival of man on the planet. Scientific and technological talent would be diverted to serve the greater ends of education in bringing the community together on a more equal material and intellectual footing. This vision is marred by the major dilemma it would present at its inception. How would it be possible to convince the haves that they had enough, and what would be the reaction of the have-nots if the richer communities would not accept a lower standard of living? The 1973 increase in oil prices demonstrated the power of countries which are less well developed economically but rich in raw materials to cause universal recession in a matter of months.

Whichever of these alternatives is chosen, the key to success will be the use we make of what is undoubtedly the vital commodity of the future: information. It seems inevitable that, unless changes are made in the way information is disseminated, we will soon become a society consisting of two classes: the informed élite, and the rest. The danger inherent in such a development is obvious.

In the meantime, we appear to be at another of the major crossroads in history. We are increasingly aware of the need to assess our use of technology and its impact on us, and indeed it is technology which has given us the tools with which to make such an assessment. But the layman is aware too that he has not been adequately prepared to make that assessment. Now that computer systems are within the price range of most organizations, and indeed of many individuals, an avalanche of data is about to be released on the man in the street. But what use are data if they cannot be understood?

In the last twenty years television has brought a wide spectrum of affairs into our living-rooms. Our emotional reaction to many of them – such as the problem of where to site atomic power stations, or the dilemma of genetic engineering, or the question of abortion – reveals the paradoxical situation in which we find ourselves. The very tools which might be used to foster understanding and reason, as opposed to emotional reflex, are themselves forced to operate at a level which only enhances the paradox. The high rate of change to which we have become accustomed affects the manner in which information is presented: when the viewer is deemed to be bored after only a few minutes of air time, or the reader after a few paragraphs, content is sacrificed for stimulus, and the problem is reinforced. The fundamental task of technology is to find a means to end this vicious circle, and to bring us all to a fuller comprehension of the technological system which governs and supports our lives. It is a difficult task, because it will involve surmounting barriers that have taken centuries to construct. During that time we have carried with us, and cherished, beliefs that are pre-technological in nature. These faiths place art and philosophy at the centre of man's existence, and science and technology on the periphery. According to this view, the former lead and the latter follow.

Yet, as this book has shown, the reverse is true. Without instruments, how could the Copernican revolution have taken place? Why are we taught that we gain insight and the experience of beauty only through art, when this is but a limited and second-hand representation of the infinitely deeper experience to be gained by direct observation of the world around us? For such observation to become significant it must be made in the light of knowledge. The sense of wonder and excitement to be derived from watching the way an insect's wing functions, or an amoeba divides, or a foetus is formed comes in its greatest intensity only to those who have been given the opportunity to find out *how* these things happen.

Science and technology have immeasurably enriched our material lives. If we are to realize the immense potential of a society living in harmony with the systems and artefacts which it has created, we must learn – and learn soon – to use science and technology to enrich our intellectual lives.