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The men and the machine

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1. INTRODUCTION

That science will advance is both desirable and inevitable. In order to take full creative advantage of new technology it is a pre-requisite that the potential for liberation from meniality that exists is presented in a positive light. History should have taught us that, as well as freeing the spirit, advances in technology have a darker side which at worst, have inspired a violent revolution.

Why should new technology so frequently precipitate a negative response and cause such deep distress within the labour force? It is the authors' view that in trying to arrive at an answer to this question one fundamental truism is frequently overlooked; humans have learnt and inherited crafts and skills through experience and knowledge passed on by their ancestors, whereas machines require "programming" only for their operation. Herein lies a gulf. The "grey - area" between the execution of an inherited craft or skill, and "programming" may offer a possible explanation as to why the introduction of new technology has historically generated a terror of a future with a surplus of humans, a future in which machines have been seen as usurpers, metaphorically as cuckoos, displacing and destroying others in the broader 'nest' of the labour force.

This paper will offer a critique of the consequences of automation in terms of reconciling the inevitable, and unquestionable need to take full creative advantage of new technology with the aspirations and hopes of a labour force, whose precious skills must, at all costs, be preserved. Failure to address this latter point will leave the construction industry both culturally, and morally, impoverished. Automation, and its effect on those it will displace, will be explored both in the context of the construction industry, and in a broader historical context in order to give a more "in -depth" view of the issues at stake. There have been many examples in the past where a revolution in manufacturing has induced feelings of fear and distrust from a workforce confronted with new technology, and some of the more significant of these will be discussed. It is the authors view that the reasons behind the frequent uneasiness with which workers, both skilled, and un-skilled, greet new technology must be addressed in order that this technology can be both presented in a more positive light, and further, that creativity should flow, not bloodshed or disillusionment, when inevitably, it is introduced.

2. SOME HISTORICAL PRECEDENTS

An apprenticeship system has been part of the construction industry for centuries. Until recently only very few people could afford to employ someone to design a building on their behalf. Those that could were generally associated with either the church, or the ruling aristocracy. Opportunities for both education, and training, were therefore limited as, beyond the apprentice system, no formal mechanism existed for education. Nonetheless, some influential "contemporary" construction has, of course, always taken place throughout history, and correspondingly there were therefore always some gifted people who were given the opportunity to work with, and to learn from, master - craftsmen. These were people skilled in their particular craft, be it joinery, carpentry or stonemasonry for example, and an opportunity existed for their skills to be both inherited, and developed by those who worked alongside them. The knowledge and skills that the "master - craftsmen" possessed could be gleaned only slowly. An intangible understanding of the nature and properties of the materials which were worked had been acquired over a lifetime and could not simply be "taken" as if from a text book. Apprentices learnt through association and observation, as well as through discussion and direction. The most talented, and possibly those with hitherto unrevealed "latent" skills, developed their "craft " and more significantly, began to develop an understanding of the science involved in the skill, and were thus able to advance the scholarship of their craft.

These people became the decision makers. Invariably they would interact with others, but nonetheless, their inherent appreciation of a craft, and its related science, meant that others with a less developed appreciation, would inevitably work under their instructions. Thus a labour force developed which was concerned with only a microcosm of the broader overall considerations that it is necessary to fuse together in order to create "Architecture". This labour force was directed by master - craftsmen.

3. THE MASTER - CRAFTSMEN

There are many examples of such master - craftsmen. For example, Leonardo Da Vinci created beautiful paintings and sculptures. In order to do so however, he possessed a clear understanding of the science involved in, for example, the cutting of a piece of stone in a way which would allow both sculptural fluidity, and structural stability. This understanding of, and interaction with science is fascinating. One can only fully appreciate the depth of the interaction however, if some of the technical studies produced by Leonardo of, for example, flying machines, which were well in advance of anything that his contemporaries were capable of, are looked at alongside his paintings and sculptures. The drawing below is an example of one such machine. Similarly advanced were Leonardo's anatomical drawings.

Genius on such a broad scale is rare, there are nonetheless many other examples of influential master - craftsmen. Amongst these is certainly the architect Brunelleschi, who created buildings such as the Pazzi Chapel, The Foundling Hospital and perhaps his best known achievement, the dome of Florence Cathedral. This latter work, in common with Leonardo's creations, represented a distillation of a number of ideas of pure art and pure science. In addition to being a significant piece of architecture, the building also represented a major technological breakthrough in the design of large domed structures, the huge dome being seemingly impossible to support using existing technology. Peter Murray, in his book, "The Architecture of The Italian Renaissance", assesses Brunelleschi's solution to the construction of the dome as follows, "It is, from any point of view, a work of genius. It would

imposts, etc.; all these units, which big industry can supply, are based on a common unit of measurement: they can be adapted to one another exactly. The framework of the house being made, these elements are set up in their proper places in the empty shell and temporarily fixed with laths; the voids are filled by plaster slabs, bricks or lathing; the normal method of building is reversed and months of work are saved. A further gain, of the greatest importance, is architectural unity, and by means of the module, or unit of measurement, good proportion is assured automatically." *5

A contemporary of Le Corbusier, the expressionist Italian architect, "Antonio Sant'Elia", similarly viewed "architecture" and "machines" as one and the same thing. This view is evident in his wonderfully sculptural drawings of huge architectural projects which, seductive though they may be, are difficult to imagine inhabited with human beings, and it is no coincidence that people rarely appear in his drawings therefore.

For a while after the second world war it did seem that an unlimited supply of cheap energy was an attainable dream. The problems of pollution, global warming and nuclear disaster had not yet been considered. An unlimited supply of energy meant that the contribution of the individual skilled worker would potentially become subservient to the seductive possibilities of the wholesale adoption of techniques of cheap mass production. Architectural theorists such as Le Corbusier, Sant'Elia and others like them were able to envision a world where this process was taken a stage further. Mass production housing and the arrival of the motor car were to change the nature of the building industry irrevocably. That the linking of men and machines would exert an increasingly influential effect upon our futures was by now inevitable. The invention of the computer and the robot could only further consolidate this inevitability, and a new generation of designers emerged as technology further developed. The ideas of the "Modern Movement" architects discussed above were developed to propose architecture that was unimaginable even in the previous decade. For example, a group of architects whose principal spokesman was Peter Cook, working under the collective title of "Archigram", proposed building solutions entirely reliant upon technology such as "walking" cities. It was to be technology that would assist humans in the control of their lives, their environment and their futures, not the efforts of skilled people.

This vision once again assumed a building industry with only a relatively few, gifted, motivated, trained and educated individuals capable of creatively supervising construction. It was assumed that only unskilled labour or narrowly trained workers, would be required to assemble the new methods of construction. Instead of relying upon craftsmanship, the precision of a factory finish was perceived to be the generator of quality. As the demand for new building during the period between the end of the second world war and the onset of the current recession appeared to be unending, these unskilled and mainly not very well educated workers assumed that there would always be a requirement for their limited skills. However this assumption we now appreciate was a myth. Throughout history similar dreams have been shattered with sometimes dire consequences. If the same problems are not to be a consequence of the introduction of robots into the construction industry, changes cannot be imposed upon the labour force in such a brutal and uncreative fashion as has been the case in the past. Considerably more forethought and planning will be necessary.

5. WHAT HAPPENS WHEN THE BUBBLE BREAKS?

The classic apocalyptic example of what could happen in the building industry should the workforce be confronted by the prospect of unemployment due to the introduction or intrusion

seem that for a thousand years no one had really understood or had even attempted to understand how the enormous Roman vaults and domes had been put up, and Brunelleschi must have worked the whole thing out by wandering around the ruins and asking himself questions which no one else at that time had even thought of formulating." *2

There are clearly many other examples of master - craftsmen, but it is not the aim of this paper to list them all. It is relevant to draw attention however, to the notion of "decision makers", which is what the master - craftsmen were. The remainder of the workforce, those with less appreciation, could only work and survive because the master - craftsmen gave direction. They simply obeyed commands.

The long training and service necessary in order to achieve the status of a master - craftsman required considerable motivation on the part of the apprentice. However, the possibility of advancement in social and academic standing was an incentive, as was the prospect of financial reward, and the respect accorded to the position finally attained. The majority of the workforce on a site would be unskilled manual labourers, with a few trained and educated individuals to guide the project. This eventually led to a "Brotherhood" of skilled workers who were able to execute and to enrich the ideas of 'designers'. Thus a complex relationship began to develop. This relationship was one in which the precise identity of the designer, in the construction of the great cathedrals, as an example, became blurred. The contributions of the architect, mason, sculptor and joiner were fused in the realisation of one great work.

4. THE RENAISSANCE AND BEYOND

The Renaissance, or "The Age of Enlightenment", saw an increase in the number of people who could afford to commission an architect. Commensurate with this increase was an expansion in the training of the construction workforce, which in turn, created a reasonable number of skilled individuals who could provide the lead in an expanded building programme. This expansion of the apprentice system continued for hundreds of years. It only decreased significantly as recently as the onset of the first world war. A decline which accelerated markedly at the end of the second world war.

Thus from about 1945, when peace was restored once again to most parts of the world, the number of apprenticeships began a rapid and permanent decline. This decline was probably due to two principle factors. The first being the development of knowledge gained during the wars of the potential of the nuclear industry, and with this, a dream of an unlimited supply of energy and the value of sophisticated unmanned weapons. The second factor was the emergence of a new generation of architects with influential and utopian visions of a future based upon mass production and machines. These architects included amongst them, Le Corbusier, who in his seminal book, "Towards a New Architecture" goes so far as to describe a house as ,

"..a machine for living in. Baths, sun, hot water, cold water, warmth at will, conservation of food, hygiene, beauty in the sense of good proportion. An armchair is a machine for sitting in and so on."*4

In 1915 Le Corbusier began experimenting with the use of reinforced concrete for mass housing projects. The dwellings were to be filled with artefacts made by machines. Of the house illustrated below he writes,

" Mass-production doors, windows, cupboards: the windows are built up of one, two, a dozen units: one door with one impost, two doors with two imposts, or two doors without

of robots is that of "The Luddites". The legendary figure 'Ned Ludd' gave inspiration at the onset of the British Industrial Revolution to hundreds of manual workers in the weaving industry. Incensed by what was seen as an onslaught upon their heritage of craftsmanship, these workers, men and women, went on in 1811 to smash and destroy machinery on a scale unparalleled in the history of technological advancement. From this devastation came the term 'Luddite' which, even today, is used as a label for those who oppose or doubt the value of mechanisation. The mentality of the Luddites is still a prevalent one, and one that we must overcome in order to advance our world.

One of the major problems in 1811 was that the workers replaced by machines were unable to find other employment. Lord Byron in a speech to the House of Lords attempted to address this issue. Speaking about the riots and in an attempt to understand why they should so suddenly and so dramatically have taken place he said,

".... whilst these outrages must be admitted to exist to an alarming extent, it cannot be denied that they have arisen from circumstance of the most unparalleled distress"

He goes on in the same speech to add,

"Considerable injury has been done to the proprietors of the improved frames. Machines were to them an advantage, inasmuch as they superseded the necessity of employing a number of workmen, who were left in consequence to starve. By the adoption of one species of frame in particular, one man performed the work of many and the superfluous labourers were thrown out of employment".*8

Those few workers left in employment had their wages reduced and could not afford to maintain their standard of living. Although the machines had made it possible for far more people to afford a greater selection of clothes, it did not benefit the original employees, who now, as a direct consequence of a supposed leap forward in technology found themselves either unemployed, or unable to afford to buy the articles that had been produced by their machine usurpers. Only the frame owners benefited ultimately. The lack of any system of state assistance to help the unemployed former mill workers created genuine hardship, and made an appreciation, or acceptance of the benefits of new technology a virtual impossibility amongst the labour force. The only exception to this state of affairs occurred when an employer, such as Joseph Rowntree, took on a philanthropic role. Whilst such philanthropists did exist, they were rare indeed, as they remain today.

6. A LATE TWENTIETH CENTURY WARNING

We do not need to look very far back into the history of mechanisation for reminders that the potential to ignite the fuse to civil unrest still exists even in the late 20th century. In the 1980's the printing industry underwent a revolution in technology. This positive revolution ignited a second, and wholly negative response from an expensive and skilled labour force at the printing plant of the ill - fated "Today" newspaper. Specialist printing trade unionists correctly identified themselves as a target for displacement. The subsequent violence and unrest that took place outside the News International printing works of Rupert Murdoch in Wapping, London, made headline news for months. As with the mill owners before them, it was the newspaper owners who stood to make greater profits by employing fewer people. Theoretically, the public in general profited as the price of newspapers could be kept down and therefore more people would be able to afford to buy more newspapers and society as a whole could remain well informed and educated. The distress caused to the workforce was not allowed to interfere with this vision, and the dire consequences described above were the

result. It is essential that this scenario should not develop once more, this time in the Construction Industry, as it takes its turn to accept the challenge and potential of new technology in the form of a much greater use of robots. Le Corbusier, writing about different machines, in a different era, nonetheless summed up brilliantly both the potential that mechanisation brings, and the beauty that can be found if only we use it positively,

"In every province of industry, new problems have arisen and have been met by the creation of a body of tools capable of dealing with them. We do not appreciate sufficiently the deep chasm between our own epoch and earlier periods; it is admitted that this age has effected a great transformation, but the really useful thing would be to draw up a parallel table of its activities - intellectual, social, economic and industrial - not only in relation to the preceding period at the beginning of the nineteenth century, but to the history of civilisations in general. It would be quickly seen that the tools man has made for himself, which automatically meet the needs of society, and which till now had undergone only slight modifications in a slow evolution, have been transformed all at once with an amazing rapidity. These tools in the past were always in man's hands; today they have been entirely and formidably refashioned and for the time being are out of our grasp. The human animal stands breathless and panting before the tool that he cannot take hold of; progress appears to him as hateful as it is praiseworthy; all is confusion within his mind; he feels himself to be the slave of a frantic state of things and experiences no sense of liberation or comfort or amelioration. This is a great but critical period, above all of a moral crisis. To pass the crisis we must create the state of mind which can understand what is going on; the human animal must learn to use his tools. When this human animal has put on his new harness and knows the effort that is expected from him, he will see that things have changed; and changed for the better. *9

7. A WAY FORWARD

For the human mind to accept change and adaptation, learning is necessary. Learning is, by implication, not just limited training, but is as full, as broad and as far-reaching as is possible. The Building Industry is already aware that several of its skilled categories of designers, inventors and craftsmen are likely, in the near future, to be replaced by robotic machines. The industry must take the initiative and re-educate these skilled people in order that new creative employment openings are provided for them and the idea of welcoming change rather than fighting it is, for the first time in the history of technological advancement, the prevalent attitude. For others it is likely that their work will become more rewarding as they have greater access to information and greater potential to utilise this information. To use a metaphor from the animal world, the futuristic ideals of mankind, based upon dreams of the pleasures of greater leisure time and inhabiting other worlds made possible through the creative application of technology, and requiring the assistance of robots in order to progress, should perhaps be viewed as simplistically as the symbiotic relationship between the shepherd and sheep dog. Two beings share a common task, in this case, the protection of a flock of sheep. The shepherd has the 'craft', the dog is acting out the role of the machine. This is a positive interaction that can be seen metaphorically as a role-model for inspired co-operation between a traditionally organised labour force and one organised around robots in the future.

Within the Construction Industry, designers, surveyors, technicians, craftsmen, manual labourers and manufacturers can all benefit from positive interaction with new technology. The use of computers enables architects and engineers to explore their designs in a way which is infinitely more sophisticated than was possible using conventional drawings and hand-built

models. They are able to communicate faster and more effectively through linking to other computers, and, in turn to other designers. If this improved access to information and to individuals helps to prevent some of the misunderstandings which inevitably occur during both the design and construction phases of a building project, it will improve general building project management. This, as well as providing greater opportunities for creative interaction, will in addition reduce the incidence of arbitration, and ultimately of legal proceedings.

8. THE NEED TO SEEK POSITIVE USES FOR NEW

In order to utilise technology to its full potential, positive uses must be sought. This may seem obvious, but it is necessary, on occasions to "stand back" and question whether or not the application of the technology is an appropriate one. For example, one does not need a robot to carve a piece of timber or to hammer wrought iron into shape. In both instances the beauty of the finished object is married to the skill of the craftsmen. If the skill is sometimes flawed in some tiny way, then perhaps this is so much the better. From being able to sense the involvement of a human being in creating the object, its beauty is generally enhanced. However, a major advantage of robots is their utilisation where precision is a pre-requisite, or in the execution of dangerous tasks. Whether it is holding a cladding panel to the outside face of a fifty storey building while the fixing operator remains safely inside, helping in underground tunnelling with the humans on the surface directing operations, holding the replacements for the Hubble telescope while the space crew secure the new part, or helping with exploration of the sea bed, robots provide a shield for the fragile human body. These are all positive applications. It is towards applications such as these that advances in technology should be directed.

There are suggestions that designers will eventually be replaced by computers who have been so 'brilliantly' and comprehensively programmed that they will be able to replace the human brain. In science fiction, for example the films 'Blade Runner" and "2001 A Space Odyssey" , the ascendancy of the intelligent computer is axiomatic. In these films the inventors and programmers, and indeed the machines themselves, are the 'heroes'. The scenario painted in both instances is a terrifying one, and one in which the machines themselves ultimately dominate. That new technology will produce jobs for those who improve and innovate the design of robots, as well as those who repair them is inevitable. That this should end in the albeit fictional apocalypse illustrated by the film "2001" is not inevitable. Historically, the wheelwrights, coach makers and candle makers were probably worried that the invention of the motor car and electricity would be catastrophic for them. However, the explosion of new jobs these discoveries produced, increased the requirements for skilled labour and invention, and should have given hope and encouragement.

9. EDUCATION FOR CHANGE

Education for change will require two key ingredients. The first is the concept of continuing learning through life as new innovations are made. The second is the active involvement of skilled workers in transferring their skills to robots in order to magnify the impact of those skills, ie an interactive process between humans and robots. The knowledge that we have acquired through experiment and experience in understanding and manipulating materials is not wholly tangible and is not therefore easily transferable. However, in the

interest of positively and creatively utilising new technology in the Construction Industry, new skills must be developed in order to promote a healthy interaction between those who understand and have an inherent empathy with materials and those who can transmute these complex skills through machines to create Architecture.

CONCLUSIONS

Since the industrial revolution, there has existed a belief that man is capable of comprehending the Universe, of gaining control of, and moderating the more destructive aspects of nature, and of progressing to discover first-hand what it means to be part of creation, through the exploration of Space. This belief was inspired by the ability to travel greater distances, faster, through the development of trains and cars, aeroplanes and spacecraft. This enabled a greater proportion of humans to explore other civilisations and ideas, and to accumulate more knowledge and to learn new skills through familiarity with different cultures. Humans did accept some change, and were impressed by some new technology. For example the advent of buildings using iron frames, the use of steel, aluminium and glass in buildings such as Joseph Paxtons "Crystal Palace" and the magnificent train sheds that trumpeted the advent of rail travel. Similarly, in America the application of new technology to create "skyscrapers" caused amazement in the eyes of the general public. There are, of course, many more examples, including bridges, tunnels, airships and planes which illustrate positive and successful utilisation of technology. These examples demonstrate clearly that the lust for new technology does exist and that in appropriate circumstances, it will be positively received.

If we are to use robots in construction we must address the issue of how to positively encourage their operation and learn from the successes of the past, as well as the failures. To do this we must not even consider the notion of 'de-skilled' operation. If we do, we will have lost our 'shepherds' and replaced them with servants. With this loss will go a real opportunity to positively and creatively utilise new technology in the construction industry. It must be accepted that education is a necessary requirement for everyone, and no longer just basic education, but one that prepares the human mind for on-going and persistent learning.

In the present day, information is disseminated at incredible speed, through television, air-travel and computers. Designers are becoming attracted to the control they gain through an ability to explore ideas in greater detail, in a shorter space of time, through the use of computers. Information is literally at their fingertips thanks to the immense power of technology to store and retrieve data quickly. Education at schools and colleges into the potential that exists is reducing the fear of redundancy. The aim of the construction industry must be to show skilled personnel that the machines, seen as potential "usurpers", can in fact be "companions", who can help to promote job satisfaction. For centuries craftsmen provided their own 'tools of the trade'. These had a special place in their life, cared for and reverently cherished. In the future the relationship between the craftsman and robot may be similar to the craftsman and his tools. The robot may become the loved and cherished 'tool'.

Perhaps, the human race will once again be able to strive to understand the Universe through the exploration of space. If we do, it is important that instead of 'star war' devices roaming around we are met instead with trusted robots helping us to create an appropriate and inspirational Architecture to suit the environment in which we find ourselves, whatever that turns out to be. Le Corbusier's understanding of the nature of machines is surely the correct one, and should be remembered by us all,

"The machine, a modern phenomenon, is bringing about a reformation of the spirit across the world. Nonetheless, the human factor remains intact, since the machine was invented by man to serve human needs. The machine is conceived within the spiritual framework which man has constructed for himself and not in the realm of fantasy - a framework which forms his tangible universe; this framework, wrested element by element from the world around us, is sufficiently cogent to permit the creation of organs performing functions similar to those of the natural world.The machine is all geometry. Geometry is our greatest creation and we are enthralled by it." *10

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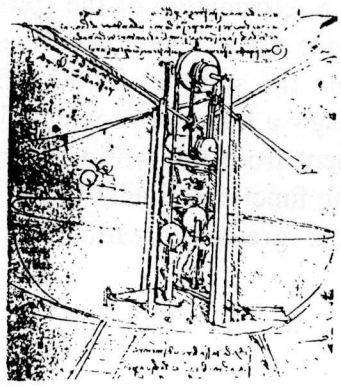
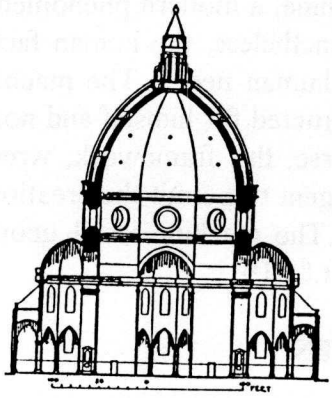
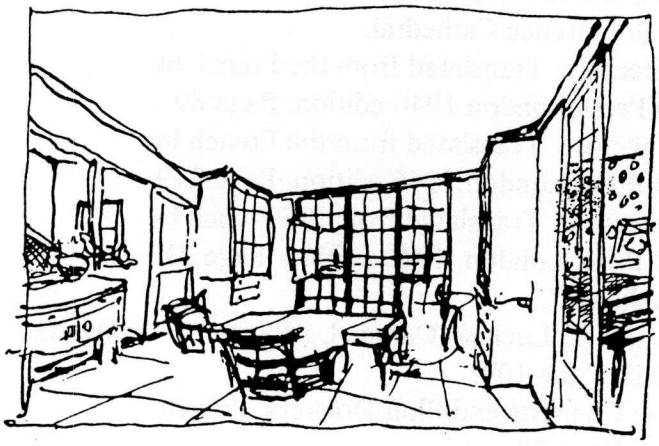


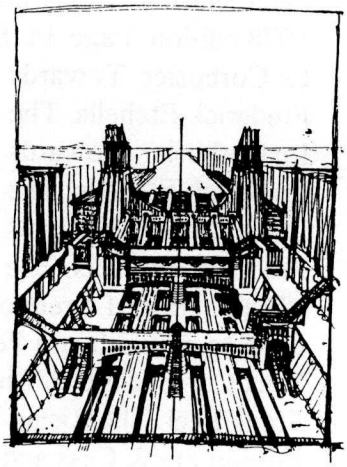
Leonardo da Vinci. Drawing of a flying machine.*1



Sectional Drawing through Florence Cathedral. *3



Le Corbusier, 1915. Interior of a reinforced concrete house. *6



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