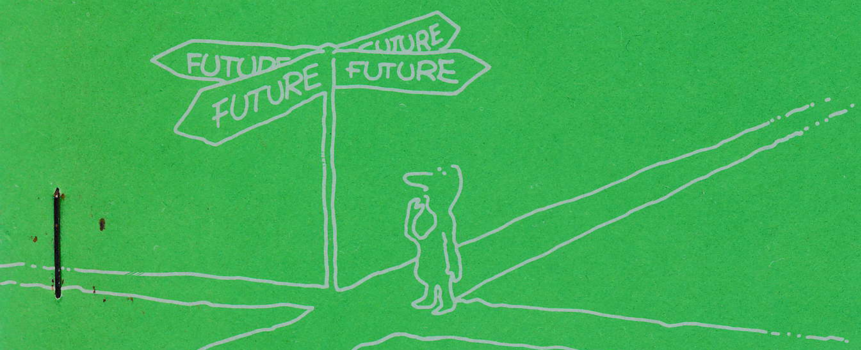
THE ELECTRONICS AGE

A discussion paper by
W. R. WILLIAMS



COMMISSION FOR THE FUTURE

THE ELECTRONICS AGE

A Paper Prepared For

THE COMMISSION FOR THE FUTURE

by

Commander W.R. Williams

Convenor of The

EXTERNAL INFLUENCES COMMITTEE
of
THE NEW ZEALAND COMPUTER SOCIETY

March 1979

REPORT NO. CFFR1/79

ISBN 0-477-06205-9

ACKNOWLEDGEMENT

The author wishes to thank those of his colleages who assisted with their comments on earlier drafts and especially;

Professor Graham Tate

Mr Ed. Fitzgerald

Mr Martin Anderson

who, as members of the External Influences Committee of the New Zealand Computer Society, have been associated with the project since its inception.

THE ELECTRONICS AGE

For the so called 'developed nations' the latter part of the nineteenth and the first three-quarters of the twentieth centuries have seen profound changes in the life-style of its people. Much of this change has been based on a prodigious growth in the use of energy. We see examples everywhere around us, our means of transport, the manufacture, distribution and built-in obsolescence of consumables from motor-cars to plastic spoons, and an ever-rising use of resources to achieve even higher levels of aspiration in convenience and comfort. Indeed so remarkable have been the manifestations of this large-scale exploitation of energy resources that they have overshadowed equally important developments in other technologies, the utilisation of which will have an even greater, and almost certainly longer lasting impact.

In particular, this applies to electronics. Until perhaps the early 1950s most of the changes introduced by developing electronics technology had come upon us unremarked. Probably this is because changes had been evolutionary rather than sudden or dramatic. The telephone, for example, which is so much a part of our daily life was invented 100 years ago. It has taken about this time to change from a new scientific wonder to the near necessity of today. But we are now in the days of 'present shock'. Electronic computers were unknown 35 years ago, today their impact is everywhere as great as the telephone. ENIAC, an early computer completed in 1946, was a monster weighing 30 tons and requiring a warehouse to hold it. There were 19,000 valves and 500,000 vulnerable soldered joints. Electricity consumption was rated at about 150 kilowatts, enough to cook 30 to 40 family meals. It required a small army of technicians to keep it going. Today's infinitely more powerful computers fit into the corner of a room, contain no valves, relatively few soldered joints and in general are maintained by the occasional visit of a service engineer. The first commercial computer was sold in 1951, today there are more than 200,000 in world-wide use. Microprocessors are now being manufactured at over 2 million per month.

Whether we have appreciated it or not there can be no doubt that we are now firmly committed to the Electronics Age, the result of a new technological revolution. As Abelson and Hammond in their paper (1) on the subject have written:

> "This revolution which is destined to have great long-term consequences is quite different in nature from the industrial revolution. The industrial revolution was based on a profligate use of energy (mainly fossil fuels). Much of its technology was

crude, with only a modest scientific or theoretical base. In large measures what the industrial revolution did was to make available and to employ large amounts of mechanical energy.

In contrast the electronics revolution represents one of the greatest intellectual achievements of mankind. Its development has been the product of the most advanced science, technology and management. In many applications electronics requires little energy. Indeed, one of the factors that guarantee enduring impact for the electronics revolution is that it is sparing of energy and materials."

We will here examine the general implications of the electronics revolution. Later papers will develop in more detail the impact of the new technology for New Zealand.

While much of the discussion will revolve around computers, it must in no way be assumed, as perhaps is becoming fashionable, that ´electronics´ and ´computers´ are synonymous terms. We must not overlook the non-computer aspects of electronics. Without electronic sensors, for example automated process control would not have reached its present advanced state and who among us has, at one time or another, not become aware of the traffic department´s radar speed detectors?

THE GROWTH OF THE ELECTRONICS AGE

We shall throughout this section refer frequently to ´electronics´ and to ´electronics technology´. It would be well from the outset to define what we mean.

In general terms electronics has to do with the control of electrons (negatively charged particles that are a constituent part of all atoms) by means of thermionic valves (as in older radio sets), their more modern equivalent the transistor, or similar devices. It follows that electronics technology is the means by which theory is put into practice. Electrons were first isolated in 1897 by J.J. Thomson. That today, eighty years later, electronics technology should play a decisive part in our lives is a remarkable phenomenon.

There are many factors that have brought this about but, if one is to be selected as the most significant, the choice must undoubtedly lie with the silicon chip and its use in large-scale integrated circuits. It is the development of the integrated circuit that lies behind the present miniaturisation of components, increased speeds of processing, reduced costs of computer memory and reliability.

Silicon chips are about one-sixteenth inch square and a few hundredths of an inch thick. At the end of the 1950s a typical chip was able to hold one component of a circuit, the equivalent of one radio valve. By the mid-60s it was about 10 components a chip, five years later 1,000 and 1978 saw the arrival of 65,000. As an indication of what this means in practical terms let us consider two measures of key performance in the computer field - the speed of calculating and cost per unit calculation. (Table 1).

TABLE 1

Computer Type	Speed (1,000s of Operations/second	Relative Cost (1960 = 100)
FIRST GENERATION Late 1940s-1950s (Thermionic Valves)	1 - 5	1,200-250
SECOND GENERATION Late 1950s-Early '60s (Transistors)	2 - 500	250-50
THIRD GENERATION To early 1970s (Integrated Circuits)	500 - 2,000	50-10
PRESENT DAY (Large Scale Integration)	Up to 10,000	10-1

Table 1 shows that, between 1960 and today, the cost per unit calculation has fallen by a factor of 100 while basic computing speeds have increased by a similar factor.

It might be thought that such rapid growth cannot be sustained but most are agreed that, for the next 20 years at least, we may expect the present growth rate to continue, or even accelerate. We shall be looking later at some factors that will limit growth, but in the meantime it is worth noting as an example of current thinking the projections of the Japanese MITI (Ministry for International Trade and Industry) (Table 2).

TABLE 2

APPLICATION	EXPECTED BY
DATA TRANSMISSION	
Optical communication with very high data transmission rates.	1988-1995
Nationwide use of digital data communications network.	1986-1991
All electronic telephone exchange.	1982-1988
DATA PROCESSING	
VLSI for Chips - 100,000 elements per chip.	1984-1988
Voice recognition.	1987-1994
Computer with learning ability.	1990-1997
DATA STORAGE	
Large, low cost data file with non-moving access scheme.	1986-1993
Human voice input.	1993-1999
File with 100 billion bytes at very low cost per byte.	1990-1995
DATA BANK	
Science/technology data bank for professional use.	1991-1996
Medical data banks with patient records (Social consensus dependent).	1988-1998
RELIABILITY AND SECURITY	
Computer capable of self-restoration.	1990-1998

To a certain extent this table is open to the question as to what is meant by some of the categories. The target for'computers with learning ability', if this is to mean any considerable ability, is probably ambitious. On the other hand some degree of voice recognition in commercial applications is with us today. So are data transmission by optical fibres and electronic telephone exchanges. The overall pattern however is clear and it should be noted that the projection relates to marketable products in general supply not to laboratory prototypes.

CONSTRAINTS ON DEVELOPMENT

The two factors that will impose some dampening on the otherwise run-away growth of the Electronics Age are firstly, technical limitations and secondly, the natural resistance to change of people and institutions. Of the two it is the latter that will prove the more important.

TECHNICAL CONSIDERATIONS

In the technical areas we have as an absolute barrier, at least for all practical purposes, the speed electrons move - close to the speed of light. Also there are limits to how close components can be placed and there is the problem of dispersing the heat generated. It is to overcome this last restriction that the concept of immersing processors in liquid helium (the so-called Josephson computer) has been evolved. In this way resistance on the electronic circuits is lowered significantly, which means that speeds of 100 to 200 times faster than in today's fastest processors will be possible.

If we confine ourselves to techniques now being developed in the laboratory or undergoing early field testing, we can make some reasonable forecasts for the next 15 years. Beyond this there is an ever-increasing degree of uncertainty but, as we shall see below, it is unlikely that technology will be the main factor governing growth patterns.

In making predictions for technical growth it is also necessary to take into account the inherent inertia of industry. In anybody's terms the electronics industry is 'large industry'. Large industries cannot afford to obsolete all their own products too quickly. It is thus reasonable, as has been done, to extrapolate past curves of growth since in reality they represent planned growth, or to put it another way, constrained growth. It is clear that technology would 'allow' faster growth but that this is being strictly held to a level that manufacturers, users etc. can actually live with.

If we take a consensus of those writing on the subject a picture something like the following emerges.

- Processing speeds will increase by a factor of at least 100, the faster computers achieving 1,000 million operations a second.

- Mass data storage devices holding in excess of 100 million characters with records capable of being accessed in less than one-tenth of a millisecond (thousandths of a second) will be readily available.

- Chips holding 1 million bits of information or 100,000 circuit elements will form the basis of micro-computers which will be used not only for computing but as controls for devices ranging from the trivial (electronic games) to those involving life and death (as in medical applications for example).

- Wired and micro-wave communication circuits will be supplemented by optical fibres. This will not only increase the speed of data transmission (a single optical fibre can carry several hundred times as many bits of information per second as can a copper wire) but will eliminate electronic interference which today is a major inhibiting factor. The use of laser beams is another technology that has significant potential in the communication field.

- While, as we have noted elsewhere the need for written reports etc., will decline, printing will still remain an important medium for communication and record keeping. The limitation of electro-mechanical printers today is a significant bottleneck. This, in part, will be overcome by using techniques such as electron beam lithography or other photo-electric means of writing and drawing which do not involve moving mechanical parts.

OTHER FACTORS

Traditionally the chief factor that constrains the introduction of new techniques, whatever they may be, is cost. The electronics area is no exception. Initially it was the cost of 'hardware' that held things back but, as we have seen, the costs of semiconductor chips, mass-storage devices, display units and communications facilities are everywhere falling. The office supervisor in the future will give no more thought to the cost of installing a word-processing machine than today he does to the replacement of a typewriter. The pocket calculator will cost less than a book of log tables. Hardware costs are becoming less and less significant.

As hardware costs have fallen, the cost in human resources necessary to design, oversee and install systems has risen, not only in absolute terms but even more significantly in relation to the reduced hardware costs. It is certain that the cost of 'software' (computer programs) and the skilled personnel who sustain the new technology, will continue to rise. We are desperately short of such people at the moment and this trend will continue. It has for instance, been predicted (7) that in 1985 software will absorb 80% of EDP systems costs.

The high cost of software and the high salaries being commanded by practitioners in the electronics field is but a sympton of the overall shortage in trained personnel. This will not be solved overnight. Throughout the world, the shortfall in both computing specialists and informed users is growing. Current education practices are not helping. The world´s educational systems are surprisingly conservative and it takes time to train and change teachers, curricula, etc. It would seem that the present shortages will continue for the next decade at least and, in consequence, the use of computers will continue to fall below their potential.

In the long run shortages of personnel and high personnel costs will be overcome, partially by training, but also by the use of ´software packages´ and specialised preprogrammed hardware, designed to carry out defined tasks with little or no intervention by users. In other words costs will be contained by the traditional method of making systems less labour intensive. The ultimate, if we follow this line to its logical conclusion, are the so-called ´intelligent´ systems, systems that will communicate with users in a higher level (near to everyday) language and make decisions that are not, as now, directly pre-programmed. Progress in making intelligent systems is painfully slow. All the brute strength of hardware will not overcome these problems and forecasts of progress in this area have traditionally been too optimistic.

Finally we have the social implications. Unless computing development is rather carefully controlled worker resistance, which is starting to emerge strongly in Europe for example, is likely to limit growth in labour intensive industries. Areas of particular concern include office workers of all grades (including middle management), skilled and semi-sklled manual workers whose jobs can be carried out by micro-processors and all others engaged in repetitive type employment. While it might be considered an advantage to have deadly dull or unpleasant tasks done by a computer-controlled robot, the problem of providing meaningful occupation to those displaced needs no stressing.

But it is not only the work-force that is involved it is the whole community. The social implications for every-day living if the dispersion of office work away from the centres of cities comes to pass, is but one example. The trend for recreational activities to be centred on the home is another. It is social factors that, in the end, must play the decisive part in deciding how fast and how far we proceed in the electronics age.

THE IMPACT OF ELECTRONICS ON OUR FUTURE

It would probably be easier to list areas which will not be affected by electronics technology than to attempt, in a short paper, to cover the field. However, here is a summary (in no particular order) of current thinking on the subject.

THE SMART GADGET

There can be little doubt but that we shall see a proliferation of devices based on the micro-processor chip that will monitor and control the familiar processes of everyday living. On the roads electronic controls will adjust fuel settings and timing in cars, trucks etc. for maximum fuel economy and to eliminate undesirable exhaust fumes. There will be monitors that can prevent drivers operating their vehicles when at risk from lack of sleep or when affected by drugs or alcohol. In the home all manner of domestic appliances will be controlled by micro-processors, often aimed at the optimum use of energy in such areas as water heating, air conditioning and cooking. The recording and playing back of television shows and telephone calls will be the norm. Eventually most homes will have their own built-in computer centre, not to mention their friendly electronic baby sitter or 'domestic robot' to do the tedious, routine chores.

RECREATION

Electronic games of ever greater complexity will become commomplace and little more expensive than a pack of cards. Programmes such as 'Its In The Bag' with contestants sitting at home will be possible. We can imagine instant 'postal' chess being played without adversaries having to move from the comfort of their own fire-sides.

THE PUBLIC SAFETY

There is immense potential for the development of tools for law enforcement, including general surveillance and intruder detection, rapid communication between law enforcement agencies, fire detection and safety devices generally. In this area, above all others, it will be the public conscience rather than technical difficulty that will limit growth.

HANDLING THE WRITTEN WORD

Word processors, stand alone micro-computers that control typewriters, and the use of computers in the printing industry are manifestations of the rapid change that is taking place in the way we deal with the written word. Hand-set type was used for four centuries before being replaced by hot metal typesetting (Linotype). Less than one hundred years later linotype is in turn being replaced by the new technology.

The principle is the same in both areas. Drafts are recorded via high speed terminals on temporary computer files. From here they can be retrieved, shown on visual display units and corrected or editted at will. Mistakes are simply over-written and whole phrases can be added or deleted anywhere in the text. Special instructions as to how the matter is to be laid out (paragraphs, headlines etc.) can be added. Where there is much repetition, legal work is a good example, the basic text can be kept on permanent files and only the variable portion need be added. When all correction is satisfied a single instruction causes the formatted text to be typed at very high speeds or output to the next stage of the printing process, as the case may be. This report has been prepared on a computer text editor developed by the author´s company.

The impact of all this will be far reaching and probably in the very near future. Word processors increase the output of a typist (thirty to fifty percent has been experienced). The effect on newspaper production and the printing trade, where traditional crafts and skills will be retained in a few specialised areas only, needs little imagination.

Reduction of job opportunities in these areas will, in the longer term, be compounded by a dramatic reduction in the use of paper and printing as a medium for recording and exchanging information. "It simply makes no sense to transport half a pound of paper for the sake of one gram of ink that is put on it." (8) Letters, newspapers, reports of all sorts, plans and books, especially reference books, will to a greater or lesser extent be replaced by their electronic equivalent. The householder will ´open´ the morning mail at the press of a button and, item by item, it will be displayed on his screen. The same screen will be used for providing news and weather reports or, for the masochist, the state of his bank balance.

EDUCATION AND RESEARCH

Computer-aided instruction with each pupil progressing at his own pace is already here. It will be most interesting to see how this develops. As far as research is concerned, many of the limitations imposed by present equipment will disappear with significant advances in precision and accuracy. Information held in electronic libraries anywhere in the world will be available to local enquirers. Extensive indexing and searching procedures will be developed.

Simulation as a research tool will gain in importance with the growth of the capacity of computers to deal with more complex relationships.

NATIONAL SECURITY

It is impossible, even today, to think about defence and the armed forces without taking account of the nation´s electronics armoury. Much of the information in this respect is classified. It will be sufficient to say here that the role of electronics in military operations, both in offence and defence, will become of even greater significance.

THE CASH-LESS SOCIETY

It is a relatively short step technically from the present elementary computer banking system to one where any monetary transaction can be handled by the system. A purchase at a local store can be directly debited to the purchaser's account and credited to the store via a terminal at the point of sale. From the shop-keeper's point of view this has many advantages, no bad debts (for the transaction will not be completed if the intending purchaser has insufficient funds or has exceeded his credit), and a sub-system can also form the basis of his stock control. Automatic cash dispensers (already in use overseas) will supply pocket money once the individual has identified himself. At first he will do so by some sort of credit card, but eventually the processor will be able to recognise his voice pattern or some other personal identifier. Great train robbers will be out of business but the future for 'white collar' crime looks brighter.

AUTOMATION OF MANUFACTURING AND PROCESS CONTROL

Here we can do no better than again to quote from Abelson and Hammond (1).

> "In the past automation of manufacturing and process control has moved slowly because of fear of dependence on a central computer and the cost of controlling units. The first process control computers introduced in the late 1950s for example, cost about $300,000; mini-computers reduced this to less than $100,000 by the late '60s; now micro-processor controllers are available for $3,000, cheap enough to automate control and data collection for even small process steps. What seems to be evolving is a linked hierarchical arrangement in which micro-processors are used to control individual pieces of equipment; mini-computers collect and process management information from the micro-processors for an entire factory; and large central computers use the resulting data in compiling corporate financial reports."

Another factor in this respect is that since the control units will be 'programmed' rather than hard-wired it will be relatively easy to change them and controllers will become cost-effective in shorter and shorter production runs.

HEALTH

In the 1970s we have barely touched the potential of electronics in the Health area and indeed, in most cases where attempts have been made, the results have been disappointing to say the least. Neverthtless the break-through cannot be far away. Medical record keeping, relatively simple patient registers at first, but expanding into full clinical details on each patient is actively being pursued. As well as being used during treatment, such records will form the basis for medical research, health resource allocation and planning and the setting up and controlling of regimes for preventative medicine. Process control procedures are as applicable in the hospital laboratory as elsewhere. The combination of microwave cooking and the use of computers to sort out diets and the patient's choice of dishes from a comprehensive menu will revolutionise hospital catering. Electronic monitoring of a patient's condition will become routine and, in other than acute cases, it will not be necessary for the patient to be kept in hospital for this purpose, thus freeing hospital beds and benefitting patient morale. Diagnostic tools will reach even higher levels of sophistication. Already in the experimental stage are interactive computer programs to assist in taking initial case histories and to provide a tentative diagnosis. As a separate field is the unique power of electronic devices as a prostheses to supplement or replace damaged neural tissues. As well as better cardiac pacemakers, doctors are forecasting an implantable electronic ear for the deaf and similar applications. These advances are possible because modern circuits now approach the size, power consumption, and logical capacity of the natural tissues themselves.

THE WIRED CITY

In a separate report the Commission for the Future's Technological Working Party have pointed out that when telecommunication broad-band networks become readily available, the scope for information transfer to people in their own homes will be enormous. Some of the possibilities are:

a) Picture Telephony - the ability to see as well as hear during a telephone call. This technique can be further extended to provide conference facilities which enable face to face communication between parties in different locations.

b) Pay Television - the receipt of special television programmes on payment of a specific fee.

c) Library Service - page by page display of selected books. This, as previously noted, can be extended to display on the home television of such things as weather information, news items, stock market reports, etc., some of which is already happening overseas.

d) Display and ordering of merchandise.

RETURN TO HOME INDUSTRIES

Once business and general records are held on computer files the necessity for staff and managers to be physically located together disappears. Clerks, typists, middle managers and tycoons can all stay at home, each with his own terminal on which to carry out his work. The saving in resources in not having to move bodies backwards and forwards to work will be a strong incentive to bring this about. The social implications need no stressing, although they are by no means all bad as some would suggest.

THE INFORMATION EXPLOSION

The ready availability of large capacity, compact data files at low cost will make it practicable to collect and store ever increasing volumes of information in computer systems. More importantly, it is going to be possible to correlate data on different files with ease and to produce comprehensive reports on individuals and organisations alike. It is going to become increasingly difficult for anyone to know what information about themselves is being held, to find out how it is being used, or whether it is correct.

While information is held in manual filing systems there is less cause for concern. Since file searching is laborious and costly, and there is no assurance that relevant information will not be missed, it is undertaken only when there is a real need. The new technology will make all data available at the press of a button. However, it should not be overlooked that computer files can provide superior facilities for guarding sensitive information against unauthorised access. Equally the purging of incorrect or outdated records is relatively inexpensive and one can be confident that it will be complete.

Nevertheless, so powerful are the possessors of large data files likely to become, and so threatening to individual rights is the potential, that a complete re-think of the ethics of information handling must come; and the enactment of laws to control the holding of personal and sensitive information on computer files will be inevitable. It will be necessary for such laws to be agreed and enforced on an international scale. It will be to no purpose for New Zealand to prohibit the holding of certain personal information on computer files, if the same information can nevertheless be stored in Central Africa and accessed by satellite as if it were in the next room.

WEATHER PREDICTION AND CONTROL

The factors that produce our weather are governed by natural laws and therefore, in theory, capable of prediction. At present it is the complexity of the weather patterns that defeats us. A start has been made and as computers become more powerful so will the ability to predict weather become more an exact science. It is but one further step to work out whether it is possible to influence the weather over specific areas. This is one of the applications used to justify development of the Josephson (liquid helium cooled) computer mentioned earlier. A Josephson computer will be very expensive both to perfect and to run but, it is argued, the costs are fully justified when compared with the economic gains or the increased food production possible if we can accurately forecast the weather and perhaps influence it to some extent.

REPAIR BY REPLACEMENT

To some degree we have always followed the principle of repair by replacement; no-one, for example, bothers to repair a broken milk bottle. In the electronics field however, the tendency towards replacement of defective parts rather than repair will be accelerated by the fall in relative costs of 'hardware' noted previously. Thus the skills required in the electronics servicing industries will be significantly lessened. But some occupations not hitherto associated with electronics will also be affected. Here the watchmaker is a good example. Soon it will be as hard to find a watchmaker as it is to find the once flourishing farrier. We may retain the watchcase, for this will be the most expensive part, but the 'works', once defective, will simply be replaced.

THE AUTOMATED OFFICE

Some of the most dramatic changes to be brought about by the electronics revolution will be seen in the office, especially the larger ones. Office workers collect, process and distribute information and it is precisely in the areas of communications and information processing that electronics technology is making its greatest impact.

The ultimate possibility, as we have seen, is the complete disappearance of the office as such, to be replaced by a greatly reduced staff working from home; not likely, however, in our 30 year time span. What is likely is the development and wider use of existing facilities and those now coming on the market. We shall see the general introduction of versatile private telephone exchanges that will automatically re-route calls and record messages. Much greater use will be made of facsimile document transmission, closed circuit TV for individual discussion and conferences, word processing and electronic mail. Paper files will all but disappear to be replaced by electronic data banks or microfilm storage systems. Cross referencing and document retrieval will be by way of a master computer index. There will be fewer typists about but they will have added skills and will be in charge of "multi-purpose office work stations" - word processors with communication adaptors through which the electronic mail will be channelled and which will also control a facsimile transmitter, copier and document reader. Dictation will be by way of recorded messages with, eventually, drafts being prepared by processors programmed to recognise individual speech idiosyncrasies. There will be the opportunity either to concentrate operations, or to disperse them. If staff are hard to find in the head office area selected functions could readily be transferred elsewhere.

What is clear is that there will be little need for anyone, manager or clerk, to move about. The office could very easily become a lonely sort of place.

CONCLUSION

(Louis XVl - "C´est une révolte?"

La R-Liancourt - "Non, Sire, c´est une révolution")

We are probably standing too close to be able to assess impartially the revolution taking place around us. Yet revolution it surely must be. This paper has attempted to show the nature and pace of the changes being brought about by electronics technology, where we have reached today, and where it is likely that we are going.

While the possibilities for new gadgets have a compulsive fascination it is to the social implications that we must direct our chief attention. It has not been the purpose of this paper to follow these through, this will be done elsewhere in the series. But if highly undesirable consequences are to be avoided careful planning will be needed. We didn´t do too well in the Industrial Revolution. It is to be hoped that we do better this time.

long term loan
Myra Harpham
2011

REFERENCES

1) Paper by Philip H Abelson and Allen L Hammond - Science Vol. 195 March 18, 1977 pp. 1087-1091.

2) "Waves of Change" - Charles P Lecht. Pre-Publication extracts printed in "Computerworld" April-October 1977.

3) "Computers and Their Social Impact" - Martin O Holoien - Published John Wiley and Sons, 1977.

4) "Scientific American" - May 1975, September 1977.

5) "Computers And The Year 2000" Published by National Computing Centre 1972.

6) Reports of TGC (Technical Committee 9) of the International Federation for Information Processing - "Relationship Between Computers and Society".

7) Paper by Richard W Hamming "The History of Computers to the Year 2000" (Publication details not known).

8) Peter F Drucker, Keynote address 18 CIOS World Management Congress, December 1978.

Kindly donated for permanent loan to the
James Duncan Reference Library
by
Myra Harpham