PART THREE:

1. THE FIFTH WAVE?

EMBARKING ON THE NEXT FORTY YEARS

The persisting stagflation of the past four years no longer looks like the usual short-run recession or the 'ten year business cycle'. Not only is it persistent and world-wide but it has proven unresponsive to Keynesian and Friedmannite economic solution.

Unemployment has not reached the levels of the last Great Depression but in all western economies it has grown greatly amongst the young. Increasingly it looks like structural unemployment. Growth in job opportunities is not taking place in traditional leading sectors and wastage is being met by temporary employment of women rather than by offering career opportunities for the young.

Governments, singly or collectively, have been unable to demonstrate any understanding of the situation, let alone stimulate economic recovery. When the costs of job creation in existing productive industries are analyzed it seems impossible that economic recovery could be on a scale that would take us back to the full employment economy. Insofar as any new investment in these industries is going to be more labour saving the goal of full employment appears even more remote. At the present, this is where new investment is going (Greenspan, note 1).

Another perspective on the present recession is possible, namely, that our economies are in the trough between the fourth and fifth long Kondratiev cycles. If this is so it gives us a new perspective on the conditions necessary for economic recovery.

Two prominent analysts, Rostow (1975) and Forrester (1978), have argued that this is the case. Rostow arrived at this conclusion after reviewing the classical empirical studies of historical economic trends, and Jay Forrester from computer simulation of growth in capitalist economies.

Taking Rostow's date of 1783 for the birth of the world economy then the big economic depressions corresponding to the end of one Kondratiev cycle and the beginning of the next are:-

1790-
1844-51
1890-6
1929-34
1972-

It will be noted that these cycles are of about forty to fifty years. On this scale we would expect one in the 1970's. Rostow observed that "In 1972-3, the world economy experienced a turning point in foodstuff and raw material prices, a break as sharp as those of the 1790's, 1840's, 1890's and 1930's" (ibid, p749). As in these other cases he did riot expect this to be a sustained growth in relative prices.

In each of the historical cases the depressed period was longer than the figures given here indicate eg. the long decline from 1873 to 1890 and the painful recovery in the late thirties until full war mobilization was effected.

In retrospect we can see that recovery in these crises was unplanned and, in each case, recovery was effected by the movement of capital and labour in unexpected directions. By contrast the recovery from short-term cycles is usually characterized by a recovery of the markets that existed before the recession. As this happens factories etc. re-engage labour and move back to fuller utilization of capacity. With further recovery these productive facilities are expanded, modernized or duplicated. One can sit out these cycles, as it were, and wait for the first signs that it is time to take up where one left off.

The depth of uncertainty that confronts key sectors of the world economy is well illustrated by the iron and steel industry. It is worth bearing in mind that they stand between the massive investments we have in mining and shipping and the mass markets for the automobile and domestic white goods. The report released from the International Iron and Steel Institute conference, Rome, Oct. 1977, read as follows:

> "Steelmakers fear the future. They are being carried into uncharted waters by currents they do not understand. Apart from the weakness in demand, structural weaknesses in the industry in several countries are now becoming apparent.... In the Western world demand for steel is falling when by the rules of the game it should be rising." (Canberra Times 16/11/77).

If this is the predicted Kondratiev crisis then there is indeed reason for the leaders of such a basic industry (and their major customers) feeling that their environment has gone turbulent. The reason is that recovery from such a crisis in the past has been associated with non-traditional technologies assuming the role of the 'leading parts.' New technologies that offer the opportunities for very profitable investment and 'limitless' growth; they attracted capital and labour away from the traditional technologies.

These new technologies proved so significant for the emergence of these forty year cycles, and the shaping of their courses, that historians are prone to refer to these technologies as a shorthand with which to describe that historical period.

Thus the first cycle, 1790's to 1840's, is characterized as 'the age of textiles' (or 'the age of machinery', for the textile industry): the second cycle 'the railway age': the third 'the age of electricity' or, from it's major derivative, 'the chemical age': the fourth 'the age of the internal combustion engine', 'the electronic age' or 'the age of plastics'. (Emery 1973,76). It is difficult to imagine a student of modern history being confused as to which era is being referred to.

The implications of this are important, as Forrester has pointed out. If we seek to hasten recovery by subsidizing employers to hold workers in their present jobs (by economic 'autarky' or by direct subsidization of jobs) then we will in fact prolong the crisis. It would, in a Kondratiev slump, be equally mal-adaptive to train the unemployed in the expectation that recovery will be quicker if the work force has been up-skilled in readiness to man modernized versions of the existing technologies. Of course, a generalized argument could be made to the effect that these measures offset the demoralizing effects of unemployment by maintaining some semblance of labour discipline and earnest work habits.

This argument rings strangely hollow when the displayed wisdom of the individual employing bodies, public and private, has been to leave a very high percentage of the young potential workers without any work experience.

What I am suggesting is that our planning for job creation and eventual economic recovery ignores the real possibility that we are in a Kondratiev crisis. In so ignoring this we may well be acting so as to delay recovery. At the same time we have the evidence that intuitively the potential employers are limiting the entry of the young into the existing work-force, and the young are showing a marked reluctance to take up the limited career openings offered by traditional employers.

These latter judgments seem to show a better intuitive sense of reality than what we get from governments and their advisers.

At this point I want to short-circuit the argument. If this is a Kondratiev crisis then we will only get deeper into the mire (with the ever-present risk that a growth in national economic autarky will produce a 1930's crash in international trade) if we think we can find direct solutions to unemployment and inflation by manipulating current realities. Other questions have to be answered first. I am going to assume that this is a Kondratiev crisis and then see what follows. From what follows we can see how seriously this assumption needs to be investigated.

Naturally I proceed in this way because I attribute a high degree of probability to the assumption. I do not think it is a wild hypothesis. It seems to me most unlikely that the next period of growth will be driven forward by the love affair the mass of private consumers had with the car, TV, private dwelling and the domestic white goods in the 1950's, 60's and early 70's. A change away from those particular driving forces must have repercussions, not only throughout metal manufacturing, the iron and steel industries and the plastic industries, but also right back to the extractive industries.

I have indicated what, on this assumption, seems to he actively mal-adaptive strategies by well-meaning governments. I have indicated the passive non-adaptive strategies that are reflected in the high order of youth unemployment. Our ability to respond more adaptively to the current economic crisis depends on our success in identifying what technologies will be the leading parts in the next cycle of economic growth. If we can do this with any degree of certainty then planning measures for redirection of investment, training of the work force and research and development become sensible, and self re-enforcing.

<u>What then are going to be the leading technologies in the fifth Kondratiev cycle?</u>

I do not wish this paper to be read as if it were a detective story so I will state the best judgment that I could arrive at from my studies; and then explain why I was led to this judgment.

<u>The leading technology of the fifth forty year Kondratiev cycle will be the micro-processor and its manifestation in new generations of 'smart' devices and in domestic energy generation.</u>

Already, in 1967, it was obvious to me that the 'information technology (was) the leading part of the technological/productive system' (Emery, 1967). By 1975 it was clear that this technology had been deformed into providing massive centralized number crunchers on the procrustean bed of the fourth Kondratiev cycle. Its own potentialities had been subordinated to the dominant technologies and organizational forms, primarily military, of that advanced industrial era. (Emery and Emery, 1975). In 1977 it became clear that in the few preceding years the technology had broken free from this procrustean bed and was growing at a fantastic rate to assume its own proportions and form. The whole of the March 1977 issue of Science was given over to the exploration of the many facets of this 'electronics revolution'. The editors noted that 'Major changes are occurring in a year or two in contrast to a time scale of a decade found in other spheres of technology ...As the vigour of the industrial revolution fades, the electronics revolution will provide impetus for the reshaping of society in new directions.' (p1085) In September, 1977 Scientific American devoted its annual special topic issue to the same electronic revolution, and the issue consultant, R.N. Noyce noted that 'there has also been a true revolution: a qualitative change in technology, the integrated microelectronic circuit, has given rise to a qualitative change in human capabilities...

And we are only slowly perceiving the intellectual and social implications of the personal computer... ' (p63). The Economist followed suit in an article in its issue of March 4, 1978 and the Time magazine with a thirteen page feature in its issue of February 20, 1978. Clearly something was afoot that was of interest to business as well as to science.

I intend to look at three major trends that suggest that microprocessors are a serious contender for the role of being a leading part not just a fad. I think this is necessary because many of the current applications, to toys and watches, seem to be no more than trivial improvements on current technologies. The three trends that have serious import are:-

(1) the long-term growth, over the last two Kondratiev cycles, of the percentage of the work force in western countries who are engaged in the 'information sector';

(2) the emergence of the electronic battlefield;

(3) the remarkable reduction in the costs of microprocessors and the translation into their relative prices and the relative prices of technologies to which they are applied.

I will discuss these trends.

The information sector.
With respect to the first trend it should be noted that at least in Australia, growth in the service sector and the manufacturing sector has levelled off or fallen off in the last decade whilst growth in the information sector climbs more rapidly than ever (Jones, 1978). It is already at a level where it employs as many as does manufacturing. It is up to 32-36 percent

of the total work-force in countries like Germany, France and the UK (voge, 1977) and close to 50 percent in the USA. (Porat, 1976) All started from 7 to 10 percent around 1900.

On the face of this evidence new jobs are emerging in the information sector and declining in the manufacturing and service sectors. This is heartening. The educational profile of the under 25's matches this job demand profile far better than it matched the profile of a labour market dominated by manufacturing and services. We should note, however, that the information sector has been born into an artificially structured market for skills and developed on the assumption that computer supported devices can be programmed, operated and maintained only by highly certificated workers. With programmable micro-computers this is no longer the case.

They are cheap enough already that secondary school students are gaining familiarity with them. They are cheap enough not to bother with difficult fault finding and maintenance. They are cheap enough not to demand very clever programming in order to get high utilization of capacity. Their programming to new uses demands some cleverness but when one is talking, as in the USA at the moment, of some 750,000 available sets, the resourcefulness of a lot of clever and enthusiastic people is being tapped. The where-with-all to interface with micro-computer supported systems generally requires no more than some secondary education with occasional small blocks of specialist job training. Probably less than ten percent of the emerging work-force is unequipped to enter the information sector.

I think that it is possible to give some sort of explanation of the apparently relentless growth of the information sector. The cost of material transformation or of transportation is a joint function of the cost of energy and the availability of knowledge of the possible paths for transformation or transportation. We understand the first notion very well: no one in his right mind would use a sledgehammer to crack nuts. We are not always too clear about the second notion. I have, for instance, deliberately used the term 'availability' to apply to knowledge as contrasted with the term 'cost' applied to energy. I am well aware that cost is a very relevant characteristic when knowledge is not available and R and D have to be undertaken; or when knowledge is not readily available because of patent laws or because it is treated as the property of some priesthood. Knowledge, however, has the property of being nearly costless when it is generally available. It is well established that with deeper knowledge of the possible paths of material transformation, eg., catalysts, the relative cost of energy used and material transformation achieved can be radically changed. Ditto, if mathematical modelling is applied to transportation routes. Thus, if we have an advancing information sector in our economy then we have a basis for increased productivity. Jean Voge quotes evidence to suggest that in most western economies a fourfold increase in productivity has followed from a fourfold increase in the information sector in this century. This is not, however, the whole of the picture, as he very obviously realizes.

Looking at the performance of our economies there appears to be a 'saturation point' where this correlation between the growth of the information sector and the growth of productivity breaks down. Voge calls this the 'fifty percent law'. It is a property of closed systems, as so well indicated by the mathematical modelling of 'Limits to Growth'. We have seen the phenomenon in the reversal of growth in science and tertiary education.

The payoff in education has disappeared because there was no thought about changing the strata of 'concerned parents' (Emery, 1977). Money for this education was pumped into the society without concern for change in the society that was supposed to produce enough keen young
women and men for entry into higher education. A very clear analogue to what happens in this sort of situation is provided by hydrodynamics: pump a fluid through a pipe (or drive a ship through water) and at a certain point so much turbulence is created at the interfaces that it absorbs any extra effort pumped in, whilst flow rate (or speed of the vessel) remains constant. In the information sector the parallel is the generation of noise eg. foot thick piles of computer print-outs and pin-head learned papers.

Most of the socio-technical systems of which we have knowledge (if not all) are only enabled to act as closed social system by reason of legal artefacts of law (eg., governmental departments) or economic monopolies. As they approach saturation point they can fail or they can dissipate to cellular, non-hierarchical structures. The work of Prigogne etc. on the thermodynamics of open systems leaves no other alternatives. (1976) For this intellectual leadership Prigogne received a Nobel Prize in 1977. It was not just a passing bright idea.

These are very general considerations; I can be more specific. This information revolution was not a marked feature of the first three Kondratiev cycles (unless one looks at the emergence of the knowledge professions). As I tried to analyze in Futures We are In (1973, 1976) the information revolution is only characteristic of the last two cycles.

The information revolution was embodied in the emergence and spread of very large bureaucracies, and it was technologically propelled by the wars and the war preparations that were such a marked feature of these last two cycles. The saturation point, to which Voge referred was a saturation within bureaucratic structures. The dynamics of information flow in a bureaucracy, generate a much higher noise-to-signal ratio than occurs in 'dissipative, cellular' structures. In the latter, the information sector may grow well beyond the 'fifty per cent rule' before saturation is again reached.

To sum up, the growth of the information sector has itself generated powerful pressures toward a particular kind of system change. These changes will be necessary if information technology is to remain a major source of productivity increase.

The electronic battlefield

The revolution that is 'the electronic battlefield' was dramatically unveiled with the opening hours of the Israeli-Arab war of October, 1973. 'Smart' missiles, in the hands of infantry, forced tanks and jet aircraft off the battlefield. The micro-processors and sensors brought this smartness to the battlefield.

The very large role of war in the last two cycles has imparted an impetus to the growth of electronics that is very much greater than could have been expected from pursuit of peaceful economic purposes. In fact it has been asserted that the transistor is the only significant development since the forties that did not flow directly from defence research. Cost has been of little hindrance to research and development when there was promise of some advantage on the battlefield. With the emergence of more lethal and expensive weapons there was a massive technological thrust toward electronic target acquisition, high speed data processing and improved guidance. At the same time there was a thrust toward miniaturizing this technology so that its 'benefits' could be distributed on the battlefield and thus rendered less vulnerable to counter measures.

The result has been the emergence of a whole generation of 'fire and forget', smart weapon systems. The conventional modern battlefield was characterized by a multitude of missiles more or less blindly seeking targets that usually survived. On the electronic battlefield relatively few precision guided missiles seek out and follow their well-defined targets with a very high order of lethality. The targets are as good as dead once they have been electronically detected, and they may not be aware that they had been detected.

The cost-effectiveness of these smart weapon systems, in terms of energy saving, precision and reliability, is such that it is inconceivable that the same principles and techniques would not flow over into all machine systems used in civil life (from lawn watering systems to multi-turreted lathes).

This brings me to the third trend that strongly supports the emergence of the micro-processor as the next leading part (or at least as central to a cluster of leading technologies).

Cost and relative prices

The mass production for military purposes of micro-processors and their associated miniaturized sensors and actuators has led to dramatic reductions in cost and these cost reductions are being quickly passed on to consumers.

It is enough to quote one figure, out of many, to indicate the sort of price trend we are confronting with this new technology (new insofar as it did not exist in 1970): for each year since 1970 prices, per unit of performance have been steadily reducing at 35 percent per year. (Growth of the US steel market was 2 percent; electronic market grew 200 times, 1971--6).

There is nothing yet perceivable that is likely to lead to a plateauing of this trend. Firm expectation is that in the early eighties we will not just have the micro-processor on a chip, as we do today, but a computer-on-a-chip; that is, the processor with its two memory storages (ROM and RAM) and inputting and outputting facilities on an inch square plate. Expected capacity; 16 bit cpu, 32 k-bits of memory and simple 1/0 interfaces; speed in the range of 10^5 to 10^6 instructions and price $10.

As Rostow pointed out it is only technologies that display this trend toward cost reduction that are contenders for leading a new Kondratiev boom.

Cost reduction might not mean a great deal if it were just reduction of cost-unit performance as a computer: mini-computers and the CRAY monsters might be found to be doing much better. The really significant cost reductions of micro-processors lies, as in smart weapon systems, in the Midas touch. They reduce the cost of just about every machine system they touch and in the majority of cases throw in as a gift performances that were previously desirable but too expensive to offer. We will come back to this shortly.

Let us first sound a need for caution. Let us recall that it was less than a decade ago that nuclear breeder reactors were being hailed as offering a future of almost costless energy compared with oil, coal and gas. Furthermore, the graph of annual commissionings, under construction and firm orders, had, by 1973, revealed a very remarkable exponential curve. It showed all the signs of an industry that had taken off and attracted truly massive investments. By 1974 the US, AEC was not alone in assessing this cost advantage as an illusion; despite the great upward movement of oil prices in 1973. The exponential 'take-off' curve has crumbled quite dramatically.

This is fair warning that sheer novelty and scale of technological growth does not guard us from embracing 'a future technology whose time has passed' (As Lovins said of nuclear energy in general, 1976).

The dimensions of choice

The three basic dimensions of choice have been spelt out (Ackoff and Emery, 1972). It seems most unlikely to me that societies would re-order themselves about any technology that failed on any one of these dimensions.

It is only by looking at the actual and probable applications of the micro-processors that we can assess:-:-

(a) the continued ability of this technology to lower costs whilst delivering better results (the dimension of choice labelled probable Effectiveness);

(b) the likelihood of micro-processors playing a significant enough role in our socioeconomic intentions to act as the leading part in transforming our economies (dimension of Relative Intention);

(c) whether - the technology generates ready social acceptance or the concern and opposition generated by nuclear energy and the big computer systems. (Probability of Choice - familiarity).

Probable effectiveness and relative intention

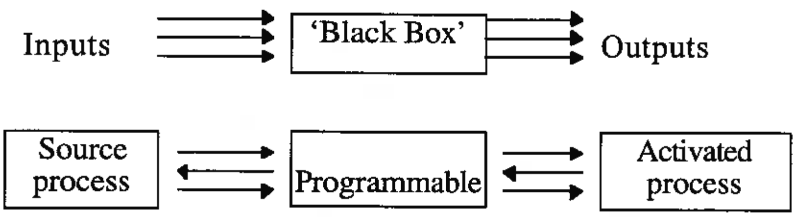
The first point about application of micro-processors, and their associated input sensors and sensor actuated outputs, is that they can, theoretically, be used to replace all electro-mechanical devices.

Since the emergence of electricity as the leading edge of the third Kondratiev cycle (1895 c) our utilization of electricity has been harnessed to, and eventually throttled by electro-mechanical devices, from brass light switches to the motor drive in video-cameras. The mechanical parts of these devices have to be more precisely engineered in order to convey more information, and hence become more expensive. They are subject to little understood processes of material wear and material failures and are hence unreliable, with resulting high maintenance and replacement costs. When they were developed as control mechanisms and servo-mechanisms it was inevitably as fixed analogues or mimics. In this mode longer production runs and hence lower costs could be achieved only by higher degrees of quality control and standardisation of the mechanisms they were designed to control; once again higher production costs. Micro-processors have proven that they can break this bind in several ways; they eliminate mechanical connections together with the associated problems of friction, wear and structural failure; operating in the digital model they can use the logic of arithmetic to register, memorize and statistically analyze variations in the sources of their inputs and the performance of the recipients of their outputs, and adapt accordingly, within their programmed range; they can be reprogrammed to make use of knowledge generated elsewhere; they can generate knowledge from their own performance that provides the basis for their own re-programming for a continuously closer fit to the requirements of its own job. It is the ability of the micro-processor to diagnose what is happening in the machine it is working with and the environment of that machine (whilst still monitoring its own performance and the performance of its 'slaves', its sensors and activators) that raises the smart machine above the status of the robot devices that previously held our imagination (eg. Capek's RUR or the 1960's dream of central computer control of process plants). What has emerged is a very cheap way of making all of our machines and interdependent sets of machines 'smart' ie. able to act purposively, to the limits of our ability to identify the operating parameters, sense significant variations and programme the memory and processing capacity of the chip. Used in the mode of George Box's Evolutionary Operations Programme (EVOP) the micro-processor can replace the expert statistician as the tool for achieving better definition of the operating parameters. (Box, 1957).

In systems terms we are now talking about level 3B, active, multi-functional systems, not robots at level 2B - re-active, multi-functional systems. (Ackoff & Emery, 1972 p.29) Diagrammatically the difference can be represented as follows:

a)

b)



Logically the first systems are dealing sophisticatedly with L_{12} and L_{21} relations and their interactions. The systems achievable with micro-processors can deal with L_{11}, L_{12}, L_{21} and L_{22} relations, and their interactions. (Emery, 1973 P.83) What they can be made to do in these respects may look very limited to what we expect of @ human being, but it is qualitatively different from what we can get from electro-mechanical servo-mechanisms; and it does this extensive inter-connecting under conditions and to a precision that we would not even wish to emulate.

As we would expect the first civil applications of micro-processors have been generally timid and faltering. The brief history of the entry of micro-processors into the car industry is typical. (Ludvigsen,, 1978) Strong resistance from the powerful and proud clan of automotive engineers; who at first could not believe what the electronic engineers were on about. Gradual acceptance of micro-processors as replacements in analogue form to do what was already being done by advanced electro-mechanical devices: advanced applications to trivial ends, eg. tracking stations on the car radio: finally, ventures into degrees of smartness about serious matters, eg. Ford's Electronic Engine Control (EEC 1) on this year's Lincoln Versailles. This latter is an interactive device optimizing for an electronic spark control system, sensing on three variables, and a fuel flow control system sensing on four variables. The system offers greater emission control and fuel savings. The same sort of development is underway and being marketed in product fields as diverse as copiers, microwave ovens, radios, watches, central heating controls, telephone services, typewriters, theodolites.

At first flush the advent of the micro-processor might be seen as simply producing the following scenario:

A housewife reclining in an armchair watching television. With one hand she picks chocolates from a box, with the other she taps out commands via the buttons on a compact remote control console. A robot device is thus commanded to vacuum the carpets; windows are opened without leaving her chair; laundry in the chute automatically released into the washing machine; the TV set switched on command to the "View-data" made to display the day's bargains at the local supermarket; deciding on her purchases she taps in the "items" code numbers, her account numbers, the store number and presses a button for automatic despatch to the store's computer. Then by the same remote control, switches the TV back to one of her favourite video cassettes.

I suggest that the impact of this new technology will be of much greater depth. To evidence this statement I will consider in turn the probable impact on the metal working industry, the telephone system and the energy sector.

Component parts production

At the heart of the metal working industry is the batch production of component parts. This segment has been intensively studied at Centres in Japan and to USA with a view to automation. US figures, which should be broadly indicative of the position in advanced industrial nations, show that component parts production (CPP) engages 40 percent of the total workforce in the manufacturing industry. Computerization of CPP would reduce labour requirements by 80 percent. This computerization has been attempted with so-called mini-computers. It has encountered formidable difficulties in producing a hierarchy of programmes because at the very first level, ie. at the tool-face, they found that they did not really know what was going on. Oil refineries struck the same snag in the sixties when they enthusiastically went for centralized computer control and Detroit's first effort with truck braking systems found that they did not really know what happened in such systems. Computer costs dictated this top-down strategy and the programming difficulties were under-estimated. Mathematical efforts to design reliable hierarchies based on unreliable parts continue to meet without success unless they can afford extraordinary degrees of redundancy (as is the case in some military applications eg. the CRAY computing machine for breaking top Soviet cyphers and protecting US ones.)

The cheapness of programmable micro-processors allows a bottoms-up strategy starting from a broad range of applications in a batch production workshop. As with the application to the car we can expect the initial applications to be to single functions, starting with those best known. No one application in itself would constitute a significant advance toward automation but collectively they would. As a body of knowledge, and useful sub-programmes, emerges for numbers of functions then 'interactive' programmes can be tackled with some degree of hope. The aim would still not be for a hierarchical central control but rather for interfacing cellular groups of functions; computer aids for the interfaces being independent of intra-cellular computer control.

This strategy is only economically feasible because of the low cost of the microprocessors. It is this strategy, which calls for a lot of fairly low-order programming, not the difficult and costly stuff associated with centralized workshop control. More than that, this strategy allows one to start with the observable operating characteristics of machines and plant; one does not have to wait on long research programmes to identify fundamental physical and chemical parameters. We demonstrated in the mid-sixties that a productive socio-technical system can be analyzed so as to yield its 'matrix of variances'. Such a matrix identifies where and in what form unpredicted variances arise in the production process, and where corrective action can arise. This sort of systems analysis is all that is needed to identify where micro-processors can be immediately introduced to yield a quick pay-off. Programmed to store their analyses they provide the knowledge base for their re-programming, for interactive links and for much more accurate pin-pointing of where additional controls on sensors are needed, or even fundamental research. I have perhaps written as if the micro-processors would simply be replacing human operators. This is not so. Many of the sources ofvariances arise from machines and plant starting to go off line. The diagnostic capabilities of the micro-processors would undoubtedly be harnessed wherever they were introduced for operational analysis and control. The consequence would be also a rational reduction in the maintenance force.

It would only require 3-5 years to automate even a large workshop to an eighty percent reduction in workforce. Market pressures would encourage competitors to follow suit.

Let us convert these notions into jobs. What I am suggesting is that in the recovery to the next Kondratiev boom some 500,000 (half-million) jobs may be lost to the Australian manufacturing industry. And that is simply from the application of micro-processors to the batch production of component parts that is estimated to engage forty percent of the industry's workforce,

The telephone system

As the next example of 'impact in depth' I wish to consider the national telephone system. Jean Voge, as chief engineer of the French PTT, has already been quoted with respect to the 'saturation point' of centralized systems such as our current national telephone systems. I wish to look at the vistas opened up by the micro-processors.

The telephone system must be easily our largest single national socio-technical system (international?). At this moment they are committed to replacing the electromechanical exchanges with computerized exchanges. This offers a great reduction in maintenance and replacement. However, the choice today has been extended by the emergence into civil affairs of the microprocessor. It is now possible to realistically ask what savings are achieved, and what extra services feasible, if computerization is sought via micro-processors attached to each phone rather than centralized computer capability at the exchanges? (Telecom systems seem so addicted to thinking of themselves as closed systems that this question has already generated the reply that if there are real economies in this why should they not be realized by the authority building dedicated micro-processors into their hand-sets rather than customers using their own freely attachable and personally programmable micro-processors).

First, we can return to a problem noted above, namely the redundancy required by a hierarchically organized information system. The fact is that the large computers with this architecture are increasingly consumed by their own operating system (OS) in order to reduce the noise to signal ratio in the mass processing jobs they do. And I am not talking about using ten to twenty percent of capacity but of figures much above fifty. By contrast, down-time on a micro-processor does not keep idle a vast slave force. As in the remarkable Hewlett Packard watch (HP-01) it can earn its keep when employed to less than ten percent capacity. The on-the-phone micro-processor is not engaged in mass processing and hence is always likely to have cost free spare capacity for new phone uses that people can dream up for their own personal purposes.

The contracting benefits can be spelt out in tabular form:

Exchange computer	**On-phone micro-processor**
Absorbed in self-regulation	Spare capacity
Programmed for pre-determined classes of services	Personalized to extent required
Dependent on expensive high level programming	Operate on cheap low level learning programmes, available in the marketplace
Subservient to the national telephone system; can be made to serve 'national' ends	Can be programmed to hinder external examination
Dedicated to purposes of the system	Multi-purposes; spare capacity available for other household purposes

It will be noted that the potential cost/benefits for the phone owner are all one-sided. For the Telecom system replacement displaces a great deal of maintenance and also a great deal of their bureaucracy.

Domestic energy production
This third example of 'impact in depth' is by far and away the most significant, and also the most radical. The accumulated experience and scientific achievement of the preceding four Kondratiev cycles that crested in the recent aborted surge toward nuclear energy appears to be being displaced by the scientific achievement of micro-processing that emerged so as to avoid mutual nuclear destruction.

Jay Forrester went on record as saying "Energy networks with larger and larger power plants are not, I think, the wave of the future' (ibid, p. 148). Lovins and Price have pointed out that over the period we are considering, since 1783, 'the exponential growth of energy supply has been made up of successfully added curves, each initially exponential, and each introduced as the previous ones - representing the previous 'new energy source'- matures or begins to falter." (1975, xxvii) With the oil price increase in 1973 we had to accept that the energy basis for our economies had matured and faltered overnight. It was not taken too seriously as it seemed that, as always before, something, and this time nuclear power, would step in to sustain the long-term exponential growth. Nuclear power was already on to a sharply growing exponential curve of its own. As I pointed out earlier, that curve crumbled. Direct and indirect costs, and social concern about the latter, created undreamt of obstacles to the transition to nuclear power generation. Lovins and Price point to a fundamental issue that may help explain the dilemma we are in, with respect to our next energy base, 'each (new) source must be capable of faster growth than the preceding one. The traditional succession of sources - wood, coal, oil, gas - permits this because of its trend towards increasing technical simplicity per unit of output, culminating in gas, whose relative simplicity at large scale has let it account for about two-thirds of US energy growth in the past few decades. What, then, is the next big source, simpler than gas and therefore capable of even faster sustained growth?' (ibid, pxxvii, my emphasis).

The answer is not to be found in boosting the existing centralized networks by returning to more plentiful fossil fuels like coal. We have already referred to Jean Voge's theoretical explanation, drawing on the theory of the thermodynamics of open systems, as to why in the growth of such systems they get to a point of consuming most of what they produce.

He evidenced the example of centralised telephone systems. Others have demonstrated the same regression in the large computer systems. Lovins, in 1976, has documented the startling proportion of national energy consumption that enters into electricity grid systems but never gets through to the end-users for the simple reason that it goes into the systems own requirements for generation and distribution.

They have posed the same question that I would have posed in this framework of analysis, 'What is the next big source, simpler than gas?'

I might attach more urgency to getting an answer (if that were possible) because the emergence of each new Kondratiev cycle seems to have been boosted by the availability of a new and cheaper energy source. The textile age took off on the over-shot water wheel, the second was the age of coal, the third the age of electricity, the fourth oil and natural gas. If the answer we are looking for is not in a small number of very large generating units supplying large numbers of users then we must look in the other direction, very large numbers of smaller generating units each supplying small numbers of people.

Theoretically, this alternative path offers considerable economic advantages in reduction of distribution costs, equipment, maintenance and power losses, and a finer match of capacity and requirements.

In practise these theoretical advantages are unlikely to be realized if the large numbers of small generator units required a transport network to distribute fossil fuels; as when coal was used in the UK for space heating, or wood in Australia. This narrows our consideration down to solar and wind sources. There are very few houses, or housing clusters that do not receive some or both of these energy inputs. (It is also true that only an empty house does not generate garbage, and hence a potential for methane generation, but the argument I wish to present can be laid out without this further complication). Again the theoretical advantages are unlikely to be realized if the operating efficiency of the solar and wind generators and their storage costs make them significantly more expensive as a source of supply than the existing centralized systems.

Let us briefly look at where these two technologies are at so that at least we can start from what has been established as technologically feasible in the way of lowering costs. The hybrid Savonius/Darrieus vertical wind-mill, generating through a geared up A.C. induction motor, is well proven. It seems close enough to what we need in terms of efficiency; 'simplicity; ease of construction and mounting; and ability to extract power effectively from gust.' (Clark, 1976, p8l) The ANU solar collector, generating through a closed ammonia cycle, is proven through its experimental phase and, insofar as scaling up is not involved, it is ready for deployment depending only on the economics of construction. No doubt there are many other systems of solar collection that are at a similar state of 'proven possibility'.

This will do for our discussion. Several points about this technology are significant, (1) it generates high grade energy readily convertible to electricity (2) it can continue to do this with a considerable degradation, cheapening, of its structural components (eg. parabolic reflector dish) because (3) it is a smart device; it tracks the sun through its daily and seasonal variations in such a way as to maximally focus the incoming energy. Unlike the great majority of the cheaper solar collector devices it does not just lie on its side and wait for the sun to come to it.

The ANU solar collector would be irrelevant to other than centralized energy generation if it remained dependent on the mini-computer. It does not. Tracking the sun requires no more processing capacity than a micro-processor has. The system is so efficient that construction from cheaper and less efficient materials is readily tolerated and, being controlled by a micro-processor, there would be minimal reliance on expensive and unreliable electromechanical devices.

This brings us back to the role of the micro-processors. We have noted their significance in making a feasible economic proposition of the ANU solar collector. Clark had already shown the very considerable economic advantage that follows from adding a one dollar Fairchild uA 742 electronic chip to the circuitry of a passive solar collector. (ibid p34).

The micro-processors have a much greater role to play. Certainly very much greater than providing us with smarter cars, refrigerators, air-conditioners. First, they can drastically reduce the capital cost and maintenance of wind generators by replacing electromechanical transmission by electronic transmission. Second, and this is the crunch, they offer a way to integrate wind and solar generation with common high level energy storage.

Both of these matters are important to the economics of domestic energy generation. Integration of wind and solar energy generation at the same local point offers a much extended input over almost all times of the day and the year, for almost all localities. 'Common high level energy storage' has two implications. First, if it is high level energy it will be economical to exchange it within fairly extended localities or else pump it into the existing electrical grid. Second, if it is common high level energy coming from the wind and solar collectors there is no reason why the existing distributive system for electricity within the house cannot continue to be used. (eg., lights, irons, ovens)

Common storage could be via hydrogen. Flasks could be on hire and traded locally or to the SEC'S.

Several problems remain. For a country like Australia we are clearly thinking of several million integrated wind-solar-storage units. In terms of cost we are thinking of units costing much less than a car and closer to the cost of a refrigerator. We are thinking also of an investment that reduces future outgoings and hence dependence on paid work.

A growth in employment in manufacturing is not envisaged. These products fall into the component parts sector.

A very considerable growth in the computer software industry is expected. It is not expected that this will be any more vulnerable to centralization than is artistic production.

It is expected that the learning curve in this application of micro-processor technology will primarily be in software development ie. labour intensive, non-bureaucratized work.

The details of the preceding scenario are not in themselves very significant. More competitive local energy generators undoubtedly exist or will be brought into existence to suit particular conditions. Likewise alternatives exist to hydrogen storage. The key lies in the cheap micro-processors, sensors and activators, that can make these generators smarter, cheaper and more reliable. The integration of supplementary systems offers further significant windfalls.

Beyond this are the energy savings from the simple application of micro-processors to light, heat or cool only those parts of the home where the sensors detect people (subject to sensible delays and over-riding manual controls.) Similar savings can be expected as micro-processors are introduced to the devices that use energy (as already applied to the Amana range of micro-wave ovens.)

Those who are aware of Lovin's specification of the desirable new energy system will have noted that I have ignored his rejection of electricity, '..because it is the costliest form of energy to make, store or transport in bulk' (ibid, pxxviii, also 1976). I do not question his facts. It is simply that I think that in a nation with almost every dwelling wired into the existing electricity grids, and richly equipped to use electricity in most diverse ways, the new technology will grow from within by gradually drawing less from the grids and some dwellings dropping out entirely as hydrogen distribution networks emerge in their localities. Decisions about replacing old parts of the grid or costly up-grading will then have to be made in a new economic climate.

What new industries would have to be brought into being? Wind generators and parabolic solar collectors are not complex structures and do not need to be machined to high precision or made of exotic materials. As mentioned we are probably considering an outlay for an integrated set of about that currently paid for automatic washing machines or refrigerators. Much less when people choose to build their own, or assemble a kit. It is an investment that should certainly pay itself off in five to seven years and thereafter reduce outgoing money or even, if well-sited for air and wind generation, or a low consumer, generate a smallish income. Long run automated production lines seem economically feasible.

It is not at all clear whether the local production of the all-important chips should be attempted. There are defence advantages in local production that certainly outweigh the arguments about buying an air-superiority fighter, like the Grumman Tomcat, as a Mirage replacement. On the other hand there seems to be no future obstacle to bulk purchasing from overseas, at very attractive prices. As a precaution we should perhaps establish research into the next logical phase in their production direct electron beam manufacture instead of the present process mediated by photo-lithographic production (at present it is a hard problem but short-cuts will almost inevitably emerge).

The novel industry is the domestic industry of programming; an industry that started to get off the ground with the first programmable hand calculators. This is of particular relevance because the instructions built into most existing electromechanical servo-mechanisms are neither complicated nor long; it is the physical analogue devices that are complicated to manufacture or repair. It is quite within the scope of the enthusiastic amateur to write these instructions into a programmable micro-processor and to store the data needed to improve the programme. We would expect equipment manufacturers to soon grasp the marketing logic of installing programmable micro-processors, instead of dedicated ones, and providing a set of basic injectable programmes. The thriving market would be in the sale or exchange of the hobbyists products.

The third criteria I suggested for judging the future role of micro-processor technology was "whether it generates ready social acceptance or the concern and opposition generated by nuclear energy and the big computer programmes." The extensive growth of hobby clubs devoted to playing with the micro-processor had, for fairly obvious reasons, no parallel in the nuclear or the big computer fields. Gamesmanship did develop in the world of the big computers but it was confined to those who had legitimate access and was discouraged except when it served to project the marketing image of the computer as all powerful. The reaction of the hobbyists is only a litmus paper reading. Much more important are the intrinsic capabilities of the micro-processor. My views on this should be clear from the earlier comments on designing future telephone systems. The micro-processor makes it possible for individuals, even those without tertiary education, to exercise greater control over their personal circumstances. It does so at a cost which is fairly negligible and it does not expose them to invasion of their privacy. Its application to the devices that saturate their life space frees them from the tyranny of the 'repair services.'

In general, the thrust of the micro-processor technology is the same as that of the so-called counter-culture: energy saving, non-pollutant, dissipative.

Summary

We appear to be in the slump between the fourth and fifth Kondratiev cycles. This being so, the next boom will require new technologies that offer major cost-savings and operational simplicity. The micro-processor seems to be the prime candidate. Three arguments are advanced for this assumption:

(a) the growth of the information sector;

(b) the emergence of the electronic battlefield;

(c) the rapid reduction of prices for micro-processor functions.

The probability of people choosing to go down the paths opened up by micro-processors was examined by looking at applications that would attract usage by reason of their efficiency (component parts production in the manufacturing industry and the national telephone system), by reason of their importance (domestic energy generation) or because they fitted in with cultural demands.

Postscript

Since its birth, circa 1783, the world economic system has been dominated by a system of centralized nation-state economies. The forty odd year cycle of Kondratiev has been closely paralleled by the forty year cycle of warring discovered by Singer and his colleagues? Both cycles may be characteristic of the international system of centralized systems (Emery 1955). It may be that a system change to 'dissipative, cellular structures' will free us of those particular dynamics. It is to be hoped so. In every other Kondratiev trough we have, as now, been remarkably peaceful but as we have moved out of the trough we always increased our warring and it seems that it was not any one nation or group of nations that did the warring. As the figures stand a massive re-occurrence of warring will occur with the boom of the next Kondratiev cycle (there can be fewer more dismal occupations than working out five-year moving averages on the Singer data). Maybe the system dynamics will have changed in the ways suggested in this paper.

Notes

1. 'Consumption is still on track, business investment is not.
It is still far short of where one would expect it to be at this stage of the business cycle.' Alan Greenspan, Fortune, 13 Feb, 1978, pl40.

2. "The shut-out generation" Time November 4, 1977, pp24-38.

3. Granted that these international sector conferences are playing to an audience of national governments the facts remain facts. In the USA, UK and Japan the industry is operating well below capacity, world demand is sluggish (only two percent growth in the USA) and, despite the rosy picture of rapid recovery that was painted in 1976, investment is still attracted only to short-term labour saving and not to long-term growth prospects. This is not to deny that there are still niches for profitable mini-mills using such technical short-cuts as natural gas to sponge iron, and sponge iron with scrap via electric furnaces to quality steels.

4. The changing structure of the labour force is well indicated by the following UK Department of Employment figures (quoted Economist 4 March, 1978):

	Industrial Sector			
Percent	computers	electronic capital goods	all engineering	cars
white collar	60	57	30	21
foremen & skilled	17	27	29	27
semi-skilled etc.	23	16	41	52

5. The only surprise in this was the misjudgment of the Israelis. On October, 6-7, and again with Adan's counter-attack on the 8th, they sent their tanks in piecemeal and without the co-operation of forces that could have suppressed the enemy infantry. On October 14, they made no such mistake: of the two thousand tanks involved 270 were knocked out, of which 264 were Egyptian. Mortars played a very significant role in keeping down the infantry. Interestingly the flexibility of the mortar has been greatly improved by the introduction of a cheap, instantly programmable micro-processor fuse. It eliminates from the inventory seven different types of non-adjustable fuses.

6. With the emergence of precision guided ordnance it has been said that, 'The shift from predominantly direct to mainly indirect fire will be terrifying and perplexing. Nearly every incoming round will be deadly and almost every antagonist invisible. This increased lethality, coupled with a likely decrease in number of rounds fired, will profoundly alter the nature of combat' (R.A. Doughty and L.D. Holder 'Images of the future battlefield', Military Review, February, 1978).

7. These two developments are not necessarily incomparable. The case for computerizing exchanges is unbeatable. The question is whether the computer at the exchange merely replaces the existing electro-mechanical systems or goes on to offer additional, but dependency increasing, services that could be done at least as well by home micro-processors. However, the picture will change radically when micro-processors digitalize the voice message at the hand set.

8. The current answer is more natural gas. (International Workshop on Alternative Energy Strategies, 1977). This, however, appears to be a move toward a more complicated technology for liquefying, transporting and re-gasifying the gas. The ships for this trade are the most sophisticated and expensive that have ever been built for civil purposes. Cost of each of the tankers currently under study for bringing out Canada's Arctic gas are estimated at about $200 million (Noroil April, 1978). The Lorneterm, New Brunswick, terminal for just re-gasifying Algerian liquid is a $355 million project (ibid).

9. It has been strongly argued against Kondratiev that there could not be such long-term systemic functions because we knew the very marked effects wars and new discoveries of precious metals have on price movements: and wars and mineral discoveries are independent, exogenous factors. The very sophisticated statistical studies by Singer and Small must cause us to doubt that wars are exogenous. They found strong evidence of a forty year cycle in 'amount of international war.' This was clearly not a property of any one or a few of the nation states in the international system but of the international system itself. Running a five-year moving average over this statistic I find that it corresponds to the Kondratiev cycle to the extent that the troughs correspond. When the system is in a Kondratiev slump one thing it does not do is produce warring between nations. With recovery the warring cycle seems inexorably to build up. Just calculating the moving average was a spooky experience.

   Singer and Small found also a twenty year cycle. On my graph this is very clear and spotted near the middle of each Kondratiev cycle ie. it does not appear to be an independent cycle. Rather does it seem that warring is part of the process of re-ordering the new international economy, that function achieved, it loses its relevance only to build up again as the strains of living with the new order emerge. This interpretation is for the moment speculative - further analysis of the Singer and Small data should settle it. It will also be necessary to establish the relation between this and Kuznet's twenty year cycle.

   Blainey's meticulous study of mineral discoveries in Australia goes a long way to show that at least in this case it was not an exogenous variable.

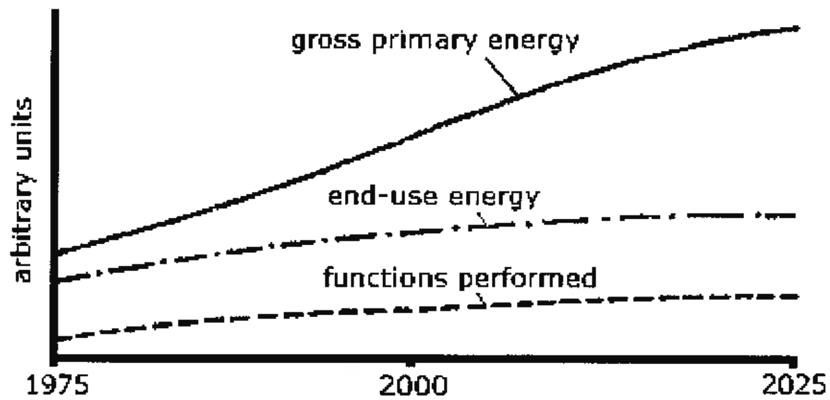
10. I must stress again that the technologies that are being most forcefully pushed as the answers to meeting our future energy requirements do not meet these specifications. Through the fifties and sixties the marginal capital investment to deliver to US consumers the enthalpic equivalent of 1 barrel of oil per day was of the order of $2-3,000. With North Sea oil it is now about 10,000; with Alaskan and deep-shelf

production it is expected to raise toward 25,000; with the conventional high-temperature, high pressure coal burning electricity station and the nuclear light water reactor it is expected that in the mid-eighties (at the same 1976 dollar value) the marginal capital investment will be about 200,000, with coal below that figure and nuclear above. (Lovins, 1977, table 8-1). Interestingly the projection for large scale centralized solar energy, and also wind, generation for the mid-eighties is also around that 200,000.

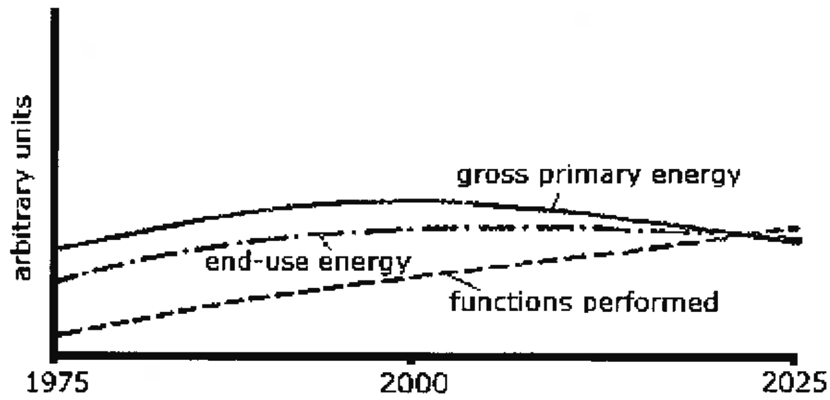
It is technological sophistication and size that drives up capital requirement, regardless of the fuel source. "In contrast, the motive capacity in US central power stations - currently totalling about one-fortieth as much as in (all) US cars costs perhaps ten times more per kW, partly because it is not mass-produced." p41).

The hard realities of our world economic situation will, I think, force us to choose the soft path in the following alternatives:

2. Energy Strategy: The Road Not Taken? 47



(a) A HARD PATH



(a) A SOFT PATH

(Lovins, 1977,47)

Appendix A

The situation in manufacturing industry and the unemployment situation

1. Situation appears to be one which lacks leadership. Many can see the problem but seem not know what can be done or how to get started. Also the situation appears to be that the leaders of the industry cannot come together spontaneously and must have help from outside to achieve this.

2. We came to the conclusion that whatever else needed to be done there were three key and interrelated principles to be implemented if the situation were to be stabilized and recentred with minimal disruption.

   (i) There must be no job-creation schemes as such. It will be necessary to accept that at any given time only perhaps 1/3 of the potential working population will be engaged in what are at the moment called jobs.

   (ii) A "job must be redefined. All forms of productive activity - from housekeeping, voluntary community service, learning, helping etc, must be called "jobs" and carry the current status of a "job."

   (iii) There must be a minimum guaranteed income for all over the age of 16 or on leaving school. This must be a rational and adequate level of income which guarantees dignity of lifestyle to those who receive it.

3. These three principles amount to a radical transformation of the socio-economic infrastructure of current society. They break away from some traditional and usually unspoken assumptions.

eg. 1) that the unemployed will grab any job created regardless of whether it is a "good" or "bad" job (most job-creation schemes created "bad" jobs);

2) that the potential workforce consists ultimately of adult men and that the only societal unit worth considering is a stable family with a single breadwinner who is male;

3) that there is a sizeable group of people who are unemployable or bludgers and that a lot of people only engage in productive activity for the money;

4) that there needs to be constant growth in the workforce or expansion of manufacturing industry. In fact there is good reason to believe that 1/3 of those currently employed in manufacturing could, if properly organized and working with efficient technology maintain, if not increase, the current level of productivity sufficient to maintain the country and its exports at current standard of living;

5) that it is necessary to maintain stratification of society into various economic classes which are then rationalized socially by reference to the personal qualities of individuals within the classes;

6) that school is where "children" learn and working cannot be a proper substitute learning activity for this age group. The corollary of this is that many of this group do not wish to take their place in transformative productive activity;

7) that people cannot tell the difference between a "good" job and a "bad" one, or that they do not care;

4. Action to be Taken. A small group of leaders of industry, union and government be brought together to explore the current situation and the points made above. Hopefully to arrive at strategic plan for action which will end the current phase of inactivity and consequent decline of manufacturing industry, and begin a phase of action which has been thought through to a desirable end state.

5. 35 hour week?
job sharing?
etc. ??

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