“The Electronic Plateau”

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The message which I have to give you with respect to prospective developments in electronics is, `It ain't going to happen that fast.' There are limitations and problems which will prevent the rapid explosion of microelectronics we have all been led to expect. To illustrate these I will discuss a number of possibilities, and then come up with some hard policy questions. It is a delight to me to give this Ralph Slade lecture because Philips Electrical Industries, which Ralph Slade worked for is also the body which is supporting the New Zealand Science Fair, and has done for four years. I have been involved in that quite extensively and therefore it was very easy for me to find out, from them, all about Ralph Slade. I never met him, of course, but in reading about him, I have wondered what he would have said then about the future of electronics 30 years hence when he had that reception of the radio transmission from America while he was still at school. Because that's the problem you're setting me. What is it going to do?

Electronic Marvels

Well, the first thing that can be said, of course, is that it will be all pervasive - electronics is in everything. It is, of course, chemically based! You remember the silicon transistor. As all electronic engineers know, silicon has tetrahedrally arranged bonds with a network of silicon atoms arranged tetrahedrally in solid silicon. If some are replaced with arsenic atoms so that one puts in five instead of four electrons one gets a negative type conductor; and if one puts in aluminium atoms instead of some silicon atoms one gets a positive type conductor. Just a positioning of n and p type conductors give a typical transistor, which conducts one way and can be used as the basis for amplifiers and rectifiers. The chemistry of introducing such trace impurity atoms in a controlled way is the basis of your industry.

The applications of electronics are, of course, widespread. I propose to consider the implications of these applications in several areas of importance to New Zealand. I first want to say something about energy. The electric car is coming up on us fast. In modern designs the batteries can be changed at garages at about 150 mile intervals so you could go to Auckland by changing the batteries once between Wellington and Auckland. They have a top speed of about 80 km per hour. Electric cars have fairly rapid acceleration. The drive is often through the front wheels.

Of course it depends on batteries. Batteries are being re-designed. One modern type of lead-acid 6v battery has three containers (three cells), a thin lightweight durable polypropylene container, single point watering, low resistance, high efficiency, and computer designed grid for the electrodes. That's one of the new designs which are arriving. Of course, research is being done into many different kinds of battery - there is a lithium-iron-sulphide cell, an updated more efficient version of the Ni-Fe battery and others. A feature to

recognise is that there is a chemical law called `Avogadro's Law' or `Avogadro's Number' which says that if you want a certain amount of charge, (if you want 6 x lO^{23} electrons, for instance), you need one mole, = one gram molecule if you like. That limits the size. You cannot get a small mole, = a small gram molecule. Therefore, that means the batteries will never get smaller. They may get lighter. There are other electronically driven transport like the solar bus in which a parabolic system is used to collect the solar radiation and beam it onto a photovoltaic cell system for powering the batteries. Photovoltaic cells are now being exploited and developed extensively. One from the Sharp Corporation is used for solar powering a house. It gives 33.2v at 31.6 amps, using lead-acid battery cells from 23 M2 of photovoltaic cells. And that handles all the lighting, the pumps, the fans and the refrigerator in the house.
Another example is the use of photoelectric cells to collect solar radiation from a satellite for ground power generation. The satellite is, of course, in space. Electronic-based industries of other kinds will also be developed in space. The preparations of materials, like the "chip" or vaccines (using freeze drying and vacuum drying techniques) or anything which involves high vacuum technology is feasible. But perhaps the most important will be satellite radio, T.V, and information transmission. This is already being done by satellite as the familiar Landsat pictures of New Zealand illustrate. These are used for weather forecasting. Even here in New Zealand, surface scanning is being done by aeroplane. At the Aokautere Science Centre of the Ministry of Works and Development the technique is to scan the surface, taking pictures at several different wavelengths. Then they are printed in quite different colours. The result is that, in this particular case, the red is the green foliage, the green are old erosion patches and the white is the recent erosion patches. Now electronics is involved, of course, merely in taking the photograph, because the silver iodide in the emulsion is converted to silver. But more particularly, having taken these pictures, one can measure the areas of different colours and so estimate what the grass growth is on the different erosion areas. The Aokautere Centre has shown that one cannot get regeneration of the grass growth for about 50 years. And so one can estimate the loss in production due to erosion and then convert into money, which in this case corresponds to a loss of about $1 M pa from erosion in the Wairarapa Hills simply from the grass production which is lost.

One can then take this further and say, well, we look at this picture and we look at similar pictures for the entire country. We also classify all the land into different types. There are eight different types. We put all this in a mini-computer and we work out what kind of land use is possible for New Zealand, under different kinds of assumptions. That is an example of the use of electronics in a way which electronic engineers might find a little novel.
The distribution of mainframe computers amongst professions in New Zealand is roughly as follows: 100 percent of the universities (and the computer services have them); accountants 74 percent; 88 percent in manufacturing; government departments 17 percent. It has been said that we are the most computerised community in the world per head of population. We ought therefore to be able to get things done. But we have only just begun to see the beginning of the electronic revolution - especially in the application of microprocessors. We haven't finished our marvels yet, there will be lots of new developments. The 250,000 bit "chip" is coming up. The line thickness is about 2-3 microns at the moment, and can get down to a 1 micron limit. We are going

to get advances in chip technology by using Josephsen junctions, in about five years. This is a lead alloy junction cooled in liquid helium which allows much more power, about 20 watts per chip, to be dissipated. There are other developments too, of course. The silicon chip is coming close to its limits, and that means we will be going into things like gallium-arsenide on sapphire and indium phosphide which give better cooling properties and better electrical properties; (and particularly reduces the electrical capacitance). So there are still many technical developments possible and it looks like there could be at least a factor of ten improvement on the power of microprocessors and computers over the next 10 years. The consequences of this are expressed in Table 1 which is the result of a Delphi study of expert opinion in France of the kind of things we might expect.

TABLE 1 Summary of French Survey on use of Computers

1985 Most likely year Most banks connected through a computer network
1990 Electronic mail the main means of communication in business and industry
1985 Direct access of individuals to data networks by ordinary telephone lines
1990 TV-oriented interactive information systems for households
1990 More than half of manufactured articles produced in plants with automated parts making operations
2000 More than half of manufactured articles produced by plants with automated assembly operations
1995 "Paperless" administration: massive use of computers in offices and administrations
1990 Automatic translation of unambiguous texts
1990 Computer-aided diagnosis in doctors' offices
1990 Massive use in higher education of sophisticated computer aids
2000 Massive use of medical consultation at home by computer

The Social Impact of Technology

Most people are worried about the social impact of microprocessors. This is epitomised by the use of robots transferring goods routinely from one location to another, or doing dangerous jobs. Now imagine that it is in a kitchen, ladies. That is almost the same thing. Robots can now do almost any mechanical operation, in a factory, a domestic house or elsewhere - picking up this stick and putting it down there, or switching on the oven, doing the cake mixing and choosing the ingredients. There is no technical reason why we cannot have robots in the kitchen.

In fact electronics at home are the coming thing. The home office of the future might look like this: There is a visual display unit, at which the typing is done under instruction from the boss who is in a different city. The typist might be, for instance, at Aokautere, and the boss in Palmerston North and they may be sending an electronic letter to me in Wellington. So the letter is first composed and corrected, and at the press of a button it goes down through the telephone line to Wellington and I reply within two hours on the teleprinter. We've abolished the Postman. And indeed that's what is already happening to some extent with telex and telephone. But there are two important social aspects about this. First, one can have such offices in any situation even remotely. It can be done in the country on a farm; or in a lighthouse; or in a hospital; or in a prison. That allows isolated people to be in social contact with the rest of the world. And if it is objected that this is expensive, the answer is nonsense. None of these instruments would cost more than a thousand or two dollars even at current prices. People already spend $10,000 on a car, at least. Well, it depends on your car of course. We are familiar with that, but everybody looks at this new electronic technology, shudders and says, "I wouldn't want that sort of thing", I think that is because of the unknown fear of isolation with big impersonal machines. You can imagine that kind of thing happening in a small town centre with other people - like Wanganui, for instance, or Levin or Palmerston North, or Aokautere. What you would do, is to walk down the street to an office where there might be 100 people working for different organisations hooked into their Head Offices in some big city like Auckland or Wellington. In other words you could get over the commuting problem and still allow the social contact, which is vital and really necessary for the individual. Well, that's a development which is an alter-native life-style, and it is relatively cheap. But let us return to the home. Frequently one will not notice the presence of electronics. A washing machine may be full of microprocessors, but it will look exactly the same as a present-day washing machine. It will allow automatic handling of washing. Microprocessors will be just about everywhere in your home - for instance, in the vacuum cleaner. A recent competition for `Micro Mouse', was to design a device which would sense its way around obstacles. It has tentacles with sensors at the end of them. They are sensitive to walls and barriers, enabling Micro Mouse to walk around a maze. And this is a small step to design a vacuum cleaner so that it cleans the room without touching the furniture. It will be full of microprocessors.

Your domestic life will be altered in other ways too - like automated ordering of shoes. You go to a shop, you have your feet measured, and by microprocessor techniques you automatically have selected the style, the stock and if necessary, you can even have the thing made automatically - all controlled by microprocessors. This means that stock levels can be kept small and money is saved. Similarly, an artificial limb of the future may be controlled by microprocessors, combined with precision engineering. This is an example of the kind of thing which New Zealanders have a future in - combining microprocessor control with mechanical devices.

The paperless office is also coming fast. All the information and correspondence is handled electronically. Each desk has a variety of displays, and a mini computer for filing, cataloguing of addresses etc. The electronic blackboard should be of value to Massey University. What is written on a blackboard in Palmerston North can appear through the telephone line on a visual display unit anywhere you wish without the use of TV cameras. Again there is `Viewdata'. In this one can choose what information is wanted and have an iterative discussion with the computer database. It is not simply a question of waiting for some-thing to appear to the passive observer. You may wish to buy a lawn mower, or a book, or go on a holiday, or take a trip somewhere, or book an aircraft or a theatre seat, or buy some vegetables. For all of these you can find out by discussion with your Viewdata terminal what's available and what is possible. For instance, in selling houses, one would expect an estate agent no longer just to put catalogues into the Viewdata base. If you said, "I like the look of that house, what's the plumbing

like?", then it would be expected that the Viewdata would give you some clue about the state of the plumbing, the outlets, the drains and so on, which would enable you to make some kind of a judgement about the house before you ever went to look at it.
Finally, satellite communication techniques will enable individuals to have access to information and help wherever they are. People will have wristlet trans-mission stations into which they can talk. A person, for instance, with a car broken down, or a policeman who's just arrested a person, or a person stranded at sea, are typical examples.

The New Utopia?
Well, all this does not form the basis of a new Utopia. There are certainly examples, in New Zealand, which are highly successful. We heard this morning about taximeters. There is also the foetal heart beat detector, the control of machine tools, light-control systems, blind-aids, radiotelephones, solar-powered electric fences, mastitis testers, tree growth recorders all being made or developed in New Zealand. There is no doubt that we can exploit this technology, if we wish.

But, in one of your papers you will find the statement that the social implications of microprocessors and electronics does not seem to be understood by these futuristic commissions we have around. I'd like to correct that! First of all the Commission for the Future started the microprocessor debate, two and a half years ago. *It has taken two and a half years for us not to do anything.* And I don't think that's good enough. We were involved in the original showing of `The Chips are Down', and encouraged TV2 to show a film on what was happening in New Zealand. The FOL came up with their pamphlet called `The Crunch'. This is full of rather interesting cartoons. There is one, for instance, of one microprocessor talking to another. The first one says, "I displaced three typists and two technicians this month". And the second one says, "Too bad, you'll do better in the 80's". In spite of these doubtful suggestions, in cartoon form, the important thing to notice is that what the pamphlet actually says makes a lot of sense. It says that any wealth should be shared, retraining is necessary, economic growth is desirable, and also we should all be involved in making these decisions. There is no doubt that microprocessors will have important social consequences. Some time back, I looked at the redeployment rate in five industries - Manufacturing, Transport, Communications, Finance and Insurance. I did not include agriculture, forestry or fishing, for in-stance because the data was not readily available. But even in these five industries there will be a minimum of over 300,000 people to be redeployed. That should not frighten you, because this has been going on for years, but it is something we should take account of and we can see it coming in advance.
So as I say, this is not the basis for the new Utopia. Technically it is certainly feasible. New Zealand has not yet examined the consequences of the widespread use of microelectronics in anything like enough detail. Questions like, `Where should our expenditure of funds be best located?'; `What are the most appropriate areas for New Zealand to develop?'; `Should it be in education, in small scale manufacturing, in telecommunications, in energy production and saving or in the information industry?'; Now I've mentioned a number there, which seem highly appropriate. Some of them involve important social changes.

Hard Choices

Let me tell you about the Plato system of education. This involves a mainframe computer in America hooked up to mini-computers in schools, industry or anywhere where training is needed. There is already one installed in Australia and at least 25 in America. Now this system will enable one to teach anything from adding up and simple spelling to driving a Boeing 707, to learning about Mendelism, to doing sophisticated wave mechanics. The programmes are there. There are already several thousand of them. If you want to teach a child to spell for instance, you have a little picture of a pussy cat, on the plasma screen, you press a button and the cat changes to CAT. When you press it again, it goes back to a picture. And then you can make up a little sentence. `The cat ran after the dog into the house'. So you put these in order, press the button to ask "Is it right?" The computer replies "Yes", but it also shows a little picture of a cat chasing a dog into a house. Of course, if you get it the wrong way, "The cat chased the house into the dog", you soon know about it because the picture shows you! Now there is an important point about this. With these techniques you *either learn or turn it off.* You cannot sit there as often happens under the education system we have at present, let the knowledge flow over your head and think you're learning. You either learn or you turn it off. And indeed, there are examples of getting through one and a half years' teaching, at age ten, in 22 hours. They take people off the street in Washington to use it - people who have been illiterate to the age of 30. They put them in front of these machines, in education `shops'. You just walk into a shop, pay your nickel and away you go, and learn to read in about 20 hours' exposure. There have been cases in Chicago of kids breaking into schools to get at a machine! You either learn or you turn it off. Now nobody is suggesting that students should spend all their time learning in front of one of these machines. It would drive a person mad. You would certainly need teachers to guide students carefully as to what they should learn. But it is certainly a vehicle for changing attitudes and for changing approaches to education. It would cost about $3,000,000 to get installed in New Zealand. I am not saying we should go that way, but here is an option. Do we put our money into that kind of thing - an educational development - or into others? And how do we mesh such networking with the developing trend in schools to install mini-computers for educational purposes?

Another place where there are options is in the energy scene. Here is again a major crunch choice. I do not think the community realises how serious it is. The prognostications for the increase in price of oil are simply frightening. They're talking about $75 a barrel by the end of the 80's. Three times what it is at the moment. And this arises, partly because countries like Russia are showing signs of importing oil, partly because of in-creasing costs of production and partly because of shortages forcing up the price. If it goes like that you will be forced into an alternative lifestyle because you cannot afford to travel. Therefore, you either get stuck in and fix this liquid fuel thing, or you are in alternative lifestyles where you do not travel anything like as much as at present. *And so I say that if we really want to maintain our present lifestyle we should be putting our money where this sort* of *thing really can count.* That is the choice. Indeed I think it would be fair to say if you want to maintain your present lifestyles we are not going anything like fast enough in the producing of liquid fuels. *Because even on our present programme, we will only really be maintaining the present status quo with regard to overseas exchange over the next 10-IS years.* That is a major crunch choice.

We can go into microprocessors as one alternative lifestyle. As the Minister said this morning, one has less pollution that way. You could, of course, go back into the land and use labour intensive operations to grow food, back to Ohu's and that kind of thing. That's another kind of lifestyle. But although the Commission for the Future has been talking about this, I don't think you should run away with the idea that they think it is necessarily the right thing. The point is that it is a choice which will be forced upon us unless we fix it. But there are other aspects to this choice. What technical limitations are there in New Zealand in the use of electronics? Well, there are a number of possible limitations here and these are also quite serious. One is, "If we're going into using microprocessors for controlling small scale devices, will there be enough available?" Now I believe the answer to that is "Yes". It looks as if we will be able to have enough microprocessors to do what we want. *But we will not have enough systems analysts, software programmers and people to* fix *microprocessors. That has severe limitations.* The people who design the things, the people who feed in the software and the people who mend them. Here arises another major decision. If we wish to use microprocessors for economic growth, we need much more systematic development of training programmes for all of these types of people and we need to get on with it. We could possibly import some of these people from overseas, but only in competition with the rest of the world and not likely in anything like sufficient numbers. Unless we get on with it, once again, we will get to the stage where that redeployment becomes unemployment. We will be forced into government-subsidised service industries and for every dollar you put into that you lose $1.50 in the private sector. That again is a choice. Can we go fast enough in microprocessor development or are we limited by the availability of people? I believe the answer is that we are so limited and unless we do something to produce such people, we will fall way behind the rest of the world in the application of microprocessors.

To analyse such questions the Commission for the Future is just beginning to set up its policy analysis research groups. The first one is on `Communications'. Microprocessors will be one aspect of this study which will also include telecommunications, radio, networking, education, foreign affairs, libraries, and other aspects. The Policy Research Group will bring down a report which will present hard options and the implications of those options. It is too early to be definitive about the outcome but my present views concerning microprocessors are something like the following - this is why 1 titled the address "The Electronic Plateau". The worldwide constraints which I have indicated, particularly those imposed by the lack of systems analysts, programmers and electronic technicians will limit the rate of growth of electronic applications. There is not likely to be an explosive development in the application of microprocessors. We just cannot cope with it. In New Zealand, we will probably fall behind unless we get on with the business of providing the expertise to use it. So we will reach a plateau in the exploitation of electronics. There is more likely to be a steady growth than an exponential explosion. And New Zealand will certainly be left far behind the leaders of the Western world, unless she takes steps to ensure training programmes provide adequate numbers of the types of people I've been mentioning. If she is left behind, you will then be placed in the position where you will buy a black box, a mini-computer, a microprocessor-controlled oven, or vacuum cleaner, or process control units just to keep up with the American, European and Japanese "Joneses". In my view New Zealand could best benefit by restructuring its innovation and inventiveness to developing small scale devices incorporating microprocessors in those areas where we have particular expertise in our main industries - in agriculture, in the fishing industry, in forestry, in energy, in manufacturing and in education. But of course, if we're going into a nationwide information industry, there is another problem. I want to illustrate this by reference to the recent ANZUS debate again. Now some people have formed the view that the Commission for the Future is advocating withdrawal from ANZUS. Let me now emphatically deny that. That is not our position. What we have been doing is asking the question "What is the view of the New Zealand population on this question". We did not know the answer to that before we asked the question. The answer to that question then acts as a constraint on our thinking. If the community at large were to wish to withdraw from ANZUS this would certainly be the component of our thinking. Having heard the debate, and there are obvious arguments which can be used in both directions, I have come to the conclusion that since both major political parties now say they wish to stay in ANZUS at present, at least, that's it. There may be changes in the long term future, or course, but that's a different matter. Now, of course, there will be people who disagree with that. Whether that's the majority view or not it remains to be seen. To establish a community view on that (and lots of other things too), we are also in the next two months arranging for N.R.B. to conduct a social survey of the opinions of New Zealanders in several definitive areas. And if I am right, that the major parties and the major view of the population is such that we stay in ANZUS, that will come out loud and clear. If that is right, as is my present opinion, remember that ANZUS is not merely a defence pact. It is a collaboration pact. Under those circumstances, bearing in mind the kind of problems I have discussed above - of redeployment, of maintaining employment, of social harmony, of maintaining markets, it seems to me that the right stance within ANZUS is to say we want to play this for the benefit of the community, on a wider canvas than defence only, for the benefit not only for New Zealand, Australia and U.S.A. but also our Pacific neighbours. An aspect would be to arrange rapid exchange of medical, technical, business and economic information, library material, educational and so on. In other words we set up a communication network. Notice now there is another choice. In setting up our communications information service, which in this scenario involves collaboration with the entire Pacific area, do we set it up to ensure an effective, nationwide internationally compatible system designed to meet the needs of all, or rely on an ad hoc, stand alone, system in which each individual or company buys its own computer independently of others for economic reasons. To enhance social harmony, we might need to set up a network in which John Smith in Palmerston North wants to know something about bees, for instance, so he asks the mainframe computer about this; and it turns out that somebody down in Bluff or maybe in Samoa or perhaps on the West Coast of America, has just the answer to the problem he is seeking.

Conclusion

You can see out of this simple topic of microprocessors some very large issues arise. In summary:

1. If we want to get economic growth out of microprocessors, we need to train the expertise to do it.
2. If we want our lifestyles to stay as they are, much more effort is needed in the liquid fuel area. Otherwise we will be forced within ten years to alternative lifestyles.

3. How can we use ANZUS for social benefit?
4. Do we wish the information industry to arrive on an ad hoc basis or to be designed to benefit every individual in New Zealand, and the Pacific?

And so I will finish with two quotations which relate closely to our interests and goals. The first one is from H. A. Rowland at his address to the American Association for the Advancement of Science in 1883. He said of American science, but I think the same is true of all science, "Science is a thing of the future, not of the present, or of the past". And if you look back to 1883, those of you who can, he was right. So if I repeat that, I hope in the year 2083 somebody will quote it from me and say I was right too. "Science is a thing of the future".
Finally, C. P. Snow in 1960 said "Scientists have it within them to know what a future society feels like, for science itself, in its human aspect, is just that".