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Memorandum to the Prime Minister on British Computing

from Norman Sanders

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1. Preamble

This memorandum is my response to your letter of November 5th. It has been written at two sittings without any time for consulting articles or obtaining numbers. It is concerned explicitely with digital computers only, not analog (of which there are very few). I have therefore referred to them as "computers" and not given them their full name.

I feel that the main point at this stage is to state the problems and make recommendations as soon as possible. Details can be provided later as needed.

It is based very much on personal experiences of computing in both industry and the universities, and I have not attempted to make it an academic exercise.

The articles are arranged in the right order if you have time to read it all. If not, read articles 6 and 12. These two articles taken together state that if it is felt advisable to maintain a British computer industry it can only be done by amalgamating the three principle companies, I.C.T.-Ferranti, English Electric-Leo and Elliott-N.C.R. into a British Computer Corporation.

Also that the Minister of Technology should appoint a special adviser on computing, with responsibility for education, consultation and approval of subsidies.

The Appendix contains information of a general nature which you could read if you had nothing better to do, also a recommendation for a subsequent enquiry by the Minister. Such an enquiry would produce information needed to confirm or deny the gloom of this memorandum.

2. Historical Perspective

There seems little doubt that the first two computers ever to work were both British. It is, of course, difficult to point to the precise point in time when a laboratory device can be said to work, but certainly useful results were coming out of EDSAC in Cambridge and the Manchester machine in 1949. (A more authoratitive statement could be made by Dr. M.V. Wilkes of the Mathematical Laboratory, Cambridge). Work began earlier in the United States, but the Eckert and Mauchly machine, EDVAC, built at the Moore School did not function properly until 1950.

At any rate, there was little in it at the beginning of the last decade. But by the end a new Industrial Revolution had been wrought, and Britain was vastly behind America.

During the first two or three years the initiative lay with the universities and research centres on both countries, in England at Cambridge, Manchester, London and N.P.L., and in America at the Moore School, Harvard, Princeton and M.I.T. But the cost and reliability requirements soon forced the Universities to defer to commercial companies which I discuss below.

In the fifteen years of the existence of computers the developement has been phenomenal. In size, working stores have increased a hundred-fold and mass-storage up to thousands of millions of decimal digits. Speeds have increased a thousand-fold and are now approaching the limit of the speed of light. Reliability has improved from a few minutes to months of error-free running. But perhaps even more important has been the developement of the solution to the man-machine interface problem, even though many of us regard things as still primitive.

The man-machine interface is partly a problem in ergonomics, the physical manipulation of the hardware, and partly a problem in communication; program-writing and information conveyance. At first input to computers comprised hand-punched paper tape or cards read by the machine at about 100 characters per second, and output printed characters at about 10 per second. Today information can be fed to the computer at speeds of a hundred thousand characters per second and more. Much input comes directly from the information source, e.g. satellite, industrial process, engine test bed, bank-teller's cash-register. And much output, instead of being in the form of human information, is in the form of automatic control information, e.g. machine tools, missiles, industrial processes, traffic lights. I.B.M. even have a crude experimental human-speech input device and a production voice output device (male or female).

The programming problem has led to the evolution of so-called "software", formal languages and automatic operating systems. A great deal could be written on this subject. A great deal has certainly been done on both sides of the Atlantic. However software is much more difficult to prescribe and therefore evaluate than is hardware. Consequently it is the subject of much controversy, often fanatical and much too often uninformed. On the other hand far too few people realise its importance, and even today it often comes as an after-thought in the design or selection of a computer, despite the fact that the manufacturers spend approximately the same on software as on hardware. (For a description of software please see Appendix A).

The evolution of the computer market is a fascinating tale in its own right. Competition hasbeen bitter, salesmanship degrading, marketing often lamentably incompetent, technical support often poor and even sometimes lacking altogether. The publicity stunts haven't even been worthy of vacuum cleaners. I will mention one that the Director of Computing at Northrup told me. One day the President of Northrup received 21 red roses from Remington Rand without a word of explanation. So he phoned the computing department and was sent a copy of that day's "Wall Street Journal" which contained a full-page advertisement giving 21 reasons why Remington Rand were the leaders in the computing field, (which they weren't !). The antics of the salesmen bear no relation to the technical excellence of the product or its vital place at the centre of the western economy.

Any discussion of the British industry inevitably involves a discussion of the much larger and more advanced American industry. Let us take that first.

Remington Rand were the first in the field in 1951 with the UNIVAC computer. They had the foresight to buy up Eckert and Mauchly and were off to a flying start which was not to last very long! I.B.M. did not enter until 1953. Then followed Burroughs, R.C.A., Philco, G.E. Honeywell, C.D.C. (not in that order quite) and a host of smaller companies.

I.B.M. soon established a clear lead in volume of sales, quality of its customers (rarely appreciated but vital), reliability of its equipment, adequacy of manufacturing, breadth of research and promptness of service. Current estimates are that I.B.M. have 80% of the American market, the balance shared by a large number of companies most of whom will eventually cease to exist. The Univac Division of Remington Rand seem to lie second, with upstart Control Data Corperation third. G.E. are fighting desperately to stay in the market but my personal feeling is that they, together with R.C.A., Philco, Burroughs and Honeywell will be bought up or coalesce.

Britain also began with a polyglot of manufacturers, Ferranti, Hollerith, J.Lyons & Co., Elliotts, English Electric, to name the main ones. But their total output has only been a fraction of that of one American company, I.B.M. And judging from the plants that I have visited in Britain and America, C.D.C. and Univac, and probably G.E. are larger than any British company. However the figures are available.

During the rapid developement of the 1950's it became more and more evident that computing was very big business. Large computers cost as much as aircraft. It took large companies to build them. Consequently, in Britain particularly, there have been a lot of mergers. I.C.T. was formed from such a merger and has now taken over the Computer Division of Ferranti. English Electric and Leo (J. Lyons) have merged and Elliotts and N.C.R. have a close relationship whose legal status I am not sure of.

As to the sheer volume of computing it is difficult to obtain reliable numbers, but in a recent survey some 18,000 computers of all sizes were accounted for. (There were two, remember, fifteen years ago). But knowing the number of computers and their average speed (say 20 microseconds per operation) we can say that the information contained in our modern society is being acted upon by about 1,000,000,000 computer operations every second. And it must be understood that this is the crux of the second industrial revolution, as we fancy calling it. I take up this question again in Appendix B. This section may be followed by section 6.

Entrenched Applications

I do not think it necessary to dwell at any length on the present place of the computer in the economy. So I will content myself with short summary.

In my lectures I use a fanciful slide in which I show the computer at the centre of a circle of sketches of the main divisions of the economy:- extraction of basic raw materials (including agriculture); refining; marketing; design: manufacture; selling; distribution; teaching; medicine; finance; defence; government; planning, with research in a special position showing its own indispensible role with respect to the computer.

Already the computer is playing a non-experimental, practical and now indispensible role in these divisions. There is no going back. Switch off the machine and see what happens to your economy!

Specific applications are legion and I do not think that you have the time to read up on them, although I could always send you more detailed information. But I do think that it is important for you to see a little way ahead. Of course, it is very difficult to predict the swings of evolution. Predictious for today made 100 years ago show steam engines all over the place. No one foresaw Beeching! But many people now feel that the key to the future is in understanding the nature of information. And if it turns out that many modern problems are interpreted as information problems I think we can be a little clever and direct our energies properly . Hence the examples given in the next section which interpret two pressing topical problems in this light. This section may be followed by section 5.

Examples of the Role of the Computer in Other Key Fields

The purpose of this section is to suggest that many of our modern problems can be seen as problems in information. And if this is true, that the solutions to these problems could be radically different from what they are today. The examples I take are supersonic travel and town-planning.

i) Supersonic travel

I have written to you before, from the point of View of an aircraft manufacturer, pointing out the practical difficulties of manufacturing an aircraft in different places and different languages. But I think that the following argument against the Concord is even more telling.

The problem is that of reducing the flight time from London to New York from eight hours to four, say. Adding on a conservative value of one and a half hours at each end for buses etc., we reduce the total from about eleven to seven, a saving of a little over a third. But by any standards eleven hours from the old world to the new is pretty fast. It is certainly fast enough for rich widows and visiting professors. Really, the only people who do not consider eleven hours fast enough are business men, peace-makers and the like.

But the fact of the matter is that if eleven hours is too long, so is seven. Really their need is immediacy. They don't want supersonic travel. They don't want travel of any sort. However fast it may become it will always be time-consuming, wearing on the physiology and accident-prone. And while travelling a man is virtually incommunicado.

There is no point in conveying all this meat and bone. The reason why such people travel is to transmit and receive information, not to see the Empire State Building for the hundreth time. Therefore we should leave his body in rest and safety at home and convey only his intellect.

This is not a purely computer problem - nothing is. But the computer is so closely related that I think it is right to identify it with information.

If this is correct, then, that long-distance high-speed human transportation is an information problem in disquise, we should put a tremendous effort into developing and cheapening long-distance communication techniques and dropping plans for civilian supersonic travel.

The telephone service will have to be improved out of all recognition. Direct-dialling to anywhere in Europe or America must be a prerequisite. But voice is not sufficient. People communicate by hand waving, grimacing and drawing sketches. This means closed-circuit television.

If a business man in London can essentially place his counterpart in Rome or Los Angeles right in his room where he can see and hear him, show him pictures and shake his fist at him, merely by dialling his number, why should he bother to make the journey?

ii) Town Planning

Another problem of our age is the growth of large cities. People collecting together in practically unmanageable masses - for the purpose of exchanging information. Millions of people journeying to the heart of London every day to pass pieces of paper about.

And the suggested solution is that the business be made easier. Monorails, hovercraft, expressways-attracting an even greater density.

What the planners are fighting for is decentralisation. and the only genuine counter-argument is the associated information problem.

iii) Current Progress

Even without any well coordinated or articulate campaign, efforts have been made to solve both these problems as information problems. A very successful cooperation has taken place between I.B.M's design and manufacturing facilities in Poughkeepsie, N.Y., and the I.B.M., U.K. research laboratory at Hursley near Winchester, connected with the design and manufacture of a computer in both places simultaneously. Information was passed back and forth between computers across the Atlantic as an integral part of daily procedures. And since so much of the design work of new computers is performed by existing computers the contribution of this communication link was considerable. (For further information contact Mr. John Fairclough ,the director of the Hursley laboratories).

This is not to say that no human travel has taken place. This link is the first of its kind. However the amount of travelling must have been reduced, and Mr. Fairclough could probably give an estimate of the extent of this and the shortening of the project life-span.

A second specific project is that of the Post Office in plug-in computer communication, the DATEL systems. I have not received any technical information yet, but as I understand it the aim is fast, reliable digital information transmission over large distances.

A more general endeavour taking place now is automatic message-switching by computer. It frequently happens that a single message has many destinations. It is therefore convenient to send it once to a computer which stores it and then relays it automatically to a list of addresses.

And as a basis to much of the communication systems of the future is the developement of global television via satellites. Thus it appears that a beginning is being made in providing the technical aspects of cheap, reliable and convenient communications and that, backed by determined political pressure and placed in the right planning environment, developements could come along fast enough to solve some of our problems in a radically different way.

This section is something General de Gaulle could not be expected to understand.

5. Importance of Computers to the British Economy

This section follows from section 3 in which the role of the computer in the economy is briefly stated. The reason for this is that our economy contains vast quantities of information which cannot be handled by human beings because they are too slow, too expensive, too error-prone and,by now, there are not enough of them.

Our competitors in the world market realise this and are rapidly arming themselves with computing equipment. To compete we must compute!

It must be realised now that the computer is going to be fundamental and not peripheral to modern society. I do not think it necessary to belabour this point.

The point I do wish to make is that it is vital to the British economy that it uses computers not that it builds computers, necessarily. Similarly, there is no question that we use aircraft, but there has been considerable debate about whether we should build them.

I think that this is one of the most important points for your consideration, and I take it up in greater detail in section 12.

6. British Computer Industry and its Foreign Competition

This section follows section 2. In that section I outlined the evolution of the American and British computer industries. Let us now take a look at the remaining computer industries to see how Britain stands competitively.

Computers are also built in France, Germany, Sweden, Italy, Denmark, Holland and Japan (in the western world). In France the Bull company is in great difficulties. They emerged from punched-card office machinery in an attempt to create a French computer industry. After the failure of the Gamma 60, Dreyfus, their key man, as far as I can tell, resigned, and production of computers ceased. Instead they bought about thirty small R.C.A. machines which they are currently marketing without much success.

G.E. have now bought up Bull after a lot of opposition from De Gaulle. I strongly doubt whether they can survive.

Ollivetti in Italy has also been bought up by G.E. There is no possibility of their amounting to anything.

In Germany computers are made by Zuse, one of the early pioneers, Telefunken and Siemens. They have produced few sales, none, I believe, outside Germany.

In Denmark Dansk Regnecentral manufactures one very small machine which has been sold in Scandinavia and eastern Europe. They have plans for continuing but have no hope of substantial sales.

The Swedish manufacturers SAAB and Facit have both given up. SAAB may continue to make machines for its own use but, as I understand, not for sale.

The Japanese industry will probably do well in Japan but sales and service outside can hardly be possible.

Computers have been made in Holland by Elektrologika and a new one is planned but cannot amount to anything.

In summary the entire European production of computers looks, today at any rate, pitifully small. There are too many companies, and the problems of cooperation between countries are as great in computers as in other spheres.

Therefore what is far more serious than the European manufacturers is the presence of the American manufacturers in Europe. And the Americans have been very successful in doing something in Europe that the Europeans themselves have not been able to do, that is to get an organisation going across national lines.

I.B.M. World Trade are everywhere. I do not have up-to-date figures, but I.B.M. are far stronger than anyone else- possibly than the rest put together, though it is not quite so obvious as it is in America. Univac and C.D.C. are also strong, and N.C.R. have been fairly successful in the banking field.

So it is quite clear that it is only the Americans that Britain is up against. But the American competition is formidable. And to explain why it is now necessary to take another look at its evolution.

Computers have developed in a very haphazard way both in structure and application. This is to be expected, of course. It has been an evolutionary process. And as such there have been powerful environmental forces at play. And in America the environment has been extremely rich, particularly in the vast aircraft and space industries. Computers cannot grow fat on the stony soil of weak economies and small industries. I.B.M, in particular, have been phenomenally clever (or lucky) in getting almost all the good customers, which have provided I.B.M. with money, problems to solve, ideas and personnel. The other American manufacturers have also had a small share of this lucrative market.

British computing has had a large industry to feed off, but the way it has been done has been appalling, and the results consequently very poor.

By 1963 there were myriads of incompatible computers of all shapes and sizes posing a terrible strain on the limited design, manufacture, marketing and servicing personnel and facilities available. Also providing a strain on the people responsible for the selection and the programming. What happens, for example, when my machine becomes too small and I order a new one, do I have to rewrite all my programs? (The times that has happened to us!).

Also computers seemed expensive. (Although the cost of doing a job on a computer is often far below the human cost.)

So in April of this year I.B.M. announced a new era (sic) of computers, the 360 series (the 360 (degrees)encompasseth all!).

Instead of being one machine it is a series of machines from the very small, to the very large. They are identical (almost) in logical structure which means that you can replace a small one by a larger one with no re-programming. They have a (by present standards) sophisticated range of input-output equipment including male and female voice. They are manufactured using very modern "solid logic" techniques. Their ability to handle vast masses of information is incomparable. And the price has dropped 60%.

Furthermore the 360 is manufactured and marketed by a phenomenally successful company. And company from whom one can learn many lessons. I.B.M. has very good design people, vast, modern production facilities, a responsive and efficient marketing organisation and excellent management.

With the possible exception of design I have yet to see any of these features in a British computer manufacturer.

The 360 could be almost unbeatable competition two years from now. It could mean a complete clean-up for I.B.M.

Yet when I put these points to the chief engineer of one of the British manufacturers, a man who ought to know these things, he put down his sherry glass, leaned back in his chair and boomed, patronisingly, that customers only dealt with I.B.M. because of lack of imagination. Perhaps. But as far as his computers were concerned you had to use a lot of imagination.

That may not be typical, but I have found a great deal of complaisancy in the British industry. And this seems to be the best place for me to recite my personal adventures with that industry.

Having left the Mathematical Laboratory at Cambridge I found my way to Boeing, in Seattle, where one of my responsibilities was to evaluate and select equipment. Consequently I got to know the American industry quite well. Then, when the Atlas was announced, (I felt at the time that it was best in the world, despite Stretch and Larc) I got in touch with Ferranti who sent over two large waves of people, sales and engineering. They were very keen on placing an Atlas in the U.S., and I think that we came the closest to anybody to ordering one. (The fortunes of Ferranti in the U.S.A. could be checked with John Fotheringham, I.C.T.-Ferranti).

However, we did not want to be the only company in America to have an Atlas because of the lack of back-up in case of failure. So I took the initiative in trying to interest a group of the largest computer users in America to each order an Atlas if they too were in our position of being interested but afraid of going it alone. Their replies were very similar. They regarded Atlas as an excellently designed machine but had no confidence at all in Ferranti's ability to manufacture, deliver or service it. It was also overpriced.

So we sent one of our people to Manchester to meet the top management and inspect the plant. He came home most depressed. Ferranti's manufacturing plant was years out of date. They had no hope of producing Atlas in the time and quantity needed to make it an economic venture.

This was followed by more rounds of discussions in Seattle in which we told Ferranti, frankly, that if they wanted to invade the American market they must build the plant to manufacture a sufficient number to give us the confidence to order. Their position was the reverse; if we placed the orders they would create the plant. It was a vicious circle which it was encumbent upon the manufacturer, if he wanted to do business, to break. Not the customer. Ferranti failed to understand this. And that was the last we heard of Ferranti.

I think that Ferranti's attitude epitimises the British computer industry - and many other things British I regret to say. If Britain wants to compete they must modernise their marketing methods and attitude.

A short while afterwards English Electric announced that they were interested in marketing the K.D.F. 9 in America. I told them that they would be welcome in Seattle to state their case. It was an interesting machine and we would like to hear about it, but I gave them no promise of success, of course.

Arrangements were made for them to fly over from New York. We expected them on a certain day. No one showed up. We never heard another word. When I asked them about it in London a year later they said that they had decided that the time was not ripe and had not thought it necessary or important to inform their prospective customers.

But it happened again! English Electric came to Oslo trying to sell the K.D.F.9 at a time when I was in the market for a machine of that size here in Trondheim. They were told that their only chance of placing a machine in Scandinavia was in Trondheim. They said that they would contact us immediately, but again I did not hear a word. So I assumed that they had decided against trying to sell in Scandinavia.

Some months later their Oslo agent phoned me to say that he had heard that we were going to order a machine. By that time discussions had gone a long way with I.B.M., C.D.C. and Univac. It was very late to enter the field. However, I visited Kidsgrove and gave English Electric a thorough evaluation. But they were utterly uncompetitive. For one thing their delivery date was very late. Why? Because the factory was too small. But it was a brand new factory built for the express purpose of manufacturing the K.D.F.9, the pride and glory of the British computer industry now that the Atlas had been discontinued.

I have a lot of technical criticisms of the machine too, but they would be out of place in this report.

I wrote to Professor Fox at Oxford and asked him why he had selected the K.D.F.9. He replied but would prefer to keep his reply confidential. His opinion on English Electric would be worth soliciting.

I have no experience of Elliotts. They have had a small sale of machines of various sizes. My Polish friends tell me that the 803 in Gdansk is working well, but I don't think it competes with equivalent American machines. Elliotts, however, do have some valuable control experience but I have only discussed this with Elliotts and not with the Steel people.

Now let us return to the I.B.M. 360. This is the machine with which the British industry will have to contend, and the machine which will sell like hot cakes in Britain. (I have no up-to-date figures,but I.B.M. would probably be glad to furnish them. If they are reluctant I can get them from New York.)

The only answer to come from Britain is the I.C.T.-Ferranti 1900. This is, again, not one machine but a series. I have discussed it with I.C.T. but have not visited their plant. The philosophy is much the same as that of the 360. Technically it seems to be inferior but its delivery time seems to be better than the 360. But it must be stressed that neither machine is in use yet, so we will have a lull for a year or so before reports come in from the customers. It may be that I.C.T.'s management is better than Ferranti's (it couldn't be worse), and it may be that their manufacturing facilities are a vast improvement on anything Britain has seen before. It may be that the software will be delivered with the first hardware, a historical moment. It may be that Manufacturing will fulfil the promises of Sales. If these factors, and a few others like reliability and maintenance, are something approaching I.B.M.'s, the British computer industry might stand a chance. If not the future is very black.

This section may be followed by section 12.

7. I.B.M. U.K.

I think it is important to make a special reference to the I.B.M., United Kingdom company. I am not too sure of the share-capital situation, but I understand it is mostly British (perhaps entirely). However, it is British-managed. For example, the Director of the research laboratories at Hursley is a very young and capable Englishman, John Fairclough. And most of the staff is English.

Some of the 360 hardware manufacture will take place in France, and some of the software in England. In fact there is great hope for a growing emphasis on British development within I.B.M. I have correspondence with B.O. Evans, Vice-President in charge of large computers, indicating recent surprise and pleasure at the success of the British contribution to the 360. (It is my private view that British design is superior to American, but it is not backed by the other aspects of business.)

I say this to point out that in the event of a complete collapse of the home industry it would not mean a complete American take-over.
(And I should add that Hursley is the only place that I have seen in Britain which looked remotely well-managed and thriving. But I have not seen I.C.T.'s premises.)

8. Special and General-Purpose Computing

I think it would be useful at this point to distinguish between special-purpose and general-purpose applications and machines since it has some bearing on the importance of a home industry.

Most computers are known as "general-purpose". That is to say, they may be applied to a wide range of problems and are usually connected to simple input-output equipment. Also such problems are fed in haphazard order to the computer, having no relationship between each other. The only special aspect in general-purpose computing is the specific program written to deal with each problem.

"Special-purpose"applications normally involve the computer performing one task only, such as on-line control of industrial processes, air-line reservation systems, missile-guidance. The computer for a special purpose may be an ordinary computer arranged in a particular way, or may be a computer specially constructed for the application. Whatever the case, the main point to be made is that two special applications are rarely alike. No two paper-making machines are identical, consequently computers for controlling such machines must be differently engineered. I.B.M. and Elliotts, to name two of the leading manufacturers in the control field, have both discovered this to their cost.

Elliotts, for example, have now acquired considerable experience in the Steel Industry. But each new on-line control application that comes along requires extensive new work even by engineers with considerable experience.

Another way of looking at this is that in general-purpose computing centres we have libraries of programs usable in different applications. There are no libraries of special-purpose computing.

The conclusion to be drawn from this is that from the special-purpose point of view it is particularly important to have a strong home industry, whereas this is not so true from the general-purpose aspect.

9. The Importance of Programmers

It ought not to be necessary these days to have to stress the importance of computer programmers. The newspapers advertise for them every Sunday. They are famous by their absence.

But they are all too frequently overlooked. For this I very much blame the salesmen. If you examine the glossy advertising material you see glowing description of the capabilities of the machines but never a word about the fact that they need programming. Nor that programmers are much harder to get than machines - and cost about the same.

Any coordination plan for computing in Britain must inevitably involve procedures for improving the means of obtaining the necessary programmers. I discuss this further in the sections 10 and 12.

10. Education and Research

As stated in section 2 computing found its start in the research and university sector. But the subsequent history of university computing has, in my opinion, been lamentable. The responsibility of the university computing departments is to conduct research, teach such subjects as Numerical Analysis and <u>to provide a computing service</u>.

To the best of my knowledge the latter has been done nowhere in Britain. It may not even be recognised as being a part of their responsibility at all. At Cambridge, for example, the service on the EDSAC II was so poor that the Engineering faculty had to get its own machine.

In Britain the universities have been very late in acquiring computers compared with their American counterparts. And now that they are being installed it is a case of too little too late. It costs about £300,000 for a decent, usable computer and I understand that the universities are getting about half this. However, a part of the solution is Jack Howlett's centre near Harwell which operates an Atlas providing a free service to research, as I understand it. But I haven't been able to find out how one transmits one's programs and data back and forth to Harwell. Since so much research computing consists of checking out programs, a process which needs two or three shots at the machine per day, I cannot regard the Harwell solution as the right one. However, the data-transmission problem may have been solved by now. A good person to consult on this would be David Wheeler at Cambridge.

My experience in the universities is that they are poor at stating their case, so I doubt whether many good cases have been put by the universities, or if they have, whether anyone in Whitehall has understood. (I have also worked in Whitehall!) So it is fairly understandable that the universities are not doing their job (at least in the way I think it should be done).

The way in which I think a university computing centre should be run is, naturally, the way in which I am running this one, with the main emphasis on service. If you make the machine available and do a decent job of the teaching, the research will come automatically. But the machine must be available. At this university we give lectures to all comers , with a special emphasis on first year. And the machine is available to anyone night or day. May aim is that every Norwegian engineer shall be a computer programmer.

In Britain, and the west generally, there is a great shortage of programmers. (Boeing, for example, has just asked me to hire 86 programmers in Europe because they cannot find them of sufficient calibre in the States.) And here the responsibility ought to lie with the universities. They should be given the resources, both machines and manpower, to provide the manpower basis to modern industry. If you educate the young in the right way, they will force changes that are much more difficult to force from above, in my opinion. The computer revolution in America has almost entirely come from below. Top management had no idea what was happening until the bill got big (1958 or so) by which time there was no going back. By that time industry had come to rely on computers, but no company had ever made a concious decision that this should happen.

Furthermore, many ambitious computer schemes have fallen by the wayside because of lack of programmers,not because of poor machinery.

11. The Consultation Problem

Another unpublicised problem that must be tackled immediately is that of consultation. A company seeks to modernise itself by means of computing. How shall it set about it? Must it have its own machine? If so, which? If not, how? What sort of personnel does the company need? How should the new group fit into the established organisation? Tough enough questions for experienced computer people!

How do you get these questions answered?

Most people, it seems, employ the services of so-called computer consultants or management consultants. Their fees are exhorbitant and their competence is frequently nil. There is a saying in the profession: a program and you are a programmer, two programs and you are a consultant!

This is a serious problem. What is the point of building wonderful machines if they aren't properly placed, properly programmed and properly managed?

Once you have made a decision it is practically impossible to go back on it. It is not like buying a car. But there are too many cases of hopelessly inadequate solutions and of overselling, purely as a result of incompetent advice and irresponsible salesmanship. As a result computing gets a bad name. The "Wall Street Journal" frequently publishes stories of irate management throwing out a computer installation and trying to return to the cave. And, reading between the lines, I am convinced that the application was sound. It was ill-advised management that was wrong.

In Britain, managemant must have some reliable means of obtaining advice. I take this question up again in the next section.

12. Recommendations For Rationalisation

In sections 6, 9, 10 and 11 I have outlined the problems of the home computer manufacturing industry and the nature of its foreign competition; the problem of producing the necessary manpower and that of correct selection of equipment. In this section I want to make firm recommendations for solving these problems.

Let me take that of the manufacturers first. I hope that it is clear from the previous sections that the British computer industry is in sad shape, and that the already stiff competition is going to get stiffer. The question, then, that has to be answered is whether Britain needs a computer industry at all. Why not let the Americans build the machines and the British use them? After all, the important thing is for industry etc. to use computers. It need not worry particularly where they came from. So the question cannot be brushed off as entirely absurd.

But against this are two arguments, one that there must be a choice. The market must be kept competitive. There must not be a capitulation to I.B.M (which is what it would amount to). The other is discussed in section 8 on special-purpose applications. Special-purpose inevitably involves manufacturing; and you can't manufacture in vaccuo, you must have a modern, competitive manufacturing competence. So you are forced to manufacture for the large market, that is to say, the general applications market.

It might also be argued that strategic reasons force us to maintain a thriving industry.

However, if there were a capitulation to I.B.M. it would not be a national disaster as I have tried to point out in section 7.

But if we are to continue production we cannot do it competitively under present circumstances. The three companies now in existance, I.C.T.-Ferranti, English Electric-Leo and Elliott-N.C.R. must combine to form one strong, efficient company. Call it the British Computer Corporation.

It would immediately stop competition with itself and must immediately discontinue all non-competitive lines. And I would guess that this means everything except the untried 1900 series of I.C.T. It would have to rationalise and strengthen its production facilities; bring all its design teams together to evaluate collectively the market situation; set up sales organisations in each European country (where local non-American competition will not amount to anything, as pointed out in section 6); work with the G.P.O. on an all-out effort to create the data-transmission facilities required (section 4); set up a strong program of research and development in hardware and software.

Only in this way do we stand a ghost of a chance. I.B.M. is big and we must be big to meet its challenge.

How can you set up such a corporation? Nationalisation is out of the question of course. Would the managements of the various companies do it spontaneously? Do they see the weakness of remaining alone? Would they need inducements? Or would they welcome it? Who is going to take the initiative? There would be jealousies. Three chief engineers would be reduced to one, and so forth. But I don't see these things as real problems. There is going to be more than enough work for everybody.

My solution to the problem of amalgamation is for the Minister of Technology to call a conference with the three managements, put the case frankly and offer governmental assistance if they will cooperate. And the assistance I would strongly recommend is a three year subsidy (say 20%) on all justifiable British computer orders (within Britain). This subsidy would have the beneficial effect of pushing a lot of senile management in the right direction.

This brings me to my next recommendation, the setting up of a full-time adviser to the Minister of Technology on computers. He should be given great responsibility and wide powers, amongst others that of approval for computer subsidies. He should be the Minister's watch-dog in the Computer-Corporation, and therefore should be acceptable to the Corporation. He should be responsible for coordinating all Government computer activity, for cutting out waste and duplication etc. I mention other duties below.

You would need a good man. He must be a man from industry, preferably an experienced user. I know of no one in the British universities who could do it. They have precious little contact with industry and have no experience of the real problems. Perhaps someone from I.C.I., Rolls Royce or the Steel industry. Whoever it is, he will be hard to find.

Now I come to the manpower problem. There must be a nationally coordinated educational program in the universities and technical colleges concerned with the subjects of basic programming, Numerical Analysis, Operational Research, Management techniques etc. I admit that this sounds very American, but why not? They are doing better than we are.

This should also be a responsibility of the Minister of Technology through his computer adviser.

Then to the question of consultation. The Minister should arrange for the setting up of a private but Government-backed company for the purpose of advising computer-users, actual or potential, on problems of acquisition, management, training etc. Fees must be low (or the service even free) because proper acquisition of computers must be regarded as in the national interest. But if a company wants to pay for the services of a private consulting firm, of course it is perfectly free to do so.

Again you'll need some good people. And my advice is to employ them on a well-paid two-year contract, then turn them back to productive work. Developments are so rapid in this field that one cannot afford to be away from daily use too long.

This activity, too, should be under the eye of the Minister's computing adviser.

This concludes my recommendations for rationalisation and the main body of the report.

13. APPENDIX

A. Technical: Software

In discussing computers you will frequently hear the term "software" mentioned. This is an important subject, so I thought it perhaps useful to summarise it.

The basic problem is that of the man-machine interface. What can you do to make the computer easy to handle; easy to communicate with?

The solution has been an evolutionary process of language development which began to take distinct chape by about 1957 with the invention of the FORTRAN (FORmula TRANslator) language by I.B.M. FORTRAN, which has since evolved to a far more sophisticated level, is a formal language whose sentences comprise a mixture of English words and mathematical symbols. Its syntactical structure is rigorous and it admits of little semantics. Its purpose is the rapid programming of scientific and engineering applications.

Each computer has its own language - we call this "machine language" - and there are similarities and differences between such languages. To begin with all programming was performed in machine language, but such programming is slow, it is a tedious business to make corrections, and a program written for one machine will not run on another.

Computers are devices for removing tedious, error-prone and time-consuming tasks from human beings. Such a task is the very business of computer programming, therefore it was perfectly natural for the programmer to help himself and arrange for the computer to program itself. Thus the programmer decides the logic of a program and lets the computer arrange the details. Hence FORTRAN and similar languages.

As well as FORTRAN there are other languages for scientific and engineering purposes of which ALGOL is very important because it aims at international acceptance and has a better structure, in many ways, than FORTRAN.

There are also languages for other applications, COBOL for business (payroll, inventory etc.), APT for numerical control of machine tools, IPL5 for a so-called "artificial intelligence" game-playing and problem-solving, SIMSCRIPT for simulation problems.

Such languages are called variously, "higher-level","algorithmic" "problem-orientated", "machine-independent".

To enable the programmer to use such a language a translator has to be written for a particular machine, in the language of that machine. And in the jargon of the trade a formal language translator is called a "compiler".

The productivity of a higher-level language is very high. It reduces programming time by a large factor, say weeks to days. In other words it helps overcome the man-machine interface problem. Hence it is vital that all computers have good compilers written for them, and that these compilers are delivered with the machines. In other words, the hardware and the software must be considered as integral parts of a computing "system". And it is in this area that the manufacturers have performed the worst and must perhaps work the hardest to provide the service paid for by the customers.

One final point worthy of mention is that of standardisation. Obviously you do not want too many languages trying to do the same job, yet you must have experimentation and several lines of development if you are to get anywhere. (And there's a long way to go yet!) Consequently we have the problem of whether or not to standardise.

I have served on the American Standards Association FORTRAN committee and I think I understand the problem. The point is that there should be a current standard for any useful language, but it is much too early in the game to standardise on a particular language for a particular task.

There were too many "dialects" of FORTRAN and we wanted to boil them down to two. But it was not our aim to make FORTRAN the standard language for scientific computing.

The American government made the tragic error of standardising on COBOL before anyone had used it. Now that it is in use its shortcomings are becoming known, and since no one can afford now to experiment with other business languages, it may mean evolution from the Dodo!

13 B. Philosophical: The Computer as a Survival Factor

It is interesting to interpret the computer as a survival factor of modern society.

Man has evolved over geological time in a certain environment to which he is by now well adapted. But in recent times he has created a new, artificial environment to which he has no hope of adapting other than very superficially. But somehow he has to adapt to survive.

Let us examine the essential difference between these two environments. Man's evolutionary environment was characterised by small groups moving at speeds not exceeding about five miles per hour, rarely confronted with anything more dangerous than a tiger, engaged in limited wars of short duration. That is to say the information that man had to cope with was very little, and his brain developed to the point at which he could cope with ~~them~~ it sufficiently well to survive.

But in man's created environment he lives in vast groups, moves large distances at speeds often exceeding that of sound, is in constant danger of death by vehicle or missile, engages in global holocausts over which no one has any control. The modern world is characterised by information in quantities much too great for assimilation by the human system. To control, the necessary amount of information must be processed sufficiently quickly. The human brain can no longer do this.

Modern society often operates on the limit of stability. Traffic on the Los Angeles freeways is a good example. As soon as something goes slightly wrong, it becomes disastrous. Fifty cars in one accident is not uncommon. A jet pilot during take-off and landing works very close to the limit. Step inside the cabin of a 707 and see how much information he has to absorb.

In many sectors activity takes place far from the limit and is very stable, but then it is not efficient because most of the information generated is ignored. As examples one may cite the management of large companies, scheduling of shipping, warehousing and supply. Such activities would be far more effective or profitable, or less wasteful if the information generated could in some way be collected, absorbed and reduced to quantities assimilable by the people making the decisions.

In a sense we are drowned in a sea of information.

Modern society is getting bigger, faster and more complex. The information needed for its control is increasing rapidly in magnitude, far exceeding the ability of the unaided human system to cope with it. And failure to cope means failure to adapt, which, in evolutionary terms, means extinction. And in practical terms means an eventual collapse of the society.

The only hope, of course, is to create a buffer between man and his created environment to absorb and reduce its information to the assimable level of his evolutionary environment. In other words, to use computers and associated equipment with which to simulate the primitive conditions to which human beings are well adapted.

13 C. Political: The Computer Gap

It is impossible to know whether the information that has been obtained from Russia is up-to-date or reliable. It is certainly true that the Russians have computers and they have published enough on the subject of software to indicate that there is a fair amount of activity. But all indications are that in both development and numbers they are years behind the west. I have good friends in Polish computing who confirm this.

Yet the Russian form of centralised government needs information in much larger quantities than ours. And as stated in various places in this report, this cannot be done without computers. Yet the Russians do not seem to realise it. They know they have information problems, and these were Mr. Kruschev's basic reasons for trying to decentralise, but they seem to be doing very little else about it. For the survival of their administrative machine the Russians would have been wiser to have put their efforts into perfecting magnetic tape instead of satellites. The Space Gap is only an ephemeral aspect of the mid-1900's, the Computer Gap is the real problem, but it has no appeal to the Great Uncommitted. And it may not even be understood by the Russian leaders themselves. For one thing I doubt whether they could wage a modern war of any length. They would lose track of their boots.

13 D. Information to be Collected by the Minister of Technology

In order for the Minister to appreciate the computing situation in concrete terms he will need to know the following figures. It will take some work to obtain them because there is no decent reporting or coordinating system yet set up, an ommission one hopes will be remedied.

But the task could be handed to someone with long experience and good connections in the profession, and I would suggest Dr. Douglas of D.S.I.R.

Reports needed would be as follows:-

i) For each computer delivered or on order its user, purpose, price, delivery date, delay of delivery of both hardware and software, reliability, management, number of users.

ii) Projects of major importance such as electricity grid control, air-traffic control, steel-processing control, defence.

iii) Forecast by users for requirements over next three years.

IV) Special status report on the universities.

V) Volume by number and value of computers delivered by each manufacturer.

VI) Status of orders of the I.B.M. 360 and I.C.T. 1900.

VII) Report on computer-associated courses given in Britain.

VIII) Volume by number and value of British computers delivered abroad, including the Commonwealth.

IX) Report on British computers replaced by non-British.

X) Financial report of the British computer manufacturers covering the last five years.

From these reports the Minister should be able to determine the health of the home industry and the degree to which Britain is computerised generally. And should then be able to take the necessary action.

In obtaining this information the cooperation of a lot of people will be needed. To get this cooperation they must be told why the information is needed. And above all that it is needed to help them. If they can benefit by it they will be very willing to participate. We get far too many unexplained questionnaires!