

VOL. 34, NO. 12 : 15 DECEMBER 1979

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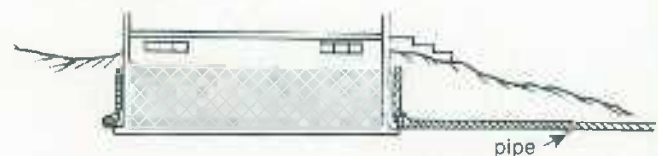
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The journal of

THE N.Z. INSTITUTION OF ENGINEERS, Fourth Floor, Molesworth House, 101 Molesworth Street, P.O. Box 12-241, Wellington 1.

President, D. A. THOM, C.ENG., F.I.C.E., F.N.Z.I.E.

Secretary, A. J. BARTLETT, M.A. (OXON)

Designed for

The New Zealand engineer and planned to cover all aspects of professional engineering. This journal is received by all members of the N.Z. Institution of Engineers.

Opinions expressed in the journal are not necessarily those of the Institution or of the publishers.

Published monthly by

TECHNICAL PUBLICATIONS LTD., 127 Molesworth Street, P.O. Box 3047, Wellington, N.Z. Telephone: 735-739. Telegrams: Tecpub.

Managing Editor

F. N. STACE, B.E.(ELECT MECH), B.E.(MECH), C.ENG., F.I.E.E., F.I.S.T.C., M.I.E.E.E., M.N.Z.I.E.

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R. M. (BUD) LITTLE, Dylit Media Ltd, 24 Platina Street, Remuera, Auckland 5. P.O. Box 28-372. Telephone 548-222.

Overseas representatives

UNITED KINGDOM AND EUROPE: MEDIA NETWORK EUROPE, 27 Wilfred Street, London, S.W.1. Telex 28905. Telephone: 01-370-6269.

U.S.A. AND CANADA: S. S. KOPPE AND CO. INC., 10 Stuyvesant Ave., Lyndhurst, N.J. 07071, U.S.A.

AUSTRALIA: F. W. PUBLICATIONS, Suite 103, 84 Pitt Street, Sydney 2000. Telephone: 231-5891

JAPAN: SUN-GAIN SHIA LTD., Tenroku Hankyu Bldg., No. 5, 6 Chome Tenjinbashi-4, Oyodo-ku, Osaka.

Subscriptions

Post free: New Zealand \$15.00 per year; overseas \$23.00 per year.

Microfilm

Microfilms of *New Zealand Engineering* are available from University Microfilms Inc., 300 North Zeeb Road, Ann Arbor, Michigan 48106, U.S.A.

NZ ISSN 0028-808X

Leading article

Christmas message 269

Papers and articles

Huntly power station: Building services design and construction problems *J. A. Gallagher* 270

The Dobson Lecture: The electronics revolution and its possible impact on employment and development *M. C. Probine* 273

Graduates' assessment of engineering school courses
J. B. C. Taylor 279

Energy conservation of General Foods..... *Stuart B. Thorn* 281

Energy savings at Lane Walker Rudkin Ltd.
Richard E. Pocock 285

General

N.Z.I.E. news 288

Press releases 288

N.Z. Timber Design Society 290

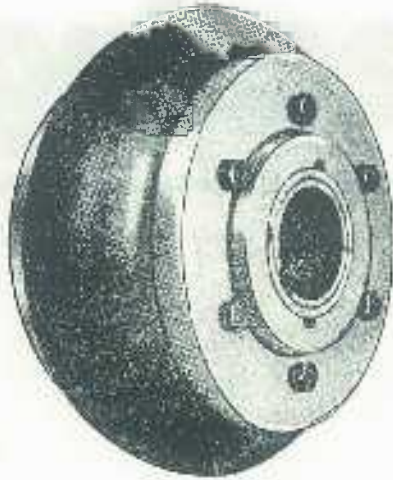
Noteworthy 291

An Engineer's Bookshelf 292

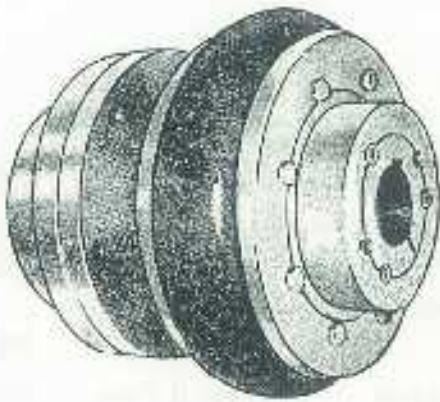
Cover picture

Aerial view of Huntly power station, March 1979 — see paper on p. 270.

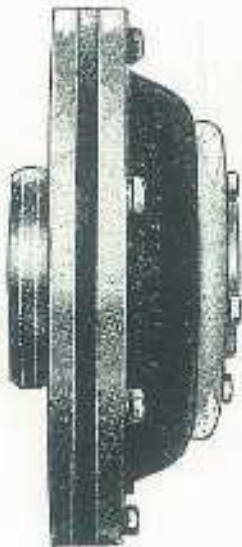




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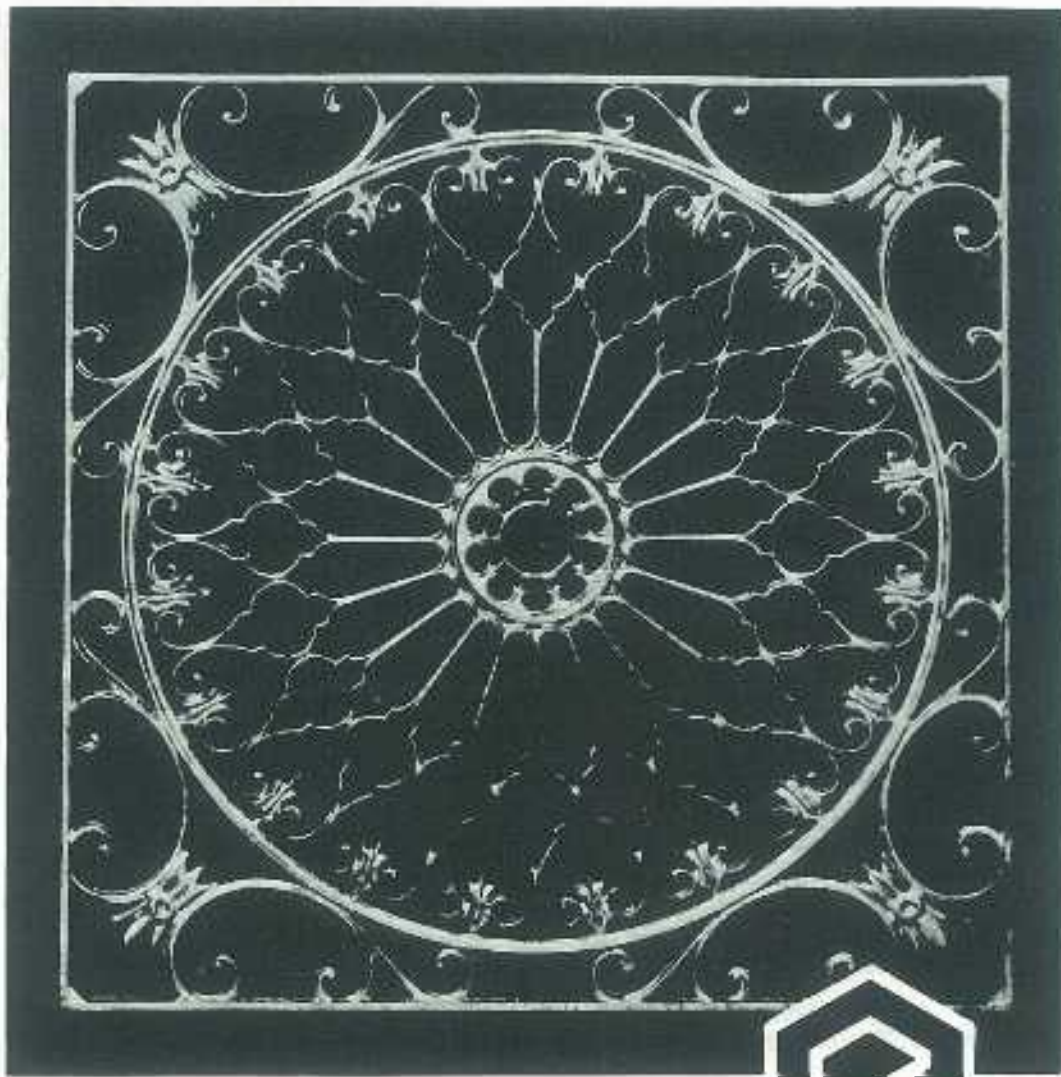
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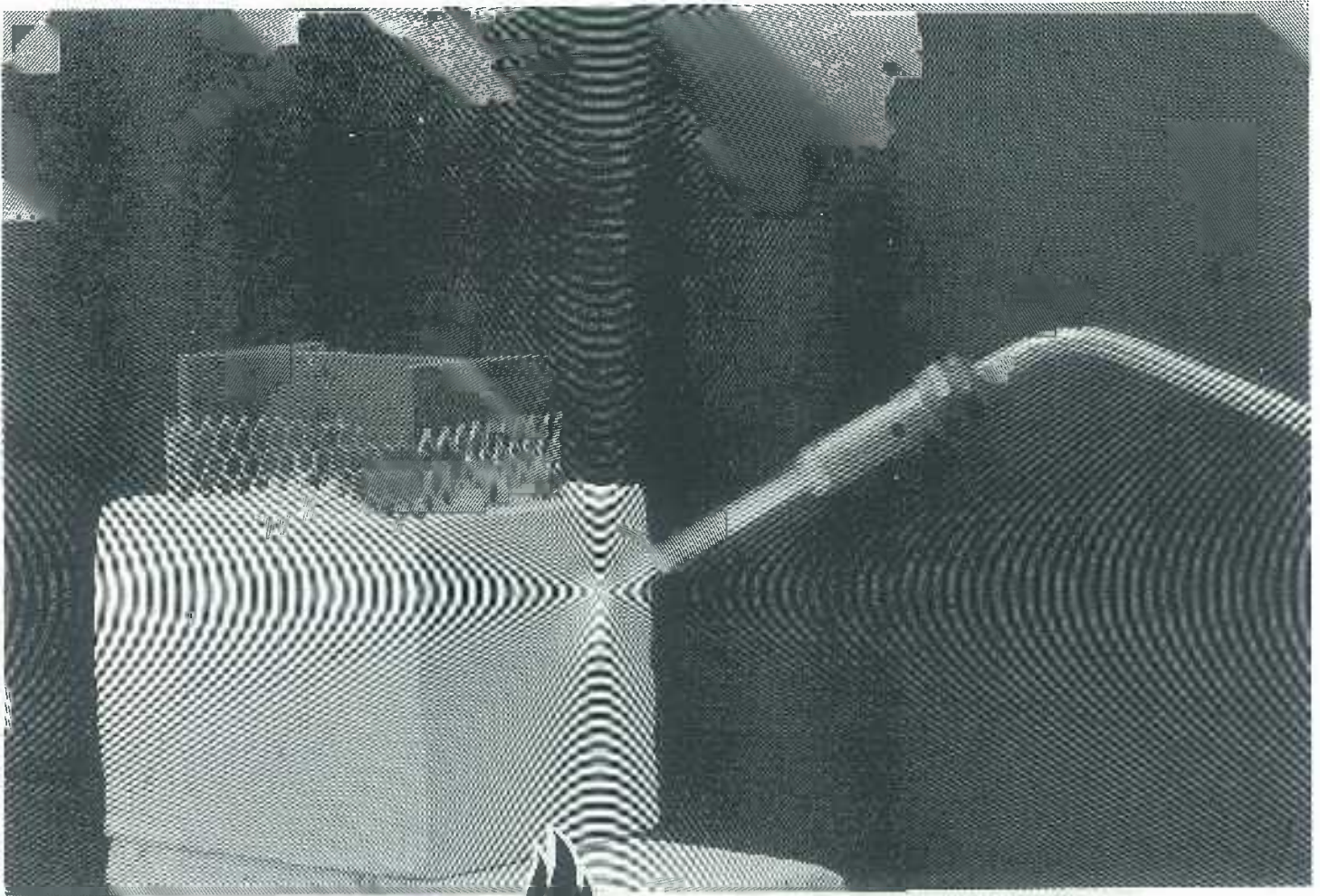
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Christmas message

Christmas is a time when we show our appreciation of friendships, and of contributions to all kinds of endeavour, the Institution included.

The past, the present, and the future of the Institution all rest on the efforts of devoted men and women. Nowhere does one see this more clearly than in the branches, and for this reason the branches have a special place in the life of the Institution. Each branch uniquely reflects personalities and personal effort, as well as something of the vast range of activity comprised in the ongoing progress of our profession. For these reasons, the branch visits represent, for any President, one of his most enjoyable and impressive experiences.

The message that comes clearly from the visits is the reality of our involvement with the life of this country. In his tours the President meets engineers working in many facets of industry, all aspects of transportation, education, telecommunications, building, soil and water management, and energy production and distribution. Our standards, and the service we provide relate very directly to the social and economic wellbeing of New Zealand.

New Zealand, in its turn, is reflecting the turbulent events of a period of instability. The determination of strategy has replaced trend projections. The homework of policy has to be done with comprehensiveness and great thoroughness. The age requires vision, courage, and flexibility.

The Institution, reflecting these events at its level, is engaged in policy change, adjusting its own mechanisms for the high seas of the age of change. There is much in our favour. We are singularly fortunate in our unity of all disciplines within the same professional body. The Institution is running comfortably within its capacity. I believe its potential to be much greater than we are yet realising.

In some leading articles this year, I have talked about the issues currently facing us. Fundamentally, they are all to do with making more of this potential, and with the relationship between a strong technical institution, and a community which is very dependent on technology.

I hope that *Print-Out* and the journal have between them communicated both the issues and Institution action on them. The year has seen the further development of many areas, including continuing education, engineer in



society, public relations, and our role in relation to standards. Two issues have been paramount. The first has been the purchase of *New Zealand Engineering*, the setting up of the Institution's own publishing company, and preparations for a new journal. The second has been the complex issue of registration, and, from the studies and debates on registration, the decision to look to "strengthen the Institution first" policy, without forgoing legislative options.

These have not been the only developments. The central theme of "communication" has been pursued with ministers, parliamentarians, and others. Decentralisation is providing the opportunity for more involvement in Institution affairs, and both the welfare committee, and the committee for the future have made considerable progress. "Engineering and local government" will be under study shortly, as will the Institution's policies on education, and relationships with industry.

I have touched on just a few of the Council concerns during the year. These are but a small part of total Institution activity as represented in the branch programmes, the technical groups, the division, and the annual conference.

But all this work has depended on personal contribution: engineering is done for people, by people. At this time of the year, that personal contribution comes to all our minds. The Council and staff of the Institution send warm appreciation and good wishes to all, and to the Institution's many friends.

A joyous Christmas and a happy New Year.

D. A. THOM
President

* Unless specifically indicated, statements or opinions in *New Zealand Engineering* do not necessarily reflect the views of the Institution or the publishers. Correspondence on material published is welcomed.

Huntly power station: Building services design and construction problems

J. A. GALLAGHER*

B.E.

Large thermal stations, with highly complex and extensive plant and a large workforce required to maintain them, require more building services than previous power stations in New Zealand. This paper describes the problems encountered during two years of site supervision of building services contracts at Huntly power station and makes suggestions to reduce these problems in future projects of this type.

1. BACKGROUND

HUNTLY power station is a \$400 million, 1 000 MW, coal/natural gas fired station. Construction work began in 1974 and first commercial power is programmed for April 1980. It is proposed to operate two 8-hour shifts per day. Earlier thermal stations were almost entirely overseas designed; for example, a significant portion of the mechanical and electrical design of the 600 MW thermal power station at New Plymouth was undertaken in the United Kingdom. Huntly is the first major thermal station largely designed in New Zealand.

The value of the building services for the station is approximately \$4 million, including air conditioning, ventilation, fire protection of the buildings (but excluding plant protection), lifts, lighting, plumbing and potable water services. The building services are more extensive at Huntly than at New Plymouth because of increased sophistication of plant and plant controls, differences in climate, and more attention to protection, safety and comfort aspects within the buildings.

The air conditioning, ventilation, lifts and fire protection sprinklers were supplied and installed under contracts supervised by the Ministry of Works and Development (MWD). Plumbing and potable water services supply and installation were done by MWD whilst the New Zealand Electricity (NZE) installed lighting and electrical fire detection.

It is not the intention of this paper to provide a detailed account of the building services design but to give examples where problems have arisen and make recommendations to reduce these problems in future major projects of this type.

2. BUILDING SERVICES

Building services requirements included the provision of large volumes of combustion air to the boilers, removal of heat generated by numerous plant items, air conditioned environments for the control equipment, and the provision of services for approximately 300 staff.

The main areas where services input was required were the control block, services wing, administration building, coal administration building, auxiliaries bay and the turbine house.

Fire fighting is to be carried out by the station staff who have their own fire tender, and to make fire fighting easier for the station staff two of the main fire control panels are located inside the turbine house, well away from outside access. The Huntly borough brigade provides only a back-up service.

* Assistant mechanical engineer, power division, Ministry of Works & Development.

This paper was first received on 14 July 1978 and in its present form on 17 September 1979.

The enormous size of the buildings creates its own problems; for example, the provision of a sink in each of four rooms equally spaced along the 400 m length of the auxiliaries bay required a single graded waste pipe whose cost far exceeded that of the sinks.

3. THE ROLE OF THE SITE BUILDING SERVICES ENGINEER

The main role of the site building services engineer was as an agent to the building services engineer in Wellington. To provide a service to the civil section to ensure that building services requirements were clearly defined before construction was one of the main priorities.

Economic considerations demanded that station design and construction were concurrent activities at Huntly, unlike high-rise buildings where construction starts only when drawings are complete. For the services engineer this is an unusual situation, requiring involvement in the initial stages, providing a preliminary design and singling out the essential parts such as plant areas, duct routes, and service shaft requirements relating to the basic building construction. Very few of the blockouts and embedding details required by the designs of the building services engineers ever appeared on the structural drawings.

The services engineer had to liaise with a large number of civil design teams working on different areas of the station and overcome their initial lack of appreciation of the meaning of "building services". Building service requirements had little influence on the construction programme.

A typical problem created before building services staff arrived on site was a missing blockout for a services duct from the plant room in the control block so that a 1 500 mm square hole in 300 mm thick reinforced concrete had to be cut later. Another problem was the inadequate provision of a service area in the basement of the services wing where the large number of pipes and cable trays under this building has meant substandard access and maintenance provision. (Fig. 1.)

4. SOURCES OF PROBLEMS IN BUILDINGS SERVICES DESIGN AND INSTALLATION

4.1 Design changes

Approximately 80% of the mechanical services design was done by several consulting engineering firms, the other 20% being undertaken by the building services section in the power division of MWD.

Many problems stemmed from the lack of clear definition of the clients' requirements and the consequent numerous design modifications required. Such changes often did not arise until construction was well advanced and alterations then became expensive. At such times

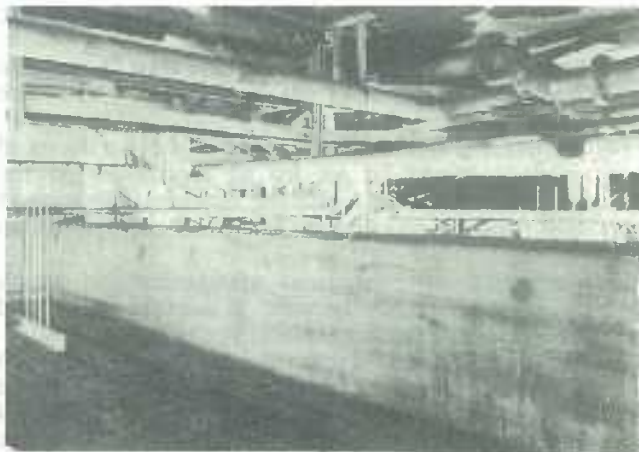


Fig. 1: Services wing basement — deep structural beams restrict work runs and access.

consulting firms had completed the design work and were committed to other projects; this led to time lag in answering queries. Examples follow.

4.1.1 Changes to laboratory layout

In the services wing an extensive testing and analysis laboratory is provided; some of its functions are boiler fuel analysis, boiler water quality testing, lubrication oil analysis, and condenser cooling water testing.

The original design called for compressed air, instrument air, hot and cold water and propane gas reticulation. At an advanced stage of construction the layout of the laboratory was changed, deleting the instrument air and adding acetylene, nitrogen, nitrous oxide, vacuum and ultra-pure water. Also added were a muffle furnace, tube furnace, moisture oven and an atomic absorption unit. These changes required extensive services redesign to include these extra services and to cope with the reclassification of some areas in terms of the storage of dangerous goods regulations, as well as a redesign of the ventilation system.

4.1.2 Changes to location of mess facility

Inside the station a mess facility is provided for the operators, consisting of a tearoom, toilet, lockers and showers covering an area of 250 m². In addition to the normal plumbing and water services, the area is served by an air conditioner. Originally this mess was located at the north end of the turbine house; this was changed to the middle of the station in the boiler house and the services design was done accordingly. At a late stage those facilities

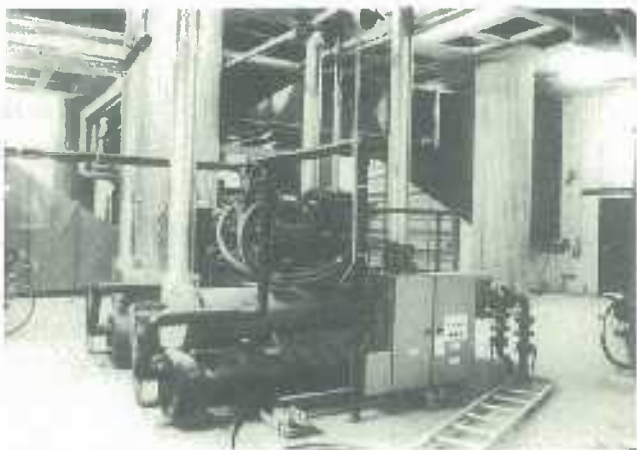


Fig. 2: Control block plantroom showing the two MacAlpine 125 kW chiller units.

were moved back to the north end of the turbine house because of the potential gas hazard.

4.2 Lack of detailing on drawings

The problem of drawing detail was partly due to poorly defined design requirements and partly to substandard or incomplete draughting caused by lack of knowledge of the building structure or by the drawings conflicting with one another. Because of this problem, a building services draughtsman was employed at Huntly from 1978, correcting and detailing much of this work.

4.3 Lack of contract standardisation

Huntly power station comprises a large number of buildings each differing greatly in form and function. However, they are all part of a complex that will be administered by one organisation and they are all subject to the same climatic conditions. These two points are important considerations in building services design.

The first means that all employees are working for one employer and expect similar working conditions. The second directly affects calculations and equipment specifications.

At Huntly there were five contracts, each worth more than \$100 000, for the "pure" building services work (excluding lighting, lifts and fire protection). All except two were designed by different groups and had different specifications.

These differences created problems for both contractors and contract supervisors. Many details varied from specification to specification. The situation arose where a contractor was using one specification on a building and another on a different building. This was confusing and could have led to a particular requirement being overlooked. The different layout of specifications was also frustrating. Sentences which presented the same facts could have been interpreted differently, depending on their form.

4.4 Lack of standardisation of equipment and manufacturers

The policy at Huntly has been to allow the contractor to choose the manufacturer of equipment and as long as it met the basic design function it was acceptable (Figs. 2 and 3). This meant that a variety of manufacturers' equipment was installed which may prove costly in the future when maintenance work becomes necessary. No matter how good the design, installation and commissioning of a system, it is the maintenance of the system which will often determine its success in the long run.



Fig. 3: Services wing plantroom showing one of the two Carrier 300 kW chiller units.

4.5 Interpretation of the role of the engineer

The role of the building services site engineer could be interpreted as ensuring that the standard of workmanship is in keeping with the best trades practices and that the designers' intentions are met in all respects.

The work involved in the first interpretation is dependent on the standard set by the building services supervisor. At Huntly the supervisor required very high standards and the site engineer was principally involved in ensuring that the designers' intentions were met.

Regarding the second point, at Huntly the civil construction programme dominated all decisions, the site was 560 km from the building services design offices, and the building services design requirements were still being clarified. It became very important that more of the design intention was put on the drawings; there were many examples, such as notes detailing why indirect duct routes were used, why a particularly fine filter was chosen, why a standard material or code was varied.

"On the spot" decisions were a fact of project life and a full appreciation of the design intention must aid the making of these decisions.

5. RECOMMENDATIONS AND CONCLUSIONS

Huntly power station has provided the building services engineer with a tremendous and exciting challenge. Unique problems of Huntly have allowed a chance for a fresh appraisal of some aspects of services design.

It is suggested that the following points should receive consideration:

- (1) In the particular circumstances at Huntly the use of consulting engineers caused some problems which could be avoided by an appreciation by civil engineers of the requirements of the building services engineer and vice versa early in the project.
- (2) Design changes should be kept to a minimum and where they become essential all the facets of the

changes must be considered and advised to all site organisations affected by the change.

- (3) Draughting and draughting detail must be of adequate standard and sufficient site staff provided to ensure that this is so.
- (4) A standard specification with standard conditions of contract should be set for all contractors on the project; features of a building requiring alteration of the standard specification could be supplied as an appendix.
- (5) A policy of equipment standardisation needs considerable study because a suitable policy will reduce maintenance problems in the future.
- (6) If a single supplier is selected at an early design stage for similar equipment throughout the project with the aim of equipment standardisation, then careful consideration must be given to the effect later design changes will have on the price of equipment supplied and reaction from unsuccessful original tenderers.
- (7) Problems can be reduced:
 - (a) By the inclusion of "design intentions" on drawings.
 - (b) If good rapport exists between building services site and design offices.
 - (c) If site changes are relayed to the design office as soon as possible.

The need for a comprehensive services involvement with all disciplines in thermal power station design has now been established, providing a sound background upon which to base future jobs.

6. ACKNOWLEDGMENTS

K. J. Harrison, former design engineer, building services power division, MWD; L. W. Bonner, mechanical overseer, MWD, Huntly power project; N. C. McLeod, Commissioner of Works, MWD, for permission to publish this paper. ▽

The electronics revolution and its possible impact on employment and development

M. C. PROBINE

PH.D., F.R.S.N.Z., F.INST.P.

This 1979 Dobson Lecture was delivered in the hall of the Hamilton Teachers College on 9 October. The lecturer, Dr Mervyn Probine, is presently Commissioner of the State Services Commission, and was formerly Assistant Director-General of the DSIR. From 1967 to 1977, Dr Probine was Director of the Physics and Engineering Laboratory, DSIR, and his principal interests in the past twelve years have lain in New Zealand's industrial development and the contribution that science could make.

THIS lecture is in honour of one of New Zealand's early engineers, Sir Arthur Dudley Dobson, who lived from 1841 to 1934. He was born in England and arrived in New Zealand on the barque *Cressy* in 1850. He went to school in Lyttelton and in 1861 became topographical surveyor to the geologist, Doctor Von Haast.

He gave his name to a very famous geological feature and route from Canterbury to the West Coast as the discoverer of Arthur's Pass in 1864. In 1871 he became provincial engineer in Nelson and in 1878 went into private practice with his father in Christchurch. From 1901 to 1921 he was city engineer for Christchurch. He was President of the Institution of Engineers in 1924-5 and knighted for his services to engineering in 1931. He died in 1934.

If this lecture is about anything, it is about change; and change was no stranger to Dobson. He was born in England during the railway building boom when steam was "king". At that stage electricity was in its very early infancy and had not yet been applied to practical tasks. During his lifetime sail gave way to steam, electricity and the internal combustion engine became important sources of motive power, the telegraph and radio changed the face of communication (during his presidency of the Institution of Engineers in 1924 the first radio communication was established between New Zealand and the United Kingdom); he saw the introduction of the motor car and the aeroplane, and he would have seen the introduction of refrigeration as an important factor in the development of New Zealand's overseas trade.

He would have seen important changes in the social area also. He lived through almost the whole of the Victorian era, the Edwardian era, the post-First World War era and into the great depression of the early thirties. He lived through the Maori Wars and World War I and saw New Zealand grow from a primitive colony to a young nation. Indeed, his life spanned almost the whole of our first hundred years. In the science area, too, he saw the introduction of some of the great concepts of science that not only advanced our knowledge of nature, but had a profound effect on our social and technological thinking.

In 1859 Darwin published the *Origin of Species*, and in 1866 Mendel published his work on heredity (which remained unnoticed for quite a long time). In 1869 Mendeleev revolutionised chemical thinking when he published his work on the periodic table of the elements; in 1911 Rutherford published his model of the atom and the atom was "split" about 20 years later, and, finally, a patent

was taken out in Britain for a "chain reaction" involving neutrons in the year of his death (1934).

He lived, therefore, from the birth of electricity almost to the birth of nuclear energy and the nuclear bomb, and he saw the introduction of many technologies that had a profound effect on the way in which men did things and on the way in which they lived.

I have summarised, briefly, some of the changes that took place during Dobson's life to illustrate the point that change is *not* new. The world as he left it was very different from the world he was born into.

In this lecture we are considering the changes that have been brought about, and that will be brought about, by the "electronics revolution". With it is coupled a revolution in "communication". In a recent film, *The Chips are Down*, widely seen throughout New Zealand on television, it was stated that these developments "are the reason why our children will grow up without jobs to go to". And during the recent one-day general strike, a film shot was shown on television of a striker walking down Queen Street in Auckland and shouting at someone in the crowd words to this effect: "New developments in technology will mean you have no job to go to in a couple of years."

Are these statements likely to be true? Have we something special to fear? What should we be doing about it?

These are some of the questions that will be considered in this paper.

THE SILICON CHIP

The heart of the change in electronics is the silicon chip. Almost all of the important components of a computer are contained on its tiny surface which is built up by a series of chemical, metallurgical, and photolithographical processes repeated again and again until all the microscopic components and inter-connections have been layered on.

The pace of this development has been truly remarkable. In 1957, the germanium transistor was introduced and it swept the valve aside in just a few years. The germanium transistor was followed by the silicon chip and by 1963 manufacturers were able to get the equivalent of about 8 transistors on a chip. This year (1979) we have components in commercial production using a single chip of silicon on which 64 000 bits of information can be stored. Chips are in experimental production capable of storing 256 000 bits of information and no doubt they will be in commercial production before long.

These developments have had, and will have, a very significant effect on the development of computing, of

communications, and of technology. The table below illustrates the speed of change in computing over, approximately, the last 25 years. The figures are from IBM.

| | | |
|--|---|------------------------|
| Size — equivalent computer power | | |
| 1953 | — | 11.34 m ³ |
| 1959 | — | 2.83 m ³ |
| 1971 | — | 0.22 m ³ |
| 1976 | — | 0.0087 m ³ |
| 1979 | — | 0.00087 m ³ |
| 13 000 times | | |
| Cost — per million bytes of storage | | |
| 1952 | — | \$222 000 |
| 1957 | — | \$105 000 |
| 1964 | — | \$ 28 800 |
| 1976 | — | \$ 3 800 |
| 1979 | — | \$ 430 |
| 500 times | | |
| Processor speed — multiplications/second | | |
| 1952 | — | 2 193 |
| 1958 | — | 4 166 |
| 1964 | — | 12 000 |
| 1976 | — | 43 000 |
| 1979 | — | 239 120 |
| 110 times | | |

COMMUNICATION TECHNOLOGY

Paralleling this development in computing, and to some extent stimulated by it, there have also been significant developments in communication technology. These are illustrated by the introduction of new means of transmission including coaxial cables, wave guides, optical fibres, and satellites. Digital transmission of data is now common and digital transmission of audio and video signals is in its early stages. We are seeing the beginning of the change from circuit switching to "packet" switching. Computers are also having an influence on the development of switching in exchanges, and are now being widely introduced into the communication system.

INFORMATION TECHNOLOGY

Information technology comes out of the marriage of computing and telecommunications. The computer has the power to store a large amount of information and to process it at high speed. The cost of computing, as already indicated, is falling rapidly. The new developments in communications are allowing us to transmit a large amount of information over very large distances and the cost of transmission is also falling rapidly.

These two techniques together provide the following:

- (a) The ability to store large quantities of information in a compact space.
- (b) The ability to retrieve, digest, analyse and manipulate it.
- (c) The ability to direct and transmit information over large distances.

Hence we are at the beginning of the "information revolution". This information revolution is likely to have significant social impacts which are summarised below:

Educational:

- "Self teaching" methods
- "Open University" concept
- Education in the Third World

Personal:

- Privacy/Right of access
- Concentration of power
- Employment restructuring
- Citizen participation
- Alienation

Legal:

- Copyright
- Regulation of information transfer
- Censorship
- National sovereignty

International:

- International outreach
- Standards.



Demonstration of a word processor

A SOURCE OF INNOVATION

These developments in technology which have been briefly summarised and which include microprocessors, large-scale integration, computing, satellites, and optical fibre transmission are surely a rich source of innovation coming from the marriage of technology and imaginative ideas.

We have already seen examples of such innovations of which we might give the following by way of example:

- Worldwide travel reservations.
- Electronic banking.
- Point of sale transactions.
- Telephone conferencing.
- Word processing/text editing.
- Electronic information services.

In the television film already mentioned, *The Chips are Down*, we saw chips being implanted into the brain of a deaf man and used to teach him to hear, voice control of a wheel chair (voice recording of grades in a meat works has already been used in New Zealand), medical diagnosis, and robotics.

In the engineering profession computers are widely used in this country for engineering design and I am told that, in the Ministry of Works, computer aided design can save, on average, about 8% on the final cost of a major project.

There seems little doubt that these new technologies, in the hands of imaginative men, will have a profound effect on the way we do things and that things that are presently not practical, or even possible, will be possible in the future.

THE USE OF MICROPROCESSORS IN NEW ZEALAND

Microprocessors are already being used widely in New Zealand by research workers and in research equipment imported into the country. They are already beginning to be used in industry.

In the meat industry, microprocessors are used in equipment which weighs meat carcasses electronically, and records the weight, grade, mob number, and carcass count; and this information is then transferred to a computer for both accounting and statistical purposes. A logical extension of this application is automatic marshalling of carcasses as they come down from the dressing floor to the cooling floor and must be marshalled according to grade. On a single chain in a freezing works carcasses are passing a given point at the rate of about 1 every 8 seconds. In a "6

chain" works, therefore, carcasses are entering the cooling floor at about 1 every second and the task of marshalling these by grade is a very significant one. Automatic marshalling would relieve human operators of a boring, demanding, and tiring task.

Some varieties of New Zealand apple (notably Cox's Orange) suffer from a disorder called "bitter pit". It can be alleviated by fertiliser applications, but this method has not been entirely successful — possibly because some growers are not applying fertiliser, or fertiliser in sufficient quantity. The Apple and Pear Marketing Board showed, in experimental trials, that apples could be treated for bitter pit post-harvest by dipping them in a solution which corrected the deficiency. Approval was given to build a full-scale treatment plant at Nelson to treat the entire crop in a fully automated plant. This plant is very sophisticated and the heart of the automation is a microprocessor. The treatment has been entirely successful; and not only have Cox's Orange apples been arriving in the United Kingdom market free of bitter pit, but we have been receiving approximately double the price for these apples that we would have received had they not been treated. The plant is a very sophisticated venture into chemical engineering; but, from our point of view, it is another example of the use of microprocessors to control industrial processors.

Another successful application has been undertaken by Fisher & Paykel Ltd. In the United States manufacturers of refrigerators and deep freezers, because the home market is such a large one, can afford to have a separate production line for every model of refrigerator or deep freeze.

In New Zealand that is not possible since our home market would not support the capital investment required. Fisher & Paykel have tackled this problem in a bold and imaginative way which is a story in itself; but from our point of view by rationalising cabinet sizes, door sizes, compartment sizes, etc., and by working from sheets of steel with a few basic widths and lengths, Fisher & Paykel, in association with another New Zealand company, have been able to develop a line for the manufacture of cabinets on which all models can be produced. In other words, there is just one production line for eleven models and it is possible to reset the equipment automatically in about 10 seconds in order to change from the production of one model to another. Again at the heart of the mechanism for resetting the line is a microprocessor. By using techniques of this kind it has been possible for Fisher & Paykel to reduce the time for the manufacture of this kind of product from 25 man hours to 5 man hours; and, with developments presently under way, it should be possible to reduce the time for the manufacture of one of these products further yet. The result is that Fisher & Paykel are internationally competitive; they are able to export their products overseas and thereby enlarge their production; they are able to employ *more* people than they were previously because of their enlarged market; and the real cost of their products, to the consumer, has been reduced to about one-quarter of the price 15 or 20 years ago. This is one of New Zealand's success stories and microprocessors have played a small, but significant, part in it. I would like you to note, particularly, that it has not led to reduced employment — indeed it has led to increased employment.

New Zealand manufacturing industry is generally characterised by firms manufacturing a variety of parts in relatively small numbers. High production, special-purpose machines are not always appropriate in these circumstances. One development which is particularly suitable to some aspects of New Zealand production is the use of numerically controlled and computer controlled machine tools. They are extremely flexible in the tasks that they can carry out; they are particularly suitable for short and medium production runs; and one can change from

the manufacture of one part to another by using jigs of a relatively simple design and by changing the paper, or magnetic tape, in order to convey a new set of instructions to the machine. The use of these machines has grown rapidly in recent years and at last count (1979) there were 101 of these machines known to be in use. Some of them are extremely sophisticated and cover such a diversity of applications as milling, lathe work, and punching. Again this kind of development is only possible because of the introduction of this new technology.

I could give many other examples which would include the production and export of equipment for dispensing petrol, and the development of acoustic blind aids to enable blind people to move about more freely. I hope that I have given sufficient examples to show that we have begun to move into this field and that the results have been highly beneficial.

ROBOTICS

Some of the developments referred to above lead us naturally into considering a further development — that of robotics.

In 1977 I visited Sweden as part of a trade mission and visited the motor division of the big electrical company ASEA. I saw many industrial robots in use there. For example, I saw one robot attending four machines — the robot would reach out and pick up the end bell of an electric motor and place it in a lathe; the lathe would machine the surface and bore the hole for the bearing; the robot would then reach in and place the end bell in a precision grinder which precision ground the bearing hole; the robot picked it out of that machine and placed it face up on a numerically controlled milling machine where holes were drilled and tapped and certain milling operations carried out; the part would then be lifted on to another numerically controlled machine for further milling operations on the reverse side; and, finally, the robot would lift out the part and place it on an output device for transfer further up the line.

One robot was attending four machines and working extremely fast to transfer parts from one machine to the other so that all machines would have been cutting metal for, I estimated, about 85% of the time. The robot did not go to morning tea or lunch and, indeed, could have worked for 24 hours a day (less maintenance time). There were no human operators on these four machines. I asked the man who was showing me round if the unions objected. He said they did not object because they realised that if Sweden used this kind of technique it would be internationally competitive in the production of electric motors, it would sell more on world markets, and there would be more job opportunities for people in other parts of the operation. The company had an enlightened training and retraining programme.

This was my first acquaintance with robots, which are basically devices for transferring parts from one operation to the next. Basically they consist of a shoulder, an arm, a wrist, and a hand. They have a large number of degrees of freedom of operation and they can be programmed to undertake a wide range of operations in a very flexible way. The skills of a human operator can easily be taught because the machine can remember a task "taught" to it by a human operator.

Later in the same trip I saw 42 robots doing all of the welding on the body of the Volvo car. From the time panels came together they were not touched again until the body of the car emerged fully welded. We also saw robots spraying bicycle frames; and I was told that there are factories in Sweden where one man owns a robot and several machines, and, operating from the basement of his own home, he produces a variety of parts for large companies. While he is programming the next part, out

marketing his products, asleep, or just taking a leisure break, the robot downstairs is attending to his machines and getting on with the production.

Robots are used in a variety of industrial situations such as mechanical handling in operations such as forging, die casting, machine minding and work transfer, attendance on furnaces, and automatic punching.

Their special benefits are that they can work in dangerous environments, undertake heavy work, undertake work which is boring and repetitive, or work which must be carried out in unpleasant environments.

The use of robots is growing rapidly. In 1978 there were 6 000 in use in the United States of America and their use was increasing at the rate of 50% per annum. At that time there were about 3 000 robots operating in Western Europe.

AUTOMATIC ASSEMBLY

Another potential use of robots, which is just beginning, is their use in automatic assembly. Assembly of components is a significant part of the time taken to produce many products. Some United States figures for the percentage of total time represented by the assembly operation in product production are as follows;

| | |
|-------------------------------|-----|
| Motor vehicles | 33% |
| Farm machinery | 30% |
| Radio and TV receivers | 24% |
| Metal working machinery | 11% |

A saving in assembly time therefore offers the opportunity to reduce cost.

The requirements of such a robot are that it should be adaptable and programmable; accommodate to position errors of parts; be capable of being taught new tasks; and perform a number of tasks in sequence.

There are significant problems in automatic assembly that are not normally encountered by a human operator because he can feel and sense when trouble is occurring, or even about to occur. Two significant problems are that of "parts mating" and "the assembly system".

Problems which must be overcome or dealt with under the heading of parts mating would include:

- Geometry of the parts.
- The clearance between parts.
- The degree of misalignment (lateral and angular) at first touch.
- The influence of contact and frictional forces as parts slide together.
- Conditions of wedging and jamming.

Under the assembly system one must consider the nature of the manufacturing tasks that must be carried out (peg in hole, push and twist, screwing, force fit, flip part over, provide temporary support and remove support, crimping, welding and soldering, insert peg and retainer); ensuring that one machine does not overtake another; economic study of costs and benefits; and design of parts for automatic assembly.

The problems are being worked on and there are already machines for automatic assembly of alternators, vacuum cleaners, etc.

WORD PROCESSORS

One application of the technology that is coming into use quite rapidly in New Zealand is that of word processing. The advantages are many: the text can be typed into the memory very quickly and corrected simply; storage and rearrangement of the text are simple; it is easy to produce printed copy which is error free; justification of line lengths is possible; standard text can be stored in the memory and called upon with insertions or deletions to suit special cases; and it is possible to prepare text for printing on other machines. It is possible to increase the productivity of

typing very significantly and one estimate suggests that one typist can do about ten times more work than by use of a conventional typewriter.

DISPLACEMENT OF PEOPLE FROM JOBS — IS THE SITUATION "ABNORMAL"?

The applications discussed above all have the potential of displacing people from existing jobs. In some cases the jobs will disappear, and in other cases the need for so many people to fill the jobs will be reduced. Examples of applications in this kind of category would be:

Computing in all its forms.

The use of numerically controlled and computer controlled machine tools.

The use of robots for mechanical handling or automatic assembly.

The use of microprocessors for automatic control of industrial processors.

The use of word processors.

Stored programme exchanges.

If people are going to be displaced, or some jobs lost altogether, why use these techniques?

First of all, we have to recognise that there are very real benefits from their use. These include:

Better service.

A more efficient and internationally competitive industry which will earn more by way of exports.

The elimination of boring, hazardous, unpleasant jobs.

Real benefits from the use of medical applications based on this technology.

Better use of resources.

In my view we cannot afford not to use these techniques where they provide benefits of the type outlined above. I will amplify my reasons for this view at a later stage.

A question which should be addressed, however, is whether what is happening is in any way abnormal. Reorganisation of work in response to changing technology has been a normal process throughout history, and through the whole of the last century. It was true during Dobson's lifetime as was pointed out in the introduction, and it certainly seems that it will continue to be true in ours.

In my view, therefore, what is happening now is similar in kind to what has gone before; but what might be different is the *speed* of the change. The speed of the change may well be significant because it becomes much more difficult to adapt, in the ordinary way, to change if events are moving quickly.

This brings us to consider, therefore, whether the speed of the change is likely to be "abnormal".

FACTORS AFFECTING THE SPEED OF CHANGE

There is no doubt that the rate of change of technology, in so far as the rate of change of components is concerned, is impressive. The potential for significant changes and developments in computing, in communications and in the technologies that are presently developing, is, as has already been said, very impressive. But are we going to snap up and apply all of these components and devices the moment they appear?

In some cases, I believe the answer is "Yes". Developments in the watch industry and in the calculator industry provide examples where the technology was introduced extremely rapidly and led to the collapse of existing industries. It must therefore be acknowledged that the possibility of catastrophic change does exist in some cases.

There are, however, limitations to the rate of adoption of some of these technologies which will slow their

introduction down. This is particularly true in the "big systems" area where there are two very significant limiting factors to the speed of adoption of new technology. They are the cost of implementation (capital and labour), and the ability to manage its introduction.

THE INTRODUCTION OF "LARGE SYSTEMS"

It is true, as many commentators have pointed out, that it is now possible to recover information from data bases in the twinkling of an eye; to transfer vast amounts of information over large distances; and to integrate business operations on a scale never before possible.

But there is more to this kind of operation than that of carrying out just one single transaction; and few people seem to discuss the larger problem.

Let us look at what has to be considered in the design of a large system for managing a department's operation and for creating a data base.

Some elements of the management task in introducing such a system are summarised in very abbreviated form below:

- Cost and benefit estimates
 - Work flow patterns
 - Who deals with what/how/where
 - What kind of actions at each step
 - Design of forms
 - Flow of forms
 - Inputting of data
 - When/who/how/checking/authentication
 - Design of stock letter for correspondence with client
 - Action in non-standard situations
 - Automatic cancellation
 - Management information
 - What/how often/what form
 - Retention of information
 - How long/where/what form
 - Security
 - Access/fire/earthquake
 - Volume of transactions/size of data base
 - Staffing requirement
 - Hardware definition/screen and printer requirements/communications system.
 - Procedures for changing data base
 - Availability/response time/down time
 - Siting of terminals/filing/microfiche
 - Program specifications
 - Acceptance criteria
 - Coding/testing/documentation
 - Manuals
 - Staff training
 - Implementation
 - Cost and benefit review
 - Post-implementation review
- (It is easier to talk about than to do!)

When one considers the magnitude of some of the tasks for management in introducing large systems, I believe that they will not happen just as quickly as some commentators have suggested. We have to consider the following: The capital cost and the cost of the labour to implement the "software aspect" will slow the introduction of new technology (for example we will not scrap the present telecommunication network overnight just because a new technology has appeared on the horizon). The task of managing the introduction, the initial cost, and the maintenance cost will also have an effect on the speed of introduction.

We might summarise, therefore, by saying that, although the speed of introduction is potentially very impressive, and while there may well be disruption to existing industries in some cases, for the reasons I have given above the speed of introduction, in general, will not match some of the more far-fetched claims that have been made by some commentators.

In my view we may well have a labour problem in some areas; but, hopefully, it is unlikely to be catastrophic. People will be displaced from some existing jobs and will need retraining. Against that, new jobs will open up that do not exist today to mop up some of the unemployment caused by loss of jobs; although, perhaps, we need to acknowledge that the new jobs may well be those tending to require greater rather than lesser skills.

Service industries may take some of the displaced people — perhaps as a response to the greater opportunities for recreation. A shorter working week may be appropriate and desirable — assuming, of course, that increased productivity is in fact achieved. Diversification of agriculture into a wider range of products from the land (horticulture and crop) may bring more people back on to the land and again provide opportunities for employment.

On balance, I believe that the statement made on the film, *The Chips are Down*, that our children "will not have jobs to go to" is unlikely to be true; although we must acknowledge that there are likely to be changes in the organisation of jobs and in the types of jobs available.

Can we afford not to use the new technology? For economic and social reasons, in my view, the answer is clearly, No.

The New Zealand Planning Council has recommended that government expenditure (the cost of running departments of state plus the cost of transfer payments to the aged, sick, unemployed, etc.) should rise at a rate no greater than 1% less than the growth rate of the G.N.P. For example, if the G.N.P. rises at 3% per annum in real terms, then government expenditure should rise at a rate no greater than 2% per annum in real terms.

To achieve a growth rate of 3% per annum of G.N.P. implies a 5% growth rate in exports in real terms; and this would be made up, say, by a 2% annual growth in exports of traditional products and a 10% annual growth in non-traditional exports (manufacturing, forest products, fishing, etc.). This latter rate of growth is a very high one and will only be achieved if our manufacturers are competitive on world markets in quality, price, and design (i.e., if they are internationally competitive). In my view, we can only be internationally competitive if we can match the performance of our competitors or do better. If our competitors are using methods that significantly increase their productivity and reduce costs, can we do less?

If we do not compete internationally, and if we do not build up our exports of non-traditional products at the rate I have indicated above, then we cannot achieve a growth in the economy that will enable us to meet our social goals.

We are therefore in a curious dilemma — there are social risks in using modern technology; but we may not achieve our social goals unless we use the new technology wisely to increase our productivity.

It seems, therefore, that we cannot escape using production systems that offer the possibility of increasing our productivity in real terms; and the only real choice we have is to use these methods wisely (for example, by enlightened use of training and retraining such people as are displaced from existing jobs). In other words we should use these methods as an opportunity to be grasped — as, I believe, Arthur Dudley Dobson and his generation grasped the opportunities presented to them.

AN INDUSTRY BASE

The electronics industry and the "software" industry are going to be very important. How, then, are we going to seize the opportunities and exploit them for our benefit?

We begin with one disadvantage — a relatively weak electronics industry! It is true that some very good things are being done in the electronics industry; but as a national resource, in absolute terms, it is not strong.

It is probably true to say that its future does not lie in component manufacture because the home market is too small. It almost certainly lies in innovative application of the technology, and this is an activity that deserves encouragement. Innovative application of the technology applies not only to the hardware but to the software also.

Encouragement of the industry can come in many ways, but so far as the government is concerned there are actions that could be taken by government departments to assist (particularly those that are large purchasers of equipment and software). As a matter of policy the following actions might well assist to encourage a New Zealand-based industry:

- (1) Regular briefing of the electronics and of the software industry on a department's forward plans so that they will not be caught with too little time to respond when major tenders are called.
- (2) Advising hardware and software companies of the names of overseas companies from whom tenders will be sought for major developments. This would allow New Zealand companies to get in touch with the principal tenderers and attempt to make arrangements for some production in New Zealand.
- (3) Favouring tenders that include a New Zealand content.
- (4) Letting development contracts to the electronics industry and employing the software consultants to assist in some major developments.
- (5) Provide generous research and development incentives.
- (6) Provision of favourable terms for investment in highly productive equipment.

INTRODUCING NEW METHODS IS NOT ALWAYS PROFITABLE

Dr G. F. Stuart of DSIR has recently done some work on the efficiency of New Zealand industry — particularly on the efficient use of capital in industry (or, perhaps, on the inefficient use of capital).

in view of his findings I should, perhaps, point out that the introduction of new methods, new processes and new technology in industry should only be done if it leads to

increased productivity, efficiency, profitability, better use of resources, or better working conditions. Nothing in the foregoing part of the paper is intended to suggest that we should use these "far out" technologies if there is no advantage in doing so. It should not be necessary to say this; but, in view of our apparently poor record, perhaps I should!

SUMMING UP

- The technologies we have been talking about are limited, to a very large degree, only by our imagination and innovative application.
- The flexibility of these technologies can open up opportunities for production previously limited by economies of scale (for example, note the application of the technology by Fisher & Paykel).
- These technologies can improve our productivity and therefore assist us to become internationally competitive on world markets and to earn export income.
- Some jobs will diminish, and some will disappear, and it is therefore important that we should have an enlightened programme of training and reprogramming for those that are displaced.
- Communication technology could play a powerful role in education (it seems such a waste to use a powerful medium like television for entertainment purposes only when it could also be used for education as it is in Britain).
- Electronics companies and computer software companies should be encouraged; and one possible avenue of government assistance is by enlightened use of government purchasing.
- The new technology will place great demands on management — in the management skill required to implement large systems successfully and in the enlightened management of employment problems.
- The application of these technologies holds great promise for improving the use of our resources (for example, as is already being done in engineering design).
- These technologies open up opportunities of which we have not dreamed and we should seize them and use them boldly. ▽

Graduates' assessment of engineering school courses

J. B. C. TAYLOR*

M.SC. (HONS.), B.E. (HONS.), C.ENG., F.I.MECH.E. (FELLOW)

A survey was carried out to find the opinions of engineering graduates on their engineering school courses. The main conclusions were (1) that 85% of all graduates from both schools of engineering thought their courses were satisfactory, very good or excellent, and (2) that there should be more in the courses on management and technology, and less on mathematics and engineering science.

1. INTRODUCTION

A SURVEY was carried out for the Institution to find how engineering graduates regarded their courses in the light of their subsequent experience in the real world of engineering. The survey was based on replies to a questionnaire sent out to all members of the Institution in May 1978 with a request that replies should be made by graduates of Auckland and Canterbury of up to 10 years' seniority.

2. THE SURVEY

The questionnaire form contained 13 questions, the more important ones of which covered (1) engineering school attended, (2) degree taken, (3) department (civil, mechanical, etc.), (4) number of years since graduation, (5) method of entry to engineering school, (6) field of employment since graduation, (8) rating of undergraduate course in preparing them for their subsequent career, (10) whether the content of certain types of work in the courses should be varied, and (12) whether an M.E. or Ph.D. degree had been of significant value in their career.

3. ANALYSIS OF RESULTS

A total of 1120 valid questionnaire forms were returned, 371 from Auckland and 749 from Canterbury graduates. It was decided to analyse in detail the 922 forms returned from graduates of up to 15 years' seniority, in three groups, 0-5, 6-10, and 11-15 years since graduation.

3.1 Question 8: Value of courses

The replies were allocated numerical values as follows: Excellent 5, very good 4, satisfactory 3, fair 2, poor 1. These numerical values were then combined to give a mean value, and a standard deviation for the group concerned. This was done for all replies, then for Auckland and Canterbury separately, for each department (civil, mechanical, etc.) and finally for each seniority group. In addition, for each of the categories mentioned above, the replies from N.Z.C.E. entrants were compared with all others, and those from each field of employment were compared in turn with all others. An outline of the results is shown in Fig. 1.

3.2 Question 10: Content of courses

In this question, graduates had been asked whether the following types of work should be increased, kept the same, or decreased in engineering degree courses:

* Senior lecturer in mechanical engineering, University of Canterbury, Christchurch.

This paper was received on 28 September 1979, and is a summary of a text that will be published in full in *N.Z.I.E. Transactions*.

Engineering design, engineering mathematics, engineering science, applied engineering or technology, general studies, or the "engineer-in-society", management or administration, projects, and practical work in industry.

Replies were given values as follows: Increase greatly 5, increase 4, keep the same 3, reduce 2, reduce greatly 1. The numerical values were analysed as for Question 8 replies, for each type of course (design, mathematics, etc.) and an outline of the results is given in Fig. 2.

4. DISCUSSION OF RESULTS

4.1 Question 8: Value of courses (see Fig. 1)

The overall mean value of the replies from 898 respondents was 3.315 and the standard deviation was 0.722. If normal distribution is assumed, it will be found

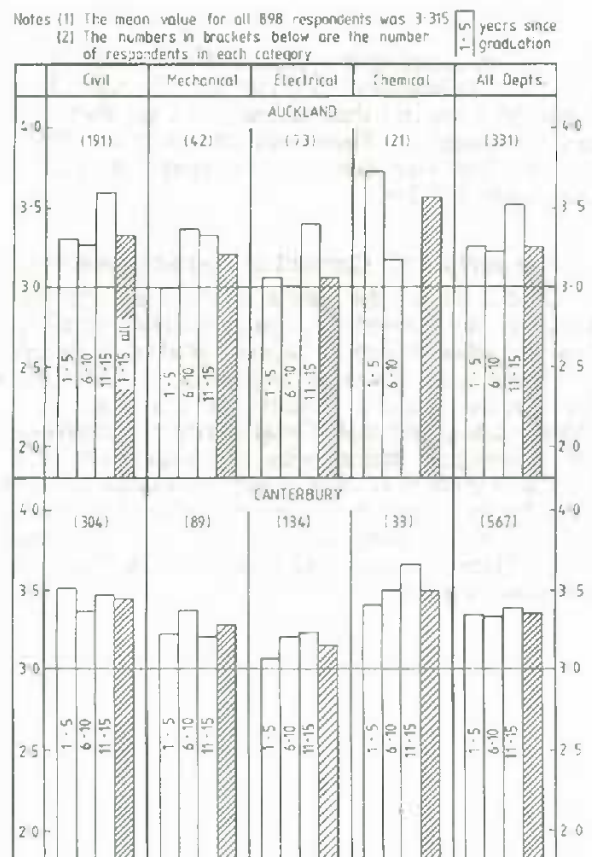


Fig. 1: Opinions on value of courses vs. engineering school, department and seniority (2.0 = poor; 3.0 = satisfactory; 4.0 = very good).