CRANKS & NUTS

Cranks and Nuts 1969

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Students' Club

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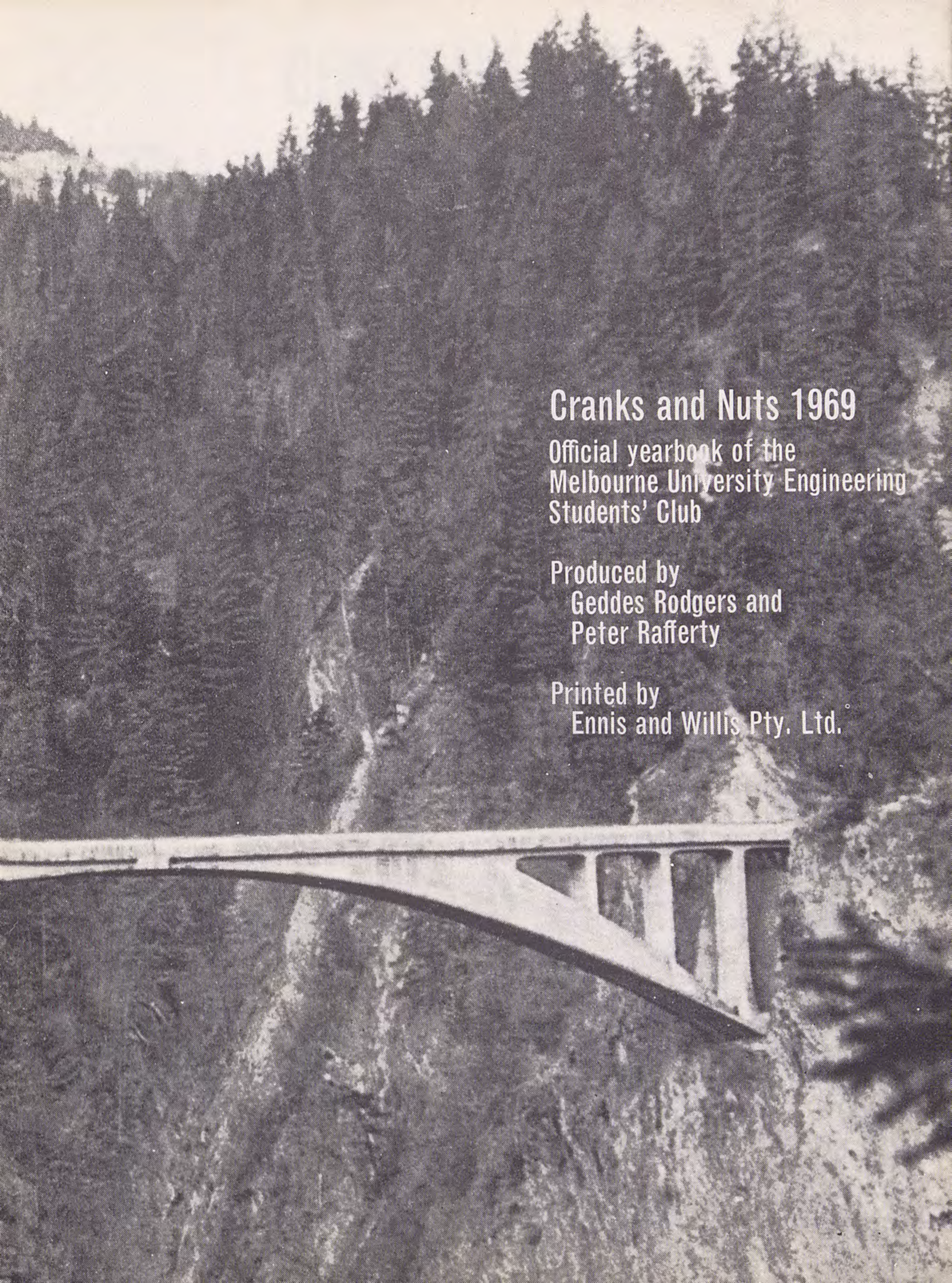

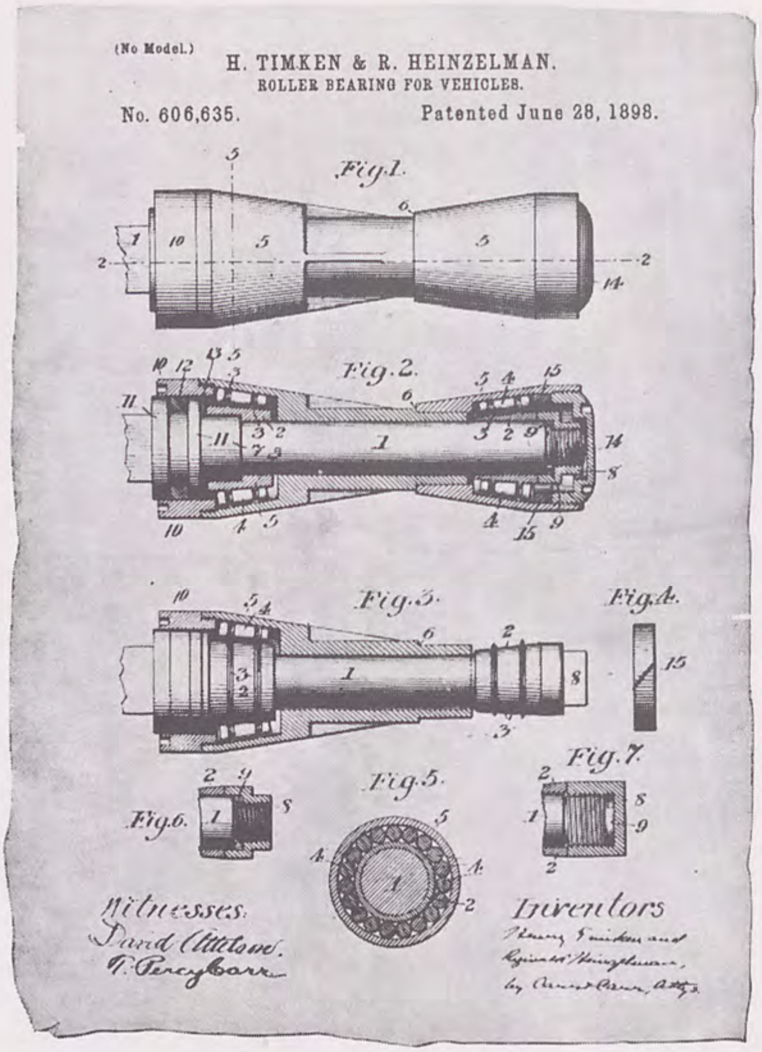

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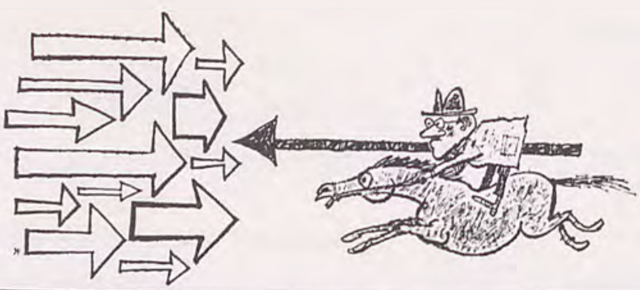
CONTRIBUTORS

RESEARCH and OTHER THINGS

Professor Peter Whitton



Following last year's issue,—which included articles on atrocities around the world, black power, and drugs, it seems appropriate to write in a somewhat more cheerful vein, but at the same time not to avoid some questions of quite serious consequences. And so these writings principally intended to say something of the type and significance of research work we do, must of necessity also answer, or comment on, some of the criticisms or doubts which, for one reason or another, come our way on some days of every year, from employers, from father and mother, and from governments. What is a Master's degree really worth? Do we over-encourage research work? A good pass man is worth two or three honours boffins in practice!

By example, I will set out a selected few of our advanced projects—to attempt to cover all of our work in research would be out of place here and now; full details are always available in the Faculty Annual Research Report which for mechanical engineering alone covers nearly sixty separate researches.

What use is a Master's degree to "industry"?

(We accept that it is useful for research type careers)

One of our projects is concerned with collecting, setting out, analysing, simplifying and presenting the relevant factors of decision making in industrial organizations of various sizes in Australia. This problem, its difficulties, ramifications and huge variety of applications is possibly reducible to certain accepted principles which in the majority of cases, can be simply set out. It is, if you like, a detailed study of what is best represented by a large industrial Technical department. It can be tackled in part statistically, in part technically, in part by common sense.

The answers will not be "yes", or "no", or "later on", for it is aimed at examining the known and unknown facts, the factors needed for a decision and the possible and probable effects of various decisions. This is the life blood of all manufacturing concerns dealing with people, machinery and money.

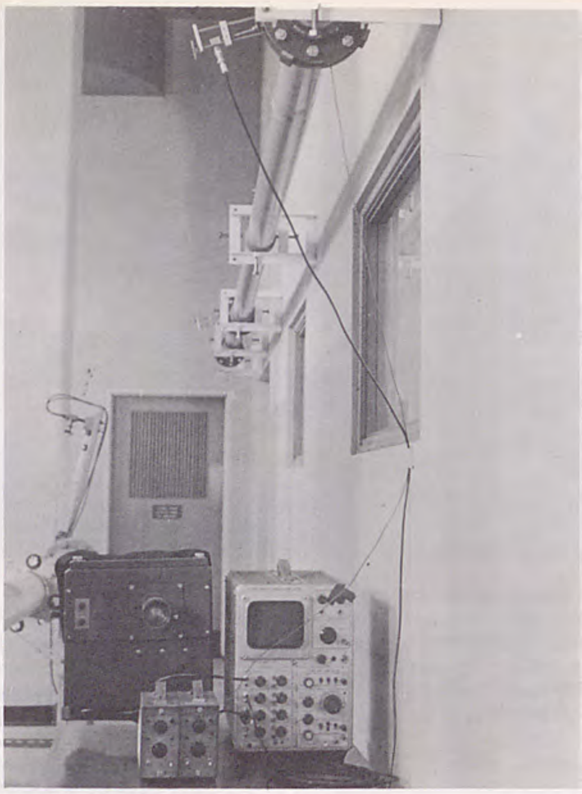
A second piece of work started off as basic Master's research training and lead on to a Ph.D. Put simply, how best does one design an assembly line, a reasonably complicated one, to ensure that the assembly of say, a motor car, is (a) most efficiently (b) most economically (c) most quickly—carried out? How many assembly points are needed, how many operations can be effected in a given time at each point, what speed of conveyor belt is optimal, how long can operators continue to work—and with what interval of rest?

This is an everyday problem in mass-production industry. First degree engineers may have some training in its solution, depending on their branch of study, but it is not a simple problem. Do we need to train people to be skilled in applying these techniques to many different assembly problems? Is trial and error or practical experience adequate? Other countries, Japan, U.S.A., Germany, put this type of training on an advanced study basis. Can we afford not to?

"Do we ever see the results or is it all long term, basic research?"

Any surgeon will tell you that elderly people often experience particular difficulty in the repair of their bones when broken, particularly when they are over about sixty-five and often particularly when they are ladies. Sometimes repair can be effected by closed reduction (correct positioning of the fractured parts by manipulation) and protracted rest. Often this is not possible, either because of bone fragmentation etc., or because protracted rest may cause other difficulties. Repair may then be by operation; nailing, screwing, fitting and hammering—all with skill obtained by practice. Does it surprise you to know that the screws used are never left handed? Or that only in 1967-68 did really reliable research examine the best point angle of the drill to bore human bone? Or that flat plates are commonly used in repair of curved bones? Or that the mechanical properties of human tendons and ligaments, and even human skin, all amenable to grafting, are little known?

Let us be clear on the point here. There is a wealth of information of the case book variety, and there are countless recommendations on such matters from practice. There has been a wealth of ad hoc experiment. But systematic engineering investigation is often lacking. Is investigation of this, by engineers working with surgeons, likely to yield results that we can see in our lifetime? Some of our postgraduates work on problems such as these.



Unsteady Gas Dynamics Testing

This study involves an investigation of the effects of friction and heat transfer on a one-dimensional pressure pulse moving down a pipe.

The pressure pulse is formed by rapidly moving a piston down the pipe. Peak piston acceleration is about 40,000 ft/sec² and its velocity reaches a maximum of about 330 ft/sec. The pressure pulse formed in front of the piston has an amplitude of approximately 7 lb/in². This pulse steepens as it travels down the pipe and would eventually form a shock wave (pressure step). In the present project, interest is confined to the stage before the shock front is formed.

The friction and heat transfer effects on the pulse are investigated by means of piezo-electric pressure transducers and fine wire resistance thermometers. The sensing elements of the resistance thermometers are constructed of .0001 inch diameter tungsten wire giving a probe of fast dynamic response.

"A Good Pass Man is worth two or three Honours Boffins, with Ph.D's."

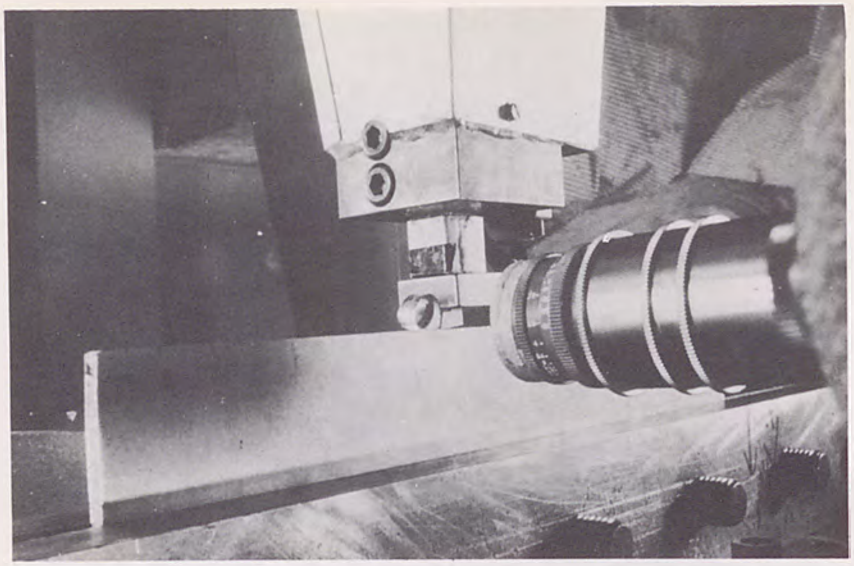
Comments like this are quite common, and often there is truth in the particular application referred to. The fault usually lies in the use to which people with a certain training are put. Without doubt, there are certain tasks a person with a first degree or diploma can do as well as a more specialized person. Where personal qualities enter into the picture, as they often do in engineering circumstances, then the question needs to be rephrased. Good personal qualities are randomly distributed.

A very interesting investigation by Mr. W. P. Lewis throws some useful light on the judgement of creativity, or consideration of what is important in an engineer. Mr. Lewis teaches engineering design principles to the Faculty and design work to third and fourth years of the industrial and mechanical engineering course, and is an ardent believer in the value of creativity in design. Recently, he investigated, with the aid of students in the Faculty, whether good examination results can be correlated with design creativity. Setting 119 second year students the same series of design exercises, he found that five of the students showed consistently high creative effort. The performance of these five in previous university examinations varied from high honours to failure, and more generally, Mr. Lewis deduced that it would not have been possible to predict performance in creative design exercises from a knowledge of previous examination results.

Thus, as far as we know at present, it is quite possible that a particular person with a pass degree may be more creative, and perhaps could be better fitted to research, than a particular first class honours man. That is why other factors than degree result are always considered before admitting someone for postgraduate work.

While on this subject it is well worth while defining what higher degree training does, and commenting on what first degree training does not do to any marked extent.

An "undergraduate" course does not specifically teach how to survey a particular field for a set purpose; how to develop something that has not been tackled before; how to work perhaps fourteen hours a day for months with only personal impetus; how to argue verbally a case with due care for reputation, superior knowledge, bigotry and the like; how to put a complicated set of data down in a report and convince an unbiased but knowledgeable observer that the conclusions reached are correct, obtained in the right way, thorough and forward looking. If a "postgraduate" course teaches all these things, and it does, then it is teaching exactly what many engineering employees want in addition to basic knowledge. The trouble is that the time factor prevents proper training in these matters in the undergraduate course through special projects at final year attempt to tackle the problem.



High Speed Machining of Metals

This machine can cut at 2500 feet per minute and the object is to obtain basic data in three dimensional working. Metal is removed as shown, curling off past the tool in the centre. The workpiece moves past the fixed hard tool. On the right, the camera films the process at up to 8000 frames per second.

The Road Accident Problem

Some of our research works which receive the most publicity undoubtedly are the human engineering projects concerning themselves with the road accident problem, with all its complications. But the solutions, or better perhaps to say, moves towards solutions, are sometimes indirect. Several postgraduates in the department working on various aspects of this find themselves forced to study psychology, physiology, statistics, anatomy, in order to properly apply their engineering training. A motor car is a mechanical product; a roadway is a civil engineering product; the driver is, by a long chalk, the most complicated "factor" of all. He may drive under strain, or be tired; he may, on the road, be faced with a situation in which things happen so quickly that he simply cannot cope unless prior study and design has put him in a position to cope. Human responses can be timed; a human being can deal with a certain number of signals or operations in a given time and no more—if exceeded the driver: road: vehicle system is overloaded—often with dire results. So our students work on statistical possibilities and how to gain a driver more time; on vehicle design to improve vision, steerability, tyre design; on studying the responses of a range of people to find out what they can cope with at different rates. One recent (March 1969) study led to a prediction that at pedestrian crossings. the risk to pedestrians was greater from cars leaving a marked crossing than from cars approaching. Available collected accident data confirmed this.

Such research does not only have application to the accident rate or the diminution of damage to people. It can be applied to aircraft cockpit design, ships' bridge design, management decision making, the design of engineering machinery, performance at athletics meetings and other things. The department has now some fourteen people investigating problems in this general area.

Vehicle Handling.

The object was to examine driver performance experimentally when certain vehicle variables were changed. Amongst these—vehicle response time, steering ratio, steering torque, and near and far sight distances. The course was a narrow winding one marked by traffic cones.

In Conclusion

Sometimes putting advanced projects into simple language can have the effect of oversimplifying what is really a very complicated problem at the doctorate level. For example, a stress analysis of the neck of the thigh bone for a person standing in a still position embodies the analysis of the forces acting in twenty-two muscles acting at different angles in three dimensions around the pelvis, each force being spread over an area; and attempting to model such a system for photoelastic stressing involves building a model to simulate the construction of human bone which itself has one strength component built in a network enclosed by a hard surround of different strength. Similarly, analysis of human response times and analysis of human input and output requires the most careful preparatory work to obtain meaningful results.

Of necessity, therefore, many projects have not been mentioned at all, in the fluids field, in automatic control and in thermodynamics. This is because a large proportion of our students are in first and second year and have not yet had the pleasure of delving into the intricacies of turbulent boundary layers, time optimal control and solar heat collectors. Perhaps in a year or two . . . ?

PROFESSIONAL ENGINEERS in AUSTRALIA

Sir Maurice Mawby C.B.E.

Sir Maurice Mawby,
Chairman of the Board,
Conzinc Riotinto of Australia Limited,
95 Collins Street, Melbourne.

Dear Sir,

We would be very pleased if you could contribute a few of your thoughts to our annual faculty magazine.

Could we suggest that the following ideas form the basic framework for this discussion.

Firstly, we would be interested to know your opinions on the standing and qualifications of Professional Engineers in Australia;

1. Do you feel that we are at present understaffed with high-grade engineers in Australia?
2. What would you say their main role will be in the immediate and long-range development of this country?
3. Do you think that their training is sufficiently oriented in these directions?
4. Can you see any inherent dangers in the present spread of technological changes as it applies to the environment and social structure in Australia? . . . in New Guinea?
5. In this regard also, do you feel, through your association with both the educational and practising aspects of Professional Engineering. that there is a need for greater efforts to be made?

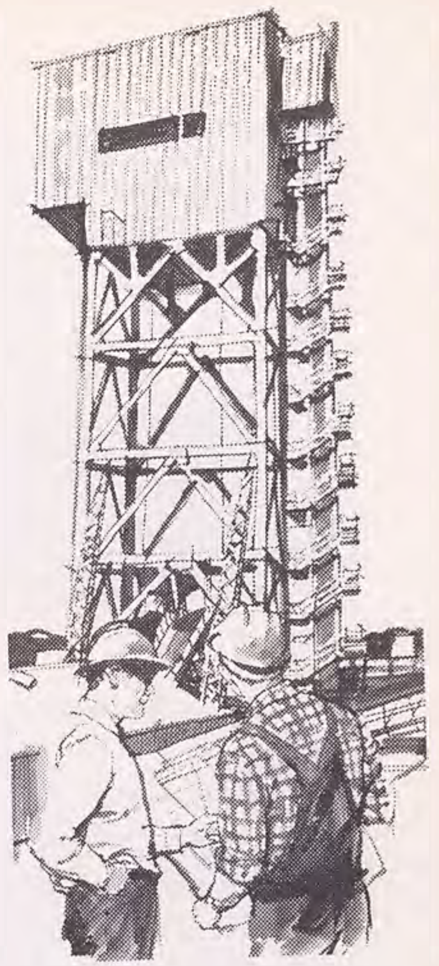
The past decade has been one of the most exciting in Australian history. It has seen strong growth in nearly every sector of our economy, and in some, particularly mining, the expansion has been spectacular. In addition, a successful immigration programme, coupled with quicker international air and sea travel, is changing our way of life and necessitating greater investment in homes, buildings and communications. The execution of most of these new projects is the task of the engineer, who is required to plan and to carry out the construction of public works, industries, mines, ports and harbours. As well as an increased volume of work which requires engineering skills, a whole gamut of new techniques and practices must be assimilated by the practising engineer.

It is not surprising therefore that at the present time Australia is short of engineers. It is not easy to assess the extent of this shortage and figures reported by employer companies may be unreliable. However, in order to make realistic forward plans for training facilities, a survey was recently undertaken by the Australian Mining Industry Council in Canberra of the current and future requirements of professional men including engineers, scientists, mathematicians, economists, etc. As regards

engineers, this survey showed that the mining companies in Australia in 1967 were employing 914 engineers. This total comprised 335 mining engineers, 303 mechanical, 156 electrical, 50 civil and 70 'other engineers'. At this same time, the same companies reported that, had they been available, they could have employed about an additional 100 engineers. The companies were also asked to forecast their maximum requirement in the year 1972. This forecast requirement totals 1866 engineers, the proportions mining, mechanical, etc., being approximately the same as in 1967.

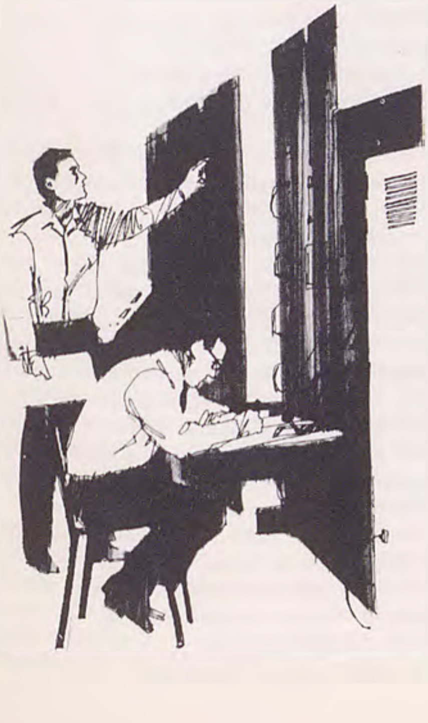
The survey shows that the mineral industry is likely to double the number of engineers it employs in the five year period 1967-72. Geologists, chemists, metallurgists, physicists, etc., being classed as scientists and not engineers are not included in the above figures, but the increased demand for these skills will probably be in the same proportion.

As well as there being too few engineers, there can be no doubt that amongst those who are available some do not fully measure up to the standard required. Generally speaking the engineering training of the output from universities is good. Graduates have an adequate knowledge of engineering skills and are able to make a worthwhile contribution in design work and supervision of engineering operations. The work of an engineer is, however, not confined to these tasks. A young project engineer joining a company will frequently be called upon to give an opinion on such things as the economic background of a project, the best procedures in calling tenders and the advantages and disadvantages of imported materials against the background of Tariff Board decisions. In these and other ways he must be prepared to give a 'rounded' opinion not merely a technical engineering one. In addition, there is the all important field of financial control of engineering projects. These are usually constructed on a strict budget, and over-expenditure may not only upset existing financing arrangements but may also, in the long term, adversely affect the profitability of the whole operation.



It is axiomatic to say that the training of an engineer never ceases, he is always learning on the job. There must however, be a 'cut-off' point where formal education ceases and productive work starts. It is probable that existing four year engineering courses at universities are adequately long for instruction in engineering subjects, and it is doubtful whether any more can usefully be included. It is important, however, that the young graduate should not consider that on graduation his education is completed. As soon as he has established himself with the company of his choice he should plan his further education on a part time basis. The subjects open to him are Accountancy, Law, Economics, Business Administration or possibly a language. The majority of these subjects can be studied by correspondence if no suitable university or technical college is available.

From the point of view of increasing his value to himself, to his employer and to his country, the average graduate would do better to study one or more of the subjects enumerated above, rather than an additional engineering discipline. We are living today in an era of great and rapid technological changes. This in itself is producing paradoxes. We send a man to the moon at thousands of miles an hour yet take ten minutes to travel a city block in the morning rush hour. Technological change, many call it progress, is natural and acceptable so long as man remains in control of his destiny. It is of vital importance that specialization is not allowed to reach the pitch where opinions based only on specialized data are allowed to prevail against the more widely informed counsels of men with broader experience, which is gained through the study of books and of people. The ability to mix with others and to communicate easily with men and women of differing interests is one of the many benefits which derive from university life.



In conclusion, the Professional Engineer in Australia has an exciting and challenging future. He will be concerned with an infinite variety of problems in developing this country. In the immeduate future, the mining industry will be looking chiefly for mining, mechanical, civil, metallurgical and chemical engineers.

Much of their work will be in the northern half of this continent and these men will have the satisfaction of bringing new communities into areas which previously were uninhabitated. In the more populated areas of Australia, development of communications, roads, airfields and railways, as well as radio and television, will make a big demand upon resources. Before long, engineers will be required to handle nuclear power projects, a field which in this country we are still relatively inexperienced. Training facilities at our universities and technical colleges may have minor imperfections but they are basically well found. It is important that they should be used to the full because in these days education is a lifelong process.

ART and ARCHITECTURE in ENGINEERING

Richard Donald

There seems to be little point in opening this article with yet another rapturous appraisal of man's technical endeavours and achievements in the twentieth century. It seems that this century has heralded yet another era of self-congratulation brought about by unconsciously comparing man's ingenuity with that of his animal counterparts—immediately after admitting how much more advanced he is than them. It must be confessed, however, that the engineer is generally not responsible for such self-congratulation. This is usually left to the politicians, historians and sociologists; in short the humanitarians. The engineer is mostly quite happy to peacefully proceed and develop his device—whether it be a machine or an industrial layout—without too much worry about the vaguaries of social implication and his responsibility to other associated groups.

It is important to clarify this last statement since there is no question of a Morrisonian rejection of the cult of the machine being intended, with a subsequent return to the arts and crafts. Such a reversion may well be possible when the process of automation reaches its ultimate conclusion, but certainly not at a time when it is only just developing. Rather, what is meant is that a realization of the responsibilities of engineers in a sophisticated, mechanised society is necessary. These responsibilities extend into many fields. What is thus being advocated, is the exoneration of much of the responsibility of the administrator or beaurocrat, and placing it instead on the engineer or designer in the hope of achieving a more humanistically balanced product. Such reallocation of responsibility may, of course only occur, if there is a realization of the need for such a consideration, for the administrator, or beaurocrat to deal with in the first place. Much of the structural work in Australia in recent years seems to indicate there was no such realization. No beaurocrat in his right mind would have permitted some of the engineering atrocities of modern urban Australia if he was already aware of this need. Of course this criticism applies with equal strength to men of pure science who all too often find their influence in the social orientation of their ideas and brain-childs completely ineffectual.

In this article we are concerned primarily with the liason between architects and engineers—that is, mainly civil and structural engineers, though still to an important extent electrical and mechanical engineers. We are thus limiting ourselves to the consideration of one particular branch of the engineer's responsibility—that of maintaining aesthetic standards—to society. It is probably the most direct and immediately felt field of responsibility for the engineer because there is no time lag between the installment of the device and its effect on the public. A computer, for instance, requires quite some time in operation before its full labour and time saving ramifications can be appreciated. Only after that initial time lag do the problems of say staff upheaval or re-orientation make themselves apparent. Furthermore, computers and other electrical or industrial innovations are discreetly tucked away in the isolated corners of large buildings far from the harsh reality of the people whose lives or destinies they affect and even control.

However, there is nothing discreet and tucked away about an ugly nest of electric pylons or power lines. Nor is there any time lag between their erection and the impression they make on the inhabitants of the environment. For these structures—outrageous or otherwise—*are* the environment, and their effect on the crowds who pass them each day or who work in them eight hours a day, is immediate. It is thus felt that engineers—particularly in structural and civil fields—should cease to pay lip service to the demands of aesthetic standards, and implement them more rigorously.

In Australia in the past, the liaison between engineers and architects has never been the best. There was always a tendency to isolate the tasks of each, and only at the last minute, when the finished plans were submitted for inspection, was there any concerted attempt to integrate both fields. The engineer had his assignment—to satisfy the architect and client—and that was the beginning and end of his mission. His success was judged purely by the satisfaction of these two parties and not by any broader considerations.

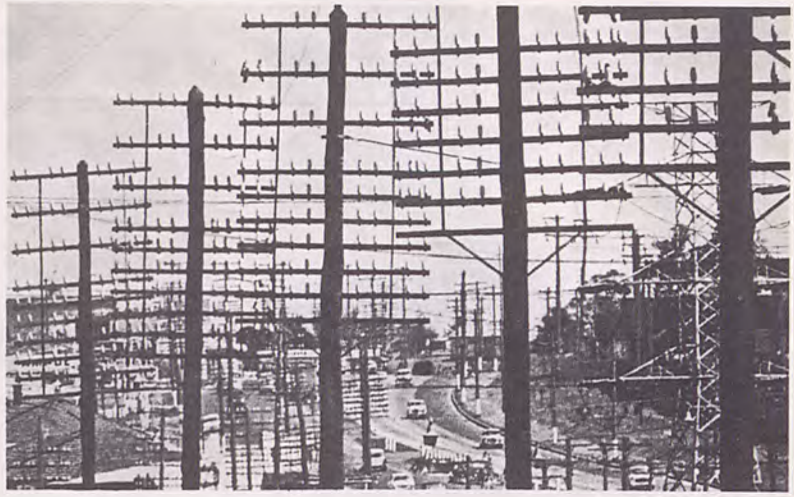
Today this state of affairs is slowly changing for two main reasons. Firstly "clients" are no longer mainly small private firms commissioning a new small office building or a factory—but instead are often enormous industrial or economic complexes. The works they commission are consequently much larger and often house several thousand people. There is, therefore, an obvious debt on the part of the engineer, (and indeed the architect though this somehow needs less justification) to these people, as well as directly to the commissioning clients. In other words, with the broadening of client size and nature there occurs, or should occur, a corresponding increase in social awareness of the engineer. This of course does not imply that on smaller works the engineer is exonerated from such responsibility.

The second reason is due to the development of new materials and techniques in both the architectural and the structural field. These have recently served to bridge the gap between the spheres of operation of the engineer and the architect and have accelerated the movement already mentioned above. It is noticeable that throughout the world wherever these new methods are being introduced, there is a new concern for aesthetic structures unfamiliar in other parts. It is then with these structures, materials and techniques of construction that the remainder of this article deals.

Modern practices in structural engineering began during the Industrial Revolution when the use of iron was first included with masonry in buildings. The first such case is generally regarded as a freak since it occurred in Alcobaca, Portugal, where cast iron columns were used to support a chimney. The inventiveness of the Industrial Revolution discovered methods for the industrial production of cast iron after about 1750. Structural uses for it were found in France in the 1770's and 1780's by Soufflot for the staircase of the Louvre and by Victor Louis in the Palais Royal in 1785-90. Then this new material spread to England where wrought iron and steel were developed. Towards the end of the nineteenth century, reinforced concrete appeared as an alternative.

However, the Modern Movement in architecture or International Style, as it is now known, did not grow from the single root of industrial and technological progress. The Arts and Crafts movement headed by William Morris was a primary source of the philosophy of modern design. This movement was a rebellion against the processes of mass production which flooded the market with cheap and rapidly produced goods.

The skilled craftsman found himself becoming redundant and reacted by returning to the Medieval ideal of simplicity of form and devotion to duty. The modern movement was now equipped with both the technical possibility and a philosophic ideal for self propagation.



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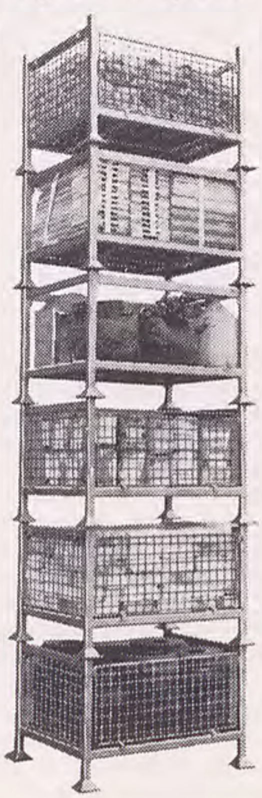

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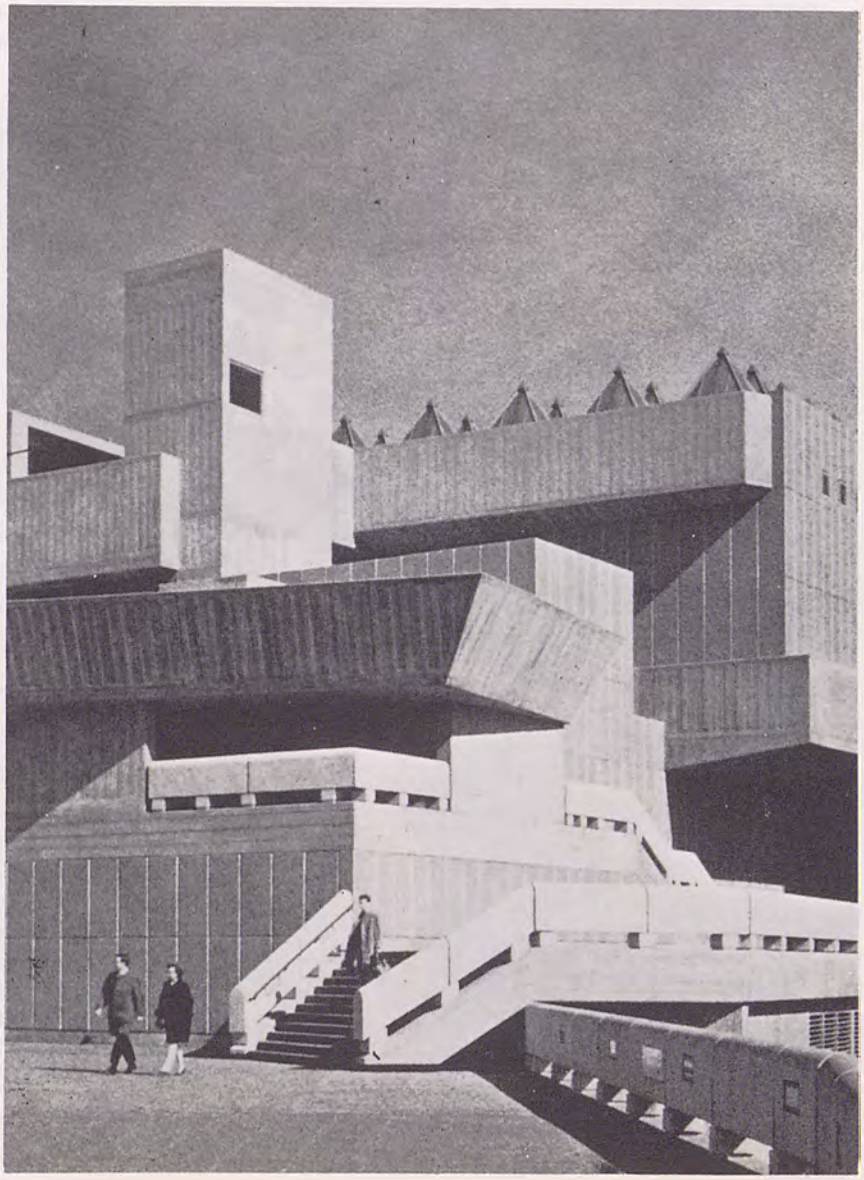
However, there was a third and final influence on the Modern Movement in architecture which occurred at the turn of the century. This was Art Nouveau. Art Nouveau was an ornamental, decorative and architectural craze based on the supple qualities of the curved line. It was also an anti-industrial movement, essentially romantic and anti-historicist. It was based on social theories and inspired by aesthetes such as Ruskin, Wild and William Morris, attempting to integrate art with social life. In practice and from the cultural point of view, it assumed the manner of a reactionary bourgeois movement aimed at renewing contact with nature and seeking to rehabilitate the tool as the "lengthener of the hand". It is important because at a time of the most prodigious industrial development, which saw the works of Eiffel, Contamin and Dutert and the the early Gropius, Art Nouveau kept painters, sculptors and architects at a respectable distance from the complex of technology. It enveigled them with a concern for virtuous craftsmanship rather than for machines and attempted to protect the quiet little dream worlds of Ruskin, Tolstoy, Dickens, Renan, Zola and many others.

Modern architectural concepts were first formulated in Germany by the Deutsche Werkbund—a group of architects and craftsmen who agreed to dedicate their work to the principle of "sachlichkeit" a word best translated as reasonableness and sound good sense. From this sprang our modern criteria of Functionalism and structural honesty. These precepts reach their ultimate expression in the glass box scryscrapers of Mies Van der Rohe and Thomas Hood. The Deutsche Werkbund led to the formation in Dessau, Germany in 1919 of the Bauhaus school of design, building and craftsmanship. Walter Gropius was elected as its head and it was he who first proposed that the architect should also be a craftsman. He felt that a building should be the result of teamwork by all participants in its construction, so that each is aware of the relation of his particular duty to the whole. The Bauhaus met with much criticism from conservative members of the community since it was associated with Socialism. The Nazis eventually closed it in 1933 and most of its members fled to either England or the United States. A corresponding movement in the United States had already gained momentum from the works of Louis Sullivan and Frank Lloyd Wright.

This in brief is the history of the Modern Movement in architecture. Because any form of human endeavour which strives to reflect man's relationship with the outside world is never static, this movement itself is undergoing gradual change. The most recognizable quarters for this change are in the United States and Britain where the new style beginning to emerge has been termed the "New Brutalism". It has given conscious form to a mood prevalent among younger architects in the 1950's which rebelled against the smugness of the elders who were able to build because they were well placed with the Establishment. Further anger had arisen because these young architects sensed a feeling of traditionalism in the concepts of Functionalism etc., which almost served to perpetuate itself. The Brutalists rebelled violently against Functionalism especially as they did not accept the maxim that—"If form followed function, does not efficient function automatically produce beautiful form?" The output of these literal functionalists is all around us today, for all to see. Every big American and Australian city is studded with office and apartment buildings designed—if that is the word—by some sort of automatic, "functional" process e.g. Skidmore, Owings and Merrill's computerized design process in the U.S.A. imitated on a smaller scale by Yuncken and Freeman in Australia. The exterior shape is determined by zoning laws; the exterior surface papered with curtain wall patterns picked out of a manufacturer's catalogue; the interior layout is determined by rental experts; the core by the stop watches of elevator specialists; the roof is designed by the cooling tower fabricators; and the lobby by the newspaper distributors. Result: chaos in the name of functionalism.

Brutalism, however, does not represent a radical departure from the now traditional Bauhaus conception of architecture. It is not comparable to the technological extremism of Buckminster Fuller, Eduardo Torroja, Pier Nervi or Felix Candela. These men are the proponents of the new 'architecture-engineering', where a revolutionary technical treatment is developed for structures of an entirely different type. It is with these methods that a new unity between engineers and architects is being achieved.



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The manufacturing activities of Mobil Oil Australia Ltd. are conducted by Petroleum Refineries (Australia) Pty. Ltd., which operates modern refineries at Altona, Victoria, and at Port Stanvac, South Australia. Each refinery processes crude oil from Middle East and Australian sources into a full range of petroleum products. The total investment in these refineries exceeds $160 million and there is a $26 million expansion proceeding at Altona.

Initially, a lubricating oil and bitumen refinery was built at Altona in 1946-49. During 1952-54, a new crude distillation unit and a catalytic cracking unit were installed. Since 1954, catalytic reforming, alkylation, catalytic desulphurization, bitumen oxidiser and sulphur recovery units have been constructed and crude oil distillation capacity has been expanded twice. The Altona capacity is now 65,000 barrels per day* and products include aviation and motor gasolines, jet fuels, diesel and furnace fuels, bitumens, LPG, refinery gas, petrochemical feedstock and sulphur. After completion of expansion the capacity will be 84,000 barrels per day.

The refinery at Port Stanvac in South Australia came on stream in February, 1963, processing naphtha-enriched crude oil. Processes include crude distillation, catalytic reforming, catalytic desulphurization, sulphur recovery, sulphur dioxide extraction, solvents fractionation, and bitumen oxidation. Its present capacity is 47,000 barrels per day of motor gasolines, illuminating and power kerosines, diesel and furnace fuels, bitumens, LPG and refinery gas, petroleum solvents and sulphur.

Work of the Graduate

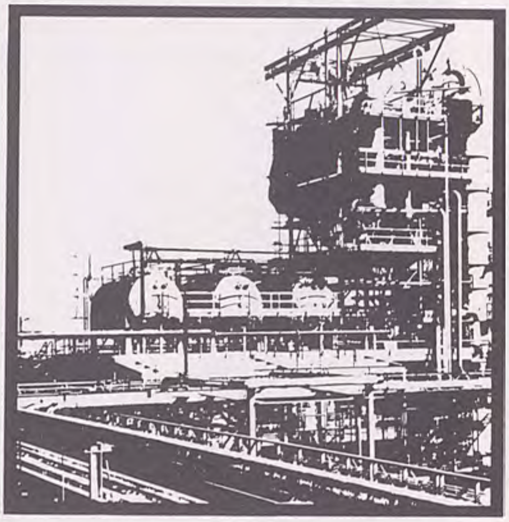
In both refineries, Process departments have engineering and science graduates responsible for the control and supervision of refinery operations. Technical services for operations are provided by engineers and chemists in the Technical departments. Plant engineering sections, comprising chemical and mechanical engineers, provide professional assistance in overcoming day-to-day process and equipment difficulties and in improving unit operations.

The development of new facilities and major modifications to existing facilities are handled by the project engineering sections, staffed by chemical and mechanical engineers. Mechanical engineers plan and supervise maintenance activities. Computers and operational research techniques are used extensively. A Central Technical Group of experienced refinery engineers assists in the use and development of computer techniques, and handles short-range operational planning and product supply problems, long range planning and special techniques studies.

Training

On appointment, the graduate takes a series of brief working assignments which provides an overall understanding of the major refinery departments. With this essential background he is then promoted to a regular Engineering position where his technical knowledge and professional skills will be developed fully.

The Company conducts an executive development programme, and the graduate is encouraged to take technical or business courses and may be assigned to Mobil affiliates overseas, including U.S.A., for further training and experience.



Type of Graduate Required

Chemical and Mechanical Engineers. You are invited to write or phone for a copy of our booklet "Career Opportunities for Engineers—1969".

Contact:

H. H. Scrivenor, 2 City Road, Melbourne, 3205. Telephone: 62 0231.

*1 barrel = 35 imperial gallons.

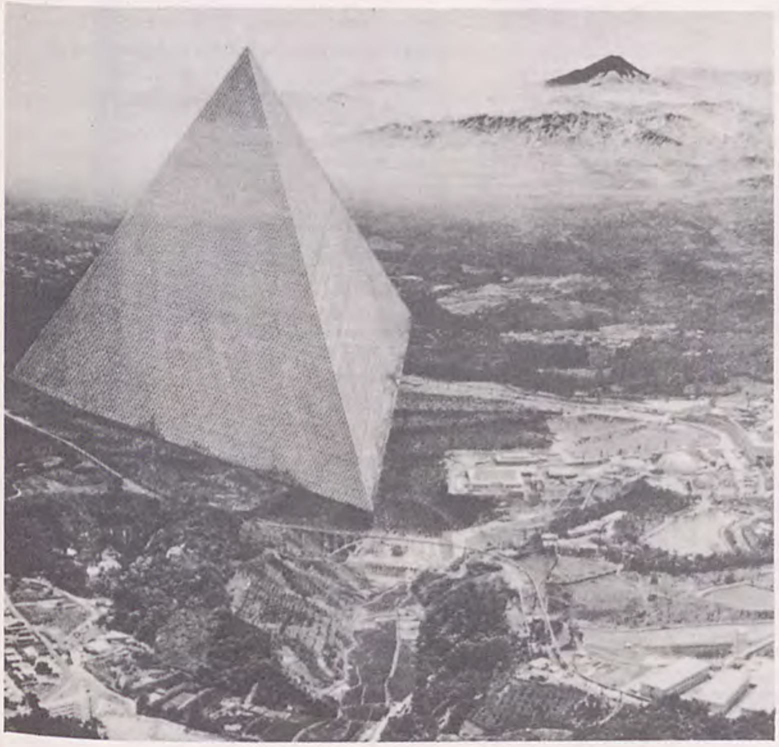
Petroleum Refineries (Australia) Pty. Ltd.

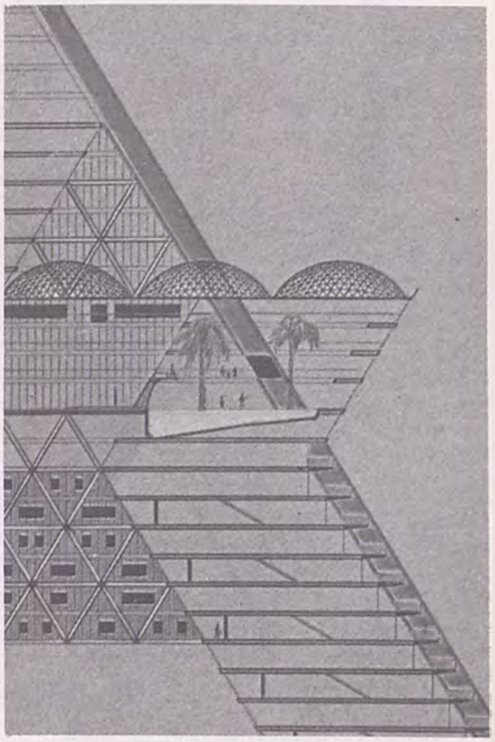
ME6913.38

The Structures of Buckminster Fuller

Buckminster Fuller was not an architect in the traditional sense of the word but rather an inventor whose creations reflect uniquely the twentieth century machine aesthetic. His first invention was the "Dymaxion House"—a kind of machine for living in., which is best considered as an assemblage of mechanical services in conjunction with living areas. His most important invention, though, was the Geodesic Dome—a structure of metal, plastic, or even cardboard based on octahedrons and tetrahedrons. The domical shape was used not for any traditional architectural reason, but simply because it allowed the enclosure of the maximum space with the minimum of surface area and hence material. The largest of these domes is at Baton Rouge, L.A., and is 384 ft. in diameter.

A further, more recent suggestion by Fuller has been the "city of the future", which is a visionary plan for a tetrahedral superbuilding housing up to 1,000,000 people.





The hyperbolic paraboloids and shell structures of Torroja, Candela and Nervi—design considerations for thin shells

Thin shells are usually employed to cover large floor areas and are designed to support:

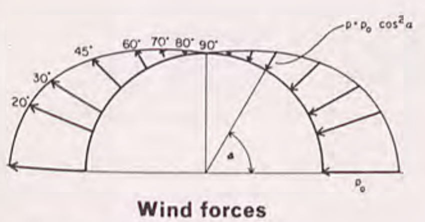
1. their own dead load,
2. a live load, commonly snow.
3. pressures and suctions due to wind,
4. concentrated loads due to special equipment.

Often so-called 'secondary stresses' are induced in thin shells by shrinkage of concrete, uneven foundation settlement, temperature differentials between various structural elements and by continuity between the shell and its supporting elements. Although these loading and stress conditions are considered in all structures, in shells these secondary stresses are frequently the determining factor in shell design. If all these considerations were rigorously attended to, shell design would be an almost insurmountable mathematical as well as engineering problem. Fundamentally, the considerations are simple.

Shell loads:

The dead load is estimated per unit area of sloping shell for a thin curved slab of reinforced concrete. The live load—usually snow load—is commonly assumed as a uniform load per unit area of horizontal shell projection. The wind load is important for large shells but can be neglected for small flat shells. When not flat the wind pressure is assumed to vary with the angle between the tangent to the shell and the horizontal, as shown in the diagram below; i.e. the wind becomes a perpendicular pressure on the windward side and a perpendicular suction on the leeward side.

The complete building must be checked against the tipping force of the wind and larger shells must be designed for under pressure, capable of blowing out the windows.



Wind forces

Shell Stresses:

For the analogous situation of a thin cable in equilibrium under its own weight, it can be simply shown the tension is directly proportional to the radius of curvature of the cable.

These are evaluated differently depending on the shell form. In cylinderical shells for example, consideration of an element with sides parallel and perpendicular to the cylindrical axis indicates that the stress per unit length is T=Z. R where R is the radius of curvature, and Z and Y lb./ft.² are the radial and tangential components of the load on the shell cross-section.

Membrane Stresses

A similar process of analysis is carried out for other shell forms where the meridonal force T and the parallel or Hoop stress T are related to the geometry of the shell and to the load distribution. (n.b. in our case above, the hoop stress was T).

Once the stresses are calculated, account must be made for the fact that membrane stresses may not be capable of sustaining the load around the edge because of conditions of support and constraint. For instance a hemispherical dome under action of its own weight on a circular wall support has a vertical T stress. This is balanced by the wall reaction and if the shell boundary is allowed to move freely outward due to load, stresses will be of the membrane type everywhere. If the angle is less than 90°, the horizontal reaction cannot be balanced by the vertical wall reaction, and bending stresses will be induced in the shell. However, these do not penetrate deeply inside the shell and remain localized near the support-shell boundary.

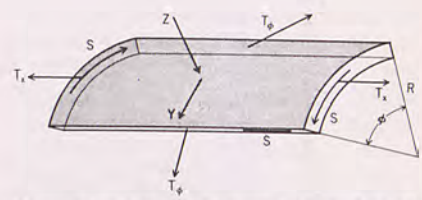
The Hyperbolic Paraboloids of Candela

Candela believes that the hyperbolic paraboloid is the easiest and most practical way to build. His Church San Antonio de las Huertas in Mexico consists of a system of three-groined vaults with no edge beams. The surface is developable by a system of linear generators and thus construction is facilitated.

The above structures are no doubt forerunners of a new architecture embodying for its survival, a new liaison with engineering. Their development constitutes a victory for the proponents of organic, coherent form as opposed to the piecemeal approach to construction in many modern buildings. Perhaps inherited concepts of functionalism and structural honesty will diminish in importance or emphasis, but one may rest assured that the great illuminaries of the International Style will still remain a driving force for the future. This may be either due to their intellectual clarity or their honest presentation, but they will continue to influence structural philosophy well into the future.

Tipping wind force

Wind underpressure



Membrane stresses in cylindrical shell

australian post office

The A.P.O. is the Commonwealth Government Department which provides and operates all public telecommunication and postal services throughout Australia and provides all transmission and relay facilities for the national broadcasting and television services.

The provision of these services involves the use of a wide variety of plant and equipment within the main categories of telephone and telegraph substation instruments and exchange equipment, long line (multi-channel) and radio bearer equipment, radio broadcasting and television transmitting plant and antenna systems, external line plant, underground cables, power plant, mail handling machinery and automotive plant. The engineering activity associated with all of this equipment is directed to the co-ordinated performance of such functions as planning, design, construction, installation, maintenance, research, and the provision of supporting engineering services.

The A.P.O. is Australia's largest business undertaking. In the Engineering Divisions there are approximately 1500 professional engineers and 45,000 other employees who are engaged on maintenance works costing over $100 million per annum and new works costing over $200 million per annum and there is every indication that expansion at this rate is likely to continue.

The principal projects in current programmes are concerned with the provision of large numbers of additional subscribers' services to meet continuing heavy demands, the provision of additional common control exchange equipment, extension of broadband trunk line facilities by means of coaxial cable and microwave radio systems, nationwide subscriber trunk dialling, additional television transmitters for the national network and the extension of mechanised and automatic mail handling facilities.

The Engineering Works Division and the Engineering Planning and Research Division of the Central Administration are located in Melbourne and are responsible for the determination of engineering policies, practices and standards relating to the installation, technical operation and maintenance of telecommunications plant, and for research and development, national network planning, plant design, planning of major projects and the technical aspects of works programming and plant purchasing.

The Engineering Division in each State Administration is responsible for the field operations. These include the detailed planning and design of network development and the technical direction and management of plant installation and maintenance activities in accordance with overall standards and policies determined by the Central Administration.

Work of the graduate

The A.P.O. offers a wide variety of engineering employment. Approximately 35% of A.P.O. Engineers are employed on Research Planning and Design work, the remainder being employed in the Installation, Maintenance and Services areas. Services activities include engineering management studies, training, automotive plant maintenance, workshops facilities, material acceptance testing and buildings engineering services.

A graduate may, for example, be appointed to a position concerned with research in a specialised field of communications engineering, or the design of equipment used in microwave radio, telephone switching systems, or external line plant. He may participate in the technical direction and management of plant installation projects.

Type of graduate required

The work of the Engineering Division of the A.P.O. is very diversified and there are opportunities for graduates and diplomates in electrical, mechanical and civil engineering and in allied disciplines. However the predominant requirement is for graduates and diplomates in electrical engineering particularly those who have specialised in electronic or communications engineering.

Contact

Mr. H. J. Gregory, 9 Spring Street, Melbourne, Victoria, 3000, Phone 630 7742, or Mr. R. W. Venning, 199 William Street, Melbourne, Vic. 3000, Phone 630 6462.

Anthony George Maldon Michell
1870 - 1959

"*In Hoc Signo*" pale nor dim
Lit the battle field for him,
And the crown he sought and won,
Was the prize for Duty done."
Anon. (1858)

Among the most able and gifted scholars who were associated with the University of Melbourne in the years around the turn of the century were the brothers Michell. The elder, John Henry, was a brilliant mathematician who wrote many outstanding papers in hydrodynamics and elasticity. He lectured at Melbourne from 1891 until 1928, occupying the Chair of Mathematics for the last six of those years. The younger brother, Anthony George Maldon Michell, has been described as Australia's most distinguished engineer. The Michell Hydraulic Laboratory in the Department of Civil Engineering is a permanent memorial to his name and fame. The bronze plaque in the entrance hall bears the following inscription:—

A graduate of this Engineering School he graced his country and university with his discoveries and yet he remained humble.

1870-1959
A. G. M. Michell
F.R.S., M.C.E., Watt Laureate
Engineer, Scientist, Inventor

The Michell Thrust Bearing, his greatest invention without which the great ships and water turbines of today would not be possible.

Since the centenary of the birth of this great Australian will occur next year it is fitting that a tribute to his memory should emanate from the Engineering School of his Alma Mater.

A. G. M. MICHELL

In the year 1854 a young married couple, John and Grace Michell, sailed from England to try their fortune on the Australian goldfields. They made their new home in the small but booming gold mining town on Maldon, at the foot of Mount Tarrengower some 100 miles to the north west of Melbourne. Both the Michells and the Rowses (Grace Michell's family) had been active in the mining industry in Cornwall and Devon since the beginning of the 19th century, so the young couple quickly became acclimatised in the Colony of Victoria in the heady atmosphere of the great gold rush which had begun in August 1851. In due course three daughters and a son were born to them. It seems that they prospered for in 1870 they were able to make a return visit of three years to their homeland. On the 21st June, 1870, at Islington, their last child was born and named after their adopted home town in Australia, Maldon, which incidentally has now been declared a National Trust Town.

Anthony George Maldon Michell returned with his parents to Maldon when he was 3 years old, and here the foundations of his education were laid, first at home with instructions in the rudiments of English and Arithmetic from his sisters and brother, and then at the Maldon State School where he was found to be very advanced for his years. The child's quick mind took note of the discussions between his father and other miners and he saw the simple mechanical apparatus used to win the gold. The engineer had already begun his apprenticeship.

In 1877 the Michell family moved to Melbourne and George attended the State School in Punt Road, South Yarra, where Geometry and Latin were added to the curriculum in lessons after school. At 14 he was enrolled at "Perse" Grammar School in Cambridge, having gone to England to join his brother who had now proceeded to Cambridge University. At Perse he studied Latin and Greek classics and Mathematics and completed his secondary education with, as usual, high honours. Proceeding then to Cambridge University he attended lectures on Physics and Chemistry, and the theory and practice of Mechanics at the new University Engineering School.

In 1890 he returned to Australia and enrolled for the courses of Architecture, Civil Engineering and Mining Engineering at the University of Melbourne. This ambitious programme was soon reduced to more manageable proportions by dropping architecture. In 1895 he took the Degree of Bachelor of Civil Engineering with first place in the list of honours, and completed the course in Mining Engineering with second place in the honours list. He proceeded to the Degree of Master of Civil Engineering in 1897.

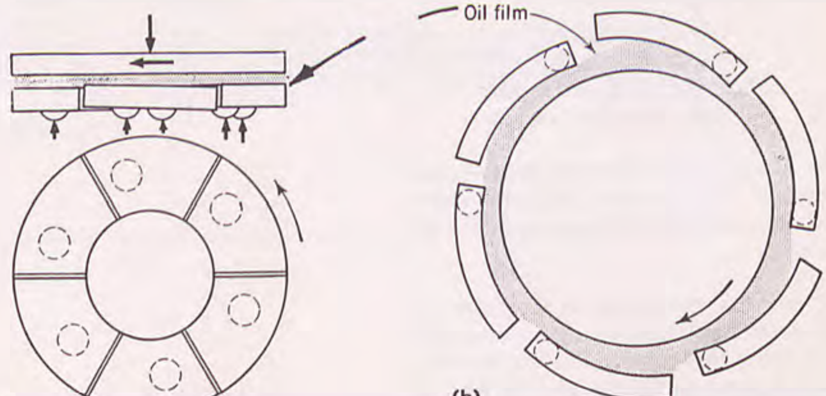
George Michell now entered the consulting engineering field, joining his former teacher in the Engineering School, Bernard A. Smith. This partnership resulted in the patenting of the Smith-Michell regenerative centrifugal pump in 1901. "In this pump the fluid issuing from the rotor impinges on a turbine wheel geared to the pump shaft, and, though at the expense of some mechanical complication, as much as three-quarters of the kinetic energy of the issuing fluid is utilized in helping drive the pump. Many pumps of large capacity were built and operated successfully on various irrigation schemes in Australia." He subsequently spent a year as examiner in the Victoria Patents Office, and in 1903 he opened his own consulting office. From this time he was in constant demand in connection with irrigation and hydro-electric schemes in Victoria and Tasmania and elsewhere in Australia.

An interesting comment in a letter written by Michell's friend and colleague Dr. J. G. Burnell, is worth quoting. "The first commercial application of the Michell thrust bearing was in 2/33″ vertical spindle centrifugal pumps, designed by Michell and built by Weymouth in 1907; these replaced older pumps at the Cohuna Headworks (their acceptance was one of my first responsibilities when I joined the Water Commission as Mechanical Engineer in 1908). At Nyah and Merbein 24″ Smith-Michell patent pumps were provided to deal with the 85 feet heads. Michell, George Weymouth and I made a number of visits to Koondrook, Swan Hill, Cohuna Headworks, Nyah and Merbein to carry out official trials of the new pumping plants. It was a great object lesson to me to observe how Michell used his mathematics and physics for the rapid solution of the practical problems encountered. He particularly enjoyed our visits to Mildura, where the great benefits—and dangers—of irrigation could be seen in concentrated form. Before it was cleared, the Merbein area adjoining Mildura had many handsome trees, particularly Murray pine and belah and flora of considerable variety; mallee, sandalwood, tobacco bush, wild cherry, quondong, needlewood and small grevilleas. All these were a source of interest and pleasure to Michell who had a considerable knowledge of the native flora."

In 1905 Michell's famous paper on the theory of lubrication was published in the *Zeitschrift fur Mathematik und Physik*. This has been described as mathematically remarkable and the only really important extension of Reynolds' theory yet effected. His findings enabled him to "invent the tilting pad, which automatically adjusts itself to the inclination appropriate to the load and speed, and he embodied it in his thrust-block bearing of 1905. Few inventions have provided so complete a solution of an engineering problem, and it belongs to that small class in which there is little scope left for further development."

Up till this time the question of the bearings for water turbines had been a troublesome one. The problem was to design a bearing to take an axial thrust along the shaft. Michell, working on Osborne Reynolds' theory of film lubrication publication published in 1886, evolved the solution of using pivoted bearing pads which would automatically tilt and provide the tapered film of lubricant essential in Reynolds' theory. Reynolds' theory was based on a series of experiments in lubrication by Beauchamp Tower, published in the Proceedings of the Institution of Mechanical Engineers, 1883 and 1885. He (Reynolds) used the findings to illustrate the phenomenon of lubrication in terms of the theory of the viscous flow of fluids, and "showed that under certain conditions the solid surfaces are completely separated from one another by fluid films of appreciable thickness and by the relative movement of the parts are enabled quite automatically to support the pressure imposed on them. A feature common to all the bearings to which the Reynolds theory can be applied is that the surfaces of the adjacent moving parts are slightly inclined to one another. In his mathematical analysis of the cylindrical journal and the inclined plane, Reynolds assumed infinite length and so, by avoiding leakage at the sides, simplified the problem"

Michell's innovation was accorded ready recognition in Australia, and his thrust bearing soon became historically famous as it was found to have application not only to water turbine, but also to marine propulsion. The fact that tremendously increased horsepower could now be transmitted by shafts with bearings designed on the new principle made possible the building of much larger ships, and during World War I (1914-18) many naval vessels used Michell's thrust bearing to great advantage.



(a) (b)

Basic sketches of:
(a) thrust bearing
(b) journal bearing.

Since then its use has become universal in the shipbuilding industry. One of the early Michell thrust bearings is on display in the Michell Laboratory.

Michell next set about improving the design of journal bearings, and the development of pivoted bearings, by the application of his tilting-pad principle, which he also applied a little later to his crankless engine. Although compact and most efficient, this invention did not gain the approval of manufacturers. Precision engineering to an unusual degree of exactitude was required, and the use of this invention was not found to be an economic proposition. However, some crankless engines were manufactured by Thompsons Pty. Ltd. of Castlemaine, and one was operated by the Metropolitan Gas Company in Melbourne. It would seem that Michell was reluctant to accept the economic failure of his crankless engine, to which he had devoted years of his life and tremendous effort. In the years 1925-33 he promoted his invention on a long tour overseas, during which he exhibited a small model to illustrate the principles of his engine, air being used as the lubricant between the adjacent faces. Unfortunately his efforts were largely abortive as well as being financially burdensome. Another of his inventions which, apparently for the same economic reason, has not been developed by manufacturers is the Michell water turbine although efficient and differently operated from other commercial turbines. A small model and one of several prototypes is housed in the Michell Laboratory.

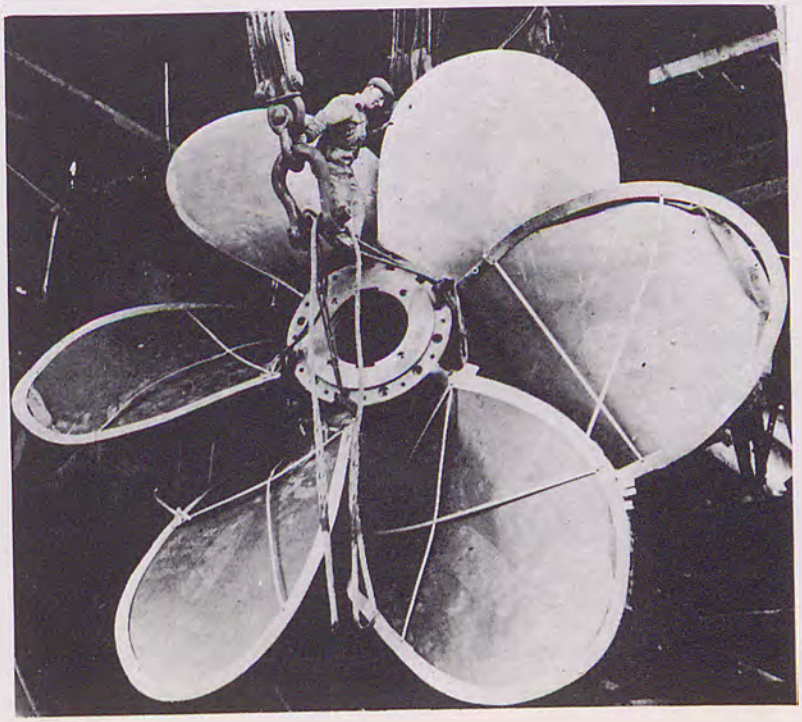
At this point in his career Michell joined his last partner, the late Mr. A. J. Seggell, who died in May 1961. This was undoubtedly a most harmonious partnership. Seggell, who was Michell's executor, had intended to write a biographical memoir of his illustrious partner, but unhappily no draft has been found of such a work.

An interesting result has recently flowed from a paper published by Michell in 1904 in the *Philosophical Magazine,* entitled "The limits of economy of material in frame structures". About 1950 this work was discovered and extended by aeronautical engineers, who found that the strain fields which he introduced have affinity with plastic flow fields.

The above discussion of necessity touches only briefly on the great volume of work, both theoretical and practical, accomplished by Michell. It is hoped that it will give some idea of his remarkable intuitive powers in his approach to problems of mechanical engineering. It seems fair to suggest that the mathematical genius of his brother, with whom he shared his home over many years and whom he greatly admired, probably made a significant contribution to the success of his ideas and inventions.

It is good to know that his work was honoured by his peers in his lifetime. In 1934 he was elected to the Royal Society, an honour which pleased and moved him deeply, particularly as 32 years earlier his brother had been elected to the Fellowship for his work in Mathematics. In 1938 he was awarded the Kernot Medal of the University of Melbourne for distinguished engineering achievement in Australia. On the 22nd January, 1943, the Institution of Mechanical Engineers conferred on Michell the highest honour which it was in their power to award. *Inter alia* the citation for the award of the James Watt International Medal read: "I commend to you Anthony George Maldon Michell as one who, because of his international reputation as a mechanical engineer and the ability which he has displayed in applying science to the progress of engineering, is eminently worthy of the highest honour which it is in the power of the Institution to award, the James Watt International Medal."

In his professional and personal life George Michell adhered to rigorous standards of excellence. A shy man, he did not marry, and made few close personal friends. Among those who did know him well and cherished his friendship were Professor T. H. Laby, F.R.S., Dr. J. G. Burnell, then an Engineer with the Victorian State Rivers and Water Supply Commission, Sir Walter Bassett, the well-known engineering consultant, Lord Casey of Berwick, and his partners B. A. Smith and A. W. Seggell. With these people he was at ease and enjoyed discussing matters of moment—he had no interest in small talk and despised humbug.



One of the four 32 ton propellers for Queen Elizabeth II.
Thrust developed by these propellers, to the order of a half million lbs., is supported by Michell thrust bearings.

He was an energetic walker, which stood him in good stead in rough terrain in Victoria and Tasmania when visiting engineering work sites. During his school and university days in England walking had constituted his main recreation, and he walked hundreds of miles seeking out mediaeval cathedrals to admire and sketch. He had a considerable knowledge and love of botany and horticulture. In 1911 he acquired his forest-farm, "Ruramihi", at Bunyip, 50 miles from Melbourne, which he protected as a sanctuary for indigenous plant and animal life. In this peaceful atmosphere his spiritual and creative life flourished unimpeded by the stresses of the commercial world. The same tranquil climate was achieved in his home in Prospect Hill Road, Camberwell shared by his brother and sisters while they lived. This house, built on a large corner site, was noted for its unusual garden of tropical trees, palms and shrubs, with exotic fruit trees—cumquat, guava, feijoa, and an enormous mulberry tree around which he constructed a cage to preserve the fruit from marauding birds. In the quiet of his two homes he enjoyed the pursuit of French and English literature, and occasionally composed English verse.

In his excellent biographical memoir, written for The Royal Society, the late Professor Sir Thomas Cherry gives this apt description: "Michell emerges as a man of firm principle, precise thought and expression, and considerable reticence; but something must be added to the picture. The mental characteristic in which he was outstanding was his combination of disciplined intellectual power with inventiveness in the spheres both of physical things and of ideas; for example, his viscometer was described by Andrew Robertson (on the occasion when his James Watt International Medal was presented) as a typical Michell invention: a mathematical analysis, and then a clever device to effect the desired end." This is consonant with his motto, taken from Leonardo da Vinci: "Theory is the captain, practice the soldiers."

A full and notable life came to its close at his home in Melbourne on 17th February, 1959—88 years given in the service of mankind.

Margaret M. Nevill.
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Acknowledgements:
I am indebted to Dr. J. D. Lawson, Reader in Hydraulics, for help and advice on the technical content of this article, and to Mr. Adrian Seggell, son of the late A. J. Seggell, for assistance on some of the personal aspects.

Recourse was had to the biographical memoirs of T. M. Cherry and to the Institution of Mechanical Engineers' publication of the Award of the James Watt International Medal to Mr. A. G. M. Michell, F.R.S., 22nd January, 1943.

Engineering School 1901

A SUITABLE CASE FOR TREATMENT

geoff hjorth

The whole plan came to him very quickly, and he looked up from the log book leaving an expectant space in the "Speed—r.p.m." column. He looked briefly around the lab., then leant forward and pressed the button.

The bang came sooner and louder than he expected. The machine shuddered, began smoking, slowed to nothing, turned twice in reverse and then stopped: still smoking.

The demonstrator ran up and looked in horror at the machine. Gabriel picked up his log book and shook off a few pieces of ash that had settled on it; he looked at the demonstrator. The demonstrator looked at the machine. During the silence that followed, Gabriel picked up his slide rule and folder and put them in his bag. The demonstrator looked at the machine.

Finally without taking his eyes away, the demonstrator said:

"What in God's name have you done?"

"Well, actually, I thought you'd have a better idea of that than I have".

"You've wrecked it!" his voice was squeaking more than usual.

"Yes, I suppose I have".

Slowly and with trepidation, the demonstrator turned from the machine —whose oil was forming a growing black pool on the floor—and faced the perpetrator of the crime.

"But you've wrecked it!" squeak squeak.

"Mmm. I had an idea that would happen".

The Senior Demonstrator busily made his way through the crowd which had quietly gathered. He looked briskly at the machine and turned to the demonstrator.

"How did this happen?" he asked.

"He, he pressed the FUEL INTAKE!" the demonstrator gurgled, pointing a shaking finger at Gabriel. Gabriel moved forward to pick up his bag and the demonstrator recoiled, almost falling backwards over the machine.

"You come with me;" the Senior Demonstrator motioned to Gabriel and a reverential path, in the direction of the Senior Demonstrator's office, opened in the crowd.

The Senior Demonstrator was terse:

"How did you come to push the Fuel Intake button?"

"Well I leant forward slightly, and extended my right arm, and with the forefinger of my right hand I applied pressure to the button marked 'Fuel Intake' . . ."

"You what?" he said, slightly incredulous.

"Ah, it might have been my thumb; but it was definitely my right hand."

"But hadn't you been warned about what would happen?"

"Oh yes!"

"And didn't you see the big red warning sign below the switch?"

"Yes I saw that too."

"So you knew exactly what was going to happen?" now completely incredulous.

"Well I wasn't quite sure. But as it turned out the idea I had was pretty close to what actually happened"; he smiled appealingly.

Suddenly the Senior Demonstrator felt incompetant. He looked bleakly at the desk for a moment and then reached for his phone. He dialled and paused:

"Hullo Eric, Bill here. Look I've got Gabriel Smythe here. He's doing final year."

"Yes I know him, is he hurt or something?"

"No, not exactly. Er, as a matter of fact, he-er-just blew up the Rover."

"He what!" replied Eric, whose baby had been, until five minutes ago, the Rover.

"Well he shut it off and then reopened the fuel intake", he paused. "And it-er-blew up." He paused again. "Of-course" There was a long pause and then Eric said plaintively:

"Why?"

"Well that's the hard part Eric. It doesn't seem to have been negligence, it seems as though he actually wanted to do it."

Throughout the conversation Gabriel sat in apparently perfect composure, and the Senior Demonstrator looked sometimes nervously at the desk and sometimes nervously at Gabriel.

"What do you mean 'wanted to'? I know the lad, he's a perfect student. He couldn't possibly want to even if he wanted to!"

"Yes Eric, I know; but that seems to be the way. I think that you should have a talk with him".

"But it sounds as if he's gone off. You know, cracked under the strain. Or something. Anyway it doesn't sound like my job to talk to him."

"Well Eric," said Bill, who was, after all, only a Senior Demonstrator and didn't feel at all happy about the thought of consulting the Professor direct, "it's your subject you know".

"Just because I lecture in Thermo doesn't mean I have to take responsibility for some bloke going off his head in your lab!"

"I'm not suggesting that you take responsibility Eric. I just thought that you were the next person who should see him. Perhaps we should send him straight to the Prof."

"Ar—no. I wouldn't like to do that without speaking to him first. Send him up now will you Bill."

"Right Eric."

He turned, a little stronger now that the matter was foreseeably out of his hands, and said with precarious sternness:

"Dr. Johnston wishes to see you. Right now".

"Thanks very much Mr. Anderson", said Gabriel, and smiling politely he rose and left the office.

He knocked on the door marked "Dr. Johnston" and waited as he had done on a number of occasions.

"In!"

He entered the office and could immediately see that Dr. Johnston was in no way sure about how to greet his top student just turned baby killer. Dr. Johnston stood up, coughed, and then sat down. Gabriel walked in and stood in front of the visitor's chair and waited expectantly.

"Yes, yes, sit down".

He looked long at Gabriel and said:

"How did this happen Gabriel?"

"Well I shut off the fuel supply to the turbine and then as it was losing speed . . . ."

"Yes, yes, I know that. But what made you *do* it".

"Well Doctor, I'm not sure really. think I wanted to see if what the demonstrator was telling us would happen, would in fact happen. You see when the demonstrator was warning us against the danger he didn't seem to be taking the possibility too seriously. So I got to wondering if he'd really thought it out. As it turned out, his prediction was amazingly accurate".

A long silence was broken by Gabriel who said:

"No, I don't think that's the real reason. I think that's just a peripheral reason. The real reason was that I wanted to press the button".

This time the lecturer broke the silence:

"You realize how serious this is, don't you?"

"Oh yes; quite serious"

Yes very".

"Very Serious".

The lecturer picked up his phone and dialled.

"Hullo Mrs. Hammond, Doctor Johnston here. Is the Professor in?"

"Yes Doctor, hold the line please".

"Hulloo".

"Hullo John, Eric here. There's a chap in my office here who has just purposely blown up the Rover".

"Good Lord! Purposely you say?"

"Yes."

"Who is he?"

"Gabriel Smythe."

"No! That's incredible!"

"That's right. I thought you'd better see him".

"Well, I don't know Eric", the Professor said thoughtfully. "Does he seem O.K.? I mean he's not apparently—er—disturbed or anything is he?"

"No he seems fine".

"Well there must be something amiss with him. I know that he wouldn't normally damage anything. I mean, I think we'll have to get him to see a psychiatrist. I'm just not sure what I should do about this. I can't see that my interviewing the boy will be of any value".

"Well John, I can't recall a case like this before. Perhaps this should go straight to the Dean."

"Yes, well I suppose I'd better see him before that happens. Get him to come and see me tomorrow morning at nine will you Eric?"

"Right John".

Dr. Johnston replaced the 'phone and turned to Gabriel;

"Could you manage to see the Professor tomorrow at nine Gabriel?". he he asked pleasantly.

"Yes Doctor, that will be fine".

At 9.00 the following day Gabriel was admitted to the Professor's office.

"Please sit down Gabriel", the Professor said gesturing towards a chair. When Gabriel was seated the Professor sat down.

"Tell me Gabriel, how has the year been going?"

"Oh, quite well thanks Professor".

"Very hard year, final, don't you think?"

"Not really; I mean I think that third year was harder".

"Ah yes. Well I imagine that depends on how much work you're doing. I suppose you're going flat out at the moment eh?"

"Not really Professor, I'm just working at my usual rate".

"Oh well, that's good to hear", he smiled strangely.

He paused and shifted uncomfortably in his chair.

"Ah, about this business yesterday, I've spoken to the Dean about this".

He coughed nervously. "It's not everyday that we lose a $50,000 turbine is it?" he smiled thinly.

"Anyway, the Dean says that he'd be most obliged if you could pop in and have a word with him as soon as you've seen me. Would that be alright? Good. Well then I'll get on the blower and let him know that you're on your way up"

The Professor rose and showed Gabriel to the door and with just perceptible hesitation offered his hand which Gabriel shook firmly. As soon as the door was closed the Professor heaved a sigh, and then made for the phone.

The Dean opened the door and grinned broadly:

"Ah Mr. Smythe. So glad you could drop in". Gabriel shook the warmly proffered hand.

"Please sit down Mr. Smythe", the Dean indicated a chair and Gabriel sat. The Dean sat down in the other visitor's chair which faced Gabriel. From the box on his desk the Dean offered Gabriel a cigarette which he refused.

"You don't mind if I do?" the Dean asked smilingly.

"No sir, not at all".

In silence the Dean tapped his cigarette on his lighter, slowly placed it in his mouth and then lit it. After he had sat back and drawn and exhaled a lungfull of smoke he said:

"You know Mr. Smythe, there are a Dickens of a lot of pressures in modern living. Don't you think?"

"Yes, I suppose that's true sir".

"Yes, I think there are, particularly for the student". Pause. "Tell me Mr. Smythe how are things at home?"

"How do you mean sir?"

"Oh you know, how are the parents, and the family?"

"Oh they're all fine".

"Oh that's good", he said enthusiastically and paused.

"I've found that a lot of students have trouble reconciling their social lives with their studies. You know, the old question of priorities. Do you find any trouble in this regard?"

"No sir, not really".

"Oh well that is good", another pause.

"Look, I've made an appointment for you to see Dr. Albert. He's the University Psychiatrist. You know psychiatrists can be tremendously helpful at letting us know more about ourselves. I often think that a lot more people should have a friendly chat with a psychiatrist. And we think you may have been working too hard so it would be a good idea if you took the rest of the week off from lectures. You don't mind do you?"

"No sir, not at all".

"And you will get along and see Dr. Albert won't you?" He handed Gabriel a card.

"Yes sir."

"I feel sure that Dr. Albert is going to say that you need a bit of a rest". He rose. "Well I won't hold you up any longer; can you come in and see me next Monday at say ten?"

"Yes sir".

"Good, I'll look forward to seeing you next Monday then. Cheerio Mr. Smythe". and again they shook hands.

Gabriel saw the University Psychiatrist four times that week and had long chats and ink blot tests with him. On the following Monday he reported back to the Dean with a certificate from Dr. Albert saying that it was his (Dr. Albert's) opionion that "Mr. Smythe is fit to resume attendance at lectures and practical work".

Gabriel continued to see the psychiatrist, once a week, for the remainder of the academic year.

Eleven months later Gabriel Smythe B.E. (Mech.) sat in front of the desk of the Medical Corps Captain who was completing his Medical Examination for National Service Trainees.

"Not much more to go Mr. Smythe, just a bit of background. Have you any medical history of Asthma?" the Captain asked,

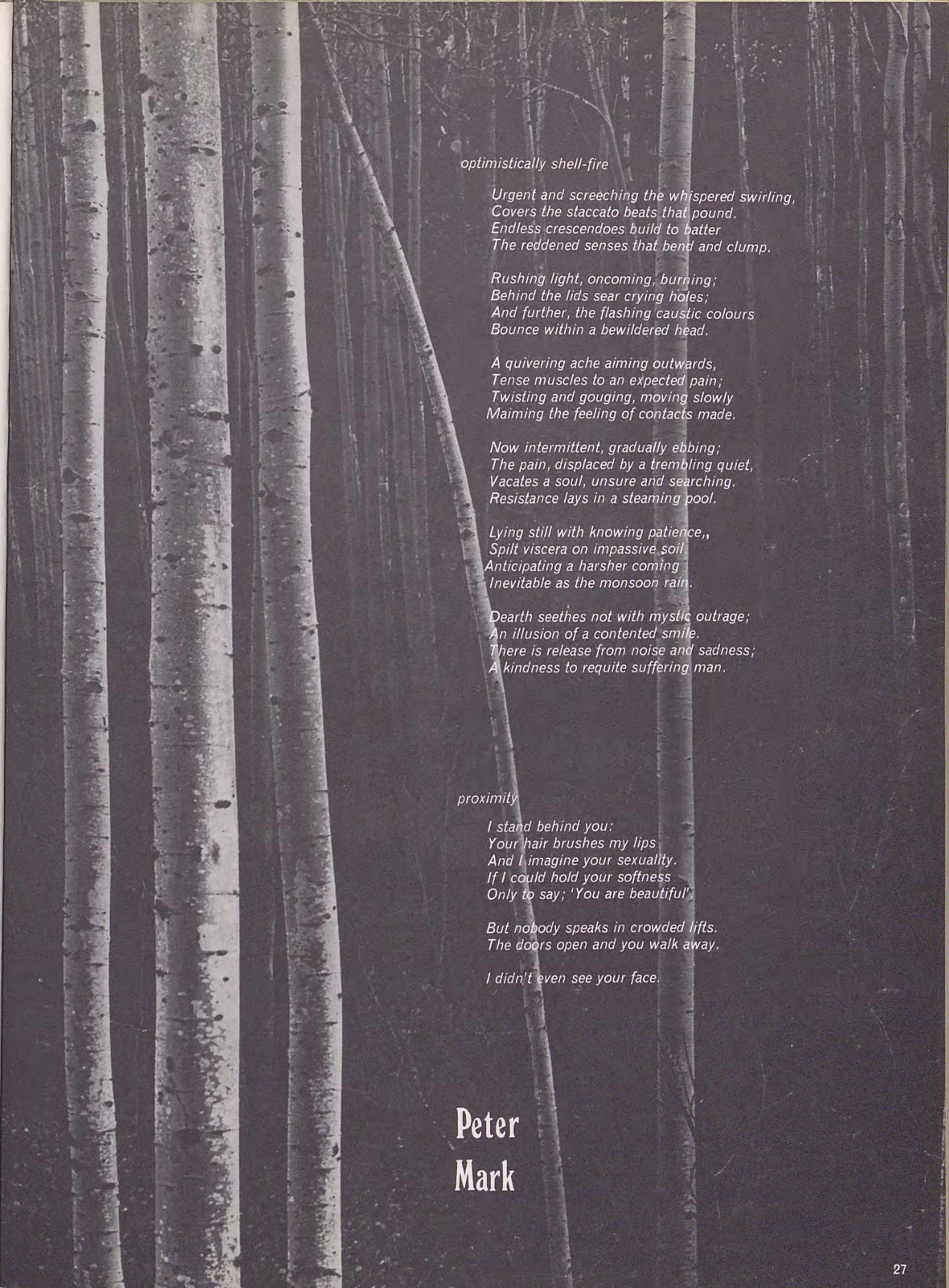
"No".

"Any history of Epilepsy?"

"No".

"Any history of Psychiatric Illness?"

"Well as a matter of fact . . . " said Gabriel and his left hand moved to his inside coat pocket.



optimistically shell-fire

Urgent and screeching the whispered swirling,
Covers the staccato beats that pound.
Endless crescendoes build to batter
The reddened senses that bend and clump.

Rushing light, oncoming, burning;
Behind the lids sear crying holes;
And further, the flashing caustic colours
Bounce within a bewildered head.

A quivering ache aiming outwards,
Tense muscles to an expected pain;
Twisting and gouging, moving slowly
Maiming the feeling of contacts made.

Now intermittent, gradually ebbing;
The pain, displaced by a trembling quiet,
Vacates a soul, unsure and searching.
Resistance lays in a steaming pool.

Lying still with knowing patience,,
Spilt viscera on impassive soil.
Anticipating a harsher coming
Inevitable as the monsoon rain.

Dearth seethes not with mystic outrage;
An illusion of a contented smile.
There is release from noise and sadness;
A kindness to requite suffering man.

proximity

I stand behind you:
Your hair brushes my lips
And I imagine your sexuality.
If I could hold your softness
Only to say; 'You are beautiful'.

But nobody speaks in crowded lifts.
The doors open and you walk away.

I didn't even see your face.

Peter Mark

EXAMINATIONS in a Social and Educational Context

Julian Pop

In Cranks & Nuts 1968 *Mrs. Barbara Falk, in her article on Student Evaluation of University Teaching, outlined some of the difficulties facing any objective rating or means of improving, the teaching of various subjects within the University.*

We asked Julian Pop to look at the various forms of examinations and evaluative procedures with the aim of furthering the argument of the previous Editors. We are concerned about the attitude to student evaluation, especially in the earlier years of the Engineering Course, of the Staff of the Engineering School, and this outline of examinations in their educational and social perspective may provide some beginnings for further thought and practical action.

In order to justify the existence of examinations in other than the psychologists' terms of 'Stroking' and satisfaction', we must ultimately view this evaluation process within the context of prevailing social requirements. Methods of evaluation, of which examinations comprise but a small portion, play the part they do today because of the great changes which have taken place in the nature, values and requirements of social life during the last century. These changes have initiated a massive sub-culture of technology, the limits of which nobody at present, can foresee. Since society may change even more rapidly in the future and since the innate differences in human beings will remain, some form of testing and guidance will be essential for its progress.

If the role of engineering is to use science and technology for the benefit of mankind then society has an obligation to ensure that the knowledge that engineering accumulates is not only correct but that the agents effecting this knowledge reach a minimum level of qualification. By the use of examinations, through the institutions of University and Technical College, it can protect its welfare by regulating entrance into the skilled professions and occupations.

The fact of the presence of examinations within society can be seen in the considerable part they play in determining the occupational grouping of individuals. Their influence is greater than what appears on the surface for the strictures of their operation increases with the importance of the occupation concerned.

Assuming that examinations serve a purpose, it remains to be defined firstly, to which uses may they be legitimately put and secondly how can they be made adequate instruments to this end? This, unfortunately, is the domain of the Educationalists and not of the aspiring engineer. What can be done however is a review of some of their work; the main purpose of the following discussion.

The important features that any examination system must contain to be effective appear to be as follows:
1. relevance to course objectives;
2. appropriateness in marking.
3. impartiality;
4. consistency and,
5. interpretability.

The first feature necessitates the discussion of the status and relevance of evaluation procedures in education. At present examinations are used to:
(a) assess the level of skill or knowledge attained by a student;
(b) predict the likelihood of success in the future;
(c) as an incentive to study; and
(d) as an educational tool, feeding back information about the course to both student and teacher.

The policy regarding examinations will be modified as the educational goals are changed. For instance if it is thought that the important goals are those that emphasise attitudes and 'frames of mind' rather than the procurement of skills and 'means of doing'. The relationship between the educational objectives, learning processes and evaluation could possibly be viewed as in fig. 1. A diagram of this type cannot hope to display the subtleties and richness of the interchanges between the different areas.

As indicated by Cunningham[2]; "Examinations dictate, to a large extent at least, the forms of knowledge and skill to be acquired by all young people. Their influence is greatest at the most impressionable age of development; the stage where interests and habits are crystallizing into the forms which they are likely to maintain throughout life."

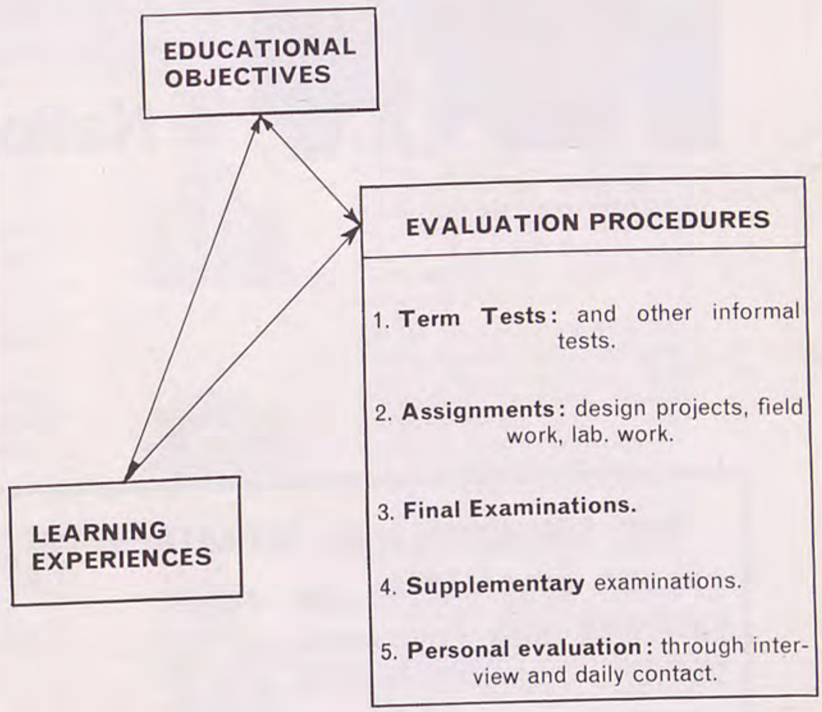


fig. 1.

APPENDIX 1

The number of alternatives available to the examiner in his attempts to assess a student's factual knowledge, skill and understanding, as discussed previously is not large. The alternatives are summarised below;

AIM
Certainty of Decision

Examination A
Single Task, X% of group right.

Examination B
Several Tasks at X% Rel.
Similar Content
High Intercorrelation

AIM
Comprehensive Sampling of Subject Matter at X% Rel.

Examination C
Several Tasks at X% Rel.
Diverse Content
Moderate Intercorrelation
'Comprehensive Skill' assumed.

AIM
Comprehensive sampling at x, y, z % Rel

Examination D
Three Groups of tasks of test C.
Type at x, y, z, % Rel.
In addition, uniformity of characteristic over a range of difficulty (complexity) is assumed.

Examinations A, B

Examinations of type A are characterised by the single task resulting in a "yes", "no" or "true", "false" answer. The index of performance in this case is the single Pass/Fail criterion.

When a number of examinations of type A are used to assess a student examination type B results. It becomes more difficult to decide whether a student has passed or failed since it is uncertain at what level the number of correct answers becomes "significant" enough to warrant a "pass". Examination type B affords some measure of the students' consistency in answering questions of this type. In practice the difficulty of the "tasks" to be carried out varies.

Examination C.

Examinations of type C attempt to cover a comprehensive sampling of the subject matter in the course. The index of performance here is uncertain because of the diversity of the skills required in answering the questions. Where diversity of materials and skills characterises the examination task, an index of a student's performance expressed as a proportion of success to total number of tasks is of doubtful meaning unless some comprehensive skill is "postulated". It is therefore often very difficult to know what a total of the students' marks in a number of varied subjects really means. This type of examination assumes that the subtasks provided the same stimulus for each student so that each task demands the same method of attack and solution from every examinee.

Examination D.

An examination of this type seeks to establish the proportion of students passing the task at a selected crucial difficulty level of say 40, 50 or 80%. If the examiner wants to increase the statistical certainty of this assessment, he may, say, treble the number of tasks at each level. The difficulty in this approach lies in that uniformity of the characteristics which the examination seeks to measure cannot be safely assumed even if it were possible to have similar content at one level. The response by examiners differ not only along a quantitative scale but also in terms of quality so that the above quantitative model is not a fully satisfactory description of reality. This of course is realised by examiners and is one of the reasons why examinations are not the only means used to assess a students capabilities.

APPENDIX 2

The indices most commonly used in the numerical assessment of examinees for exams composed of tasks graded in difficulty are:

1. A simple description — weights, norms.
2. The most difficult task successfully completed.
3. A count of successes.
4. A count of successes beyond an economic level until a criterion of failure is reached, and
5. Other indices, e.g. count of wrong answers.

Index (1)—the simple approach—is usually a weighted average. Weights are assigned arbitarily to different "difficulty levels", which may be an entire or part of a question. The sum of the scores so obtained is added up to obtain an assessment of the student's ability as a particular task.

If the relative performance of the candidate is required a cumulative or normalised cumulate frequency distribution of the performance of a group of students (with respect to certain attributes) can be compiled so that an individual student may be related to the proportion of a group of students succeeding in the task. The difficulty inherent in this approach is that the weights are arbitrary and hence vary from marker to marker.

Index (2) uses the most difficult task in which a person succeeds as the measure of student performance. Difficulties arise when trying to relate individual performances to group performance on this basis since it cannot be fully assumed that the individual student will succeed on all tasks less difficult that the most difficult yet successful tasks and that his failures below these are 'errors of measurement'. Students who get most questions in an examination correct may not always get the most difficult task, as defined by group performance correct.

Index (3) is the most common in use. It involves simply counting the number of students' successes at several tasks, irrespective of the fact that the task may vary in the proportions of a group in them. This view assumes that the units of score obtained by answering 'easy' tasks are equivalent to those obtained by answering difficult ones.

This works better in practice than may first appear since students achieving high scores tend to be the only ones succeeding on the difficult tasks as long as the content of the examination is not too diverse.

Index (4) is in fact a combination of (1), (2). and (3). Successes are counted from a chosen level to a point of diminishing returns. It is evident that the more comprehensive the examination content is in its sampling of abilities the less justified is the view that failures, below the most difficult success a student achieves, are errors in the assessment process. A comprehensive examination would contain appropriate verbal, numerical and figural content. It would be unwise to conclude from the observation that if a student was able to pass a verbal task at a certain level of difficulty he could also pass tasks of numerical and figural content of the same difficulty. If an examination is designed to measure skills over several grades it can reasonably be expected that students will be competant at skills appropriate to two or three grades lower. This position is that of assuming an 'economic' level of competence and marking consists of a count of successes from this level until some pre-elected number of successive failures is recorded.

Index (5) contains other appropriate means of assessment of minor importance.

Unless examinations are closely interrelated with the objectives, instructional methods and materials of the curriculum examining and instruction methods work in opposition to each other. The close relationship between examination development and educational processes necessarily means that with every major change in view there has to be a change in the field covered by the examination in order that it maintains its social significance. If the objective of a course is to develop understanding, an examination based upon information recall will be clearly in appropriate as a measure of the students ability at understanding. Although information is a prerequisite to understanding it cannot be taken as sufficient evidence that understanding also exists.

In preparing for examinations students will generally concentrate their efforts on those parts of the course and those particular kinds of learning (be they recall, understanding, analysis, synthesis, judgement or application) which will most affect their chances of success in the examination. A crisis arises when examiners see different parts of the course as more important and weigh them accordingly in their marking scheme.

The types of examination available to the examiners are summarised in Appendix 1.

Since no examination can hope to reproduce the actual conditions of learning and of professional work the results so obtained will always be open to interpretation as to their meaning and significance in predicting the success or otherwise of the candidate.

The 'indices' used in assessing student performance in an examination are set out in Appendix 2.

There appears to be two distinct views in assessing the performance of the individual as follows:

1. The **absolute** view, where the examiner is not interested where the student stands relative to other students within his year or class. He is primarily interested in discovering how much the

student knows, understands and is able to apply. When taking this absolute view an examiner can at best only sample ideas and abilities he feels are relevant to the main purposes of his course. This type is usually graded in difficulty; some questions appearing that only the best students can answer and others that all but the poorest can attempt. The weight that determines the grade of each question must necessarily be chosen at the time of setting of the question.

2. The **relative** view which assumes that the level of ability is the same from year to year and any assessment made is relative to other students within the year. The examinations set tend to be highly discriminatory in an attempt to maximise the range of scores from highest to lowest. Difficulties arise when an apparently important part of the course does not discriminate between students of high and low achievement. For this reason the examiner who also may be the teacher, can never (without an intensive study of item statistics) know exactly what is being measured. He can only assume that the total score is relevant to his course objectives.

In both the above views the problem appears to be one of the definition of skill, which in the last analysis rests on a discussion as to how specific a skill can become before it lacks meaning.[4] For the sake of both practical and educational convenience an 'index of performance' is assumed to be meaningful, and that this index is such that one student is assessed in terms of the same 'dimensions' as another and that these dimensions do not vary from one occasion to another.

There must be some degree of comprehensiveness in an examination task for a result to be meaningful but for the same end it must be sufficiently specific. The final compromise depends on the objectives of the examiner. Information used in student evaluation (see 6) is in general, not available equally for each student. There is a bias towards the best and poorest members of the class and to those who are naturally aggressive.[4]

In evaluating student performance the examiner assumes that he is measuring student abilities which are lasting characteristics and not unique to a certain test or observation. These abilities are then assumed to be consistently observable. Educationalists usually speak in terms of 'reliability', meaning the degree of consistency in the final assessment made by an examination with respect to the variables;

1. examiner variation,
2. time, and
3. variation in examination content.

In terms of the **absolute** and **relative** views discussed previously, both procedures attempt to equate a given level of achievement with a certain mark, regardless of the particular time or group involved. In courses where the content and evaluation procedures are quite stable it has been found that the Absolute mark is quite reliable. In groups where course content or teaching methods vary, but student abilities are reasonably constant from one term to another, the Relative view proves more reliable.[4]

Reliability becomes important when predictions of success in other examinations or succeeding years, or in engineering as a profession are made. Reliability of examinations is, however, more conceptual than real, for students generally do not sit for a statistically significant number of examinations in the one subject for any valid conclusions to be drawn.

We come finally to the uses of examination results and more particularly to point out that any result derived from examinations should have a recognised meaning among the potential users.

Since Deans, Registrars, scholarship committees and potential employers all draw heavily upon records of academic achievement in making their various decisions, any evaluation should as close as possible reflect the true state of affairs. An evaluation will therefore only be good or bad to the extent that it conveys the judgements that its users intend it to reflect.

To briefly recall what has gone before: We have looked at the role of examinations in both the social and educational context and enumerated the features which an effective examination system should contain. The type of examinations available to examiners and the 'indices' used in assessing the students' performance were described.

In conclusion, it was seen that examinations are used for:

1. Assessment of skills and present levels of knowledge,
2. a basis for prediction,
3. an incentive or goal, and
4. an educational tool.

Now, about the Future.

Present trends indicate that examinations will gradually lose their retrospective character and will increasingly assume a prospective function concerned less with assessment and more with guidance. More account will be taken of the general record of each student together with results from tests and examinations, emotional characteristics and interests and habits.

Finally it may be of comfort to remember that examinations,

> "are all in a sense games, played between the examiners and the candidates and as in any game, the rules can be selected quite arbitarily provided they are understood by both sides."

Acknowledgements:

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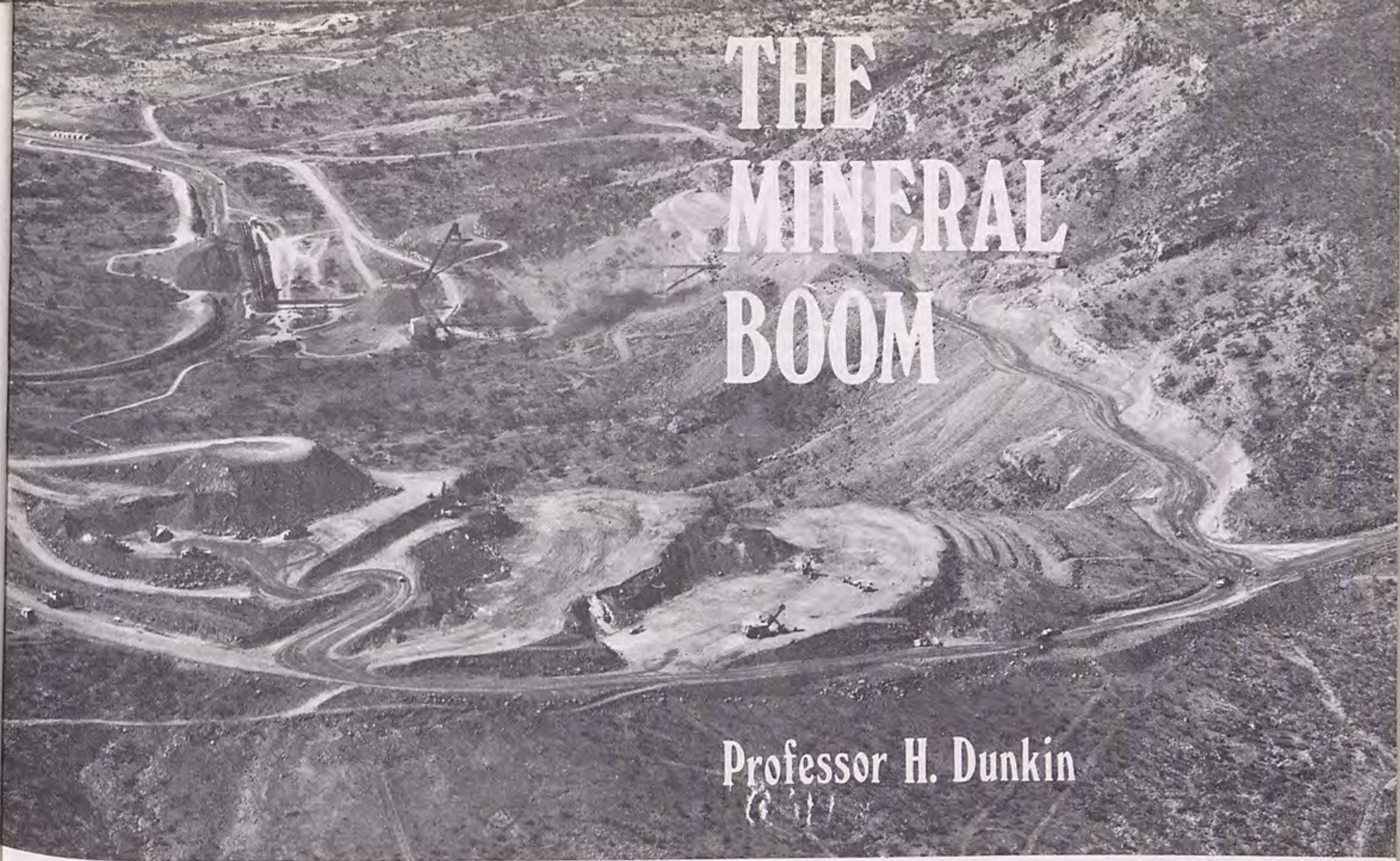
REFERENCES

1. **BERNETE:** GAMES THAT PEOPLE PLAY.
2. **CUNNINGHAM,** K.S.—EXAMINATIONS IN AUSTRALIA—Year Book of Education.
3. **BLOOM,** B.S.—CHANGING CONCEPTS OF EXAMINING AT THE UNIVERSITY OF CHICAGO—Board of Examinations, University of Chicago.
4. **LATHROP,** R. L.—A POINT OF VIEW ABOUT GRADING—Examinations Services, Bulletin No. 11, University of Minnesota.
5. **CHRISTOPHERSON,** Prof. D. G.—THE ENGINEERS IN THE UNIVERSITY.
6. **DUNSTAN,** M.—INDICES OF SUCCESS IN AN EXAMINATION—Education Research Unit, Bulletin No. 9, University of N.S.W.

MINING IN AUSTRALIA



THE MINERAL BOOM

Professor H. Dunkin

To those who have not been associated with the Australian mineral industry, its recent rapid expansion may have come as a surprise; however, since the 1950's such a rapid phase of new development has been confidently and frequently predicted by leaders of the industry.

The revolutionary phase of expansion we are now experiencing has its roots in quieter, slower evolutionary developments over the years since the 1930's. Behind the present exciting boom lies the work of the Bureau of Mineral Resources, and a variety of technological advances such as the development of rugged four wheel drive vehicles and of reliable helicopters; improvements in the design and performance of equipment for drilling, earth moving, rock excavation and removal; the invention of rock bolting techniques and of new materials such as ammonium nitrate—fuel oil and slurry type explosives. Also in the background are developments in structural geology, geophysics, geochemistry, rock mechanics and electronics, and their application to mine exploration and excavation. There has also been a major increase in the use of mathematical and statistical techniques as aids in making technical and financial decisions.

Since the early 1930's a few of the more progressive established Australian mining companies have been ploughing back a proportion of their profits into the search for new ore bodies. Associated with these companies were men of vision who staked their professional reputations on the thesis that, while any ore body being worked was a wasting asset, a mining company could ensure successful continuous operation by devoting effort, skill and money to the task of finding new orebodies to replace those being worked out. The experience of these companies in the use of new equipment and techniques was gained in the course of patient campaigns of mineral exploration over many years, which involved the investigation of thousands of prospects.

To develop and equip a working mine, finance is needed, and the necessary funds may be much harder to get at one time than another. The exciting gold discoveries in New South Wales and Victoria, which were made in 1851, did not lose their impetus quickly, so that during the second half of the nineteenth century money was generally available, particularly in England, to finance gold mining development in Queensland, the Northern Territory and Western Australia, as well as notable base metal fields such as those at Mt. Bischoff, Broken Hill, Mt. Lyell and Mt. Morgan.

The discovery of highly profitable diamond and gold fields in South Africa late in the nineteenth century diverted the attention of English financiers away from the Australian industry. Other events prolonged this trend—for example, the first world war and the great depression, the discovery of immense copper reserves in the Congo and Northern Rhodesia (Zambia), the development of Malayan tin mining and the upsurge of the Canadian mineral industry. Although mines were developed at Mt. Isa and Tennant Creek between 1920 and 1940, and although there was a general revival of gold mining during depression years, it is fair to say that the financing of Australian mineral exploration during the first half of this century was more difficult than in the late nineteenth century. But, since the end of the second world war, widespread unrest and political instability in Africa, Asia and South America, and the gradual depletion of mineral reserves in the United States, have redirected the attention of overseas financiers towards opportunities for investment in mineral development in this country.

In circumstances such as these all that was needed to catalyse an upsurge of mineral exploration and discovery was one or two developments of a type to stir the imagination and attract wide publicity. Given these as a stimulus, all the slowly accumulated expertise and the necessary finance were available to support widespread, intensive, new style mineral exploration throughout the country.

My personal opinion is that the first fillip was provided by the realization in Australia about 1950 that the beach sand industry was the world's leading producer of high grade rutile. It was realized that these companies were making profits and signing long term contracts with overseas buyers, including producers of the glamour metal titanium. In a similar way the success of uranium producers at Rum Jungle, Radium Hill and South Alligator, and particularly the dividends paid by Mary Kathleen brought this industry forcibly to the attention of the Australian public. Space age and nuclear age metals were putting a new face on the Mineral Industry.

Next came the electric shock of Wapet's discovery of oil in the original Rough Range well. Nothing could have been more stimulating. No longer was Australia a country geologically too old for petroleum production. Instead, attention was directed to the numerous, extensive, sedimentary basins, virtually unexplored, in any or all of which oil or gas might be found. Oil search was given a tremendous boost and the Commonwealth Government helped by offering subsidies for oil exploration programmes. Discovery of the Moonie and Barrow Island fields and of numerous gas and oil shows in other parts of the continent followed, and then the remarkable success in drilling off the Gippsland coast.

While oil exploration was gathering momentum, geologist Evans reported the Weipa bauxite deposits to his company, C.R.A. Suddenly, Australia which had been importing bauxite to feed its single small alumina refinery and aluminium smelter at Bell Bay, Tasmania, found it possessed one of the very large bauxite deposits of the world, which contained something like three thousand million tons of ore, (close to the Carpentaria Coast). The deposit was sampled, feasibility studies carried out, markets secured and finance provided to start a brand new major industry. Soon afterwards smaller but still very significant deposits were located in the Stirling Ranges near Perth and at Gove, N.T. Very large refineries are now established at Gladstone Qld., and Kwinana W.A., while another is to be developed at Weipa itself; smelters at Bell Bay, Geelong and Kurri Kurri will soon have a capacity of nearly a quarter million tons of aluminium metal annually and fabricating facilities have been greatly expanded. Australia now is a major exporter of bauxite and exports of alumina and of aluminium metal are rapidly expanding.

In 1960 the Commonwealth Government lifted the embargo on export or iron ore which had been imposed in 1938 While the embargo existed there had been little incentive to search for or prove iron ore. The Pilbara was known to contain ore but the questions "How much?" or "What Grade?" were only of academic interest. Three years after the embargo was lifted it was known that there were at least fifteen thousand million tons of high grade ore in the Pilbara and even larger tonnages of lower grade but concentratable material. There was so much that the exact amount did not matter. There was enough to support a large industry for centuries. Not only did Australia have world class bauxite, it also had iron reserves that could only be matched by two other countries, Brazil and India.

Development in the Pilbara was very rapid. During this decade we have seen three major iron ore operations started, with another to follow in the next three or four years. The present rate of iron ore production in the Pilbara alone is twice the total iron ore production of Australia in 1960. And within five years it will be much greater. New towns and ports have been created, hundreds of miles of heavy duty rail track laid, the first pellet plant built and operated and a major export industry established in a remote part of the Australian continent. Although overshadowed by Pilbara developments. other major iron ore industries have been established at Koolanooka and Koolyanobbing in W.A., in the Savage River district of Tasmania and in the Northern Territory.

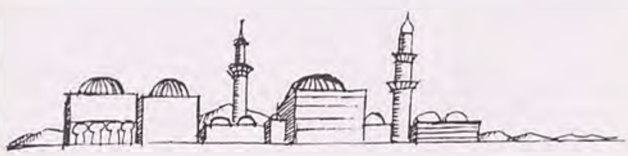
Basic markets for iron ore and pellets were found in Japan, but export to Europe has also started. Factors of great importance in the competitive position of the new Australian mines were the use of large, efficient vehicles for road and rail haulage, the provision of rapid ship loading facilities at the ports and the development of bulk sea carriers of 60,000 and 100,000 ton capacity. When the Western Australian Government granted mining leases it specified that by certain future dates the companies must provide facilities for ore benefication or pellet production, and eventually for increased iron and steel production in Australia. It now appears that matallized agglomerates containing over 80% iron will be made from Pilbara ore in the not distant future.

By the time the size of new iron ore discoveries was realized, the new era in Australian mineral exploration was well under way. Existing companies intensified their exploration programmes, new Australian and overseas exploration companies were formed, and the public was asked to subscribe capital for all types of mineral exploration. Teams of geologists, geophysicists, geochemists and mining engineers began to criss-cross the country.

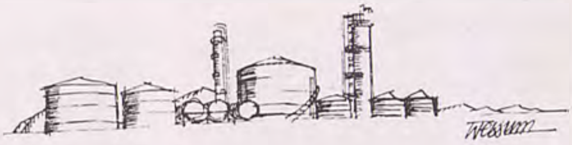
Excitement reached a peak when Western Mining Corporation announced the discovery of a large high grade nickel deposit only 30 miles south of Kalgoorlie. All likely companies, and many unlikely ones, set out to look for nickel and a share market boom was under way. At the present time some of these explorers have found economic nickel orebodies, while some are still searching. Not all who look for nickel will find it, and it may take twenty years or more to find all the major deposits, but it is already certain that we are seeing the start of another important mineral industry in this country. Export of concentrates is increasing and the first nickel refinery is under construction at Kwinana.

The Australian public, and Australian and overseas mining companies are now convinced that there are prizes to be won by investing in mineral exploration and development in this country.

Other discoveries over the past ten years have received less publicity but



are worth noting. B.H.P. has developed a major source of manganese ore at Groote Eylandt in the Gulf of Carpentaria. Broken Hill Companies have re-opened the Cobar field and are producing copper, lead and zinc concentrates, and further exploration there is planned. The E. R. & S. Company at Port Kembla has expanded smelter capacity to treat Cobar copper concentrates. Extensive phosphate deposits, on which feasibility studies are being carried out, have been located in Western Queensland and adjoining parts of the Northern Territory. Several new tin mines have been established. The coal industry of New South Wales and Queensland has proved large new reserves and established a growing export trade with Japan. New copper and zinc deposits have been discovered in South Australia. Mt. Isa has quietly proved another immense lead-zinc orebody twelve miles north of the existing mine, which it will bring into production within seven years. A very large solar salt industry is developing in Western Australia, mainly for export. Some potassium salts will also be produced. The search is on for diamonds, vanadium, and many other minerals. Brown coal production continues to increase and production of a wide variety of non-metallic and constructional minerals is expanding steadily.



Certainly there will be more new finds and these may continue for a long time. Over the past five or six years the value of Australian Mineral output has about doubled, and it is probable that the next ten years will see the present output doubled again. *But while this expansion of the industry will continue, the major part of the stock market speculative boom may soon be over.* During part of last year it was hard to lose money in the mining section of the share market, but already operators are more cautious and more selective. Many newly listed companies will succeed but others will not. Not every company which seeks will find a payable orebody.

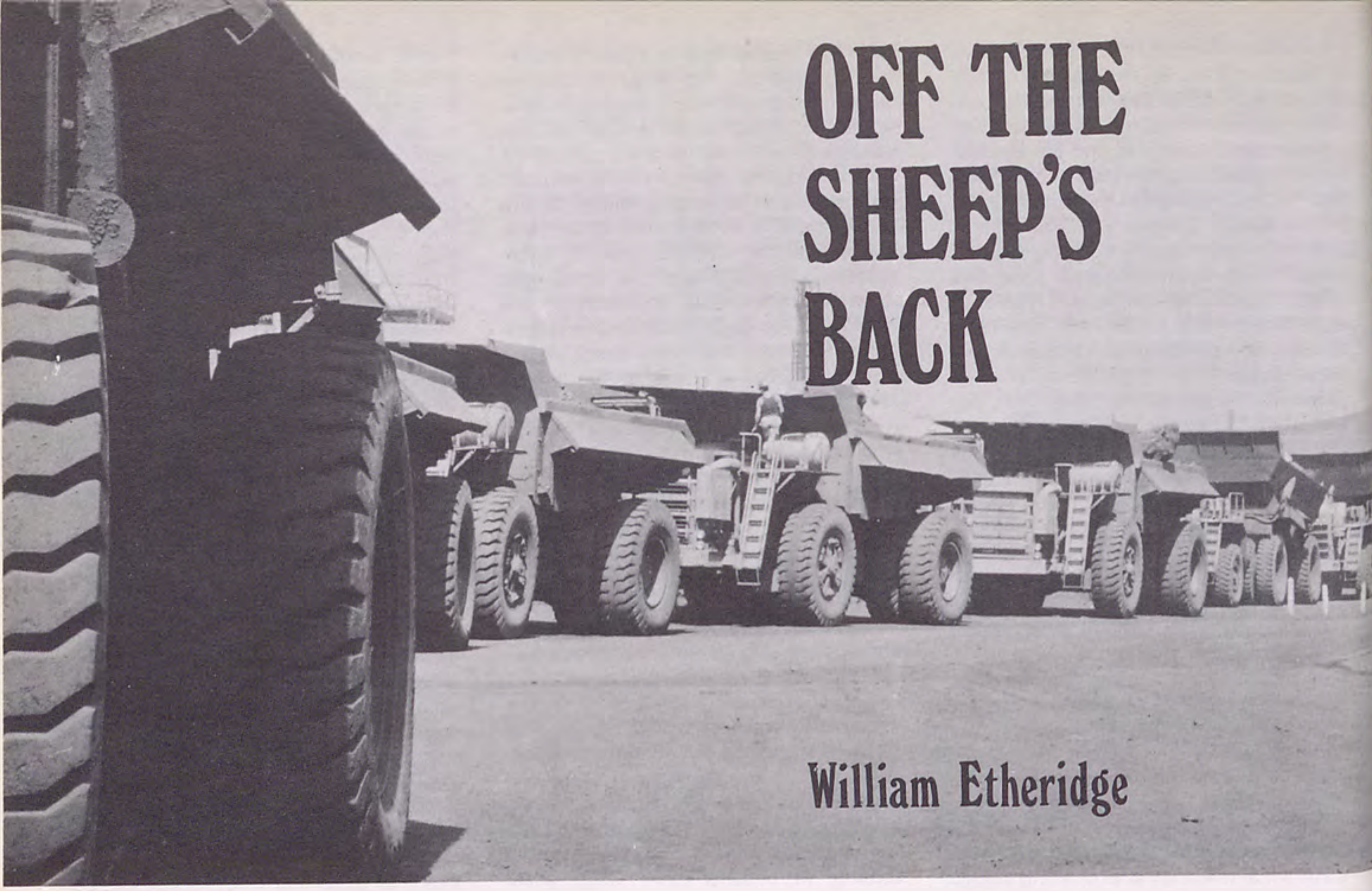
There is always an element of risk in mining investment. When examining a new prospect which has only a favourable geological environment or perhaps a few encouraging surface assays, there is a real risk that all money spent in examining the prospect will be lost. At the other extreme, when the critical early risk is taken by a company which is feeding profits from other operations back into exploration, tonnages and grades of ore may be known, mining and treatment methods studied and evaluated, costs estimated, markets secured and estimates of profits made before shares are offered to the public. In these conditions the residual risk is comparatively small. There are signs that Australian finanical institutions are responding to such situations by recognizing that once the initial high risk has been removed, there is scope in the mineral industry for fixed interest loans to bring mines into production. This fact was recognized by Canadian institutions forty years ago.

Although the long-term outlook regarding demand for all metals is good, because the world population is increasing and material standards of living are tending to increase, in the short term one can not overestimate the importance of secure markets when establishing a new mineral enterprise. For this reason, the fact that the Japanese market was looking for minerals, has been of major importance to Australian development. Of course there is the danger of putting too many eggs in a Japanese basket, but Japanese contracts for iron ore did assure the viability of a long term, large scale industry requiring large initial capital outlay. Once such an efficient, competitive industry has been established the prospect exists that other markets can be penetrated. The Hamersley company has already demonstrated this. In 1968 Hamersley shipped 6.7 million tons of ore and pellets to Japan and 2.4 million tons to Europe and North America. Corresponding figures for 1969 are expected to be 9.5 and 3.0 million tons. Other companies will doubtless follow the same pattern.

Warnings against excessive control by overseas interests of Australian Mineral enterprises have been numerous. Naturally the Australian equity in our own industries should be kept as high as possible but it is a fact that already Australia devotes 26% of its total output to public and private expenditure of a capital nature. Meeting this demand means that a large part of our limited resources is diverted from the satisfaction of immediate needs to provide for future requirements. An even higher figure would almost certainly create public opposition and resentment, while a higher proportion of the 26% diverted to the mineral industry would retard the development of roads and water storages, manufacturing industry and housing. It seems inevitable that much of the capital for mineral development must come from overseas, preferably from an Australian point of view in the form of fixed interest loans.

Here it may be of interest to note that the past history of Australian mining, indicates that companies originally financed from England, have tended with time towards increased Australian ownership. This has been the case for North Broken Hill Ltd., Broken Hill South Ltd., The Broken Hill Proprietary Company Ltd. and Western Mining Corporation Ltd. It can be claimed that the expenditure of such vast sums in Australia as are needed for major mineral developments provides higher tax and royalty returns to governments, greater employment and a stimulus to manufacturing and service industries, and that these benefits easily outweigh the possible loss in the form of dividends payable to other countries. Probably the best way to generate the capital for an expanded steel industry in Australia is to make profits in the first place by exporting iron ore and pellets.

The Mineral Industry will go forward. To Engineering students this means greater opportunities for employment and advancement in a rapidly expanding industry which is continually using more advanced methods, techniques and equipment. The industry employs every kind of engineer, most kinds of scientists and graduates in economics, commerce, mathematics and even medicine. In particular there has been a shortage of mining engineers and metallurgists. Although enrolments in these courses have increased, the present and certain future expansion of the industry guarantees opportunities for them all. In view of the present and certain future impact of the mineral industry of the whole Australian economy it is my personal belief that this University, as the only one in this State where the necessary basis exists, should expand facilities, equipment and staff in the special fields of mineral industry interests—geology, geophysics, geochemistry, petroleum engineering, mining and metallurgy.



OFF THE SHEEP'S BACK

William Etheridge

1. INTRODUCTION

According to their occupational pursuits, most people are to some degree aware of the recent growth in activity within the Australian mineral industry; few, however, realize or appreciate the reasons for this development or its inherent consequences beyond some vague impressions garnered from the usual news media.

This article aims then to *present a concise portrait of our mineral industry today, and to elucidate its causes, modifiers and effects.*

2. RESUME OF RECENT SIGNIFICANT MINERAL DEVELOPMENTS AND PROSPECTS IN AUSTRALIA

2.1 Iron Ore

Until November 1960, there existed a complete embargo on the export of iron ore from Australia because it was thought we were deficient in this material — stated reserves of iron ore in Australia were about 400 million tons.

Today, less than nine years later, six mining groups in Western Australia hold firm export orders for 466 million tons of iron ore (lump, fines and pellets) from the Pilbara region—worth in the vicinity of $A4000 million.[1] "Estimated" reserves of high grade iron ore (55% Fe) in the Pilbara are around 20,000 million tons so its seems unlikely that we will be short of iron ore for many years yet.

Exports of iron ore and pellets are expected to grow in value from $A103 million in 1967/68 to $A278 million in 1973/74.[2]

2.2 Oil and Natural Gas

The discovery of extensive oil and natural gas fields by Esso/BHP under Bass Strait will alleviate our major mineral deficiency; crude petroleum and its derivatives have regularly constituted about 70% of our mineral imports and in 1968 the bill for crude petroleum alone was $A213 million. It appears that by early next decade the Bass Strait fileds will be meeting at least 60% of our petroleum demands on present estimates. Marginal contributions will come from the Barrow Island field in Western Australia and from the Moonie field in Queensland.

It can only be hoped that the current intensive oil exploration program in Australia—particularly in the offshore areas, will supplement these discoveries with further worthwhile finds.

2.3 Coal

Coal is not commonly recognized as one of Australia's most important minerals. In terms of production it is easily our most valuable mineral, being worth more than $A200 million[3] in 1968 compared with iron ore and pellet production worth around $A120 million in the same year; while in terms of export, black coal becomes our second most valuable mineral commodity after iron ore and pellets. Due mainly to the discovery and exploitation of the huge black coal deposits in the Bowen Basin of Queensland, exports of black coal from Australia will rise from $A85 million in 1967/68 to $A247 million in 1973/74[2] on the basis of present contracts. Japan will be a major market for the coal, taking about 20 million t.p.a.[4] by 1972: 8-10 million t.p.a. from N.S.W. and around 12 million t.p.a. from Queensland.

2.4 Bauxite/Alumina/Aluminium

Australia possesses about one third of the world's known bauxite reserves, major deposits being located at Weipa in northern Queensland, at Jarrahdale in the Darling Ranges near Perth, at Gove in the Northern Territory and in the Kimberleys of Western Australia—these are being developed by Comalco, Alcoa, Nabalco and Amax Australia. An integrated alumina and aluminium metal industry has been established in Australia based on these huge reserves of bauxite.

This is a major export industry of rapidly growing strength; thus, exports of bauxite/alumina/aluminium are forecast to increase by 319%; from $A59.2 million in 1967/68 to $A248 million in 1973/74[2] based on planned expansion of the Kwinana and Gladstone alumina plants, on the Gove development, and on exports of aluminium metal.

2.5 Copper

The value of copper exports should rise from $A35.6 million in 1967/68 to $A98 million in 1973/74[2] through increased production at the Mt. Isa and Mt. Lyell mines—however, these figures would alter sharply if the Bougainville copper project is given approval to proceed: Bougainville may be producing about 160,000 t.p.a. of copper (in concentrates) and 500,000 oz. of gold p.a. by 1973, more copper and gold than that produced by all other Australian mines.

2.6 Nickel

With the spectacular discoveries of nickel sulphide ore in the Kalgoorlie region of Western Australia, another of Australia's mineral deficiencies has been replaced by a thriving export industry. Western Mining Corporation is expanding its mine and mill production to 30,000 t.p.a. of nickel in concentrates and is constructing a refinery at Kwinana to produce over 15,000 t.p.a. of refined nickel. Important finds have been made by WMC, CRA/Anaconda/NBHC, Metals Exploration and Great Boulder. By 1973/74 Nickel exports are expected to rise to the order of $A100 million.

2.7 Beach Sands

The mineral sands industry (rutile, zircon, ilmenite) has a bright future; there is a rising demand for the metal titanium, particularly from the aircraft industries where it is being more widely used in the construction of high speed aircraft and missiles. Again, it is a major export industry earning about $A36 million of foreign exchange in 1968.

2.8 Other Developments

Manganese exports, mainly from Groote Eylandt in the Northern Territory and salt exports from Western Australia are expected to be worth $A16 million and $A8 million respectively in 1973/74[2] —these industries have arisen only in recent years.

Among recent developments which promise to increase further our silver-lead-zinc output, has been the disclosure of Mt. Isa's plans to double output from their mine in Queensland.

3. FACTORS CONTRIBUTING TO THE GROWTH OF THE AUSTRALIAN MINERAL INDUSTRY

3.1 Evolution of well financed, managed and executed mineral exploration and evaluation programs.

Beginning with the establishment of W.M.C. in 1933 by W. S. Robinson, the management of Australian mining companies came to appreciate the value of organized, extensive exploration as opposed to lassez-faire prospecting. The positive exploration policies of private enterprise, assisted by such government bodies as the Bureau of Mineral Resources, have contributed significantly to the recent abundance of rich mineral discoveries.

The second major phase in mineral development, after exploration, is the feasibility study. A comprehensive feasibility study encompassing all features of a proposed development project and utilizing modern economic evaluation techniques enables a company to assess more accurately the economic potential of a mineral deposit. This not only enhances the company's success but also permits easier access to loan capital for the financing of a project, a cheaper method of financing than equity.

The trend towards the extensive feasibility study has accelerated with the emergence of huge capital intensive schemes such as Hamersley, Mt. Newman and possibly Bougainville, which require initial capital expenditure of the order of $A200-300 million.

3.2 Advances in Technology

This factor has been felt in two respects:

(i) Exploration techniques and methods of increasing sophistication are now available in the search for hidden mineral deposits. Methods of detecting deposits of minerals must improve as the richer, more easily located orebodies are discovered and exploited and also if we are to find the deeper low grade deposits.

(ii) Improvements in technology have contributed to the lowering of operating costs in mining projects by the provision of more reliable and larger capacity equipment. This, along with rising demands for most metals and minerals, has made it more possible to economically extract mineral deposits of lower grade, and in more remote location, and as indicated in (i), these deposits also demand greater effort and technical skill for their discovery.

3.3 Foreign Investment—Capital and Know-How

The contribution of overseas investment to the growth of the mineral industry in Australia, especially since the last war, has been quite substantial and may be delineated by the following factors:

(i) Large foreign mining organizations have been prepared to engage in expensive and risky exploration activities in Australia where the smaller local company might consider the element of uncertainty too high to justify the necessarily heavy expenditure on mineral exploration.

Washed and screened bauxite moves along a conveyor to the shipping stockpile at a rate of 800 tons an hour.

Silver Lake Shaft, site of the first nickel strike, at Kambalda, W.A.

(ii) The Australian capital market is limited severely in the extent to which it can finance the costly mineral development program presently being conducted in this country, and without the liberal inflow of foreign capital, the program would have to be sharply constricted. Projects such as Hamersley, located in remote areas, are inevitably very expensive to develop, demanding the provision of ports, towns and railways as well as the mining installations themselves.

(iii) Technical skill and managerial ability are other major legacies of foreign investment. Again pointing to the large development schemes such as those based on the Pilbara iron ore deposits we can see foreign talent in management and technology to be an essential factor in their success. However, there has been an agreeable trend towards staffing the projects with local engineers and scientists right up to board level in order to encourage greater local participation.

(iv) The overseas investor has also played an important role in securing export outlets for our mineral commodities—in the case of the Aluminium industry, development could not have possibly reached its present state without the foreign partner performing this function.

3.4 Resurgence of Japan as a Major Economic Power

Japan's rise from the ashes of the last War to its position of economic and industrial strength today has provided Australia with a large and expanding market for many of her natural resources —such materials as iron ore and pellets, black coal, aluminium, copper and salt figure in valuable export contracts with Japan.

4. CONTRIBUTION OF THE MINERAL INDUSTRY TO THE NATIONAL ECONOMY

It is impossible to indicate accurately the contribution of Australia's mineral activity to our economic performance in view of the difficulty of differentiating the industry from the manufacturing and processing industries based on it.

A useful quantitative approach to the question is to consider the contribution of the mineral industry, firstly to the Gross National Product (GNP) at constant prices and secondly to our international trade balance.

Furthermore, to maintain the present rate of development within the industry will require increasingly flexible and imaginative management—however, we have already been shown that the rewards justify the effort.

4.1 Contribution to GNP at constant prices

A reasoned measure of this figure is made by Victor Tobocz in Growth 16, a publication by the Committee for the Economic Development of Australia (CEDA) in June 1968. He suggests, with suitable qualification, and with due regard to the intangible nature of the problem, that the total contribution of the mineral based industries to GNP at constant prices was 4.2-7.7% in 1964/65.

This figure in spite of its inherent limitations is of a fairly small order and must be kept in mind when considering the impact of mineral development on the level of local economic activity.

A greater contribution could be expected if more of Australia's mineral production was processed locally rather than being exported in the raw state. However, the extent to which minerals can be treated locally depends on the circumstances surrounding the particular raw material—it is nevertheless a policy to be actively encouraged.

4.2 Contribution to the Trade Balance of the Balance of Payments

The import of current and planned mineral developments on the balance of payments is likely to be most significant in the future with an increasingly positive contribution to the trade balance as exports of minerals and their derivatives rise.

The value of mineral exports has risen from $A151 million in 1962/63 to $A542.3 million in 1967/68 and by 1973/74 is expected to be in the vicinity of $A1258 million[2] according to existing contracts and not allowing for new sales.

This trend should, however, be regarded in the light of several other factors:

(i) Imports of equipment, machinery and other materials will necessarily rise to serve the requirements of the mineral development projects.

(ii) The rise in mineral exports, should have a two-fold effect on the 'invisibles' account of the balance of payments.

Firstly, there will be a credit through the increased spending by foreign vessels as they collect exports from Australian ports. Secondly, interest and dividends payable abroad will increase causing a debit on the account although the likelihood of the increase in this item exceeding the improvement in the balance of trade is remote—primarily because of the Government's 45% tax participation in all company profits.

5. FACTORS AFFECTING PRESENT AND FUTURE DEVELOPMENT IN THE MINERAL INDUSTRY

Apart from those influential factors outlined above, there are a number of other factors which have, or will have, a considerable bearing on the progress of the mineral industry in Australia.

5.1 Policies of the Commonwealth and State Government

The task of the government in the continued development of the mineral resources of Australia is to provide and promote a favourable political, social and economic environmental framework within which private enterprise can operate to produce optimum results. The framework should be so designed that it favours certain industries over others depending on the relative worth of these industries to our productivity and growth. Australia is well endowed with mineral resources and to maintain an extensive, successful mining industry based upon these resources requires special consideration by the Government for the unique development problems therein.

The Government can assist the mineral industry in such ways as:

taxation concessions

depreciations allowances on assets

levying fair royalty rates

provision of essential facilities such as towns and community services.

5.2 Imminent Shortage of Technical Manpower in the Mineral Industry

A recent survey by the Australian Mining Industry Council confirmed widespread suspicions that the demand for technically trained specialists in the mining industry will rise dramatically over the next five years and it seems unlikely that Australian tertiary education facilities will be able to meet this demand—especially in the fields of mining engineers and extractive metallurgy.

Any severe manpower shortage, as might develop, would be detrimental to the progress of the industry, the only way to guard against such an undesirable situation is to expand the local training program to an extent where the prospective shortage can be alleviated from within — we could not rely on foreign manpower this is equally scarce.

5.3 Emergence of financing/development consortiums amongst Banks and Private Companies

A commendable trend of late in the financing and development of mining ventures in Australia has been the formation of such partnerships as Newain and Partnership Pacific Ltd. among leading Banks and companies. These consortiums will be concerned with the management and financing of proposed ventures rather than with the exploration phase, i.e. they will attend to the development of located mineral properties.

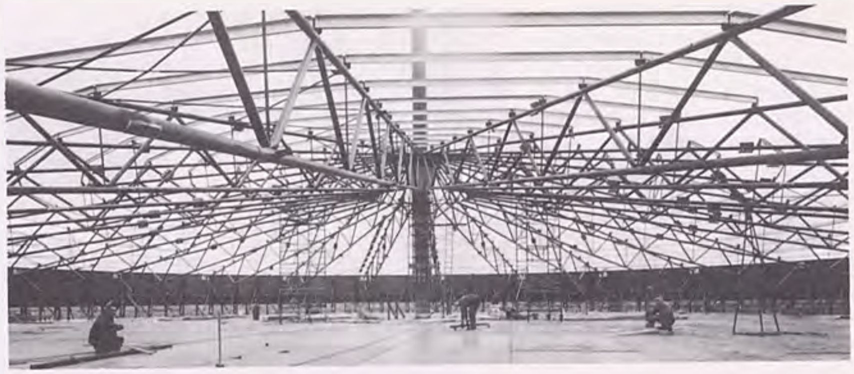
6. CONCLUDING REMARKS

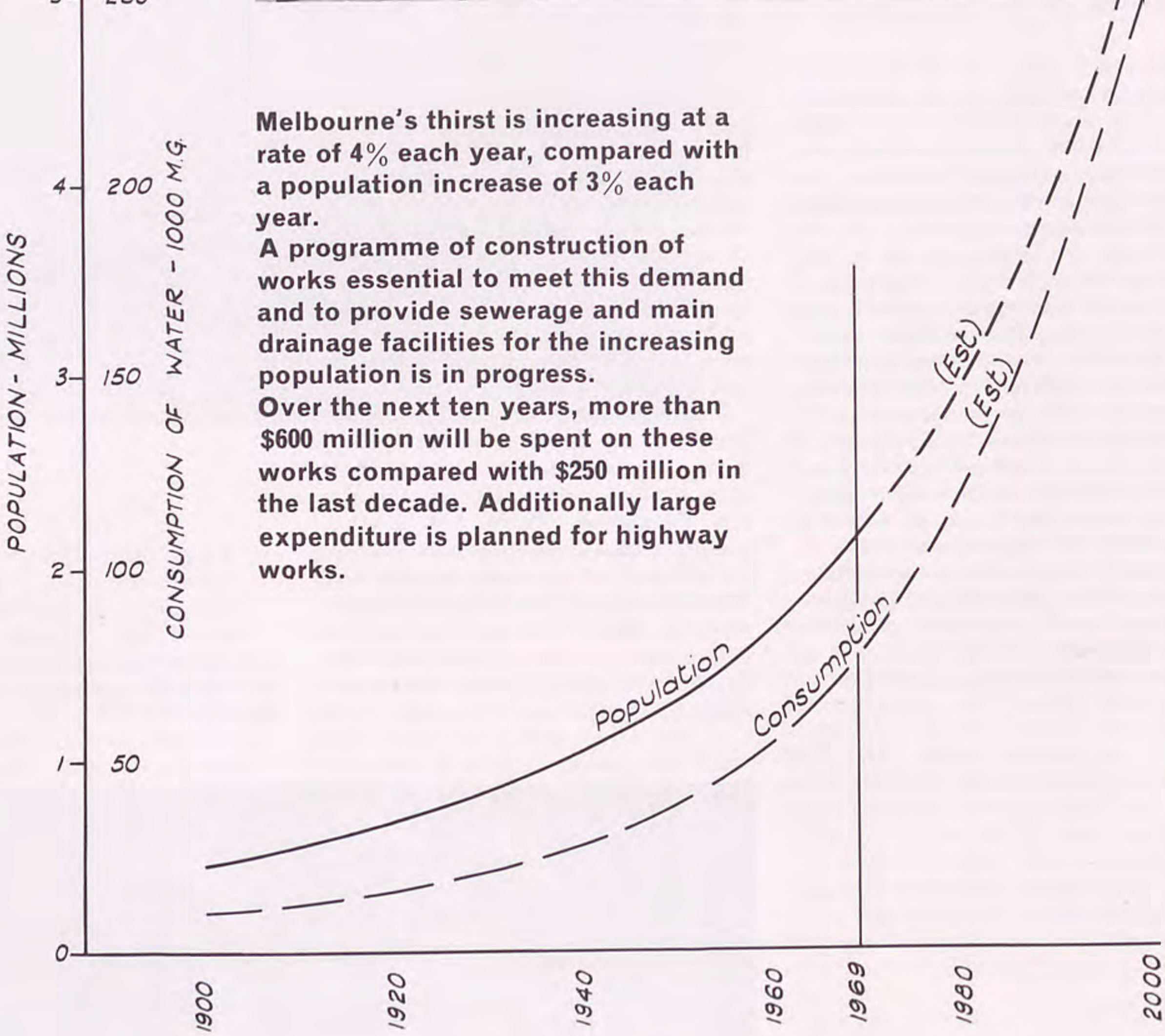
Perhaps the most important conclusion to be drawn from this discussion is that the mere presence of a rich store of mineral wealth does not imply that a successful extractive industry will necessarily follow. The Australian mineral industry has only attained its present heights through sustained, constructive co-operation amongst private enterprise and government, from the level of the individual through to the largest organizations. This was neither an inevitable nor fortituitous development but the deliberate exploitation of a propitious set of circumstances.

The final comment to be made is a comparison of the mineral export figures with those of primary produce export. Annually, Australia exports wheat to the value of about $A300 million and wool to the order of $A800 million; as quoted previously, by 1973/74 the value of our mineral exports will be in the vicinity of $A1285 million; at last we are a minerally virile nation, certainly no longer riding on the sheep's back.

A 12 cubic yard Marion Shovel dumps ore into a 100 ton capacity Dart truck, Mount Tom Price.

Roof framing—St. Albans Tank. 170 ft. diameter, 48 ft. high, 6.7 m.gals capacity.





Melbourne's thirst is increasing at a rate of 4% each year, compared with a population increase of 3% each year.
A programme of construction of works essential to meet this demand and to provide sewerage and main drainage facilities for the increasing population is in progress.
Over the next ten years, more than $600 million will be spent on these works compared with $250 million in the last decade. Additionally large expenditure is planned for highway works.

Join the team building for the Melbourne of the future.

MMBW

Ring Mr. E. J. S. BATTEN, Executive Engineer

Phone 62-0221, Ext. 495

Rock Mechanics

W. E. Bamford

To rationally predict and analyze the behaviour of a material in response to changes in the forces acting upon it, a good understanding of its mechanical behaviour is necessary. Rock is no exception to this, and the theoretical and applied science of rock mechanics deals with the mechanical behaviour of rock, in masses ranging in size from continents down to sand grains.

Rock mechanics is an inter-disciplinary field, using some of the methods of, and having contributions to make to, mining, metallurgy, civil engineering, geology, and geophysics. Its general usefulness in engineering practice may be summarized as in Table 1.

TABLE 1

Desired Effects	Static or quasi-static Forces	Dynamic Forces
Trying to prevent failure of rock, or to lessen the effects of failure.	Design of shape, size and orientation of excavations on the surface (open-cut mines, quarries, road or railway cuttings, etc.) or underground (tunnels, power stations, shafts, stopes, room-and-pillar workings, etc.)	Design to prevent or to minimize the effects of rockbursts, minimize the effects of earthquakes, nuclear explosions, etc.
Trying to cause failure of rock with greatest efficiency and minimum cost.	Design of excavations to promote caving of a block of ore and its reduction to a state in which drawing and flow of the broken granular material can take place readily.	Drilling holes in rock. Blasting to produce desired shattering, or volume of loosened rock, or minimum disturbance behind a rock face. Comminution { Crushing, Grinding

Rock Mechanics and Soil Mechanics

The exact boundary between these fields can be only arbitrarily defined, usually in terms of some property, such as porosity or permeability of the material studied in each field.

Most soils are formed by the chemical and mechanical decomposition and degradation of solid rock, by dissolved gases and chemical compounds in circulating groundwater or by living organisms. This process is termed "weathering", and a characteristic profile developed in the uppermost portion of a mass of rock near the earth's surface shows a transition upwards from the freshly unweathered rock, through increasingly weathered rock, to the completely weathered material, which could hardly be recognised as a rock, if it was isolated from its parent rock, and the transition was not visible. The transition from fresh to completely weathered rock usually covers a few tens of feet, but sometimes ranges down to a few inches or up to a few hundred feet. The completely weathered material may be removed by erosion, transported by water or wind, and re-deposited as a transported soil or a sedimentary deposit.

In general, rock mechanics deals with the characteristics of fresh and slightly to highly weathered rock, while soil mechanics deals with completely weathered rock, and residual and transported soils.

Some Basic Features of Rock Mechanics

Rock mechanics is distinguished from other aspects of mechanics by the inherent heterogeneity and variability of rock, which often makes its behaviour less rationally predictable than that of other engineering materials.

Two of the basic concepts are the "grains and glue" concept, and the distinction between "rock material" and "rock mass".

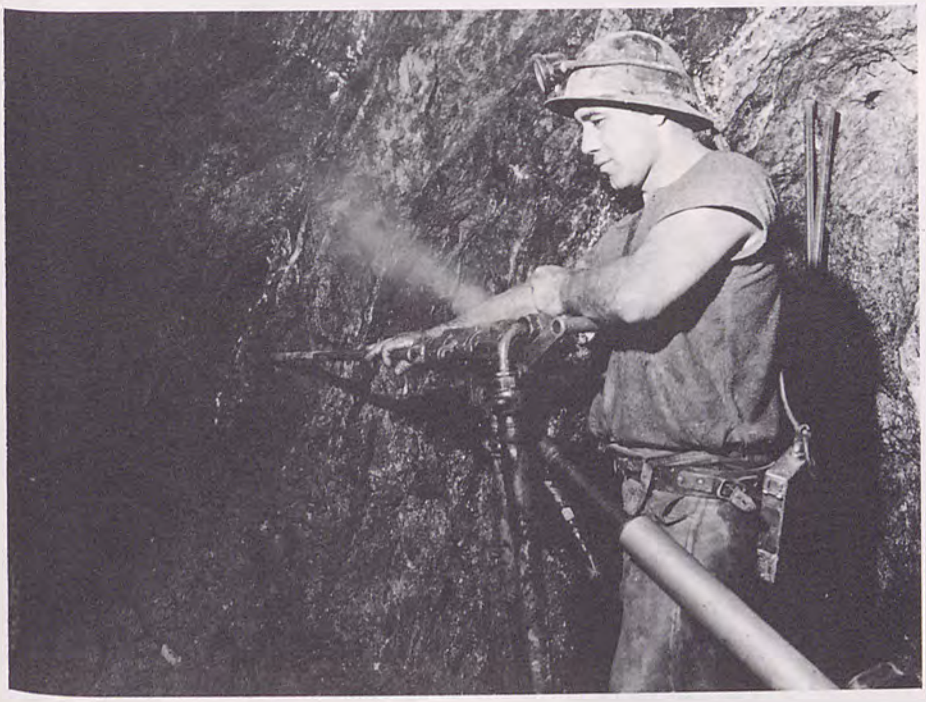
Any mass of rock in nature consists of blocks or prisms of intact rock material, separated by discontinuities, which are given geological classifications such as joints, bedding planes, faults, shear zones, etc. In general, the distinction between different kinds of discontinuities rests on whether a tensile failure pulled the rock straight apart (joint) or a shear failure moved adjacent blocks laterally past one another (fault). Whatever the cause the rock was broken at some earlier time, and the behaviour of the discontinuity in response to stresses in some directions will now be different from that of the blocks of rock material.

Very few rocks are completely homogeneous and isotropic, even in small laboratory samples. The "grains and glue" concept provides an explanation. Every rock consists of mineral "grains" and a cementing "glue". Most rocks, except for some monomineralic rocks like limestones or clean quartzose sandstones, are composed of more than one mineral. Each mineral will have different deformation modulus and strength. There may be preferred orientations of mineral crystal axes, especially when the rock was originally deposited in layers under water. The crystals may be intergrown and interlocking, or they may be held in a "paste" of non-crystalline material, such as quartz, calcite or clay. The response of such a heterogeneous system to changes in stress may be complex; as adjacent particles in contact will want to deform by different amounts in response to the same stress; viscous or plastic components, such as the "glue", will tend to flow under sustained loads, until only the more elastic "grains" are in contact; and when the stress increases to the vicinity of failure, grains of one material component will tend to fracture before those of another, so throwing increased loads onto the remaining intact grains, and causing irregular stress-strain curves.

This also leads to mention of the natural variability of rocks, which is inherently higher than that of most other engineering materials. It is not hard to visualize why several random samples of a multi-component system should have varying amounts of each constituent, although the mean composition of the entire group of samples approaches that of the entire system. When each constituent has markedly different properties, then it is to be expected that the strengths, or other properties of rock samples from a statistically uniform rock mass vary markedly. The standard deviations of groups of test results from rocks are rarely less than 10% of the mean, even in rocks of the most homogeneous appearance, while many rocks have standard deviations of 30% to 50% of the mean. The standard deviations of other common engineering materials, such as steel and concrete, are usually much lower. Taking the mean of a group of strength tests as a design criterion implies that half of all randomly selected samples will be weaker than this. Dividing the mean by a "factor of safety", and so using only some fraction of the mean, however, results in a much lower chance of encountering a weaker specimen. However, as rock is inherently so variable, the uncritical use of this practice can be dangerous. Every Engineer should appreciate the fact that natural variability increases from man-made materials, such as metals and plastics, through "artificial rocks", such as concrete, to natural soils and rocks, and that concepts and procedures developed for the understanding of the first group to be at least modified when dealing with the latter two groups.

Another interesting feature of rock behaviour is the size-strength relationship, which has also been observed in other materials. The strength of a large body of rock material is diminished by the presence of flaws or micro-cracks, which by acting as "weak links" reduce the strength. The larger the volume of the sample, the more chance there is that such flaws are present, and moreover being present in the orientations most likely to cause failure under any particular direction of loading.

So, the use of rock as an engineering material has to proceed in the understanding of it as an inherently inhomogeneous, discontinuous, anisotropic substance, more variable than most other engineering materials, and displaying significantly lower strength and deformation modulus in large masses than in test samples.



Application of Rock Mechanics in Engineering Practices

A typical sequence, as applied to the construction of excavations in rock is:

(1) Classify the materials present, determine their extent and spatial relationships, assess their strength and deformation properties.
This is done by geological mapping of the rock mass and measurement of the orientations of the discontinuities.

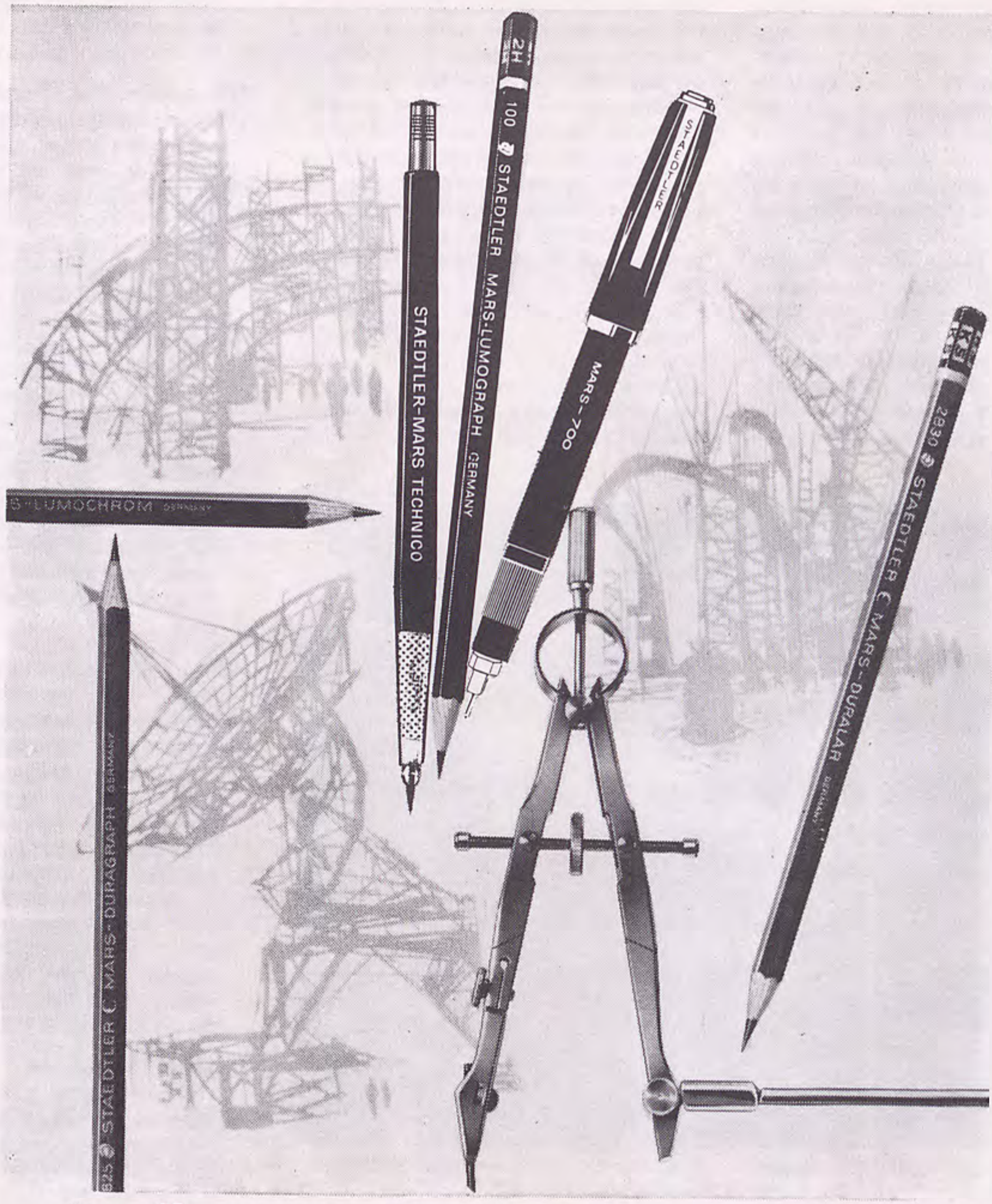
(2) Measure the mechanical properties of the rock materials and the rock mass.
Laboratory tests on small samples of rock material are carried out more easily and cheaply than large-scale field tests on the rock mass, although only the latter directly measure the most important properties. The laboratory tests are often extrapolated, with the aid of experience and the geological classifications, to the scale of the rock mass, with a few large-scale field tests to check on the accuracy of these extrapolations.

(3) Determine the natural stress fields in the rock mass. When excavations are made below the surface the weight of overlying rock will cause vertical stresses, with lateral stresses of lower magnitude (induced from the vertical stresses by the Poisson effect, in elastic rock) or of equal magnitude (if the rock behaves plastically). In many parts of the earth's crust horizontal stresses, probably of tectronic origin, of several times the magnitude of the vertical "gravity" stresses, have been measured. For this reason the vertical and horizontal stresses cannot be assumed as a function of depth below the surface, and density and Poisson's ratio of the rock, but must be measured, as they have considerable influence on the next step.

(4) Stress concentrations around openings.
Starting from classical elastic theory models of holes in plates, and knowing the magnitudes of the applied stresses distant from the openings, the stresses induced around the excavation may be assessed, and compared with the rock's strength. It may be possible to modify the shape of the opening to reduce stress concentrations to below the design strength, and so prevent failure; if not, failure of the rock must be anticipated, in the next step.

(5) Design of support.
If the rock fails, it will tend to continue failing until it has modified the shape of the excavation to a shape which is stable under the stress field acting on the rock mass. If this naturally modified shape and the consequent production of broken rock will interfere with the use for which the excavation was constructed, artificial support is used to hold the rock back. A knowledge of the shape and size of the zone in which failure is likely to occur, as well as the expansion of this rock on failure, can enable estimates of the pressures on the supports and the deformation which they must allow, as the broken rock expands into the opening.

(6) Monitoring Instrumentation.
Before excavation is completed instruments may be installed to monitor the post-excavation behaviour of the structural supports and the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MARS-700
S-LUMOCHROM
2830 STAEDTLER MARS-DURALAR
825 STAEDTLER MARS-DURAGRAPH

surrounding rock mass. If movements and pressures in both rock and supports are measured over a long period they can give warning of any impending failure and also enable comparison of the prototype's behaviour with the predictions, leading to refinement or modification of the design procedure.

Future Developments

Many of the best dam sites have been built on, and the life of any reservoir is limited by filling up with silt. So, it may be expected that many of the poorer dam sites will have to be used in the near future, and study of the foundation rock characteristics will be an important part of the investigation and design procedures to ensure against foundation failures.

Similarly, many of the richer mineral deposits near the surface have already been worked. Existing mines may have to extend their workings down to great depths, aided by developments in environmental control, such as ventilation and cooling, to allow miners to work protected from the high rock temperatures prevalent at depth; the high rock pressures also expected at these depths will cause very high stresses around excavations, and call for improved rock testing and design procedures to minimize the risks of catastrophic rock failures.

The cut-off grade below which it is uneconomic to mine large ore-bodies should continue to fall, and these huge low-grade ore bodies will mostly be mined by deep open-cuts. Several open-cut mines more than 1,000 feet deep are now in production or being planned, and these depths may become commonplace. The steeper the walls of an open-cut mine, the lower the amount of useless overburden that must be removed before recovering each ton of ore (and so the lower the mining costs), but also the higher the risk of landslides in the wall slopes, with consequent risk to men and machinery and possible interruption of production. The design of deep open-cut mine wall slopes is a complex mixture of rock mechanics and economics.

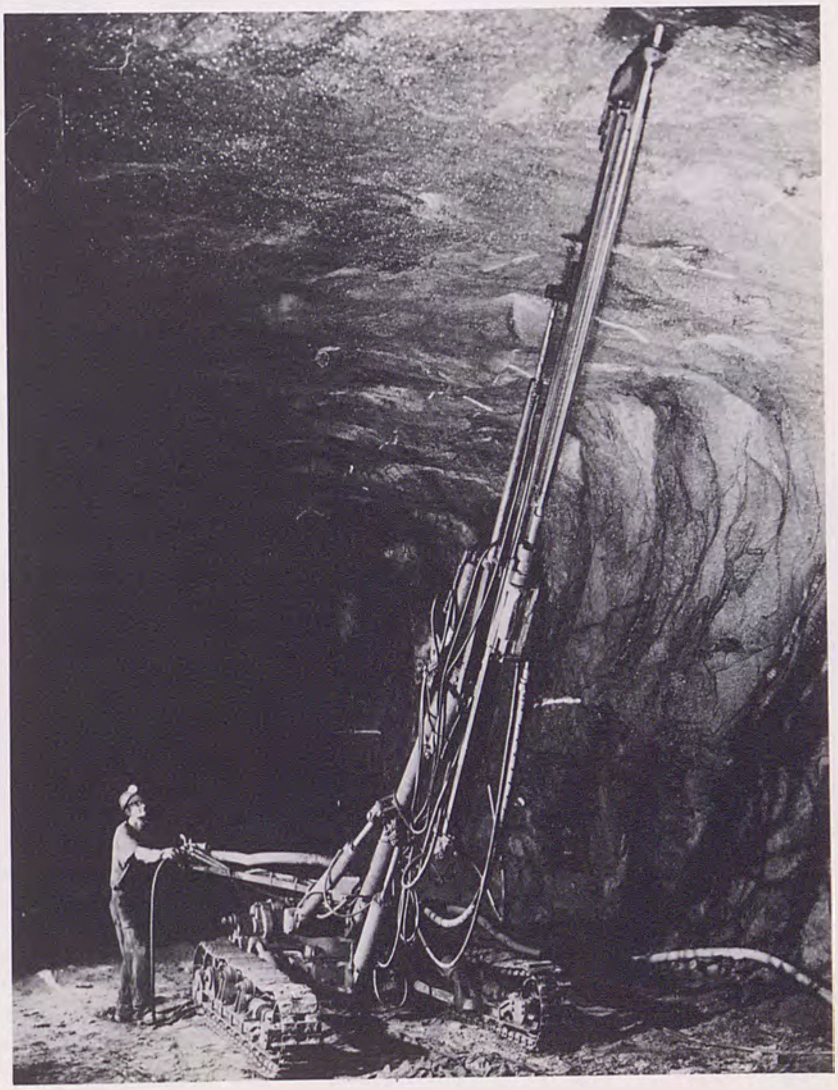
Comminution is an important part of mineral processing and extraction. A block of ore, say 100 feet cubed, has to be reduced to the size at which liberation of the valuable particles from the barren material is most effective, say less than a hundredth of an inch. This is typically accomplished in stages: blasting with explosives, several stages of crushing, several stages of grinding. Several separate sets of criteria may govern the size reduction for the purposes of ore extraction, of broken ore transport, and of mineral processing. The optimum efficiency of each separate stage may not be compatible with the optimum efficiency of the entire process, so the total system approach to energy requirements in comminution is important; a minor inefficiency in one stage may lead to even greater efficiency in another. Rock mechanics can help to determine the most effective method of breaking rocks and ores.

As well as the increased needs for water and sewage tunnels to meet the demands of expanding population, transportation tunnels should become increasingly important for inter-city and city-suburb travel, as airways and airport-city roads become increasingly crowded. This will require a lot of tunnelling at relatively shallow depths, where the rock may be affected by weathering, and so need accurate design of tunnel supports and linings. It will also require the further development of mechanical tunnelling machines, with the rock's properties and failure characteristics determining the design of cutters for a particular rock.

Research at the University of Melbourne

A brief summary of research work in progress in the Mining Department will round off this survey of rock mechanics.

1. Development of finite element computer methods for prediction of stresses and displacements around excavations, if rock properties, discontinuity properties geometry and spacing, and natural stress fields are known.
2. Study of time-dependent deformation and fracture of rocks, and development of methods to predict long-term behaviour.
3. Methods of measuring stresses in jointed rock masses—laboratory calibration of instruments in an artificial rock mass within a loading frame, and field testing in mines and tunnels in Victoria, N.S.W., W.A., and Tasmania.
4. Rock mechanics survey and application to design of mining excavations at Kambalda nickel mine, W.A.
5. Study of cutting mechanism of 6 ft. diameter raise boring machine, and development of laboratory methods for predicting drillability and cutter life.



YOU WANNA JUMP ?

pete rafferty

The main bar of the Travellers Hotel was quiet, unusually quiet for a Saturday following a Goldfields' payday. Strange, thought Trevor, strange indeed. The clock in the town hall tower struck twice,—obviously the half hour he reasoned, for even Kalgoorlie hotels would be shut by two a.m. The day had been a complete write-off; he was exhausted, annoyed, subdued but felt somewhat relaxed. Much earlier he had switched off his inbuilt timing system, yet now was curious to know the hour. Nine-thirty he guessed.

Glass in hand, he wandered through the battered swing doors to the street. The luminous dial read ten-thirty. Good, he congratulated himself, time was passing faster than he had expected. From the row of power poles in the centre of Hannan Street incandescent bulbs lit the roadway. He noted too, that no two poles stood at the same angle. Quaint, Trevor mused, yet it appeared to suit the colourful nature and history of Kalgoorlie. In the few weeks he had been in the area Trevor had developed a liking for this strange town. He tried to visualise Paddy Hannan riding through the scrub seventy-six years ago, to picture him panning silently, deliberately and to see his excitement on discovering the first minute nuggets of gold.

The street, too, was quiet. To Trevor this was welcome peace. On the bar, a fresh pot was waiting. Peter, Gerry and Bob were playing darts, their gloom apparently forgotten. All three had come from Melbourne and were forced to take surface work employment at Kambalda, site of the glamorous nickel strike. The engine of their ute had suffered a cracked head near Kalgoorlie. The pub crawl had evolved earlier in the afternoon when jack-of-all-trades Trevor had diagnosed much more serious damage. Brian, a well built Liverpudlian, and surface driller at Kambalda was chatting with a grey-bearded prospector. On Brian's left cheek was a three inch scar, a memento of terrorist knives and military service in Aden.

Trevor ordered another round and headed for the toilet. A naked electric globe shone dimly in the courtyard. On a rubbish tin under the wooden stairs a drunken Irishman sat hurling obscenities at passers-by. From the darkness beyond the rear gate a dishevelled aboriginal slouched forward. There was purpose disguised in his shuffle as he moved to intercept Trevor.

The aboriginal transfixed Trevor with eyes that shone blood red. Dim light reflected from the beads of perspiration on his full-blood brow. His breath betrayed, as he moved closer, much alcohol consumed.

Since coming to Kalgoorlie curiosity had been pricking Trevor to discover more about these fringe dwelling people, these indigenous Australians, often seen wandering in the streets. Trevor lent the full-blood a receptive ear. Without a word, in a mood of quiet acceptance, he awaited the aboriginal's approach.

In a nonchalant tone bespeaking a history of refusals, he unashamedly begged of Trevor,

"Listen, mate, you wanna buy me some plonk?"

Obviously this man had lost his "rights" through alcoholism and was not permitted to drink in hotels.

"Youwantsomeplonk", echoed Trevor.

"O.K., wait here!" Trevor turned and strode back into the bar. He returned with a glass of Hannan's Lager. With hand outstretched, the aboriginal took the glass and swiftly, silently consumed it in a flash.

"No, no", he added promptly, returning the glass.

"Not enough. Go buy me a bottle", he ordered.

Enjoying the progress of this somewhat mild drama, Trevor dismissed the cost of a bottle and returned to the bar. The aboriginal had not moved. Passers-by seemed to notice not. An aboriginal woman appeared in the gateway, Before her she wheeled a battered pram. One wheel, grotesquely buckled, bumped forward on the concrete pavement. Two urchin children clung to her tattered dirty frock. In their hair were unmistakeable traces of fairness. The whites of their eyes were attractively large and clear.

On his return Trevor handed the bottle of ale to the beggar, yabbering concernedly in dialect to the woman now beside him. Furtively she snatched the bottle from him and hid it under the mattress in the pram. The sleeping baby did not stir.

"No, no, not enough. Go get a big bottle of Stoneyfell", demanded the full-blood, realising the generosity of his benefactor.

This time Trevor paused. Stoneyfell was $2.50 per gallon. The beggar had made no offer to pay for the wine. Thoughts passed swiftly.

"Well," Trevor mused to himself, "I may as well write off the cost of the bottle as the price of getting to know some aboriginals, and drink some of my own plonk doing it."

In the bar once more, he selected a gallon of port. He dropped the change into his pocket and handed his wallet to Brian lounging sombrely over the bar.

"Here, look after this for me will you Brian. I'm going to drink plonk with some aboriginals".

"You're what!" exclaimed Brian. "You're daft mate" but he knew better than to question Trevor's decisions.

"When will you be back?" asked the driller.

"No idea." Trevor shrugged as he backed through the swing doors and disappeared.

Brian's quizzical look faded quickly; he returned to pondering the rings of froth in his glass.

The aboriginal's eyes shone brighter still as he spied the flagon of Stoneyfell.

"Right, where can we go to drink this stuff" asserted Trevor, retaining the bottle under his arm.

"Where to?" The taxi driver lit a cigarette. Trevor turned to the nameless aboriginal crammed in the back seat with his family. The efforts of the day and the alcohol had left Trevor somewhat indifferent and he permitted events to run their own course.

"To the pepper tree" demanded the full-blood.

When the taxi driver did not ask "which pepper tree" Trevor's suspicion was aroused at the use of the definite article. However, he did not bother to question the aboriginal. Being a stranger to Kalgoorlie, Trevor memorised—as a precaution—the route taken by the taxi, taking care to note specific landmarks illuminated by the headlights.

When the taxi stopped a few minutes later, Trevor knew they were in the North Kalgoorlie diggings area, near Mount Charlotte where Paddy Hannan first discovered gold. The full-blood alighted. Trevor followed. Without a word spoken, the taxi continued with the family. Several hundred yards distant the taxi stopped at an isolated ramshackle dwelling outlined dimly by the headlights.

Beside the dirt track a solitary pepper tree, *the* pepper tree guessed Trevor, stood in an expanse of uninhabitated ground. In the darkness he could recognise the familiar shapes of knee-high saltbush and blue bush.

"Anyway, my name is Trevor. What's yours?"

"Me Tommy . . . Tommy Smith".

Tommy folded up and sat aboriginal style on the gravelly earth. Trevor imitated the style and found the posture surprisingly comfortable.

Trevor threw away the stopper and Tommy took the bottle first.

"Where do you live Tommy?"

"Over there, where there is light".

"What do you do for a living?"

"Work for the Railways."

A falling star distracted Trevor's attention.

"What do you do for the Railways?"

"I work for the railways in Menzies."

"But Menzies is 80 miles away!" Trevor exclaimed.

"My wife, she's a Sambo; we come here to see her people."

"How do you manage to live, what do you do for money? Do you work here in Kalgoorlie?"

"Government; Social Services."

"You mean you live on unemployment benefits?"

"Yeah, that's right".

"How much do you get?"

"Thirty seven dollars fortnight; easier than work."

Trevor's anger arose momentarily. This lazy bastard received as much from the Government as he paid in tax. He wondered, as he calmed down again whether the benefit was just because he was black, because he was too lazy to work. (Why, mused Trevor, the aboriginals needs are so different. Basically he needs food alone to stay alive and $37 goes a long way). Anyone would be a fool to work if he was satisfied with this form of existence *and* received $37 a fortnight from the Government.

Tommy's face was indistinguishable from the blackness of the night. Stars appeared, disappeared behind his head as he leaned from side to side. The night wore on. Port warmed in their hands and was consumed. The conversation continued.

"Do your kids go to school, Tommy?"

"Albert; he go to school in Menzies but not here. Books are in Menzies."

"You mean he is not going to school?"

"No", replied Tommy, "Not here!"

"How come?" Trevor probed.

"He's not happy. He does not go to school!"

"But don't you see that if he goes to school and has an education he can work in a good job and be better paid?"

"Naw", drawled the aborigine, "He sees me happy. He wanna be like me."

"What do you do during the day."

"Sit under a pepper tree, do nothing; sing, drink. I be happy. Albert wanna be happy like me. Not happy at school!"

Trevor realised there was no point in attempting to raise issues; he saw that the aboriginal was happy and had no desire for material things. He even envied the simple philosophy which could give these people so much happiness. He was sad, too, to think that no price could provide such happiness in his own way of life. Tommy passed the bottle. There was a lull in conversation.

"Listen" Tommy began, and paused; his tone had changed completely. Trevor anticipated a change in topic of conversation.

"Listen, mate" he repeated, "You wanna jump?"

Suddenly the unexplained loose ends of the evenings events were explained; why the aboriginal had not offered to

pay for the wine; why the taxi driver understood without question the location of *the* pepper tree; etc . . .

It took Trevor half an hour to explain that he was not there for the sake of black prostitution, but for the sake of being Tommy's friend, to meet his family if possible, to get to know some aboriginal people.

To a man who had often before sold his wife this was strange—he could not comprehend that this white man was different.

Tommy accepted rather than understood. The friendship developed and Tommy warmed increasingly.

In the darkness beyond visibility the women could be heard approaching. Their yabbering in dialect was frequently interspersed with Australian profanity.

"Listen Tommy" Trevor began, tiredness and alcohol now taking full effect.

"I want to see you tomorrow to see more of your people. I'll come and see you tomorrow at ten o'clock under this pepper tree."

Tommy, too was tired, and seemed not to comprehend the concept of time.

"When the sun is up there, I'll meet you under this pepper tree", explained Trevor with arm raised eastwards.

"Here" said Trevor, amicable with booze and backing his judgement of trustfullness in Tommy.

"Here, take my watch and I'll see you at ten o'clock!"

Again he seemed not to comprehend, but responded with a new dimension of warmth and trust, as Trevor handed him the watch.

Suddenly, "You come and sleep with me" demanded Tommy's sister-in-law, a woman in her forties, fat and unkempt. Her face was covered lightly with grey whiskers.

"I just want to sleep" Trevor did not feel like walking three miles to where the boys were staying and hoped that he could sleep in the house, on the floor if necessary, but not with that whiskered woman.

The party adjourned to the house. Tommy and his wife disappeared. Trevor followed the whiskered woman into the darkened house. Floorboards creaked, snoring sounds arose from the floor of the first room and appeared to come from all directions of the house as well.

An elderly man appeared in the hallway, and yabbered angrily in dialect with the woman.

"Aw, shuddup, grandpa; get back to your room!"

"Wha you bring dis bloody white man here for?" his high pitched voice displaying disapproval.

Grandpa attempted to push Trevor out and a shuffle ensued; the house began to awaken. Voices were raised, and two men appeared.

"Get him outside, Uncle Jacob", screamed Grandpa, picking himself up from the floor.

Trevor attempted apologising. To no avail. He back pedalled from the house, Uncle Jacob on his toes; he realised his error and his danger and attempted to Pacify Uncle Jacob.

Tommy was nowhere in sight.

Uncle Jacob would have none of the professed friendship. Suddenly a torch lit the scene; Trevor spun around; a coarse Australian accent came from behind the beam and two figures were outlined against car headlights.

"What's going on here?"

"This fella make trouble; you take him", Uncle Jacob expressed relief. Trevor's bewilderment ceased instantaneously . . .that gruffness, the outline of peaked caps, the torch . . .

The Kalgoorlie goal was indeed quiet. The town hall clock struck once. But time did not matter to him any more. "O.K. turn out your pockets, take off your shoes".

Trevor complied, trying to disguise his somewhat drunken state with deliberate actions.

Name, Occupation, Address. Further questions followed.

"What were you doing in North Kalgoorlie" rasped the double striped cop.

"Getting to know some aboriginals" was the reply.

The cop sneered, making all attempts to display his opinion of the aboriginals.

"Can you read and write?"

With indignation instantaneously aroused, Trevor retorted,

"Listen here, I can probably read and write better than both of you guys put together!"

Too late. Treatment was much rougher.

"Get in there and join your bloody black brothers", ordered the offended constabularly.

A boot from behind sent him sprawling into the cell. The iron door slammed shut.

The cell was dark, hot, airless and stank. The floor was strewn with the Saturday night drunks, some black, some white. From each body came a characteristic snore, the sum total of which reached nightmarish proportions.

Being the last to enter the cell, there were no spare blankets or mattresses available. Trevor found himself lying on the concrete floor in the only remaining space, adjacent to the waste bucket. The stench was pungent. But exhaustion defied all discomfort and rolling onto his shoulder he promptly fell asleep.

Nearing midday both Trevor and Peter Morrison (who provided bail) stood on the summit of Mt. Charlotte overlooking the barren and devastated North Kalgoorlie diggings. Silently, and several yards ahead of Peter, he began to descend the hill. His thoughts flashed back to the events of the night before. His shirt chafed his right shoulder blade. The rough concrete floor of the gaol had exposed new skin. His stomach protested spasmodically and his system felt generally ill. And there was his watch. It depressed Trevor when he forced himself to accept the worst. His excursion among the aboriginals had cost him much more than he had expected. But on the other hand, he mused, he would joyfully laugh the experience off if he retrieved his watch. In the distance under a pepper tree they could see groups of aboriginals. Hoping to find Tommy among them Trevor made his way down-hill towards the trees. As he picked his way over mullock heaps and around disused open shafts one of the group rose and began walking to meet them. On his full-blood face was a tremendously heartwarming and honest smile, in his hand sunlight glinted off a chrome plated watch—

Tommy's first words were

"You didn't think you'd get it back did you?"

Trevor was overjoyed at having found the man so trustworthy and honest, and when Tommy suggested "Hey let's go buy some more plonk", the three men agreed instantaneously and set off again to Kalgoorlie.

C.A.R.E!

Computer-Use And Retraining of Engineers

Dr. Brian Thompson

To those outside their respective professions, engineers and mathematicians must probably seem fairly incompatible playfellows. Although both groups have traditionally been much, (and for engineers even mainly), involved in the development and use of the science of mechanics, so that one would expect them to share many common interests at least in this large field, nevertheless their approach to practical problems is known by most people to be conditioned by the type of divergent goals that would tend to make them uncomfortable in each others' workshops.

By and large the mathematician is interested in practical problems only in order to extend his and the world's repertoire of what are commonly but loosely termed "mathematical methods" Confronted by a problem—for definiteness let us say it is a problem in mechanics—he will immediately try to conceive a mathematical analysis of it, starting from mathematical-physical laws over which he and the engineer would certainly be most likely to agree. But, having once set up the problem in the form of equations he is then most likely to lose interest in it from a physical point of view in order to concentrate on the mathematical methods to which it gives rise. If his analysis is baulked by difficulties it is quite in order for him to *modify the original* problem so as to make the mathematics tractable, and provided the modified problem still leads to new and interesting mathematics he can publish his solution in the learned journals and thus earn his dinner.

The engineer seldom has the liberty to modify problems in this way. The method of solution must still be mathematical, but permissible adjustments can only be effected as modifications in the attainable accuracy of his answers, the original problem being immutable. Since large error estimates must be compensated by generous but mostly inefficient safety factors, he is anxious to acquire any new expertise the mathematician can offer to him; all too frequently, however, consultation with his mathematical brother reveals that the latter indeed knows his problem well but only possesses good methods for vastly simpler cases of it.

Of course, if the problem is an important and general one neither party can long remain satisfied with this state of affairs. Each in his own way continues to seek a "breakthrough" and from time to time these do occur, originating with one group or the other, and subsequently both groups will take them up and develop them in fresh directions.

"Breakthroughs" *may* appear in the form of powerful new theoretical methods, but they can also be associated with nothing more apparently exciting than the production of a new set of tables—such as, say, the zeros of a new order of Bessel function—or new, more accurate solutions of a specially important equation.

A really great contribution to technology that occurred just after the second world war was the publication of a number of very extensive and accurate new tables of various important mathematical functions by the National Bureau of Standards in U.S.A. and the National Physical Laboratories in England, copies of which are to be found in every respectable university library today.

At the time when these were produced only mechanical desk calculators were available and vast labour and personal dedication was required to produce them. The human genius that went into the basic calculations was actually small compared with the bulk of largely repetitive processes which were the major requirement, but considerable genius went into the methods of checking them and ensuring their accuracy—as is often the way.

Today these repetitive processes would be done by computer in a miniscule fraction of the original time spent on them, but it is doubtful whether many of today's operators would know or appreciate how to make checks equally as careful as those applied by these older teams to verify the validity of their results. This is definitely to our loss, and we will return to this point at a later stage of our discussion.

Although these were notable achievements, they could not, of course, be relevant to *every* numerical problem, and in the middle 1940's it became clear that an earnest attack on two separate major areas of quite a different type could no longer be deferred—namely, the numerical solution of large systems of simultaneous linear equations in many unknowns, and numerical solution of the non-linear partial differential equations associated with high speed flight. Many other problems were also urgent, but the need for a breakthrough on these two was recognized as the outstanding problem of the day.

One day while at my work . . .

When the required breakthrough was achieved it proved to be largely the brainchild of one man—the late Dr. John von Neumann—and the solution was partly mathematical, partly technological. The key dates are easily located: in January 1947 the ENIAC automatic programme computer was inaugurated at Harvard, and the notion of *programming* its calculations was von Neumann's, while in November of the same year there appeared the now classical paper "Numerical Inversion of Large Matrices" by von Neumann and Goldstine (Bull. Amer. Math. Soc. 53, 1021-1099 (1947)) covering the first problem in much detail.

Since that date, technological development has been so rapid that virtually all universities, and many other research and design establishments, now possess highly sophisticated *and mass produced* automatic programmed computers as a matter of course; and two new specialist scientific disciplines have arisen—Numerical Analysis, and Computer Science. So great, indeed, has been the activity of the "computer age" that even those of us who grew up before it have some difficulty in recalling former times.

Alongside these two specialist sciences—and of maximum relevance to our discussion—there has also come into existence a hybrid preoccupation. It has no official name, but we shall find than an apt enough title for it is "Computer Use".

This latter activity already has a history that is by no means a happy one. Partly the difficulties that have arisen are the natural "growing pains" of a new technology, but many that could have been forseen were not, and still are not being, forestalled. Our concern here will be to examine the particular problems that have arisen in universities, expecially in the physical and engineering sciences, and if possible to conceive ways of overcoming them. Not unexpectedly, we shall discover that the common root of all of them has been under-estimation of all that a computer, despite its enormous calculating capacity, leaves its human operator to work out by himself.

The use of computers, as might be expected, began at the research level, and has only flowed down into the undergraduate segment of the universities in quite recent times. Strangely enough, in many cases it did not begin amongst the experienced and practised research workers who formed the staff of university departments but, rather, amongst their research students.

Now in general it can be said that the supervisor of a research student is acting very irresponsibly indeed if he allows that student to undertake a research task that he could not confidently undertake himself with a very high probability of success.

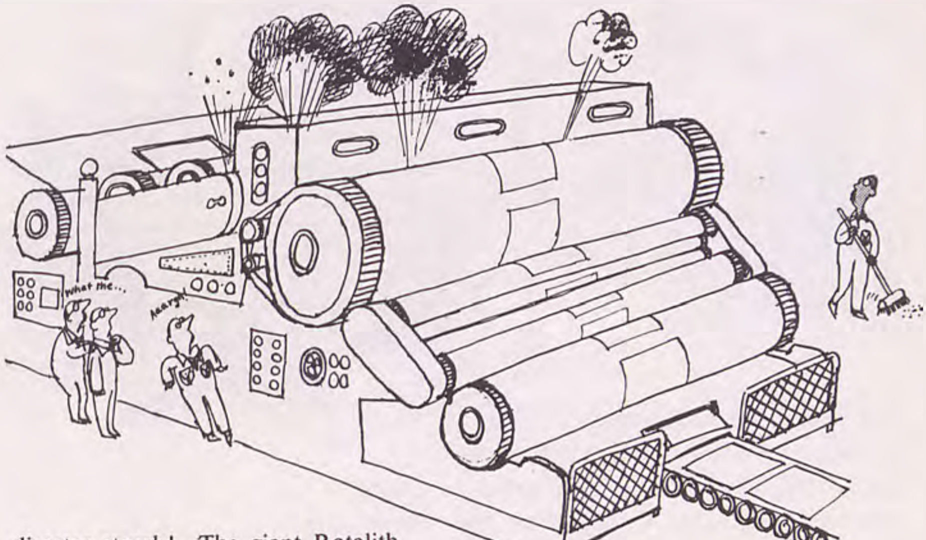
The advent of computers, however, found both students and supervisors equally uninformed and inexperienced over their use, and unable in particular to assess realistically the order of magnitude of the labour required to get any given problem "on the air". Computation departments would often have been competent to give advice on this latter issue, but their staffing was much too small for them to set up as a general consultative service to their respective universities and they soon learned to protect themselves by using a well-known technique which the Bible itself (with only a little help) supplies: "an unhelpful answer turneth away questions!" (cf. Proverbs 15:1).

Ph.D. students were thus sent off by their supervisors to learn computing, as likely as not with only a crash course in FORTRAN (or other such language) by way of formal training to help them, and these unfortunates were then expected to pick things up as they went along, whilst officially they were engaged upon a special research task that had already been set for them. By the time this reached the computer it usually proved to be a problem of really very considerable scale and mathematical difficulty, notwithstanding the fact that the student's undergraduate training had not been primarily mathematical, and had in any case contained no segment in numerical mathematics.

In the "normal" course of events such students often buried themselves in their Departments and tried manfully to concoct as their first real programming effort a large and elaborate computation, whose instructions alone would fill several pages of foolscap, the preparation and debugging of which might well, owing to its complicated decision logic, occupy the time of even an experienced programmer over a period of weeks or months.

In this situation many students laboured for periods of up to one and two years before they could convince their supervisors that the task was really beyond them: unfortunately some even committed suicide reather than own up to this highly obvious fact.

Let it be stated firmly, here and now, that the production of accurate and relevant numerical results bearing on any significant scientific problem is a *job of skill,* which should only be reasonably assigned to a person who has been trained to do it through adequate preparation in the subject of numerical mathematics *in addition to* adequate elementary experience in the writing of programmes for the local machine.



. . . disaster struck! The giant Rotalith came to a shuddering halt.

A "crash course" in FORTRAN of the type currently furnished by computation departments does not *remotely* meet this specification, and a "graduate" of such a course is no better equipped to submit jobs to the computer than a man turning up at a car trial with only a steering wheel is equipped for the road. Such courses are appropriate only to people with plenty of experience of numerical procedures who simply want to transfer from desk calculators to an automatic machine.

People may well wish to reply to the last remark that *they* did not possess all this experience, but their programmes "ran". Very often this is just the trouble: there are many invalid numerical procedures (whether they are invalid from initial bad choice or faulty programming is irrelevant) which will produce sensible-looking answers with the most satisfactory rates of convergence and yet these answers are actually wildly wrong. Consider for instance the example $I = \int_0^1 \cos 64x\,dx$ to be found by Simpson's rule. A common check that integration by Simpson's rule has given an accurate enough answer is to double the number of steps, and then see if the same answer is obtained (within an acceptable tolerance). If we use 4, 8, 16 or 32 steps in *this* example we shall get $I=1$ each time, but the *right* answer is $I=0$ (a graph shows why).

Prof. L. Fox, who is head of the Computer Laboratory at Oxford University has publicly suggested that for not 20% of the computations done on that university's machines would he accept the accuracy claimed for them, and that as many as 40% probably contain gross errors (ie. errors with magnitude above 5% of the correct answers). Since in many cases it is just the programmes which utilise the greatest amount of computer time that contain the worst errors and most inefficient procedures, it is hard not to be depressed by Prof. Fox's gloomy estimate.

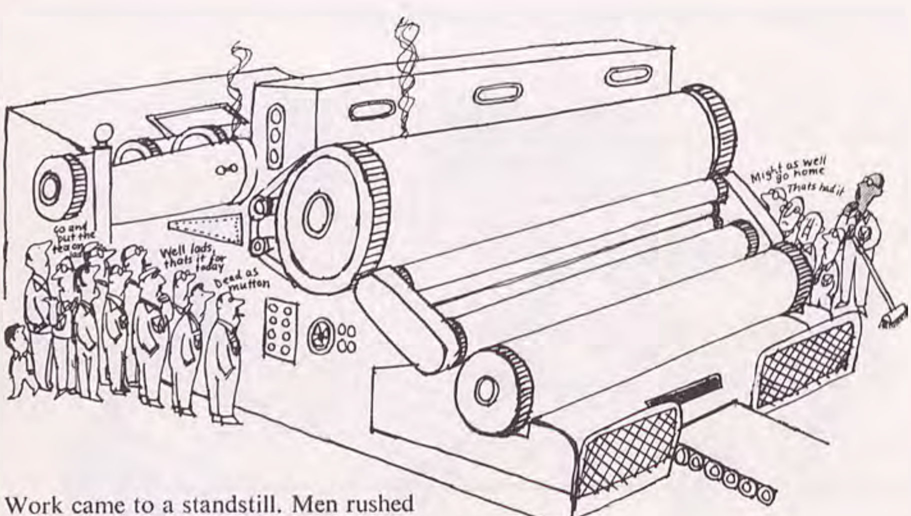
And yet the techniques of proper error analysis and assessment are not grossly more difficult than other parts of numerical mathematics. They were well known to the workers at the N.B.S. and N.P.L. who produced the great tables of the 1940's, and have even been improved upon in recent years. Fox and Mayers' book "Numerical Methods for Scientists and Engineers" (Oxford, 1968), for instance, gives an excellent treatment of these matters, and as well it is an excellent general-purpose account of numerical mathematics.)

It is rather difficult to suggest specific checking methods in a general discussion, but certain standards always apply. One of these should be obvious enough once started, but it is very frequently transgressed: Every calculation offered up for scientific acceptance must be completely reproducible by the worker concerned, and formal checks of its veracity should be not only possible, they should also have been carried out and reported on.

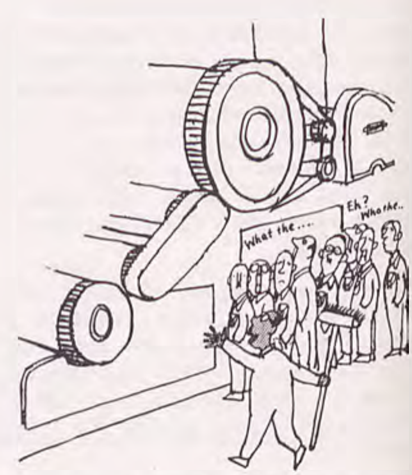
Complete veracity and reproducibility can only be achieved by designing safeguards into all programmes, and generally speaking such designs will add to their complication, particularly in respect of the number of branching points exhibited by the flow diagram. This is one good reason why the programmer should not be stretched to his limit by the basic problem itself: if the basic design is too hard for him he will lack both the energy and the expertise to design safeguards. The remedy, of course, lies in adequate numerical education and realistic choice of research problems.

How can we build in safeguards for reproducibility? First of all, it is absolutely vital that sufficient information always appear *on the printed output* of of each run of a programme to identify it completely from every other run undertaken either during development or in later use. (This can easily be achieved in FORTRAN by beginning the first deck with a comment card naming the programme, the date and the serial number of the run counted from the very first test. This automatically appears at the head of the programme printout.)

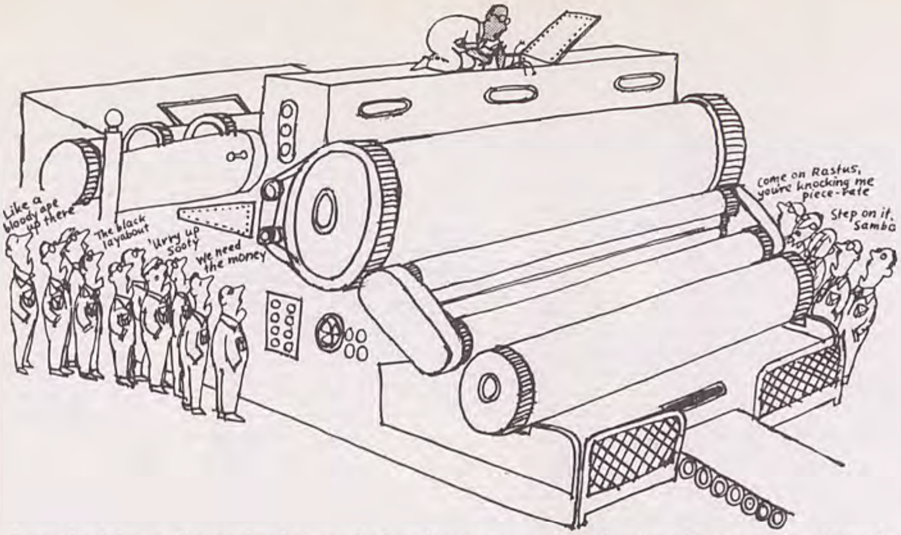
Secondly, all data fed in must be available to the programmer for checking even months later when the card decks may have been dispersed. For small numbers of data cards this should be done through a provision for immediate printout of the data as soon as it is read in, *using the same FORMAT specification as was used for inputting* (Blatt calls this "echo checking"). If the data cards have been copied from a table, then this echo must be reconciled with that table *in the book from which it was first copied,* and after the first run it must be ensured that *every separate single figure* of this output agrees with the original table. Data cards should also bear a *unique serial number* so that



Work came to a standstill. Men rushed to the machine, trying desperately to get it started. But all in vain. The men stood there, grim and silent, thinking of the money they would lose. (Some of them had houses, wives and children to think about.)



I could stand the suffering of my comrades no longer. "I know what's wrong," I cried, rushing forward.



I worked in a silence broken only by the encouraging shouts of my workmates. A few minutes later, the mighty machine started. The day's production was saved!

Yes, it's certainly an exciting life as a factory sweeper—especially when occasionally you get a chance to use your higher degrees in science and engineering.

in future runs they can be tested for wrong sequence (as might happen if they were dropped and reassembled in wrong order). An out-of sequence card should be made to cause immediate job-termination.

Once a programme has been run, it is a good idea to write prominently on the output document a full commentary on its meaning for the whole project. Naturally this should be done as soon as possible after the output is obtained. It should state, at the least, whether the run was successful, if the data was suitable, whether the results are worth retaining, *whether the printout contains any systematic error* and if so whether it will be run again or whether the error is just a wrong power of 10—which can be corrected by eye.

If the results are to be retained, one must *resist* the temptation to pencil or ink in modifications for the next run on the printout of the coded programme instructions themselves. If these are defaced then the reproducibility of the current results is in question. A photocopy is cheap and can be defaced at will.

Library subroutines, particularly from non-local sources such as SHARE, cannot always be just "plugged in" to a programme. They should always be documented *and the author acknowledged* in publication of the results. This is only in part scientific courtesy. The reader considering the results should be told when "foreign" material intervenes in the work, and be able to decide for himself if its source is reputable. One must also make sure exactly what the borrowed cards will do before running them. Indeed, I once had an eigenvalue SHARE library subroutine which without warning commenced by printing out the whole store map, and generated 3000 lines of printing to do it!

A final word of advice may be given while we are discussing these "organizational" matters, although it is not connected with safeguarding techniques. It is easy to produce ideas for modifying a programme already under development, but many people still ask me, "when you have an entirely new programme to write, how do you ever stop chewing your pencil and get it under way?" This is a problem every beginner has experienced, but fortunately there is a simple answer. *By designing the output*. Personally, I always begin by planning the expected printed page in complete detail, headings and all, then and only then do I attempt to write up the flow diagram *which should always precede coding*. Next I sketch out major loops, and consider the possibility of shunting some of them off in subroutines that can be designed and tested separately. The logical decisions involving branches and the minor loops they entail follow this, the general tendency being to work back from the end to the beginning. Lastly I code the programme, working outwards from the innermost loops until last of all I get to its beginning. This sounds bizarre, but really it is only saying that you must decide what you want before you can work out what is needed to get it. Moreover, it works!

In this article I have tried to examine some problems of contemporary computer use in the context of which have some experience, namely the engineering and physical sciences. I have also tried to avoid dealing with areas that are adequately treated in the standard textbooks, and this may explain to the experienced reader why some of his pet ideas have not been discussed.

My main theme is the proposition that this field of activity needs proper training if it is to be worked on effectively but I am not suggesting thereby that specialist programmers should be the sole computer users. It is entirely possible to educate every engineer and physical scientist in the basic numerical mathematics necessary to enable him to do most of the jobs that come his way, and—even more important—to know when and from whom to seek advice when problems get beyond him. I hope we will soon be doing it!

BRIDGE SPANS DARKNESS
an example in organisation

While Berlin slept, fifteen men solved a traffic problem.

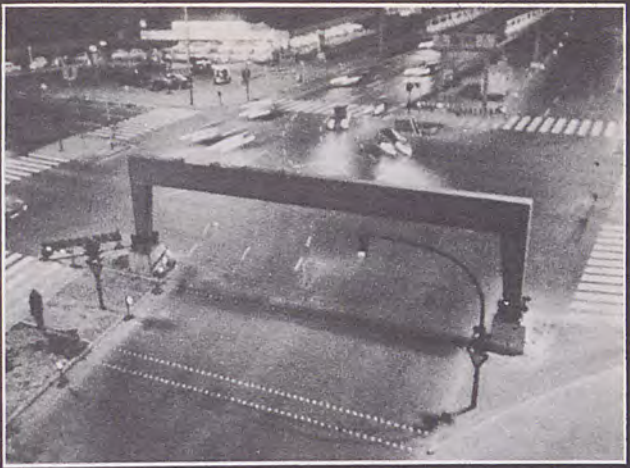
Kurt-Schumacher Square, (comparable to St. Kilda Junction) one of the most congested spots in Berlin, handles 65,000 vehicles per day. Frequent accidents, long delays and frayed nerves finally resulted in a public demand for an improvement in the capacity of the junction. The City Senate found a solution; a steel freeway over the junction would ease the congestion. $A650,000 from the city coffers purchased for Berlin a 970 foot long prefabricated steel bridge.

The approaches and intermediate portal frames were erected beforehand without disruption to the traffic. Overnight, **in 6 hours,** fifteen riggers completed the task.

In ten years the bridge will be phased out and **sold** when more comprehensive redevelopment and new traffic planning will have taken place. This type of bridge, because of the nature of its design and fabrication, can be used in other situations to solve similar problems.

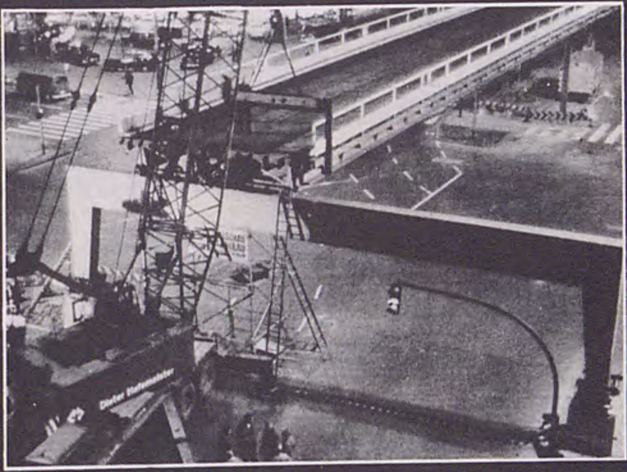
3.54 a.m.

2.30 p.m.



1.00 a.m.

1.40 a.m.



2.27 a.m.

7.12 a.m.

2.30 p.m.

The intersection is loaded with afternoon traffic. A large number of vehicles make diamond turns at the intersection.

The southern approach and a portal frame are visible; the frame is wider than the bridge to allow this passage of cars underneath.

1.00 a.m.

The last cars pass the intersection before it is closed for placement of the bridge sections.

1.40 a.m.

Two 80 ton mobile cranes raise the first section into position. Floodlights illuminate the scene. A single man directs the whole procedure. A wrong hand direction could lead to catastrophe. During the night many Berliners watched the birth of the bridge.

2.27 a.m.

130 ft. of bridge, 23 ft. wide are in position. The sections are completely prefabricated, including guard railing and bitumenised surface.

3.54 a.m.

(See photograph, left-hand page); The third 60 ton section is in position. The fourth, the right traffic lane, is just moving into position on a low-loader.

7.12 a.m.

Completed and operational, the bridge carries its first traffic. The expected estimated capacity is 20,000 vehicles per day.

Comment:

A similar radical solution could well solve the Sydney Road bottle-neck here in Melbourne. A series of portal frames and prefabricated concrete deck slabs could be erected over the adjacent Coburg, Fawkner railway line from Park Street, West Brunswick to Fawkner. This could be a much cheaper solution than the expensive alternative of widening Sydney Road.

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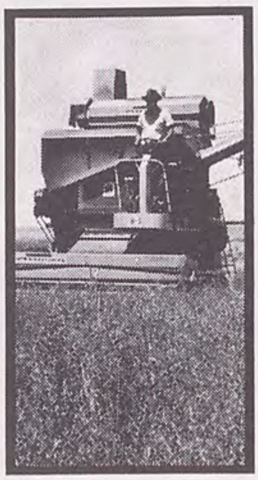

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President's Report

The formation of this committee in August 1968 was somewhat unique in the history of the M.U.E.S.C. The lull in club enthusiasm and activity was due largely to the existence in 1967/68 committee of two divided and somewhat opposed factions. The failure to communicate and the lack of mutual understanding in the absence of directed, coherent leadership denied integrated organisation in most activities and hence led to a rather inactive and unsatisfying year. The end result was an all time low in the level of club enthusiasm and image, the 1967/68 committee were somewhat glad to be relieved.

Hence the present committee, comprising largely of first year students admittedly naive, yet wildly enthusiastic, stood largely unopposed.

The initial, overriding problem was combatting a general lack of interest in club activities among the Engineering students; the plan of attack was to aim at providing something of interest to as large a portion of the student body as possible.

The committee this year has also become aware that S.C.I.I.A.E.S., that notable bastion of purity, is no longer an excuse for, or reason for irresponsibility as in previous years. Among its aims, the Club attempts to improve facilities for the study of Engineering eg: by fostering staff/student relations and providing feed back on curricula etc!

The nature of S.C.I.I.A.E.S. is returning to the original idea of being a lighthearted outlet for responsible exuberance, eg: trike race. There is little point on the one hand fostering communication and understanding (for the benefit of the students) with Faculty Staff and on the other hand earning ourselves their disrespect by perpetrating irresponsibility under the lily flag.

Generally, the year has been successful, marked largely by both individual and collective enthusiasm, which in turn has increased the level of responpse by club members.

"By Jove! A customer!"

SUMMARY OF ACTIVITIES 1968/69

Freshers Camp: Organised by Peter McLure, held at C.E. Boys Camp, Frankston again; included a tour of the A.C.I.-Fibre Glass plant at Dandenong; featured talks and discussions by members of staff — Professor Hargreaves, Professor Whitton, Mr. Rotenburg, Mr. Olver, Mr. Bamford. Gratitude is extended to the staff who gave their time and wisdom and thanks also to later year and graduate students for their assistance. The camp is definitely a most valuable introduction to freshers, with the accent on getting to know and communicate with the staff.

Orientation Week Dance: An excellent dance; highly profitable; full marks to Bruce Cornwall.

Films: Lunch time films are always well patronised; screened fortnightly; Ray Moon found that films containing sex, violence, suspense and sex were most popular. Technical films have been well appreciated too.

Quo Vadis: printed, edited by Ken James, stapled by Pete Dumble; appeared regularly, entertaining and occasionally informative. Difficult to maintain a good flow of student contribution.

Miss Engineering:

Full marks, too, to Brian Jackson (working at what he knows best) who happily gathered girls for the contest, for his ingenuity raising the entrance fees (lotteries, licensing lecturers etc.)

"Yes sir, I just took a fox to the fifth floor!"

Purity Week

Grand Alf—the Wizard of OZ pogoed to Melb. for WUS Week; highlighted the gatherings and enchanted all. Saluted by a white guard of honour; leader of ingenious maiden abduction rag and guest of honour at the Purity Breakfast, Alf was a Wiz. All success attributed to Brian Jackson and his organisational ability.

Trike Race: Ten carloads of engineers met at London Bridge the evening before zero hour; the weather was evil, much spiritual warming was required; the sturdy trike conquered the distance but too much spirit, insufficient muscle won fifth place only—healthy activity.

Symposium A.N.E.S.A. (Sydney—May 1969) 60 delegates attended; a fine piece of work by Jeff Gray for the organisation and also for the $400 subsidy solicited from Industrial benefactors; highlighted by the Gentleman's Dinner, enjoyed by all.

Our thanks are due to:

Lloloma Mining Corporation N.L.	$100
Western Mining Corporation Ltd.	$100
A. V. Jennings (Australia) Ltd.	$50
Broken Hill Proprietory Ltd.	$50
Australian Timken Pty. Ltd.	$47
Carlton and United Breweries Ltd.	$20
Siemens Industries Ltd.	$20
C. V. (John) Holland (personally)	$10
World Services and Construction Pty Ltd.	$10

In addition, Aberfoyle Ltd. sponsored two students for the Symposium.

Barbeque: The End of the year Barbeque held at Domoney Reserve was well patronised.

Visiting Speakers: During Third Term last year a symposium of lunch time speakers elucidated on "Divisions of Engineering"; well patronised by First, Second and Third year students. Further talks on the Australian Economy, Developments at Tullamarine, and Developments in the Mining Industry were also capably organised by Justin Lynch. Further talks are arranged to occur fortnightly throughout term.

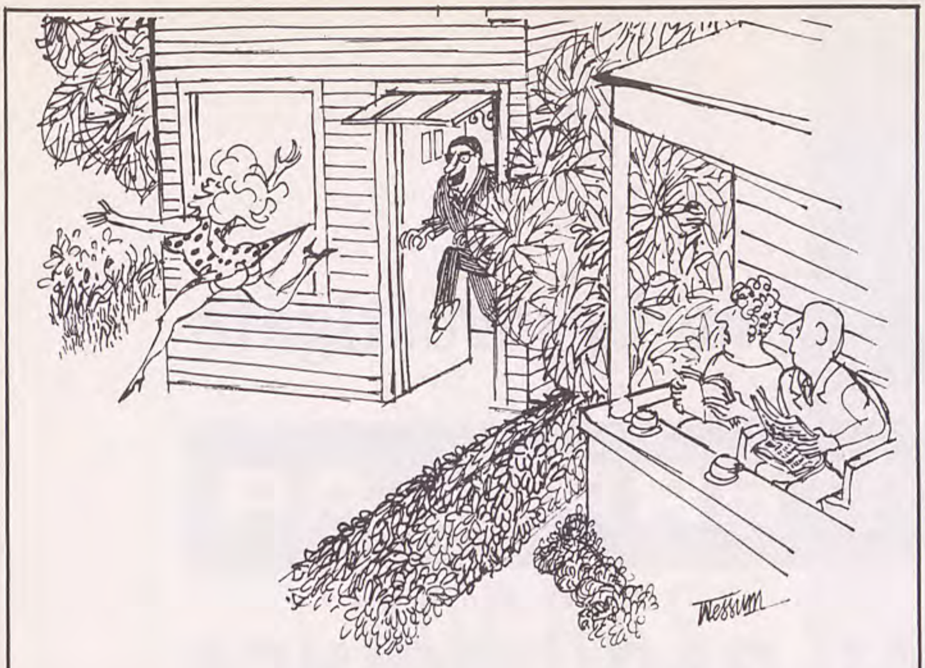
Forum Dinner

A "mixed" forum dinner; attendant celebrities were Professor Whitton and Mr. Vasey. Successful due to the presence of the fairer sex. Congratulations to Max. Ervin and Neil Aplin for their efforts.

In Conclusion:

Further activities currently on the present committee's schedule are the Annual Revue and Ball, a car trial and barbeque.

In conclusion, sincerest thanks are due to all the members of the committee for their enthusiasm, work and productivity, and also to Professor Hargreaves and other staff members who have been most encouraging in their interest in the club.



"I bet she's a lousy cook."

muesc committee

Back Row: Col. Leitch, John Berry, Ken James, Peter Liversidge, John Dunlop, Ray Moon, Brian Jackson, Ian Hodgson.
Centre: Peter McLure, Max Ervin, Alan McKay (President), Neil Aplin.
Front: Chris Adams, Bruce (Man Mountain) Cornwall, Justin Lynch.

Was that the Engineering School?

ROGUES GALLERY

CIVIL

AHERN, Patrick A.
Teed off at the first, June 1948 proceeded to play the outward nine via Pomanae S.S., Snake Valley S.S., SPC Ballarat and AC Kilmore. Arrived at Uni. 1966 on ass followed by strange crowd bearing palms.
Has yet to hole-in-one as he approacheth the 18th, hopes to find much satisfaction at the 19th.
Ambition: Richest pro. on the circuit.
Probable fate: Most educated pro. on the circuit.

AGOSTA, Tony John
Quiet man.
Italian expatirate of 16 years.
Maintains appearance of hard worker but to those who know him better he spends much time at soccer in Park, and at test driving sports cars at the local yards.
Ambitions: Specialise in structural and foundation engineering, to establish consultant practice. Never been past Geelong, raves about travel.

ATKINSON, Dave (Caveman)
Born in a dark cave on the rocky slopes of East Kew in 1945 and is often seen there when not sporting 18ft. cutler on Port Phillip Bay.
Ambition: to circum . . .e the world, solo.
Plays with Jill, footballs, parking meters, and yachts.
Likes: Practising hydraulics in P.A. and Faculty Passes.
Dislikes: Practising hydraulics in Eng. School, Parking cops, Parking meters, Malt Ale.

AUZINS, Andy
Born: 3rd October 1947, Augsburg, Germany.
Education: Strathmore state school, Essada Technical school, University High School and here.
Sport: Avid basketball player. Learning to ski. (snow).
Other interests: Usually shared with a certain young lady with the initials B.B.

BATTEN, David Frank
Born: Wee hours of morn on 3.3.47. Flitted thru' the cordinal, gold and blue to shatter the shop in '65. Lost a year but not the beer between now and then.
Likes: Ros, kidneys, Ros, brains, Ros, Pernod, Ros, white minis, Ros . . .
Dislikes: Parking cops, claret, red minis, beards, and blokes who run around with blonde Poles.
Ambition: To make kidneys and brains compulsory.
Probable fate: To lose his own.

BRAZENOR William John ("The Nose")
Told his first crude joke in 1948 and later decided to do engineering at Melb. to increase his repertoire. Holds the record for most damage in the electrical laboratory during a five minute rampage. Believes in white superiority, turns with free beer, and racial prejudice.
Dislikes: Buying beer, steel designs and morning lectures.
Probable fate: Highly paid street sweeper with Footscray Council.

BUSH, Richard Allan
Found floating in the froth on Carlton can. Took 18 years via Scotch to dry him out. Operates a mini and various women; he feels that a sacrifice in performance from the mini is compensated for by better performance from the women. Destined to become doormate at the house of ill repute—C.R.B.

CARSE, Leo
Came from the STYX of Gippsland, wandered thru' Warragal High and fell into Newman in 1966. Unearthed an insatiable craving for the fruits of this world, but not necessarily of his labours.
A fierce desire to grow apathetic has characterized his efforts.
Well done Leo.

CHOO, H. N.
Came from Sarawak, Malaysia.
Matriculated from Newlands High School.
Interests: Basketball, table tennis, Australian football.
Ambition: To build roads and bridges in the jungles of Borneo.

CHOO, Yoon Seong ("Lucky" Choo)
Arrived in Australia from Malaysia in '64. Entered Melb. Uni. via Taylor's in '66. Tried all sort of living, from full board to College (I.H.) and found them disgustingly unsatisfactory. Got married in '68 and settled down well ever since. Wishes he had done that much earlier.
Loves: Wife and animals (esp. dogs and horses).
Hates: Racists, bigots, snobs, murmurers, and flies.

CRAPPER, Tony
Found in a manger outside the Natimuk hotel sometime in 1947. Early training at Marcellin and entered Melb. Uni. in 1966. Drank his way through Uni., 2nd, 3rd years and hope to get out without repeating.
Likes: All vices known, fresh mountain air of N.Z.
Dislikes: All forms of work, Horsham police, steel designs.
Aims: Prime Minister of Patagonia.

DAWTREY, Brian W.
First seen 13/1/47. Early indoctrination at Strathmore High School.
Likes: Mini Coopers, the occasional bird, bed, sleeping in, the Bombers and surfing (not necessarily in that order).
Dislikes: Work.
Ambitions: Early retirement.

ELLIS, H. R. (B.I.)
Born in Newcastle coal mine—the biggest shaft in Australia. Next conquest was Yallourn open cut—the biggest hole in Australia.
Accepted by Melb. Uni. because of wide experience.
Likes: shafts, holes, Carlton Inn, subsidising the stock market, and his bird, Snoopy.
Ambition: millionaire share-holder.
Fate: C.R.B. engineer for shafts and holes.

EVERY, R. J.
Believed to have been found under the proverbial cabbage leaf at Shepparton on 2nd October, 1947 Received formal education at Shepps. High and that statuart bastion of Methodism, Wesley College. Has been a Queen's resident throughout Uni. career.
Likes: Playing organ, having missed marble ballot.
Dislikes: Work.

FELLA, C.
Born Cyprus 1946. Entered Australia 1956. Went through Fawkner S.S., Fawkner H.S. and finally went through Melb. Uni. Result: Yet Unknown.
Ambition: 7% of $3,000,000 contract.
Probable fate: Get 3,000,000 contract at 7c.
Hobbies: Midnight drives.
Sport: Driving to Uni. down Sydney Road.

GODFREY, Arthur
Uneducated "Street Fighter" gives up the good sport and dives under the thumb.
Ambition: To show a clean pair of heels and get the hell outer here and make much monies.

GOULD, Roger
Poly-unsaturated 25-6-48.
Obtained high protein, low cholesterol education at Kedron High, Brisbane. Pedigreed at University High, Melbourne Uni's only red-haired piano-accordian-playing-vice-president of Anglican Society.
Ambition: Moonee Ponds Forever!
Probable fate: Statically indeterminate court musician to the Bishop of Moonee Ponds.

HADINGHAM, Kevin Frederick
A Unique Structural Form of Predominately Column Action synthesized on 30-6-1948 during post war construction boom. Modifications of design at Reservoir High School. Became statically indeterminate (and thus beyond his scope) in 1965. Currently a roads scholar (with C.R.B.) Walking madly with M.U.M.C. to reduce his effective length and establishing footings for aboriginal land rights.
Ambitions: 1. To fit into an Alfa Romeo.
2. To be able to buy one.
Probable fate: Constructing C.R.B. Superfreeway through middle of Wilsons Prom and Lake Tyres.

HILBERT, T. A.
Born: 13-6-47, Melbourne.
School: St. Bernard's C.B.C. Essendon.
Abode: Essendon.
Future: Indeterminately ambitions.
Ambition: Populate this country with Polish immigrants.
Likes: Sexy blonde Polish Catholics.
Dislikes: Bearded public schoolboys.

HORSFALL, I. C.
Rose from the mire of Scotch College in 1965 to begin a further degredation at the Eng. School.
Likes: Anna, lemon squash, minis of all descriptions.
Dislikes: P.A., Malt Ale, sedimentary claret and parking cops, hair transplants and M.M.B.W.
Ambition: To get a positive handicap and design a battled sandwich.
Probable fate: To marry Anna and have 20 bearded kids.

HOWARD, Eric
Unsuccessdully reincarnated in 1947.
After a spent youth in Warrnambool, Eric arrived at Uni. in 1966 in the hope of reformation. Four years at Newman have effectively dulled his youthful ardour and his efforts are now devoted to a religious attendance of lectures and design sessions.
Ambition: To produce foot deep wheel ruts to Warrnambool by end of year.

JOHNSTON, A. C. (Shagger) B.I. (Hons.)
Popped out of a whiskey bottle in Edinburgh and landed in the Yallourn Open Cut. Has been crabbing in and out of open cuts for 23 years.
Favourite hobbies: Evading cops, falling off the Exhibition Building, copying up lectures while drunk.
Pet hate: Copying up lectures while sober.
Likes: Carlton, Courage, Tooheys, Tooths, Resches, Cascade, Coopers, Swan, Gold Top, alcohol and prewarmed beds.
Dislikes: Nightwatchmen.
Fate: Highly qualified jackeroo or life member of Coburg Clinic.

JORDAN, C. L.
Born Feb. 1948. Attempts at an education were made at a number of schools ending in a year of celibacy at Melb. High School.
Likes: Merrilyn, Mini's Royal Park at night, all blondes.
Dislikes: Work, Blocko's, M.H.T.
Is shocked to the Melb. Harbour Trust as a cadet engineer and will probably sink several wharves before they sink him.

KEARTON, Ross D.
Began existence somewhere in Melbourne in 1948 continued at Strathmore High until 1966 when made grand entrance to Melb. University. Turned to gambling by overabundance of fairer sex in Eng. faculty. Now lives by goodwill of various bookmakers. Drives EJ Holden in increasing fear of repossession.
Interests: Golf, Gambling (compulsive), N.S.W. football, golf clubs, hiking (24 hour walk after dark).
Dislikes: Army, Liberal Governments, Bolte, first 2 years of Eng. course.
Ambition: To build a series of racecourses in Vietnam.

KHOO, Kim Sin
Arrived from Malaysia in 1965 Matriculated in Northcote High. Four years here makes him feel like doing nothing. Will disappear as soon as possible.
Dislikes: Pie.
Likes: Steel designs and football.
Home address: (in case you drop in) 49 Hugh Low Street, Ipoh, Malaysia.

MACKIE, R. J.
Excreted 18/5/46. Exiled from Tasmania in 1960 and after 5 years hiding at Geelong Grammar decided to venture into the world; arrived at the shop in 1965. Spent much time up North for 3 years but has since decided North is too far away and lives mainly in womens, JCH.
Likes: Hondas, women, beer, skiing, golf, balls.
Ambition: To investigate in Chinese the theory and preactice of elections.

MEILNIK, Joseph M.
Born between humps of Camel. 12th April 1947—Tel Aviv, Israel.
Arrived in Australia January 1952.
Matriculated 1964—University High.
Interests: Birds, booze, sport, records, guitar, fast cars.
Ambitions: To design a system of metropolitan freeways to permit 60 m.p.h. plus speeds. (Naive idealist, what!).

MIDDLETON, Ian James
Born in Melbourne in 1947 and matriculated at Camberwell Grammar School. Started Melbourne University in 1966 and obtained a C.R.B. Cadetship in 1967.
Interests: Transport Engineering, hockey, cars, music, C.M.F.
Ambition: To travel overseas to study transport problems.

MILES, Chris
Fast developing naive idealist. A Babe of the bush, 19-10-48. A resident of I.H. for four years; notorious for passing exams without work.
Dislikes: Boongs and Racists Engineers.
Likes: Union Council, engineering block votes.

NG, B. H.
Born in 1900 still going strong, consequentially known as Mr. "Energy".
Dislike: Estate Agent who required married couple only as tenants (still single).

NIALL, Robert
"A poor player that struts and frets his hour upon the stage". Quiet boy, potential dictator. Born 1948 naive and unwordly, entered Uni. the same, will leave more so.
Likes: Everything in moderation, agriculture (a growing (sic) interest).
Dislikes: Voluminious designs, the thought of the 9 to 5 job.
Ambition: To "get around".
Probable fate: An 8 to 6 job in a design office.

NOBLE, Robert Hewett

PARKINSON, Warwick
Surprised his parents 1947, had a liberal education at Coburg High School for 6 years. Should be doing Med. for "Academic" interest.
Aims: To beat Leo at squash and keep a 10 year love affair going.
Likes: Sun, surf, sand, s . . . , s . . . .
Dislikes: Not making money.

KOUSMIN, Tanya
Born 1948 in Aleppo, Syria—rode a camel at 2 years of age.
Likes: Eric Butler, Classical Music, Dancing, Eng. students.
Dislikes: Civil Engineering Design, Beer, Girls.

PECKHAM, Brian
Born England 1947, Deported 1949. Educated in everything at renowned Reservoir High School.
Likes: Engineering Balls:
Dislikes: Comm. Department of Works, Blocko's Chained to Carol and Department of Works till doomsday.

PIRAINO, Mario
Another smooth talking Italian bastard. Educated—various primary and secondary schools. Snatched from motherland at the sweet age of 9 to be brainwashed into an Aussie. Switched to Civil Eng. after unsuccessful attempt at changing Archi-lecture to Renaissance style.
Ambition: To become a successful greyhound owner-breeder-trainer, and filthy rich.

PLESIOTIS, S.
Born in the mountains of Pelloponessus in 1947. Exiled to Melbourne 1955. Studies at Melb. High.
Likes: Throwing cans at soccer umpires.
Dislikes: Blocko's, short left leg, (due to mountain birth).
Ambition: To design better goat tracks in Greece.

PRICE, Ian
Arrived 1946. Served 12 years hard labour at Scotch College but still managed to fail 1st year Eng. Fooled powers-that-be into repeating, contrives to fool them each year.
Ambition: To feel them just once again.
Dislikes: 9.00 lectures.

SAMUEL, Michael
Arrived 24/7/1947. Central Europe.
Emmigrated 1948, here ever since.
Interests: Girls, squash, engineering, lacrosse. Captain University B lacrosse team. Intervarsity lacrosse member 2 years.
Ambition: To be a great engineer and to be called Michael.
Probable fate: Be rich engineer called Sam.

SCHMIDT, Ralph
Overdue 30/3/48, has been late ever since. Development frustrated in Newman, but prefers the easy life there.
Ambition: To live high without any means of support.
Probable fate: Invent Schmidt skyhook with patent invisible support.

SEARLE, John Weston
Born in Melbourne October 1945. Arrived at the Uni. from Scotch College in 1964 and fully intends leaving this year.
Likes: Faculty passes, Alison, final year.
Dislikes: Designs which are impossible in the time allowed.

SHAW, Peter Robert

SNASHALL, Charles Edward
Yon Carlos has a mean and nasty look. Migrated from England 11 years ago. Matriculated at Upwey High after trying 4 schools in six years.
Interests: Food, sleep and Clene.
Ambition: To own a Jaguar.

STRACHAN, Graham
Life history: Reincarted 3/2/48. Uneducated at Haileybury College. Expelled to the Shop in '66.
Likes: Bronwyn, Bronwyn, Bronwyn, weeties.
Dislikes: Tripe and sharks.
Ambition: To grow big and strong by eating weeties.
Probable fate: To grow small and feeble by eating weeties.

STELLA, Leo
Shocked his parents in 1948 by being a boy. Received anti-education at Porode and surprised everyone by passing.
Likes: Lela, driving, squash, drinking (lemonade)
Dislikes: Purple, brown, old engineers, studying, E=mc., having photos taken.

TAN, S. T.
Funny man Tan of "question" fame; delivered Penang, Malaysia, 1948. Mother threw away child and reared afterbirth: end product, a wise, witty, amicable fellow, naive and knows everything about nothing.

THOMPSON, Alan
Hatched—23/3/48. Dispatched—G.O.K. Place of Abode — Croydon. Indoctrinated — Croydon Primary and Secondary Schools. Likes: Football (getting kicks not being kicked) and other sports. Dislikes: Getting kicked and not getting kicks, trains and all other traffic using Kew Junction and Johnston Street. Ambition: Nothing definite. Probable fate: Quite definite, oblivion.

TUCKER, Malcolm
Emerged in 1947 at Frankston from where he has irritated his parents ever since. "Educated" at Frankston High School then by way of R.M.I.T. to Carlton Tech. in 1968.
Likes: (Not necessarily in order): Geelong F.C., Travelling from Frankston by train daily? Women, weekends.
Dislikes: 9 o'clock lectures, work in general.

VANSELOW, Bob
Born in Melbourne on 2nd Jan. 1947. Raised amongst the juice-buggies, pigs and Z-vans of the high irons. Converted to sand-groper 1967-69
Favorite expressions: Drool and guffive.
Favourite: saying: Over in the West . . . .
Davourite song: Mrs. Brown you've got a lovely daughter.
Ambition: To win the first OXO K. & C. sticker.
Likes: Helen, steam, the Narra', Double V's, climbing, christening and crashing off mountains.
Dislikes: Inn prices and bus tourists.
Probable fate. Scrub-bashing across the Nulla'.

VASS, Roger J.
Condensed at the foothilles of the Dandenongs 11-10-47. Graduated with a degree in tar painting from the Quadrangle, Ringwood State. Proceeded to Ringwood High School where became prefected and perfected for University, 1965.
Interests: Smashing tennis racquets, hiking, music, Jenny, Economic and Attractive Civil Eng.
Ambitions: To drown Northern Victoria in irrigation canals, after Post Graduating (in drain digging).
Probable fate: Being drowned in his own ambition.

WILSON, Leigh D.
Managed to survive 23 years so far. Hopes the next 23 are a bit better. Learnt the tricks of the trade at various state and high schools until he saw the light and became a gentleman at Carey Grammar. Sincerely believes that you get more out of something by taking your time over it. e.g. sex, getting a Civil Engineering Degree, blondes, blondes, blondes . . .
Likes: The thought of perhaps eventually graduating. Blondes, blondes, with blue eyes.
Dislikes: Driving an old FE Rust Bucket. The thought of working for a living when he graduates. Birds who aren't blonde and don't have blue eyes.
Possible fate: Fail his Civil Engineering Degree, end up marrying a brunette with brown eyes.

ZYHAJLO, Emil
First appeared in Europe in 1946. Taught the basics at Yallourn Tech.
Dislikes: 9.00 a.m. lectures, and reckons day should start at 11.00 a.m.
Interests: Birds, football, music, nags.
Ambition: Still working on it.
Probable fate: Spend life investigating a suitable ambition.

SELBY-SMITH, Peter

ELEC.

ALBERT, David
A silicon chip produced at University High School. After four years of doping hopes to become an integrated circuit.
Probable fate: The original vodka, a diffused semiconductor.

BANKY, George P.
Born, 1946. In 1958 exchanged by the Hungarian Pioneer Movement for a koala bear (on some bases a fair exchange). Commenced his capitalist education at various central schools; eventually ending up at Melbourne High. His career at M.U. has been successful so far—to the the surprise of staff and fellow students alike.
Hobbies: Theatre and cinema (unusual for an engineer) and a certain female student (not so unusual).
Probable fate: Chief light globe tester at Strand Electrics.

BOLAND, Patrick
Generally famous already. Over a period of five years in Newman has systematically moved the contents of the college library into his room. Despite this moribund preoccupation, has had notable academic success. Is trying to discover before next year what Electrical Engineers do in the Department of Supply. Is programmed to arrive ten minutes late for lectures. This is not his fault—an unknown external force is responsible for it.

BOLZ, George
Born: Vienna, Austria, 1948.
Arrived in Australia, 1952.
Secondary education at St. Joseph's M.B.C. North Fitzroy—thwarted in attempts to enter a monastry, so came to M.U. instead.
During his stay at M.U. has attempted to reform a number of his fellow students, but to no avail.
Probable fate: Buddhist army chaplain in Vietnam.

EVANS, Peter A.
Born, and has been living ever since. Only managed to last two years in a College called Newman. Has lasted longer with a Department called PMG. Hopes to convince the PMG to convert to twenty-three digit dialling before it's too late. After premature retirement from PMG will probably start a Cybernetic Farm and breed multi-coloured cybernets. Vigorously denies charges that he is a hardened cynic, or, worse, existentialist bore. Has a particular dislike for mediocre fairytale writers.

GALLAUGHER, Jim
Born 31-12-48. Arrived at the University, 1966.
Likes: Cortinas, beer, football and the obvious.
Dislikes: Electrical Engineering, drunken drivers, P-plate drivers with sports cars, the S.E.C.
Ambition: Get the hell out of the S.E.C.

IVE, Richard
Evolved 17-2-47. Began career as professional student at Benjaroop Bules class. Drifted through Hamilton and Warrnambool Tech., diffused at R.M.I.T. and finally integrated into Shop for fulfillment as BLOCKO. Obligated to Army if and when he leaves campus. Drives hot Datsun 1000
Aim: To install hot line from Datsun 1000 to White House.
Probable fate: See next edition of Cranks & Nuts.
Likes: Birds, booze, birds.
Dislikes: Lectures, exams, verbal reports.

KOPERSZMIDT, Alexander
Synthesized in Poland 19/4/47. Sailed into Australia in 1958 where he was processed by Princes Hill High. Extensive experience of lunch eating during lectures. Has broad interests eg. the Big Bang Theory. Wants Engineering Award pay in the army and a woman conscript in a bunk next to his.

LEE, David Seng Seong
Air lifted to Australia in 1965 and recruited by Mount Scopus College. Planned to study Applied Science/Electronics but persuaded to do Electrical Engineering. Enjoyed lectures, pracs., and excursions, but hated examinations.
Ambitions: Not yet finalised.

LEE, Hin Min
Arrived from Malaysia in '64 and was converted at Heidelberg High. Meant to do Science but was persuaded to try Engineering; trying to get out ever since. Enjoys Australian seasons.
Ambition: To get married once graduated, and to work without practising engineering.

LEE, Siow Yee
Left Malaysia early 1964 to discover Australia and to matriculate at Essendon High School. Therefore slight tendency towards Bombers.
Likes: Badminton, music, relaxation.
Dislikes: Hard work.

McDONALD, Wayne
Born: Yes (1948).
Educated: (barely) Balwyn High.
Entered Uni. 1966.
Achievements: Busting rocks over leg in Lerderderg Gorge; overseas trip last long vacation, grew insulation against the cold.
Dislikes: Tasmanian drivers, women drivers, error messages, non-electricals.
Likes: Noddy wagons, walking, driving getting honours.
Probable fate: Death, work (ugh!).

MARMING, Andrew
Refused to write blurb about himself. Born in bed with a woman and ashamed of it ever since. Fell out of cot which accounts for shortness. Fast growing hair. Reserves seats in front row of lectures.
Likes: Female lecturers with short hair.
Dislikes: Peddling battering Vauxhall to Uni.

MOORE, R. B.
Born: 29/10/46.
Educated: Blackburn High, entered Uni. 1965, failed 3rd year.
Likes: Passing exams, Uni. vacations, sunshine.
Dislikes: Power, electronics, written reports, failing exams.
Ambition: To fail *that* medical. Head north towards the sun.
Probable fate: Pass medical, tank driver.

NORMAN, Col...
Born Melbourne '48. Early life spent getting fit for chasing birds by running round an athletics track. Later retired to football and drink.
Likes: Birds, Gillian, mathematics.
Hates: Wires, Gillian, arithmetic.
Probable fate, to be a nuclear engineer, press the wrong button, and take the rest of the world with him.

PYKE, Rodney
Arrived 1946. Received Diploma from Footscray Tech. and then joined S.E.C. They didn't want him so he left there to become a "Blocko" in 1968.
Dislikes: Wine women and song, Datsun 1000's Union Building, Writing blurbs about himself.
Likes: Studying, (what?), work (vac. work), reports (rifle reports), lectures (giving them).
Probable fate: Drop out.

SEXTON, Kenneth R.
1947 Model Human. Initial training at Strathmore High School. Arrived M.U. 1966 and decided on Elec. Eng. course. Sold out to P.M.G. in 1967 and became Cadet Engineer. Fanatical Essendon supporter. Drives '56 Vauxhall (car?).
Probable fate: Installing telephones on the moon. Call exit.

STEEL, Jack
Argued his way out of a tight spot on 30/6/46 and again through the Iron Curtain, to sail into Melbourne in 1958.
Likes: Sleeping, eating, Richard, dollars, big cars with lay-back seats, and Jenny. (In uncertain order).
Dislikes: The five days between week ends.
Ambition: To be judged unfit for the army.

TUCKER, Rodney
Entered the world in 1948 and quickly came to enjoy the finer things in life. Educated at Scotch College and came to Melbourne University in 1966. Rod recently wrote a report entitled "A General Matrix Inversion Subroutine and its Application to a Fortran Computer Program for Nonlinear Multiple Regression"
Main ambition: To disprove Ohms Law.
Likes: Food, extra curricular activities, cream Volkswagons.
Dislikes: Blockos, 9 o'clock lectures, red Holdens, verbosity.

YAP, Chin Hua (John)
Trying to save a year doing G.E.C. (Advance) in Malaysia, entered a "707" which shot into Essendon High in 1965. Having enough of it, flight redirected into Engineering School in 1966.
Likes: Least work with best results, V.W. and holidays, get away from shop forever.
Hates: Early lecture and practical verbal reports and tests.
Probable fate: Departed home for sake of Malaysia.

SURV.

BIRD, David
Chicken-man fell from stellar space 15-1-47 and supposedly received his secondary education at Melb. H.S. Cunningly arranged the downfall of MUSSC by being its president this year.
Likes: Beer, beer, beer. (Not necessarily in that order).
Dislikes: C.R.B. Cadets.
Ambition: To complete bond with C.R.B.
Probable fate: Chemical analysis of C.R.B.

O'BRIEN, Tony G.
Emerged November, 1945, holding a can, Monivae, Hamilton. Great believer in faculty pass system.
Destiny: A two year oriental vacation at government expense.

SHAW, Geoffrey John
Born 1948. Passed exams at Bendigo High School while playing sport for 6 years. Resides in I.H. and is still trying to qualify for an Honorary Phys.Ed. Diploma.
Dislikes: Astro on cloudy nights and B8's on Monday Morning.
Ambition: To adjust a diamond to a least square and to flatten out the earth.
Probable fate: Looking at V.C.'s through a Jigger.

MECH.

ANGLIN, MAURIE
Put down in March 1947 with the other fine wines of that year. Arrived at Newman in 1966 to be matured and aged in the ancient cellars of Melbourne University.
Survived the annual wine tasting each with only slight label damage and hopes again this year to survive the November stall banquet.
Ambition: to restore an A40.
Probable fate: to be consumed at a later date by the department of supply.

ANTCZAK, Eugene
Born: Austrian Alps, 1947.
History Captured coveted diploma from Gordon Institute of Technology in '66. Spent following year relaxing on Department of Works finances in New Guinea Highlands. Returned to Melbourne '68 to see what a white land looked like again and also to collect B.E. from Melb. Uni.
Likes: Redheads and Fiats.
Dislikes: Empty vodka bottles.
Ambition: Bulk coln and to return to those alps.
Motto: 'Blotta Blockos forever'.

BARTLETT, Geoffrey
Ambition: Probably air-conditioning.
Likes: Photography, piano, bible-reading.
Dislikes: System Theory. People who think I'll be a garage mechanic.
Born: 5th May, 1947, Melbourne.
Home: In the smog of Brunswick.
High School: University High School.
Commenced course 1966, completed 1969?
Probable fate: Garage mechanic.

BRAUNSTEINS, Janis
Born Germany '46. Migrated '49. Went to school, Fawkner, Coburg High. Friendly, easy-going chap.
Ambitions: Not to work.
Probable fate: Not to work.
Favourite saying: That nasty In and Out word.

CAMPBELL, A. B.
(Blocko B——) from Swinburne
Born 27.2.?
Here due to kindness of S.E.C.
Fate: Back to S.E.C.
Marital status: Married.
Likes: Riding small motor cycles.
Dislikes: Tramlines—painted white lines
Hopes: One day to build his own car.

CHONG, Tack Sing
Discarded by Monash and wandered into the shop in 1967. Most fluent improvement in the faculty of "Upside-down speech".
Likes: Girls with . . . out bikinis, shaving.
Dislikes: System theory and small cars.
Probable fate: May end up selling Malaysian rubber in Australia.

DEAKIN, Greg
Drifted into Engineering '66.
Will not probably drift out of Engineering 1969.
Likes and Dislikes: It depends.
Greatest Enemy: the Education System.
Often dismissed as a musical eccentric, Greg—Lives in constant peril of death at the hands of Nationalist Chinese room-mate.

DELUCA, Domenico Antonio
Born Italy 1944. Imported to Mildura grape farms 1952. Decided farm life dreary 1960 so visited Victorian Railways and joined. Collected Mech. Eng. Diploma from Preston Tech. 1967. Decided to become Honorary Blocko, M.U. 1968. Likes: Trains, hunting (for Birds?). Dislikes: Grog, smokes. Ambition: To design an automated Loco.

DREW, John D.
Born: 24.12.48 Hobart.
Exiled to Darwin '51.
Fled to Queensland '54.
Slipped into Melbourne '57.
Entered Shop '66.
Ambition: To be released from Shop 1969.

EDWARDS, P. J.
Born in the recesses of a dark English castle saw the light and came to Australia in 1962. Entered Melbourne Uni. via Strathmore High School.
Ambition: To fail army medical.
Probable fate: Late for morning army parades.
Likes: M.G.B., V.W., Grog, sleep, birds.
Dislikes: Army, 9 a.m. lectures, Parking attendants.

GALVIN, David J.
Born: Yes.
Educated: Yes.
Ambition: Yes.
Favourite saying: More, More, More.

GASPARINI, S. G.
Born in Italy in 1946. Discarded by Mafia himself and oil slicked his way to the shop through spaghetti and pizza pies.
Likes: Birds . . .birds . . . birds.
Ambition: To put the most into birds.
Probable fate: Ten years in pentridge recuperating.

HJORTH, Geoff
Life: Born 16.9.45. Died: To be arranged.
Melbourne High: Born 3.2.59. Died: 19.12.62
Eng.: Born 14.3.64. Died: Much later.
Beliefs: Six years (or will it be seven?) is too long for an Engineering course.
Aims: To have the Engineering Course reduced to 5 years.
Prospects: To take nine years to get a law degree.

LACEY, Raymond H.
Born: 19.7.46.
Educated: Scotch College.
Arrived Melb. Uni. 1965. Expects to leave 1969 after an extended stay. Succumbed to female wiles early in '69.
Likes: Jane, Hot Healeys (going), more Jane.
Dislikes: Hot Healeys (not going), nasty computers.
Ambition: To computer design the perfect Healey.

LOWEN, John H.
Emerged in Sydney 19.10.46. Began a scholastic career at Carey until arriving at Eng. school in 1965. Has since been involved in many activities to the detriment of work and benefit of . . . ?
Hobbies: Rowing, skiing, flying 403——
Ambition: To get out of here in 1969.

MAYNARD, H. J. V.
White, Caucasian. Age: Unknown (lost in the mists of time).
Usual Domicile, Swinburne College (Pigs Creek Tech.).
Alias, Blocko. Dad.
Offences: Larcency of Finite Differences, Crossing of Matrices with Extreme Cruelty. Fate: Old Age and Wisdom.

OLIVER, Roger N.
Misconceived on 10.1.46. Born 10.10.46.
Likes: Bawdy songs, Wagnerian Opera and Beethoven. Faculty passes (3) and Symposia.
Education: Melbourne Grammar School.
Distinguished appearance due to C.U.B. footy jumper and Lederhosen (leather shorts).
Ambition: To fly a man powered aircraft, non-stop to Munich in 1972 and subsequently to set up the Australian Republic in a Beerhall.
Probable fate: Lavatory attendant in a Munich Beerhall.

PETERSON, Leigh F.
On 28.10.47 a man with a fine military bearing (which he later threw into the air and caught) emerged from the shadows into the light. Now a gentleman of refined tastes, is occasionally heard quoting Shakespeare or Carroll, to the amazement of many people.
Interests: Classical music, modern jazz, photography and bush-walking.
Dislikes: Bad undies in "Girlie" magazines, "Bush Carpenter" type engineers. C2 H5 OH.
Ambition: Plenty.
Probable fate: Achieving ambition.
Favourite quotation: "For the Snark was a Boojum".

POP, Julian John
Born: 7.7.48 in Germany.
Previous school: Camberwell High.
Halfway through February 1966 a taxi stopped outside the Engineering school with a jerk—the jerk got out—Julian had arrived!! Destined to haunt the Mech. Engineering school for the next 4 years, after an initial education at Camberwell High School.
Born in Germany 7.7.48, has since taken to driving a black vehicle of the same vintage and doubtful roadworthiness. Has definite ideas about certain subjects—attempted reorganizing third year 1968, system theory lecturer migrated to England 1969.
Other remarks: You're a pest, Pop!

SEONG, Chong Min
Dropped out of a banana tree in Malaya. Couldn't understand lingo so true to the old spirit took off to get saturated with good shop Engineering but finished up getting a red-a-vino blood transfusion.
Ambition: To go back, be somebody and travel.
Probable fate: A mad looking chinese furiously blowing on a raft-canvas across the pacific.

SCOTT, John Balfour
This 1946 model, produced in Gippsland has undergone rigorous trials in the hands of the State Preliminary Testing Authority, the Scottish Collegiate Bureau of Investigation, the Swinburne Technological Board and now finally, the Melbourne Universal Joint Inc. It is to be hoped that some useful service may be obtained before the equipment becomes obsolete.

THOMPSON, Blake McGrath
—seen enjoying Parkville's balmy clime for 6th year. Doubtful Scot-Irish extraction. Basic existentialist instruction at Comberwell Grammar limited by lack of understanding of words of more than one syllable.
Other information in second episode—rogues gallery 1970.

Van PROOYEN, Adrian John
Premiere: 30.11.45, arrived M.U. 12.3.65 from C.B.C. Victoria Parade 7.2.54.
Ambition: To succeed at whatever there is to succeed at.
Probable fate: to succeed at nothing (public service).
Lately developed acute hydrophobia tendencies after running ship model into end of tank.

WELCH, Gavin
Born 25.12.47—Bright, educated Champagnet, Wangaratta, Marcelin, Bulleen.
Likes: Women, golf, etc.

WHARTON, Chris
Born in a fog back in '47, drifted through school where he acquired a liking for hockey, scraped into Uni. acquiring two more vices—drinking and sheila.
Likes: Hockey, drinking, Albury carnivals, rowing, drinking, squash, eng. balls, and sheila (not quite in that order).
Dislikes: 9 o'clock lectures.
Probable fate: To drift out of Uni. eventually.

INDUS.

ALSOP, Simon F.
Born between the two atomic bombs in 1945. Thought to be heading for record number of years as student when amazingly passed third year 1st go. Expected to press for a stamp commemorating Colonel Pewter.

DAVEY, Martin
Riddle: What; plays Association football, is friend of Janis Braunstein, lays in bed Sunday mornings making animal noises, is known to some as 'sleepy' and 'speed' is a film addict, has spaghetti bolognaise with Devonshire tea, is the star attraction at Women's College barbecue for 3 years running, takes orders for dim-sims at start of lectures, carries 'Nausea' with front cover outwards, regularly staggers through the grounds of St. Hilda's on Friday nights shouting obscenities to the sky and fights a never ending battle against other people's contentness, moderation and the single-minded engineer.

DODGE, Ronald William
Born in Richmond 11.11.47 (the reason for 3 minutes silence on this day). Attended "Brockhurst" kindergarten where he managed to acquire his tremendous toilet training skill. Continued to degenerate at Caulfield Central School where he even managed to urinate in the direction of the headmaster. Melbourne High School added little to his education but he learnt many methods of skipping House Choral Rehearsals and a distinct hatred for sportsmasters. He passed through the industrial engineering faculty with the maximum possible bother. Ron is now looking for a job which requires a great amount of toilet training, very little physical education and definitely no vocal ability.

MARK, Peter
'And it is curious how often in steep places you meet someone short who frowns.
Ambition: To carry the Nationalist Chinese flag around the University singing happy 81st birthday to Chiang Kai Chek.
To the guys who have ever lent lecture notes, problems and prac. reports: Thanks fellas!
Never been too sure of what to be . . .
'When the whole thing makes sense: it comes, but all I recall are doors banging'.
'but the crowd rejects no one, joining the crowd is the only thing all men can do'.

RODGERS, Geddes Andrew
This packet of mischief is sure to provide instant thrills for a lot more than the odd Fijian.
Madly in love with Jane, Liz, Mary, Libby, Julie, Carmel, Mandy, Christine and a few others. Plans to marry them all.
Probable fate: Out of the soup and into the noodles.

AGRIC.

BURROW, Paul
Skipped from heaven to the high Andes, 1947, and continued sliding downhill to South Australia. He regained the upward path on admission to Melbourne 1968.
Should go high, insurance premiums paid every Monday lunchtime.

CLIFT, Terry
Found on a dictaphone, '47, talked and blustered through to pacification in 1969 and under the full forces of the Commonwealth.
Peculiarities: Dog and girlfriend named Su.
Likes: Su, talking, Su.
Probable destiny: Flushing Viet Cong from 5 acres at Dandenong.

FISHER, Ian
Dropped in Sydney, '48, bounced in Victoria, lobbed in Western Australia and ejected back to higher learning in Melbourne.
A 60 percenter with high hopes of seeing the end. Great expectations of a Dickens of a time with a Charlie in Adelaide.

FULTON, Pat
He has not come far since his infiltration into Heathmont 1948. Recently fortified his bunker against the ARMY, As yet the Army has been slow to take up the challenge. Prides himself on passing with infinitesimal notes.
Aspirations: Irrigating rice paddies in H division.

GRAY, Alan
Country boy makes good in the big city. Native capatilistic instincts were accentuated by a visit to U.S.A. He now makes regular killings on the Stock Exchange, the last of which resulted in a pilgrimage to Asia.
Fully occupied by: Wine and trike peddling, eating, photography, sleeping.
Occasionally occupied by: Shaving, Margaret, Agricultural Engineering.

THIEN, Do My,
Blown from Vietnam, richochtted off Brisbane and lodged in Melbourne University.
Academic record: Attendance above average—Punctuality: same as the rest—Talks classical Australian, should graduate in strine if nothing else.

CHEM.

BATCH, Ray
Born Melbourne 1948.
Sweated through Rosanna High until 1965. Was stupid enough to do Engineering—enough said!
Likes: Money.
Dislikes: Poverty.
Probable fate: Miser..

BURNHAM, Graeme
Hit foot on this planet '46. Arrived at Carlton Tech. '64, from MacLeod High. After an initial set back in first year, has maintained a commendable academic record, especially in the collection on faculty passes.
Aspiration: To get that damn degree with the minimum of work.
N.B. Any similarity between Mr. Rolf Harris and Mr. G. Burnham is purely intentional.

COX, Geoff
Born 16-8-46 at Clyde, Vic. with brown arms and has been stirring ever since. Left Dandenong High School in '63 and started Elec. Eng. Saw the light after second year Elec. and changed to Chem. Eng. spending a year part-time in Brown Coal.
Aspiration: Chief of own brewing company.
Probable fate: Barley grower in Mallee.

DALEY, Graham
POFS

FRYDLEWICZ, Edward
Born in Germany of Polish parents 8.5.47. Sought political asylum in Australia in 1949. Educated by a chain of religious institutions but broke the link on entering Melbourne Uni. '65 (from St. Bernards C.B.C. Essendon) kicking a round ball.
Likes: Soccer, Marianne, I.V.'s, A.C.I.'s $26 a week.
Dislikes: Punchy soccer players, the thought of possible marriage.

GAN, Eng Sin
This natural rubber was exported to Australia from the jungle of Malaya. First refined in University High and finally processed under chemical eng. to be a valuable product.
Like: Censored.
Dislike: Straight-line.

GREGORY, John S.
Arrived 6-4-47 hibernated in Surrey Hills, processed by Camberwell High School. Joined Engies 1965, enjoyed it; so repeated 1st year.
Likes: Beer, cuddly women, blue FE Holdens, getting money, visits to CUB.
Dislikes: Work, skinny women, parting with money.
Ambition: Make $50,000 on stock market for $10 outlay.
Fate: Lose $10 on stock market.

HARROWER, John D.
Born Kew 16-10-47, ran away to North Balwyn, escaped from Balwyn High 1965, joined the Engies, caught by CMF, found loophole to be finally downed by Gaye.
Likes: Gaye, V.W., shares that GO, eating in lectures, stirring.
Dislikes: Being stung for engagement ring, wedding arrangements, V.W. shares that don't go.
Ambition: To escape from the Lecturers.
Fate: The Mind Boggles.

MAJOR, Ron
One of the '47 vintages. Came from quiet background at Swinburne Tech to enter Uni. in '66. Immediately fell into bad company. Since starting his four years of planned corruption his only achievements have been a fine selection of not very successful hairy growths, an interest in making MUCESS a world power and an unbroken record of handing in prac. reports two seconds before the deadline. All-round he is just a conscientious student who cannot find enough of the straight and narrow.
Likes: Women with Vermillion MOA'S, money, "snivelling pigs".
Dislikes: Shaving, prac. reports, Brown coal.
Ambition: Retire at 25 and grow the world's longest beard.

JACKSON, B. L.
Emerged from a test tube around the end of '48. One of the greatest converts yet to pass through our ranks, he started off, fresh from a high-class grammar school, as an anti-sexual teetotaller. However, he rapidly improved and now stands with the best of us.
Likes: Bikies and racing systems.
Ambition: To move out with a Healey.
Destination: Home in a Hillman.

KOH, Thong Juay
Born in Kuala Lumpur, brought up in Singapore. Stopped in Hampton High, Melbourne. Hope to get out of Melbourne University very soon.

McCARTHY, N. E.
A Married Pounder, he emerged at Coburg in late '47, then moved to Altona swamp in '58. Escaped Altona High in '65, moved into the ranks, and has been steadily deterioriating ever since.
Likes: Eating, bed, Lucille and sleep—in that order.
Dislikes: Hopeless lecturers and the like.
Ambition: To get the hell out of this place.
Probable fate: A dozen kids at Altona swamp.

OATEN, A. P. (Sam),
Dropped out 5th Feb. 1947 and has been dropping out ever since. Expelled from Auburn State South School, 1st grade for drunken driving, then went to the North Balwyn State School, among the elite where a taste for culture developed. Picked up doubtful virtues at Balwyn High ('59-'64) then staggered into Eng. School dribbling a basketball?
Likes: Basketball, booze, birds, being manager of women's basketball team.
Dislikes: Lectures, lecturers, married students (fools) and pikers.
Probable fate: An uncultured drunken, back aching, virile general manager (unmarried) of the brewery.
Favourite saying: Bloh-bloh.

RADFORD, R. D.
Evolved 1948: nicknamed Redlich Redhart. On the roll at Ivanhoe Grammar in '53 and attended occasionally until '65 when he was talked into Chem. Eng.
Was then on the roll at Melb Uni. in '66 and attended even less frequently. Still managed honours in between a wife and son and seems assured of a good honours degree.
Loves: S.F.A.F.O.H., work, gardening, work, gardening . . . .

REID, P. G.
Dropped onto a Geelong operating table 7/3/47. A very quiet lad during his tender formative years. Educated at C.G.S. and has been in Queen's throughout his University career—no longer quiet.
Likes the odd Aristotle, jock activities, and fraternization with the female species.
A dislike of 9 o'clock lectures makes him a regular contender for the "last-in stakes".
Ambition is to be a retired gentleman.

SEWARDS, Gordon J.
Crawled out of the South American jungle in 1946 and travelled around Argentina, Bolivia, Equador and finally Columbia, still crawling most of the time. Remained in Bogata for 10 years. After 3 years at the local University met an Aussie bird and after hearing about the good life in the "land of the young", applied for a transfer to Melbourne Uni. Arrived Jan. 1968, entered 3rd year, got married in May, and has been enjoying the good pleasures of life ever since.
Ambition: "How to succeed without trying at all"

STUCKEY, David C.
Transmitted 6-11-47 in Ballarat, spent until 1956 using an abicus in Hong Kong. Deported to Camberwell Grammar in 1957 to pay for his sins. Promoted by school chaplain to Scotch in '60, played basketball for five years until he became captain of the V14 D's. Fresher in '66 still fresher in '69.
Likes: Beer, fast cars, fast women, Meredith, sex, beer, sex, sex, Healey's Beards.
Dislikes: Terms, lectures, passing backward at 70.
Ambition: To crack a quarter in 10 flat or to crack 10 flat in a quarter.
Probable fate: To be awarded O.B.E. (order of the Crown elbow).
Favourite saying: Censored.

TECK, Low Hee
Parachuted into Singapore on 4.11.48 and left that overcrowded island on 7.1.66, searching for fresh air. Found at last this land loosely populated, full of Koala bears, Kangaroos, footballs, and beer. Considered not good enough for either chemistry or engineering, but hoped to do better when combined.
Dislikes: Soft and fast spoken lecturers, noise of Melbourne fire engines.
Likes: Playing table tennis with friendly people, cooking for not more than three people.
Probable fate: A Private in the Singaporeon Army.

TENEN, Jack
Born: Hadera, Israel, 1947.
Educated: Mt. Scopus College, Melbourne University?..
Likes: Ada, getting married ina few weeks, piano, chess, photography.
Dislikes: Chem. Eng., University, Fascists.
Ambitions: Get out of here and get some peace and quiet.

WALKER, D. J.
Started life at Kerang, 1948. Left Kerang High for Melbourne in '66 and has lived at Trinity since.

WITTON, R. E.
Born Melbourne 9-6-48 with pewter mug in one hand and VW gearstick in the other. Processed at the Primary and High of the unknown suburb of Maribyrnong. Arrived at Melbourne Uni. in 1966.
Likes: Plant visits to C.U.B., MUCESS sherry parties, blondes, brunettes and redheads.
Dislikes: Home brewed beer, the day after MUCESS sherry parties.
Ambition: To drag a Monaro GTS 327 in VW 1200
Probable fate: Spend 3 years completing a PhD. in the finer arts of panel beating a cream VW, or else will spend entire income on smash repairs.

ZUGNA, B. O.
Born, Trieste, Italy, 26th May, 1947.
Swam to Melbourne (via Cape of Good Hope) in 1956. After struggling through primary school, entered Strathmore High School.
Rolled up to Melbourne University in 1966 to dubiously participate in Chemical Engineering course.
Likes: Skiing trips.
Dislikes: Useless ancillary subjects.
Probable fate: Cleaning heat-exchanger tubes.

MIN.

ETHERIDGE, Bill
Appeared in Ballarat in 1966 to carry on the mining tradition of that area, and has since gained fame as a film star of dubious ability. Conspicuous by his absence from certain lectures he may often be seen pulling oars on the Yarra. It is believed he is destined for things other than mining, and he usually manages to stir hell out of his fellows. Know him by his sniff.

LOH, Kok Hu
Climbed out of a dredge bucket in Pesak, Malaya in the dark days of 1945. The days have been darker ever since. Reputedly educated at Northcote High and Carlton and United, he spends much time pursuing women, and has aided our understanding of management with certain axioms like "Sack them!" Notable for his ability to stir Austin and be then declared an "Oriental Shit".

McINTOSH, Bill
The baby of the group, he crawled out of his first dark hole in 1949. It is widely thought that he should have stayed there as he only occasionally shows signs of life. Famous for his ability to ride his Suzuki down Royal Parade while still asleep, he claims to be a product of New South Wales, but is actually a renegade Melbournian. Claims Rikky as pastimes, and also things that bang.

MATHIESON, Graham
This well travelled character made his appearance in 1947, and immediately showed his wanderlust by being educated first at Traralgon and the all over the bloody place. Local authority on Malaysia, food poisoning relations with the Bougainville Boongs and Pidgin English, he has iron-clad control of the MUMMSS and is gaining ulcers for his trouble. He spends his time wenching and taping, and sleep learning with both.

NEVILE, Will
Similar to Job—conceived and born on mound of bird dung in Nauru Island 10.10.48. Received a "broad" education at Wesley, Perth and Croydon High. Often seen disappearing across the lawn at crib-time—says he works in the Bailleau.
Likes: Wood parelled mini
Dislikes: Inefficiency (especially lecture time), and certain mining companies whose shares fall after he buys them.

RICHARDS, Hew
Product of Newcastle Collieries 5.5.46, Educated? M.C.E.G.S. and Lloyd St. State School.
Likes: mucking around old gold holes in the hills, She's and ski's like a maniac. Drives fast-back V-type (Vanguard). Last seen disappearing on Ellenis for Canada with microbiological specimen.

SLEEMAN, Jon
Extracted from beehive coke furnace 10.11.46 at Wonthaggi. Occasionally left the pits for education at Wonthaggi Tech. High School. After a short bout at the Board of Works and part-time R.M.I.T. saw the light (coal-burning, of course) and entered Melbourne Uni. in '66. A famed historian of the Wonthaggi coal mines, and Victorian gold fields.
Ambition: Design a coal-burning Peugot.
Likes: Would you believe coal mines, Wagnerian operas, and beehive coke furnaces.
Dislikes: Biased lecturers, metal miners.

MET.

CARD, Peter
Discarded 1947—reached M.U. after many attempts. Evicted from lodgings in Waverley, South Yarra, etc., so he bluffed his way to responsibility at I.H. Consistent behaviour at pie-nights responsible for complete break down of staff-student cordiality (esp. w.r.t. Dave & Max).
Conservative, liberal (esp. when boozed).
Dislikes: Post Pie Nital Apologies, Labour, S.O.S. reds.
Ambition: Nationalizing B.H.P.

COLDHAM, Richard
Little Dick dropped out in '48 and entered M.U. in 1966. Appointed as unofficial welcoming committee for new lecturers.
Likes: Bullcrap, Sniff & Grunt (i.e. rugger) Hot Austins.
Dislikes: Thick beards, S.E.C. dual bonds.

CUTTRIS, Robert
Developed in Hobart from 1949. Young Robbie came to Melbourne in 1966 innocent, inexperienced and alone in the wild city. Was soon beset by birds and now faces the altar.
Likes: Pie nites, mittacars.
Dislikes: Pie nite postlude.
Ambition: Long engagement.
Probable destiny: PhD. Developing selective regent for preferential flotation of waste material from napkins.

DAVIS, Robert Ralph
Delivered in 1947. Passed through Caulfield Grammar to Uni. in 1966. Did too much thinking to be a successful engineering student. Despite conscientious activity with e.u. was still debauched by the immoral behaviour of students. Rebellious in dress, appearance, ideology.
Likes: God and secret birds.
Dislikes: Balls, dry turns.

HARVEY, Maxwell Robert
Born, Fairfield unmarried mothers home, 1946. Educated (?) Rosanna High. Arrived here in '66 and hasn't stopped trying to improve reputation.
Likes: Squash, Helen, Balls, Mt. Isa, two pots.
Dislikes: Helen finding out about Mt. Isa.
Ambition: No ambition.
Probable destiny: Fulfilling his ambition.

McMASTER, Ian
Discovered in Hobart in 1948. Formative years were spent in the country—thus explaining strange behaviour at Scotch College.
Large Larynx—partially channeled to a useful outlet in the choral society. Also spends much of his time with the organ.
Likes: Eating in lectures, B.B. (basketball) B.C. (bullcrap).
Dislikes: This caption.
Probable destiny: Studying corrosion-fatigue in a Jelly Bean machine.

RATTRAY, Alan
Lifted the flap in 1948, Entered M.U. in '66. Gave up bikie image in '69 to cultivate the clean cut wholesome look of an Ormond scholar.
Honours in Library Sleeping Technique III A.
Likes: N.B.G.
Ambition: RATCRA.
Probable destiny: CRAPCRA.

STEVENS, Dave
FAT MAX—Dug out of the Blue-Stone Pile in '65. From majoring in football prior to '65 has now become a pure academic applying himself to physical metallurgy, (high tensile rods, nuts and screws), Susan and boozin'.
Ambition: To carry out torsional and tensile tests on live parking cops.
Likely fate: Fit—kind of fat and funny looking footballer, with upper left molar impaled in bottle top.

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