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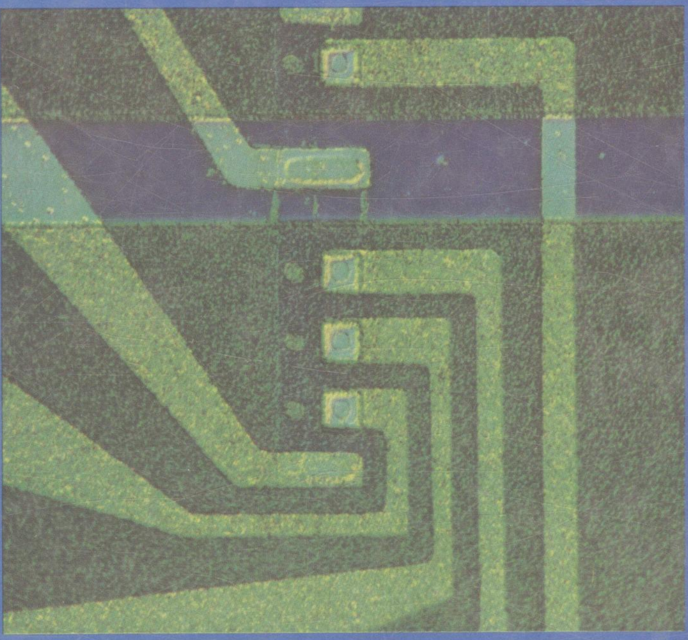
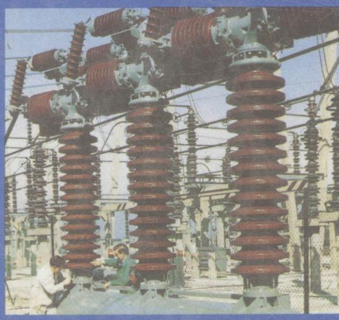
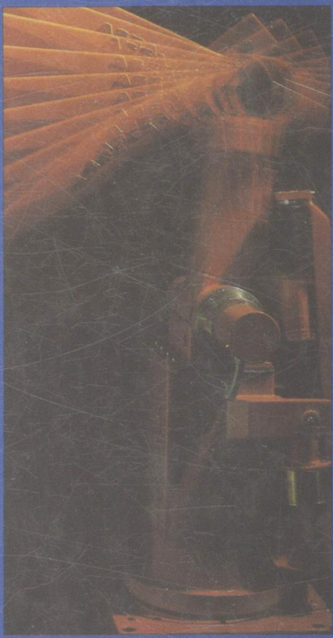
75 Years of Engineering







FACULTY OF ENGINEERING

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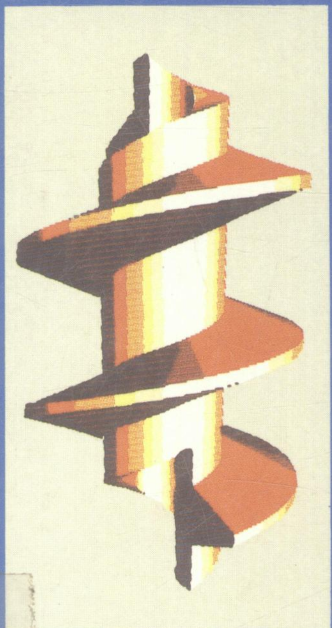
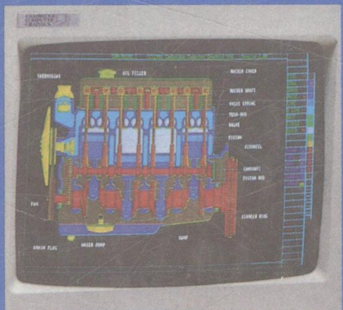
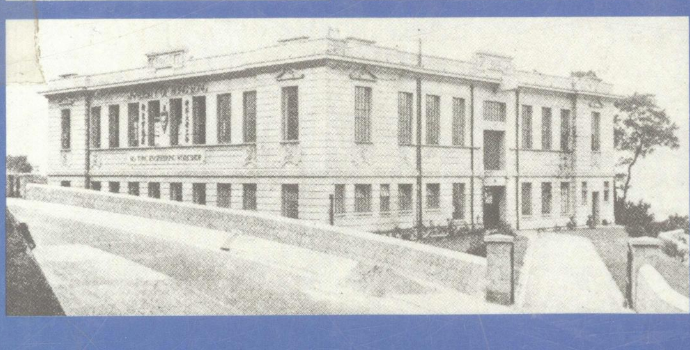
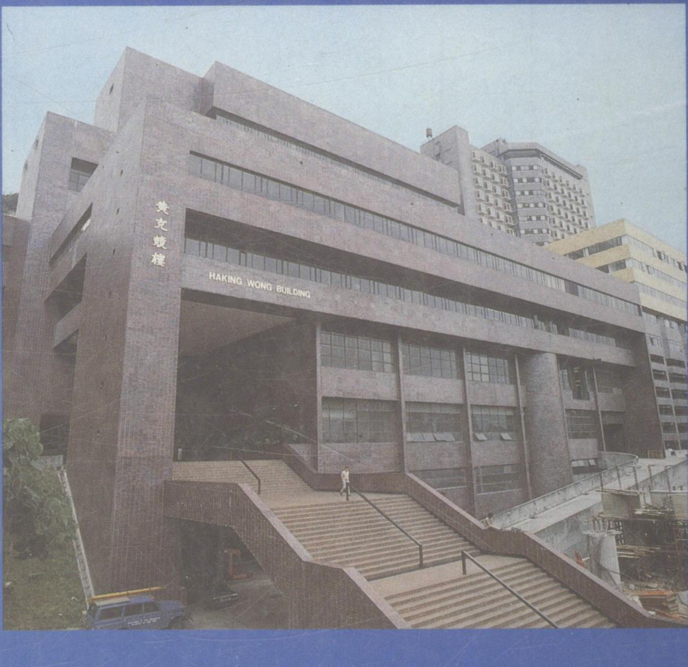








75 Years of Engineering

75th Anniversary
Commemorative Publication

Faculty of Engineering
University of Hong Kong

CONTENTS

ENGINEERING TOPICS

CURRENT RESEARCH

PREFACE

The purpose of this volume is to provide a tangible reminder of the fact that in 1988 the Faculty of Engineering of the University of Hong Kong celebrated 75 years of eventful existence. Whilst the function of the publication is principally commemorative, it contains a variety of material drawn from many sources within the Faculty, and elsewhere, which reflect experiences of yesteryear, a little comment and criticism, and a description of small number of the technical and educational activities being pursued by members of staff and students. Thereby it is hoped that some interesting reading will be provided for all browsers, particularly our friends and supporters in Hong Kong industry and commerce. They are the people whom we serve most directly, and we are probably guilty of not communicating with them sufficiently thoroughly and sufficiently often.

The 75th Anniversary was celebrated with an inaugural ceremony and cocktail reception at the University on 24 June 1988, with a technical open day at the Haking Wong Building on 29 October 1988, and with a celebration dinner at the Regent Hotel on 9 November 1988. On these occasions we were most gratified by the support given by all sectors of society interested in education and technology, from the Governor of Hong Kong, His Excellency Sir David Wilson, to our most recent engineering graduates.

The publication itself is a compendium; it does not attempt to convey any particular message or theme, and if it should have done, then the fault is ours alone. Our wish is simply that there will be something in it that interests, entertains, or captures the attention of anyone who has the inclination to turn the pages. There is a definitive history of the Faculty which alone is a good enough reason for a publication of this kind. There are comments from former staff and Heads of Departments, and from ex-students. Articles describing recent developments in research, engineering education, and industrial liaison are also included.

The Special Publication Sub-Committee, whose members are Dr. C.C. Chan, Dr. J.B. Evans, Dr. S. Lingard, Mr. F.J. Newland, Dr. S.M. Rowlinson, and Mr. D. Sculli, are greatly indebted to all who contributed, but, in particular, wish to thank Faculty Secretary, Mrs. Mariana Choi, and Executive Officer, Miss Vania Cheng, for their unstinting efforts to meet tight deadlines, and Miss Helinna Lau for her dedication and typing skills.

Finally, in recording some of the events and personalities of the first 75 years of existence of the Faculty and conveying a little of its present atmosphere, it is appropriate to look to the future, observing the standards and qualities already painstakingly achieved. The Faculty hopes to merit your continuing support and is pledged to ensure that the second 75 years are even more successful.

S. Lingard
Chief Editor

November 1988

MESSAGE FROM THE CHANCELLOR

HIS EXCELLENCY SIR DAVID WILSON, KCMG

The Faculty of Engineering of the University of Hong Kong has played an important role not only in the University's history, but also in the history of the development of our industrial sector. When the Faculty of Engineering was first established in 1912, Hong Kong's industry was virtually non-existent. Since then, the Engineering Faculty has expanded substantially, keeping pace throughout these years with the progress of technology in the world as well as with Hong Kong's dynamic industrial development.

I congratulate the Faculty on its achievements over the past seventy five years and send my best wishes for the future.

Governor

MESSAGE FROM

THE HON SIR S.Y. CHUNG, CBE, LL.D, D.Sc, Ph.D, F.Eng., JP

On the occasion of the 75th Anniversary of the Faculty of Engineering, University of Hong Kong, I would like to proffer my warmest congratulations to the University and in particular to members of the Faculty for the good work they have done in the education and training of professional engineers in Hong Kong for three-quarters of a century.

Fifty years ago when I was an engineering student at the University the student enrolment in the Faculty of Engineering was about 80 as compared to the current 1,600, -- an increase of nearly 20 times. There were no post-graduate courses. To gain admission to a course in engineering, a student not only had to face severe competition like today but also had to have adequate means to meet an annual cost of about $1,800, which was a substantial sum of money in those days. There were no grant or loan schemes and, unlike the present time, many young men and women were deprived of university education simply for lack of financial support.

Despite the absence of natural material resources, we in Hong Kong during the past three decades have made remarkable progress in economic development and have become one of the most affluent territories in Asia. This achievement is to a large extent due to the successful development of our export-oriented manufacturing industries.

If we in Hong Kong wish to continue to prosper we must be capable of sharpening our competitive edge in world markets. To do so, we have to move up market and put greater emphasis on high-quality and high-technology products. This means that we need more and better professional engineers not only for production but also in the fields of research, development, and design.

The recent establishment of The Hong Kong University of Science and Technology will no doubt provide additional impetus to the education and training of professional engineers in Hong Kong. Nonetheless, it is hoped that your Faculty of Engineering will continue to play a significant part in the development of high level technical manpower in the territory. May I take this opportunity in wishing your Faculty and your members every success in what you do for the good of Hong Kong.

June 1988

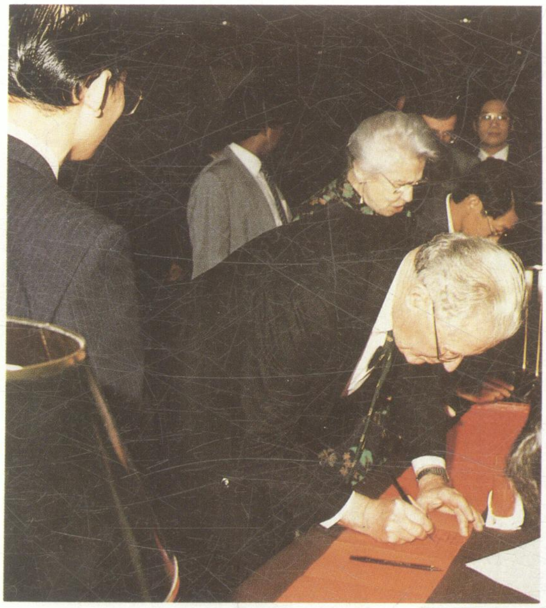
ANNIVERSARY PHOTOGRAPHS AND SPEECHES

75th ANNIVERSARY INAUGURAL CEREMONY
24 June 1988, Rayson Huang Theatre

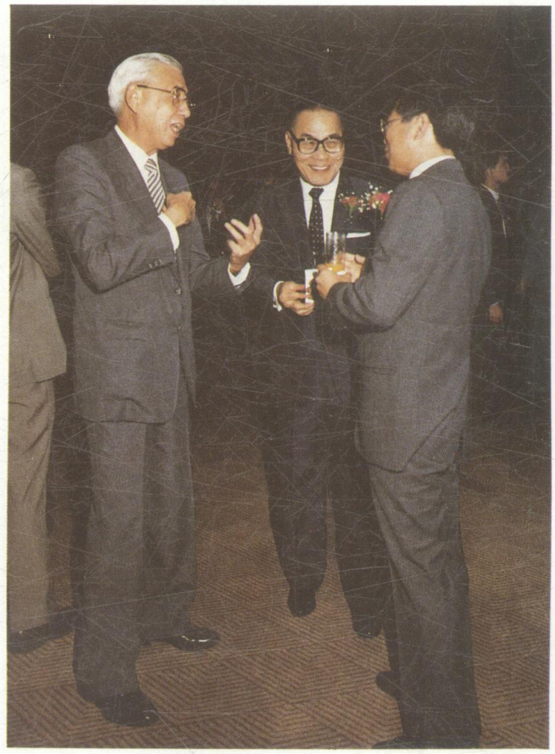
From left to right: The Hon. Allen Lee, Dr. R.C.T. Ho, Dr. Wang Gungwu (Vice-Chancellor), Prof. Y.C. Cheng (Dean of Engineering).

The ceremony was attended by over three hundred guests.

75th ANNIVERSARY DINNER
9 November 1988, Regent Hotel



Former professor, Mr. W.A. Reynolds and Mrs. Reynolds, visiting from England



Mr. Hung Sik Chiu, Sir Sze-Yuen Chung, and Prof. Y.C. Cheng during the cocktail hour

Prof. W.S. Leung, the longest-serving teacher, addressing the audience.

The Hon H.K. Cheng and Dr. Wang Gungwu enjoying Prof. Leung's speech.

Right: Dr. Paul Tong (right), Chairman of the Hong Kong University Engineering Alumni Association, presents the Association sponsored video about the Faculty to Prof. Y.C. Cheng, Dean of Engineering.

Left: Dr. Wang Gungwu (Vice-Chancellor) proposes a toast to the Faculty.

Below: Alumni, guests, and staff respond to the toast.

75th ANNIVERSARY OPEN DAY
29 October 1988, Haking Wong Building

While Prof. Y.C. Cheng (Dean of Engineering) looks on, Dr. Wang Gungwu (Vice-Chancellor) and the Hon. H.K. Cheng cut the ribbon.

Guests touring the laboratories of the Faculty of Engineering.

SPEECH GIVEN BY THE HON. ALLEN LEE

at the Inaugural Ceremony of the 75th Anniversary Celebration of the Faculty of Engineering on 24 June 1988

It is a great honour for me to participate in the auspicious occasion of the Inaugural Ceremony of the 75th Anniversary Celebration of the Engineering Faculty of the University of Hong Kong.

I would like to use this occasion to speak on the co-operation among the universities, commerce and industry, and the Government as well as the important role that Government should play in the promotion of technological advancement in Hong Kong.

Today, Hong Kong is a commercial, financial, and shipping centre in the Far East. Our development in the past was much dependent on a consistent Government policy of free economy and free enterprise. We are the world's largest exporter of garments, toys, and electronic watches as well as being the third largest financial centre and possessing the largest container port in terms of through-put.

We are at a cross-road of our development in the 1990s. We are facing the problems of transition in the political matrix as well as maintaining a sound economy which we have enjoyed during the past decade. I was asked recently by a Chinese scholar what is the single most important problem that Hong Kong will face in the future. I had no hesitation in replying that it is the development of science and technology. There is no doubt in my mind and those involved in studying the Hong Kong economy would agree with me, that our greatest weakness is the lack of science and technology. During the past, I have urged our Government to pay attention and to invest in the areas related to the development of our science and technology in order for us to compete with South Korea and Taiwan. However, our Government sees differently. As you know, very little was spent on the tertiary education sector on research and development and none at all was spent on technological advancements of our industries. These few years have seen the tide begin to turn as our Government begins to realise that without a sound technological base, Hong Kong cannot compete and survive economically in the longer term. Therefore, activities such as the commitment to the Hong Kong University of Science and Technology, boosting the research and development budget and our tertiary education sector along with paying attention to the developments of the Hong Kong Productivity Council and its related activities, and the aggressive promotion to attract overseas hi-tech companies to invest in Hong Kong, are indicative of a change of attitude on the part of our Government. I am encouraged to see such activities but in my view, it is only the beginning as our Government is to commit a portion of its resources in the future. We must focus on the one single weakness that we have and that is to establish Hong Kong as a technology base in the Far East. I do not intend to go into details of the advantages of being a technology base. I believe it is well-known to the audience here today. However, I do want to spend some time to speak on the technical co-operation between the universities, commerce and industry, and the Government.

It seems to me that there is a lack of attention being paid to the tripartite relationship of these three major institutions of Hong Kong. However, in my view, we have misused our resources and we have not utilised the strength of our tertiary education sector. If we look at our commerce and industry, it is basically export orientated particularly on consumer products where the technology level has been low. However, due to the recent changes of the markets around the world, there is no doubt that we need to upgrade both the design and quality of our products. Our entrepreneurs are currently struggling with the lack of technology. However, we have recently been utilising the quickest route of obtaining technology by technology acquisitions or joint ventures with foreign companies in order to enhance our technological advancement along with promotion of hi-tech companies to come to Hong Kong. Our entrepreneurs have not actively looked at our tertiary education sector and to co-operate on projects on product innovation and design, and neither is our Government promoting the concept of tripartite relationship. It is my strong belief that our Government should take the lead in establishing the tripartite relationship not only through the establishment of advisory committees but also to actually lay out a plan for the technical co-operation.

In the years to come, Hong Kong cannot rely on the quotas of our garment exports nor can we rely on low and medium end consumer products to survive. Our recent export surge and economic performance has been mainly due to the open door policy of China which encouraged many of our entrepreneurs to establish manufacturing facilities across the border, particularly in the Pearl River delta area. It is estimated that there are two million workers working on Hong Kong products for export. These are traditional products. We are fortunate that we are able to compete and we have a good manufacturing base across the border. However, the developments around the world are focusing on technology. We must move swiftly in this area. The establishments across the border only give us some breathing room which I assess to be about ten years. This gives us the chance to develop our technology base. In this aspect, it is important that Government plays its role in promoting technical advancements. There is a proposal to establish a science park in Hong Kong. It is my view that it should be established without further delay. In this science park, the universities and commerce and industry can participate and contribute on a project basis. The park should be creative, innovative, and be a point of convergence of our entrepreneurs, scientists, and technologists. I envisage that by the establishment of a science park, the pace of technological development in Hong Kong will be quicker. I also believe that our Government must use its resources adequately in promoting technological advancement. As I said before, this has to do with our longer term survival. Hong Kong can become a technology centre in the Far East with the dedication of all parties. I believe we can achieve this during the next ten years. Our Government is more aggressive now than ever. I am quite sure that investments in technical advancements will be made in the future.

I would also like to use this opportunity to urge the University to play a more active role in the tripartite relationship that I mentioned before. For my part, I will do my utmost in proposing to the Government greater increases in the funds for research and development for the universities and polytechnics and also in promoting the co-operation among the universities, commerce and industry, and Government.

Recently much concern has been expressed in our community with regard to the 'brain drain'. It is a real problem and a problem which we must face. For those who do not have confidence in the future of Hong Kong, they will use their means to emigrate. Hong Kong will no longer be their home. That is why I say Hong Kong stands on the threshold of changes. But to those who are committed to the future of Hong Kong, the development and training of human resources will be the single most important aspect of the future. The responsibility of training our managers and technologists of the future lies with our tertiary education sector which must train and educate our young people to take up the challenges of the future. The task is enormous but I have much confidence in the younger generation of Hong Kong. I am sure you have noticed that a great majority are coming from our housing estates. They want to see improvements in Hong Kong and they want to participate in the greater challenge of the future. In my view, the 'brain drain' will represent a short term problem for Hong Kong but I am confident that we will train our own people to fill the gap. If our young people see our commitment to technical advancements of the future, they will be much encouraged and will be interested to participate in the technological field. I hope I have laid out the responsibilities of the universities and our entrepreneurs along with our Government this afternoon and I believe these goals are achievable. I will continue to play my part as I have done for the past ten years in promoting technological and industrial development which is vital to the economic performance in our future.

SPEECH GIVEN BY DR. RAYMOND HO CHUNG-TAI

at the Inaugural Ceremony of the 75th Anniversary Celebration of the Faculty of Engineering on 24 June 1988

THE ENGINEER'S STATUS AND HIS CHANGING ROLE IN SOCIETY

The Faculty of Engineering was one of the earliest faculties established within the University of Hong Kong. It is really fortuitous for us all to be celebrating its Diamond Jubilee. I am therefore very honoured indeed to have been invited to speak on this grand occasion. Maybe it is because I was the first HKU graduate to become the President of the Hong Kong Institution of Engineers.

In the last year or so, you may have from time to time heard about professionals requesting that appropriate clauses be incorporated in the Basic Law to ensure future autonomy of professional practice without interference from the future Hong Kong Special Administrative Region Government in the assessment and conferment of professional qualifications. You may also have read about professionals meeting regularly to discuss issues of common interest such as registration of professionals. More importantly, you may have noted that in all such public issues, the engineers' input has been prominent.

Except on the Continent of Europe where the engineer is well respected and is enjoying very high status, traditionally the engineer likes to work quietly though conscientiously in pursuit of job satisfaction while maintaining a very low profile in society. This has unfortunately led to some misconception of the work of the engineer in the eyes of the public. When I first set foot in Britain in the early sixties, I was shocked to come across a news headline which read "Engineers down tools for threepence." At first I was down-hearted to realise how hard up engineers were. I was even more frustrated when I discovered that the public was really confusing engineers with shop floor workers using spanners!

Hong Kong has seen considerable changes in last 15 years. In these numerous changes, one can easily identify many outstanding engineering achievements, such as new towns, the Mass Transit Railway, double tracking and electrification of the Kowloon-Canton Railway, container terminals, elevated roadways, over water bridge structures, tunnels, high-rise buildings, and computerised traffic control and surveillance systems.

On the industry side, there have been many success stories in manufacturing which put our export performance on the world map. In telecommunication and information technology, we are keeping pace with the advanced countries. The engineers' contributions to all these and many others have not gone unnoticed by the public but they are yet to be convinced that the work of the engineer is closely linked with the economy of Hong Kong. We are now in the transition period with only nine years left prior to the changeover of sovereignty. We all have a duty to ensure professional practice is unchanged and our engineering standards are maintained at international level. Our international status and standards are amongst the real "values" of Hong Kong.

Hong Kong will continue to move ahead despite some loss in confidence and will need adequate engineering expertise and resources to assist our infrastructure provisions, investment projects, and industrial developments. We must establish a system whereby talent is identified and expertise is assessed irrespective of nationalities and places of origin, as long as our professional standards are reached. Registration of engineers is one such system which, when implemented next year, will differentiate professionals from sub-professionals, and consumers' interests will be adequately protected and public safety better guaranteed.

I wish to take this opportunity to offer my sincere congratulations to the Dean and all the staff of the Faculty of Engineering for their considerable efforts towards the impressive success in the past and my best wishes for the future development of the Faculty.

SPEECH GIVEN BY PROFESSOR Y.C. CHENG, DEAN OF THE FACULTY OF ENGINEERING

at the Inaugural Ceremony of the 75th Anniversary Celebration of the Faculty of Engineering on 24 June 1988

On behalf of the Faculty, I wish to express my sincere thanks to all of you for taking time from your busy schedules to come to the inaugural ceremony of our celebration. We are, indeed, honoured by your presence today, and are grateful for all your help and encouragement in the past, without which our faculty could not have arrived at the stage that we are now at. There is no doubt that our faculty has contributed, in one way or another to the present prosperity of Hong Kong, but we must look forward to the future. With your continued support and participation, we expect to make an even greater contribution to the stability and prosperity of our homeland. In addition to being a joyful time of celebration and reunion of alumni and friends, we want to make this anniversary an occasion to promote university - industry technical cooperation.

We have planned a series of activities to celebrate the anniversary, and at this time, I would like to give you some details about the events. We seek your support and participation in these activities.

There will be a technical open day on October 29th, which will provide an opportunity for the industrial community and our past graduates to be informed of the level of technical expertise and facilities available at the University. From time to time, there may have been some technical services or expertise in the Faculty which were needed by industry, but were not made available due to unawareness or lack of communication. We hope this technical open day will mark the beginning of a dialogue between the University and the industrial community on future technical cooperation.

A celebration dinner will be held on November 9th at the Regent Hotel. We have invited Sir S.Y. Chung, our outstanding graduate, to speak on that evening. To wind up the celebration activities, we plan to put out a special publication to commemorate the occasion and to highlight activities and future plans of the Faculty.

Let me now spend a few a brief moments to reflect on the development of our engineering faculty and to find out how it has been influenced by worldwide technological developments. HKU's Faculty of Engineering began its first academic year, 1912-1913, with 37 students out of a total of 54 undergraduates. They studied civil, electrical, and mechanical engineering. This shows the importance of engineering education right from the beginning of the University. While I was looking through some articles and newspapers on the University's early development, I made some interesting observations:

- The first full-time member of the university staff to be appointed after the Vice-Chancellor was the Professor of Engineering.

- Several significant developments were made possible because of generous donations from companies such as Swire and concerned citizens such as Sir Ho Tung.

- The University served many students from China and S.E. Asia.

Subsequently, the Faculty went through many interesting developments leading to today's enrolment of 1639 students in 1988. The first 50 years has already been very skilfully described in the Golden Jubilee publication by a former Head of Civil Engineering, Prof. S. Mackey. I shall, therefore, restrict my thoughts to the last 25 years. Within this period, the world has made tremendous progress in almost every field of science and technology. Obviously, this rapid development has had a large impact on engineering education and on the direction taken by Hong Kong industries.

We have often heard people make remarks that more scientific knowledge has been generated and more technological developments have been made in the last 25 years than in all the other periods together since the beginning of mankind. This remark may be somewhat exaggerated, but I don't think it is far from the truth. Over the past 25 years, we have seen the appearance of silicon chips, computers, robots, optical fibres, and many other similarly important inventions.

In view of these rapid changes, how did our Faculty respond and evolve in our curriculum development and research activities? On one hand, we are faced with a knowledge explosion -- new scientific advances and novel technological developments are made almost every day. On the other hand, we have to train engineering graduates and to conduct research to meet the needs of the local community to help them keep up with worldwide technological changes. This is no simple task, especially with the constraints of scarce resources and the limited number of technical personnel as determined by the small size of Hong

Kong. Obviously, the stereotyped image of an ivory tower has not been applicable to the Faculty of Engineering for many years as we do work closely with the industrial community. The Department of Industrial Engineering was established in 1973 to emphasize the training of graduates for the manufacturing sectors. A sandwich programme was introduced in 1981 to allow the students to have more industrial exposure. Many short courses and workshops have been organized throughout the years to cater for specific industrial needs as a result of new technological developments. Instead of discussing these activities in detail, I would like to focus just on three major areas which are of utmost importance to Hong Kong. They are concerned with the enhancement of our manufacturing capabilities, information technology, and environmental pollution.

In the last thirty years or so, we have witnessed Hong Kong's growth from a small trading port to a major manufacturing centre and a major trading nation in the world. Hong Kong has experienced prosperity by taking advantage of the world trend of technological development. We are all familiar with examples of the use of microchips in manufacturing all types of consumer electronic and toy products, the manufacturing of telecom and computer equipment, etc.

Many people in Hong Kong are multi-talented with an entrepreneurial spirit and good marketing instinct. With this kind of talent, technology transfer can be accomplished with or without the participation of foreign companies from advanced overseas nations. Hong Kong's earlier success arose as a result of the marriage between overseas advanced technologies and local inexpensive labour forces. Hong Kong enjoyed this long honeymoon period which did not require a high-level of technological know-how. As a result, there were very few research and development activities in the industrial sector in comparison to overseas. Engineering graduates with knowledge of advanced technologies and with/without higher degrees were not needed, and the Government continued to apply its non-intervention policy to industry.

Unfortunately, the scene has changed rapidly in the past several years. Driven by rapid advancement of technology and challenged by severe competition due to the technological upgrading of nearby neighbours such as Taiwan, South Korea, and Singapore; Hong Kong has been steadily losing its competitive edge in manufacturing, and the added value is diminishing. The Government quickly realized the situation; several studies were done and some action was taken. The industrial sector was keenly aware of the situation and efforts to upgrade and to diversify were attempted. The education sector is not ignorant of what is happening either -- our curriculum has been constantly modified and up-dated short-courses are conducted, in spite of our modest resources and equipment. All three parties acknowledge that we have a common goal -- to help Hong Kong to survive the competition and to continue our economic prosperity. Our Faculty has been keen all the time to help Hong Kong industry through this tri-party collaboration. The Electrical and Mechanical Engineering Departments are among the pioneers in working with the Industrial Development Board on IC technologies for the electronics industry, and on CAD/CAM technologies for the toy manufacturers, respectively. Another recent example is related to Government's Application Specific Integrated Circuits training scheme in which our Faculty, the Industry Department, and Motorola are working together in the design of industrial chips in an effort to provide local training facilities.

We are approaching a crucial threshold for the manufacturing situation in Hong Kong -- either we upgrade our technological level and innovate products or we face serious consequences. Our Faculty has obviously an important role to play at this moment -- we should supply both the appropriately trained graduates and provide some form of R & D back-up in the process of technology transfer. Therefore, I think it is very appropriate for us, on this occasion, to promote and to encourage university-industry technical collaboration. Also, we hope the Government will take a more positive role to foster this joint effort. There are many successful examples in the world and to mention just a few: California's consortium programme for industry to work with Stanford and UC Berkeley, Canada's PRAI (project-research applicable to industry) program at universities, and Taiwan's various projects in Hsinchu. I think the Government is becoming more willing to help, judging from the recent ASIC training scheme, the provision of more funds for research at tertiary institutions, and the establishment of the Committee on Science and Technology; but I think the Government should, and hope it will, take a bolder step than before, to further promote University-industry collaboration.

Moving from industrial manufacturing, I think it is also the right time for the Faculty to play an important role in other sectors of Hong Kong. Information exchange is such an important part in our lives that it would be difficult to survive if our information links were cut off. Just imagine if we had no phones, photocopiers, electronic banking, data communication, computer information processing, etc., what our lives would be like. Engineering obviously plays a key role in all these developments. Someone coined the phrase *information technology* to describe the broad spectrum of the application of computer and communication technologies to the service sector, commercial world, financial world, and our daily lives. Our curriculum and research activities are definitely being influenced by the developments of information technology in this information age. It is timely to announce that in a week's time, the Department of Computer Science will formally become a member in the Faculty of Engineering. There was already a strong collaboration between Computer Science and the four existing engineering departments, and we are proud to mention that the Faculty is the first to have a Computer Engineering programme with emphasis on both hardware and software subjects. In the years to come, our Faculty will be in a stronger position to serve Hong Kong as we enter into the information age.

Turning lastly to the environment, recently much attention has been focussed on the environmental condition of Hong Kong. So much damage has been done to local water that many people fear that it may soon pass beyond the stage of redemption. Our Faculty has been interested in pollution monitoring and environmental control for some years. We have a good track record of active research in water, noise, and air pollution. Recently, the UPGC has supported an M.Sc. programme on environmental studies and our faculty is taking a key role in the teaching of waste management and environmental control. In addition, staff members in these groups have been very active in helping to solve water, air, and noise pollution problems in Hong Kong. The recent announcement of a joint research effort between the Government Fishery Department and our Department of Civil & Structural Engineering in developing a warning system for red-tide is an outstanding example of government-university collaboration.

As we are approaching the 1990s, our Faculty is faced with a very complex task. On one hand, we are charged with the responsibility of turning out graduates, hopefully to play the role of future leaders and innovators in the local technical and industrial community. As I mentioned a while ago, we are in a period of knowledge explosion and extremely rapid technological development. We need feedback from the industrial and commercial sectors so that we can plan our courses meaningfully and effectively. On the other hand, we also have a moral responsibility to help the local community to make progress in technological matters, realizing we have a high concentration of technical expertise in the Faculty. However, we need the collaboration and participation of local industry and the Government in order to accomplish our common goal, i.e. to bring about economic prosperity through R & D activities.

We appeal to our past graduates, industrialists, and Government officials to truly work together with the Faculty in a joint effort to help Hong Kong to maintain its prosperity into the 90s and beyond. Hong Kong is a small place; the academics, industry, and the Government cannot afford to have separate goals, but must work together to help Hong Kong to be successful in all its technical and industrial ventures.

SPEECH BY THE HON. H.K. CHENG

at the Opening Ceremony of the Technical Open Day of the 75th Anniversary Celebration of the Faculty of Engineering on 29 October, 1988

I am greatly honoured by your invitation to join you at the Opening Ceremony of your Technical Open Day which is one of the important events in the 75th Anniversary Celebrations of the Faculty of Engineering. I wish to take this opportunity of offering my heartiest congratulations.

My participation today reminds me of the privilege of taking part in the Conference on the Design of High Buildings organized by the Faculty of Engineering some 25 years ago as a part of the activities in your Golden Jubilee celebration.

The last 25 years have seen enormous developments in our economy, finance, and infrastructure, which have made Hong Kong the world's sixth largest exporter, the third largest financial centre, the largest container port and indeed an international city with remarkable prosperity.

During the same period, we have also seen extraordinary advancements in science and technology to which academic institutions, including your University, have had much to contribute.

For many years, I have admired your engineering graduates who have contributed immensely towards the well-being of our society. Not only are they outstanding in their professional knowledge and skill, they have also played a leading role in many sectors of our community, be they professional, academic, government, or in business and industry.

I appreciate the good objective of your Technical Open Day which provides engineering professionals, graduates, and students with an insight into the facilities of your Faculty.

I am fully aware of the success of our developments for which the credit has been largely shared by your engineering graduates during the past few decades.

In looking to the future, I firmly believe that plenty of opportunities will arise for engineers to be actively involved in our economic development. Government will soon have to make many important decisions on plans for our new airport, port facilities, road networks, urban renewal, and environmental improvements. There will be a continuing demand for engineering graduates to strengthen our workforce and such need has become especially distinct at a time when we are suffering the problem of a brain drain. In the circumstances, your Faculty of Engineering has an important role to play.

Vice-Chancellor, Professor Cheng, Hong Kong is very proud of your engineering graduates. May I sincerely wish you continued success in the growth of your Faculty of Engineering and many more anniversary celebrations in the future.

SPEECH GIVEN BY DR. WANG GUNGWU, VICE-CHANCELLOR

at the Opening Ceremony of the Technical Open Day of the 75th Anniversary Celebration of the Faculty of Engineering on 29 October, 1988

I am very pleased to welcome you to this Technical Open Day which is being held to celebrate the 75th Anniversary of the Faculty of Engineering. This Open Day has been organised to give the engineering community of Hong Kong an opportunity to see the contributions that the Faculty of Engineering at the University of Hong Kong is making in the various areas of engineering and computer science, and I am sure you will all find your visit today most worthwhile.

Engineering has played a key role in the development of Hong Kong, especially in the last twenty years, and this development has provided scope for both large-scale engineering undertakings and for the individual engineering entrepreneur. Over the last two decades there have been many major engineering feats in Hong Kong, for example the cross-harbour tunnels, the Mass Transit Railway, the Island Eastern Corridor, as well as the building of new towns and many high-rise commercial and residential complexes. Alongside these major projects, there have also been many smaller-scale developments, all of which have played a part in the continued growth and expansion of Hong Kong.

These projects have required a massive deployment of manpower and the application of the latest technology, and have also led to a great demand for engineers educated to the highest standards of the profession, and able to direct and organize these important engineering projects. I am pleased to say that the Faculty of Engineering of the University of Hong Kong has played a large part in the training and the education of many of these engineers.

The Faculty of Engineering is as old as the University itself, being one of the two original faculties that were set up when the University was first established. Although the Faculty of Engineering remained small until the general expansion of the University in the 1960s and 1970s, it nevertheless kept pace with developments in the engineering world, and was always in the forefront of engineering research.

In 1983 all the departments of the Faculty of Engineering moved to the new Haking Wong Building, where we are today, and for the first time the whole Faculty was brought under one roof and was housed in purpose-built accommodation. The Haking Wong Building became the focal point of engineering education at the University, and as a result of the move, further expansion and developments have been possible, the latest being the establishment of the Department of Computer Science earlier this year.

The Faculty of Engineering has kept abreast of the many developments that have taken place in the engineering field, as technological knowledge has extended the range and depth of engineering work. It has always pursued a pioneering course, encouraging research in many areas of the major branches of engineering, and wherever possible sophisticated and up-to-date machinery and equipment have been installed to help with the training of our engineering students and to foster research.

This Open Day will give you all a chance to visit the various departments and units of the Faculty and to get an inside view of its teaching and research facilities. I hope you will take the time to look at what is being undertaken here in the Faculty of Engineering and I am sure you will find your visit of great interest.

SPEECH GIVEN BY SIR S.Y. CHUNG

at the 75th Anniversary Dinner of the 75th Anniversary Celebration of the Faculty of Engineering on 9 November 1988

I am very grateful indeed to the Dean of the Engineering Faculty, Professor Cheng, for the kind invitation extended to me to attend the dinner this evening to mark the occasion of the 75th Anniversary of the Engineering Faculty of the Hong Kong University and to speak to such a distinguished gathering. May I first offer my heartfelt congratulations to all the past and present members of the Engineering Faculty for all the good work they have done and are doing in the education and training of professional engineers.

My association with the University has extended over a period of more than 50 years and I believe in an occasion such as this evening it would be appropriate to make some comparisons over half of a century. I therefore would like to share with you some of my memories.

During the pre-war years, we normally attended six years primary Chinese school plus eight years secondary English school before admission to university. In secondary education, we commenced at class eight and finished at class one, which is in contrast to the present-day system of starting from the lowest form one and finishing at form seven.

University courses were generally four years except in the case of medicine which, if I remember correctly, was six years. In the Engineering Faculty, the first two years were basically common for all the three major branches of civil, electrical and mechanical engineering.

I remember that during my years at the University, there were about thirty students in the first year and approximately twenty in the 4th and final year, making a total of about 100 students in the whole Engineering Faculty as compared to about 1,500 today. In fact, the whole University had a student population of about 500, as against some 7,000 today.

Before the Second World War, I believe Hong Kong University was the only one in South East Asia offering higher education in engineering and, for that reason, quite a significant proportion of the student population were from Malaysia and Singapore and also from India.

In those pre-war days, Hong Kong was an entrepot and there were few manufacturing industries. The only real industry was ship building and repairing, but most of the engineers in the shipyards were from the UK. Civil engineers were mainly employed by the Public Works Department of the Government and architectural firms in the private sector; the demand for local electrical and mechanical engineers was minimal.

With regard to post-graduate studies, I remember that up to 1940 there were only two or three awards of Master's degrees in the Engineering Faculty and they were part-time degrees by thesis. There were no post-graduate students, and Doctorate degrees were almost unheard of. None of the professors had a Ph.D. degree, let alone a D.Sc. Today I understand that the Engineering Faculty has about 40 full-time post-graduates reading for Doctorates and about 200 reading for Master's degrees.

Coming to the cost of attending university, I recall that in the late 1930s we paid $400 per year for tuition and about $1,000 per annum for boarding and lodging in hostels. Including other incidentals and depending on individual circumstances, it required about $1,600-$2,000 per year to support a student. It was quite expensive by those days' standards, as an engineering graduate would make only about $2,000 to $2,500 per year on first employment. Furthermore, there was no such thing as student grant and loan schemes for the less well-off students. Accordingly, only reasonably well-off families could afford to have their children receiving university education in those days.

Today, a local undergraduate in residence in the University requires about $15,000 to $20,000 per year for living and incidental expenses, as well as tuition fees. On the other hand, an engineering graduate would be able to get about $50,000 to $100,000 for the first job. University education is therefore very much cheaper and hence more widespread today. In fact, it is the present Government policy that no one will be deprived of tertiary education simply because of lack of financial means.

In pre-war days all students had to reside at university halls. Exemption was only granted after a year or so when the student could show good academic results and demonstrate good reasons for such exemption. This is contrary to the present situation where universities do not have adequate residential accommodation for the students. I consider that this is a very retrograde policy because hostels contribute much to the quality of university life and provide opportunities for early professional affiliations. This is particularly so for engineering students, who spend a very large part of their day time attending workshops and laboratories, leaving only evenings for mixing socially with their fellow students.

After the War only the Department of Civil Engineering was re-opened. However, as a result of the two major developments in this part of the world at the turn of the half-century, the economy of Hong Kong has changed significantly since the 1950s. Export-oriented manufacturing industries became for two decades the largest contributor to Hong Kong's Gross Domestic Product. Even with the rapid expansion of the tertiary industries in recent years, the manufacturing sector remains as one of the major components of the local economy and the largest employer of the 2.7 million workforce.

The development of the manufacturing industries has created an ever-increasing demand for professional engineers in the areas of mechanical, electrical, electronic, and industrial engineering. In order to meet such demand, the University re-opened the Departments of Mechanical and Electrical Engineering in 1958 and established the new Department of Industrial Engineering in 1973. The Department of Electrical Engineering was also renamed the Department of Electrical and Electronic Engineering to emphasize the growing importance of electronics.

Nonetheless, the expansion of the Engineering Faculty at the Hong Kong University alone was unable to satisfy the rapidly rising needs of the community, and the Government had to upgrade the Hong Kong Technical College to become Hong Kong Polytechnic, in 1972 and to create a second polytechnic, known as the City Polytechnic, in 1984. The Chinese University also joined in to provide a degree course in electronic engineering in the 1970s. At present, the four tertiary institutions under the UPGC have a total enrolment of about 7,000 engineering and technology students either reading first degree or degree-equivalent courses or pursuing post-graduate research or coursework.

Since the signing of the Sino-British Joint Declaration on the future of Hong Kong in 1984, Hong Kong's economic relationship with China has greatly deepened. Hong Kong's booming re-export trade, which has more than doubled in three years since 1984 and increased by more than 49% last year and by 46% for the first six months of 1988, reflects this growing interdependence. It is estimated that 70% of all foreign investment in China has came from or through Hong Kong.

Above all these, the most significant economic development between China and Hong Kong since 1984 is the shift of Hong Kong industrial production into China. The creation of perhaps two million industrial jobs in the Pearl River delta, as against the 900,000 working population in local factories, has to be seen to be believed. Not only are wages over the border very much lower, but more surprising is the fact that their labour productivity in some instances is higher than that in Hong Kong.

If this trend is to continue, more and more factories in Hong Kong will move their production into China. The possible exceptions are those which are engaged in the manufacture of products which are under export quota or are eligible for GSP duty-free imports or require sophisticated production processes. The growth of those products under export quota, such as textile garments, is limited and the number of markets granting the GSP privilege to Hong Kong is decreasing. For example, Hong Kong will be losing its GSP eligibility in its largest market, the USA, next year. Obviously, if Hong Kong is to continue to rely on its export-oriented manufacturing industries, greater efforts have to be put on the development of technologically-advanced products requring sophisticated production technology. This means that Hong Kong will not only need more professional engineers but higher quality professional engineers.

It is gratifying to see that the need is recognised by the Government and plans are in hand to expand facilities for the education and training of professional engineers. First, there will be the gradual expansion of both the size and range of the Engineering Faculty at the Hong Kong University. For example, a fifth department, known as the Department of Computer Science, has been established this year.

Secondly, the Chinese University will have a School of Engineering. Thirdly, the City Polytechnic is currently moving into its new campus at Kowloon Tong and embarking on a major expansion programme during the next few years. Lastly, a new University of Science and Technology is being built at Clearwater Bay to specialise in the fields of technology, science, and business management.

I believe that we, as members of the Hong Kong community with particular interest in higher engineering education and training, will welcome this development which should greatly help Hong Kong to further its economic growth and prosperity for the benefit of the whole community.

Ladies and gentlemen, in conclusion may I ask you all to rise and drink a toast to the continual development of the Engineering Faculty of the Hong Kong University and to the health and success of those studying and working in it.

A HISTORY OF THE FACULTY

FACULTY OF ENGINEERING 75th HKU

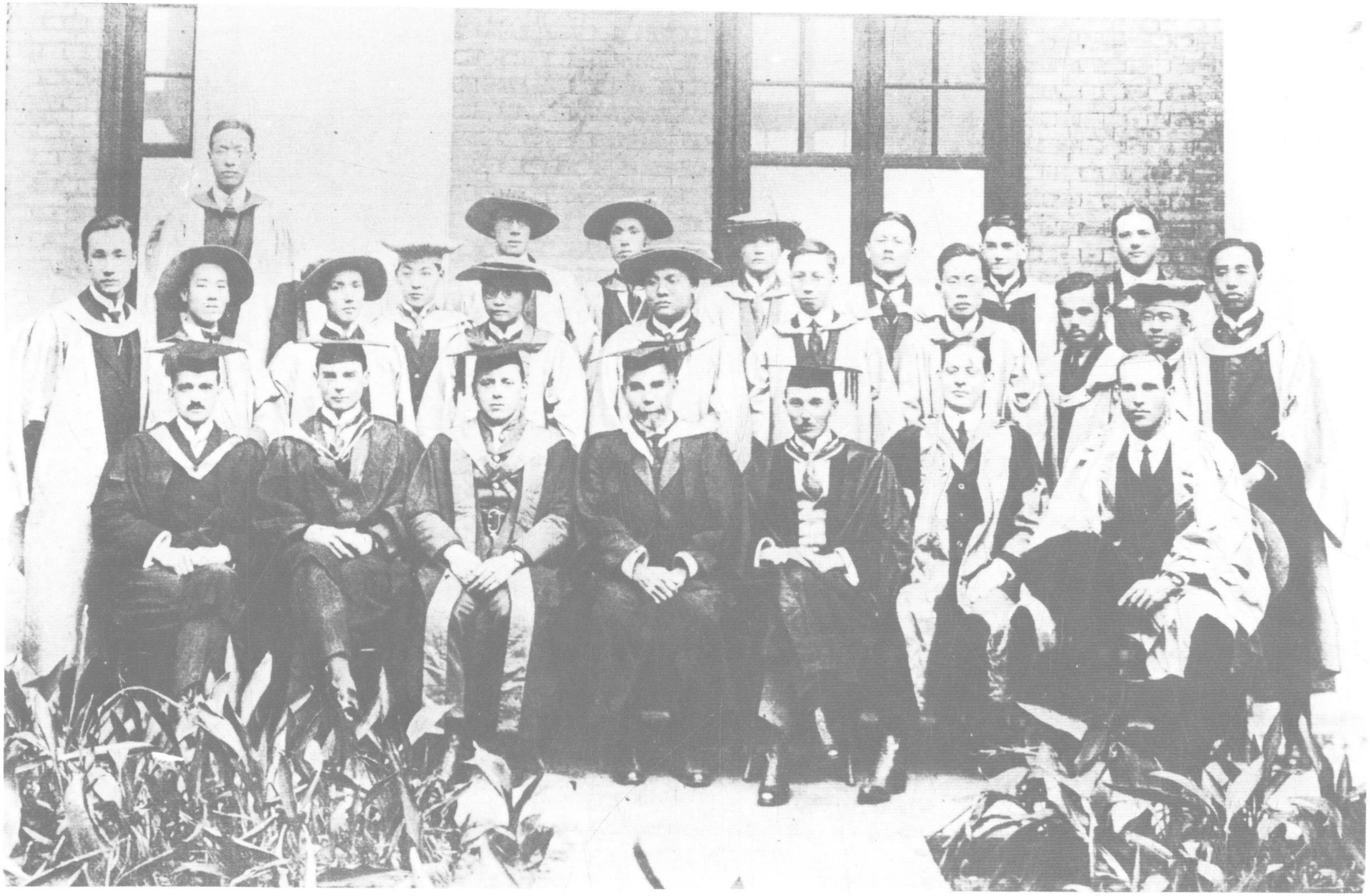


Fig. 1 Graduation Day, May 1916

Standing:- 12 B.Sc.(Eng.) graduates, Mr. A.C. Franklin, Mr. G.E. Marley, Mr. W.R. Noble, Mr. I. Day, 2 demonstrators
Sitting:- Prof. W. Brown, Prof. F.A. Redmond, Prof. T.H. Matthewman, Prof. C.A. Middleton Smith, Mr. E.J. Surman, Prof. A.G. Warren, Prof. T. Stuart

THE HISTORY OF ENGINEERING AT HONG KONG UNIVERSITY FROM 1912 TO 1988

Joseph A. Clark

This account of the history of the Engineering Faculty dating back to the appointment of the first chair of engineering in 1912 is an attempt to present the historic facts with reference to student numbers (undergraduates and postgraduates), the contributions made by academic staff, and a brief chronological record of the buildings which were employed in an undertaking which spanned two world wars and a period of 76 years in the middle of the twentieth century.

B.Sc.(Eng.) GRADUATES (1916-88,INCLUSIVE)

Seventy years of accumulated teaching have produced 4,969 first degree engineering graduates. The first 30 years of pre-war endeavour yielded 340 graduates (Table 1A). A full list of these successful candidates (with honours classifications) is found in the HKU 1941 Calendar, pp. 111-119. Detailed research using consecutive University Calendars dating from 1916 showed eight errors in graduation dates which have been perpetuated through University Records, and in addition, there was a degree awarded *in absentia* in 1950 to a 1941 graduate. It is of interest to note that of the pre-war graduates about 15% were non-Chinese and 30% overseas Chinese and students came from all over the Far East; from many Provinces in China, from Malaya, East Indies, Siam, and even Japan. Also the number of students who had to discontinue their studies was probably of the order of one-third with casualties at every stage of the degree curriculum. Figure 1 is an historic photograph of the Engineering Faculty on the first Degree Day in May 1916. It is believed that along with 2 Chinese demonstrators all the 12 engineering graduates are present, viz.,

Chan Iu Choo	Leung Nai Hang[2]
Foo Ping Sheung[1], LL.D.	Ling Man Lai
Ho Wing Kin	Tang Ying Lam[2]
Ip Hin Fong	Wei Wing Hon, M.Sc.
Lai Hau Yeung	Wei Wing Lok
Lau Chan	Wong Tai Cho

(Superscripts indicate honours classification, and HKU higher degrees shown)

During the pre-war era the engineering degree required 4-years of full time study. For the first three years all engineering students took the same lectures and then specialized in either Civil (C), Mechanical (M) or Electrical (E) Engineering in their fourth year. Up to and including 1932, the numbers of these respective graduates were 99C, 33M and 43E from a total of 175. It was not surprising to find that, as all graduates studied the fundamentals of civil, mechanical, and electrical engineering, some of the civils found employment in mechanical or electrical work and *vice versa*. At that time the students lived in Halls of Residence and in relation to the total annual cost of an engineering student in the University the 1933 Calendar states: "Probably about $1,400 represents the minimum amount which, at present prices, would cover a student's annual expenses including vacations". Also, the Hong Kong Government had established two student apprenticeships for engineering graduates of this University in the Public Works Department. The posts were tenable for two years at a salary of $150 a month which should be compared with the wage for a skilled manual worker of about $40 a month, with unskilled labour about half that price. University education was very definitely for the rich.

Table 1A B.Sc.(Eng.) graduates (1916-1941, inclusive)

		Degree Classifications				
Year	Accumulative Total	1st	2nd	Pass	Annual Total	5-Year Sub Totals
1916		1	2	9	12	
1917		-	4	11	15	
1918		1	7	7	15	54
1919		-	1	7	8	
1920	54	1	1	2+	4	
1921		2	1	8	11	
1922		4	3	14	21	
1923		1	1	6	8	59
1924		1	2	11	14	
1925	113	1	-	4	5	
1926		2	-	3	5	
1927		1	-	9	10	
1928		1	4	4	9	38
1929		-	1	4	5	
1930	151	1	1	7*	9	
1931		-	2	10	12	
1932		2	5	5	12	
1933		2	3	7	12	65
1934		2	3	9	14	
1935	216	1	4	10	15	
1936		-	3	15	18	
1937		-	6	26	32	
1938		-	-	7	7	103
1939		1	-	29*	30	
1940	319	1	3	12	16	
1941	340	1	2	18	21	21
30 Yrs	340	27	59	254	340	340 Sum

\+ One War Degree, i.e., Jack, J.M 1920
* Female Students, viz., Miss Tsang Tin Chien 1930
Miss Wong Yuet Lan 1939

The Faculty of Engineering, as well as satisfying the needs of Hong Kong for professional engineers, to which the debt of the territory is immense, also provided a source of supply for China. By the early thirties HKU engineering graduate associations had formed in Shanghai, Nanking, Hankow, and Canton and our graduates had made a major contribution to the rapid construction of new roads in the provinces of Kwangtung and Kwangsi. In the making of roads and railways, development of communication, reinforced concrete structural work, the installation and running of machinery (electric supply plants in industrial establishments, like cotton mills), HKU engineers were active in China.

The University Engineering Society Journal which began its career in 1929 provides personal employment information on B.Sc.(Eng.) graduates. In particular, Vol. 1 (1929) and Vol. 6 (1934) list the whereabouts of the majority of the HKU graduates at these respective times. Interesting observations regarding those who became academics were:-

Chao Ming Hsin	1918	Professor of English, Shangtung University, Tsing Tao
Chao Yu Chen	1926[1]	Lecturer, Ho Pei Provincial Institute of Tech., Tientsin
Liu Chen Hua	1918[1]	President, Pei Yang University, Tientsin; Prof., Tsing Hua Univ.
Pih Chin Tou	1921	Lecturer in Yunnan University
Shih Chih Jen	1922[1]	Professor in Pei Yang University, Tientsin
Tsang Tin Chien (Miss)	1930	Teaching in Wuchow
Wang Wei	1924[2]	Professor in University of Yunnan, Yunnanfu
Yeung Kwai Chiu	1920	Principal of Hong Kong Educational Institute
Yu Kwei Hsin	1922[1]	Principal of Technical Institute, Peiping

Other parts of the Far East found graduates in Malaya, Borneo, Sarawak, French Indo-China, Bombay, Singapore, Rangoon, Penang, Saigon, Kuala Lumpur, America (further study), and England (further study or graduate apprenticeships).

Table 1B B.Sc.(Eng.) graduates (1949-1970, inclusive)

Year	Accumulative Total	Degree Classifications				Annual Total	5-Year Sub Totals
1949	366	War Time Degrees				26+	
1950	375	Ordinary Degrees				9	35
1951		Ordinary Degrees				11	
1952		Ordinary Degrees				17	
1953		Ordinary Degrees				13	
1954		Ordinary Degrees				14	63
		1st	2nd		Pass		
1955	438	3	4		1	8	
1956		2	5		6	13	
1957		-	7		3	10	
1958		1	5		10	16	78
1959		1	9		10	20	
1960	516	2	8		9	19	
1961	Division of	4	10		4	18	
1962	Departments	2	9		6	17	
1963		3	5		23	31	156
1964		2	16		22	40	
1965	672	6	13		31	50	
1966		5	17		33	55	
1967		3	22		32	57	
			2i	2ii			
1968		10	19	25	14	68	357
1969		5	15	25	18	63	
1970	1029	11	32	44	27	114	
22 Yrs	1029	60	290		249	689	689 Sum
		In Addition 90 Ordinary and War Time Degrees					

\+ One Posthumous War Time Degree ..... KossaKowski, Z.A.

Since the birth of University, the final engineering examination papers have always been sent to the United Kingdom to assessors who before the war were examiners in London University; and every year since 1916 a statement was received that certain graduates of Hong Kong had reached the standard that was required for the honours B.Sc.(Eng.) in London University. Also, all engineering students received detailed instruction during their first two years in the Ho Tung Workshop which was well equipped for machine shop, fitting and other manual instruction; the mechanical engineering students continued this instruction during the third and fourth years of their course. The practical experience was enhanced during the pre-war era by visits to places of engineering interest, such as:-

Aberdeen Water Works
China Canning Factory
China Light and Power Co.
Dairy Farm Ice Plant
Green Island Cement Works
H.K. Electric Generating Station
Hong Kong Gas Works
K.C.R. Locomotive Works
Peak Tramway Power Station
Tai Tam Tuk Pumping Station
Taikoo and Whampoa Dockyards
Shing Mun Dam

These industrial visits were organised by the Engineering Society and Figures 2 and 3 are illustrative of Engineering Society Committees of that time.

Table 1C B.Sc.(Eng.) graduates (1971-1988, inclusive)

		Degree Classifications						
Year	Accumulative Total	1st	2nd		Pass		Annual Total	5-Year Sub Totals
			2i	2ii				
1971		19	42	40	30		131	
1972		12	46	50	30		138	
1973		11	55	46	23		135	683
1974		8	48	57	27		140	
1975	1712	12	40	64	23		139	
1976		8	37	68	45		158	
1977		10	46	96	55		207	
1978		15	78	73	46		212	
1979		18	67	104	49		238	1057
					3rd	Pass		
1980	2769	19	70	103	38	12	242	
1981		24	78	112	28	18	260	
1982		13	86	112	20	-	241	
1983		18	95	128	31	14	286	1296
1984		20	100	107	21	9	257	
1985	4065	21	82	107	27	15	252	
1986		29	104	125	37	13	308	
1987		26	115	98	30	21	290	904
1988	4969	19	115	132	29	11	306	
18 Yrs	4969	302	1304	1622	712		3940	3940 Sum

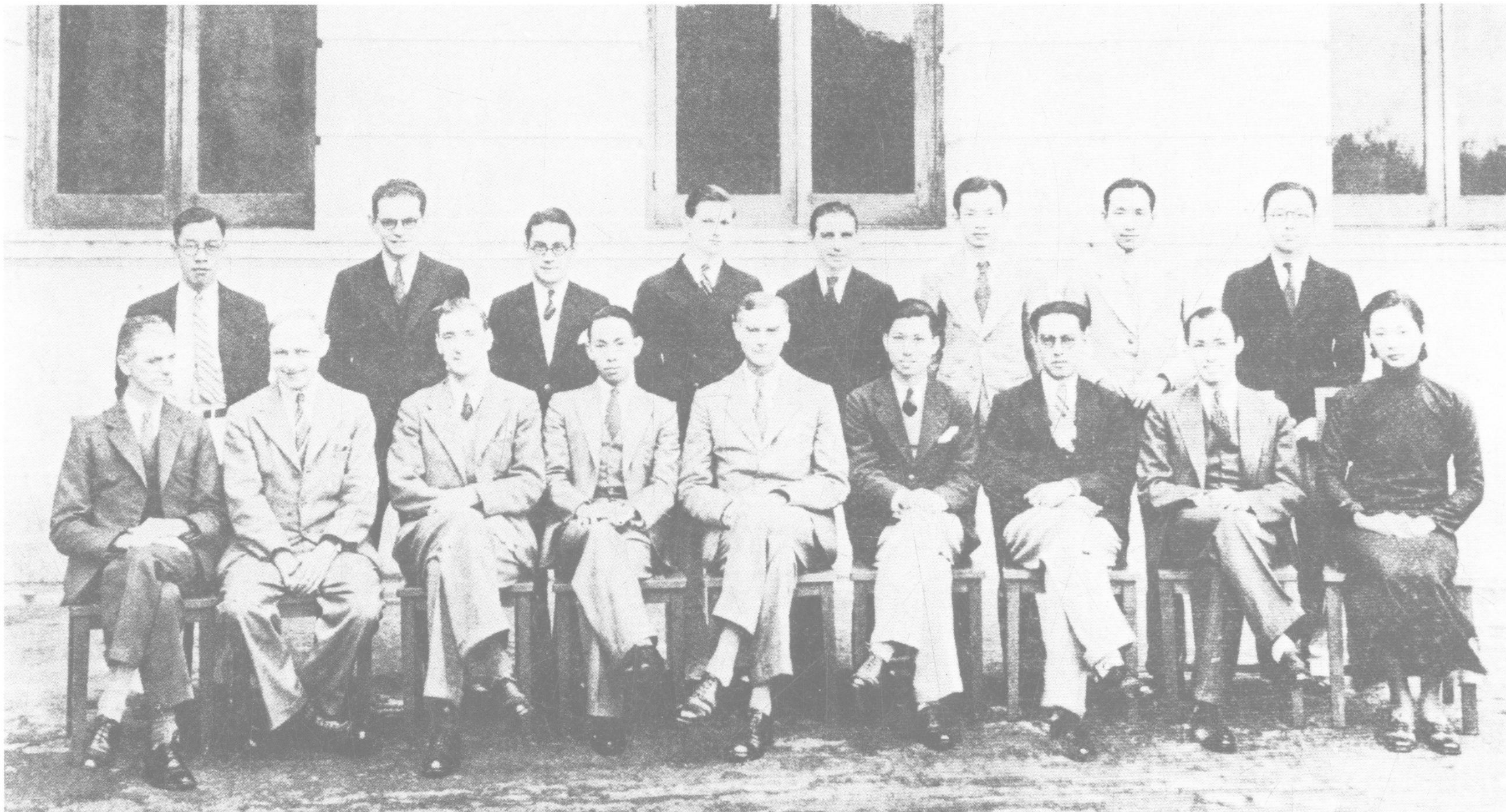


Fig. 2   1935 Engineering Society Committee

Standing:- Lo Sui Shing, W.J. Citrin, Y.C. Lau, A.V. Kolatchoff, N. Gorachenko, Tan Kai Sui, Tye Soo Cheong, Kuo Yue Lih
Sitting:- Mr. D.W. Morley, Mr. I. Day, Mr. S.V. Boxer, Fong Ching See, Prof. F.A. Redmond, Ng Kee Yeow, Tan Pek Eam, Mr. Pao Yue Lum, Miss Wong Yuet Lan

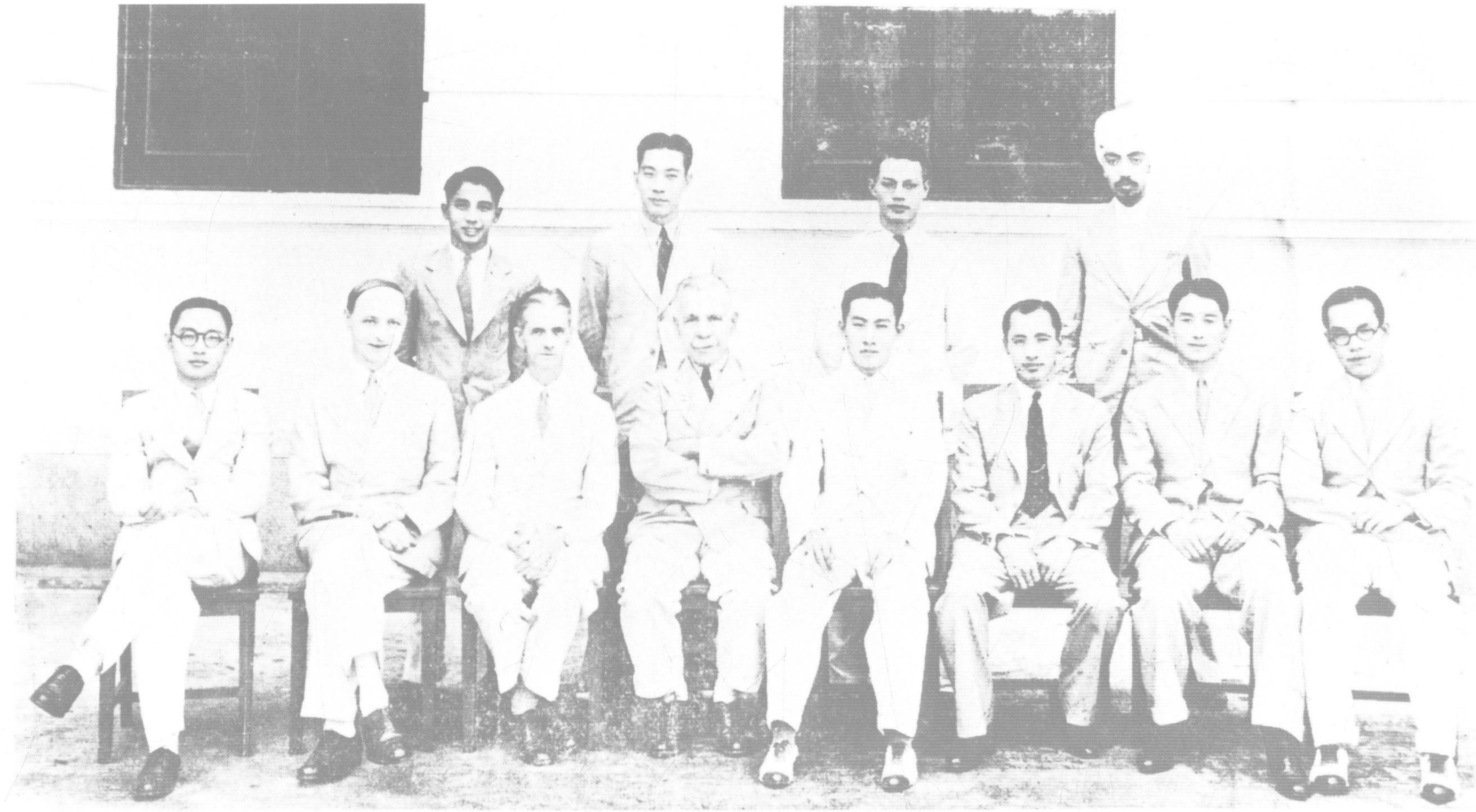


Fig. 3 1936 Engineering Society Committee

Standing:- Too Joon Ting, Sung Tsoong Tuh, Man Hung Cho, G. Singh
Sitting:- Kuo Yue Lih, Mr. I. Day, Mr. D.W. Morley, Prof. C.A. Middleton Smith, Zea Yue Kur, Mr. Pao Yue Lum, Chang Chi Yin, William Kong

Table 2 Summary of B.Sc.(Eng.) graduates (1916-88, inclusive)

Years	Dates(inclusive)	Engineering Graduates	Totals
19 11	1912-30 1931-41	151 189	340
12	1949-54 1955-60	Ordinary Degrees 90 and Classifications given 86	176
10	1961-65 1966-70	3 Depts - 156 3 Depts - 357	513
10	1971-75 1976-80	3 Depts - 683 4 Depts - 1057	1740
8	1981-85 1986-88	4 Depts - 1296 4 Depts - 904	2200
70 Yrs	1912-88	Sum = 4969	

The forty years of post-war teaching since 1948 have produced 689 B.Sc.(Eng.) graduates for the period 1949-70 (Table 1B), the numbers attaining more than 100 graduates per annum from the three departments, and a further 3,940 B.Sc.(Eng.) graduates for 1971-88 inclusive (Table 1C), the numbers increasing to 300 graduates per annum from the four departments. A concise summary is shown as Table 2 of the total B.Sc.(Eng.) graduates produced, inclusive of this 1988 Anniversary Year.

Twenty-six war-time degrees of B.Sc.(Eng.) were confirmed by University Council in 1949 and awarded at the 38th University Congregation. They were:-

Chan Si Hung
Chiu Pat Sun
Choi Tze Chong
Fong Nai Ching
Hung Shek Chiu
Kwok Wai Man
Lai King Shung
Li Sheung Ngai
Siu Che Tan
Yeung Yuk Wah
Yue Sui Lun

In Absentia

Lau Yu Chuen
Lee Ah Poon
Lee Tsam Shum
Leong Mor Sai
Li Hing Shing
Lim, John
Tan Hon Teck
Tan Khean Yeung
Tcheng Pao King
Wei Kuang Mu
Woo Kai Yi
Wong Ting Tsai
Wu Tsu Lin
Yoong Yew Moyne

Posthumous: Kossakowski, Z.A.

The first war degree of Hong Kong University was awarded in 1920 to J.M. Jack who later became the Managing Director of Electrical Contractors in Hong Kong. A photograph (Figure 4) of eight war-time

Fig. 4 War-time B.Sc.(Eng.) Civil Graduates in 1949

Standing:- Choi Tze Chong, Yeung Yuk Wah, Chiu Pat Sun, Hung Shek Chiu, Fong Nai Ching, Siu Che Tan, Chan Si Hung, Lai King Shung,
Sitting:- Prof. F.A. Redmond

civil graduates at the Congregation is reproduced from Vol. 14 of the University Engineering Society Journal.

From the surrender to the Japanese in December 1941 until the liberation of the Colony in August 1945 -- nearly four long years of misery, humiliation, and brutality -- the University, like every other institution in Hong Kong, had its share of suffering and loss. It was stripped to the bone of everything valuable and the Faculty of Engineering, with its heavy dependence on laboratories, suffered the greatest calamity. The University had, on the advice of the Committee for Higher Education in the Colonies, agreed, with some reluctance, to abolish degree courses in Electrical and Mechanical Engineering and to provide instead courses for a degree in Architecture. Thus from 1948 to 1960 only civil graduates were conferred, with honours being awarded from 1955 onwards. The post-war years until 1955 in the Department of Civil Engineering saw major changes in the Regulations for the degree of B.Sc.(Eng.). From two years on theoretical subjects, e.g., mathematics, physics, and chemistry, supplemented by drawing and workshop practice, and the remaining two years dealing with engineering subjects it was changed to only one year given to introductory subjects with an intermediate examination followed by three full years of civil engineering subjects. Then the first year became optional with exemption given to the majority of students and finally a 3-year B.Sc.(Eng.) degree course with recognized honours qualifications. 1955 marked a milestone for the Faculty with official recognition of the degree course by the Institution of Civil Engineers at the very first application followed by similar accrediting the next year by the Institution of Structural Engineers.

In July 1954 was published a Report of the Committee on Engineering Education as suggested by the Jennings-Logan Committee concerning the Faculty of Engineering. However by recognition the following year by I.C.E., any doubts of standards were immediately removed. Nevertheless it was stated, 'We are doubtful whether the Colony alone could absorb the present output of about 12 per year,...." with reference to the University's engineering graduates, and this misapprehension came from the possible future of few openings for them on the mainland of China being available. The Engineering Education Committee of 1954 nevertheless suggested the introduction of mechanical and electrical engineering which subsequently commenced in 1958, and in 1961 nine civil, five electrical and four mechanical B.Sc.(Eng.) degrees were conferred. This period of major change in curricula and syllabi is represented by two photographs (Figures 5 and 6) showing the 1951 and 1952 B.Sc.(Eng.) civil graduates and reference should be made to *The First 50 Years* pp. 116-126, for an in-depth historic account of the background to these changes.

Fig. 5 B.Sc.(Eng.) Civil Graduates in 1951

Standing:- Foo Yin Chee, Lee Ting Wai, Wong Cheng Ho, Ng Teck Sheng, Chooi Tai Kow, Huang Wei Hong, Ip Hung Wang, Fok Wai Kuen, Yu Man Kit and Prof. K. Billig (sitting)

Absent:- Lau Yick Suen, Yung Ming Kin

Fig. 6 B.Sc.(Eng.) Civil Graduates in 1952

Standing:- Chau Kai Heem, Mai Hung Kuang, Li Pai Lin, Fung Yuen Seen, Yam Chung Fu, Ho Chung, Yuan Tao Ming, Chiu Shin Moh, Wong Mang Ki, Ip Po Hey, I.R.S. Robertson

Sitting:- Teoh Cheng Siong, Arthur E. Low, Dr. S.Y. King, Mr. H.S. Tsang, Mr. L.K. Chen, Prof. K. Billig, Mr. K.C. Wu, Chong Kim Loong, Wong Cheuk Chi, Tsang Nai Lok, Sung Pei Te

By the year 1960 the divisions of the departments of Civil, Electrical and Mechanical Engineering were complete although Part I was a common first year. The next major alteration came with the commencement of industrial engineering in 1973. Finally, departmental names were changed in 1986, to reflect properly the endeavours of the Engineering Faculty, to Civil and Structural Engineering, Electrical and Electronic Engineering, Industrial Engineering, and Mechanical Engineering.

Table 3 B.Sc.(Eng.) female graduates (1916-88)

1st Class Hons.:	1983(1)	Miss Nq Kit Yin (Civil)	
	1985(1)	Miss Lam Ho Wai (Elect)	
	1986(1)	Miss Lau Mee Yuk (Mech)	Total: 4
	1987(1)	Miss Chan Choi Wan (Elect)	
2nd Class Hons.:	1973(3)	1981(2)	
	1974(3)	1982(7)	
	1975(1)	1983(7)	
	1976(1)	1984(6)	
	1977(2)	1985(4)	Total: 67
	1979(4)	1986(9)	
	1980(4)	1987(6)	
		1988(8)	
Pass Degrees, and	1930(1)	1980(1)	
3rd Class Hons. :	1939(1)	1983(1)	
	1976(1)	1985(1)	Total: 13
	1977(2)	1986(1)	
		1987(4)	
			Sum = 84

An informative statistic relating to female graduates in engineering relates to Table 3 with only 1 in 60 of every B.Sc.(Eng.) graduate of HKU, up to and including 1988, being of female gender although the proportion does seem to be on the increase.

POSTGRADUATE ENGINEERING DEGREES (1916-88)

The Faculty of Engineering has a distinguished record within the University of Hong Kong for the quality and quantity of its higher degrees; M.Sc.(Eng.), M.Phil., and Ph.D. There are not many universities that were founded before the Second World War that may boast that both its first M.Sc. and Ph.D. degrees were conferred on engineering students. Table 4A chronologically lists both the M.Sc.(Eng.) and Ph.D. graduates in engineering, indicating their primary degree from HKU (if relevant) and if they became staff members of the Faculty. It can thus be ascertained who were the first to obtain these higher degrees from the respective Departments of Civil, Electrical, Industrial, and Mechanical. Our very first M.Sc.(Eng.) degree was awarded to S.B. Ahmed in 1929 for a thesis, "Theory of Earth Pressures as Applied to Retaining Walls"; he also sat for a written examination. The second M.Sc.(Eng.) graduate was Wei Wing Hon in 1937 who presented a thesis on "High Pressure Steam Power Generation". He first entered the University in 1912 and was awarded the B.Sc.(Eng.) in 1916 with the first group of HKU graduates. Mr. Wei had a distinguished career as a mechanical and electrical engineer in China, being involved in many power station projects and meriting A.M.I.E.E. and A.M.I.Mech.E.

Our post-war firsts were respectively Huang Wei Hong with M.Sc.(Eng.) in 1953 and Chen Loh Kwan with Ph.D. in 1963, both from the Civil Engineering Department. The degree awarded to L.K. Chen at the 60th Degree Congregation was the first Ph.D. of the University and was conferred on him for a thesis, "Analysis of Indeterminate Frames by Method of Influence Moments". Many of the higher degree graduates have later become distinguished academics particularly in their *Alma Mater*. One mechanical engineering graduate Mai Yui Wing, with B.Sc.(Eng.)[1] 1969 and Ph.D. in 1972 while at HKU, is now a Professor in the Mechanical Engineering Department of the University of Sydney, Australia. From our first group of B.Sc.(Eng.) graduates after the war (1950), with ordinary degrees in civil engineering, three obtained Ph.D. degrees in 1954 at Imperial College, London. They were Chan Wai Lee, Ernest Low, and Yu Chan Wah. These gentlemen were amongst the first of our undergraduates to obtain doctorate degrees, and were preceded by King Sing Yui in electrical engineering with Ph.D. (London) in 1947 and Chung Sze Yuen in mechanical engineering with Ph.D. (Sheffield) in 1950.

Prior to the change of University Regulations concerning higher degrees in 1972, the M.Sc.(Eng.) award was a research degree based primarily on a thesis of the required standard. Table 4B enumerates the post-war higher degrees in engineering: (1) before introduction of the M.Phil. (1949-1971), and (2) after introduction of the M.Phil. (1972-1988). The difference between the coursework M.Sc.(Eng.) and research M.Sc.(Eng.) is made apparent in Table 4. The total number of doctorate degrees in engineering is 70 Ph.D. awards which includes two female graduates; Li Mei Kuen from Electrical in 1981 and Wang Jun from Mechanical in 1988. The Master degrees are proportioned 164 by research and thesis to 412 by lectures and coursework with examinations. This gives a grand total of 646 post-graduate awards in engineering between the years 1912 to 1988.

ENGINEERING HONORARY GRADUATES *(HONORIS CAUSA)*

The University has chosen to honour 11 engineers with the highest awards of Hon. LL.D. or Hon. D.Sc. This highly select group (listed in Table 5) of which only five are first degree graduates of HKU and all belong to the post-war era of university education for their primary degree, graduated in the following order:-

Foo Ping Sheung (1916)
Lee Iu Cheung (1917)
Tay Gan Tin (1918)
King Sing Yui (1940)
Chung Sze Yuen (1941)

Table 4A Post-graduate degrees; M.Sc.(Eng.) and Ph.D.

M.Sc. (Eng)	1929	Ahmed, Sheikh Basheer	B.Sc. (Eng)[1] 1925
	1937	Wei Wing Hon	B.Sc. (Eng) 1916
	1953	John, Huang Wei Hong	B.Sc. (Eng) 1951
	1960	Leung Kui Wai*	B.Sc. (Eng) 1939
		Kong Fung Kew	B.Sc. (Eng)[1] 1958
		Wong Ka Ching	B.Sc. (Eng)[2] 1958
		Yuen Bing Chiu	B.Sc. (Eng)[2] 1958
	1961	Chang Tai Hon (Civil)	B.Sc. (Eng)[1] 1959
	1963	Chung Hung Wan (Civil)*	B.Sc. (Eng)[1] 1961
		Tao Wing Fai (Civil)	B.Sc. (Eng)[2] 1961
		Huey Chung Tow (Mechanical)	
	1964	Robin, Chan Bing Fun (Civil)	B.Sc. (Eng)[2] 1962
		Ma Wing Fat (Electrical)	B.Sc. (Eng)[2] 1962
		Yu Ping Kong (Electrical)*	
	1965 etc.	Shen Chun Ming (Electrical)*	B.Sc. (Eng)[1] 1963
Ph.D.	1963	Chen Loh Kwan (Civil)*	
	1966	Chung To Kay (Civil)	B.Sc. (Eng)[2] 1963
	1970	Ko Jan Ming (Civil)	B.Sc. (Eng)[2] 1966
		Choi Cheung Chuen (Civil)*	B.Sc. (Eng)[2] 1967
		Robert Lam (Civil)*	B.Sc. (Eng)[2] 1967
		Poon Kwan Leung (Mechanical)	
	1971	Ngan Ka Mok (Mechanical)	B.Sc. (Eng)[1] 1968
		Ho Chun Fai (Electrical)*	
	etc.		
	1977 etc.	Ho Chung Fai (Industrial)	B.Sc. (Eng)[2] 1971

* HKU Staff

<u>FEMALE POST-GRADUATES IN ENGINEERING</u>; M.Phil. and Ph.D.

M.Phil.	1974	Yeung Shuk Wa (Mech)	
	1979	Betty Ng Wai Ying (Civil)	B.Sc. (Eng)[2] 1975
	1981	Angela Lee Sean Ying (Ind)	
	1983	Lui Ng Ying Bik (Mech)	
	1988	Lee, Ralphaelynne Cockingyan (Ind)	
	1988	Wendy Lee Shuk Yee (Ind)	B.Sc. (Eng)[2] 1983
Ph.D.	1981	Margaret Li Mei Kuen (Elect)	B.Sc. (Eng)[2] 1973
	1988	Wang Jun (Mech)	

Table 4B Summary of M.Sc.(Eng.); M.Phil.; Ph.D.
Faculty of Engineering

(1) 1949-1971 (Before introduction of M.Phil.):

Year	Research Ph.D.	Research M.Sc.(Eng)
1953	-	1
1960	-	4
1961	-	1
1963	1	3
1964	-	3
1965	-	1
1966	1	6
1967	-	3
1968	-	9
1969	-	4
1970	4	8
1971	2	4
Total	8	47

(2) 1972-1988 (After introduction of M.Phil.):

Year	Research Ph.D.	Research M.Phil.	Coursework M.Sc.(Eng)
1972	6	6+	-
1973	3	3	-
1974	-	9*	-
1975	2	2	-
1976	4	5	-
1977	2	8	-
1978	1	9	11
1979	2	7*	15
1980	2	7	10
1981	2*	8*	35*
1982	5	8	33
1983	3	7*	55*
1984	4	8	26**
1985	4	6	65*
1986	3	7	23*
1987	6	8	82*
1988	13*	7**	57*
Total	62	115	412

* 16 female graduates (Post Graduate Degrees)
\+ Includes 2 M.Sc.(Eng) awards by research

Totals: Research Degrees 70 Ph.D. awards
164 Master awards
(includes 2 pre-war)

Coursework Degrees 412 M.Sc.(Eng)

Sum = 646

Table 5 Engineering honorary graduates *(honoris causa)*

LL.D.	1916	Jeme Tien Yow	
LL.D.	1924	Preece, Sir Arthur Henry	KT., M.I.E.E.
LL.D.	1930	Foo Ping Sheung	B.Sc. (Eng) ... 1st Hons ... 1916
LL.D.	1939	Smith,Cades Alfred Middleton *	Taikoo Professor of Engineering 1912/38
LL.D.	1961	Tay Gan Tin	B.Sc. (Eng) 1918
LL.D.	1969	Lee Iu Cheung	B.Sc. (Eng) ... 2nd Hons ... 1917
LL.D.	1979	Tien, Francis Yuan Hao	F.H.K.I.E.
D.Sc.	1975	Szeto Wai	F.I.C.E., F.I. Struct. E.
D.Sc.	1976	Chung, Sir Sze Yuen	B.Sc. (Eng) ... 1st Hons ... 1941
D.Sc.	1977	Mackey, Sean *	Professor of Civil Engineering 1957/76
D.Sc.	1981	King, Sing Yui *	B.Sc. (Eng) ... 1st Hons ... 1940 Professor of Electrical Eng. 1966/80

* Emeritus Professors.

Bibliographies of the 7 post-war honorary graduates can be found in the official "University of Hong Kong Gazette" appropriate to the year of their awards. For unswerving dedication and loyalty to the University and engineering education, Professors Middleton Smith, Sean Mackey, and S.Y. King were honoured. Their respective contributions as scholars, administrators, and teachers are enumerated later in this historic account. Lee Iu Cheung, Yuan Hao Tien, Szeto Wai, and Sir Sze Yuen Chung have given life-long service to our community making major contributions to commerce, industry, welfare, and government.

Jeme Tien Yow (1861-1919) was awarded the Hon. LL.D. at the first congregation of the University and his major contributions as an engineer were as director general of the Canton-Hankow-Szechwan Railway System and earlier as a pioneer railroad builder. A concise bibliography of him can be found in the University Engineering Society Journal Vol. 20, (1956). Sir Arthur Henry Preece was an electrical engineer involved in telegraphy, telephone, and electricity supply undertakings and many hydro-electric works around the world, including China. He was honoured for his contributions in a consultancy and advisory role to HKU during its first ten year history.

The most distinguished of our graduates is probably Foo Ping Sheung (1895-1965) who was the first 1st class honours graduate of Hong Kong University and the first graduate of the University to be conferred with an honorary degree. He commenced his career in railway engineering, then printing and engraving, and eventually rose to the highest diplomatic positions of the Chinese Government dealing with foreign affairs, becoming a Vice-Minister and China's Ambassador to Russia.

Tay Gan Tin was also one of our earliest graduates in engineering becoming a demonstrator for four years and returning home to Singapore in 1922. Much of his career was spent associated with ships and shipping which led him to positions in its management and direction but eventually his major contributions were in social welfare and extensive humanitarian service in Singapore, for which the University honoured another one of its own engineering graduates.

STAFF OF THE ENGINEERING FACULTY (1912-42)

The first Vice-Chancellor of the University of Hong Kong was Sir Charles Eliot, a famous scholar and linguist of Oxford University. For the first year of work in the University the only other full time members of staff were Mr. W.J. Hinton (Registrar and lecturer in economics) and Professor Middleton Smith (Figure 7). The University is thus unique in the fact that the first member of the full time teaching staff to be appointed was the Professor of Engineering, a mechanical engineer by qualification. Messrs. John Swire Ltd. (London) and their associates, the Taikoo Sugar Refinery, and Alfred Holt Ltd., contributed between them to a large endowment fund of the University specifically for developing engineering studies. As a result, the first Chair of Engineering founded in the University was called the Taikoo Chair of Engineering. C.A. Middleton Smith (CAM) occupied this senior Chair of Engineering until his retirement in 1939.

Table 6A lists chronologically the 5 pre-war Professors of Engineering who without exception, excluding CAM, were first appointed as Lecturers. Professor Mathewman in 1914 became the first Professor of Electrical Engineering and Professor Redmond (Figure 8) in 1920 became the first Professor of Civil Engineering i.e., excluding CAM, who was really a mechanical engineer, with the title of Taikoo Professor. The first Professor of Physics in the University was the Ellis Kadoorie Professor A.G. Warren who later became the Professor of Electrical Engineering and resigned in 1921 to be succeeded by Professor M.H. Roffey. Table 6B names the non-engineering Professors appointed to the Faculty of Engineering, whereas Table 6C lists the Lectureship appointments. During the period 1913-1929 the average staff numbers were 8 (lecturer grade and above) and for the period 1930-1939 the average number appointed was 11 staff. The first Chinese members of staff were Li Kai Yeung, Pao Yue Lum, and Koh Nye Poh in Mechanical, Civil and Electrical Engineering, respectively, appointed just prior to the War years. For the Faculty the total number of full time academic staff during the 1912 to 1942 pre-war years was 25. In Figures 1, 2, and 3 some of these academics are photographed alongside students of the same era.

Fig. 7 Prof. C.A. Middleton-Smith
(Taikoo Professor 1912-1939)

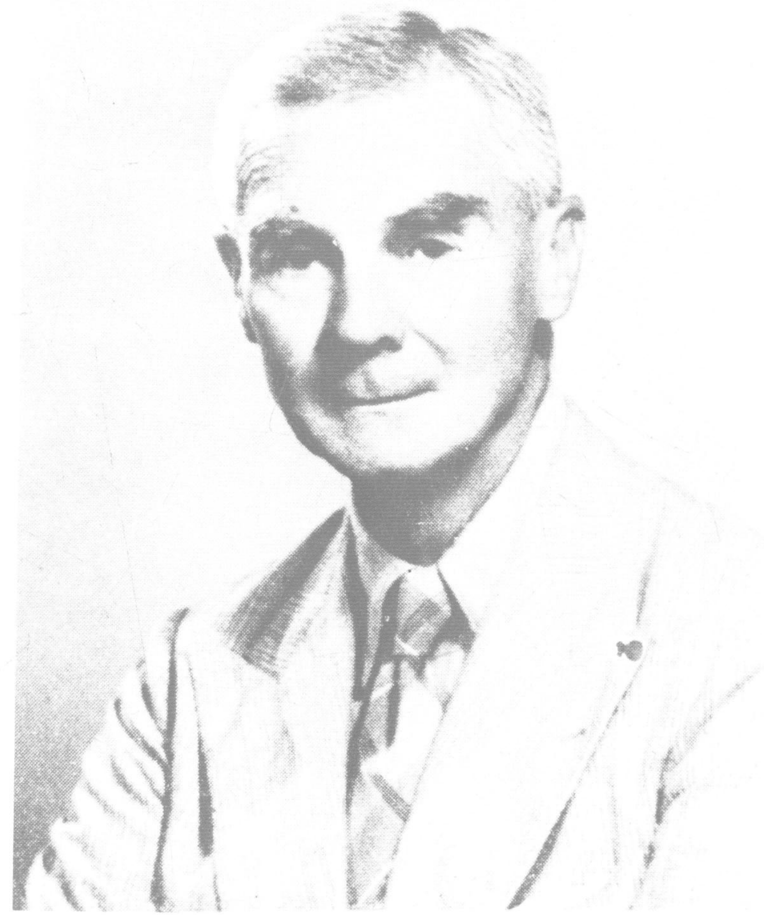


Fig. 8 Prof. F.A. Redmond
(Professor 1920-1942)

Table 6 Faculty of Engineering Staff (1912-42)

(A) Professors of Engineering :-

1.	Sep 1912 to 1917	Taikoo Professor of Engineering and Dean of the Faculty	C.A. Middleton Smith, M.Sc., M.I. Mech. E.
	1917/20	Taikoo Professor of Civil and Mechanical Engineering	C.A. Middleton Smith
	1920/39	Taikoo Professor of Engineering	C.A. Middleton Smith
2.	1914/18	Professor of Electrical Engineering (1913 L)	T.H. Matthewman, M.Eng.
3.	1914/19	Ellis Kadoorie Professor of Physics	A.G. Warren
	1918/21	Professor of Electrical Engineering (1913 L)	A.G. Warren
4.	1920/39	Professor of Civil Engineering (1914 L; 1919 AP)	F.A. Redmond
	1939/42	Taikoo Professor of Engineering	F.A. Redmond
5.	1921/41	Professor of Electrical Engineering (1919 L)	M.H. Roffey, D.S.O.,M.Sc.

(B) Other Professors of the Engineering Faculty :-

1.	1914/18	Professor of Mathematics (1913 L)	T. Stuart, M.A.,D.Sc.
2.	1918/41	Professor of Mathematics (1914 L)	W. Brown, M.A.
3.	1919/41	Professor of Chemistry	G.T. Byrne+, M.Sc.
4.	1920/23	Professor of Physics	D.C.H. Florance, M.A.,M.Sc.
5.	1924/41	Professor of Physics	W. Faid+, M.Sc.

+ Died in Stanley Internment Camp (1944)
° Died in P.O.W. Camp in Japan (1944)

(C) Lecturers of Engineering Faculty (1912-42):-

1913/14	Machine Design (1914 P)	A.G. Warren	
1913/19	Materials/Mech. Engineering	E.J. Surman	
1913/14	Mathematics (1914 P)	T. Stuart	
1913/20	Structures/Mech. Engineering	G.E. Marley	
1913/19	Chemistry (Registrar)	A.C. Franklin	
1913/14	Physics (1914 P)	T.H. Matthewman	
1914/20	Civil Eng. (1919 AP; 1920 P)	F.A. Redmond	
1914/18	Hydraulics (1918 P)	W. Brown	
1917/19	Civil Engineering	A.D. Keigwin	
1919/24	Civil and Mech. Engineering	J. Ring	
1919/21	Electrical Engineering (1921 P)	M.H. Roffey	
1922/42	Mechanical Engineering	D.W. Morley	
1923/40	Civil Engineering	A.H. Fenwick	
1929/41	Chemistry	R. Ashton Hill°	
1929/41	Physics	D.F. Davies	
1933/41	Civil Engineering (Registrar)	S.V. Boxer	
1935/41	Mathematics	Mrs. W. Faid	
1940/42	Mech. Eng. (1933 demo.)	Li Kai Yeung	B.Sc.(Eng)[2] 1932
1941/42	Civil Eng. (1935 demo.)	Pao Yue Lum	B.Sc.(Eng)[1] 1930
1941/42	Elect. Eng. (1938 demo.)	Koh Nye Poh	B.Sc.(Eng)[2] 1930
1941/42	Electrical Engineering	Tsang Ngau Fong	

AP appointed assistant professor
P appointed professor

DEPARTMENT OF CIVIL ENGINEERING (1948-60)

From the retirement of Professor Middleton Smith in 1939, Professor Redmond became the Taikoo Professor of Engineering until the outbreak of war at which time he was a Major in the Engineering Company of the Hong Kong Volunteer Defence Corps. After three and a half years as a P.O.W. he returned home to Ireland with his wife who had also been interned. After a brief period at home he returned to Hong Kong for two years at the urgent request of the University to re-establish the Department of Civil Engineering and the Engineering Faculty. By 1949 the staff consisted of Professor F.A. Redmond, Dr. S.Y. King (Asst. Lecturer), C.Y. Hui and K.W. Leung (both Demonstrators and former graduates), K.C. Wu and Dr. F.K. Li (both part-time Lecturers), and F.C. Weller (Workshop Instructor of many years service). From that year until 1954 the full-time academic staff, of above assistant lecturer grade, increased numerically by one each year until there were 7 staff members in the Civil Engineering Department. Then for four years (1955-59) the Faculty had 8 staff and in 1960 when the three Departments of Civil, Electrical, and Mechanical were established this became 14 academic staff (above assistant lecturer grade) in engineering. Professors and lecturers appointed during the 1948-60 period are given in Table 7, indicating those with HKU degrees.

Table 7 Department of Civil Engineering (1948-60)

Professors of Civil Engineering:-

1948/50	F.A. Redmond (1914 L; 1920 P)
1950/52	K. Billig, Dr. Ing. (Vienna)
1952/54	R.C. Vaughan
1957/76	S. Mackey, Ph.D. (Leeds)

Lecturers of Civil Engineering Department:-		HKU Degrees
1951/58	K.C. Wu	B.Sc. (Eng)[1] 1924
1952/67	L.K. Chen	Ph.D. (H.K.) 1963
1953/57	O. Tunnel (Snr. Lt. 1956)	
1953/82	S.Y. King*, Ph.D. (Lond) .... (1948 AL; 1955 SL; 1960 R; 1966 P)	B.Sc. (Eng)[1] 1940
1954/86	P. Lumb (1963 SL; 1966 R; 1976 P)	
1958/67	J.J. Raftery, Ph.D. (Leeds)	

* Dr. S.Y. King (Snr. Lt.) appointed Head from 1955/57; 61/80; and Warden of Swire Hall 1980/82

The Professors of Civil Engineering were respectively F.A. Redmond, K. Billig, R.C. Vaughan, and S. Mackey. For the contribution of Professor Redmond as a successful teacher, appointed in the first instance as a Lecturer in 1914, then Professor of Civil Engineering, and for his re-establishment of Civil Engineering and producing the first batch of post-war graduates in 1950, the University is indebted. Professors Billig and Vaughan each gave two years service in the early fifties. The former, who was a specialist in reinforced and prestressed concrete, introduced measures aimed at raising the level of post-graduate education. He organised a six weeks course on his speciality for 100 graduate engineers and architects and introduced a post-graduate research course necessitating the purchase of considerable amounts of modern equipment for experimental testing procedures. Professor Vaughan's service complemented his predecessor because of his regard for high quality instruction through well designed and developed laboratory equipment. Also, both Professors did much to re-organise the curriculum and syllabuses of the civil engineering degree programme with the objective of an honours course recognized by the Institution of Civil Engineers. The fifties saw the start of two major contributions to the Faculty, namely, that of Professor S. Mackey (Figure 9) and that of Dr. S.Y. King, later to become Professor of Electrical Engineering (Figure 10), the first HKU graduate and Chinese to hold such an office in Engineering. Both these gentlemen after retirement were honoured with the Hon.D.Sc. and the title of Emeritus Professor.

DIVISIONS OF ENGINEERING (1960-67)

From 1958 to 1978 the Faculty was entitled the Faculty of Engineering and Architecture. Professor Mackey was the Dean from 1958-1967 and in 1960 the engineering activities were divided between Departments of Civil, Electrical, and Mechanical Engineering. The headships of the Electrical and Mechanical Engineering Departments were entrusted to Readers (Table 8). From 1961, degrees were classified according to the disciplines of civil, electrical, and mechanical engineering. Recognition of the degrees by the Institution of Civil Engineers, the Institution of Electrical Engineers, and the Institution of Mechanical engineers, was obtained in 1955, 1961, and 1963, respectively.

Table 8 Senior staff of Engineering (1960-67)

Professor:		
1960/67	Civil Engineering	S. Mackey, Ph.D. (Leeds)
Readers:		
1960/66 P	Electrical Engineering	S.Y. King, Ph.D. (Lond.)
1960/61	Mechanical Engineering	C.D. Weir, Ph.D. (Glas.)
1962/67	Mechanical Engineering	W. Smith, M.Sc. (Manc.)
Senior Lecturers:		
1963/66 R	Civil Engineering	P. Lumb, M.Sc.(Eng) Lond.
1967 -	Electrical Engineering (1960 L)	W.S. Leung, Ph.D. (Leeds)

Fig. 9 Prof. S. Mackey
(Taikoo Professor 1957-1976)

Fig. 10 Prof. S.Y. King
(Professor 1966-1980)

Table 9 Engineering staff (1967-88)
Professors and Readers

(A) PROFESSORS Civil Engineering:

		HKU Degrees	
1957/76	S.Mackey, O.B.E.; D.Sc.(N.U.I.); J.P. (Taikoo Professor and Head of Department)		
1976/86	P.Lumb, D.Sc.(Eng)Lond. (Head of Department 1976/77)		
1977 -	Y.K.Cheung, Ph.D.,D.Sc.(Wales);D.E.(Adel.);F.Eng. (Head of Department)		
	Electrical Engineering:		
1966/80	S.Y.King, O.B.E.; Ph.D.(Lond.); J.P. (Head of Department)	B.Sc.(Eng)[1]	1940
1977 -	W.S.Leung, Ph.D.(Leeds); J.P. (Head of Department from 1980)		
1982 -	Y.C.Cheng, Ph.D.(Br.Col.) (Dean of the Faculty from 1987)	B.Sc.(Gen)[2]	1963
	Mechanical Engineering:		
1967/73	H.C.H.Gurney, O.B.E.; D.Sc.(Lond.) (Head of Department)		
1973/82	E.A.Bruges, Ph.D.(Glasgow) (Head of Department)		
1982 -	C.L.Chow, Ph.D.,D.Sc.(Eng)Lond. (Head of Department)		
1987 -	N.W.M.Ko, Ph.D.(Southampton)	B.Sc.(Eng)[1]	1963
	Industrial Engineering:		
1978/81	W.A.Reynolds, M.A.Cantab. (Head of Department from 1973)		
1986 -	N.N.S.Chen, Ph.D.(Strath.) (Head of Department from 1981)		

(B) READERS Civil Engineering:

		HKU Degrees	
1966/76P	P.Lumb, M.Sc.(Eng)Lond.		
1978 -	H.W.Chung, Ph.D.(Leeds)	B.Sc.(Eng)[1] M.Sc.(Eng)	1961; 1963
1981 -	T.C.Liauw, Ph.D.,D.Sc.(S'ton)		
1987 -	T.N.Lam, D.Eng.(Calif.)		
1988 -	A.Y.T.Leung, Ph.D.(Aston)		
	Electrical Engineering:		
1974/77P	W.S.Leung, Ph.D.(Leeds)		
1980/82P	Y.C.Cheng, Ph.D.(Br.Col.)	B.Sc.(Gen)[2]	1963
1981 -	C.F.Ho, M.Sc.(Manit.)	Ph.D. (HK)	1971
1987 -	S.K.Tso, Ph.D.(Birm.)	B.Sc.(Eng)[1]	1961
	Mechanical Engineering:		
1977/79	C.L.Chow, Ph.D.(Lond.)		
1978/87P	N.W.M.Ko, Ph.D.(S'ton)	B.Sc.(Eng)[1]	1963
1985 -	J.A.Clark, Ph.D.(Belfast)		

P - appointed Professor

Fig. 11 1967 Engineering Society Committee

Standing:- (A) Fung Ka Kit, Cheng Pui, Ha Cheung Ming, Lee Ding Kow, Wong Kwok Wai, Lu Sai Shing, Yu Hung Shu, Ng Chun Wan, Chan Chee Kin

(B) Dr. H.W. Chung, Mr. Y.S. Lung, Mr. C.Y. Hui, Mr. D.K.C. Wong, Dr. K.V. Leung, Dr. W.S. Leung

Sitting:- Prof. S.Y. King, Prof. H.C.H. Gurney, Chow Ting Ngok, Prof. S. Mackey, Kam Hing Lam, Francis Nguyen, Mr. P.W. Wong, Dr. P.C. Chiu

STAFF OF THE ENGINEERING DEPARTMENTS (1967-88)

By the academic year commencing in 1967 each department (Civil, Electrical and Mechanical) had its own Professor, viz: S. Mackey, S.Y. King, and H.C.H. Gurney, respectively. Figure 11 is a photograph of the 1967 Engineering Society Committee with the three Professors and eight other staff members. Professor Gurney was the first Professor of Mechanical Engineering since Professor Middleton Smith, the founding Taikoo Professor of Engineering, and Prof. Gurney was the first engineer staff member appointed with a D.Sc. degree. All the Professors and Readers during the period from 1967 to 1988 are listed sequentially, within their respective departments, in Tables 9A and 9B; indicated are those who have been or are Heads of Departments and their HKU degrees, if relevant. All these senior staff appointments are given in recognition of outstanding academic and research records.

Table 10 gives a complete summary of all engineering academic staff employed full-time by the University of Hong Kong during the years 1961 to 88, inclusive. This information is taken from successive University Calendars and would therefore be accurate on the appropriate dates of the respective calendars going to press. From this data and information on B.Sc.(Eng.) graduates (Table 1), Figure 12 has been constructed which clearly demonstrates the rapid expansion in engineering, particularly from 1967 when the separate engineering departments were firmly established with their own Professors.

The Department of Industrial Engineering was established in 1973 with the appointment of one Senior Lecturer (Head of Department) and two Lecturers, the Head being W.A. Reynolds who later became Professor of Industrial Engineering in 1978. Its first B.Sc.(Eng.) degrees were conferred in 1976 and since then it has made a major contribution to post-graduate engineering education conferring each year since 1978 a number of M.Sc.(Eng.) degrees. During the eighties all engineering departments have contributed to M.Sc.(Eng.) degrees by coursework (Table 4B). By the commencement of the 1988/89 session the Faculty of Engineering employed 88 full-time engineering academic staff compared with an average of only 8 during its first fifteen years.

DISTINGUISHED ACADEMIC STAFF (1912-88)

It was felt in this commemorative document that staff members of long and devoted service should be chronologically tabulated. They are thus officially recognised (Table 11) and are grouped as, (A) prior to 1942 and, (B) post 1948; the latter table is divided into Civil, Electrical and Mechanical/Industrial. It is of interest to note that before the war years

Table 10 Summary of engineering staff (1961-88, inclusive)

Year	Dept. of Civil Eng.	Dept. of Elect. Eng.	Dept. of Mech. Eng.	Dept. of Ind. Eng.	Total Staff
1961	1P - 5L} 6	1R 3L 1AL} 5	- 2L 2AL} 4	-	15
1962	1P - 5L} 6	1R 3L 1AL} 5	1R 3L 1AL} 5	-	16
1963	1P - 5L} 6	1R 3L 1AL} 5	1R 3L 1AL} 5	-	16
1964	1P 1SL 4L} 6	1R 3L 1AL} 5	1R 3L 2AL} 6	-	17
1965	1P 1SL 4L} 6	1R 3L 1AL} 5	1R 3L 2AL} 6	-	17
1966	1P 1SL 5L} 7	1R 3L - } 4	1R 5L - } 6	-	17
1967	1P 1SL 6L} 8	1P 4L - } 5	1P 5L - } 6	-	19
1968	1P 1R 2SL} 7 3L	1P - 1SL} 8 4L 2AL	1P - - } 8 6L 1AL	-	23
1969	1P 1R 2SL} 10 6L	1P - 2SL} 10 6L 1AL	1P - 1SL} 9 6L 1AL	-	29
1970	1P 1R 1SL} 10 6L 1AL	1P - 2SL} 13 9L 1AL	1P - 1SL} 11 8L 1AL	-	34
1971	1P 1R 1SL} 14 11L	1P - 2SL} 13 10L	1P - 1SL} 13 10L 1AL	-	40
1972	1P 1R 1SL} 14 11L	1P - 2SL} 13 10L	1P - 1SL} 12 9L 1AL	-	39
1973	1P 1R 2SL} 14 10L	1P - 2SL} 13 10L	1P - 2SL} 10 7L	1SL} 3 2L	40
1974	1P 1R 2SL} 15 11L	1P 1R 2SL} 13 9L	1P - 2SL} 12 9L	1SL} 3 2L	43
1975	1P 1R 3SL} 14 9L	1P 1R 3SL} 13 7L 1AL	1P - 2SL} 12 9L	2SL} 5 3L	44
1976	1P 1R 3SL} 15 10L	1P 1R 3SL} 15 9L 1AL	1P - 2SL} 12 9L	2SL} 7 5L	49
1977	2P - 2SL} 17 13L	2P - 5SL} 16 8L 1AL	1P 1R 3SL} 17 12L	2SL} 9 7L	59
1978	2P 1R 1SL} 17 13L	2P - 5SL} 17 10L	1P 2R 2SL} 18 13L	1P - 1SL} 11 9L	63
1979	2P 1R 2SL} 19 14L	2P - 5SL} 19 12L	1P 1R 3SL} 18 13L	1P - 1SL} 12 10L	68
1980	2P 1R 2SL} 19 14L	1P 1R 5SL} 17 10L	1P 1R 3SL} 19 14L	1P - 1SL} 12 10L	67
1981	2P 2R 2SL} 20 14L	1P 2R 4SL} 17 10L	1P 1R 3SL} 20 15L	1SL} 11 10L	68
1982	2P 2R 3SL} 21 14L	2P 1R 5SL} 19 11L	1P 1R 5SL} 19 12L	1SL} 12 11L	71
1983	2P 2R 3SL} 22 15L	2P 1R 5SL} 20 12L	1P 1R 6SL} 17 9L	1SL} 11 10L	70
1984	2P 2R 4SL} 22 14L	2P 1R 3SL} 19 13L	1P 1R 7SL} 20 11L	1SL} 12 11L	73
1985	2P 2R 5SL} 21 12L	2P 1R 3SL} 19 13L	1P 1R 7SL} 22 13L	2SL} 11 9L	73
1986	1P 2R 5SL} 21 13L	2P 1R 4SL} 23 15L 1AL	1P 2R 6SL} 23 14L	1P - 2SL} 12 9L	79
1987	1P 3R 5SL} 22 13L	2P 1R 4SL} 23 16L	2P 1R 7SL} 25 15L	1P - 2SL} 14 11L	84
1988	1P 4R 5SL} 22 12L	2P 2R 5SL} 26 17L	2P 1R 7SL} 26 15L 1AL	1P - 2SL} 14 11L	88

P=Professor, R=Reader, SL=Senior Lecturer, L=Lecturer, AL=Assistant Lecturer

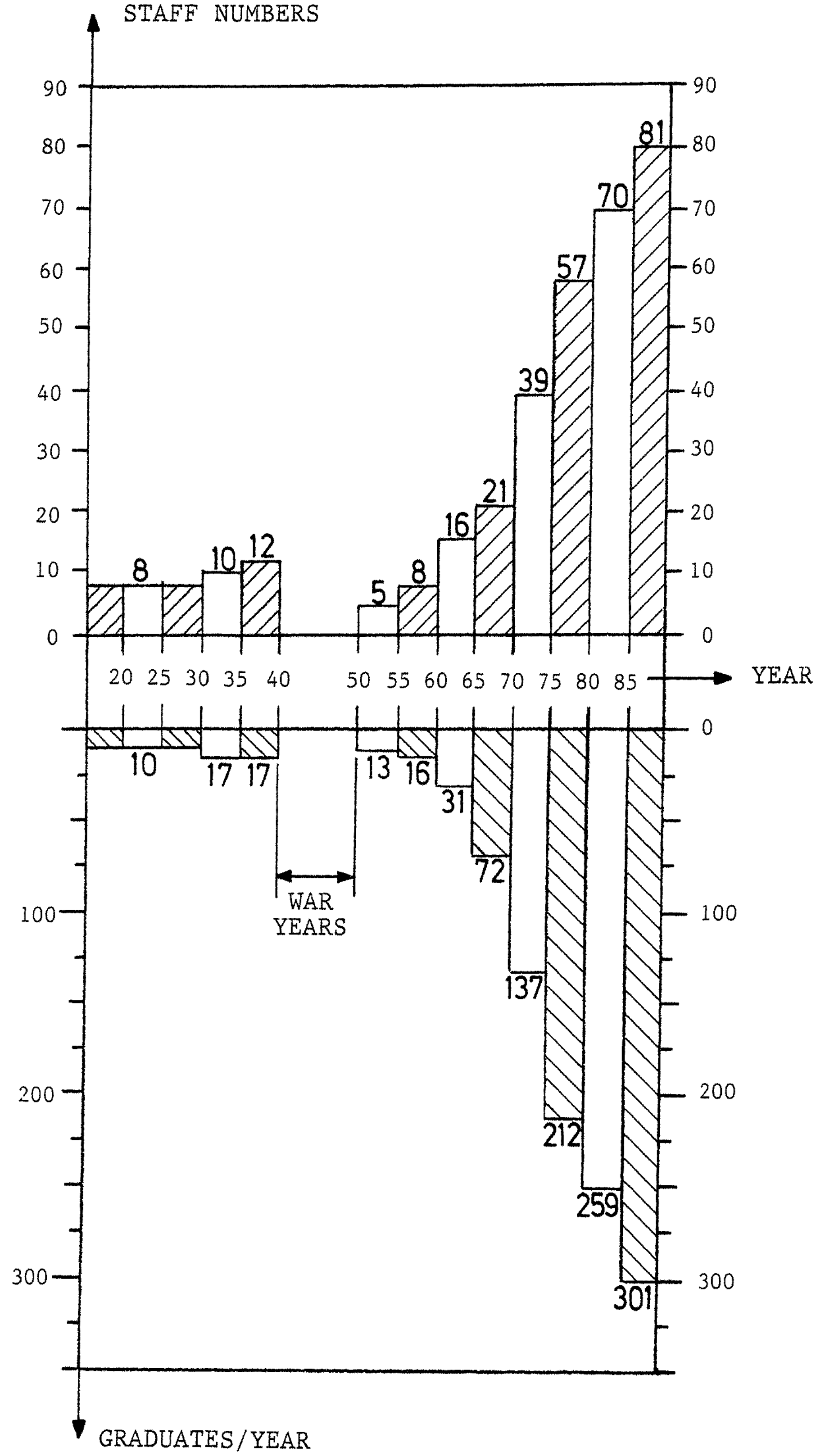


Fig. 12 Average staff numbers and B.Sc.(Eng.) graduates per annum (1916-1988)

all ten were Europeans, whereas since then the major contributors have been Chinese of whom several hold HKU degrees. Four of particularly long years of service are Professor F.A. Redmond, Professor W. Brown, Professor S.Y. King, and Professor P. Lumb, all of whom would be difficult to emulate in terms of their respective contributions as scholars, teachers, and administrators. Professor Brown had, before 1941, been Dean of the Faculties of Engineering, Arts, and Science, during his long devoted service.

Table 11 Engineering staff with 20 years service

(A) Appointed before 1942:

1912/39	Taikoo Professor of Engineering	C.A. Middleton Smith
1914/42;48/50	Professor of Civil Engineering	F.A. Redmond
1914/41	Professor of Mathematics	W. Brown
1919/41	Professor of Electrical Engineering	M.H. Roffey, D.S.O.
1919/41	Professor of Chemistry	G.T. Byrne*
1922/42	Lecturer in Mechanical Engineering	D.W. Morley
1923/40+	Lecturer in Civil Engineering	A.H. Fenwick
1924/41+	Professor of Physics	W. Faid*
1914/38	Demonstrator in Electrical Eng.	I. Day
1921/38;48/53	Foreman Instructor in Workshop Practice	F.C. Weller

+ Interrupted by War
* Died in Stanley Internment Camp (1944)

(B) Appointed after 1948:

	Civil Engineering:	HKU Degrees
1951/77	K.W. Leung	B.Sc.(Eng); M.Sc.(Eng)
1954/86	Prof. P. Lumb	
1957/76	Prof. S. Mackey	Hon.D.Sc.
1967 -	Dr. H.W. Chung	B.Sc.(Eng)[1]; M.Sc.(Eng)
1968 -	Dr. T.C. Liauw	
1968 -	Dr. H.C. Chan	B.Sc.(Eng)[1] 1960
1969 -	Dr. Ho, (Miss)Duen	
	Electrical Engineering:	
1948/82	Prof. S.Y. King	B.Sc.(Eng)[1]; Hon. D.Sc.
1960 -	Prof. W.S. Leung	
1962 -	R.Y.P. Ma, M.S.(B.M.E.E.)Penn.	
1966 -	F.J. Newland, M.Sc.(Auck.)	
1967 -	Dr. W.K. Chan	B.Sc.(Eng)[2]; M.Sc.(Eng)
1967 -	Dr. C.F. Ho	Ph.D.(HK)
1968 -	Dr. C.M. Shen	B.Sc.(Eng)[1]; M.Sc.(Eng)
	Mechanical/Industrial Engineering:	
1953/74	C.Y. Hui	B.Sc.(Eng)[2] 1940
1963 -	Dr. P.C. Chiu	
1968 -	Prof. N.N.S. Chen	
1969 -	Prof. N.W.M. Ko	B.Sc.(Eng)[1] 1963

Lastly, we have a very select group of titled Professors (Table 12) which numbers eight distinguished academics: three civil engineers, three mechanical engineers, one electrical engineer, and an applied mathematician. The oldest title is that of Taikoo Professor established in 1912 and the youngest is the Sir Robert Ho Tung Professor of Mechanical Engineering, founded in 1984 in respect of a major pre-war university benefactor. The present Taikoo Professor is Professor Y.K. Cheung, an eminent academic with the distinction of being our Faculty's first F.Eng., awarded by the Fellowship of Engineering of the United Kingdom. The principal administrator of the Faculty is the Dean but a list of Deans is not given in this historical account because all University Calendars reproduce this information under the Succession Lists. The current Calendar does not include short periods of service, with details, and omits 'emergency' Deans who had to be appointed during the years affected by the second World War. HKU Calendars of the fifties give more complete information regarding the Faculty of Engineering's Deans.

Table 12 Titled professorships (1912-88)

Taikoo Professors of Engineering:

1912/39	C.A. Middleton Smith, Hon.LL.D.
1939/42	F.A. Redmond, D.I.C.
1957/76	S. Mackey, D.Sc.(Honoris Causa)
1977/80	S.Y. King, D.Sc.(Honoris Causa)
1980/82	E.A. Bruges, Ph.D.(Glas.)
1983 -	Y.K. Cheung, D.Sc.; F.Eng.

Pro-Vice Chancellors:

1974/77	S.Y. King, Hon.D.Sc.
1988 -	Y.K. Cheung, D.Sc.· F.Eng.

Sir Robert Ho Tung Professor of Mechanical Engineering:

1984 -	C.L. Chow, D.Sc.(Eng)Lond.

Emeritus Professors:

Cades Alfred Middleton Smith (Civil and Mech. Eng.)
deceased 1951
Walter Brown (Mathematics)
deceased 1957
Frederick Anselm Redmond (Civil Engineering)
deceased 1958

Sean Mackey, O.B.E., Hon.D.Sc. (Civil Engineering)
King Sing Yui, O.B.E., Hon.D.Sc. (Electrical Eng.)

ENGINEERING BUILDINGS (1912-88)

A brief resume is presented giving an appreciation of the growth of the Faculty particularly with respect to accommodation for laboratory and workshop facilities. At the beginning, the total floor space allocated consisted of a single room, subsequently used as a Faculty Office. The Director of Public Works had advised that GBP100 should be

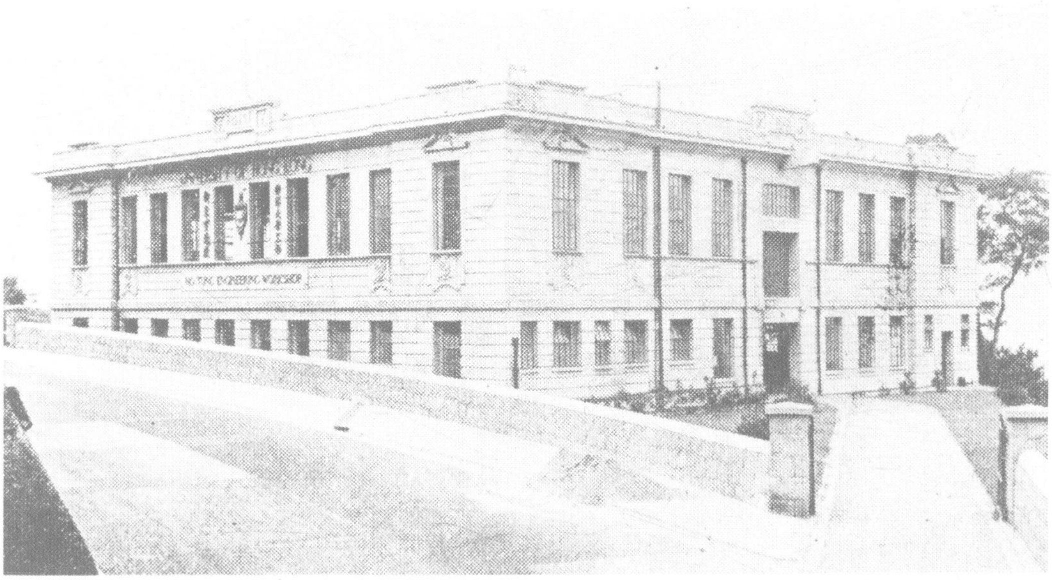


Fig. 13 The Ho Tung Workshop (1925)

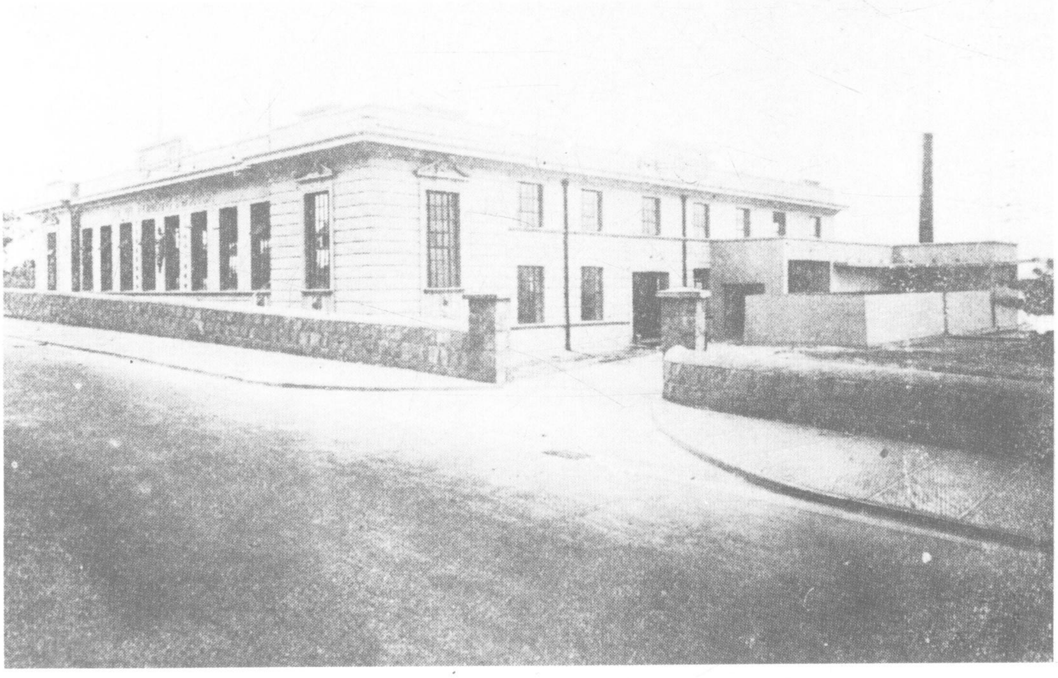


Fig. 14 The Peel Laboratory (1934)

earmarked for engineering equipment. In 1914 a workshop was erected adjacent to the main buildings at a cost of $10,000. Funds were very limited and complaints followed when it was found that the ensuing noise disturbed the academic calm of the Arts Faculty. In 1919, Sir Robert Ho Tung gave $100,000 for a new workshop. There was some delay in obtaining a suitable site, but in 1924 the Ho Tung Workshop (Figure 13) was erected and the equipment improved. Since its opening in 1925 all our engineering students have enjoyed a sound training in workshop practice. Since the workshop's inception it has served as a central facility for the whole University. During this period for some years (1914-27) apprentices were trained in the University Workshop and they also availed themselves of the opportunity to study English language in the evening at the University.

The next addition to the HKU engineering buildings was the Peel Engineering Laboratory opened officially by the Chancellor, Sir William Peel, in December 1934 and an official account of this is given in the HKU Engineering Journal Vol. 7, (1935). The Peel Laboratory (Figure 14) was erected at an estimated cost of $70,000 (HKU Annual Report, 1932) and housed internal combustion engines, steam engines, turbine and boilers, the air compressor, and refrigeration plant. It was situated on the opposite side of Pokfulam Road from the University Main Building and further West than the Ho Tung Workshop. Figure 15 is a front elevation of the Peel Lab inscribed by a quotation from the Book of Records (尚 書), Pt II Book II. In a grand scheme proposed in 1934 the civil engineers and architects, Leigh and Orange, had the Peel Lab and Ho Tung Workshop forming the extreme wings of the complete Engineering Buildings.

Another building for the Faculty did not materialise until after the war. Immediately prior to the war lecture rooms and laboratories were accommodated in five separate buildings, namely: the Main Building, an Annex containing a drawing office, the Peel Lab, the Hydraulics Building (an old Government pumping station), and the Ho Tung Workshop. A new building was designed after the war but then to provide facilities for both Engineering and Architecture. Named after the war time Vice-Chancellor, the Duncan Sloss School of Civil Engineering and Architecture was duly opened in March 1950. The building (Figure 16) had three storeys and a basement (used for hydraulics facilities) and was erected adjacent to the existing Peel Lab and Ho Tung Workshop. The Duncan Sloss Building housed staff rooms, lecture rooms, drawing offices, a library and board room, and a basement laboratory. Its estimated cost was approximately $650,000 and no further major engineering buildings were erected for more than twenty years but rapid development of the Faculty necessitated the addition of a fourth floor in 1956.

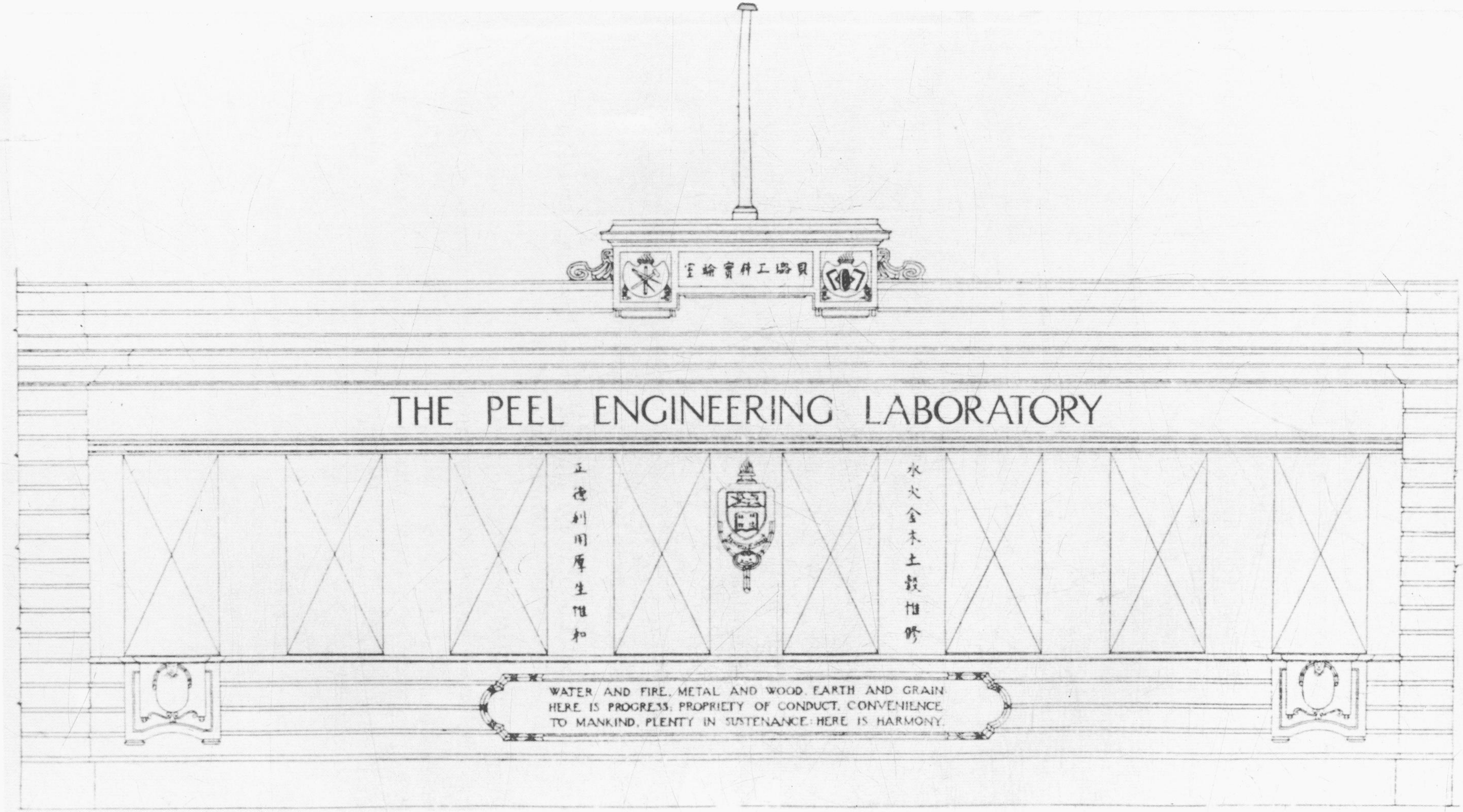


Fig. 15 Front elevation of Peel Engineering Laboratory (1934)

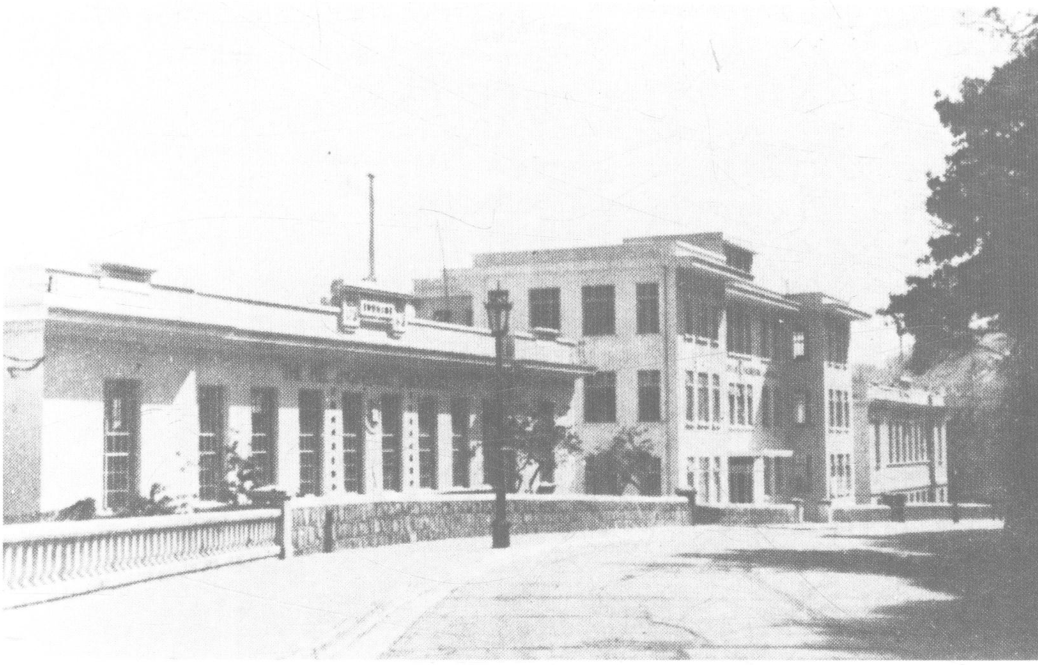


Fig. 16 Peel Laboratory, Duncan Sloss Building, and Ho Tung Workshop (1950)

During these intervening years more space and facilities were created and developed. During the late fifties an extra floor was also constructed on the Peel Laboratory and a Soil Mechanics Laboratory and new Hydraulics Laboratory were developed. These laboratories were conceived by P. Lumb and K.C. Wu, respectively, and were accommodated on the ground floor of the Peel Laboratory. In the sixties with three engineering departments operative, space and accommodation was at a premium. Around 1964 Building *17*, originally occupied by the Medical Faculty, was handed over to the Engineering Faculty and used primarily by the Electrical Department. Also an Electrical Machines Laboratory, opened in 1961 (See HKU Engineering Journal 1962) with many engineering firms generously contributing, occupied the basement of the Duncan Sloss Building and mechanical laboratories were on the ground floor of the Ho Tung Building. Not until 1971 when the Redmond Building was completed at a cost of about $800,000 was there further relief of space. Annexes had been erected, false floors constructed, and extensive use was made of partitioning; all to fully utilise the available accommodation. In the mid-seventies Building *16* and the Digby Building, originally for other Faculties, were used by Engineering.

The next major capital programme was the Haking Wong Building, finished and ready in 1982 at an approximate gross cost of the order of HK$ 135 million. All four engineering departments use its facilities which cover staff rooms, seminar and board rooms, laboratory accommodation, the central engineering workshop, and a training workshop for undergraduates. The major benefactor was Haking Wong, O.B.E., Hon. LL.D. and it was opened by the late Governor of Hong Kong, Sir Edward Youde, in October 1983.

This synopsis of the history of engineering at Hong Kong University can never really be complete but it must be obvious that many names have been omitted whose contribution is also significant. My apologies are given, but, Hong Kong and its success story this century owes an immeasurable amount to professional engineers, the majority of whom received their early education and training in the University of Hong Kong.

ACKNOWLEDGEMENTS

The help of the following offices of the University is acknowledged for their patience and understanding while the information was collected for this summary of engineering at HKU:-

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The Engineering Faculty Office,
The Information Office, and
Special Collections of the Library.

REFLECTIONS

FACULTY OF ENGINEERING
75th
HKU

REMINISCENCES OF MY EARLY DAYS WITH THE FACULTY OF ENGINEERING

S.Y. King

On the occasion of the 75th Anniversary of the Faculty of Engineering of the University of Hong Kong, I would like to share with you some of my early experiences with the University first as a student and later as a staff member of the Faculty. These early years saw a transition from an old-fashioned University to a modern one which you are now all familiar with.

PRE-WAR YEARS

Fifty years ago I joined the University as a third year electrical engineering student. At that time our engineering degree courses followed closely those of the University of London. In order to gain recognition from overseas institutions, our honours B.Sc.(Eng.) degrees were examined by London assessors who were mostly professors at the Imperial College, London. Compared with the present day faculty strength, our Engineering Faculty in the pre-war years was very small. There was one professor each in the Departments of Civil, Electrical, and Mechanical Engineering. Each Department had a few lecturers and demonstrators. Sometimes we invited engineers outside the University to give lectures on a part-time basis. Though our Faculty was small, our electrical and mechanical engineering degrees were recognized by their respective professional institutions in England for full exemption from the institution examinations. Our professor of civil engineering, Professor F.A. Redmond, was not a member of the Institution of Civil Engineers and hence no recognition by that Institution had even been sought for our civil engineering degree, which was recognized only as late as 1955. I am glad to say that though our Faculty was small before the Second World War, it was quite adequate for educating professional engineers then. A sparrow is small, but it is complete with all five internal organs. With a small faculty with only twenty to thirty students each year, some courses, such as communications engineering, were not offered. Otherwise, all the other important subjects for professional engineers were adequately taught. The Engineering Departments were not research orientated, but graduates received a good academic training for further study and research later on.

IMMEDIATE POST-WAR YEARS

Soon after the Second World War, the University decided to resume its teaching of engineering. In 1946, the first batch of engineering students were enrolled. Without any heavy electrical and mechanical plants left and without any substantial industry existing then, only the civil engineering degree course was resumed. It is interesting to recall that during the first two years the facilities were so poor that students had even to carry their own seats to classrooms! This applied to other facilities as well, and we were in bare existence. I believe nowhere else in the world was there such poor equipment for engineering training. Yet in the early 50's we produced many brilliant graduates for the engineering profession. They distinguished themselves in Hong Kong and the U.K. Quite a few won the Bayliss Prize of the I.C.E. The worst facilities for the best students! This was a great encouragement to the Faculty.

Shortly after I took over the Deanship of the Engineering Faculty in 1954, the Government notified the University of their intention to close down the Engineering Department, and move all the training of engineers to the Hong Kong Technical College (today's Hong Kong Polytechnic). This was a great shock to all engineering staff and students. The Faculty was doing well and we were asked to pack up. Both the Council and the Senate were sympathetic with the engineering course. We appealed to the Government to reconsider their decisions and, at the same time, requested more funds to equip our engineering laboratories, including electrical and mechanical. A meeting was later called by the Governor, Sir Alexander Grantham, to discuss the matter, i.e. to decide the fate of 'Engineering' at the University. On the eve of this crucial meeting, I was very worried. I had to pray for divine wisdom and guidance. The meeting was presided over by the Governor, with the Director of Public Works, the Director of Education, and others on the Government side; and Professor Gordon King, the acting Vice-Chancellor, Mr. Adrian Rowl Evans, the acting Registrar, and myself, from the University. The final decision was in our favour. The Government decided to carry on the civil engineering degree course and to provide more funds for engineering laboratories. We invited Professor Norman Thomas as our first external examiner, and our degree was soon recognized by the Institution of Civil Engineers in 1955 and by the Institution of Structural Engineers in 1956.

ELECTRICAL AND MECHANICAL DEGREE COURSES

In 1957, Professor S. Mackey was appointed Professor of Civil Engineering, and he persuaded the Government to restore our electrical and mechanical degree courses. In 1959, the first batch of electrical and mechanical students were admitted. They were taken from the first year civil engineering students. They graduated in 1961. The electrical degree received recognition from the Institution of Electrical Engineers the same year, and the mechanical degree also received recognition soon after.

On reflection, the restoration of electrical and mechanical degree courses was timely for Hong Kong. Since 1959, the electronics industry has gradually been developed, and Hong Kong has changed from its entrepreneurial economy to a flourishing manufacturing centre. I believe our Engineering Faculty has to some extent contributed to the modernization of Hong Kong.

This short article is just to tell you something of what happened to our Faculty from 1938 to 1961. It may be of interest to some friends of the Faculty who are not familiar with our struggles in the past.

Emeritus Professor S.Y. King was Head of the Department of Electrical Engineering from 1966-1980.

THE DON IN ACTION AGAIN

E.A. Bruges

In drafting this contribution to mark the 75th Anniversary of the Faculty of Engineering in the University of Hong Kong my message to Faculty is to be bold and adventuresome, brush aside the bureaucrats and allow men of vision to see the way ahead. I have adopted a quixotic approach so that I could comment at random on a range of topics -- after all there is a bit of the eccentric in all of us. Former colleagues will easily recognize old topics but I think they deserve reconsideration and I put them forward again. In the concluding section I have summarized some of the issues which I believe Faculty will have to face if it is continue to maintain its place in the academic world.

Many years ago I was a member of a Working Party of the Medical Research Council (UK). The group included a number of medicals plus a physicist and an engineer. Usually meetings were held in London but on one occasion it was decided to hold the meeting half way between London and Glasgow, in Harrogate. In those days the easiest way to get from Glasgow to Harrogate was by the Pullman -- those were the days and I fear this train runs no more. On the outward journey I had the company of a distinguished medical colleague and we spent a lot of time discussing the differences between medicine and engineering, in particular the education and training of students.

It was pointed out that engineers should have a "factory" in the University as part of the facilities, in much the same way as the medicals have, as their "factories", the hospitals, so that the engineers could blend theory and practice. I pointed out that the way engineering had developed virtually ruled this concept out. A compromise might be to defer the award of the degree, advise the student that he had passed "the theory" and ask him to return to the University after he has had some "practice". Then award the degree on the basis of both theory and practice using an appropriately structured group of examiners. Such a procedure is followed by sea-going marine engineers who have to satisfy both in respect of theory (exams) and in respect of practice (sea-time and workshop ashore) to show competency.

Let me return to the conversation in the train.

The truth of the matter is that engineering is not a closed discipline like law or medicine where their practitioners have all followed common courses and obtained the same basic qualification. Engineers do not share a common denominator and as a result are specialists from the day they enter university as students. This does not seem to be a very satisfactory state of affairs when the real world requires general practitioners in the main, although specialists are also required.

This weakness in the career development of engineers has not gone unnoticed. In the United States of America there are certain professions, architecture for example, which require a "first degree" before one can enter a professional degree course. Indeed, I believe the American Society of Civil Engineers has actually approved the concept but cannot, for economic reasons, advance the matter. Of course, one has to make some allowance for differences in educational systems, but the possibility that there could be changes in degree courses for engineers some time in the future cannot be ruled out.

The most exciting recent developments have come from Europe, where 20 countries have come together under FEANI[1] after many years of discussion. It is reckoned that some one million engineers could be registered with FEANI and virtually all of the UK Chartered Engineers could acquire the title Eur. Ing. (European Engineer). I believe it will not be long before syllabuses etc. will be re-scrutinised with a view to further development of a career structure for engineers. Those of us who trace our professional parentage through a nominated Institution to the Engineering Council may find that the driving force has moved from London to Brussels or Paris. FEANI has its headquarters in Paris but the EEC has its in Brussels and intends that the Community becomes a truly common trading block in 1992 with all that will mean for professionals. I believe that these developments cannot but be good for engineering. Indeed it could be that the student of the future will aim for Eur.Ing., through C.Eng., since the former will give him more leverage internationally. Marine technologists in the People's Republic of China are very interested in these developments and the Institute of Marine Engineers, whose branches encircle the globe, may be able to provide but one *entree* into the European network as well as into an internationally recognized professional institution[2].

1 *European Federation of National Engineering Associations*

2 *The writer is presently Honorary Secretary of the Hong Kong Joint Branch of the Royal Institution of Naval Architects and the Institute of Marine Engineers.*

Naturally I am concerned that Faculty recognize that the scope of engineering is changing very fast and that curricula will need radical reappraisal and continuing review in order to cover the next 25 years and reach the centenary. Change in Faculty and, indeed, in the University is never easy to achieve, impeded as it is by academic and administrative bureaucrats. The minutiae of the day always seem to absorb more time than the more vital academic issues.

I hope Faculty and its departments will follow the path of academic development and scorn the "no change syndrome" which is the easy way out and one certain way of becoming an isolated "island" overtaken by developments in other places in 1992, 1997, and beyond into 2013.

At this point we can follow one of two paths, either we agree that perhaps we ought to dig deeper or we decide for no change, that syndrome again, or as an old friend of mine used to say "perhaps it doesn't matter what you teach them as long as they don't like it". I propose that we follow the former path since cynicism will get us nowhere and there is still an abundance of interesting topics to note and discuss, if we have space and time. The essential difference between medicine and law on the one hand and engineering on the other may be better appreciated if we consider how engineering and its branches have developed. Very often we appreciate the present better if we recall the historical background, so bear with me as I make a simple definition and a short recollection.

Engineering is a generic word describing the activities of persons who call themselves engineers! It may be claimed that men, and women, have always been engineers since they first walked on the surface of the earth. In those earliest days there were no disciplines or specialisations; all were engineers, such was the nature of things. In due course and after the passing of many many years identification of different types of engineering activity developed to meet the requirements of the military, agriculture, and building (architecture). At the beginning of this century "Engineering" was neatly packaged as "Civil, Electrical, and Mechanical", but as we approach the end of the century we find that Engineering in the real world represents a spectrum of activities so diverse that it is no longer possible to identify the old CEM package. Indeed, we find individuals who have not passed through traditional engineering schools using a blend of skills to tackle problems which one might have expected to be resolved with the CEM package.

I came into the system as a student just before the old CEM package broke up, indeed, at that time Glasgow University didn't even have a department of mechanical engineering! Nevertheless there was a mechanical curriculum much the same as one might find in any UK university or, indeed, in Hong Kong Over the years, apart from content, basic topics have remained but I must single out materials technology and computer applications as new and vital developments in the mechanical curriculum.

Changing the curriculum to accommodate a new topic can be a nerve racking process. There is the "*ad hoc*" procedure. One needs x hours for programming so one cuts 10%, or whatever, off all existing courses!

I once witnessed this interesting "rational" academic approach.

Then there is the "no change" curriculum, apart from some modest syllabus changes, i.e. following the dictate of the relevant professional institution. Finally there is the ideal curriculum in which the student has a free hand, subject to some simple rules, and is able to pursue what interests him.

Flexibility is denied by the professional institutions, who have laid down curricula and syllabuses so that courses can be "accredited" thus exempting graduates from the examinations of the institution. I believe that these very professional institutions, aided and abetted by academics, have been the primary agents in narrowing the curricula to such an extent that the relevance of certain basic principles is no longer taught to all engineering students. It is in the interests of the institutions to accredit courses so that in time memberships and income can be increased. It also suits employers and Governments so they don't have to assess graduates, since someone else has done the job. My instincts tell me that some, maybe a majority, of the members in the Institutions who maintain their curricula are older hands (retired professors!) out of touch with the cutting edge or "state of the art". The content of the curriculum and the syllabuses is directly related to the number and length of the academic sessions, a time interval invented and sustained by bureaucrats which may or may not have any significance.

Personally I believe that it makes more sense to work in "real time" rather than in "artificial time" and I shall put forward an alternative time scale in what follows.

At this point I must observe that the University is a poor publicist leaving the occasional outburst to be developed by the professional journalists who are not renowned for accuracy in their writing, and their interest is not sustained when something more exciting comes along. I feel that the University, and its Departments, does not do itself justice. The University seems to prefer to work away in its own little "hidey hole" unaware of the advantages of a little good PR; it may be that "*glasnost*" will reach the campus yet. As a result I have little knowledge of the University's current thinking apart from what comes along the telephone line or is culled from the English language press. At one time there was a news-sheet but I presume that this has "bitten the dust" due to cash flow problems and lack of a driving force. Even if the University Administration feels it has no need of PR, I trust Faculty and its Departments might in the future ensure that not only is it heard but that its members are seen in town and not just at technical meetings!

In the coming years I believe Faculty can expect changes which will apply across the University. I believe that three term sessions will become four term sessions and that "opening hours" will be extended. The pressure for education at tertiary level will increase and the community will require that the University makes the best possible use of its facilities, especially the air-conditioned lecture rooms and teaching laboratories that appear to lie empty during three or more months of the year. Faculty would be advised to reassess its position and it may be surprised to find advantage in shaking off the existing UK scheme of things. I recall a conversation I had with a former Glasgow student who was then a professor in a leading US school with a four-term year. He pointed out that one of the weaknesses of the UK structure was that staff were required to advance simultaneously undergraduate and postgraduate teaching, do research, keep up with the latest developments, and carry some administrative load. As a result not all tasks were carried out efficiently. More effective use of staff could be achieved by concentrating all one's effort on one task at a time, for example:

TERM	TASK
1	u.g. teaching, tutorials, admin.
2	p.g. teaching, tutorials, admin.
3	research } vacation if all Dean's requirements are
4	research } met in terms 1 and 2.

Of course, it was understood any schedule had to be worked out with one's colleagues but it allowed a flexibility not possible in the average UK type structure.

Another advantage would be that degree examinations could be held in March and September with the result that the present "summer" term would not be destroyed. Also specious arguments advanced to suit the needs of external examiners would be invalid.

The adoption of a four term year might help resolve the current argument about three and four year programmes.

It is difficult to understand why all programmes across the Faculties, with some exceptions, should last the same length of time. It may be that the engineers require an additional period of study, a need which I once supported but one which merits further thought.

Why cannot we have 8, 10, 13, and 16 term etc. academic programmes using the four term year? Probably because the bureaucrats insist that the standard time interval be the "year", however defined. No other time interval is acceptable and session start must mesh with the schools.

My reservations about the engineer's need for more time stem from two aspects:

> The present three year three term course suffers from the ineffective third term. If the University were to adopt a four term year the present third or "summer" term would not be decimated. The engineers might well find that nine full terms provided adequate time for their courses and that projects might usefully run through a tenth term.
>
> My second concern stems from the fact that the real world requires engineers with a breadth of knowledge rather than specialists with a narrow experience. If Faculty were to content itself with three years of nine full terms this might make more sense than going for four years of two full terms plus four decimated "summer" terms.

Also it has been shown that very little of the material slavishly taught in the engineering courses is actually used by the student after he graduates. Having met many former students since leaving academia I find that few courses get mention as being useful in their careers! This reinforces my views that there is a mismatch between "town and gown". Again, it must be recognized that the scope of engineering and the technologies which feed it are changing so fast that departments in Faculty cannot expect to equip the graduate with all that he will need over a period of 30 to 40 years. Accordingly it is implicit that engineers will have to return to school for continuing education and specialist studies. It follows that there is little virtue in attempting to produce only specialists to suit the criteria of the admission practices of research schools in Europe and North America. I believe the time has come when Faculty should reassess its structure. It still wears the image of the CEM package with one offshoot (IE). The way new developments have been created has been on an *ad hoc* basis building on the CEM skeleton. As I have observed already I doubt if the CEM package measures up to the challenge of engineering in the real world.

Perhaps the time has come to dissolve the academic boundaries and create a Faculty of Engineering, coupled with a credit system and the courses listed in alphabetical order or merely numbered Engineering 1, 2, 3 etc. I appreciate that such action would prove unacceptable to many, especially to those who lack the vision to move forward, however I feel Faculty cannot afford to stand still. The credit system would introduce an element of competition which might not be welcome in some quarters. The professional institutions might be distressed but would have to learn to live with change. It is a quirk of history that the UK professional institutions act both as learned societies and as assessors of professional competence. Again I voice doubts about the role of the professional institutions and it seems that in abandoning the old CEI, engineers have placed themselves in the Engineering Council in which they are in the minority.

My doubts about curricula and syllabuses are reinforced by an exchange of views I once had with an American student researching in Glasgow. He told me that in his undergraduate studies he spent 70% of his time studying thermofluids-related subjects; the credit system was in use. After his first degree he took a masters programme in mathematics so he was considered eligible to undertake a doctorate in engineering. He reckoned his first degree to have been more of an educational exercise, which he enjoyed because he was allowed to choose, than a training for a vocation, also his view was that the average engineer will have forgotten much of what he is taught as a first degree student, so why not allow him to follow the subjects which interest him!

If a credit system within Engineering why not within the University? Not all courses need be on the credit list, and what about other institutions in Hong Kong? Maybe we missed out in not creating "THE UNIVERSITY OF HONG KONG" with campuses at Pokfulam, Hung Hom, Shatin, etc. Hong Kong is a small place and, if the University of London can do it why not Hong Kong? It seems we have boxed ourselves in, the advantage of size should not outweigh the disadvantages but individual campuses would not be autonomous, not that they are now whatever they may think. I have heard it said that the UPGC stands between the Government and the University and in this way the autonomy of the University is protected. This is not so; once one takes money from the public purse no organization is autonomous and the more one takes the less autonomy you have. Notwithstanding the enhanced status which "THE UNIVERSITY OF HONG KONG" might have acquired the Government has seen fit to apply the "divide and rule" principle.

In order to remind readers of the main issues discussed the following list is provided. If I was asked to identify one area of weakness which could be easily remedied I must identify public relations. We, the Community, should know just a little about present activities, future plans, and hopes.

I am leaving the easy task of drafting a new mechanical curriculum to the Department staff, but they might care to have a look at Dundee. Who said you couldn't make changes!

Award of degree on basis of theory and practice;
Engineering is not closed profession;
First degree before professional studies to give breadth;
International developments - FEANI and Eur.Ing.;
Linkage with the People's Republic of China;
Academic development to match rapid changes;
The "CEM" package is outmoded;
Lack of flexibility;
Poor public relations;
Better use of facilities;
A four term year to resolve "three or four year" controversy
Need for continuing education;
A new structure for Faculty - credit system;
Autonomy;
THE UNIVERSITY OF HONG KONG - did we miss out?

In conclusion it has been a privilege and honour to be asked to make this contribution which, I hope, will encourage Faculty to be bold and adventuresome and recognize that engineering is changing fast. My best wishes on the occasion of your 75th Anniversary.

Dr. E.A. Bruges was Head of the Department of Mechanical Engineering from 1973-1981.

REMINISCENCES OF THE FACULTY OF ENGINEERING

NIP Kam-fan

Reminiscences of the Engineering Faculty! I was caught by surprise on learning from Dr. Steve Rowlinson over the phone that he was asking me to write an article on my personal reminiscences of the Faculty. Recent times would be easy, but how much could I remember of those happy days of more than thirty years ago.

It all started on a hot summer afternoon in 1952 when I walked into an optician's shop. Before that time, I always planned to study science at the University. In my secondary school days, I was very good at mathematics and I took readily to physics and chemistry, so it was natural that I aspired to becoming a scientist in the future. Nevertheless when I walked out of the optician's shop, I felt that I had better change my plan because the optician gave me a free consultation and found out that I was weak in distinguishing the colours red and green (though I was by no means colour-blind). I thought that this weakness might be a hindrance to my further study in science. The one course open to me in which I could use my mathematics would be to join the Engineering Faculty. At that time the Engineering Faculty offered only civil engineering, which is how I became a civil engineer.

In spite of the rather unconventional way in which I chose this course of study in the University, I have never regretted the decision. In fact I was gratified that I had been guided somehow by providence to have elected to join the Engineering Faculty which nurtured me so carefully during the first four years of my career.

The first year of study was mainly in preliminary science. Therefore most of my time was spent in the large lecture theatre of the Northcote Science Building by Pokfulam Road, though a visit once a week to the Duncan Sloss Building was required to attend drawing classes. Because of the limited time I spent in the Faculty, I do not remember much of it. The one unforgettable thing in the year was the rather terrible ragging system then prevailing in the University hostels.

It was not at all pleasant to be a greenhorn. You were summoned many times in a week to appear in front of a congregation of seniors who might be in sarongs, lying on a bed (which might very well be yours) and shouting all sorts of foul language at you. You were given a most dirty nickname, to be used and repeated every time when introducing yourself. I was also given a book of dirty stories written in Chinese by a Malaysian student. I was told to read the book and then tell him the stories in English. What a terrible senior! I will never forget his name. People said he had just failed in his examination in medicine and therefore vented all his wrath upon the helpless greenhorns. In those days, every time I was on my way back to the hostel after the weekend, I wished so much that the journey could be longer or would never end. Fortunately, those unhappy days were over soon -- by Christmas.

After the first few months, everything was smooth sailing. In the second year, I spent most of my time on the ground floor of the Duncan Sloss Building and began to get to know the Faculty better. It was a somewhat small faculty. There were not many staff members or students. Everybody was accommodated on the one floor of Duncan Sloss, so we knew one another very well. Every second (and first) year student was allocated a large drawing table with several drawers in Room B, overlooking the harbour. Lectures took place in Room D which had windows opening onto Pokfulam Road. This room could be very noisy but, fortunately, traffic was not so heavy in those days and we did not experience too much inconvenience.

In the second year we had a variety of engineering subjects. It appeared that after a year in preliminary science, we had a year in preliminary engineering. Mr. L.K. Chen taught us structures. In every lecture he emphasized the need of developing structural sense in us. Dr. S.Y. King lectured on applied electricity and heat engines. Mr. K.C. Wu and Mr. K.W. Leung covered hydraulics and surveying, respectively. Mr. C.Y. Hui was the lecturer in theory of machines and engineering drawing. Lastly, Dr. K.V. Leung went through lessons in mathematics with us. All of them were very good lecturers. I still remember they were all kind to me in marking my examination papers, especially at the mid-sessional examination at the end of 1953. I later learnt (from Dr. King) that Mr. Chen (to be addressed as Dr. Chen later, of course) had to argue with Prof. Vaughan over the marks he gave me in the paper on structures.

The third year in the University was a very busy year for me. I was elected the Hon. Secretary of the H.K.U. Engineering Society. On many occasions I could not attend lectures because I had to be away, typing circulars in the general office of the Faculty. I must have got in the way of Mr. Chan, the office clerk, in the tiny faculty office near the entrance of the building, because I had to borrow his typewriter and sit on his stool, but he did not utter a word of complaint -- what a jolly good fellow. I still remember his tall stature and thin face and his pair of thick glasses. The office attendants were also very helpful. Lo Kong and Ah Sang helped in posting up circulars with my signature on notice boards throughout the University. In that year, Albert King, a fourth year student, was Chairman of the Society. He was then staying in May Hall in a room facing the sea, whilst I was occupying a room in Eliot Hall facing the hillside. Members of the two hostels must have found this combination of Chairman and Hon. Secretary very annoying, because we often shouted at night across the open space between the two halls discussing Society matters.

In the summer of 1955 (after my third year), I spent three months vacation training with the Port Works Office of the then Public Works Department, drawing a monthly salary of $225. Port Works was then constructing the Hong Kong Stadium and I was posted to site to watch the progress of the works. In fact all the major works had been completed by that time and there was not much to see. Nevertheless, every student had to write a report on his vacation work. I managed to submit a one-page report to Mr. O. Tunnell, who commented that it was a talkative report. He graded it E and posted it on the Faculty notice board near the entrance of the building along with reports of my classmates who without exception scored an A or B. I was somewhat concerned and asked Mr. Tunnell whether I needed to submit a better report. He told me not to bother because the grading of the report would not be counted towards the final results of the course.

My fourth year (1955-56) was a year of many exciting moments for the HKU Engineering Society. Under the leadership of Anthony K.L. Fung, Sports Captain of the Society, we won trophies one after another. I was not a player but as Chairman of the Society, I was invariably present to give our team moral support. I still remember the basketball final played against the medical team on a sports ground where the library now stands. Every cell of mine thrilled with excitement. I yelled and clapped to cheer our players. How delighted we were when we finally beat the medics! Besides Anthony (who is now the Assistant Director of the Territory Development Department of the Government), playing in the team was also K.L. Wong (now Director of Water Supplies). Other players included B.C. Yuen and C.H. Lee, both of whom emigrated many years ago.

Crowning the series of excitements was the news that the civil engineering degree of the University had gained recognition from the Institution of Civil Engineers and that this would take effect from the degree conferred in the year 1955. What a wonderful surprise for our 1955 graduates and an encouragement to us final year students. To mark the occasion, a celebration dinner was organized in the Great Hall of the University's main building.

My active association with the Faculty did not end with my graduation in the summer of 1956. Another phase of activity could be said to have begun in 1968. It would require quite a number of paragraphs to describe the events leading to it, but to cut it short, I shall just say that I became a Christian in 1956 and because of this I became closely associated with Dr. S.Y. King, a very fine and devout Christian, in his many church and community service projects and activities. On one of these occasions in September 1968, he said to me, "Don't waste time reading all sorts of books. Concentrate on one thing at a time. Go to see Prof. Mackey and get enrolled as a Ph.D. student." As I said earlier, Dr. King taught me applied electricity and heat engines in my second year. We Chinese tend to listen to what teachers say and of all teachers, I listened to the advice of Dr. King most attentively. Hence without much thought I went to see Prof. Mackey and got myself plunged into the deep end of a Ph.D. course as an external student without really realizing the commitment I had made.

My subject of study involved much use of the electronic computer, but at that time, the Faculty had only the old IBM 1620. I had to punch my own tapes and operate the computer myself. As I had to work in the Public Works Department in the daytime, I could only carry out my research work in the evening. Therefore in those years, I often had to work very late in the University. I had two supervisors in my research work, Dr. J.J. Raftery and Mr. K.W. Leung. I had to look to the former for his guidance in the usage of the computer. To make things more complicated for me, he resigned from the University a few years after I began my study.

Fortunately, the University obtained a much more powerful computer in the early seventies. I could therefore proceed with my research work at a much quicker pace. Then in early 1973, Mr. Leung said to me, "It is now five years. We could extend your period of study of course, but wouldn't you try to write up something?" In fact, I was not quite ready, but I promised to try writing down what I had done so far. In 1973, I happened to be posted to work as chief resident engineer on a works site and the pressure of work was not as heavy. Therefore I could manage to sit down comfortably to produce a thesis on my research work. My record of studies showed that I spent 1,900 hours on the Ph.D. degree.

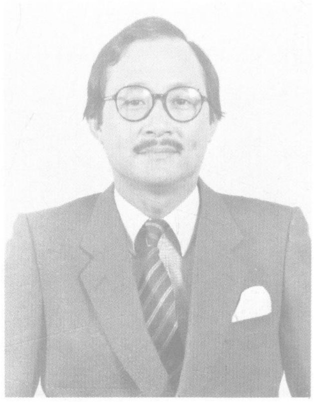
My third phase of close association with the Faculty began in the late seventies when Prof. Y.K. Cheung called me up to assist in giving lectures on traffic engineering. After getting so much from the Engineering Faculty, I believed it was high time for me to make some contribution. I have been an honorary lecturer for the Department of Civil Engineering ever since.

It is now thirty-two years since my graduation. Memories of the past days remain vivid and pleasant. What the Faculty gave me brought me smoothly through my career. In tracing what happened during those years, I can only say how pleased I am that I was guided to make the right choice. If I were to be transported back through time to 1952, I really hope I would visit that same optician so that I would choose to join the Engineering Faculty again.

Dr. K.F. Nip graduated in civil engineering in 1956 and was awarded the degree of Ph.D. in civil engineering in 1973. He is now the Director of the Civil Engineering Services Department.

PERSONAL REMINISCENCES

James Chiu



Looking back at my university days brings many fond memories. Much of what I am today stems from those earlier years of study some 28 years ago.

The fact that I am an engineer by profession is not a matter of coincidence. It was very much a conscious decision. In my last few years of secondary school, I started to ask myself what I would like to be. Like many young people, I imagined being a professional tennis player with a world class reputation, or being a pilot, travelling the world. But deep down I knew these were just grandiose ideas, as none of them matched my ambition of making a tangible contribution to the society to which I belonged.

At that time, Hong Kong was just beginning to emerge as a manufacturing and trading centre. I looked around me and found the Hong Kong skyline constantly being changed by buildings, roads being built, reservoirs being excavated, and power plants being erected. I saw myself contributing to this infrastructural development, participating in the growing sophistication of Hong Kong which would ultimately differentiate it from being "just another city in the world". Engineering seemed to be the answer, and indeed that was what I decided upon when I applied to the University of Hong Kong.

The University of Hong Kong Engineering Department was well known for its extremely high standard. The entry requirements called for four passes in the Advanced Level Matriculation Examination. Being admitted was considered not only an honour but a stroke of luck in those days. I happened to be one of the lucky ones.

Adapting to university life was a mixture of excitement and pain. I was a young adult then and being a university student gave me the status that I had always pined for. But there was no time for illusions of grandeur. I soon found myself faced with a demanding curriculum. At best, I would feel that I had found an answer to my aspiration and that the long hours I had to spend on my studies were well warranted. But there were other times when I felt that I was at a crossroad, faced with many conflicts and options.

The Engineering Department offered three streams: mechanical engineering, electrical engineering, and civil engineering. Most students opted for civil engineering and mechanical engineering then because of the prevalent job opportunities after graduation.

I, however, decided to focus on electrical engineering. The rationale being, aside from my interest in subjects relating to power and machines, I firmly believed that Hong Kong's advancement would depend largely on the ability to complement infrastructural projects with power and electrical facilities. I was also greatly encouraged by Professor S.Y. King to pursue this particular track and ever grateful to Dr. W.S. Leung for his patience and learned guidance along this path.

Aside from attending the regular classes, I was also actively involved in extra-curricular activities. Of all these pursuits, I found the year I was Chairman of the University Engineering Society most rewarding. That was during my final year of studies. By then I had a good conception of what engineering was academically, and the chairmanship gave me an opportunity to contact alumni and professionals in the field, thereby enabling me to acquire an insight into what the real world of engineering was like.

Looking back, if there was anything critical that I had to say about the engineering curriculum then, it was perhaps too academically oriented and not sufficiently industry oriented. Most graduates joined the civil service upon leaving university. Few were absorbed directly into industry. This could be attributed to the fact that during the early 60s, most of the engineering designs and expertise for large projects were imported from the United Kingdom. While this accounted for the high standard of engineering then, it also reflected the lack of local professionals in the field.

I took an alternative path upon graduation by joining industry directly. For the first 18 months, I was employed as project engineer with China Engineers Ltd. The courses that I had taken in the University provided me with the fundamental background on which to base my practical work. I next joined the Hutchison Whampoa Group's Engineering Division as Manager in 1968 and spent 12 years with the corporation, gaining valuable experience before I became a Director with the General Electric Company of Hong Kong, prior to assuming my present position as Managing Director. The 24 years of my professional life has taught me the importance of self motivation and continuous learning.

There is no room for complacency in any profession, and unless you are the best, you will be overtaken by competitors in no time.

The engineering scene in Hong Kong has changed tremendously in the last two decades. From the early days of importing European designs and skills in the sixties, to an influx of contractors in the seventies, Hong Kong is now capable of coming up with its own original engineering designs and specifications.

I can still recall in the late 70s, when the Modified Initial System of the MTR was constructed, we had to import contractors and there was little expertise in project management. But when the Island Line was constructed, Hong Kong could rely on a large number of local professionals who had acquired the expertise and project management skills necessary. I would like to stress that the process of local engineers taking over from expatriates and the strength of Hong Kong's own engineering capabilities will require the continuing technical support of the University in terms of supplying graduates of international standard. This will mean continual upgrading of curriculum, laboratory equipment, and resources for research work. Already I can see an encouraging departure from the academically orientated courses of my generation, to a more industry oriented approach, which is more realistic in meeting today's demands. To ensure that the curriculum provides a balance between the necessary academic background and industrial requirements, close communication and an active involvement of industry with the University and other educational institutes is of vital importance.

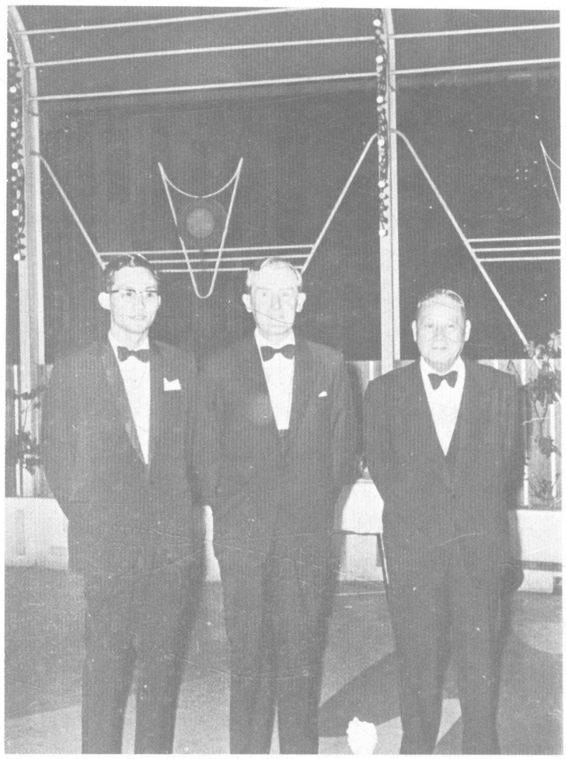
The Hong Kong Institution of Engineers, which has grown from its infancy in the sixties to a fully-fledged professional organization today, can also play a vital part in steering the engineering scene in Hong Kong and serve as a point of cross fertilization between industry and the academics.

The establishment of the 'Q' mark for Hong Kong products and the proposed standard specifications and codes of practice are excellent examples of Hong Kong's continuing engineering development.

While Hong Kong is faced with the problem of a brain drain, the issue need not be viewed negatively. The situation can be offset by the training of better, more purpose-oriented engineers of international standard by the University and the Polytechnics. On the positive side, these graduates will have an even better chance to achieve, perform, and mature quickly to meet not only local but regional demands and will be in a much better position to cope with rapid changes in today's technology.

Looking to the future, the prospects for Hong Kong engineers are optimistic and challenging, I can even visualize Hong Kong's engineering professionals passing on their expertise into neighbouring countries such as China, Taiwan, and Thailand.

In short the University has a vital function to perform and the opportunities for new engineering graduates are plentiful.



James Chiu, Chairman of the HKU Engineering Society 1963, with Prof. Sean Mackey (centre) and guest of honour, Mr. Lee Yiu Cheong, at the Society's Annual Dinner

James Chiu graduated in electrical engineering in 1964 and is now Managing Director of GEC (Hong Kong) Ltd.

DAYS IN THE DEPARTMENT OF MECHANICAL ENGINEERING

Edmund K.H. Leung

My affiliation to the Faculty of Engineering dates back to 1939 when my father became an electrical engineering graduate of the University of Hong Kong. This blessed association was furthered in 1964 with my own enrolment for the B.Sc.(Eng.) curriculum, and in 1982-83 with my Presidency of the HKU Engineering Alumni Association, the first electrical or mechanical graduate in the position.

I could not deny the influence of my father's profession and his successful lifelong career as an electrical engineer on my going for engineering studies, but my deliberate intention of not following my father's footsteps kept me from electrical engineering. My genuine love for motor cars took me therefore to mechanical engineering.

In those days the University was regarded as a place for the elite and the envy of friends and relatives fell uninvited upon anyone who successfully gained admission to this prestigious institution. It was not uncommon to have the following stereotyped conversation in every social gathering:

Auntie: "Hey! You smart boy! Which course are you taking? I guess it must be medicine."

Young Edmund: "Uh-No! Auntie, I study engineering."

Auntie: "Engineering? Um! That's not too bad, but I presume it must be civil engineering. That's almost as good as architecture!"

Young Edmund: "No, Auntie, it's mechanical engineering, because I love motorcars."

Auntie: "Oh! M-e-c-h-a-n-i-c-a-l engineering?"

This was a very common view shared by men and women in the street towards a mechanical engineering student of the University in those days. Perhaps it was an unknown or unpopular course at that time, because of the 70 engineering undergraduates in 1964, only 11 were in the mechanical engineering stream and they were not, in general, top boys in their matriculation classes.

Nevertheless, I have never regretted my choice. Having been a graduate for over 20 years, I find there is really nothing different between a mechanical engineer and an electrical engineer (though perhaps civil engineers are rather more distinct); the difference if any is in one's mind.

Back to my undergraduate days, the scenes of campus life (as a non-boarding student) and lecture attendance are deeply inscribed in my mind. As a day student, a *de facto* member of the "largest" hall -- Hornell Hall, I missed the "genuine" campus life. I could not experience the joys and sorrows of ragging or of being ragged, nor did I experience any newly found independence. My only glimpses of campus life were in fact at High Table dinners. I remember the occasions on which I had to stay late in the library after lectures, killing the seconds leading to seven o'clock in the evening before marching up to Loke Yew Hall and into the crowds (yes, crowds) then going through the ordeal of the six-course meal. The food was decidedly mediocre, and the unbridled enthusiasm of my college-mates guaranteed that every course was swallowed within 30 seconds of it landing on the table. There were hardly any table manners to speak of, and conversation amongst us across the table was at a minimum.

It was a hilarious situation that one had to attend six such dinners a year (which was really a chore!). As a result, many students tended to ask their friends who might be residents of other halls and were tired of the routine menu in their halls, or others who found it exciting to be posing as Hornell Hall members, to attend these functions on their behalf. The situation became so bad that the Hornell High Table Dinner became a free-for-all meal. On one occasion there were at least twice as many people as there were seats available. The warden became so angry that eventually he threatened to conduct an identity check and expel the imposters if non-members of the Hall did not leave the room in 60 seconds. He ordered a temporary black-out and turned his back to the crowd and within literally seconds the hall was deserted, with only about three dozen of us remaining for an unusually quiet dinner.

Attending lectures was a lot of fun in itself. The freedom to skip lectures (which in secondary school days could result in expulsion) was a privilege greatly enjoyed in the first year, despite the fact that the missing notes could make life very difficult during revision before the examinations. This privilege was not extensively enjoyed in the second and third years, as there were only 11 of us in a small classroom. At the time of the Ching Ming Festival during my final year studies, we had to attend lectures. I skipped the lectures on that day to go grave-sweeping with my family (which I thought was more important). The attention my absence drew from the lecturers and my classmates was quite unbelievable. This experience was perhaps the cause for my guilty feelings whenever I take a day off, be it for whatever legitimate reasons, when my colleagues are at work.

To those who still remember the lily pond and the azalea blossoms on the campus, I must admit that I still associate the flowering season for azaleas with the time for working hard (springtime is the busy time for university students to prepare for their internal examinations in May/June).

If you were to ask me what I honestly loved more, my university days or my subsequent career, I would have to say it is my career. I love working simply because there is greater satisfaction. My undergraduate days were however much more memorable and it was, in retrospect, a perfectly pleasant experience -- all competitions were fair and everybody was most willing to help if you got into trouble. One cannot expect such a Utopian life outside the campus.

Edmund K.H. Leung graduated in mechanical engineering in 1967 and is now Vice President, Parsons Brinkerhoff (Asia) Ltd.

THE RUMINATIONS AND RANDOM THOUGHTS OF A M.Sc.(Eng.) GRADUATE IN INDUSTRIAL ENGINEERING

T.C. Hassett

On reflection I think I could honestly say that the two and a half years I spent as a part-time student in the Industrial Engineering Department of the Hong Kong University were the most interesting of my fifteen years in Hong Kong. For the first time since taking up my post at the Hong Kong Polytechnic in 1973, I began to understand how Hong Kong industries operated and more importantly an appreciation of the people employed within these industries.

If it was the intention of the course selection committee, and I'm sure it was, to bring together a hybrid group of participants having a wide variety of expertise, then they were very successful. The course commenced with fifteen students all of whom had appropriate experience in the industrial engineering field and all were able to make a valuable contribution to the course. They came from both the private and public working sectors of Hong Kong and their work experience covered a wide variety of industrial activities. Some members of the group ran their own businesses and were contemplating giving it up to return to being an employee rather than an employer, whilst there were those who were on the verge of giving up their employment and starting their own business. Other members of the group were from the educational field, like myself, or had spent their whole working life in local industry.

The group comprised managers, accountants, salesmen, engineers, and civil servants, which all went to help make the course extremely interesting and educationally beneficial. I'm sure the staff of the Industrial Engineering Department wouldn't mind if I said that I learned as much from my fellow students as from the course content.

The course also proved to be interesting and different in other ways. The staff, for example, encouraged student participation much more than I had experienced in other courses of study, even going so far as to allowing the students to give small talks based on their own experiences or as an assigned project. I would guess that my fellow students are still wondering how I, as a U.K. expatriate working in Hong Kong, had the audacity to give a talk on "Japanese Management". The lecturer-student relationship was extremely good and much friendlier than is usually found with the same relationships on undergraduate courses. This produced a very pleasant atmosphere and was most conducive to the interchange of ideas and experiences so essential to the course. The obvious aim of encouraging student participation was reinforced by the many social activities involving both staff and students which took place throughout the whole of the two and a half years of study.

As a retired member of the 1976-78 M.Sc. group, I consider myself unique, insofar as I was at the time the oldest participant, the only expatriate, the only one employed in the education field (others took up posts in educational establishments after graduation), and finally the first of its members to retire from full-time employment. However at all times during the course I felt a strong attachment to the study group. The good working relationship which existed between the members encouraged me to seek their assistance when I was faced with a technical problem connected with the course work. Their readiness to assist me was greatly appreciated. This esprit-de-corps could only have been generated by the University, department, staff, and students working as a team endeavouring to reach a common goal. So, if only from this point alone, the department and its staff should be congratulated on its achievement but I'm sure the steady progress of the course members since their graduation also goes to emphasise how successful the course has been.

The lectures and the assignments were aimed at studying the various management techniques relevant to industrial engineering as an aid to problem solving. Being made aware of and understanding these techniques was very useful to me as a lecturer in industrial engineering but obviously the greatest benefit, to the group as a whole, was in their application. This meant, of course, that my fellow students and myself were constantly searching for real problems in our own employment where the application of these techniques would assist in finding a solution. The climax to this aspect of the course was in the final project or thesis which commenced at the beginning of the second year of study and was completed after the core subjects had been examined. In my case this was the part of the course from which I gained the most. My only regret was that I wasn't employed in industry at that time for I feel sure I would have been able to find many more interesting projects to choose from.

The course of study was being carried out during a period of rapid development in electronics and computer engineering. The manufacturing industries were in the throes of a mild revolution. Their production systems were having to be redesigned to accommodate the influx of N.C. and C.N.C. machines, machining centres, flexible manufacturing systems, automated control, and visual inspection systems etc. Educational establishments were experiencing difficulties in keeping their course curricula in front of the rapid advances being made. Furthermore, as the industrial management aspects became more and more an integral part of their production systems, our course and its assignments had to reflect these developments and take them into account. I feel the course planners and the lecturers did an excellent job under such difficult circumstances and for my own part, my knowledge of computing and computer controlled manufacturing systems was considerably enhanced by the end of the course.

I will be ever appreciative of the staff on the course including the Head of Department, Professor Tony Reynolds, who as most students and staff know, has now reluctantly retired. I say reluctantly because Professor Reynolds loved his Hong Kong. I shall always remember his contribution to our social functions when he invariably gave us a demonstration of Morris dancing. I admired his fitness and one always knew when Tony came into a room or joined the group, and not so much for his height, because he is a tall man, but because of the magnetic, forceful aura he tended to expel. His lectures were full of personal experiences and he was a firm believer in student participation.

Then there was, of course, Dr. Nelson Chen who by comparison was very gentle. He had a wealth of experience but unfortunately tended to overestimate mine and often sought my support in class discussions. I used to nod wisely even though I wasn't sure and then found, embarrassingly, my expert opinion on the subject was being sought by my colleagues over lunch.

Dr. Paul Niem was also a mild, very approachable lecturer and very interested in promoting the "department as a society". I worked with him as a member on the committee of the HKU Industrial Engineering Society, and was always impressed with the amount of time and work he was prepared to put in to keeping the Society together.

Then there was Dr. Brian Peacock whose expertise was in ergonomics. I will always remember him whispering to one of my fellow students during an experiment, which required pulse rate readings to be taken whilst riding an exercise bicycle, to watch my rate carefully and to call a halt to the experiment immediately if there was any sign of a rapid rise, because of my age. I was to understand later that the experiment showed my pulse rate as being the lowest of the group. Dr. Peacock's wife was also an ergonomist and I recollect the stimulating conversations I had with them both at social gatherings.

I will not, of course, forget Mr. Dominic Sculli who lectured to the group on operational research techniques. He was obviously an expert on the subject but I will always recall his rather unusual boardwork. He often got carried away in his lectures and I invariably found myself standing up and peering over my desk to see what he had scribbled at the bottom right hand corner of the board. He was well liked by the students and I was fortunate enough to have him as my project supervisor.

One of the most relaxed of lecturers was Simon Partridge who blended in with the students so well that it was difficult to know sometimes who was the student and who was lecturer. He made management accountancy seem so easy, I wondered sometimes why it was considered a postgraduate subject. I will probably remember him as the most amicable of the staff.

Perhaps the youngest and newest member of the staff was Dr. K.L. Mak who had the difficult job of improving our knowledge and understanding of statistics. I always thought he underestimated his own ability because he often insisted to me that it wasn't his specialist subject and yet I thought he did an excellent job. He knew some of my fellow students from his own undergraduate days and quite often joined us when we went on social functions as a student group. Some years later he succeeded me as Chairman of the I.E. Society and did an excellent job but I remember he took on the responsibility with a certain amount of trepidation.

Before leaving my memories of staff I should like to mention Dr. Gordon Redding who took us for a number of lectures as a visiting lecturer. He was the one whose approach to lectures impressed me most. His preparation was, in my opinion, faultless, and I tried often during my latter years of lecturing to copy his style. His summary of the topics was excellent and prepared well in advance of the lecture which enabled us to concentrate on the lecture and contribute more easily to the classroom discussion. His explanation on "open and closed systems" cleared up a problem I had had with systems for many years. I often wonder if he remembers the discussion.

I am sure the reader will gather from what I have written that the course had its lighter moments and wasn't all serious work. However I should conclude by saying that in my opinion it had the right balance of work load and pleasure, even though there were times when one doubted there would ever be sufficient time to complete all the assignments and studying that was needed to succeed. An excellent course, well planned, well executed, and a most interesting and pleasant group of fellow students.

T.C. Hassett was awarded the degree of M.Sc.(Eng.) in 1978.

MY PERSONAL REFLECTIONS ABOUT THE DEPARTMENT OF CIVIL AND STRUCTURAL ENGINEERING AND ITS FUTURE DEVELOPMENT

Chan Sing Hei, Edmond

I found it exciting and challenging when I learnt that I was going to be able to contribute an article for inclusion in the 75th Anniversary Publication. I feel proud to be a member of the Civil and Structural Engineering Department and also a graduate of the University at this crucial time -- not because of 1997 but the remarkable success of the department in its past 75 years.

However, while celebrating our past success we must look forward to improving our curriculum since we face competition from Polytechnic graduates and other overseas graduates. Not only our Faculty, but the whole University, shows a strong determination to upgrade the degree courses. The first movement is to lengthen its degree courses from three to four years. This will enable the Faculty to include a foundation year in the degree course to broaden the view and horizon of our graduates. Also, with effect from July 1988, the Department of Computer Science was established in the Faculty as the fifth department. All those measures will enable our graduates to maintain a prominent position in the Hong Kong industrial environment. But as a civil engineering graduate I must confine myself to some aspects concerning the courses offered and the career prospects of our graduates.

THE B.Sc. (CIVIL & STRUCTURAL ENGINEERING) COURSE:

General

The Department offers a three-year undergraduate programme for the degree of Bachelor of Science in the field of civil and structural engineering. The first two years include foundation courses in mathematics, structures, surveying, hydraulics, strength of materials, construction, environmental engineering, and drawing. Theoretical aspects and essential background concerning construction, surveying, and geotechnics are well-covered. In the final year, students may choose optional courses in various streams, such as civil engineering, structural engineering, environmental engineering, building, and engineering mathematics. This year over 50% of our graduates are in the stream of civil engineering but more are expected to be in the stream of environmental engineering in coming years.

Final Year Projects

All final year students are required under the B.Sc. Regulations to complete a project. The nature of the project can be analytical, computing, experimental, or design. The project has been a frightening prospect in the minds of most engineering students, but it plays an important part in the Part III course.

Throughout the preparation of the project, students are trained to increase their analytical power, and their capacity for logical and creative thinking. Due to the lack of experience of students in manipulating projects, each student is supervised and guided by a specific supervisor appointed by the department. At the end of the second term of the final year, when all the students have completed their projects, each of them has to present his/her work to fellow students and lecturers for assessment. In the oral presentation, he or she describes the project in about 20 minutes and there are 10 minutes for fellow students and lecturers to ask questions about the project. Finally, at the beginning of the third term, a final report in written form is submitted.

Students, however, complain that some projects are too demanding and time-consuming, the consequence of which is that there is not enough time for preparing for the degree examination. Therefore, some feel that heavier weightings should be placed on the project, since the total time expected to complete the project will in general be over 120 hours.

Future Directions in Tertiary Education of Engineers

The first question is whether there are more civil engineering graduates than jobs -- it depends on whether one takes a "static" as opposed to a "dynamic" picture of the employment situation. If one reckons that there are posts to be filled by graduates and that these posts will be occupied until these graduates die, then the answer is probably "yes, there are too may graduates". On the other hand, if one expects the graduates to be fairly creative and enterprising so that their filling the posts will in turn create more vacancies, such that the process may be described as "dynamic", the answer then is "no, there aren't too many graduates". Therefore in simple terms, we say that some able and enterprising engineering graduates will in time become engineering managers and be able to guide the technological orientation and development of their organization. This will in time create new posts for engineering graduates.

To define the future directions in tertiary education of engineers we must ask ourselves the following:

(1) Are engineering degrees designed to prepare students for a career in engineering in an absolute sense?

(2) How can we strike a balance between management subjects and technical subjects in our degree course?

(3) How can we keep pace with the industrial development of Hong Kong?

Obviously, there are no simple answers to the above questions.

Administrative and Leadership Skills of our Graduates

Most engineers have need of administrative and leadership skills but in different forms at different stages of their careers. Administrative tasks may range from preparing an agenda and keeping minutes of a meeting to administering the communication system of a large organization. The distinction between administrative and managerial skills is not always clear to people and in many jobs there is the need for both. Among the managerial skills is the ability to lead a group or organization. This is the area where inborn abilities and character play a large part and where education and training have less of a part to play. Frankly speaking, I did not learn much on these areas from my three-year B.Sc. course. Fortunately, the first degree is not an end but a beginning.

CAREERS OF CIVIL AND STRUCTURAL ENGINEERING GRADUATES

General

Graduates from our department can take up careers in either civil or structural engineering. Both professions are concerned with the planning, design, construction, and maintenance, of airports, bridges, dams, highways, housing, tunnels, and water supply.

One may specialize in structural design or construction, geotechnical, and foundation work, hydraulics; one may develop special interests in water treatment, sewage treatment, and pollution control; or one may take up some less obvious specialization such as town planning or construction materials. More mature and experienced engineers may be involved in feasibility studies, project management, or arbitration.

The majority of civil engineering graduates are absorbed by the Government, by consultants, by contractors, and by property developers. A few graduates continue to study either in Hong Kong or abroad, and some join government services or consultants overseas.

During the first few years after they leave the University, graduates undergo practical training as graduate engineers in design offices and on site. In general, it takes them four or more years to acquire corporate membership of a learned institution.

A young engineer may rise through various grades to a position of considerable responsibility and reward. When he becomes experienced through years of practice, he either achieves the top and key position in an organization or starts his own business by practising as a consulting engineer.

Employment of Civil Engineering Graduates

1985	1986
1. Civil/Structural Engineers (63.8%)	1. Civil/Structural Engineers (54.5%)
2. Teachers (17.2%)	2. Teachers (10.6%)
	3. Marketing & Sales Executives (21.3%)

- *Data from Appointment Services, HKU*

The major types of jobs were (a) graduate engineer, (b) marketing and sales executive, and (c) teacher.

Government continues to be the biggest employer of our graduates. In 1987, 19 of our graduates joined the government as civil engineering graduates but this year only 14-15 HKU graduates were recruited by the government. I am surprised to find that an equal number of Polytechnic graduates are recruited by the Government remembering that the total numbers of HKU and Polytechnic (degree) graduates are in the ratio of approximately two to one. In view of this, the first question that comes to my mind is:

Are Polytechnic degree graduates better than HKU graduates?

To make the comparison, I would like to quote a table published in the Journal of the Hong Kong Institution of Engineers, June 1988: "Why graduate training is being upgraded" - by J.C. Wright

Polytechnic	**University**
1. More hardworking	More intelligent
2. More practical	More academic Lack practical exposure

3. Pick up training quicker	Slower into training
4. More technically orientated	More administration orientated
5. More dynamic, more positive	More methodical & analytical
6. Better in design	Better in written communication
7. More dedicated to the job	More dedicated to the profession of engineering
8. Good attitude to work and integrate into industry well, less arrogant	Somewhat arrogant, have an artificially high opinion of their academic level

In short, we may say that Polytechnic graduates are more technically-orientated, more productive initially, better in design but perhaps weaker in written communication. For HKU graduates, they are more intelligent, more analytical, and better in written communication. I am confident that our graduates will perform much better later, especially when they become Chartered Engineers. Professor Y.K. Cheung has told us that the training of our undergraduates is not be focused on any particular technical issue but rather emphasis is placed on personal development and logical and analytical power training. It may be true that our graduates are less productive initially but it is the responsibility of the employers to provide the necessary training to bridge over the gap between the classroom and the outside world. Therefore it is unfair to make comments like "HKU graduates are somewhat arrogant and less productive." Don't forget that engineering graduate trainees, once appointed, are part of the company's human resources. The speed at which a graduate will absorb knowledge and improve in skills will depend upon the job, the graduate, and the employer.

While putting the blame on others, we must look forward to improving ourselves. I have no doubt that our graduates are academically excellent, but when pursuing a job we will be assessed quite differently and no longer by examination. To give some idea how an employer conducts an assessment we can look at the following table:

A good graduate engineer is supposed to have the following attributes:

1. Job knowledge	:	Technically competent to perform the requirement of position
2. Quantity of work	:	High output
3. Quality of Work	:	Work always well researched, well presented and dependable
4. Team Work	:	Co-operative in working with supervisors and colleagues

5. Leadership	:	Demonstrates power to inspire, discipline, and motivate subordinates like draftsman
6. Organization & Administration	:	Able to organize work in an orderly and systematic manner
7. Initiative	:	Looks for alternatives, suggests and makes work improvements
8. Sense of responsibility	:	Puts company interest before own interests. Always willing to accept additional responsibility
9. Strength of character	:	Demonstrates self-confidence, emotional maturity, and integrity
10. Written communication	:	Reports to supervisors always complete, concise, clear, and timely
11. Social attributes	:	Demonstrates social and human relations skills, able to mix with others

Finally I must emphasize that Polytechnic graduates do have their merits and some contractors prefer to have Polytechnic graduates as their graduate engineers. We don't have, in any sense, any objection to this since any employers have freedom to choose the most desirable candidates. But I hope that in the future that employers including the Government can, whenever possible, look into the potential of individual candidates more carefully, instead of placing most weighting on productivity, which can be short-sighted.

CONCLUSION

Despite all the controversial issues mentioned above our past graduates have been very successful and it is an appropriate time to celebrate success - the 75th Anniversary of the founding of the Faculty. Here I would like to quote a remark by Professor Y.C. Cheng:

> The Faculty's lasting endeavour and contributions in the advances of science and technology as well as the provision of high level technological education have enabled it to take pride in this historic occasion of the 75th Anniversary, which in turn marks the beginning of its increasingly active role in the future.

Lastly, I would like, on behalf of all 1988 civil and structural engineering graduates, to express our whole-hearted congratulations to the Engineering Faculty and wish the Faculty an even more successful future.

E.S.H. Chan graduated in civil engineering in 1988.

THE DEPARTMENT OF INDUSTRIAL ENGINEERING

THE FIRST EIGHT YEARS 1973-81

W.A. Reynolds

Industrial Engineering was until 1988 the youngest of the Departments making up the Faculty of Engineering. This essay endeavours to give a brief introduction to the concept and scope of industrial engineering, the development of the courses in the Department and its research work, together with some account of the staff and buildings and the contribution of the Department to Hong Kong industry of all types.

The University had been endeavouring to appoint its first Professor of Industrial Engineering for some years prior to 1973 when it again advertised, this time for both a Professor and a Senior Lecturer. In the event, no appointment of a Professor was made and the writer was appointed Senior Lecturer and Head of Department. Two members of the staff of the Mechanical Engineering Department, Dr. N.N.S. Chen, (now Professor Chen) and Dr. P.I.F. Niem were transferred to the new Department which came into official existence in May 1973 with Dr. Chen as Acting Head pending my arrival at the end of July. The three of us, with guidance from John Llewelyn, the Faculty Secretary, and Professor W.S. Leung, the Dean, had two immediate tasks: to decide on our educational aims for approval by the Faculty and to get some students.

INDUSTRIAL ENGINEERING

A frequent question put to us at that time was "What is industrial engineering, how do you define it and what will you teach?" The three of us, Dr. Chen, Dr. Niem, and I discussed what the scope of the department should be; we felt that production engineering, as understood in the UK, was too narrow in scope and that the definition used by the American Institute of Industrial Engineers was more helpful. Briefly this defines I.E. as the academic and professional studies of the organization of men, machines, materials, and money, in both manufacturing and service industries. It may thus be thought of as "man-centred systems engineering" and although the main applications have been (and still are) in manufacturing industry, the concepts and techniques are being increasingly applied in the transport, health care, communications, and hospitality industries as well as government service. It is therefore multi-disciplinary and as well as the basic subjects of engineering science it takes in ergonomics, cost accounting, and operational research. This wide field of interest overlaps with that of departments outside the Engineering Faculty. The idea that man should be at the centre of the system, and the machine or general hardware and organization designed round him and his needs and capabilities is fundamental to this approach and one which distinguishes it from the other engineering disciplines.

THE DEVELOPMENT OF THE UNDERGRADUATE COURSES

As the department was new and the time of its coming into being uncertain, it had not been included in the quota of students to be admitted to the Faculty in 1973. The other three departments kindly gave up a few of their quotas allowing us an intake of 14 and applicants to the other departments were asked if they would like to transfer to Industrial Engineering. At that time and for several years later the syllabus for the first year was largely common to all four departments and the IE students followed that for mechanical engineering. The Faculty and Senate accepted our proposals for the second and third year curricula and it is interesting to note the subjects then taught and compare the changes made by 1980. Reference to the University Calendar for 1974/5 shows the following entries for Industrial Engineering:

First Year, as Mechanical Engineering.

Second Year, seven basic courses:

- Mathematics (as Civil Engineering)
- Electrical Technology (as for Mechanical Engineering)
- Heat and Thermodynamics or Mechanics of Machines (both as for Mechanical Engineering)
- Mechanics of Solids (as for Mechanical Engineering)
- Technology and Society
- Manufacturing Processes
- Industrial Engineering Techniques

In addition to the last three taught by IE staff there were additional courses in Computing, Production Operations, Work Study, Facilities Design, as well as practical workshop training.

Third Year, four compulsory papers:

- Industrial Organization and Management
- Quantitative Methods for Industrial Operations
- Product Design and Process Planning

Production Scheduling and Stock Control

Plus two papers selected from:
Production System Costing
Workplace and Job Design
Process Technology
Process Automation and Control

In addition there was the all-important project work and coursework in automation, workshop design, and production operations. Thus half the teaching in the second year and all the teaching in the third year became the responsibility of the Department.

Over the years from 1974 the curricula of all the Engineering Departments underwent change so that by 1981 there were fewer subjects taught in common courses and the titles and contents had also changed. The Calendar entry for Industrial Engineering for 1980/81 reads:

First Year, six written papers made up of four full papers and four half papers:
Mathematics
Properties of Materials
Electrical Engineering
Thermofluid Mechanics
Mechanics of Materials (1/2 paper)
Applied Dynamics (1/2 paper)
Industrial Studies; Communications (1/2 paper)
Industrial Studies; History of Technology (1/2 paper)

Three additional courses: Primary Production Processes, Engineering Drawing, and Computer Programming Techniques.

The four full courses and the first two half courses were taught by staff of the Mechanical and Electrical Engineering Departments but all the rest were handled by the IE department.

In the Second Year the papers taken were:
Mechanics of Solids
Industrial Statistics
Quantitative Methods
Intermediate Production Processes
Ergonomics
Electrical Technology (1/2 paper)
Work Study (1/2 paper)
Work Mechanization and Automation (1/2 paper)
Computer applications (1/2 paper)

There were also additional courses in Work Measurement, Mechanization, and Engineering Practice.

With the exception of Mechanics of Solids and Electrical Technology, the IE Department was thus responsible for all its second year teaching.

The Third Year syllabus shows six written papers and a project being required. They were:

Industrial Studies; Organization and Management
Product Design and Process Planning
Production Scheduling
Facilities Design
Production System Costing and Finance
Plus one paper selected from Metal Working Technology, Plastics Technology, and additional assessed courses in Plant Layout and Production Practice as well as the project.

Although the IE Department was still dependent on teaching from other departments, especially in the first year, Industrial Engineering in return provided the 'Engineer in Society' courses for the third year of both Mechanical and Electrical Engineering Departments.

For 1974-5 Industrial Engineering was given a first year entry quota of 30 and a special quota of 10 holders of the Polytechnic Diploma entering direct into the second year. This was to give a viably sized second and third year course. We continued to have a small quota of three or four second year entry Diploma holders up to the time the Hong Kong Polytechnic started its own degree level course in Manufacturing Engineering. The experiment of admitting Polytechnic graduates was successful and the greater maturity and experience of these students was of benefit to the student body.

Among the responsibilities of the Head of the IE department was that for the Ho Tung Workshop which was under the direction of Mr. L. Kesterton who had made it into an efficient service workshop for all the engineering departments as well as providing some limited machine shop experience for mechanical engineering students. By reorganizing the layout and getting rid of some redundant machines it proved possible to make a small Production Operations Workshop for the IE Department from a corner of the Ho Tung Workshop. This was equipped with production (as against toolroom) type machines and was used in teaching production processes for both metal and plastics. It was also used during the summer vacation for the six week production operations course in which students ran the whole workshop, manufacturing batch quantities of scientific apparatus for the teaching of physics in Hong

Kong schools, whose laboratories were not well equipped. This was done in co-operation with the very active Association of Science and Mathematics Teachers and provided some tangible 'feedback' from the University to the schools from which the students had come.

Although the case for a greatly increased number of students in the Department was strongly argued, the quota for the first year entry only reached 38 for 1980-81 despite the high success rate of IE graduates in getting and retaining jobs in manufacturing industry. Special efforts were made to encourage girls to consider IE as a career and as a result their numbers have usually been about 10% of the entry (which is still much too low).

In the early years the standard of English of engineering students was not high; the Faculty at that time did not include marks gained in the 'Use of English' examination in the score for ranking applications. Largely at the insistence of the IE department (who felt that engineers must be able to communicate well in English as well as Cantonese) the 'Use of English' score was included and the students in the science stream of schools began to take the subject seriously. The Department also tried to interview all applicants, especially those with 'borderline' scores, to try to separate the good potential engineers from those who appeared to be 'academic blotting paper', soaking up everything from the chalkboard and their textbooks but with little of the personality and interest in the world around them which helps the graduate to become a professional engineer.

An important part of University education is the extra-curricular activities of the student body. The small IE Department usually lost out in sporting activities to their larger brethren but IE students appeared now and then in Students Union activities. In order to form a link between the departmental student body and those who had already graduated, an Industrial Engineering Association was formed which organized a successful Industrial Engineering Exhibition and talks in Guangzhou, as well as visits to universities and factories in that city.

POSTGRADUATE AND EXTRA-MURAL COURSES

When the Department came into being in 1973 it took over an existing certificate course run by the Faculty and the Extra-Mural Department. This was re-organised for 1974-5 into two courses: Operations Planning and Control, and Design of Production Systems and these were run in alternate years. They were intended for men and women working in manufacturing industry who had not had the opportunity to study IE techniques but needed them in order to do their jobs better. They were specialist courses with an intake of 40 of whom 33 to 35 usually lasted through the 100 hours of lectures and laboratories to take the examination.

One of the few remits given the Department on its foundation was that it should run a part-time Master's course. This was started in January 1976 following the approval of the entry qualifications and syllabus which were modelled on those pioneered by the Department of Engineering Production in the University of Birmingham but with modifications to suit Hong Kong needs and conditions. The first entry quota was 15 for each year but this was raised to 30 for the entry in January 1979. It was, and remains, a post-graduate, post-experience, day release course which ensures that the employer supports the attendance of the member and is likely to give facilities for the project work within the organisation. The course originally ran on a calendar year basis in order to ease the load at the traditional examination time of May and also give members more time during the summer vacation for their project work. Course members were usually in managerial level posts and from industries as diverse as ship-building, telephone repair, civil engineering, Government Service, and education, as well as the usual run of Hong Kong manufacturing industries.

The first year syllabus comprised three courses, Production System Design, Operation of Production Systems, and Industrial Organization and Management, and the second year had two courses, Product Design Quality and Reliability, and Production Management Accounting and Control. The project, a most important part of the course, was taken in the second year and was usually carried out in the member's own organisation. This resulted in some first class reports, the adoption of which were often of material benefit to the organisation. They also served to keep the supervising academic staff in close touch with actual conditions and practice in the industrial systems of Hong Kong.

By 1980-81 the scope of the course had widened and the other engineering departments were offering similar courses. There were still the three courses in the first year and two plus the project in the second but there were only two compulsory courses: Management of Industrial Organizations, and Industrial Information and Control Systems. The other three were to be chosen from Design of Manufacturing Systems, Reliability and Maintenance, Operational Research, and General Ergonomics.

At this time the Department also contributed to the Extra-Mural Diploma in Management Studies with lectures on technical aspects of management and the EMS Department made a return contribution to the management teaching on the M.Sc. course.

The rate of change in manufacturing and communications technology is such that the education of engineers must continue all through their working lives. In many areas, especially computing and electronics, the latest knowledge may only have a half-life of two or three years. It is therefore an increasing responsibility of universities, polytechnics, and the engineering profession to provide facilities for up-dating. Not only does the engineer need to keep up with change in his or her first discipline; the need may well arise to change disciplines and take on board new areas of expertise as careers develop. This brings the need for 'conversion' courses, especially those which help the single discipline engineer move into manufacturing, management, and technical selling.

RESEARCH WORK

It is a fact of life in engineering departments with strong industrial connections and involvement in industry-based project work by their students that this leaves less time and energy for the type of research publishable in international journals. Moreover, the work of establishing and equipping a new department makes further demands. Nevertheless, there was a small but steady flow of published papers from the Department in both research and professional journals and papers were read at international conferences. The first research degrees came in 1977 when Ho Chun Fai was awarded his doctorate for research into the hot machining of alloy steels supervised by Dr. N.N.S. Chen. This work was started in the Mechanical Engineering Department but brought over into Industrial. Titles of M.Phil. theses accepted since then reflect the practical and industrial orientation of research in the department. They include:-

- Performance studies of hydrostatic air thrust bearings
- Replacement policies for multi-component systems
- The organization and use of industrial engineering techniques in Hong Kong Industry
- The development of an anthropometric model for Hong Kong workers: a comparative study.

The research on replacement policies was carried out by Mr. Suraweera, a Commonwealth Scholar from Sri Lanka who based his research on 20 years of well kept maintenance records of the Hong Kong Tramway system. This work represented a significant advance in the understanding of the subject.

ACADEMIC AND PROFESSIONAL APPROVAL

The work and academic standards of all university departments in the UK system, of which HKU is a part, are kept up by the external examiners and, for overseas universities, by visitations under the IUC scheme. Those departments preparing their students for professional work in law, architecture, and engineering also receive accreditation visits from the appropriate UK professional body. For a new department, a visit after the first two or three years can be of great help in checking progress and giving suggestions for further advances. This was certainly the case when Professor E.N. Corlett, Head of the Engineering Production Department at Nottingham University, came in early 1976 as an IUC visitor. His report, together with the advice of external examiners, formed the basis of the curriculum changes which came into effect in 1978-9. However, the accreditation by the Engineering Council in the UK of the HKU B.Sc.(Eng.) degree in Industrial Engineering was held up for some years by the reorganization of the Council procedures. This did not prevent graduates joining the Institution of Production Engineers; it merely made the procedure more tedious and lengthy.

The Department was a strong supporter of the unification of the profession in Hong Kong under the Hong Kong Institution of Engineers and I personally think that our reliance on UK standards and division of disciplines can harm the development of the profession in meeting the needs of Hong Kong. Visiting academics have all appreciated that the position and problems of Hong Kong are very different from those of the UK and that therefore a professionally orientated curriculum suitable for HK should have a different emphasis, though no less rigorous, than one designed to suit the UK conditions.

THE HO TUNG WORKSHOP

The fact that the workshop was made the direct responsibility of the Head of the Industrial Engineering Department has already been mentioned. It was felt that it would be better if the arrangement was changed to reflect the reality that it provided a service to all the University and not only the engineering departments. A Ho Tung Workshop Management Committee was therefore set up in November 1979 with Professor Bruges, Head of Mechanical Engineering, as Chairman.

All the engineering departments and many others in the University requiring apparatus to be made or repaired, have benefited from the experience, expertise, and ingenuity of Les Kesterton, the Workshop Engineer, and Albert Tam, the Workshop Superintendent. Their ability in designing, making, and maintaining the plant and instrumentation on which so much teaching and research depends was of great value. Without their supporting service, little could be achieved.

ACCOMMODATION AND EQUIPMENT

Those who see the present laboratories, workshops, drawing offices, and staff accommodation in the Haking Wong Building today may very well wonder where all the IE Department activity so far described was housed in those early days. The staff and departmental offices were on the first floor of the Redmond Building which was shared with Mechanical Engineering who occupied the floor above. The second floor also housed the Reference Bureau, then a small interdepartmental library also used for staff meetings. We also had two rooms on the first floor of the Duncan Sloss Building which were fitted up as multi-purpose laboratories housing work study, plant layout, and low cost automation equipment in one, and metrology and ergonomics in the other. There was also a lecture room, holding about 40, on the same floor which was largely used for IE classes.

The demolition of the buildings housing the Electrical Engineering Department (originally built for Anatomy and Physiology) to make room for road widening and the new Engineering Building caused a general crowding up into the Duncan Sloss Building which had been vacated by the architects on their move to Knowles. The only extra space which the University could offer was the Maison de Bethanie opposite University Hall, a mile and a half away up Pokfulam Road. This building was originally a retirement home for Catholic clergy and enjoyed a magnificent view across the Lamma Channel to Lantau and the other islands. The IE Department decided that the only chance of getting the room needed for laboratories and staff was to move half the Department up to Bethanie despite the inconvenience of being on two sites. However, when the time came, some were quite reluctant to move out of the quiet surroundings so close to their homes in Middleton Towers and High West. The facilities set up in Bethanie included a drawing office/lecture room, ergonomics and quality and reliability laboratories, as well as rooms for six staff. This provided adequate, though cramped, accommodation for teaching until the move to the Haking Wong Building. The planning of accommodation in the new building and the choosing of new equipment with money from the Haking Wong donation and UPGC funding occupied much time and effort from 1976 onwards.

Over the years much equipment was obtained and suppliers were often generous in giving discounts. Especial mention must be made of Chen Hsong Machinery who contributed half the cost of our first plastic injection moulding machine and who have continued their support ever since.

STAFF

Whatever hardware and buildings a university engineering department has, nothings happens unless there are good students and staff to teach them and maintain their scholarship and research. As has been mentioned earlier, Dr. Nelson Chen and Dr. Paul Niem joined me from the Department of Mechanical Engineering to form the nucleus of the new department. But academic staff need technical support and we were very fortunate in recruiting Mr. Wong Wing Yuen as our first technician. He continued to lead a growing team during the whole period here covered and it is largely due to him that the practical work in the laboratories and workshops has been so successful. We also owe a great debt to the secretarial staff who provided such unfailing service over the years before following husbands or family overseas to North American or Australian pastures.

The first recruit to the academic staff was Dominic Sculli who came from Australia in 1974 with considerable experience of Operational Research applications in industry. He has since developed the computing work in the department as well as applying OR techniques to problems in Hong Kong. In 1975 two more staff came, Simon Partridge from England to carry the teaching load in cost accounting and work study, and M.C. Leung to teach machine tool technology and look after the production operations course. Dr. Brian Peacock joined in 1976 from the Engineering Production Department at Birmingham. He started the teaching of ergonomics in the University and also taught some statistics as well as providing a flow of stimulating ideas. He left in 1980 for North America and has now moved from university teaching to applying ergonomic theory to practise in General Motors. He was joined by Bill Evans in 1977 and together they built up the ergonomics teaching and research which continues to form a strong part of the Department's work. Dr. K.L. Mak came from Pilkingtons in St. Helens in 1976 to take responsibility for manufacturing system design and control, while Martin Kwok came the following year to teach the complementary subject of facilities design. In 1978 we were fortunate to attract Dr. T.C.L. Tai to teach statistics and maths and the following year Colin Partington came to take over some of the industrial organization and management teaching which I had been doing. He also brought considerable expertise in welding and other workshop processes. Alan Courtney arrived in 1980 to replace Brian Peacock in ergonomics.

The Department was thus able to recruit one or two staff every year to keep pace with the increase in numbers. Because of home and study leave absences, we all had to cover for each other at times and teach subjects outside our immediate areas but "teaching is a learning process" and the clearest exposition of a subject is often given by the non-specialist. There were also some promotions in the period; Dr. Chen gained his Senior Lectureship in 1975 and later on the University decided that the Department deserved a professor to head it. The post was duly advertised and I was appointed to the Chair in 1978 and gave an inaugural lecture entitled "A View of the Engineer" which endeavoured to set out the concepts of industrial engineering in its broadest sense.

INDUSTRIAL ENGINEERING AND THE NEEDS OF HONG KONG

It was pressure from Hong Kong industry as well as the foresight of previous Deans of Engineering which led to the decision of the University to set up the new department. From the beginning we kept in close contact with the Hong Kong Productivity Council, the Hong Kong Management Association, the Chinese Manufacturers Association, as well as the Hong Kong General Chamber of Commerce and the Department of Labour Committees which preceded the setting up of the present Vocational Training Council. There was also a happy relationship with the Production and Industrial Engineering Department and the Industrial Centre at the Hong Kong Polytechnic and some of their staff contributed to the plastics technology teaching. The Industrial Centre also provided workshop training for our students at a time when we did not have sufficient facilities for this.

These contacts led us to press the needs of Hong Kong for more well trained engineers, especially industrials, on the appropriate authorities. Submissions were made in response to the 1977 Green Paper on Tertiary Education and to the 1980-81 Review Committee on Post-secondary and Technical Education. In these and in papers presented to the Hong Kong Institution of Engineers the needs of Hong Kong for a great increase in trained people at craft, technician, and professional engineer levels in manufacturing industry were stressed. This was done by means of comparisons with what was happening in Japan, Singapore, the USA, and the UK.

Several research projects were undertaken to assist government departments. A notable one measured the fatigue levels of bus drivers following some tragic accidents to CMB vehicles. The Industrial Division of the Correctional Services Department benefited from projects improving the efficiency of the industrial workshops in the prisons. One graduate joined the CSD and is now himself working in the Industrial Division.

Tribute must here be paid to the many industrial organisations, too numerous to mention by name, who gave us facilities for shop floor based projects and allowed their staff to be questioned as to the why and wherefore of existing practices. The success of the Department and its graduates owes much to them.

GRADUATE CAREERS

From the beginning the Department tried to put over the idea that an engineering degree is not an end in itself but a means to equip men and women to design, construct, manage, and control systems which will both produce the goods and services needed by society and also provide a happy and healthy environment which uses the full abilities of all who work there. Hence the stress, mentioned earlier, on the "man-centred systems approach" to industrial engineering and on the idea that discipline is much more than a collection of efficiency improvement techniques.

How far this emphasis has been effectively passed on in teaching, remembered, and put into practice by those who have passed through the Department, only they can say. But examination of the early careers of our first graduates shows that the majority had a successful and satisfying time in manufacturing industry. In May 1981 the Hong Kong Institution of Engineers Journal published a paper of mine giving the results of a career survey of the first four groups of graduates. Of the 75 (out of 116 possible) responses, 77% had entered manufacturing industry and a further 5% went into industrial services. Nearly all stayed in industry in subsequent job changes which would indicate that they and their employers found satisfaction in their work. Of those who did not enter manufacturing, some went on to higher degree work and there were some who did not reply. It may be of interest to all, and encouragement to some, that the survey showed that performance in the Advanced Level examinations showed no relationship to performance at University or to career success!

CONCLUSION

Since leaving Hong Kong I have kept in part time contact with the teaching of production engineering in the UK. The developments (or lack of them) and the shifts which financial stringency and Government direction have forced on engineering departments have produced developments which Hong Kong would do well to avoid if it wishes to have an engineering profession which is of service to the community and respected in the academic world at large. Hong Kong must develop its own courses to meet the needs of its own people. In a memorandum to the Vice-Chancellor's seminar on "The Relevance of the Curriculum to the Needs of Society" in May 1978 I wrote:-

> Because we have no natural resources we have to adapt more quickly than others to changing needs. We are one of the sellers in the buyers market of nation states.... Hence we should be at the forefront of thinking rather than following precedents from elsewhere. The evidence of the market place is that the education system of the UK, which has been the major influence on the Hong Kong one, is inadequate and that we have to devise our own system to meet our own conditions of the future. It must produce men and women who are highly adaptable, who understand the principles of the physical, social, and life sciences in the context of history and who are prepared to produce unique solutions to the general problems of industrial societies.

Finally I must pay tribute and give thanks to all my colleagues, both inside and outside the Department, who willingly supported and shared in the gestation, birth pangs, and growth of a new offspring of the Faculty whose founding 75 years ago we celebrate in 1988.

W.A. Reynolds was Head of the Department of Industrial Engineering from 1973-1981.

THE DEPARTMENT OF INDUSTRIAL ENGINEERING RECENT DEVELOPMENTS 1981-88

N.N.S. Chen

INTRODUCTION

I was appointed Head of the Department of Industrial Engineering in July, 1981. The Department by then was fairly well established, offering both B.Sc. and M.Sc. degrees and there were also a few research students. However, the B.Sc. degree had yet to be accredited, and therefore was not recognized by the relevant U.K. professional institutions at that time.

The B.Sc. student annual intake was increased from 14 in 1973 to 40 in 1981 with a corresponding increase in academic staff from 3 to 11. As the Department expanded, more staff offices and laboratory space were required. By 1981, its facilities were located in five separate buildings, with around half the staff and some major laboratories housed at Bethanie, which was some 3 km away from the main campus. This meant that staff and students had to travel frequently between lectures. Despite all this, the Department was still short of space, particularly laboratory space. In the summer of 1982, the new Haking Wong Building was ready for occupation and all the engineering departments moved in.

ENHANCEMENT OF LABORATORY FACILITIES

At that time, the Department had no computing facilities of its own to speak of. One of the urgent tasks I set out to do soon after moving into the new premises was therefore to establish a Computer Applications Laboratory. This was necessary so that such a facility could precede the introduction of new courses in computer aided design and manufacture (CAD/CAM). A large proportion of the available funds was directed towards the procurement of a VAX 11/750 minicomputer system. Later, it became clear that there was a need for the Department to establish a flexible manufacturing cell to support courses in CAD/CAM. A computer numerical control (CNC) lathe and an industrial robot complete with vision system were added to an existing CNC machining centre to form the nucleus of such a flexible manufacturing cell.

In 1987, the Department received a four million dollar donation from Prime Computer (H.K.) Ltd. in the form of a super minicomputer together with a list of CAD/CAM software packages, including Prime

Medusa and SAMMIE. Recently, the Department also purchased three Sun workstations and quite a number of microcomputers. Thus the Department is well equipped for teaching and research in the CAD/CAM field.

The Department has always placed particular importance on the role of people in industry and this is reflected in our commitment to the teaching of ergonomics. By 1981, quite a good range of ergonomic equipment had been procured. With more space available in the new building, a purpose-built environmental chamber was installed. This chamber enables the study of people performing various tasks requiring different degrees of effort, and energy and concentration, under varying combinations of temperature and relative humidity. It is the only facility of its kind in Hong Kong.

Another area which has seen a rapid increase in laboratory facilities since 1981 is plastics technology. At that time, the Department had an injection moulding machine and also a compression moulding machine. Soon after moving into the new building, a blow moulding machine was purchased and a home-made vacuum forming machine was added to the existing equipment. In 1987, the Chen Hsong Machinery Company made a generous donation of a 12-oz. computer-controlled injection moulding machine. Recently, through a strategic research grant, a full scale plastic blown film line was installed. All this equipment enabled the Department to set up a very modern plastics processing laboratory, for teaching and research.

DEVELOPMENT OF DEGREE CURRICULUM

The Report of the Advisory Committee on Diversification was published in 1979, and one of its major recommendations was the need for local industries to diversify into high-tech and higher value-added products. As local industries moved into better quality products, quality assurance has become an increasingly important activity. There was, therefore, a need to equip industrial engineering graduates with a better understanding of quality assurance. In view of this, new courses in metrology and quality assurance were introduced for the undergraduate degree curriculum.

One of the most significant world-wide developments in manufacturing in recent years has been the application of computers in product design and manufacture. In keeping with this trend, a new final year course in computer aided design and manufacture was added to the B.Sc. degree curriculum.

Master's Degree Course for Practising Engineers

By 1981, the M.Sc. course was fairly well developed, with an intake of 30 every year. This course started off with a fixed curriculum for all students. In 1984, it was changed to a modular structure whereby students can elect to study eight modules from a wide range of subjects, including those offered by other engineering departments in the Faculty. In response to local needs, several new modules, namely industrial statistics, quality and reliability of production and service systems, computer aided manufacture (later renamed computer integrated manufacture), and plastics processing technology had been added to the list of modules offered by the Department.

The course has continued to be very popular and annually the number of applicants has been several times more than the number of available places. The profile of a typical course member is that of a graduate in his early thirties, with several years' working experience and holding a middle to senior engineer/manager position in one of the larger local companies.

STAFF DEVELOPMENT

In keeping with the introduction of new courses, the Department has recruited two new lecturers who are specialists in CAD/CAM, and one who specializes in plastics technology. I was appointed to the Chair of Industrial Engineering in 1985. Mr. D. Sculli and Dr. K.L. Mak were promoted to Senior Lecturer in 1985 and 1986, respectively.

DEGREE ACCREDITATION

A joint degree accreditation panel from the Engineering Council and the Institution of Production Engineers, U.K., came out to assess the Department's B.Sc. degree in 1985, and subsequently granted it full recognition without any reservation. Graduates in industrial engineering are therefore fully exempted from the educational requirements for corporate membership of the Institution of Production Engineers. After they have acquired the requisite training and working experience, they are able to apply for registration as Chartered Engineers.

The B.Sc. degree also fulfills the educational requirements of the Hong Kong Institution of Engineers for corporate membership in the production and industrial engineering discipline.

RESEARCH ACTIVITIES

In the early years, the Department was preoccupied with the setting up of teaching laboratories and most of the available funds were used in this way. In recent years, more funds have been directed towards enhancing research facilities, in keeping with the significant increase in research activities. The following is a brief account of some of the Departmental research programmes.

Operations Management

The Department is actively engaged in research in the applications of operations management techniques to the many aspects of running a manufacturing enterprise efficiently. This includes research on the optimum levels of inventories, appropriate location of production facilities, scheduling production to avoid delays and minimize costs, the determination of optimum maintenance schedules, and the control and testing of product quality.

Ergonomics

Research studies undertaken by the Department have been in the areas of anthropometry, biomechanics, workplace layout, noise, noise and hearing, inspection, visual-lobe mapping, and worker selection.

One of the current research projects which has received substantial funding is a study of the relationship between visual lobe size, search strategy, and performance. The visual lobe is the area around the fixation point in which an object may be seen during a single eye pause. Vision is by far the most important of our senses and knowledge about lobe areas has application in any training, job design, or equipment design situation where visual search plays an important role, e.g. driver and pilot performance, inspection work, and photo-interpretation. This research is expected to lead to a range of tests for visual lobe size and for some aspects of performance.

Quality Assurance

Quality assurance is an important function of any production system. In view of the rising costs of production in Hong Kong, there is a tendency for manufacturers to move up-market and produce more sophisticated and high-technology products aiming at more discerning markets, e.g. EEC, United States, and Japan. This in turn will require more effort in quality assurance activities.

Research in the quality assurance field includes reliability analysis of uninterruptible power supply systems, product reliability testing in the manufacture of computers, and analysis of industrial processes involving mixing of ingredients.

Plastics and Metal Working Technology

The Department has been conducting considerable research in the plastics field. Projects recently completed include the cold rolling and forming of plastics, and an investigation of fatigue strength of adhesive bonded plastic joints. A current research project involves the study of optimum blend ratio of low-cost linear low density polyethylene (LLDPE) using a conventional blown-film extruder. One of the aims is to establish scientific correlations to predict the properties of plastic films for a given resin blend ratio. A parallel research project looks into the effects of moisture on processing conditions and welding properties of polyamides (i.e. nylon).

Projects undertaken in the metal cutting field include hot machining, machining with an air jet directed at the tool/work interface, tool life evaluation and prediction, and analysis of wear land stress.

Computer Aided Design and Manufacture

Areas of research and development include flexible manufacturing systems, manufacturing cells, expert systems for design and manufacture of sheet metal blanking dies, and CAD/CAM for mould and die cavities. The last project is concerned with the development of a low-cost and easy-to-use computer aided design system on a microcomputer, using solid modelling techniques, for the manufacture of tooling and mould and die cavities. The eventual aim is to integrate with systems for computer aided design, cost estimating, and production management, to form a complete suite of CAD/CAM packages that will form the core of a flexible manufacturing system for moulds and dies.

CLOSING REMARKS

The Department has come a long way since its establishment in 1973. Starting with an initial B.Sc. intake of 14, it now has around 160 undergraduates, plus about 90 postgraduates. Graduates in industrial engineering readily find employment in local industry. Whilst the majority of them are employed in the manufacturing sector, quite a number of them also enter the service industries.

Many earlier industrial engineering graduates and a large number of former M.Sc. students are now leaders in local industries. In the early seventies, many people in the local community did not have a clear idea of what "industrial engineering" was about. It is gratifying, therefore, to see that employers nowadays regularly specify "industrial engineers" in their advertisements for senior engineering posts.

The demand for more industrial engineers will continue in the years to come, and I am confident that the Department is well prepared to do its share in meeting this need.

A NEW DEPARTMENT: COMPUTER SCIENCE

F.Y.L. Chin

The Department of Computer Science, formerly part of the Centre of Computer Studies and Applications, joined the Faculty of Engineering with effect from July 1, 1988. Computer Studies emerged as an academic discipline in the University's academic structure in 1982, following the decision of the Senate that the form of organisation of Computer Studies and of Computer Services would be that of a combined Centre of Computer Studies and Applications. Since then, it has undergone rapid development and expansion. The curriculum leading to the degree of B.Sc.(Computer Studies) was the formal responsibility of the Board of Faculty of Science on the advice of a Board of Computer Studies, the latter also having the responsibility of advising the Senate on all matters of principle relating to the teaching of computer studies in the University.

In September 1982, the curriculum for the degree of B.Sc.(Computer Studies) was introduced, with a quota of 30 students per year. In the triennium 1985-88, in accordance with the University's development plans, the intake of 30 into the B.Sc.(Computer Studies) curriculum was doubled to 60 per year and a joint programme in Computer Engineering/Computer Studies was mounted by Computer Studies and the Department of Electrical and Electronic Engineering, with a combined total intake of 40 students per year. In 1986, the Director of Computer Studies proposed that Computer Studies should become part of the Faculty of Engineering. In 1988, the Senate formally approved the re-naming and the re-structuring of the department as well as the curriculum. By that, Computer Studies would become part of the Faculty of Engineering with the name changed to that of the Department of Computer Science. Starting from September 1988, two new computer curricula, viz. the B.Sc. (Computer Science) curriculum and the B.Sc. (Engineering) in Computer Engineering curriculum, are being offered to undergraduates.

The Computer Engineering programme is offered jointly by the Department of Computer Science and the Department of Electrical and Electronic Engineering. The new curricula replace the B.Sc. (Computer Studies) curriculum hitherto run by the Computer Studies. Students admitted before September 1988 to both the Hardware and Software Orientated Streams would still to be awarded the B.Sc. (Computer

Studies) degree. The objective of the Computer Science curriculum is to offer a fundamental education in Computer Science which will enable students to pursue a career in any area of computing or to undertake further academic studies or research. The curriculum and syllabuses allow students to take courses offered by other faculties and departments, some of which may form integrated options to be pursued progressively throughout the three years of study. The objective of the Computer Engineering curriculum is to produce graduates proficient in both computer hardware and software systems. The curriculum is more structured in the sense that students will have to select from a list of compulsory and elective courses offered by Department of Computer Science and the Department of Electrical and Electronic Engineering.

The British Computer Society, one of the most prominent professional bodies in the field of computing, setting the standards of competence, conduct, and ethical practice for computing in the United Kingdom, has granted exemptions for our Computer Science majors admitted from 1988.

Higher degree programmes in Computer Science are at present purely by research, with programmes of supervised readings formulated for students lacking adequate coursework background. There are two postgraduate programmes, viz., the M.Phil. and the Ph.D. Candidates for the research degrees of M.Phil. and Ph.D. are required to follow an approved programme of study and research under the supervision of at least one staff member. Currently, we have 9 M.Phil. and 3 Ph.D. research students. The Department of Computer Science is now located in the Run Run Shaw Building but it has been scheduled to move over to the Knowles Building in early 1989 or so.

Computing facilities for teaching and research purposes include the following: a Sun 3/280S server with 3 Sun workstations, running UNIX and NFS, a HP 9000/350 colour workstation with 8 HP 9000/319+ colour workstations, 15 IBM PC/AT compatibles, 2 Compaq deskpro 386/20, 6 Wyse 3216 80386 systems and 3 IBM PC/XT compatibles. All the PCs have hard disks. Some are equipped with accessories like 80387, 80287, array processor, D/A converters, ethernet adaptors and enhanced graphic adaptor. All workstations and some PCs are connected together through Ethernet, allowing file transfer, remote login among the systems. In addition, there are 3 AT&T 3B2/300 microcomputer, an Apple LaserWriter+, a Macintosh II, a Macintosh Plus, HP ScanJets, HP LaserJets and a Tektronix 4107 colour graphic terminal.

The teaching staff of our department have been actively involved in undertaking research in various fields of computing. These research projects are supported by various research grants. For instance, a joint project with the Computer Centre (HKU) is being undertaken for establishing a network between Beijing and Hong Kong, of which the Microvax II in our department now serves as a gateway to the computer networks in North America, Western Europe, Australia, and Korea. Besides, there are some joint projects with the industrial and commercial world which have already made some concrete achievements such as the projects with Cathay Pacific Ltd., the Hong Kong Bank, Baring Securities, Quantum Designs Ltd., etc. Moreover, in order to promote computer literacy education in Hong Kong, we have a joint project with the Hong Kong Education Department for developing some educational software packages.

As a way of introducing what is currently going on in the department, here is a list of our current research activities:

HONG KONG ACADEMIC AND RESEARCH NETWORK

The Hong Kong Academic and Research Network (HARNET) was established in September 1986. It is the first academic and research network in Hong Kong. The goal is to link up computers of tertiary institutions in Hong Kong to facilitate information exchange in the form of electronic mail and file transfer. Members now include the Computer Centre, the Departments of Computer Science and Electrical and Electronic Engineering of the University of Hong Kong, the Computer Centre of City Polytechnic of Hong Kong, the Computer Centre and Electronic Engineering Department of Hong Kong Polytechnic. Linking to Chinese University of Hong Kong is under investigation. In addition, HARNET has gateways to other major academic and research networks all over the world, e.g., USENET and ARPANET in U.S., CDN in Canada, ACSNET in Australia, JANET in U.K., and SDN in Korea. Current work includes setting up connections to China (connections to Beijing and Guangzhou are now under investigation) and implementation of a Chinese message-handling system.

Investigators: K.P. Chow and N. Ng

COMPUTER NETWORK BETWEEN HONG KONG AND CHINA

The project consists of two closely related components: communication over an unreliable channel and machine translation. The first part consists of setting up an UUCP (Unix to Unix CoPy) connection between Computer Centre (CC) in Hong Kong and the Institute of Software, Academia Sinica (ISAS) in China. The communication will be over a noisy and unreliable telephone connection. Since CC already has a gateway to other major international academic and research networks, the UUCP connection will enable researchers in ISAS to communicate with other researchers all over the world. In addition, the gateway machine at CCSA will also relay the USENET news it receives to ISAS. This news contains the most up-to-date information on research and discussion on current research topics.

Our second project will emphasize developing a translation system for some specific news groups of the USENET news. We believe that ISAS will act as the gateway through which other computers in China will connect to ISAS.

Investigators: J. Yu, F.Y.L. Chin, N. Ng, M.C. Pong and D. Zhang

DISTRIBUTED SYSTEMS

The objective of this project is to design and implement a distributed system which can be used as a tool for teaching as well as a testbed for research. A distributed system is made up of a number of personal workstations or PCs that have been networked together in a way that would facilitate the sharing of computing resources in an efficient, convenient, and network-transparent manner. The software base of the system is a distributed kernel which implements such basic functions as memory management, process management, and interprocess communications. A copy of this kernel runs in every workstation that is part of the overall system. Processes are low-level objects; we plan also to experiment with higher-level objects, such as clusters or hierarchies of processes, with the aim of providing the user with an object-oriented environment for distributed programming. Kernel engineering is another area of research, which will involve experimentation with different process types, process migration, distributed I/O, distributed shared memory, etc. We are currently in the first phase of this project, in which we are using some 80386-based PCs to build our first prototype. The kernel had been derived from some existing public domain operating system software, and we are in the process of turning it into a distributed one.

Investigator: F.C.M. Lau

DISTRIBUTED DATABASE MANAGEMENT

The purpose of the project is to develop a distributed database management system (DDMS) on a microcomputer network, to study the effect of various parameters on concurrency control algorithms, and to develop new transaction management techniques. We are developing our system on the Sun microcomputer system which is connected by an Ethernet. We are at the stage of implementing a prototype DDMS.

Both locking and multiversion timestamp concurrency control algorithms are implemented. After the prototype system is available, we will test the system by varying different parameters, such as query patterns, traffic intensity and grain size, to study the effect of the parameters on system performance. In parallel, additional concurrency control algorithms will be implemented, and their performance studied. From the experimental results, we hope to report new findings on performance characteristics of concurrency control algorithms, and develop new transaction management techniques.

Investigators: E.C.M. Lam, L. Sham

A DISTRIBUTED TESTBED FOR REAL-TIME APPLICATIONS

We hope to build a distributed system that can be used to study communications in a manufacturing or industrial control environment. A real-time kernel running in the various nodes of the system will provide the necessary system functions on which higher level control applications can be built. The real-time nature of these applications requires that these system functions be meticulously fine-tuned. For communications, the manufacturing automation protocol (MAP) will be used, which will make this project one of the pioneering efforts in adopting MAP for Hong Kong.

Investigators: F.C.M. Lau, F. Tam, C.F. Chong, C.H. Lee

THE TRANSPUTER PROJECT

The first phase of this project involves a systematic evaluation of the Transputer microprocessor, a state-of-the-art single-chip reduced instruction set computer (RISC) invented and manufactured by INMOS Ltd., UK. The result of the evaluation will be used as a guide in the design and implementation of some operating software (and possibly an operating system) for a Transputer-based multiprocessor to be developed through a joint effort between the Electrical and Electronic Engineering Department and the Computer Science Department. At present, we are engaged in experimenting with some transformation program that would take a user's program, written in the OCCAM programming language, and map it to a target Transputer network. The mapping must be done in such a way that the communication overheads in the execution of the resulting program would be minimized.

Investigators: F.C.M. Lau, K.M. She

SPEECH LABORATORY

A Speech Laboratory has recently been established by the Department of Computer Science and the Department of Electrical and Electronic Engineering in response to the growing importance of speech technologies to the Hong Kong electronics industry. A number of projects are being undertaken such as large vocabulary Putonghua recognition and text-to-speech conversion and many others focusing upon the theme of man-computer communication by voice. For a general introduction, see the article "Computer Recognition of Putonghua".

Recognising Speech Patterns

Pattern recognition involves a lot of pattern matching with known references. In order to reduce the amount of work involved (hence the time required), we want to develop a technique to avoid futile matchings by discarding unlikely candidates in steps.

Static Representation of Speech Dynamics

Various techniques have been invented to portray the changing patterns of speech features. In order to apply standard pattern recognition techniques to speech patterns, it is necessary to transform the dynamics of speech patterns into a static representation. Our strategy is to capture a matrix of state transition probabilities of the speech patterns where a state corresponds to a codeword after the feature space has been vector quantized.

A Putonghua Voice-typewriter

This is a speaker-dependent recognition system for clearly articulated continuous Putonghua which outputs printed Chinese characters corresponding to the input speech. The system first segments a digitized waveform of the utterance into syllables and then labels them according to the acoustical information they provide. Labelling uncertainties are removed by consulting lexical and syntactic rules.

Cepstral Liftering

The advantage of representing short time speech segments in terms of cepstral coefficients is that they span an orthogonal space. Recently, there has been some interest in the relative importance among these coefficients and various weighting functions have been proposed but they are all heuristic. We want to perform a detailed analysis and design an optimal weighting (liftering) function on the cepstral coefficients suitable for Putonghua.

A Multi-pulse Speech Synthesizer

Linear Predictive Coding (LPC) synthesis of speech is a very popular method because of its low bit rate. However, the quality of the speech so synthesized is usually inferior to that synthesized by waveform coding techniques which unfortunately require high bit rates. Recently, LPC synthesizers using multi-pulse excitation sources have been able to produce high quality speech with little additional bit rates. We want to construct a synthesizer with a new way of positioning the multi-pulses. Furthermore, our objective is to produce continuous and naturally sounding Putonghua speech by concatenating isolated syllables as the basic building blocks.

Investigators: C. Chan and Y.S. Cheung

CHINESE WORKBENCH

Chinese Workbench (CWB) consists of software including programs and databases designed to provide an interactive and integrated environment for writers in Chinese. It includes an input processor for preparing Chinese documents, an output processor providing various output formatting facilities, and a set of tools for manipulating Chinese documents. In addition, another very important part of the system consists of software intended to improve the readability and understandability of a piece of Chinese text. The programs try to check for possible syntactic and stylistic errors of the text and provide comments on various features of the text. Different programs are concerned with different features of a text, e.g. word usage, punctuation usage, and sentence structures.

Investigators: K.P. Chow, C.T. Hung

EXPERIMENTAL WRITER WORKBENCH FOR HONG KONG STUDENTS

The aim is to develop a computer system which can assist students in English composition. The system will be able to detect the simple spelling, punctuation, and grammatical errors commonly made by Hong Kong students. Moreover, it will be capable of explaining the errors to students and giving advice on corrections.

Investigator: W.W. Tsang

BILINGUAL INTEGRATED OFFICE (BIO)

Office automation in Hong Kong's context is still in its infancy. Much progress is needed. Our project is an attempt to contribute to such progress. The primary objective is to carry out research in the area of computer-aided processing of bilingual (Chinese/English) documents. Along with our research, we are gradually developing a bilingual integrated office (BIO) system having production quality.

The BIO system will comprise a number of major components which include (1) user environment, (2) multi-dimensional dictionary, (3) Chinese character generator, (4) Chinese workbench, (5) bilingual electronic message system, and (6) bilingual language analyzer for database retrieval.

This project will help transform an average office into an advanced electronic office complete with integrated tools for the processing of information and bilingual texts.

Investigators: K.P. Chow, F.Y.L. Chin, F.C.M. Lau, K.H. Pun

CHINESE LANGUAGE PROCESSING

The long term objective of this project is to construct a system capable of processing Chinese texts and translating them into English. As a first step towards this goal, the system must be able to store the text in some form of representation which is independent of the source language and which captures the semantics of the text. Once this is achieved, translating the text into another language becomes generating the target language from this representation. Current effort is on parsing Chinese at the sentence level. With the aid of a dictionary, an input string of Chinese characters representing a sentence is first segmented into a string of words and then parsed into a case grammar structure. Our parsing method uses an integrated syntactic-semantic approach, and works bottom-up, data driven along with some lookahead capabilities.

Investigators: K.H. Pun, B. Lum

COMPUTER ANIMATION

The steps involved in conventional animation are very labour intensive. Computer animation is an alternative way of making movies and TV commercials. This project investigates various modelling techniques and algorithms in computer animation. As a result, an experimental computer-generated movie (5-10 minutes) will be made using our Sun colour workstation.

Investigators: F.Y.L. Chin, S.W.W. So

CONSTRAINT LOGIC PROGRAMMING

This project investigates the application of constraint logic programming in program testing. Selection and generation of testing data are important problems in program testing. Since the conditions for selection of test data are also constraints, it is natural to investigate how well constraint logic programming could be applied to solve these problems. The objective of this project is to develop an automated system within the framework of constraint logic programming to select and generate test data.

Investigators: T.Y. Chen, F.T. Chan, Fanny Ho, Y.K. Cheung, D.K.W. Leung

THEORY OF LOGIC PROGRAMMING

This project is mainly concerned with the study of semantics of logic programming. In particular, efforts are devoted to the development of various semantics for the class of general clauses. The parallel aspects of logic programming are also under investigation.

Investigators: T.Y. Chen, H.F. Leung

EXPERT SYSTEM FOR STOCK INVESTMENT

The long term objective is to study the feasibility of modern computing technology in assisting investment. An immediate goal is to develop an expert system which gives advice for stock trading. The development process is divided into two phases: (1) the development of an expert system kernel which derives investment decisions merely from the results of technical analysis; (2) the extension of the resulting kernel to take into consideration the other qualitative factors.

Investigators: K.P. Chow, W.W. Tsang

KNOWLEDGE-BASED EXPERT SYSTEM WITH INTELLIGENT USER INTERFACE (KES II)

The KES II Project is comprised of two interrelated parts:

a) Constraint-Based Inference Engine

We aim to implement a practical tool for developing an expert-systems shell for constraint-based problems, specifically constraint-based scheduling problems. The constraints may be rigid or flexible, and the goal is to find a schedule which satisfies the constraints in an optimal way. With the shell, a user can model a problem simply by declaring the rules and constraints. The shell will support forward-chaining rule inference, constraint relaxation, and local optimization. Many manufacturing problems are of this type, in particular roster planning.

b) Natural Language Interface

We take up the "interleaved" paradigm for language analysis. This means that conversion from syntactic structure to semantic representation is carried out during the parsing process, using a data-driven parser with some sort of lookahead facility. The knowledge base is implemented by means of a conceptual graph. The goal is to enable users to program in natural language.

Investigators: F.Y.L. Chin, K.P. Chow, B. Cheung, C.K. Hui

A FORMAL APPROACH TO INTEGRATING STRUCTURED SYSTEMS DEVELOPMENT MODELS

Various models have been proposed under the name of structured systems development. Examples are DeMarco data flow diagrams, Jackson structure diagrams, Jackson structure text, system specification diagrams, system implementation diagrams, Warnier/Orr diagrams and Yourdon structure charts. They are widely accepted by practising systems developers through the simplicity of use and the ease of communications. Because of the lack of a common theoretical framework, however, transformation from one model to another is arbitrary and can only be done manually. Development aids tend to be ad hoc and model-dependent. There is a need, therefore, for providing an integrated framework for the structured models. An initial algebra approach and a category-theoretic approach have been used to define the framework. Structured specifications can be transformed from one form to another through homomorphisms and functors. The most suitable model can be chosen for a target system independently of user familiarity. Algebraic interpreters may be adapted to validate the specifications. Development aids for one methodology may be applied to another through transformations. A prototype system has been designed to link up DeMarco data flow diagrams, Jackson structure text and Yourdon structure charts. It enables users to review a structured specification to an appropriate level of detail and to zoom in/out to lower/higher levels when required. It is implemented on a Macintosh using Turbo Pascal.

Investigators: T.H. Tse, L. Pong, C.C. Ko and Y.W. Wong

SIMIAN

The goal of the SIMIAN project is to develop a simulation programming environment to promote a declarative programming style. Anyone developing a simulation model will then not need to be aware of the implementation considerations of his simulation program, and be able to concentrate on the representation of the model. One important feature is the separation of the program into three domains covering the basic pattern of operations (engagements), the procedure of selecting entities for joint operation (allocation) and the definition of what measurements are to be taken (data-probes). Each domain is capable of being developed separately. The project is described more thoroughly in a research article later in the booklet. Currently work is progressing on language definition, implementation and a graphical input facility.

Investigators: J.B. Evans and E. Jordan

ENGINEERING TOPICS

FACULTY OF ENGINEERING 75th HKU

COMPUTER RECOGNITION OF PUTONGHUA

Chorkin Chan, Ying-Sheung Cheung

MAN-MACHINE COMMUNICATION BY MEANS OF SPEECH

It has been quantitatively demonstrated that speech is mankind's highest capacity output communication channel with an average rate of two to four words per second. Apart from the high information rate speech conveys, there are numerous other reasons why speech is the most preferred vehicle for communication. Conversation can take place in the dark and around obstacles. In addition to the contextual information speech is meant to deliver, it also manifests the physical and psychological state as well as the identity of the speaker. Experiments with the objective of determining the effectiveness of various means of man-computer communication have demonstrated that there is a sharp dichotomy between modes of communication involving voice and those that do not. Regardless of extra embellishments, it was found that communication via typewriters cannot even approach speech in terms of speed and task efficiency. The value of voice interaction in problem-solving was thus categorically confirmed.

A good reason why we sometimes prefer to listening to a radio news broadcast instead of spending the time with a newspaper is that we can listen while shaving, doing the housework, or driving the car. Indeed, speech leaves hands and eyes free for other tasks. Another key feature of speech communication stems from the widespread availability of the telephone. With a modem and a visual display unit, one needs no speech input to take advantage of the telephone network for computer information access. However, speech needs no tool other than the telephone set itself and this gives speech a substantial advantage in terms of computer access. Every office has a telephone but few have terminals.

STATE OF THE ART OF SPEECH RECOGNITION AND OUR EXPERIENCE

The very first generation of speech recognition systems were initiated by the United States Defence Department Advanced Research Projects Agency (ARPA) with the objective of obtaining a breakthrough in speech understanding capability that could then be used towards the development of practical man-machine communication. By 1976, a typical system of this venture was able to handle a vocabulary of 1000 words with a highly constrained syntax from a small number of "cooperative" speakers of the general American dialect. The machine response could be real time (i.e., almost instantaneous) on a 250 million-instructions-per-second (MIPS) computer. Over the past 20 years of continuous research efforts, remarkable progress has been made in the area of acoustic recognition as well as the structural analysis of English. It is now a simple matter to construct a recognizer of small vocabularies (e.g., below fifty words) using a microcomputer and expect a real time performance. Voice operated typewriters can also be found in the market but, in general, the vocabularies they support are not sufficient for serious applications.

At the acoustic level, the techniques for speech recognition should be more or less language independent. Nevertheless, the fact that Chinese is a syllabic and tonal language enables a unique approach to construct the speech recognizer. Unlike English, there are only 409 distinct syllables in Putonghua each of which can be articulated in five tones and each tone is characterized by a definite dynamic pattern of the vibration of the vocal cords. The monosyllabic nature of the language makes it relatively easy to segment words (mono or multi-syllabic lexical items) into syllables which serve as the working units of phonetic recognition. When compared with languages like English, these properties of spoken Chinese are of great advantage as far as phonetic recognition is concerned. The real problem comes from the fact that there are tens of thousands of Chinese characters corresponding to 1283 tone modulated syllables. How the system is going to decide which characters are meant to correspond to the syllabic sounds identified while the identification is not without uncertainty, is the centre of the problem. Nevertheless, the need for a voice input system as a keyboard replacement is urgent. If one is convinced of the value of spoken English recognizers, there is all the more reason to believe in the need of their Chinese counterparts. English, and all alphabetic languages, have the advantage of an efficient and inexpensive input device, i.e., the keyboard. The keyboard is such a strong competitor that the voice-typewriter for English has an uphill battle to fight for acceptance. Judging by the state-of-the-art of today, substantial improvement in cost, accuracy, speed, and the amount of intelligence is demanded before the English voice-typewriter can emerge as the keyboard replacement. However, a Chinese voice-typewriter may very well be born with a silver spoon because Chinese keyboards are necessarily cumbersome. Chinese characters are two dimensional ideographic symbols. Any logic to linearize them into codes of keystroke sequences cannot be perfectly consistent. That is why all existing Chinese character encoding schemes, despite their large numbers, have conflicts (i.e., multiple characters corresponding to the same code according to the scheme) to resolve.

Any user of a Chinese keyboard finds it a lot more strenuous to operate than an English one.

So we argue ourselves into a nasty problem, but fortunately an acceptable solution is not beyond our grasp. If one inputs connected utterances instead of isolated syllables, one can rely on the artificial intelligence of the recognizer to resolve the problem of homophones.

Numerous approaches to automatic recognition of Putonghua have been conducted in Japan, Taiwan, Mainland China, and the United States in the past but they were mainly preliminary studies or systems of small vocabularies with highly restricted syntax. Over the past seven years, the authors have been working on a number of fundamental problems related to the construction of a complete syllable Putonghua recognizer. We have in fact built a system on a microcomputer recognizing isolated syllables with 95% rate of success. We know exactly what improvements are needed and what bells and whistles have to be added to transform this experimental system into a practical prototype.

OUR IMMEDIATE OBJECTIVE

Building a phonetic recognizer is only the very first step towards man-to-computer communication. The next major task is teaching the computer to figure out the string of characters corresponding to the sequence of acoustic signals perceived. One must first decide which syllables combine together to form words. A lexicon of 40,000 commonly used words is a necessity for this purpose. For each word in the lexicon, the way it is pronounced, the way it is written, and the syntactic and semantic features must all be recorded. Furthermore, a body of syntactic and semantic rules must be developed together with an efficient rule driving interpreter. Each proposed string of words is then subject to the scrutiny of syntactic and semantic rules to determine the well-formedness and semantic soundness of the utterance thus composed. Character strings passing the test will be accepted as the text version of the input speech. As a result of extensive research efforts, such an analyzer for the English language does exist although it may not be very efficient and is unable to resolve some ambiguities. As for the Chinese language, the study of syntax is still a fairly young discipline and a lot of the language has yet to be understood. Our immediate objective is to build an analyzer just sufficient to assist the human operator on the selection of suitable words corresponding to the input speech. Erroneous decisions of the analyzer can be overruled by the human operator. The much more ambitious language understanding analyzer will be left to the future phase of our research.

Hong Kong, being in a unique geographic position and relationship with China, is the ideal place to carry out research projects of the proposed nature. The result of this project can serve as a viable alternative to the keyboard input device for a Chinese computer. The manufacturing of such keyboards is not an insignificant industry in Hong Kong as of today. Furthermore, Putonghua recognition systems in general will have an important contribution to the electronics industry in Hong Kong with a large market in China. The knowledge generated by the proposed research will be useful for solving other problems in speech technology, which is one of the fastest growing areas in the Hong Kong electronics industry.

TOWARDS THE UNDERSTANDING OF THE CHINESE LANGUAGE

As a long term objective, our target goes beyond just a system of rules for assisting the conversion of phonetic information into textual one. Our ambition is to computerize the language competence of a native Putonghua speaker who would normally have acquired such linguistic "intuition" in early childhood. With such intuition, one is capable of understanding speech, expressing oneself with speech, recognizing the well-formedness and ill-formedness of expressions and capturing implied semantics and detecting ambiguities in expressions. We believe that this acquired language competence appears as stored knowledge in the human mind. The computer shares with the human mind the ability to manipulate symbols and carry out complex processes that include making decisions on the basis of stored knowledge. Unlike the human mind, the operation of the computer is completely open to inspection and study. We can experiment by building programs and knowledge bases to simulate our linguistic intuition. We, as computer scientists, have no ambition of putting our linguist colleagues out of jobs, but on the contrary, we want to foster a research environment and develop with them the machine intelligence of language competence.

The consequence is not just a convenient tool for inputting Chinese information into the computer. A Putonghua analyzer of this nature is the key to many applications such as machine translation, computer creative writing, and man-computer conversation. These potential applications will become the stimulus for further research in the understanding of the Chinese language because of their commercial value.

CADCAM -- WHAT, WHICH, AND HOW?

S.T. Tan, M.F. Yuen, and W.S. Sze

INTRODUCTION

The most important feature in any commercial CADCAM system is the ability to describe shapes in a natural manner and in as many ways as possible. The use of geometric modelling modules provides this flexibility and, consequently, they normally form the central core of a CADCAM system. Once the geometric modules, or "engines" as they are normally called, are properly set up, other application modules are then added on and interfaced.

Geometric modellers within CADCAM systems normally include both solid modelling modules as well as surface modelling modules. The former are ideal for representing parts of a prismatic nature and, as such, are commonly used in machine component design and manufacture. The latter are required to describe parts with doubly-curved surfaces and are useful for toy-making industries.

For completeness, we also describe:

2D (two dimensional) drafting systems;
3D wire-frame systems; and
"2.5D" systems for numerically controlled (NC) machining ("2.5D" implies simultaneous motions in the "x" and "y" directions with step-by-step motion in the "z" direction).

Although not normally considered to be geometric modellers, these are useful in their own ways.

Solid Modelling: Types

Most of the widely used solid modelling systems in the world are based on one or a combination of the following principles:

Constructive Solid Geometry (CSG)

In CSG based systems, an object is built up from Boolean combinations of simple volumetric primitives such as blocks, cylinders, cones, spheres, wedges, and tori. The Boolean operators are union, difference, and intersection. An assembly operator is normally available for assembling individual parts into a complete structure. The latter process is useful for checking static interference between mating parts and producing an exploded view of the complete structure.

The CSG concept is very simple as can be seen in the example shown in Fig. 1. The zinc die cast part is described with three cylinder primitives and two block primitives. Union and difference operators only are involved in this case. The steps involved in building up the part are illustrated in the binary tree, where the leave nodes represent the primitives and the root represents the desired part.

With regularized set operators, CSG based systems produce real physical objects only. In other words, an object with dangling edges would be flagged as invalid in the design stage.

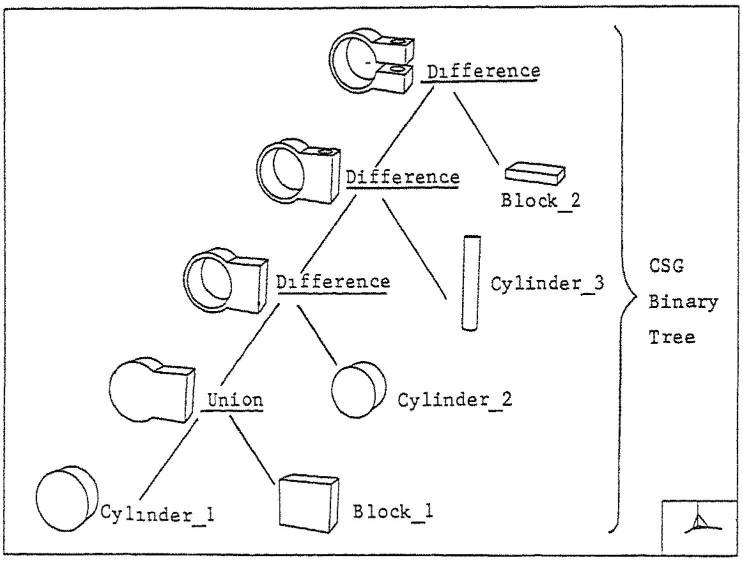


Fig. 1 A CSG binary tree for a zinc die cast part

Boundary Representation (B-rep)

The B-rep scheme describes an object by defining its boundary. The boundary is divided into faces which are of finite area. Faces meet in pairs at edges. An edge is represented as a curve which runs between two vertices. Faces may be multiply-connected i.e. bounded by one or more edge loops.

In the boundary representation, information on the connectivity between faces, edges, loops, and vertices must be properly maintained so as to defines a valid object. Such information defines the topology of the object. In addition, information on the geometry such as face and edge equations and coordinates of the vertices, must also be maintained. In a B-rep based system, the user is required to describe each face by defining its bounding edges and vertices. The surface equation is then derived, normally automatically, from the surface type, orientation, and position.

It is possible for a B-rep based system to create an invalid object (e.g. objects with dangling edges). To safeguard against this, B-rep systems usually incorporate a set of rules governing the formation of a valid object. These Euler rules that determine topological correctness are based on the numerical relationship between edges, faces, loops, shells, and genus of an object. It must be noted, however, that notwithstanding the presence of Euler rules which minimize incorrect formation of objects, it is still possible for invalid objects to be formed.

In B-rep based systems, users are able to interact with the lowest geometrical entities (i.e. vertices, edges, and faces) and, consequently, local operations can be performed on the designed object without altering its topology, as exemplified in Fig. 2. This is a major advantage not afforded by the CSG based systems.

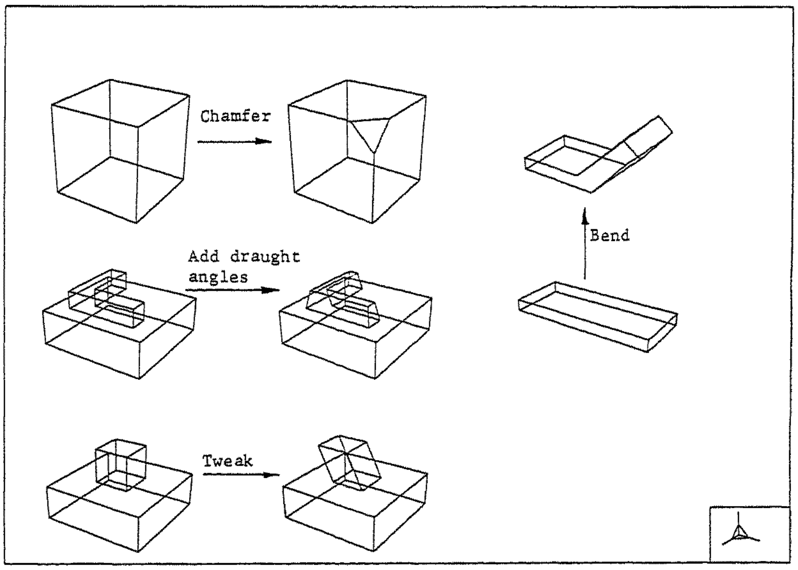


Fig. 2 Local operation of B-rep based systems

Owing to the large number of geometrical and topological data required in a B-rep based system, efficient storage and management techniques are required. Most B-rep based systems employ a wing-edge data structure, which is economical in terms of data storage space and allows direct access between adjoining nodes. Furthermore, elements can be added or deleted relatively easily. However, there are restrictions in a wing-edge data structure. For example, an edge must belong to exactly two loops and have two vertex pointers. For some objects, these restrictions need to be relaxed so that the wing-edge data structure may sufficiently define the objects.

Sweep Representation

In sweep representation schemes, an object is described by first defining its 2D boundary. The boundary may consist of combinations of straight line segments, conic curves, and spline curves. A 3D object is subsequently formed when the 2D profile is swept along a certain trajectory in the third dimension. Linear and rotational sweeps are straightforward to implement and very useful in describing certain types of 2.5D objects. For this reason, they are normally implemented in CSG and B-rep based solid modelling systems. Other types of sweep such as twisted circular and helical sweeps, which are useful for defining such parts as screw threads, worm wheels, and twisted blades, are possible choices. However, these sweeps involve more computational checking and efficient algorithms are required for determining the real edges of the set-out object. An examples is shown in Figure 3.

Sweeping of a 2D profile through a general 3D trajectory is a complicated 6D problem which may involve self-intersections of the set-out edges. Research on the conversion of sweep representations to CSG representations is being pursued with a view to generating a unified scheme of representation which could be easily and efficiently embodied in a geometric modelling system.

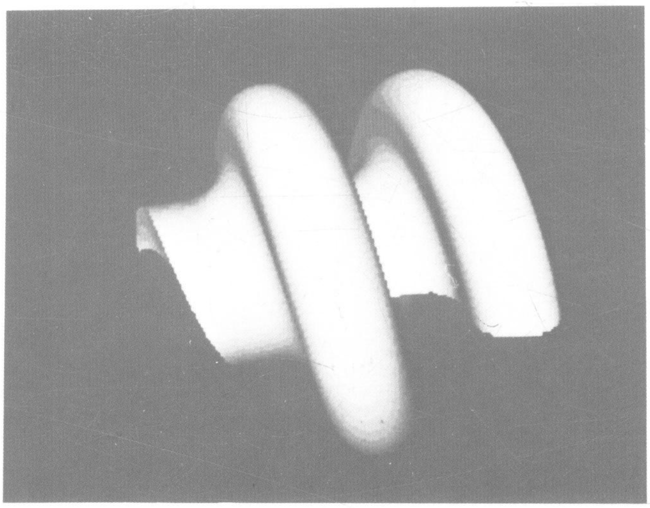


Fig. 3 Helical sweep of a grooved profile

Surface Modellers

Surface modelling techniques are well established tools. The need for surface modelling started in the 1950s in the United States aircraft industry in which accurate and repetitive manufacture of complex curved components was required. This demand also resulted in the evolution of NC (numerical control) machine tools and the associated part programming languages. The APT (automatically programmed tools) and APTMILL packages are such systems which are still being used in the aerospace industry. In these packages, simple or complex surfaces are defined using English-like statements. Motion statements for the generation of cutter path and CLDATA (cutter location data) are also required for subsequent manufacture of the part on a NC machine.

The mathematical bases employed in surface modellers are normally complex in theory but rather straight-forward in implementation. Over the years, numerous kinds of bases have been proposed for use in the surface modelling context.

With the advent of computers and graphics hardware, surface modellers with very friendly user interfaces are becoming more widely used in the manufacturing industries where moulds and dies of complex surface requirement are difficult to produce with traditional methods. Systems such as DUCT, POLYSURF, and UNISURF are typical examples.

As the name suggests, surface modellers only deal with the external shape of an object. They do not have a volume notion of the whole component. This may be a deficiency when computation for mass properties are required. Because of this, tremendous efforts are being made by major research institutions to investigate how surface modellers can be incorporated into solid modellers.

3D Wire Frame Systems

3D wire frame systems were precursors of the solid modelling systems described above. They were developed when solid modelling algorithms were still in their infancy. As the name suggests, 3D wire frame systems allow users to create and manipulate 3D geometries through very powerful graphics facilities. However, the systems only maintain the pictorial aspect of the designed object. No volume or solid representations are possible. 3D wire frame systems are very useful in aiding the design process with their powerful visualization capabilities. Many establishments in the world such as Ford, General Motors, and others still use wire frame systems extensively in the design and drawing office. Examples of some successful wire frame systems are the UNIGRAPHICS system of McDonnell Douglas and DOGS 3D of PAFEC Ltd.

2.5D NC Machining Systems

These systems were developed essentially for quick manufacture of 2D parts; in other words, for parts which are of a prismatic shape, which could be machined in a 3-axis NC machine in one or more set-ups. These systems allow users to interactively design the part and automatically generate the tool paths for subsequent manufacture on a NC machine. The tool paths can be simulated on the graphics screen for visual verification. Without notion of solid representation, these systems do not have the capability for checking collision interference with the jigs and fixtures or invasive machining of the stock materials. The useful output from the systems are generated CLDATA files which, given the available post-processor, can be converted to a format suitable for a particular NC machine. Numerous systems are available from vendors in the market, for example, the GNC system of UK CADCentre and DOGSNC of PAFEC Ltd.

2D Drafting Systems

These are ubiquitous, ranging from minicomputer-based to PC (personal computer) based systems. The main objective of the systems is to substitute the manually tedious drafting process by computer methods. With these methods, conventional drawings can be created and manipulated on the graphics screen interactively. Easy to use but yet powerful utilities such as mirror-imaging, automatic sectioning, semi-automatic dimensioning, and parameterised definitions of parts are common features of these systems.

Over the years, 2D drafting systems have been established to be the most useful features of CADCAM systems for instant and direct application in the design and drawing office. A further reason for the popularity of 2D drafting systems is their relative inexpensiveness compared to the more sophisticated solid modelling systems. The PC based systems are particularly easy and cheap to maintain. An example of a very successful PC based system which claims to have captured 60% of the USA market is the AUTOCAD system.

SYSTEM SELECTION: CRITERIA

Having been introduced to the various types of systems, potential users will now have an idea of the jargon that is likely to be encountered during discussion with consultants or negotiations with vendors. In deciding the type of modelling system which would be most suitable to each organisation's environment, it is essential that a thorough study of the organisation's design, production, and associated processes is made. It is essential that the organisation should conduct a parts survey at the outset so that the most suitable software systems are procured. For instance, an organisation that produces toys would probably be interested in surface modelling systems instead of solid modelling systems in order to satisfy its immediate requirements.

Application Modules

CADCAM software systems normally consist of a number of application modules. It is very important that an organisation should identify the modules that would be useful for their applications. For example, for an organisation which possesses NC machine tools, it may be necessary that these various NC machines be connected to the computer system and be driven directly from the NC machining module, i.e. the establishment of a BTR (Behind Tape Reader) or DNC (Direct Numerical Control) system. When evaluating the system, potential users will also need to ensure that they have automatic tool path simulation capability and that the required NC post-processor is provided. It is also important to check thoroughly the capability of the module for 3D parts as to whether collision checking and checks for invasive machining are available. With such careful examination, the initial investment cost could be kept to a reasonable level and the cost-effectiveness of the investment could be maintained right from the outset.

Another application module that is normally included in solid modelling systems is the mass properties module for automatic evaluation of volume, centroid, and mass moment of inertia of the designed object. For an organisation which engages in design analysis a finite element mesh generation module would be very useful. It is imperative that the mesh should be generated automatically and reliably without much human intervention. The post-processor for interfacing to a standard finite element analysis package should also be provided.

For applications involving mechanical design, systems with dynamic collision checking facilities may be useful. An example of such an application is in robotic path planning.

Compatibility

Compatibility between different CADCAM software systems is an important consideration if the design and manufacturing activities of the organisation depend on specifications provided by foreign orders. It is very frequent that many designs are carried out on the parent organisation's CADCAM systems overseas. Compatibility between systems will ensure that design drawings can be easily transferred and communicated. This will in turn keep the turnover time to a minimum.

Standards for object definition and picture file transfer have been in existence for a number of years. The IGES standard is one which sets out the formats for the transfer of object definition between different CADCAM systems. The National Bureau of Standards of the USA has recently released the standard for CSG based systems. Standards for B-rep systems are in the pipe-line.

Vendors have always claimed IGES compatibility in the marketing drive. However, it is always advisable to test the systems for such compatibility before becoming committed to any purchase agreement.

Benchmark Test

In order to thoroughly test the claimed capabilities of a CADCAM system, potential investors in the system should select a range of company products for real time running of the system. Emphasis should also be placed on the ease of use of the system, response time, reliability, and repeatability of the results. To be fair to the vendors, companies should assign sufficient manpower exclusively for the benchmark test so that it can be carried out without undue strain on vendors' time.

Vendors

In choosing vendors for evaluation, it is also important to judge the track record of the vendor in terms of system support capability, for instance in training and consultations. Another factor is the track record of the software proprietor. One should always look for software that is well maintained and updated continuously. In other words, one should always look for vendors and software proprietors who have a strong research, development, and support team.

Commitment

In an organisation which has decided to adopt CADCAM technology, a sense of continuous commitment must prevail. Manpower provision for the training of system and application engineers must be established so that efficient management of the CADCAM system can be achieved. Indeed, in order that the maximum benefit is derived from the CADCAM system, proper management of it is essential. Proper training and re-education of draftsmen, technicians, and designers for computer methods are also necessary for the successful operation of the whole set-up.

Consideration should also be given to continuously updating the hardware and software of the whole system. Software and hardware maintenance contracts are essential to ensure smooth running.

SYSTEM CONFIGURATION

Computing Hardware

Possible choices of computing hardware for CADCAM applications are numerous, ranging from expensive mainframe computers to the relatively cheap PCs. In between these two extremes are the more affordable minicomputer or super-microcomputer systems. The decision on the scale of investment depends on the requirements of the applications in the organisation. For example, PCs may be sufficient for 2D drafting purposes. However, for applications involving the use of solid modelling principles, minicomputers or super-microcomputers are necessary.

In terms of cost-effectiveness and capacity for further expansion, it is recommended that 32 bit super-microcomputer systems or workstations with net-working capability be considered. This is especially so for small to medium sized organisations wishing to embark on CADCAM software for their applications. The 32 bit system should come with operating system software, preferably with virtual memory capability and the necessary language compilers. Large memory space of at least 4Mb and expandable upwards would be an added advantage for running large CADCAM application programs. An abundant amount of disc storage space in the region of 100Mb should be provided, especially for virtual memory systems.

Options for graphics monitors are also plentiful, ranging from the small 12-inch to the workstation standard of 19-inch screen. Resolutions of these screens range from 24 by 480 to 1K by 1K. The 19-inch screen and 1K by 1K resolution are the most commonly used. The choice of monochrome, greyscale, and colour monitors is again dependent on the applications. Other auxiliary peripherals that are essential for the whole set-up include printers, plotters, magtape units, mouse, digitisers, and networking links to other systems.

CADCAM Software

Generally each sale of CADCAM software is for use with one specific central processing unit (CPU) and the price is dependent upon the number of workstations which that can support; so the same software may cost much less for a "micro" than a "mini" computer. Potential investors should shop only for the type of geometric modelling system and application module which they require.

Turnkey Systems

The foregoing few paragraphs describe the essential elements for configuring a CADCAM system. In academic institutions, these elements are normally purchased individually and then linked up as a complete system. Industrial organisations without the necessary manpower and knowledge should engage consultants or vendors to provide a turnkey system which will include most of the aforementioned elements.

NC Hardware

The selection of the necessary CNC (computer numerical control) machine tools such as CNC machining centres, CNC turning centres, CNC wire-cut and CNC EDM (electro discharge machines) are manufacturing applications dependent. Assistance in the selection can normally be acquired through machine tool vendors. Modern CNC machine tools are now equipped with powerful computer interface facilities. One should always look for the provision of a standard RS232 computer interface so that direct links to a CADCAM system via BTR or DNC links may be achieved. An optional switch for accepting ISO or EIA code should also be available.

Potential investors should note that CADCAM vendors and NC machine vendors are normally separate organisations and seldom provide services for linking up their respective hardware and software to form an integrated system. Consultants or in-house manpower expertise are required for this interfacing task.

TYPICAL SYSTEM CONFIGURATION

A typical system configuration comprising most of the above described elements is shown in Fig. 4.

FUTURE TRENDS

Contemporary geometric modelling systems still have a number of unresolved issues which are currently being investigated by many research institutions. Issues such as automatic dimensioning and tolerancing from solid models are typical examples. Complete automatic finite element mesh generation with adaptive refinement capability is another. Machining simulation from 3D solid models with database support of material properties, cutting strategies, and tools libraries are also important research topics.

Computing and Machining Hardware

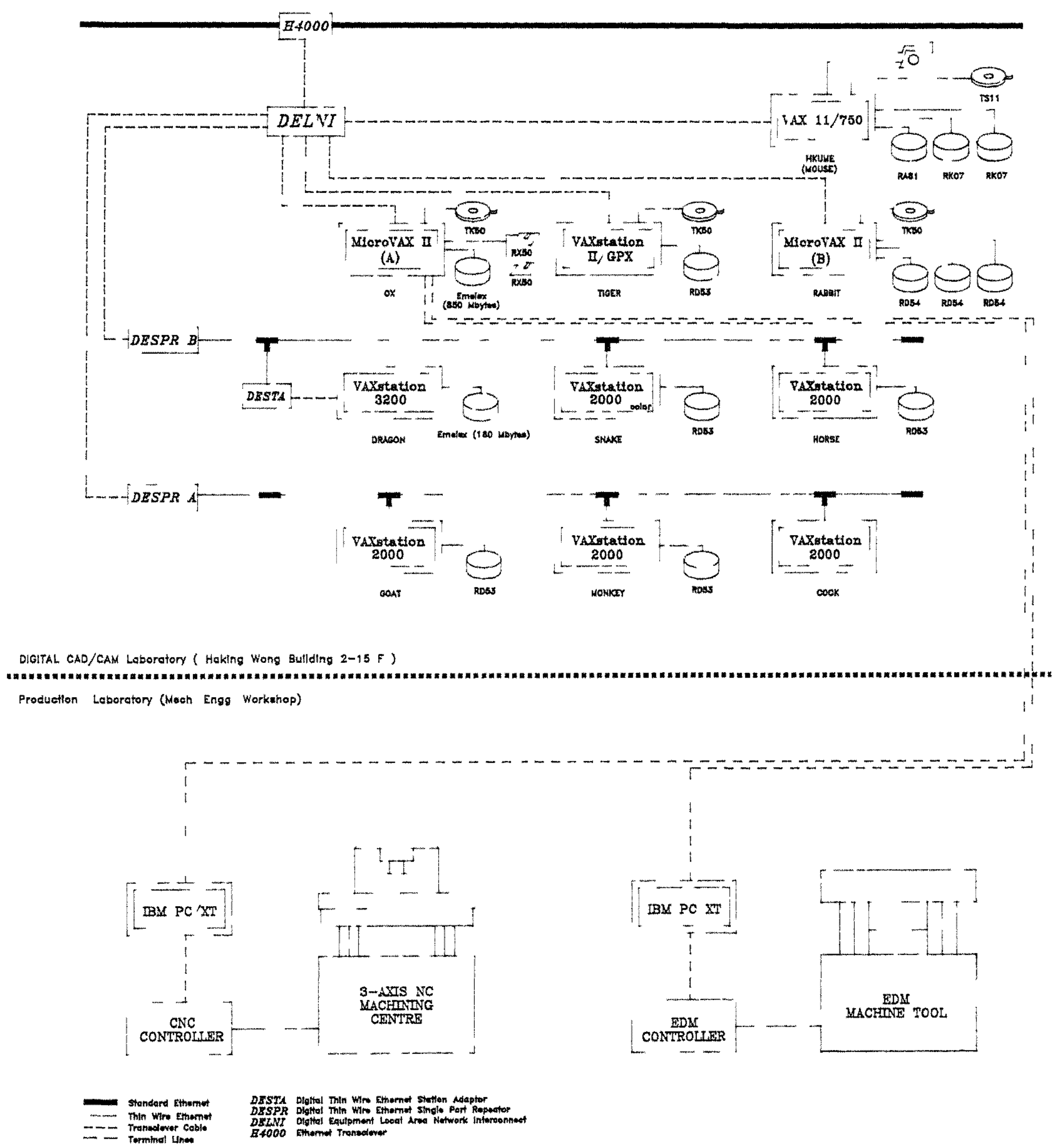


Fig. 4 Computing and machining hardware for CADCAM at Department of Mechanical Engineering

Indeed, the major deficiency of current CADCAM systems is their limited ability to incorporate an engineering technology database. It is envisaged that the next generation of geometric modellers will have engineering databases as an integral part of the whole system. Strong efforts are currently being placed to applying A.I. (Artificial Intelligence) techniques in the development and implementation of CADCAM systems. A large number of engineering problems are now being attempted with A.I. rule-based approaches.

It is also believed that future modelling systems will be of hybrid type, capable of dealing with both objects of prismatic and sculptured shapes. In other words, a unified representational scheme for geometric modelling will be realised.

On the manufacturing side, standards or protocols are presently being drawn up for linking up various hardware and software involved in FMS (Flexible Manufacturing Systems) and AMT (Advanced Manufacturing Techniques).

CONCLUSION

It is hoped that this paper will be of use to companies in local manufacturing industries in understanding more about the capabilities and deficiencies of CADCAM systems.

CONSTRUCTION PROJECT MANAGEMENT

Steve Rowlinson

INTRODUCTION

The Hong Kong construction industry is renowned the world over for two things: its use of bamboo scaffolding and its speed of construction. The former is based on traditional practices whilst the latter must be perpetually fed with new ideas and methods of construction management if rapid progress is to be maintained on the new and innovative structures being produced in the Territory. In the past, the Department of Civil and Structural Engineering has not had a tradition of research in the field of Construction Project Management. However, this brief article reports on three areas which are currently under investigation here at HKU: Cost Information Systems; Expert Systems; Leadership on Construction Sites. The projects described below have all commenced within the past year with the help of University funds and it may be some time before they reach a stage where the results can be presented to the construction industry. However, a start has been made in areas seen as being of particular significance to Hong Kong.

COST SIGNIFICANT ITEMS IN HK CIVIL ENGINEERING CONSTRUCTION

Traditionally, the bill of quantities has been used as a cost model in civil engineering construction. Typically, bills may run to hundreds of separate items (the Civil Engineering Standard Method of Measurement lists over 12,000 items). However, it has been apparent for some time that, as a general rule, 80% of the value of a bill is contained in only 20% of the items. Thus, if these "cost-significant" items can be identified, the long and complex bills in use today can be greatly simplified. By linking the identified cost-significant items into coherent cost-significant work packages the bill of quantities can be used as both a cost accounting and cost control system.

This research aims to analyse bills of quantities in order to identify the 20% of cost-significant items in civil engineering construction in Hong Kong. A relatively simple method of analysis has been identified at Dundee University in which only those items with a value greater than the mean (total value of all items divided by number of items) need be investigated. From this analysis a cost model will be built and used on further bills of quantities to test its accuracy. Such a model would be of use to the client, by providing accurate estimates quickly and at an early state of design, and to the designer by allowing him to explore alternative designs with rapid feedback on cost implications.

The aim of this research is thus to prove that the principle of cost-significant activities applies to Hong Kong civil engineering construction and to develop an integrated cost classification and control system which is much more efficient and accurate than those currently in use.

EXPERT SYSTEMS

Expert System (Knowledge Based System) development is one aspect of the field of Artificial Intelligence which has received a great deal of attention worldwide and, surprisingly for a new technology, has created a great deal of interest in the traditionally conservative construction industry. In essence, an expert system is a computer based decision-aiding tool which aims to emulate the advice that an expert would give. Two systems under development at present are described below.

BEN - Foundation Selection Adviser

BEN is a KBS designed to suggest appropriate foundation types for Hong Kong construction sites. The prototype system was built in compliance with CP2004 and so only deals with the selection of foundations for the normal range of building and engineering structures. Current research aims at developing the system to a workable status and the possibility and desirability of extending the field of application to special structures is presently under consideration. At present, the system has three main sections: soil classification; selection of deep foundations; selection of shallow foundations.

The system is being developed using the Savoir™ Shell (written in Pro-Pascal). This shell has facilities for manipulating probabilities according to a form of fuzzy logic as well as a Bayesian operator facility. Thus, the shell provides great flexibility for KBS construction with the possibility of the incorporation of probabilities into the analysis. The assessment of probability factors is troublesome as adequate past data to determine these values is not always available and so it is in this field that the true expert can make a major contribution in tailoring the system to different user's needs and localities. The system is being developed incrementally and the assessment and adjustment of probability values is now being addressed.

PRC - Claims Analysis

Development has just commenced on PRC, a construction claims consultant system. The construction industry is beset by the problem of claims by the contractor for extra payment and time in the provision of projects for the client. Although this may be the result of inappropriate decisions made during the building process it is necessary to provide some framework within which these claims can be dealt with, contested, and settled. For most construction contractors this means the employment of specialist advisers on a consultancy basis or the formation of a department to deal specifically with the formulation of claims for extra payments. Both solutions are expensive and the foundation on which this research is based is that a computer based expert system will be cheaper and more effective at fulfilling this function than the alternatives used at present. Thus the proposed system aims to enhance or replace existing diverse construction expertise and legal expertise with a micro-computer based (IBM AT™) expert system to advise on the efficacy of pursuing construction claims and the grounds for pursuance most likely to bear fruit.

Construction claims can affect any phase of the construction process and so the initial research phase has concentrated on identifying suitable, well-defined and documented domains. The advantage of expert system knowledge bases is that they can be added to and combined at a later date with a minimum of rewriting for the knowledge engineer. Identifying suitable domains for expert system development has been a problem which has caused many potentially successful systems to fail. The domain chosen should be compact and well-defined and suitable sources of knowledge, textual or human, should be identified. The knowledge must also be stable, that is it does not change rapidly over time requiring constant updating; construction claims, although complex, provide such an environment.

Summary

KBS development is a new and exciting area of development in construction management. Although demonstration systems can be built quickly, systems which can be put into operation in day to day construction work require a great deal of time and, often, highlight areas where existing theoretical knowledge and practical experience are lacking. None of the systems under development at Hong Kong University is in commercial use at present but there is no doubt that their potential has been recognised and it is only a matter of time before they are implemented as credible systems.

LEADERSHIP STYLE IN CONSTRUCTION PROJECT MANAGERS

The performance and effectiveness of construction project management is an issue of great importance to the construction client and contractor alike. Studies have shown that a major factor determining successful performance is leadership. The theory adopted in this research project is Fiedler's contingency theory of leadership style which, in paraphrase, states that a task-oriented style is appropriate in situational conditions which are very favourable or very unfavourable but in other situational conditions a relationship-oriented style is appropriate.

Recent research in England has shown that site managers are generally highly task-oriented compared with other groups of workers and that leadership style and performance are correlated when situational factors such as size of project and amount of sub-contracting are taken into account. The research seeks to replicate the English study in the Hong Kong context and to provide the foundation to extend the work further to analyse the leadership styles of Chinese construction managers, situational factors, and their effects on performance in greater depth. Management research indicates that Overseas Chinese managers are likely to be more autocratic than their Western counterparts and this suggests that a highly task-oriented style should predominate.

This may seem a somewhat esoteric research field but the ultimate aim of the research is to identify those factors which affect the performance of construction project managers and determine how these interact with the management style of the individual. It is intended that the results of this study will be useful in the future training and selection of project managers.

DEVELOPMENT OF ELECTRIC VEHICLES

C.C. Chan

Energy and environmental problems have stimulated strategic research to find alternatives to petroleum, particularly for road transport which absorbs around 30% of the energy resources and which emits about 85% of air pollution. In this context, the electric vehicle possesses the potential for decreasing petroleum dependency, reducing air pollution, and improving the utilization of our electric power generation. The Electric Vehicle Program is a key element in our overall transportation energy-conservation strategy.

The programme on electric vehicles in the Department started in 1983 and is a long term research project. Its aims are to develop advanced, high-performance, energy-saving propulsion systems for various types of electric vehicles, including mini-vehicles, road cars and commercial vans, and to develop an intelligent battery management system for electric vehicles in order to achieve longer battery life and to provide energy saving. The new Tony To Chan Electric Vehicle Research Laboratory has been set up to facilitate this research. An International Research Centre for Electric Vehicles has also been set up in the Department to promote international co-operation in the research. Support has been received from the Department of Energy and the Electric Power Research Institute in the U.S.A. Research cooperation with the University of Hawaii in the exchange of electric vehicles and technical information is continuing. Visiting scholars from abroad and from China have been working for short periods in the Research Center from time to time.

Recent progress can be summarised as follows:

(1) An experimental electric passenger car 'HKU-EV1' with an advanced PWM transistorized inverter induction-motor drive control system has been completed. The car has been licenced by the Transport Department for driving on public roads. The car has achieved the following performance figures: top speed 75 km/h, acceleration 0 to 40 km/h in 10s, climbing capability 18 degrees, range per battery charge 100 km (constant speed 40 km/h), and energy consumption 0.3 kWh/km. Fig. 1 shows the appearance of the car.

Fig. 1 Electric car HKU-EV1

(2) A novel adaptive-decoupling-controlled induction motor drive system for an electric van was built and tested in the laboratory with satisfactory results. The distinctive features of the drive system lie in its robust characteristic, high dynamic performance, and low energy consumption. Fig. 2 shows the drive system on test in the laboratory and Fig. 3 shows the electric van which is being modified to contain it.

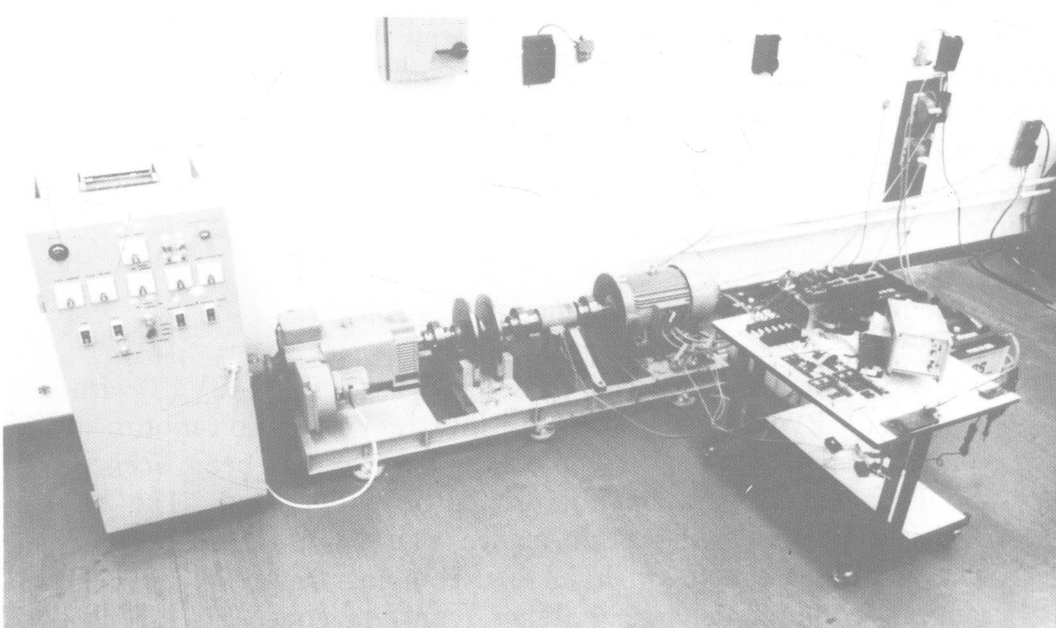


Fig. 2 Laboratory test bed system

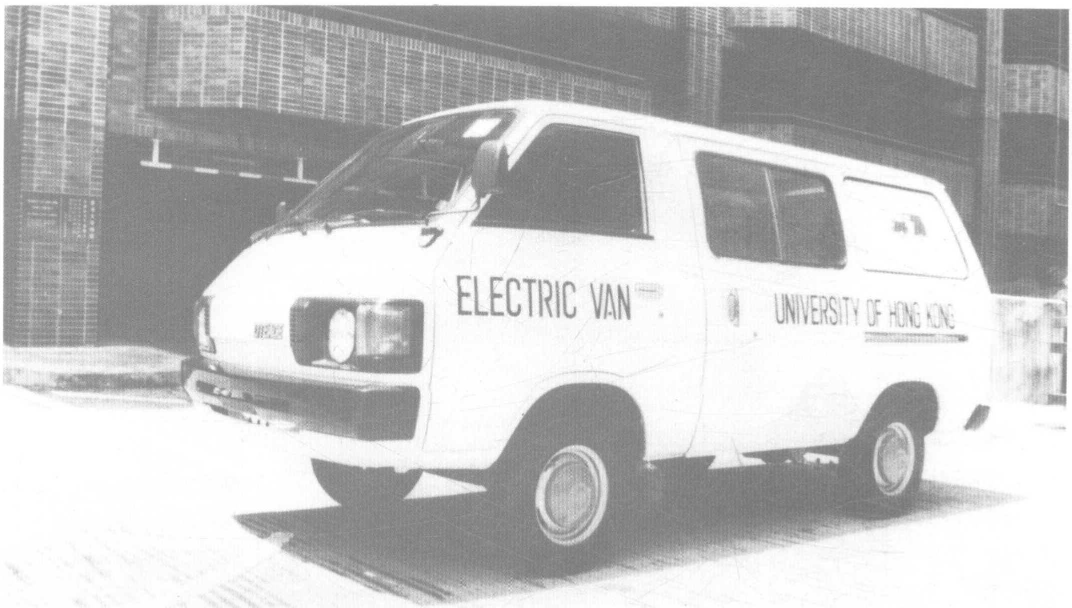


Fig. 3 Electric van

(3) Two new types of off-road electric mini-vehicles "Mark II" and "Mark III" have been built. They have a top speed of 20 km/h and a payload of 200 kg. The special features of these electric mini-vehicles lie in their robust and simple construction, good control performance, and ease of driving. The Mark III will be sent to the University of Hawaii, as part of the exchange programme.

(4) Two versions of an intelligent battery management system have been built and tested in the laboratory with satisfactory results. The system provides a means for on-board battery state-of-charge monitoring and prediction, for optimum charging pattern during the charging period, and for evaluation of the battery's performance. The special features of the system lie in its integrated multi-functions, flexibility, adaptability, and user-friendliness. Fig. 4 shows the intelligent battery management system.

The International Research Centre for Electric Vehicles in the Department plays an active role in promotion of electric vehicles internationally. Members of the Centre have been elected as Advisor for both the Chinese Electric Vehicles Institution and the Electric Vehicle Development (U.K.), and as the Vice-Chairman of the World Electric Vehicle Association Organizing Committee. The Centre will host the Tenth International Electric Vehicle Symposium in 1990 at the new Exhibition and Convention Centre in Hong Kong.

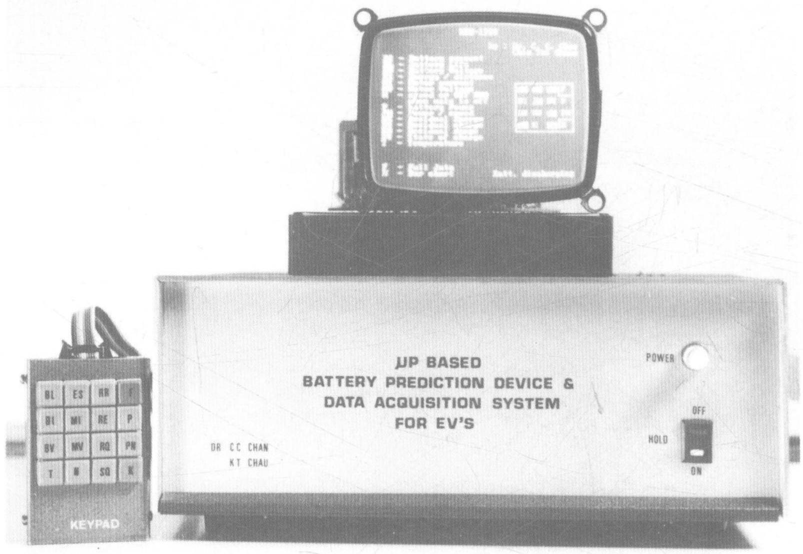


Fig. 4 Intelligent battery management device

The dream of having a commercially viable transport alternative is becoming a reality as another major energy crisis is approaching and it is really exciting that we in the University are engaging in part of a programme that has the potential for having such a major impact on the future of our society and the welfare of our future generations.

THE ABATEMENT OF ROCK DUST GENERATED BY PNEUMATIC DRILLS INSIDE HAND-DUG CAISSONS

Fang Ming, Chui Ho Kwong, Ko Wan Por, Lee Man Leung, Lum Siu Kin

INTRODUCTION

Silicosis is a common and severe occupational disease afflicting workers in the construction and mining industries. The disease is caused by the inhalation of fine respirable dust particles (five microns or less in aerodynamic diameter) containing high concentrations of silica. The process is irreversible and there is no effective treatment for the disease, thus the damage to the lungs and general health of the victims is permanent. The probability of contracting the disease is directly proportional to the length of exposure time in such an environment, and the concentration of the silica bearing dusts. It has been observed that the average age of silicosis victims in one of the quarries in Hong Kong is 53.4 years, and the average latent period for caisson workers is about 21 years, although as short as six months has been detected.

In Hong Kong, almost all construction sites have large numbers of hand-dug caissons. These caissons, with diameters around one to four metres and a few tens of metres deep in the ground, exhibit very poor ventilation, thus trapping any particulates or gases generated during the drilling process and posing an extreme health hazard to the workers inside the caissons.

In confined and out-of-reach places, some of the most common protective equipment used are dust masks and respirators. Breathing apparatus where fresh air or oxygen is supplied can also be used. However, experience indicates that when the dust loading is large, such as the case in a caisson, dust masks and respirators quickly become over-loaded and frequent changes are required. Breathing apparatus in many cases is economically unfeasible. Besides, most operators resist using these devices because they feel that they are uncomfortable and hinder their work.

In 1986, a joint project was initiated by Gammon (H.K.) Ltd. and the Department of Mechanical Engineering, University of Hong Kong to develop a system which can effectively and efficiently abate the dusts at source.

The project was divided into two phases, where the basic dust generating mechanisms and properties were first studied, such that engineering data could be obtained for the design phase which followed. Both phases have been successfully completed, with preliminary data indicating that the system is effective and efficient. The current effort is to optimize the design and to conduct extensive field tests to completely validate the system.

DESIGN SPECIFICATIONS

Based on the health, operational, and economical requirements, several criteria must be followed:

(1) The system must be safe.

(2) The system must be small enough to be used in a one metre diameter caisson.

(3) The system should not need additional power plant for energy.

(4) The system should not hamper normal operation in a caisson.

(5) The system should be cheap.

(6) The system must be acceptable to construction workers.

EXPERIMENTAL APPROACH

Because of the very nature of a caisson, being deep underground and with limited space, accessibility is a serious problem. It is obvious that equipping an operating caisson with a host of scientific instruments will present difficulties, not to mention the problems associated with the interference caused by the dusts generated and the operator. In addition, few sites are available for prolonged periods of testing, and sending researchers deep down a caisson with heavy construction activities above ground near its entrance, presents serious safety considerations.

We felt at the onset that field data should be obtained so that a more realistic picture can be obtained to aid the design of an effective local exhaust system. With all these considerations, restrictions, and requirements, the decision was made that actual drilling of bed rocks above ground in an environmental chamber would be conducted.

An environmental chamber was built to properly simulate the environment of a real caisson, to bring the underground construction site to ground level, eliminating all the difficulties and problems described earlier, and at the same time to provide an environment where good and realistic data can be derived.

The chamber consisted of a rectangular framework made from angle iron. A square cross-section was deemed to be adequate because the exhaust (flush) flow rate from the pneumatic drill was not large enough to reach the walls; thus the wall effect was reduced.

Thin clear acrylic sheets were used as walls of the chamber and the edges were properly sealed to prevent leakage. The clear walls allowed good visual observation and lighting when photographic methods were used to record the happenings inside the chamber.

FINDINGS AND RESULTS

Essential data concerning the drill and the dust generation process during drilling obtained were: exhaust air discharge rate from the drill, maximum particle velocity and distance travelled, the distance distribution of dusts from the borehole, particle size distribution in the breathing zone, total dust loading, the aerodynamic behaviour of the dusts inside the caisson simulator, and the effect of ground water layer on the dispersion of dusts.

MAXIMUM PARTICLE VELOCITY

During the drilling process a full range of particles of different sizes was generated. The resulting velocities and distances travelled by these particles also differed, depending on their sizes and the conditions they experienced when they were flushed from the drill-well or borehole. The distance distribution and the maximum velocity data are needed for the design of a collection device at source.

It was found that almost all the particles fell within the 400 mm radius, the angle of departure was approximately 80°, and only a few particles reached the height of one metre.

This suggests that the collection device should enclose the borehole and have sufficient height and width to permit the dusts to clear the borehole so that they will not hamper the operation of the drill. The larger particles should be left on the ground since they do not really pose any health hazard. Furthermore, the removal of larger particles consumes too much energy and, in turn, will increase the size and energy requirements of the cleaning system.

SEQUENCE OF EVENTS IN DRILLING INSIDE A CAISSON

In order to understand the dispersion pattern of the dust cloud in a caisson, we took a sequence of photographs during a drilling experiment. The environmental chamber was used and pictures were taken at two second intervals. The seven pictures presented in Fig. 1 give the sequence of events after drilling started.

The dust particles generated were ejected from the borehole by the flush from the drill and the motion of the drill bit. They moved upwards and seemed to concentrate near the chuck of the drill, thus forming a cloud at this height (see Fig. 1c & d). The vertical projection angles of the dust particles were small, not larger then 10° in most cases.

From these photographs it seems that after five seconds of drilling, the dusts already reached the breathing zone (approximately 1.4 to 1.5 m from the ground), and it took only 10 seconds for the particles to fill up the environmental chamber.

The formation of a concentration of particles around the chuck is probably due to the settling of larger or heavier particles after they have expended their kinetic energy. The lighter material keeps on drifting upwards with the currents and draughts, and eventually fills up the rest of the space in the simulator.

TOTAL DUST LOADING EXPERIMENT

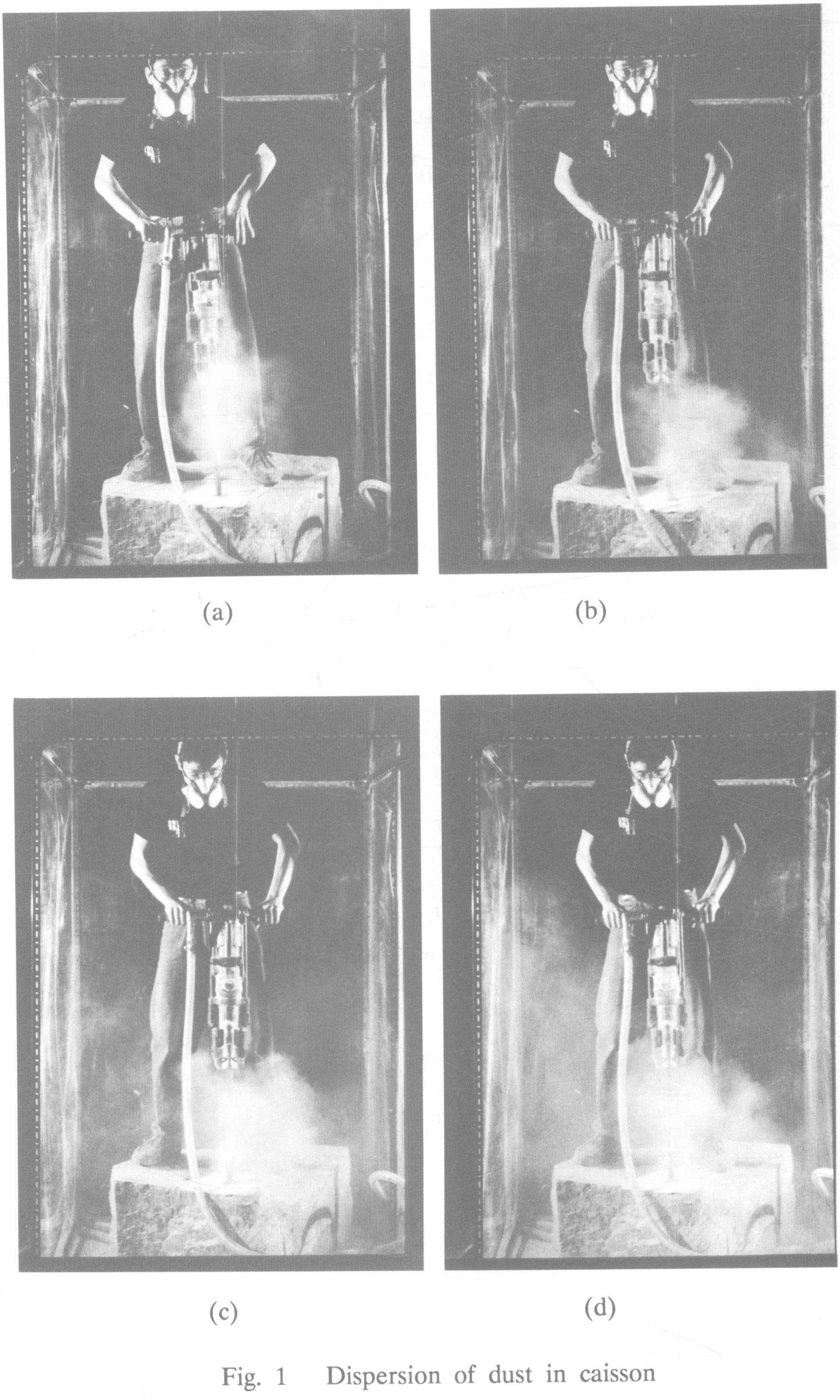
The test was simple but rather time consuming. The interior of the simulation chamber was lined with a large plastic bag to capture the dust. The drilling lasted for nine minutes, and the contents inside the chamber were left undisturbed for 24 hours before the bag was retrieved for analysis.

The dust sample was recovered by washing the bag with water and drying the dust in an oven. The particle size distribution was measured by sieving according to the standards established in BS 1796:1952.

The total dust loading experiment was used to size the transport tube required to bring the dust laden air out of the caisson.

PARTICLE SIZE DISTRIBUTION IN THE BREATHING ZONE

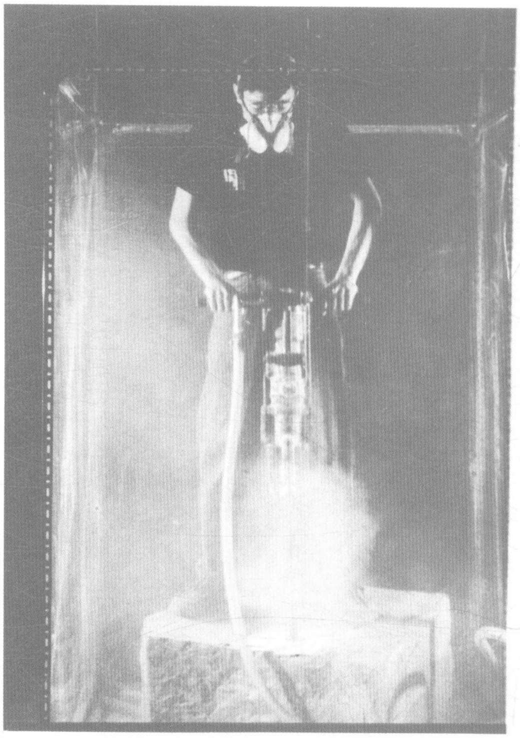
The dust particle size distribution in the breathing zone was measured by an Anderson Ambient Cascade Impactor. We obtained these data to



(a) (b)

(c) (d)

Fig. 1 Dispersion of dust in caisson



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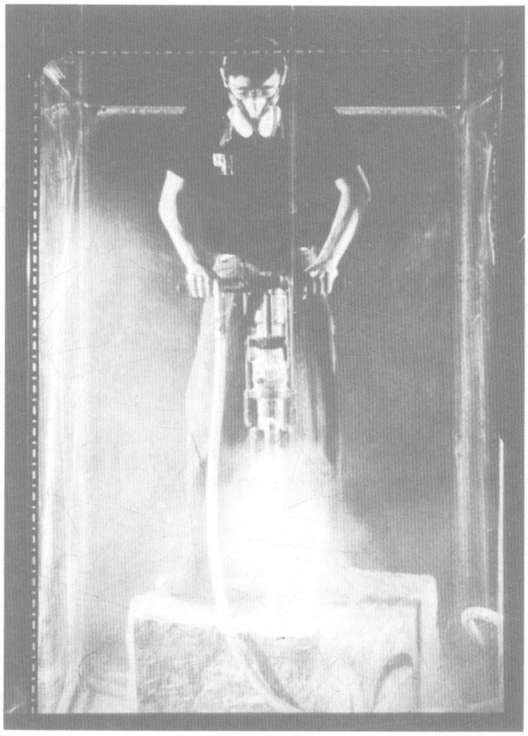

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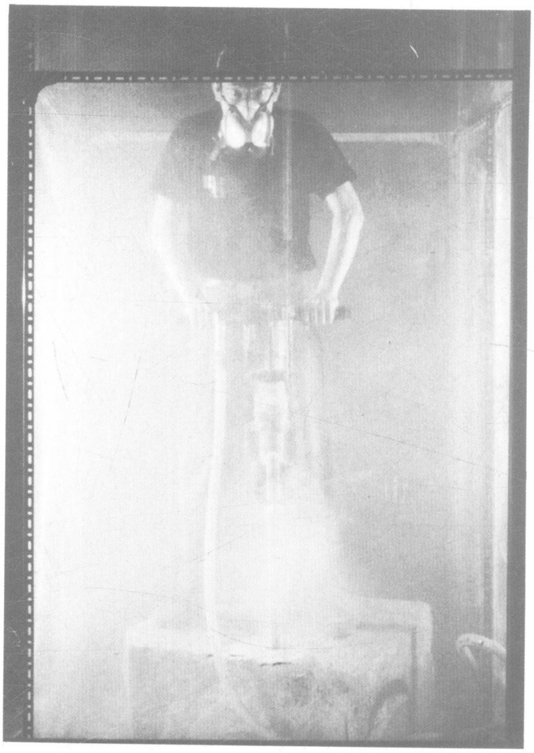


(g)

Fig. 1 Dispersion of dust in caisson (continued) determine the dust level which had the greatest impact on the worker, and to compare with the Labour Department's measurements to verify the validity of the environmental chamber. The results showed the same high severity factors reported by the Labour Department .

EFFECT OF GROUND WATER LAYER ON DUST DISPERSION

Our experiments in the caisson simulator revealed that the presence of a ground water layer impacts the dispersion of dust particles in the following fashion:

The water layer greatly reduces the exit velocity of the exhaust air from the drill bit, and this substantially decreases the dispersion of the dust particles. Furthermore, the layer also acts as a scrubbing device which removes almost all of the larger particles, as the exhaust air travels through. However, the layer does not seem to have any apparent effect on the respirable dusts.

Labour Department data show that the severity factor is lowered by a factor of two to a value of 36 in wet caissons. Our work indicates that the optimal layer thickness is about five mm.

THE SYSTEM

Our investigation leads to the conclusion that it will take a combination of clean-up methods to remove both the larger and the respirable dusts. Several systems were designed and tested, and the most effective combination was a wet scrubbing unit at the borehole, a five mm layer of water covering the borehole, and a positive pressure ventilation device to transport the respirable dusts out of the caisson. Preliminary field tests showed that a severity factor of 4 to 12 can be obtained with this system.

The system is also effective in the removal of marsh gas and product gases when dynamite is used.

CONCLUSIONS

The use of the environmental chamber to simulate a real construction caisson proved to be very effective and useful in making observations and measurements of the dusts generated when rocks are drilled in a confined space. Not only does it provide a convenient and safe environment for researchers to perform their experiments, it also offers a means for the placement of scientific instrumentation.

Qualitatively, the dust cloud formation inside a caisson is rapid, and it has been observed that within a matter of 10 seconds, the dust cloud reaches the breathing zone of the drill operator.

The experiments suggest that a pre-cleaner should be used to knock out the larger non-respirable particles thus reducing the load on the transport line, and a high efficiency cleaner is needed for the respirable dusts. Our tests indicated that the most effective combination was a wet scrubbing unit at the borehole, a five mm layer of water covering the borehole, and a positive pressure ventilation device to transport the respirable dusts out of the caisson. In addition, the workers should also wear proper protective masks to completely filter out the remnant dust.

ACKNOWLEDGMENT

The authors are grateful to Gammon (Hong Kong) Limited for a grant which made this project possible.

THE DEVELOPMENT OF A NOVEL ELECTRO-RHEOLOGICAL ROBOT ARM TRANSMISSION SYSTEM

E.C. Partington and T.N. Wong

INTRODUCTION

During the past decade robots have become commonplace in the more advanced nations. They afford major improvements in the quality and reliability of manufactured products and they liberate workers from the more tedious and repetitive tasks. They can be programmed to customise the item being made. If necessary each product can be made to differ from the one before with little or no increase in costs. The flexibility of systems based upon robotic concepts has freed the manufacturing engineer from the constraints of the conventional mass production line.

The advantages of robotic systems are the results of a large and growing body of research and development. The now conventional technologies of computing and control engineering have become synthesized in the new field of robotics. One of the major problems in this new field is that which occurs at the interface between the speed and precision of the electronic logic systems on the one hand, (the so-called "software") and the more gross and sluggish electro-mechanical system on the other (the so-called "hardware"). Hardware has to operate in "real time". It has inertia, it is imprecise, and it is prone to wear and tear. What this means in practice is that the hardware seldom faithfully follows the logic signals transmitted to it by the software. One of the major sources of motion infidelity can be attributed to the nature of the electro-mechanical driving units, for example stepper motors and servomotors, which translate the logic commands into motion. Whereas sophisticated electronic motor control systems have been devised, we are still faced with the fundamental limitations of the magnetic field which is the very agency by which motors operate. Relative to mechanical linkages, the magnetic field is "spongy" (i.e. long range and relatively weak). Therein lies the fundamental disadvantage.

One very promising alternative to the electro-magnetic motor is the *electro-static* transducer. Here, instead of a soft, long-range, spongy magnetic field, we have a short-range stiff electro-static field which is potentially capable of translating electrical energy to mechanical energy with a high degree of precision. It is also capable to producing very large forces indeed, albeit for short distances. The best known example of such a system is the piezo-electric cell which can translate mechanical energy into electrical energy and vice versa. Thus electrical "signals", or information, can be faithfully converted into mechanical action. The drawback is that, although the forces are very much larger and the motion induced is much more precise than that of magnetic motor systems, the displacements involved are minute. However, the advantages to be gained from electro-statically induced motion are so great that we are actively pursuing developments in this area.

THE ELECTROSTATIC ROBOT ARM TRANSMISSION

We are in the preliminary stages of the development of a novel system of robotic motion. The system involves the direct and precise control by computer of, for example, a robotic arm. The active component in the system is "electro-rheological fluid" [ERF]. ER fluids have a property such that the value of their shear strength can be controlled by varying the magnitude of an electrostatic field switched across them. The shear strength developed is sufficient to transmit an appreciable torque when the fluid is siutated between two concentric contra-rotating cylinders charged to high voltage.

In our scheme we have devised a rotary transmission which is driven by a conventional synchronous motor but which provides, at a final output shaft, a reversible variable slow-speed high torque output. The principle involves electro-static/mechanical coupling between the input and output shafts of a high reduction gearless transmission unit. Output speed, direction of motion, and torque are electronically controlled by phase shifting a pulse of high voltage across an ERF lubricant situated in the gap between the low-speed transmission output and the final drive shaft. This gels the fluid and effectively locks the input shaft to the output shaft for the duration of the applied voltage pulse. The reduction ratios achieved are typically in the range 100-10,000.

The potential benefits to be derived from the system include:

(a) Close and accurate control over output speed and position.
(b) Logic circuits are easily interfaced with the mechanical system by voltage pulses across the ERF-filled bearing.
(c) Electro-static fields are inherently stiffer (i.e. close-range high-force) than are the magnetic fields employed in stepper motors and servo-motors, enabling greater fidelity between the electrical signal and the mechanical motion.
(d) ER fluids have micro-second response times, allowing high frequency operation (*c.f.* magnetic fields which are inductively dampled).

MAGLEV ELECTRICAL MACHINES

C.T. Choy

INTRODUCTION

An invention relating to the method of controlling and utilizing *mag*netic *lev*itation in a specially-designed electrical machine is described. This new type of machine is named "maglev electrical machine". A UK Patent has been granted for the invention. It also won the Invention Award 1987 presented by the Hong Kong Association for the Advancement of Science & Technology.

In the construction of a conventional vertically-mounted electrical generator or motor, the thrust bearing is an essential part that supports the weight of the rotating bodies and withstands the working thrust. It is expensive and vulnerable. In some giant machines such as those installed in hydro-power stations, the practice of injecting an oil film into the thrust bearing before starting by means of an auxiliary system has further complicated the installation and operation.

A vertical electrical synchronous machine with axial-field configuration has a magnetic attraction between its stator and rotor, which can be used to counteract the downward force and eliminate the thrust bearing.

CONSTRUCTION

Fig. 1 shows the steel cores of a maglev machine. Its stator and rotor are in the form of circular discs located side by side on a common axis, unlike conventional machines in which the stator and rotor are concentric cylinders placed one inside the other. The stator cores "1" and "2" in Fig. 1 are made of laminated silicon steel straps wound to form a ring. In both upper and lower stators, there is a complete three-phase symmetrical double-layer winding accommodated in radially-cut slots on one face of the core. The rotor body is built up from a thick disc "3" shrunk or pressed on to the shaft. Laminated poles "4" comprising steel plates are secured onto the disc. Field coils are wound on the rotor poles for producing the magnetic flux "5" and for exciting the machine. It can be seen that the magnetic field in the airgap is in the axial direction, unlike the radial airgap field in the conventional machine. The stator windings and field coils are not shown in Fig. 1 for the sake of clarity.

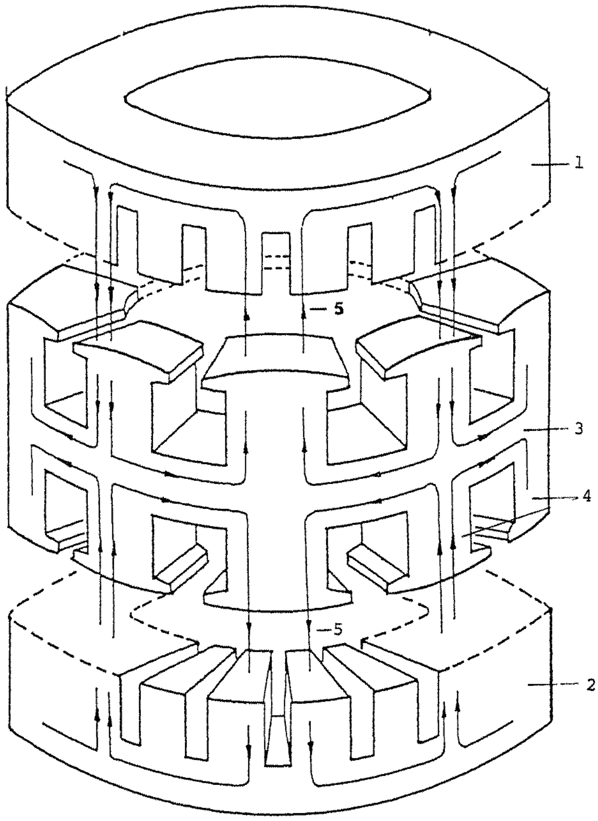


Fig. 1 Steel core and magnetic flux

WORKING PRINCIPLES

The flattening out of the airgap introduces considerable magnetic force normal to the stator and rotor surfaces, the magnitude and direction of which is controllable by adjustment of the field excitations. The whole rotating body can be lifted and floated and so eliminate the need for a thrust bearing.

The operational principle is illustrated in Fig. 2. On each side of the rotor, all field coils are supplied by an exciter "1". The currents of two field circuits "2" and "3" are independently controllable and excite the upper and lower halves of the machine separately (see Fig. 1). The stator windings "4" and "5" of the same phase are connected in series. Their polarities are so arranged that the e.m.f. generated in the upper and lower windings are additive. When the rotor is to be raised during normal running at a certain terminal voltage, the field current in the upper-pole coils will be increased, with a corresponding decrease in the field current of the lower-pole coils. The terminal voltage, induced e.m.f., phase currents, power and power factor, etc. can thus remain unchanged. In a similar way, the rotor can be lowered.

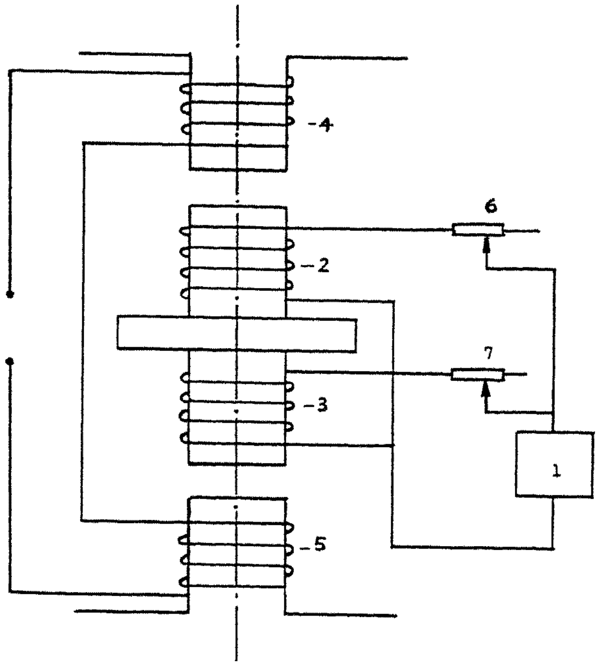


Fig. 2 Floating rotor operation

An automatic feedback control system, which takes over the function of the upper and lower field rheostats "6" and "7" in Fig. 2, should be used. This system, like any other closed-loop control system, has three parts: the controller, the detector, and the actuator. The actuator here is a field exciter supplying currents to the upper and lower field windings on the rotor. The detector measures the vertical displacement of the rotor and provides a signal to the controller which then regulates the output voltage of the field exciter. The relationship among the three parts of the control system and the axial-field machine is shown in the block diagram in Fig. 3.

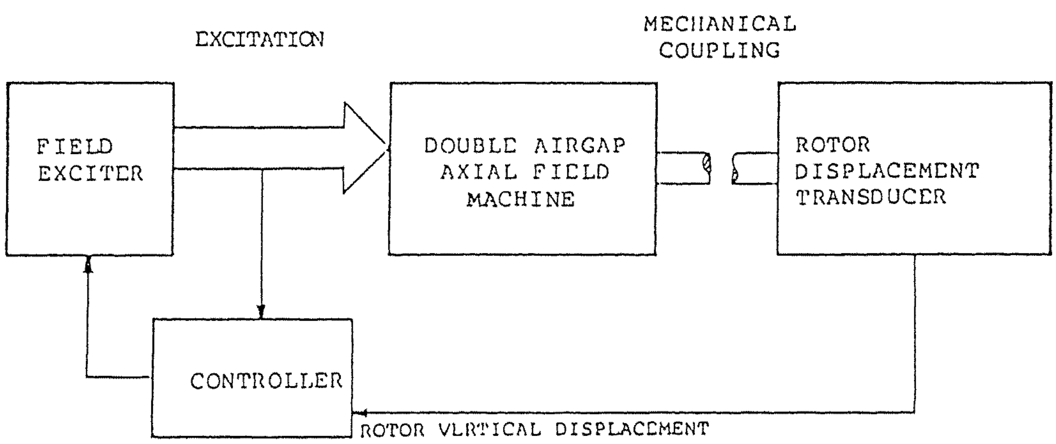


Fig. 3 Block diagram of control system

APPLICATIONS

The maglev electrical machine can replace any vertical synchronous machine which requires an expensive and delicate thrust bearing. In the following, two examples of applications are given.

Generator

The maglev machine is ideal for serving as a short-core large-diameter low-speed synchronous generator, coupled to a Kaplan water-turbine and installed in a hydro-power station with low water head and large water quantity. Fig. 4 shows its layout. Since the thrust bearing is eliminated, an oil-filled supporter "1" is used to hold the rotating bodies of the generator and the turbine when they are at rest. In normal running, the runner "3" is immersed in the thick oil, "2". In case of a fault occurring in the control system or the field circuits of the generator, the rotor tends to fall down or shoot up; however, there will be no serious consequence as the viscosty of the thick oil will damp out all shock effects. The runner "3" and the shaft "4" will eventually rest on the bracket "5".

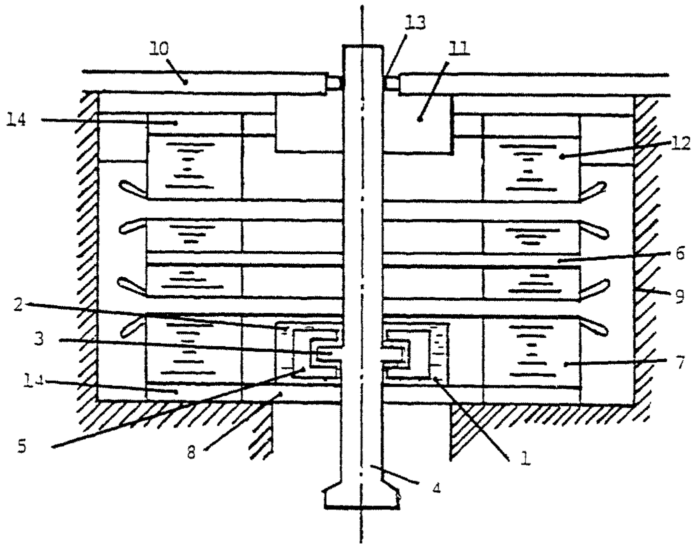


Fig. 4 Water wheel generator arrangement

The arrangement shown in Fig. 4 is of an umbrella type machine where the oil-filled supporter is placed below the rotor "6" and inside the central space of the lower stator ring core "7". The building cost of the hydro-power station can thus be reduced as the bottom frame "8" only spans the pit "9"'and is carried on the concrete foundation. The top frame "10" is light because it supports only the stationary part of the auxiliary equipment, such as the main exciter and pilot exciter, etc., which are accommodated inside the central space "11" of the upper stator ring core “12”. The figure also shows the guide bearing “13” and the air coolers “14” for the generator.

Motor

One of the applications of the maglev machine as an electrical motor is to drive a thrustor as shown in Fig. 5. The thrustor is a device producing a slow vertical movement with considerable force. The maglev machine “1” drives an impeller “2” which pumps oil “3” from above the piston “4”, thereby forcing it upwards relative to the rest of the system. The top lug “6” is forced up by the movement of the piston and is mechanically connected to the load to be lifted. The figure also shows a guide bearing “7”. An oil-filled supporter similar to that described in the last section is included in the maglev machine. In a machine of medium size, a vertical travel of 2-3 mm of the shaft will not affect the operation of the impeller.

If the thrustor is driven by a conventional motor, its thrust bearing will experience a tremendous stress. While starting and stopping, dry contact between the moving and fixed parts of the bearing creates a very high temperature. Adoption of the maglev machine will not only reduce the overall cost of the device, but also guarantee smooth and reliable operation.

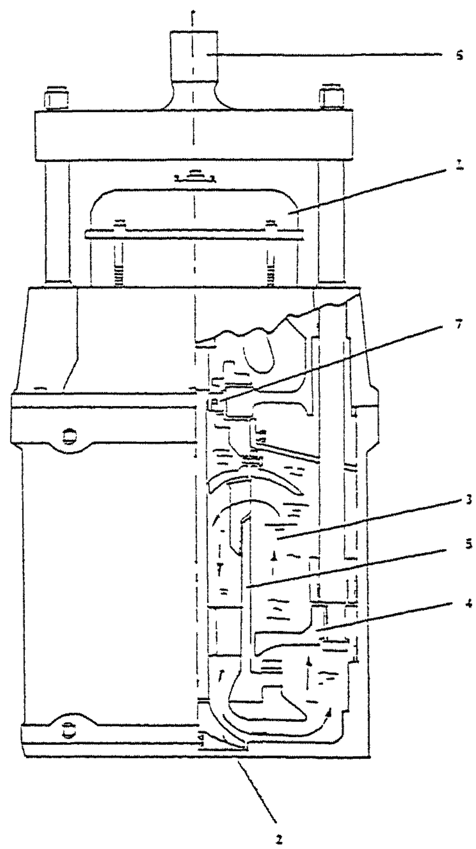


Fig. 5 Thrustor

PROTOTYPES

Several sets of prototypes of the maglev electrical machine have been built. Fig. 6 is a photograph showing the complete set-up of one model. A maglev generator, in the middle, is installed upon and driven by a d.c. motor which simulates the water turbine in a hydro-power station.

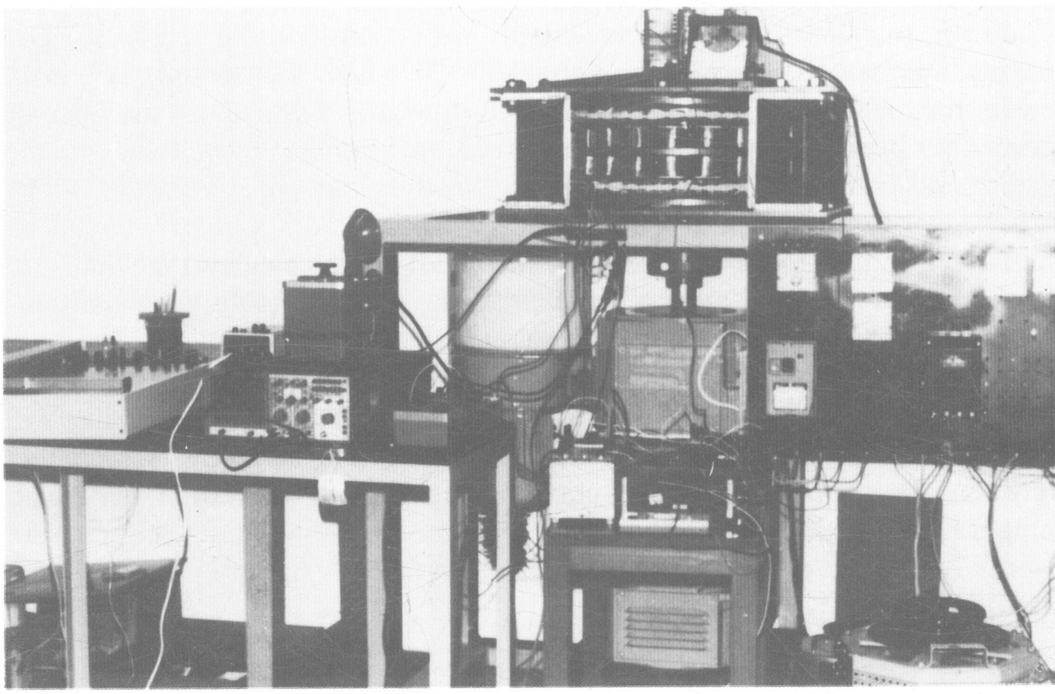
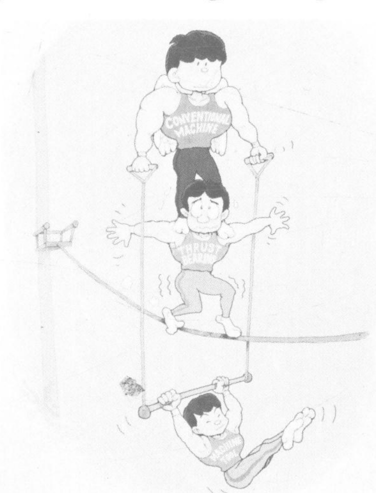


Fig. 6 Experimental set-up

Tests on the model showed that the performance was satisfactory. The maglev generator ran synchronously with the Hong Kong power system and carried loads of various power factors. The rotating body was lifted and spun at its designated position.



Left: Thrust bearing is working very hard

Right: Thrust bearing retires. Everybody is happy now.

PEDEMOIROGRAPHY

A. Asundi

A study was undertaken, in collaboration with and supported by the Department of Orthopaedics of HKU, to devise a simple method for foot pressure measurement. The shadow-moire method was used to map depth contours of a foot imprint made on a polystyrene sheet. A calibration curve related the applied pressure to the depth of imprint and was used to transform the depth contours to pressure contours. The figures below show some characteristic pictures obtained. The one on the left is a time integrated footprint during a walking step while the one on the right is of the person standing still.

RIVER INDUS HYDRAULIC MODEL STUDY

J.H.W. Lee and A.W. Jayawardena

The River Indus system has the largest catchment area of all the rivers in Hong Kong. It runs through low-lying farmlands and fishponds in the Fanling area and joins with the tributaries Beas and Sutlej before discharging into the Shenzhen River along the Hong Kong-China border. Primarily due to the limited flow capacity of the rivers, the low-lying areas are subjected to frequent flooding during the rainy season. Substantial flow resistance is also offered by the strongly meandering channels which are often clogged with debris. In the downstream region close to the Indus pumping station, a complicated labyrinth of large diameter China water supply mains poses a further obstruction to flood flows. In collaboration with outside engineering consultants, the Department of Civil and Structural Engineering has been carrying out a hydraulic model study of the flooding problem.

A distorted physical model with a 1:200 horizontal scale and 1:25 vertical scale was constructed inside the Hydraulic Laboratory. The model is designed according to dynamic similitude and simulates the unsteady propagation of a flood through the area of interest. In addition to offering physical insights to the flooding phenomenon, the model has yielded predictions of peak flood levels which provide guidelines for the design of river training schemes.

Unusually for a model of this type, many details within a relatively small prototype area have to be correctly reproduced: e.g. river cross-sectional geometry, levels of the flood plain and bunds surrounding agricultural plots and fish ponds, bridge crossings, weirs, large water supply pipes. Synthetic flood hydrographs are generated from design storms of 2, 10, 20, and 50 year return periods. By means of specially designed inflow control devices, prescribed flood inflows into the upstream ends of the three major rivers can be simulated. The transient changes in water level at key locations are monitored with a system of water level followers and wave gauges, with the aid of a data acquisition and control system. The precise roughness of the channel beds and flood plains, which have to be made greater than that in the prototype, is determined through calibration exercises against records of water levels in previous storms. The calibrated model has been found to reproduce well major features of the recent flood caused by Typhoon Warren on 20th July, 1988. In the next phase of the study the model will be used to investigate the efficacy of proposed flood control schemes.

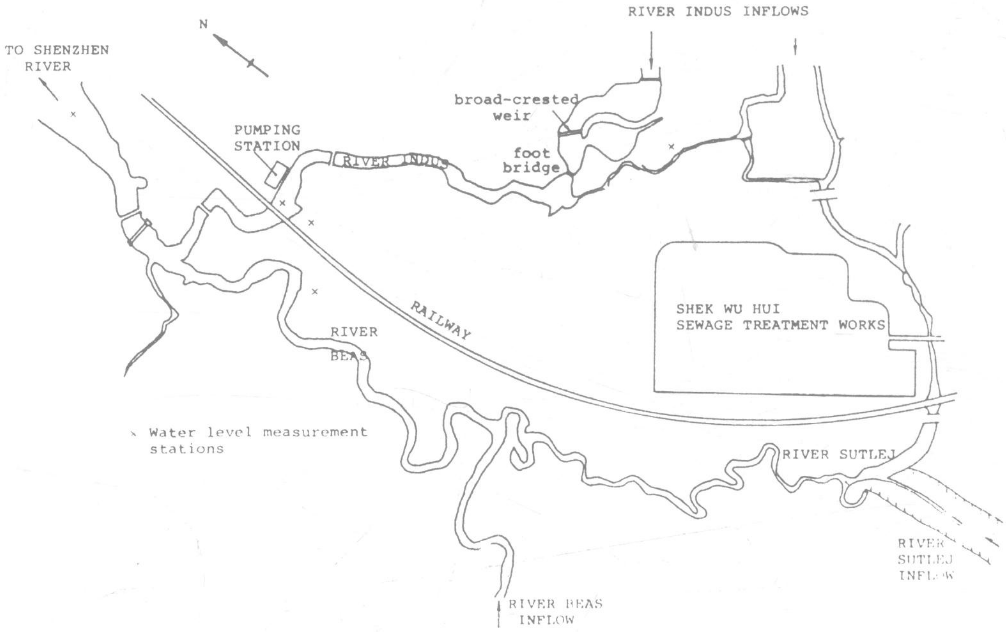


Fig. 1 River Indus Hydraulic Model: plan of 1.2 km x 0.7 km study area

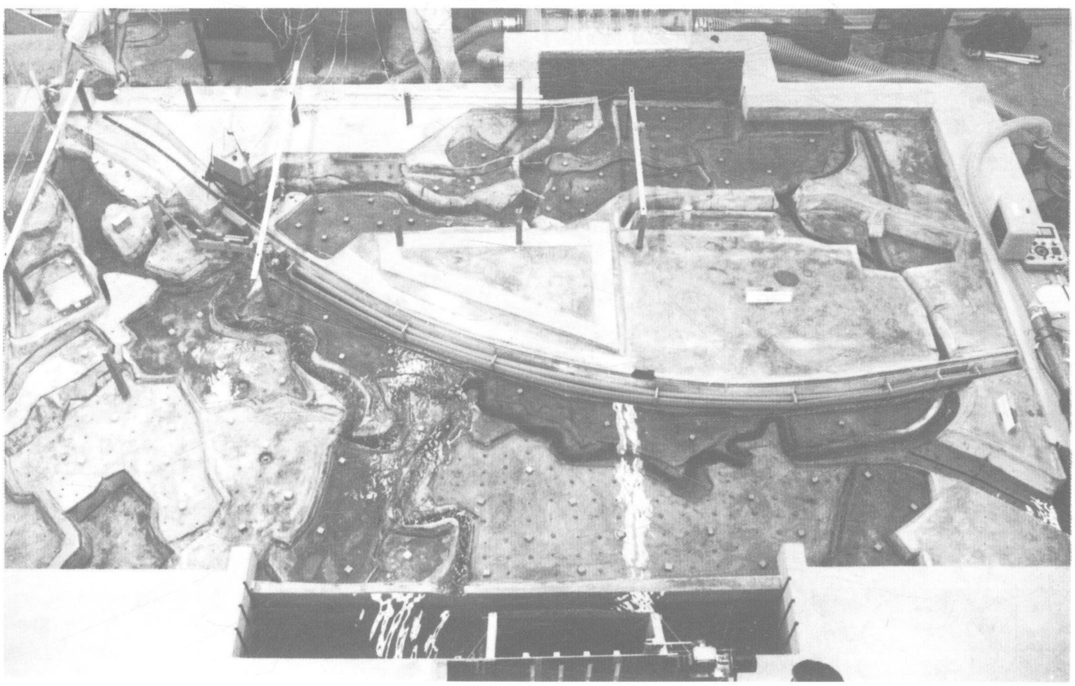


Fig. 2 Partial flooding of low lying areas caused by a 1 in 2 year flood

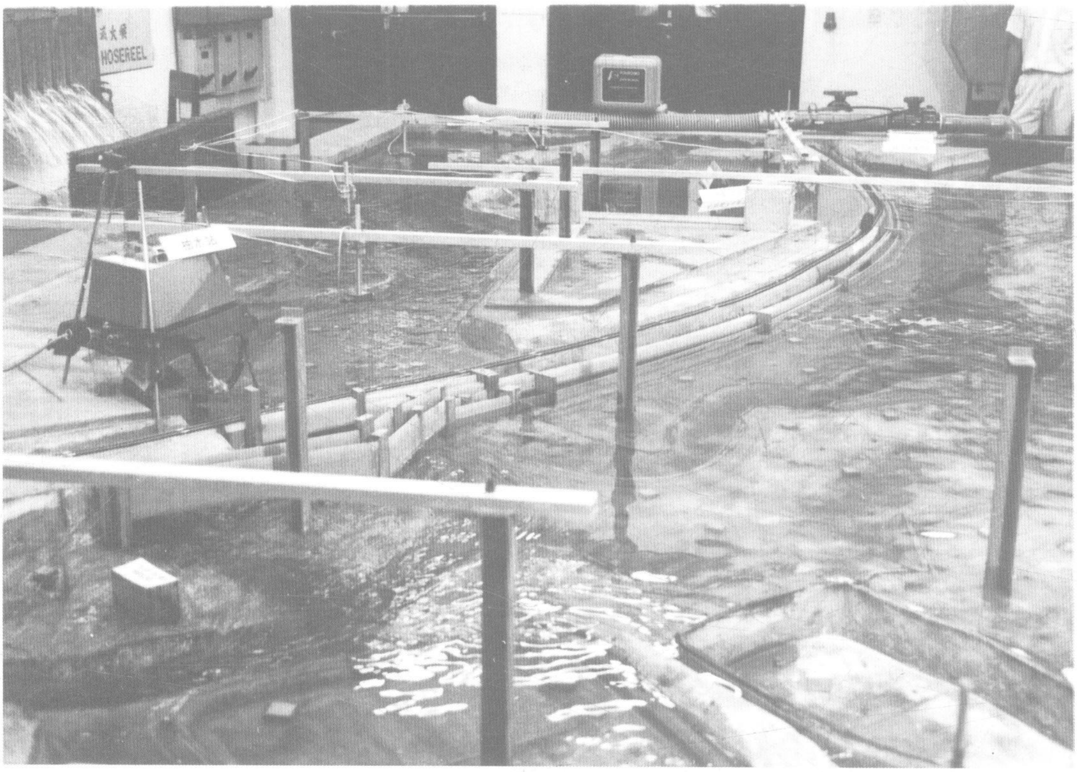


Fig. 3 Submergence of the China water supply mains next to the Kowloon-Canton Railway during the Typhoon Warren flood, 20th July 1988

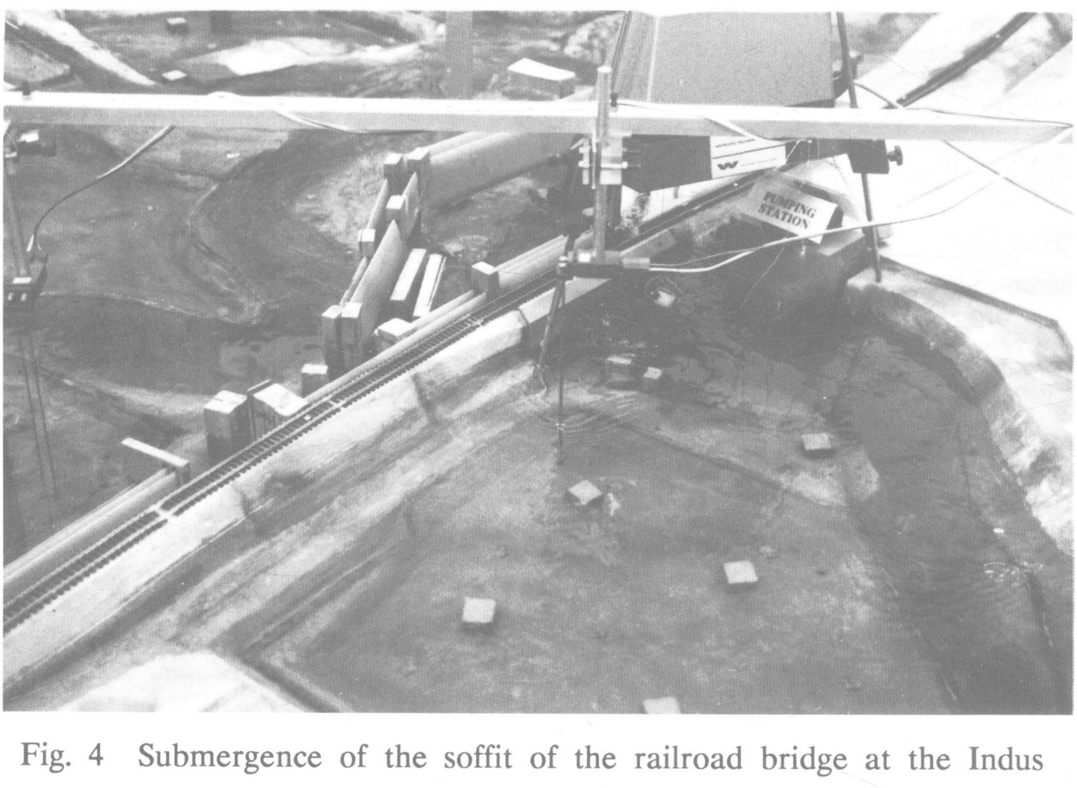


Fig. 4 Submergence of the soffit of the railroad bridge at the Indus

IT'S A MATERIAL WORLD!

B.J. Duggan

75 years ago the subject of Materials was not something that occupied the minds of young people intent on pursuing a career in the world's second oldest profession. If they were asked to name the most important materials of which things were made in an industrial society, they most likely would have mentioned cast iron, steel, brass and bronze, concrete, timber, glass and possibly aluminium. Since their time the world has been transformed in all kinds of ways, many of them obvious, some of them quite subtle. These changes in the way we live and how we relate to each other have all been influenced in one way or another by developments in engineering and technology. What I want to emphasise in this article, is the way in which Materials has helped to change both the things we do, as well as how we do them. In doing so I will show that Materials, which 75 years ago was not a subject of great importance to degree level engineering students, has, like the spy in Le Carre's story, come in from the cold.

A good example with which to start is aluminium, a metal we have had in useful amounts for a century. The price of aluminium has fallen steadily since the Herauolt process was invented in the late nineteenth century. It is light, has good corrosion resistance, and can be made very strong by alloying with other elements. The impact of aluminium on the world can be seen by trying to imagine how the world would be without aeroplanes. Clearly balloons would exist, but is it possible to imagine how the aeroplane could have developed to its present stage without aluminium to make the fuselage and wings? Aluminium allows people of quite ordinary wealth to fly to practically anywhere in the world safely, quickly, and cheaply. It is also present in every kitchen, from components hidden inside washing machines to saucepans, woks, and cooking foil. The containers of the beverages which refresh us on a hot summer's day are often made from aluminium. A world without aluminium would be a very different place!

Frank Whittle and his team of engineers demonstrated the practical possibility of the jet engine in the late 20s. The high pressure turbine blades were made of a particular kind of steel selected for its suitability for high temperature environments. They lasted for less than two hours.

Of course the steel they were made from was useless for the purpose, and nickel based alloys rapidly became the best material for all such aggressive environments. Without nickel, the jumbo jet would be a much smaller machine; a mule, perhaps?

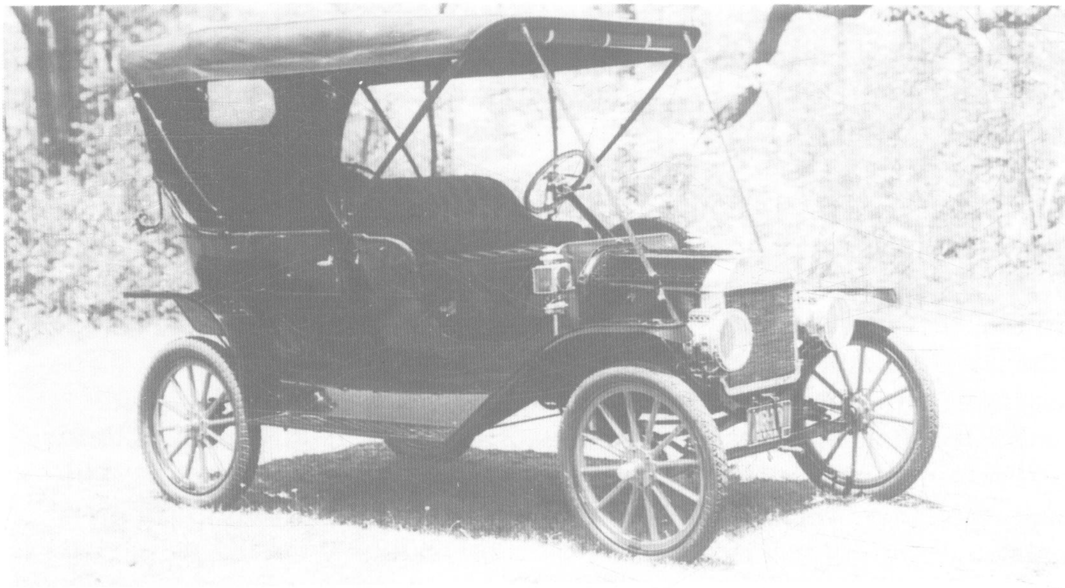
Human beings have not changed much in their physical appearance over the last 75 years. We are bigger and heavier, but we still have only two arms, two legs etc. How then do we explain the change in the shape of motor cars over the last 75 years? Cars of 75 years ago are strange in appearance, all sharp angles, not weatherproof and lacking in any kind of streamlining. Why is this? Part of the answer, of course, always lies in what the manufacturers' team of designers think is likely to be popular. But a deeper answer lies in the fact that, in those days, it was impossible to make steel sheets flow under pressure into anything but the simplest of shapes. More severe deformation led to press-work failure. Since the 1950s, we have discovered some secrets of how to make metals flow under pressure from flat sheet into the great variety of shapes we see around us. It is quite extraordinary to compare the shapes of the winged wonders rolling off the production lines of the late 1950s, with the models of 40 years earlier. Not only car bodies, but saucepans and woks, sink-units, and strong suitcases are all formed from flat sheets of metal because of fundamental work done by materials engineers.

We are all aware that the number of miles we can travel for each gallon of fuel consumed is an important factor in selling motor cars at the low budget end of the market. As this is where most academics live their lives, this factor is of great interest to university teachers. But what is not understood by most people is that the remarkable figures for fuel economy claimed by all manufactures of modern motor cars, rests, not on more efficient engines (although this is a factor) but on the fact that cars are much lighter than they used to be before the Middle East Wars of the 60s and 70s. This weight saving has been made possible by remarkable developments in steel processing. The High Strength Low Alloy (HSLA) steels can be made in a way which is easily formable into complex shapes. The high strength/weight ratio mean that less steel is necessary for structural parts of the vehicle, and so weight is reduced by between 10% and 25%.

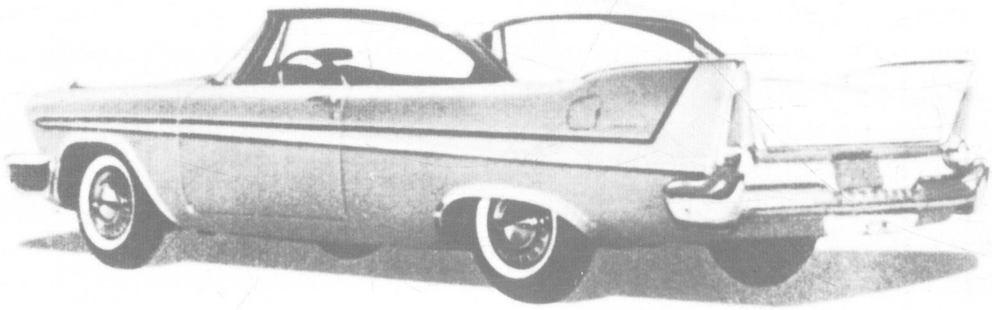
Computers are everywhere. They replace people, provide entertainment for children, guide aircraft to their destinations, and control road traffic. New industries are being created which, to young aspiring engineers of 75 years ago, would have seemed to be the stuff of fantasy. At the heart of the computer is the material silicon. Circuits of incredible complexity are imprinted on slices cut from large single crystals of silicon. We have only been able to make pure silicon since the 1940s, but it is impossible to imagine the modern world without these silicon devices. This is obvious in "high tech" industries, but even the domestic kitchen is being invaded. Cooking stoves, microwave ovens, and washing machines are often controlled by circuitry imprinted on silicon. Those people who enjoy laser vision and compact discs in the comfort of home are keeping company with the ubiquitous silicon chip.

The 1988 Nobel prize for physics went to two Swiss researchers who showed that a particular class of ceramics became superconducting at temperatures well above the temperature of boiling helium. These materials just might be important to you in the next decade or so. Ceramic engine blocks are being tested in Japan at this moment, and it is confidently expected that as we learn how to fabricate and to toughen them, that they will be standard engineering materials in the twenty-first century. And of course I haven't mentioned the materials on which much of Hong Kong's manufacturing industry relies, and they are plastics. 75 years ago the word "plastic" had a very different meaning to that which it evokes in the modern mind. Entirely new products are possible because of the properties of this class of material, and plastics now substitute for metals in a vast range of wares. It would be inappropriate in an article such as this to fail to mention composite materials. The modern aircraft has a bewildering variety of composites in all parts of its structure and engines. Mixtures of metals and ceramics, ceramics and plastics, and plastics and metals, are all used. These are designed for strength, wear resistance, stability in aggressive environments, ease of joining etc. Every home also has its share of composite materials, be it teflon coated saucepans or formica topped tables. Even musical instruments are changing under the pressure of advances in composite materials. A violin appeared more than a decade ago with a cardboard-carbon fibre reinforced plastic sound board. Apparently the sound quality does not rival that produced by a Stradivarius, but it might be only a matter of time.

Before closing this article I must apologise to all my non-materials colleagues. Materials engineering has not advanced on it own. All disciplines have grown and developed and much of what is new has come from these advances. But the point of this article is that no engineer can graduate in the few remaining years of the twentieth century from the University without having some background knowledge of materials. Its importance is clear and so all departments in our Engineering Faculty employ specialists in the materials appropriate to their disciplines. This is so because, whether we like it or not, it's a material world!



Ford car circa 1910



Ford car circa 1955

The shape of cars is determined by economics, fashion, and the technological capabilities of fabricators and the materials used. After 1950 sheet steel press performance was improved and very complex shapes could be made easily and cheaply. This is an example of "tailoring" the properties of materials to meet the requirements of the designer

SIMULATION OF CONTAINER PORT OPERATIONS

D. Sculli and P.K. Wong

The Hong Kong container port has now become the largest in the world, and an increase in volume is expected as a considerable amount of China's export trade now passes through Hong Kong. There is a strong need for simulation models to help management predict and identify maximum through-put, bottlenecks, and to forecast future handling facilities requirements.

This Operational Research project is concerned with the development of computer simulation models for the container terminal operations. The main objective of the project is to assess the resulting space utilisation and the utilisation of handling facilities with changes in the total container through-put. The project also measures the effects on inter-related resources, i.e. what impact will an increase in handling equipment have on ship waiting time. The results of the simulation will help management with general policy making and the effective deployment of resources. The simulation model can also be used to test the effects of new container stacking systems without actually interrupting existing operations.

The project covers all phases of the development of the computer simulation model: output requirements, operational-flow analysis, data collection and analysis, model building, computer programming, and model validation. The simulation model is effectively a tool that will assist the management in identifying the maximum through-put potential and the best ways of achieving this. The simulation can also help identify the procedural and physical bottlenecks in the operation of the terminal.

The simulation model is built on the two typical terminal operations of discharging and loading. The model of the fully loaded container system is shown in Fig. 1.

The main queueing features incorporated in the model include ship queueing at Green Island when quay is not available, waiting for space to place containers at quayside, tractor queues when the tractor arrival rate is faster than the straddle carrying service rate, and many other minor queues.

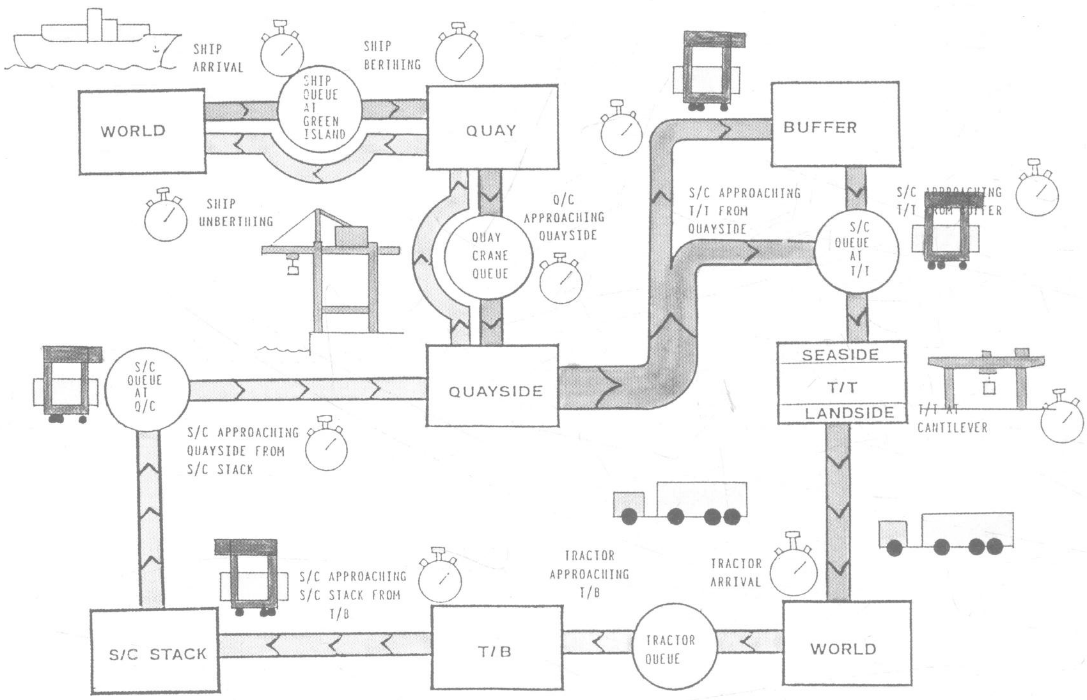


Fig. 1 Model of Fully containerised system

The simulation models developed are, in essence, planning tools to help management achieve a *balanced system*, where the handling facilities are only waiting temporarily for containers and containers are only temporarily waiting for service. The development of simulation models for container storage and transport is an on-going process. Several industrial engineers are employed by the various container handling companies in Hong Kong to develop such models and to help with the efficient planning of operations.

CASE STUDIES OF FAILURE INVESTIGATIONS

G.W. Greene

In 1980 an optional paper was introduced in the final year of the B.Sc.(Eng.) in Mechanical Engineering. It was entitled Case Studies of Failure Investigations to reflect the nature and content of the course.

The course focuses on practical service problems with emphasis on the approach to understanding and solving the problems. Motivation for this course arose from the recognition that engineers are basically problem solvers. The particular problem can be very technical but will probably involve personnel, management, and financial matters as well. An engineer needs to develop confidence in his ability to approach a practical engineering problem logically and systematically.

About 10 years ago a past graduate of engineering was asked, "What would you introduce to improve the University course which you took?" His reply was that a course in common sense and logic should be introduced, as this was so important to practising engineers but was not taught to undergraduates.

Case Studies of Failure Investigations tries to meet this need. There is an introduction regarding the purpose of investigations, the methodology, and the personal qualities needed by an investigator. Four separate topics are then taught based primarily on actual service problems:

1. Component failure and examination places emphasis on visual and more detailed study of components that have failed in service in Hong Kong. Background information is also made available to permit assessment of contributing factors. Students are required to clearly state observations before trying to interpret them, a critical differentiation in a logical and systematic investigation.

2. Mechanical failure involving of fracture and fatigue are considered. The basic concepts of fracture mechanics and fatigue failure are introduced. Examples are given to enable students to appreciate the importance of fracture mechanics and its applications to design. Cases are presented with emphasis on the methodology and the approach used in failure investigation.

3. Tribological failures are discussed in the context of the more significant types of wear, friction, and lubrication problems. Emphasis is given to methods of detection and recognition of fundamental causes of failure and the presentation is supported by examples of in-service failures. Students develop their own analysis of a suitable case study taken from recent Hong Kong experience.

4. Vibration and noise problems give rise to a broader class of failures, which may be divided into three categories: (a) component breakage due to dynamic overloading or to fatigue, (b) malfunctioning of a system which is exposed to excessive levels of vibration, and (c) a failure to limit vibration and noise to acceptable levels, thereby creating a nuisance either to people or to sensitive equipment. Studies have been made of failures which have occurred in Hong Kong and elsewhere, and accompanying site visits are arranged where possible.

The course has been chosen by about 15% to 25% of the students and has received highly favourable comment from external examiners and visitors both from academic institutions and the professional institutions.

This is one way in which degree courses are changing but there are many other examples.

COMPUTER AIDED DESIGN AND COMPUTER AIDED MANUFACTURE (CADCAM)

W.S. Sze, S.T. Tan, and M.M.F. Yuen

INTRODUCTION

The Department of Mechanical Engineering, University of Hong Kong initiated a research programme in Computer Aided Design and Computer Aided Manufacture (CADCAM) in 1983. The objective of the programme is to develop techniques for geometrical modelling of engineering parts and to apply the modelling system to different application areas.

Currently, the group comprises four teaching staff: Mr. K.W. Chan, Mr. W.S. Sze, Dr. S.T. Tan, and Dr. M.M.F. Yuen, with further contributions from ten full-time and part-time research assistants working on different aspects of the programme. The programme has won the support of the Industry Development Board (IDB) of the Hong Kong Government, the Strategic Research Grant Committee of the University, and local companies in providing financial sponsorship for research and development. Another aim of the group is to disseminate the results of the research and development projects to the industries.

Members of the group have published about twenty papers on CADCAM over the last five years. In 1987, the group won an outstanding paper award from the Institution of Mechanical Engineers (UK) in the Design and Manufacturing Technology Division.

RESEARCH AREAS AND PROJECTS

The research activities of the Group are concentrated in software development for different aspects of CADCAM techniques and applications. The research is concentrated on devising new schemes of parts representation and enhancing existing methods. Current projects in this area include:

1. solid modelling of parts with quadric and freeform surface,

2. modelling of solids using sweep primitives,

3. feature orientated solid modelling system.

The application related research is targeted towards linking the geometric representation core with different application areas. Currently, research is being conducted on the following topics:

1. cutter path generation for numerically controlled (NC) machining,

2. automatic mesh generation from solid models,

3. automatic dimensioning and tolerancing system,

4. motion simulation for mechanism design,

5. expert system for injection mould design.

The support from IDB is in two phases. Phase I of the project is near completion with Phase II currently in its second year. A total grant of HK$3.5 million was awarded to the group to develop software for applications in the mould-making industry.

The activity of the group is further reinforced by a research grant from the Strategic Research Grant Committee to conduct research in expert systems for injection moulding design. The programme was started in 1987.

LABORATORY FACILITIES

The computing hardware consists of two local area clusters with eight workstations. The system is linked to the University computer network. A major part of the computing facilities have been donated by Digital Equipment (HK) Ltd. The computers are directly linked to the NC machines for on-line machining. The NC machines include a 3-axis computer numerical control (CNC) machining centre and a CNC electrical discharge machine (EDM). The group has also received a generous donation of a plastic injection moulding machine from Chen Hsong Machinery Co. Ltd.

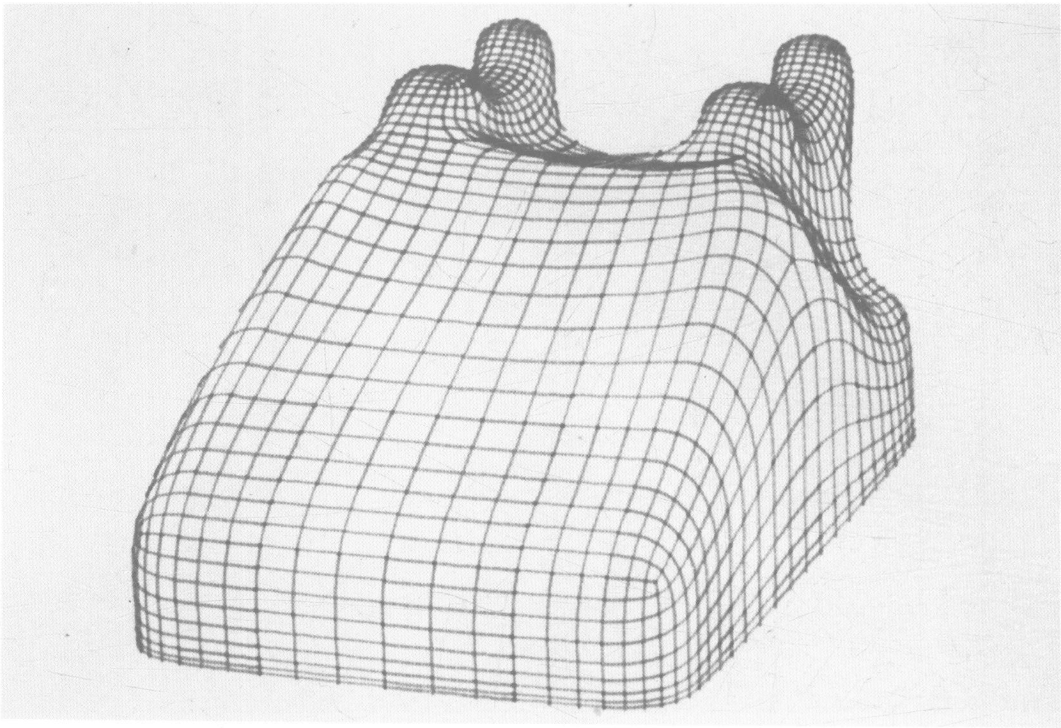


Fig. 1 Solid model of telephone shape using free form surface

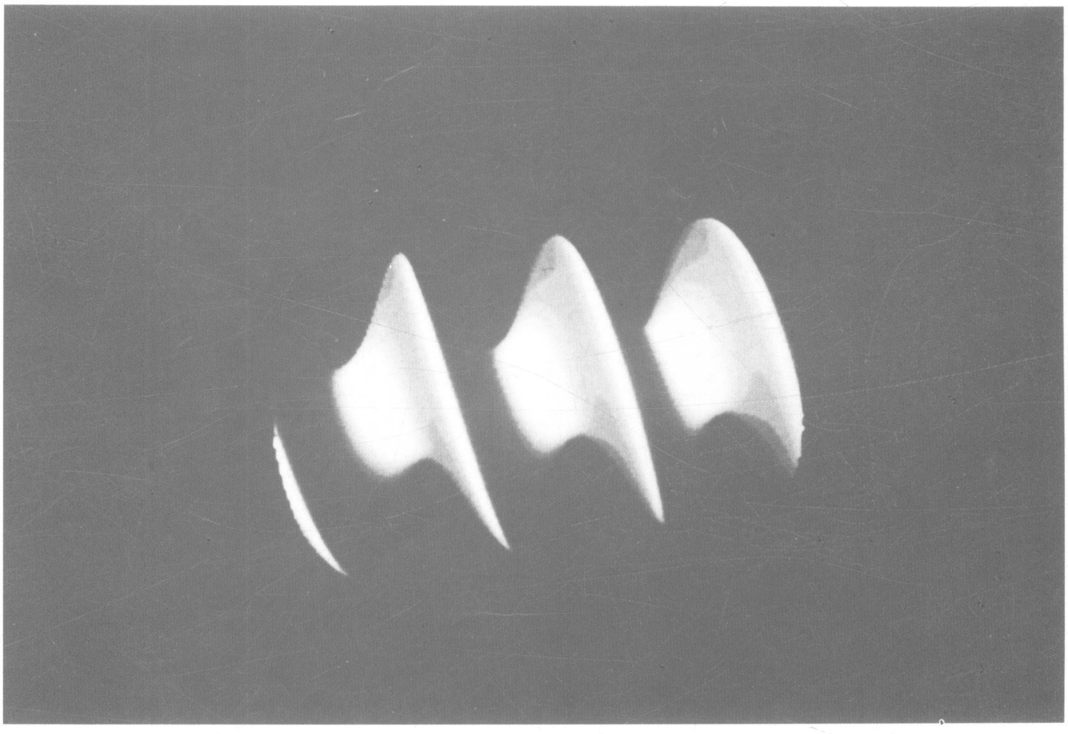


Fig. 2 Modelling of solid by twisted sweep of a circular disc

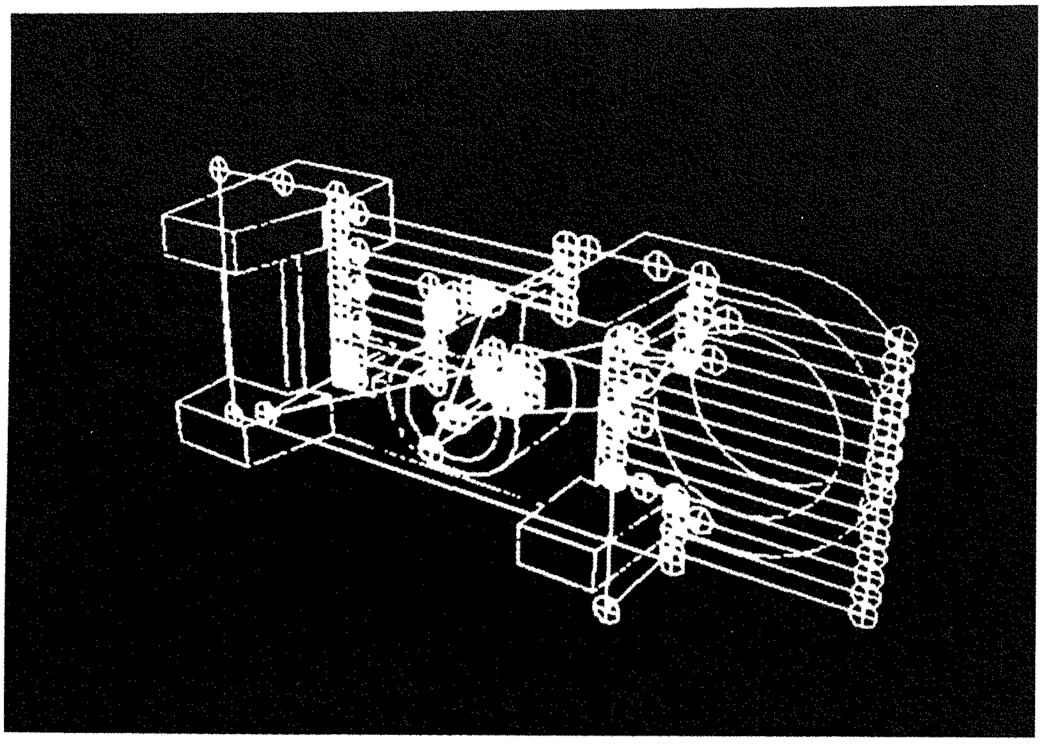


Fig. 3 Cutter path generation for numerical controlled (NC) machining

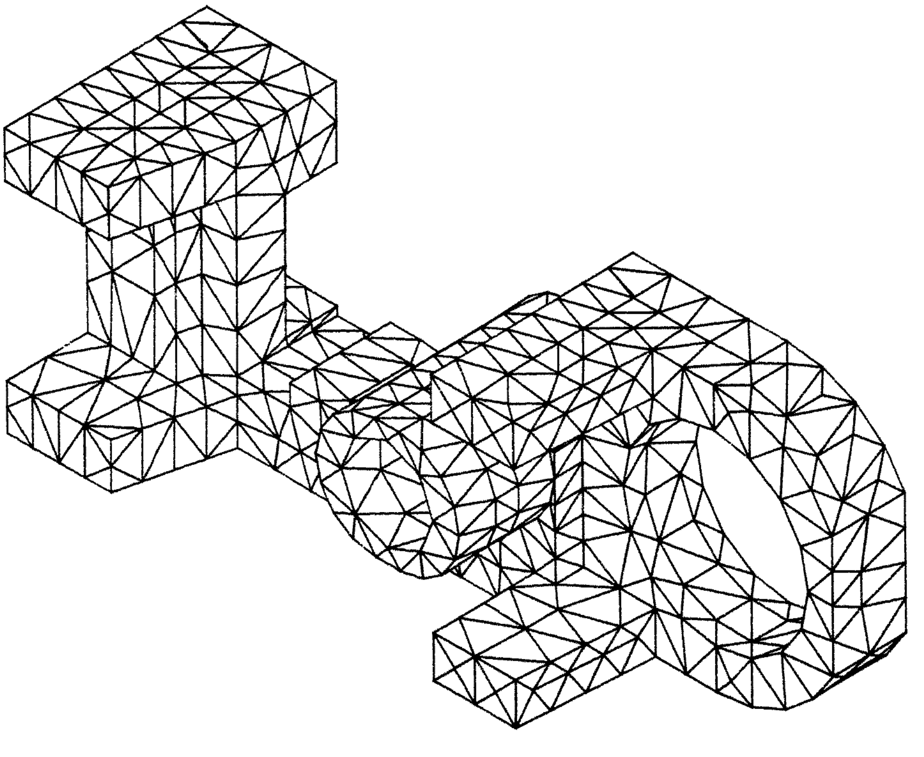


Fig. 4 Automatic tetrahedral mesh generation of a Gehause solid model

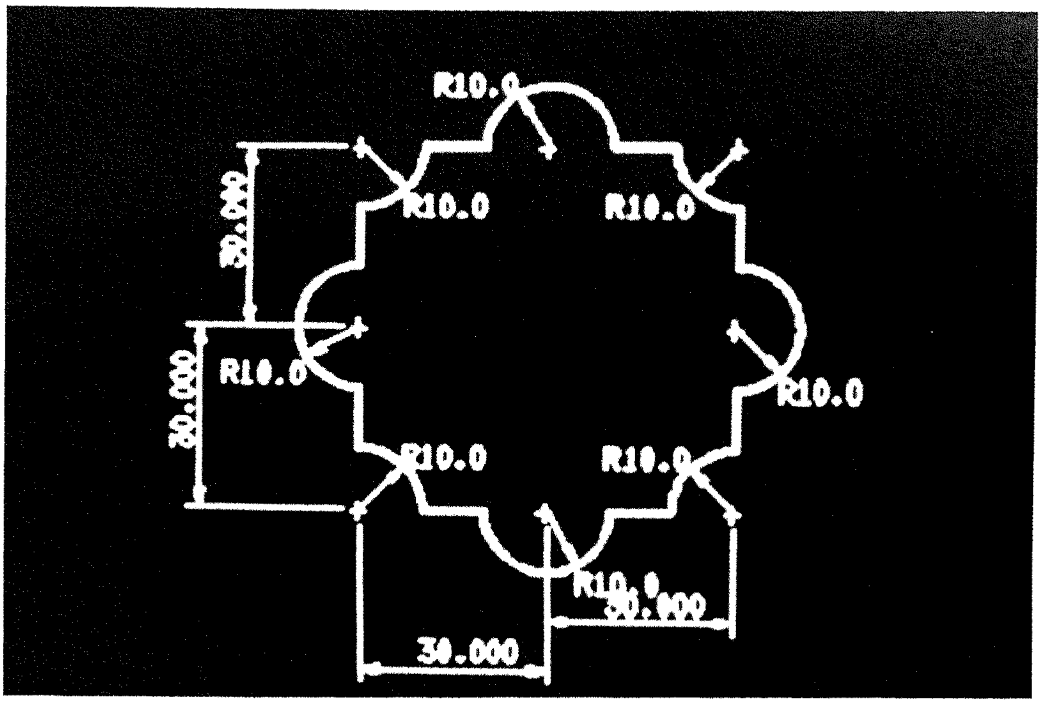


Fig. 5   Automatic dimensioning of solid model

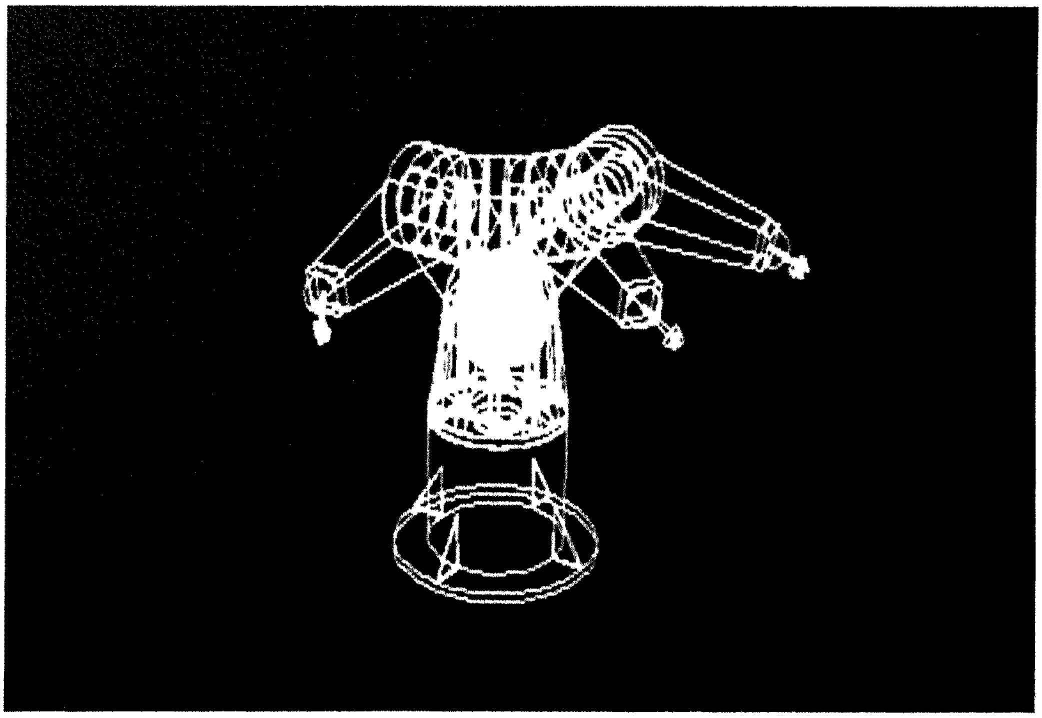


Fig. 6   Motion simulation of a solid model of a robotic arm

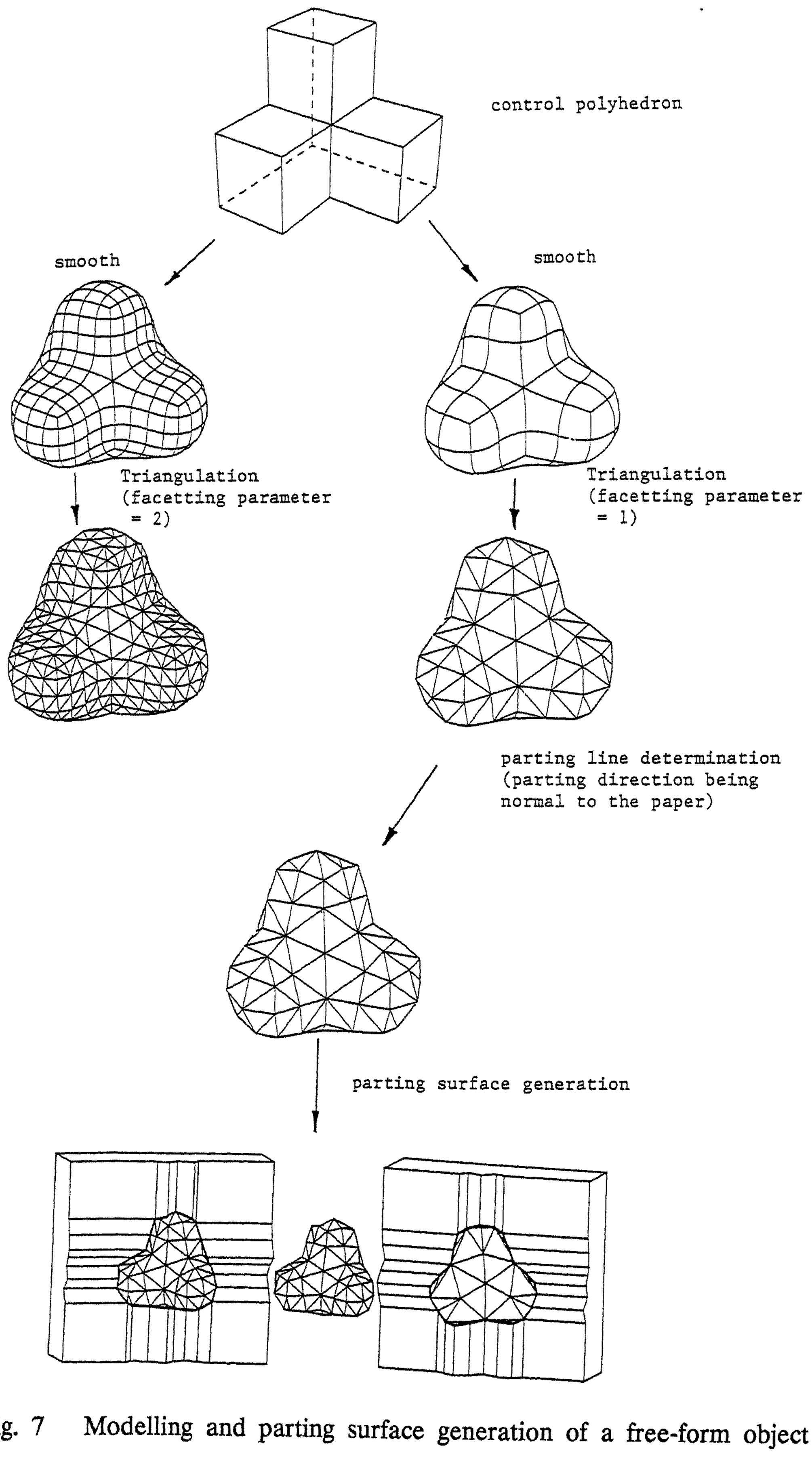


Fig. 7 Modelling and parting surface generation of a free-form object

CURRENT RESEARCH

FACULTY OF ENGINEERING
75th
HKU

ADHESIVE BONDED JOINTS

N.N.S. Chen, P.I.F. Niem, and R.C. Lee

INTRODUCTION

Plastics of high performance, with their durability and good mechanical and chemical properties, have been replacing other engineering materials in applications requiring demanding specifications. However, for large and intricate assemblies which cannot be moulded into one piece and for assemblies which involve integration of two incompatible materials such as metal and plastics, various joining techniques have to be employed in fabrications. Adhesive bonding has often proved to be the most efficient, economical, and durable method for joining plastics and for joining plastics to other materials.

Although research work on the fatigue strength of adhesive joints was reported as early as 1957, it was only in recent years that considerable effort had been made in the study of fatigue behaviour of adhesive bonded joints. However, most of the research work was concentrated on metal-to-metal joints, with plastic-to-plastic joints receiving little attention.

Fatigue testing of composite-to-composite bonded double-lap joints using different adherends and adhesives has been previously studied at a loading frequency was 1800 cycles per minute. Temperature rise during testing was found to be a function of the bond line stress level, as well as the type of adherend and adhesive material used.

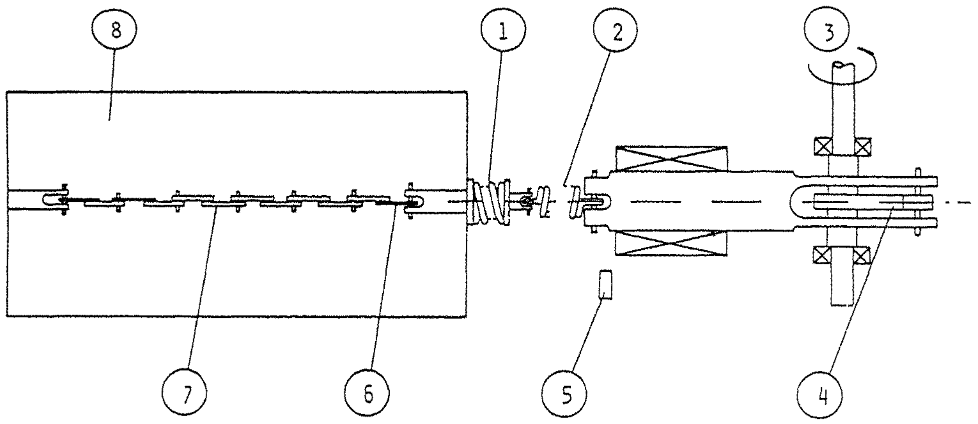
The purpose of this investigation was to study the fatigue behaviour of adhesive bonded plastic-to-plastic joints and metal-to-plastic joints under static loading and intermittent dynamic loading at low frequency.

Experimental investigations of adhesive joints involved the development of a standard joint preparation procedure, and the study of various parameters, such as adhesive thickness, overlap area, surface roughness, curing conditions, and the chemical resistance of adhesive bonded joints. An attempt has been made to derive a theoretical model for the prediction of service life of the joints.

RESULTS AND DISCUSSIONS

It has been found that the joint strength decreased as the adhesive thickness was increased and that the joint strength was not directly proportional to the overlap area, and was mainly dependent on the width of the overlap. The strength of the joint is a function of the curing process. Given sufficient time for polymerization to complete, the strength of the joint would attain the maximum level. Epoxy joints were resistant to Shell Tellus 37 lubricating oil, salt solution, and water, but showed poor resistance to kerosene.

A fatigue testing machine was designed and built for dynamic tests as shown in Fig. 1. Adhesive bonded joints with adherends, such as polymethyl methacrylate (PMMA), polycarbonate (PC), aluminium and PMMA-to-aluminium, were subjected to fatigue tests at different test frequencies, stress levels, and environmental conditions such as temperature and humidity.



1 COMPRESSION SPRING
2. EXTENSION SPRING
3 CAM SHAFT
4. CAM
5. PHOTO SENSOR CONNECTED TO COUNTER
6. TYPE MP SPECIMEN
7. TYPE PP SPECIMEN
8. ENVIRONMENTAL CHAMBER

Fig. 1 Schematic diagram of specimens loading system of the fatigue testing machine

Based on results obtained, S-N curves, which can be used to predict the fatigue life of adhesive bonded joints, were plotted and correlated using backward regression. Different types of joints showed different degrees of sensitivity to the applied stress. In general, it was found that the fatigue performance of epoxy joints was independent of the test frequency and humidity but was dependent on the stress level and test temperature.

The curing of the epoxy adhesive used suggested that the strength of the joint attained around 80% of maximum value after three days. However, the curing continued for another 45 days before the maximum strength was reached. This explained why tensile tests of specimens subjected to static loading after three days failed under a lower breaking load than those tested after 48 days.

CONCLUSIONS

(1) For epoxy bonded joints, the strength attained 80% of maximum strength after three days but only attained maximum at around 48 days.

(2) The fatigue life of adhesive bonded plastic joints and metal-to-plastic joints was independent of frequency and humidity, for the range of values tested.

(3) The fatigue life of adhesive bonded plastic joints and metal-to-plastic joints was dependent on the mean stress level and test temperature, with greater reduction in fatigue life observed in metal-to-plastic joints at higher temperature.

APPLICATION OF ARTIFICIAL INTELLIGENCE TO SOFTWARE ENGINEERING

T.Y. Chen and T.H. Tse

A typical software development life cycle consists of requirements analysis, software specification, software design, programming, program testing, implementation, and maintenance. Most of these phases are creative processes by nature and hence software development is often considered an art rather than a science. Huge amounts of resources have been invested to understand the procedures involved and transform the art into an engineering activity. It has generally been found, however, that these procedures cannot be fully automated because they involve problem solving techniques and decision making processes which can only be done by experienced software engineers. The quality of software developed varies according to the know-how of the practitioners involved. Although a number of automatic software development environments have already been proposed, they are not totally satisfactory since it is extremely difficult to have human expertise formalized in conventional terms and implemented by algorithmic programs. It is therefore vital that artificial intelligence be brought in to remedy the situation.

The objective of this project is to apply artificial intelligence techniques to the area of software engineering, so as to enhance the productivity of software development and to improve the quality of the software thus developed. Expert systems are being designed and developed to assist in the various stages of the software development life cycle.

BIOMEDICAL SIGNAL PROCESSING

F.H.Y. Chan and F.K. Lam

Cheap and fast-acting electronic signal-processing hardware now permits on-line measurement and analysis of biomedical signals. Some interesting applications are described below:

Analysis of Neuronal Spike Data

Information theory is applied to the analysis and interpretation of information conveyed by neurons in the form of interspike intervals (ISI). The entropy information content of the neuronal signals and their dependence on past history have been analyzed, giving a better insight into how neurons communicate with each other.

Brainstem Auditory Evoked Response (BAER) Measurement

Problems associated with the long measurement time in a conventional BAER measurement are overcome through the use of pseudo-random binary pulses, which permit a higher excitation rate compared to the current averaging methods. The technique has been implemented in a microcomputer-based setup that also supports the same measurement by the conventional averaging method.

Eye Movement Measurement

An eye-measurement system comprising a video camera, digitizer, and a computer has been developed. Pattern recognition and image processing techniques have been used for projects involving on-line measurement of eye movement, pupil diameter, and reaction times. Efficient windowing and target-tracking techniques have been incorporated. Development of more elaborate software suitable for further off-line analysis has also been initiated.

COLD ROLLING OF THERMOPLASTICS

N.N.S. Chen, P.I.F. Niem and Y.W. Lee

INTRODUCTION

The cold rolling of thermoplastic polymers is a useful method to modify the mechanical properties of the polymers. The effect of rolling on polyethylene was studied as early as 1961 and the results showed that cold rolling increased the tensile strength and slightly decreased the ultimate elongation in the rolling direction. Maximum strength perpendicular to the direction of rolling was reduced, but the ultimate elongation was increased. These characteristics were also observed for cold-rolled polypropylene.

Drawing and stretching are two important forming processes, and it is useful to know how they are affected by change in material properties. For metals, the two important properties are the plastic anisotropy ratio (so-called R value), which controls the ability of a metal to be deep-drawn, and the strain-hardening exponent (n value), which determines the ability of a metal to be stretched. Very limited published data, however, are available concerning formability studies of polymeric materials.

A recent investigation was carried out the aims of which were as follows:

(i) To study the effect of cold rolling on the two different processes of forming, viz. deep drawing and stretch forming of polymers.

(ii) To examine the effect of rolling on the R and n values and to find out the correlations between these two values and formability.

Thermoplastic polymer sheets which were cold rolled include polycarbonate (PC), rigid polyvinyl chloride (PVC), polymethyl methacrylate (PMMA), high impact polystyrene [HIPS], poly (acrylonitrile-butadiene-styrene) (ABS), high molecular weight polyethylene [HMWPE].

RESULTS AND DISCUSSIONS

It was found that all of the above thermoplastic materials, except PMMA, could be cold rolled satisfactorily. Generally, the maximum thickness reduction was found to be 60%, beyond which edge cracks occurred on the sheets.

The changes in mechanical properties, such as tensile, impact, and hardness of the polymers due to cold working have been investigated. In general, the tensile strength of the materials increased as a result of cold rolling. The yield point on the stress elongation curve for PC and HMWPE disappeared at 40% or higher rolling reductions. The notched Charpy impact strength of several polymers could be enhanced by cold rolling.

Deep drawing and stretch forming of PC and HMWPE have been examined. The deep drawability of both polymers was improved by rolling. After 40% or more reduction in thickness due to cold work, both materials could be deep-drawn satisfactorily to a cylindrical cup from a flat circular blank as shown in Fig. 1. Stretch forming tests have also been carried out, and the results show that cold work could also improve the stretch forming ability of these two polymers.

The plastic anisotropy ratio (R value) of the rolled PC and HMWPE specimens with 40% or higher rolling reductions was measured. The results showed that normal anisotropy (the R value) increased with rolling reduction, and was responsible for improved drawability. Cold rolling also increased the strain hardening exponent (n value) of the two polymers.

CONCLUSION

From the results obtained, it can be concluded that biaxially rolled PC and HMWPE sheets become superior materials for deep drawing and stretch forming processes. Cold working increases the R and n values of the materials. It has been shown that the higher the R and n values, the better the drawability and stretch forming ability, respectively.

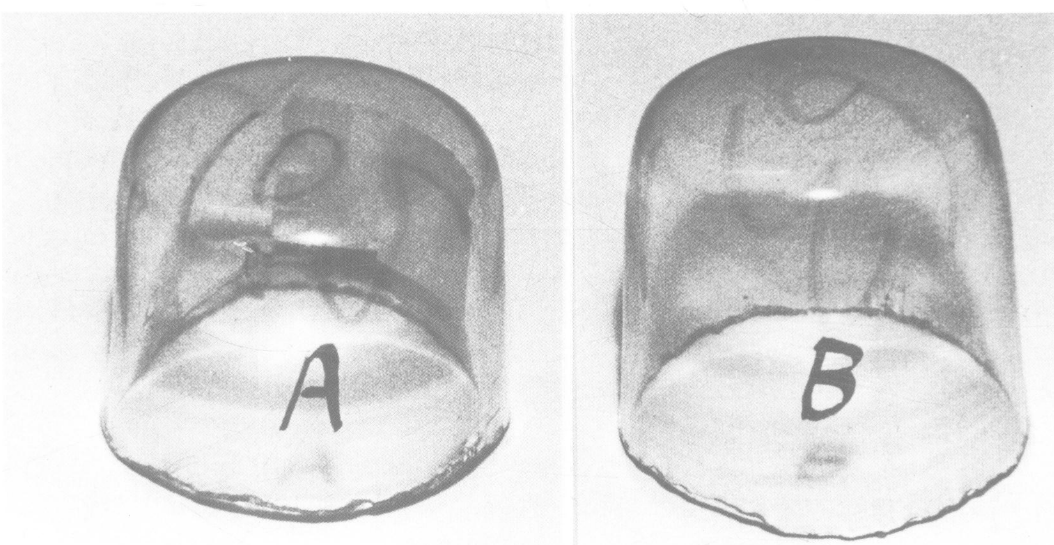


Fig. 1 Deep-drawn PC cups (A and B)

COOLING OF POLYETHYLENE BUBBLE

Anthony, Chi-Ying Wong

The blown film process may be considered as combining features of blow moulding and flat film extrusion. A typical set-up for blown film extrusion is shown in Fig. 1. An advantage of the blown film process over the flat film process lies in that the former can produce biaxially oriented film, whereas the latter produces uniaxially oriented film. Since it is known that the physical properties of the finished film such as tensile strength, tear resistance, and heat characteristics are affected by the degree of orientation of macromolecules, it is therefore expected that the biaxially oriented film would have better physical properties than the uniaxially oriented film. The orientation of macromolecules is, in turn, affected by the two most important processing variables viz. the rate of stretching and the rate of cooling.

As with any extrusion process, film blowing becomes more economical as extrusion speeds are increased. However, the bottle-neck lies in the cooling of the fast moving thin melt film. This research project is, therefore, aimed at analysing the absolute as well as relative effect of the fundamental variables such as line speed, blow up ratio, etc. on the temperature history and rate of cooling of a tubular film. It is also intended to generate a broad data base of temperature, air velocity, strain, strain-rate, cooling rate history above the air ring under various processing conditions, and to develop some empirical expressions with practical applications.

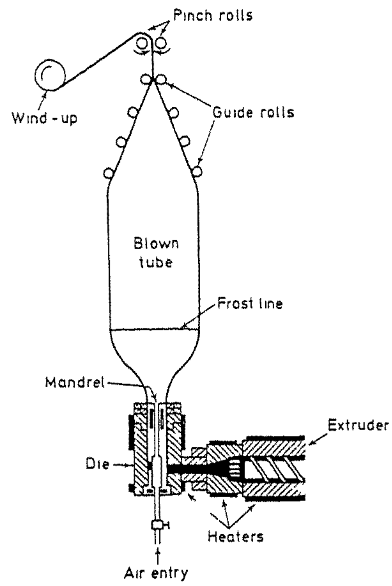


Fig. 1 Blown film extrusion

DESIGN OF A SIX-AXIS ROBOTIC MANIPULATOR

P.C. Chiu and K.F. Lee

INTRODUCTION

Robots are programmable manipulators that have capabilities of computer control and communication. They are generally recognized as basic elements of flexible automation. Robots were first extensively applied in the automotive industry, for spot welding, arc welding, and paint spraying to relieve manual workers from hazardous environments. Machine loading was probably the most important application of robots outside the automotive industry; again the workers' safety has been the primary consideration especially for punch presses, forging, and die casting. With the rapid advances in computer technology and precision engineering, cost reduction and high precision have justified the extensive use of robots in other industries which are less capital intensive. In Japan, since 1984, the electrical/electronic industry has become the largest user of industrial robots. There, the main emphasis is in automatic assembly where the robot usually cannot rely upon its capabilities to work in hazardous environments and must compete with human operators in dexterity, productivity, and quality. In general, successful applications of robots are mostly found in industries having a thorough understanding of robot technology and in the isolated work cell of automation. Integrated manufacturing systems with several robot cells as well as other flexible manufacturing subsystems have only found limited success.

The objective of the project is to design and build a medium size, medium speed open-chain articulated six-axis prototype robot that is suitable for various manufacturing tasks. The articulated type was chosen because it provided the most versatile movement. From the academic point of view, the complex kinematic, dynamic, and control problems and the fact that the complete system was known to the designer, opened up an extensive range of research work. It is intended that the manipulator will fulfil the following specification:

(1) Payload - 5 kg
(2) Hemispherical workspace with minimum and maximum reach of 0.4 m and 1.0 m respectively
(3) Repeatability - 0.2 mm

(4) Maximum joint speed - 120 deg/s
(5) Continuous path mode as well as point to point mode.

PRELIMINARY DESIGN CONSIDERATION

At the planning stage of design, decisions had to be made on the basic form of the mechanical structure in relation to the available components and materials. High torque dc servomotors were chosen as the actuators for the arm movements, each being integrally mounted with a tachogenerator, an optical incremental encoder, and a harmonic reduction gear system. The drive system is termed here as an integrally mounted (IM) actuator.

Throughout the paper, the following terms are used for motors and axes: axes 1 to 6 and their corresponding joints are driven by motors 1 to 6 respectively. Axis 1 refers to the base, axis 2 to the lower arm or shoulder, axis 3 to the forearm arm or elbow, axis 4 to wrist rotation, axis 5 to wrist bend or pitching and axis 6 to wrist rolling.

For the open-chain system, transmission mechanisms can be minimized if the joint can be directly coupled to an IM actuator. It potentially increases the reliability of the manipulator and minimizes the necessity for readjustment. Further, the open-chain structure has better dexterity and larger workspace than the closed-chain type. The main drawback of using direct-coupled IM actuators in an open-chain manipulator is that the motors driving the wrist joints are themselves loads for the motor at the elbow joint which then loads the motor at the shoulder joint. Thus the load increases rapidly along a series of active joints, requiring an excessively large motor at the shoulder joint. As a result, the heaviest load occurs at the shoulder joint. In the present case, the maximum load at the motor M2 could be as high as 185 Nm for a payload of 5 kg. This load is outside the range of even the biggest IM actuator available locally. The first method to reduce the motor load was to achieve counterbalance by placing a massive weight at the opposite side of the shoulder arm. The second method which was adopted in the present system was to mount a pneumatic cylinder as shown in Fig. 2 to support the shoulder arm by applying pressure at the rod end. The proposed balancing method relieves a significant amount of load at the shoulder joint. Consequently a smaller motor was required. One of the important features of the arrangement is that the balancing torque depends on angle β; this characteristic enables the largest balancing torque to be developed at the maximum loading condition. An important advantage of the arrangement is that active balancing is possible by varying the pressure in the cylinder.

In order to reduce the weight of the manipulator arms, particularly the wrist, to a minimum, aluminium alloy was used wherever necessary. The alloy has 80% to 85% of the strength of mild steel but only has one third of the density of the latter.

The locations of the actuators have to be carefully considered. Since it was decided that the joints should be directly driven by IM actuators wherever possible, the location of motors M1, M2, and M3 became obvious. The motor M4 was used to partially counterbalance the payload. Therefore, it should be placed on the other side of axis 3 at a location as far away from the elbow joint as possible. After considering various possible locations for the motor M5, it was decided to mount the motor M5 transversely to axis 4 and at a location near to the joint 3. Axis 5 was driven by a timing belt with metallic reinforcement through toothed pulleys. Such a design has the advantage of reducing the load at both shoulder and elbow joints. The overall layout and the workspace of the manipulator together with locations of six motors, M1 to M6, are shown in Fig. 1.

DETAILED DESIGN

A computer program was written to examine the static loads at various joints, in particular the elbow and shoulder joints, at the various joint conditions. Since the selection of a larger motor increased the load at the lower joints, the load and choice of motors and components became an interacting and repetitive problem. The specifications of the six actuators used in the manipulator are shown in the Appendix.

The procedure of selecting the size of the motors was first to estimate the loads on the wrist joints 4, 5, and 6. Approximate weights of the components were then determined and the motor M6 was first chosen. The sizes of motors M4 and M5 were repeatedly re-examined. The loads on the elbow joint were then examined by varying the positions of motors M4 and M5 and the heights of axes 4 and 5. The selected motor M3 has a weight of 6.5 kg and a holding torque of 52 Nm. Each motor was selected so that the maximum motor torque for sustaining the static loads would exceed 90% of the holding torque.

The loads on the shoulder joint and the effect of the pneumatic balance were carefully studied. By referring to Fig. 2, the simplified equation of the net torque on the shoulder joint T_M is derived:

$$T_M = T_L + L[a_2\cos(180^\circ - \theta_2)] - Fy \sin \beta \qquad .....(1)$$

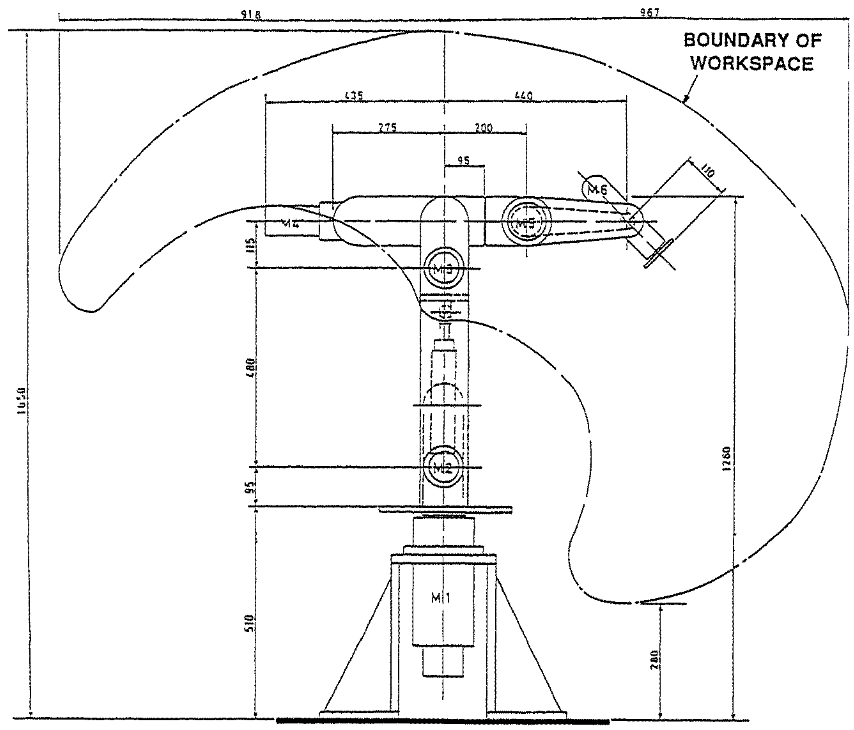

918
967
BOUNDARY OF
WORKSPACE
435
440
275
200
95
110
115
480
95
510
1650
1260
280
M1
M2
M3
M5
M6

Fig. 1

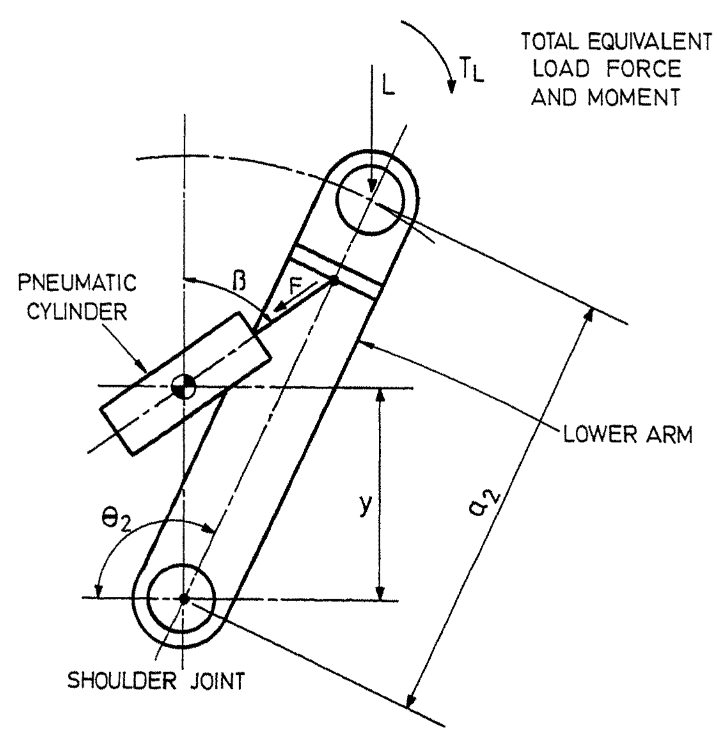

TOTAL EQUIVALENT
LOAD FORCE
AND MOMENT
L
T_L
PNEUMATIC
CYLINDER
β
F
LOWER ARM
y
a_2
θ_2
SHOULDER JOINT

Fig. 2

where T_L is the total equivalent moment due to axes 3 to 6 and the payload, L the total equivalent force due to axes 2 to 6 and the payload, and F the balancing force exerted by the cylinder pressure.

Equation (1) shows that in order to maximize the balancing torque of the pneumatic cylinder, y should be as large as possible within the physical constraints. For the available cylinder pressure of 600 kN/m^2 and the maximum required balancing torque, the cylinder was chosen to have a bore of 50 mm and stroke 150 mm. The computer results showed that under the maximum load condition, the pneumatic balance carried 67% of total load and the motor M2 only carried 33%.

The mechanical structure of the manipulator was designed to withstand the inertia and centrifugal loads as well as the static loads. The arm structures of axes 2 to 5 used similar designs. Each arm structure was made of two arm plates bolted together by transverse webs. A modular approach and flexibility were considered in the design. The forearm of the manipulator that holds the wrist is easily dismantleable. Without changing the basic geometry of the robot, the dimension of the forearm may be modified to trade off the performance between the workspace, reach, joint speed, and the payload.

Base Structure and Assembly

The main requirement of the base was to provide the manipulator with a stable and rigid structure. The most appropriate method of manufacturing the base was casting. Since this process was not available in the University Engineering Workshop, electric arc welding was adopted. Four webs, two at each side of the base, were used to improve the rigidity of the base, and 21 mm thick mild steel plates were used to provide the base with a heavy structure. The base was mounted on the floor by eight M12 bolts. As a consequence of the electric arc welding process, residual stress occurred at all joints. Therefore, follow-up stress relieving was essential.

The moving plate which supported other manipulator moving structures is driven by the base actuator M1 through an extended shaft. The method of transmission from the base actuator M1 through the extended shaft to the moving plate is by means of a single key and double keys respectively. As force analysis showed that the base is subjected to high axial as well as transverse loads when operating at the rated speed of 90 deg/s, two tapered roller bearings were used to support the extended shaft. The arrangement could tolerate a small misalignment during the assembly operation.

Shoulder and Elbow Joint Assembly

The shoulder and elbow joints used similar designs but with different dimensions. Since the actuators M1 to M4 were all supplied with a single keyway at the output shafts, the choice of the materials for keys and their fits were of paramount importance. Of all the components in the manipulator, the keys of actuators M2 and M3 were subjected to the highest stress particularly during large accelerations and decelerations. Any slight deformation due to severe shear strain caused clearance at the joint shaft and joint backlash. Chromium nickel steel was chosen as the material for the keys which were hardened and tempered to provide sufficient toughness for withstanding high shear stress.

In order to provide a better shearing resistance of the arm plates at the joint and ease of maintenance, two key plates, one for each arm plate, were used to couple the joint shaft and the arm plate as shown in Fig. 3. As the arm structure was made from aluminium alloy plates which were much weaker than the chromium nickel steel, damage would be more likely to occur at the arm plates. The keyplate served as a buffer between the two elements and was coupled to the arm plate by three socket screws at a larger radius to reduce the shear stress on the arm plate. The joint shaft was also supported by two taper roller bearings to withstand both axial and transverse loads, and to allow for a small misalignment during assembly.

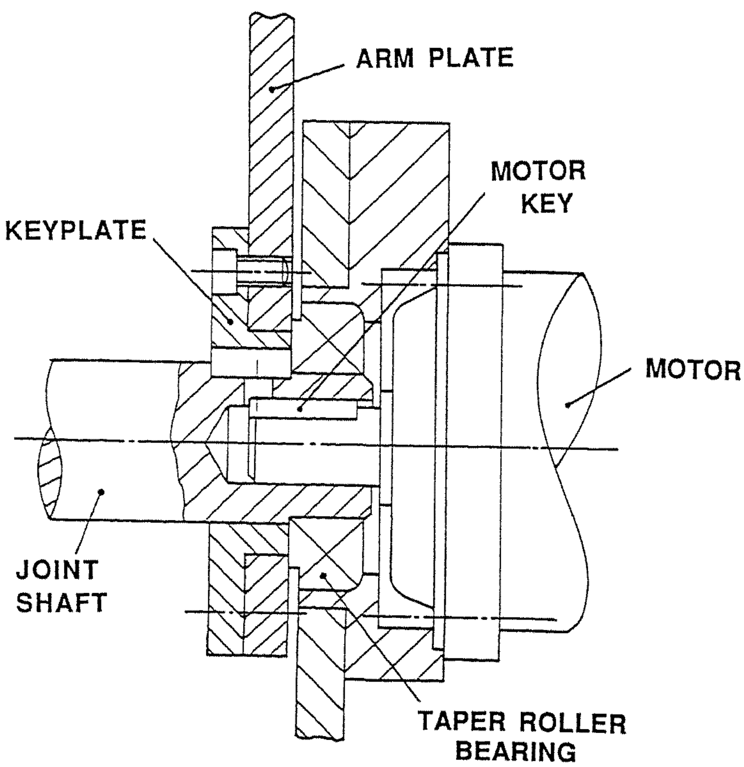


Fig. 3

Wrist Motor Assembly

As the actuator M5 was placed at a location as near to the elbow joint as possible, a timing belt with metallic reinforcement was employed to drive the axis 5 through a pair of toothed pulleys with a reduction ratio of 1:2. The actuator M5 was mounted on an assembly structure whose position could be adjusted in a direction along the axis 4 by two screws. This adjustment was necessary to facilitate the assembly of the arrangement and to provide the required tension of the timing belt.

The actuator M6 was designed in a similar way to the base motor assembly. However, due to the relatively small load carried by the joint, only the taper roller bearing and a ball bearing were used to support the moving part on which the gripper or end effector was attached.

COMPUTER AND INTERFACES

An incremental encoder giving 200 pulses per revolution was mounted on each motor. Six bidirectional counters were designed and built by the University Electronic Services Unit, each counting pulses from an encoder having three output pulse signals. Two pulse signals at 90 degrees out of phase were used for bidirectional pulse measurement. The third signal is an index signal which produced a pulse once per revolution. The bidirectional counter was designed to give a 16-bit digital output. The first 8-bits gave the pulse count and the second 8-bits gives the index count. For every count of index signal, the pulse bits were reset and the index count was either incremented or decremented by one depending on the direction of motor rotation. The counters were extensively tested. Serious miscounts were experienced due to the noise problem. This was overcome by adding appropriate filters and opto-couplers. The reliability of the counters was of vital importance for the safe operation of the manipulator. Any serious miscount would result in a large swing of the particular joint under the closed-loop control.

In the present manipulator, inductive proximity sensors were used for zero references. Except for joint 6, two limit switches were also installed at each joint to cut-off the D/A converter voltage to the driver unit when extreme position was reached. A software program was written to determine the zero references of the joints when the manipulator was at the HARDHOME position. A SETZERO program might be called that would automatically move each arm to its zero reference position.

The Intel SBC 86/12A Single Board Computer with an 8087 NDP was used as the host computer in which software modules such as teaching and off-line programming were resided. Within the on board RAM, there are 8K bytes of dual port RAM which is extremely useful for communicating with other SBC boards and relieves CUP load from I/O tasks. The Intel SBC 88/40 single board computer was chosen as the axis-control computer in which software was resided for controlling the manipulator. The hardware configuration is shown in Fig. 4.

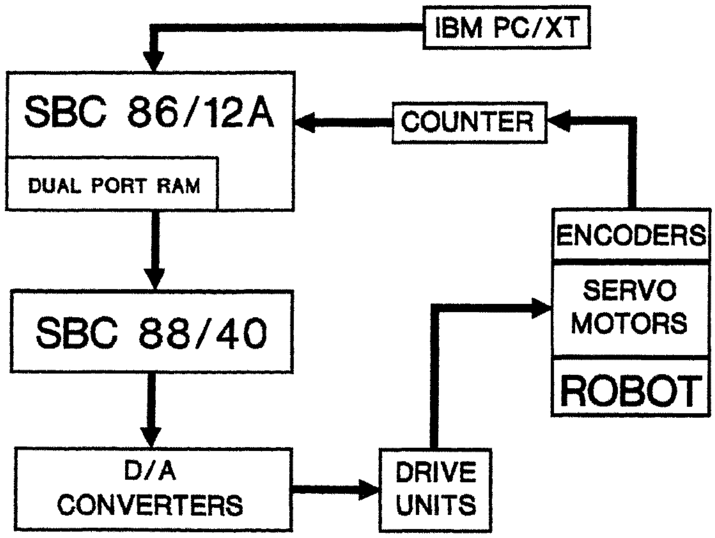


Fig. 4

Two MP8305 analogue output boards, each consisting of four 12-bit D/A converters with +10V output were also mounted on the same cardcage as the computers. The SBC 88/40 treats each of the input ports of the MP8305 as a two-byte memory which is directly addressable by the CPU. Each of six D/A outputs was connected to the input of the driver unit which consists of a PWM amplifier and receives an additional input from the tachogenerator to provide damping to the control system.

The computer software for teaching and control was written in assembly language. It includes sub-programmes for manual drive, teaching, and execution. All commands are activated by pressing a single key at the keyboard including the display of command menu. The manual drive commands include selection of axis, speed, and direction, and halt of the axis movement. The teaching commands include teaching of current point and storing current counter values, displaying current and all stored counter values, resetting the taught points, and execution of the taught path through the taught points under closed loop control. Currently only a PID control algorithm is installed in the SBC 88/40 board for closed-loop control. By acquiring the taught points and the current counter values of the axis position from SBC 86/12A dual port

RAM, the axes can be moved simultaneously along the taught path. An off-line programme written in C language is currently being developed. It includes the most common commands of the robot control language. The instructions are similar to the subset of the VAL robot language.

CONCLUSIONS

The most important part of mechanical design of the manipulator is the weight reduction of the arms and joints, particularly those of the wrist, and providing sufficient strength and rigidity. Inertia and centrifugal forces have been considered in the design. The major constraint to achieve overall weight reduction of the moving parts of the manipulator is the weight of the elbow motor M3. The highest load occurs at the shoulder joint. At certain positions where the shoulder arm is subjected to the maximum load, the effect of the weight of the motor M3 is comparable to that of the full payload. Under these conditions, the pneumatic balancing cylinder carries about two thirds of the total load on the shoulder arm, significantly relieving the load on the actuator M2.

In order to enhance communication between human and the robot on the one hand and the robot and other manufacturing systems on the other, future work will be directed towards improving off-line programming and control algorithms, and to include sensors and vision in the robot system.

APPENDIX

Specifications of Six Actuators

Item \ Motor	Unit	M1	M2	M3	M4	M5	M6
Rated output	W	138	66	70	33	1.8	6
Rated torque	Nm	87.2	42.1	35.5	16.7	3.8	2
Rated voltage	V	75	75	75	75	22.5	21
Rated speed	deg/s	90	90	114	114	204	180
Maximum torque	Nm	343	156.8	156.8	68.6	14.7	3.5
Holding torque	Nm	130	62	51	23	5.5	2.2
Reduction ratio		1:200	1:200	1:160	1:160	1:88	1:100
Weight	Kg	12.7	6.5	6.5	4	0.8	0.29

AN EASY-TO-USE AND LOW-COST CADCAM SYSTEM FOR MOULD AND DIE CAVITIES

S.H. Choi

This CADCAM system, developed for manufacture of mould and die cavities, has been implemented on an IBM PC XT/AT compatible microcomputer. It adopts a solids modelling approach and automatic generation of cutter paths to take advantage of the cheapness and popularity of the hardware and the ease of use of the system. These advantages are particularly important to small- or medium-sized die manufacturers whose financial and technical capabilities are generally very limited. A high level of graphical capability has been incorportated to allow display of a modelled shape to be manipulated for visual examination simultaneously in a number of views zoomed or rotated through any angles in a 3-D space. Arbitrary sectional views can also be displayed to reveal internal details of the shape. Hard-copies of displays can be obtained with a dot-matrix printer or a plotter. NC data can be transferred directly from the computer, or through a paper tape, to a milling machine with a FANUC control system to cut the shape. Geometrical properties of the shape, such as volume, surface area, mass centre etc., can also be analysed for design purposes. This system represents a means to help upgrade the local technological level of manufacture of mould and die cavities and their related products. Fig. 1 shows the shape of a spanner constructed using the system. Milling tools and quality of finish can be specified and NC data will then be generated for machining the spanner on an NC milling machine which can be used for electrodes for subsequent spark erosion of the die cavity.

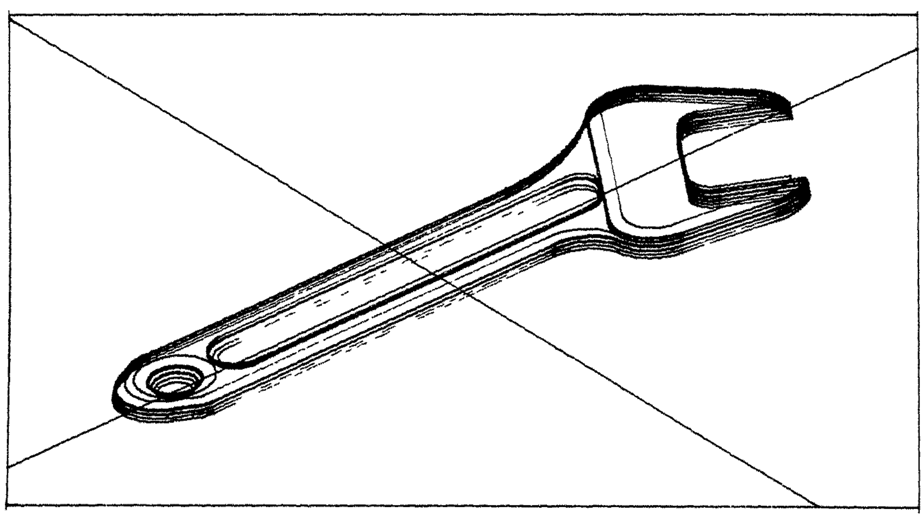


Fig. 1 Computer constructed shape of a spanner

EFFECTS OF FINES ON GAS FLUIDIZATION PROPERTIES

Anthony, Chi-Ying Wong

A gas fluidized bed is formed by passing a gas upwards through a bed of particles supported on a distributor. Studies of the characteristics of a fluidized bed usually involve measurements of pressure drop across the bed, and bed expansion. Fig. 1 shows the basic equipment required for such studies, whereas representation of response of bed to upwards flow of gas through it is stylized in Fig. 2.

Gas fluidization techniques have many important industrial applications in, for example, chemical processing, plastics, pharmaceuticals, environmental control, electricity power generation, and industry which involves the use of "J" and/or "L" valves for controlling solid flow. All these form part of the important industrial sectors worldwide. But workers in this field realize that a slight change in the physical properties concerned (such as particle size, density and shape, and relative humidity of the fluidizing gas) may drastically affect the behaviour of a fluidized bed. The amount of fines (mean particle size $< 10\ \mu m$) present in the bulk is one of such important properties. This research therefore concentrates on the effect brought about by the presence of fines on the basic fluidization characteristics which include minimum fluidization velocity, minimum bubbling velocity, discharge rate, dense phase properties, deceleration rate, and time.

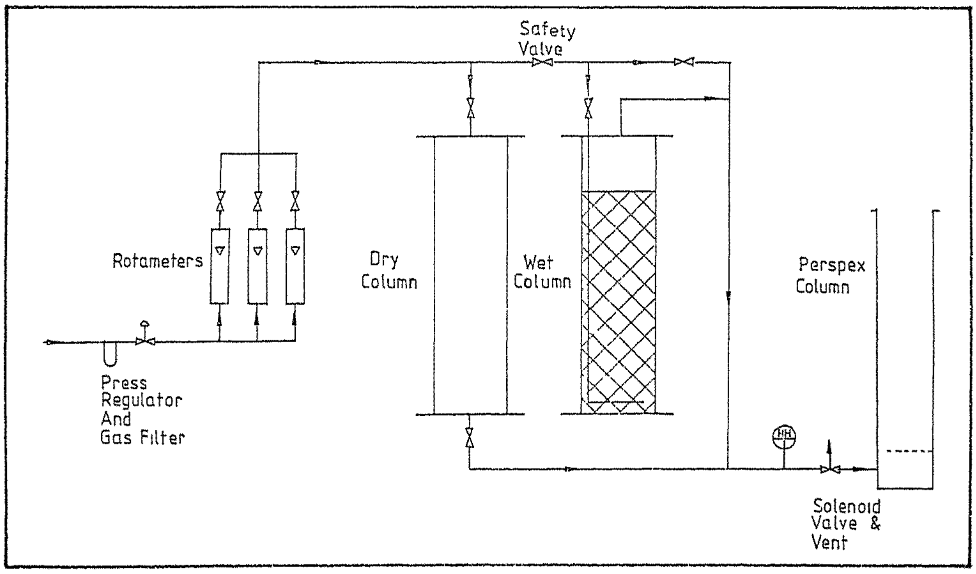


Fig. 1 Layout of equipment

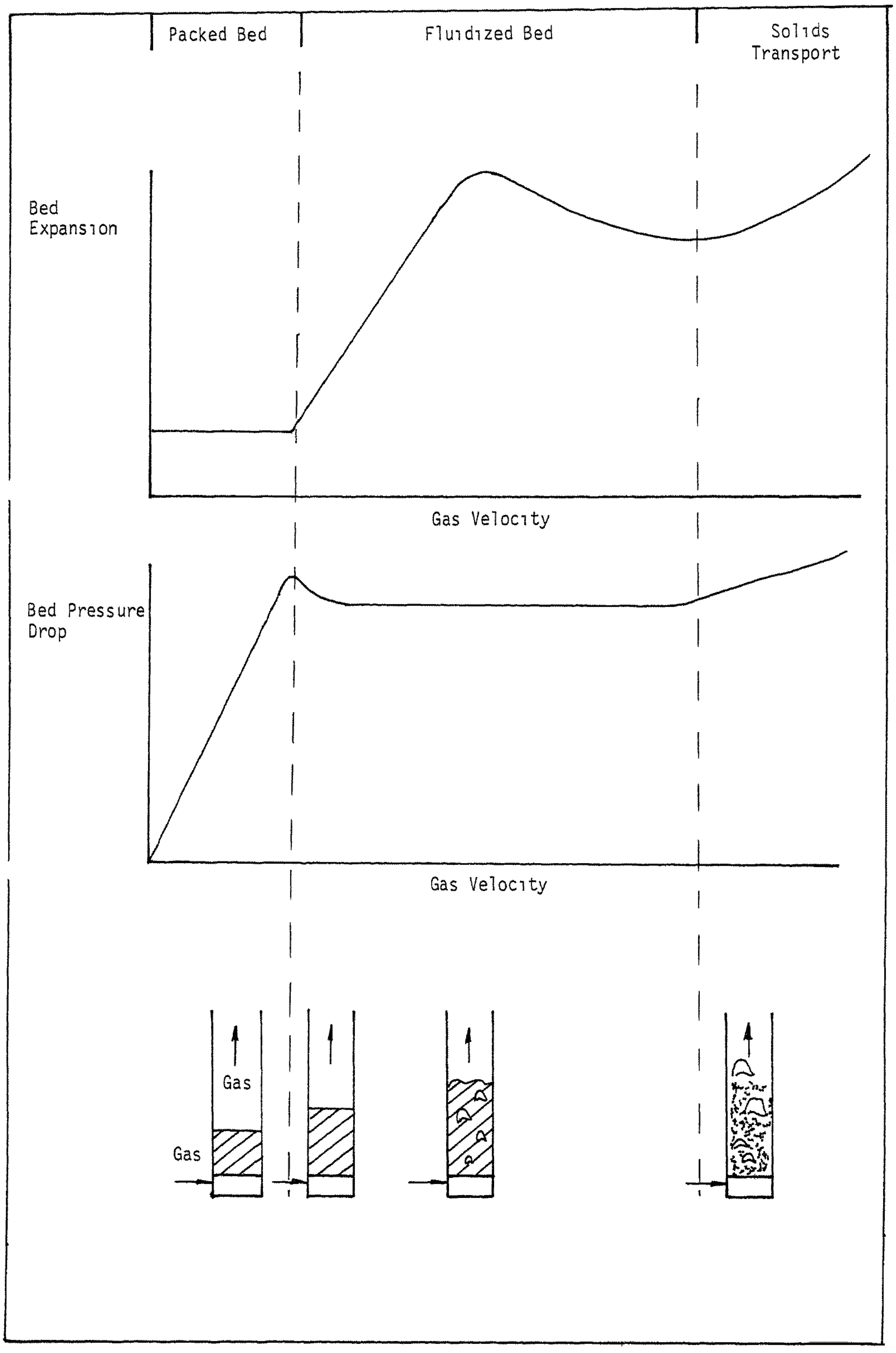


Fig. 2 Stylized representation of response of bed to upwards flow of gas

EFFECTS OF MOISTURE ON PROCESSING CONDITIONS AND WELDING PROPERTIES OF POLYAMIDES

A.C.Y. Wong, C.Y. Yue and C.F. Lau

The outstanding mechanical properties demonstrated by polyamide (e.g. nylon) have enabled it to gain its popularity and recognition in the family of engineering plastics. But its hygroscopic nature leads to two general, but rather troublesome, practices in real life. They are predrying the resins before processing and conditioning the finished articles so as to meet the requirements of any specifications or standards. This research project not only studies the effects of moisture on the processing conditions of injection moulding and compression moulding, but it also investigates the welding characteristics of nylon because there is a growing industrial and scientific interest in this area of study.

OPTIMUM BLEND RATIO OF LLDPE USING AN UNMODIFIED CONVENTIONAL BLOWN FILM LINE

Anthony, Chi-Ying Wong

The superior physical properties of the relatively low cost linear low density polyethylene (LLDPE) over the conventional high pressure low density polyethylene (LDPE) have not only brought the plastic films industry into a new era, they have also enabled the packaging industry to solve some of the problems which could not be tackled satisfactorily by conventional packaging materials. However, the intrinsic weak melt strength and high melt viscosity even at high temperatures exhibited by LLDPE have caused some practical concerns to film fabricators. Installing completely new machinery or modifying conventional LDPE blown film extruders is obviously the most effective way of overcoming those processing problems, and at the same time enjoying the advantages offered by LLDPE. But either method is rather costly and hence they are not generally accepted.

It has been demonstrated, in practice, that blending the two polyethylenes using existing conventional LDPE extruders is an intermediate solution to the situation. However, most of the work were carried out by trial-and-error approaches. Very little was conducted in a systematic and scientific way. The aims of this research are to investigate the limitations of the blend ratio of LLDPE in LDPE using an unmodified conventional blown film extruder and the influence of the blend ratio on the properties of end-products. This work is also aimed at producing some rules of thumb and practical correlations for the limitations.

FACSIMILE SIGNAL PROCESSING

F.K. Lam

Fax machines as "communicating photocopiers" provide a convenient means of directly dispatching documents. This is especially so for Chinese texts since coding of Chinese characters is inefficient. However, the structure of most Chinese characters is complicated and, for small print, an enhancement of the quality of the document transmitted would be most desirable. Investigations into the effects of pre-processing the fax signals in order to improve quality have been made. We have introduced an interface between a fax machine and a PC which is capable of fetching data from the fax machine, storing it in the PC in the form of digital gray levels, and then changing the threshold level inside the fax machine. With the video data inside the computer, processing algorithms can be written to improve the copy quality. Firstly, an inverse gradient-weighted smoothing scheme is executed to eliminate noise while preserving the image boundary. This is followed by digital high-pass filtering for image sharpening, and a notchless quantization scheme then transforms the gray level data into bilevel form for transmission. Initial results from the system confirm the viability of the approach.

MICROCOMPUTER BASED ULTRASONIC IMAGING SYSTEM

F.K. Lam

Ultrasonic imaging is a powerful means of non-destructive testing of materials. For this purpose an evaluation system based on an IBM PC interfaced to a scanner and a flaw detector has been assembled. The source transducer under microcomputer control is made to scan over the object and the received echoes are detected, digitized, and passed back into the computer. With this basic system configuration a number of projects can be tackled of which the following are examples:

(1) A digital correlation system suitable for the testing of highly absorbent material has been developed. The system which employs different pulse-sequences as the test signal uses the spread-energy method to overcome the conflicting constraints of penetration range and resolution.

(2) Identification of flaw geometry utilizing the diffracted sound field is attempted. Encouraging results are obtained in the reconstruction of an unknown straight-edged planar flaw.

(3) Display facilities other than the conventional A-, B-, and C-scans are incorporated to enhance the system capability. These include echo-amplitude encoding and 3-D interactive display.

WEATHER SATELLITE RECEIVING SYSTEM

K.L. Ho and F.K. Lam

There are a number of satellites in orbit which provide meteorological data on a continuing basis and a low-cost weather satellite system has been installed in the University to receive the transmissions. The basic system is capable of receiving the Automatic Picture Transmission (APT) radio signals from the polar orbital satellite TIROS as well as the S-band weather facsimile (WEFAX) transmissions from the GMS geostationary satellite. Work is in progress to include computerized picture acquisition and subsequent processing of the received signals. Types of processing envisaged are colour encoding, image manipulations and formatting, isotherm annotation, area enlargement, etc. such that the resultant weather maps can be more readily interpreted. It is also hoped to study some aspects of microwave propagation path characterization at a later date.

HIGH-PERFORMANCE POWER AND POWER-SEMICONDUCTOR CONTROL SYSTEMS

S.K. Tso

Superior methods of control are now made possible by the rapid developments in microprocessors and VLSI technologies. In particular, design and optimisation studies of digitally controlled static exciters, power system stabilisers, static reactive power compensators and solid-state ac drives, working either singly or in co-ordinated control systems, have been carried out. Simultaneously there is concern about the impact of electrical interference caused to other electronic systems switched by the more sophisticated solid-state loads. A systematic assessment of these disturbing effects and their means of containment is underway.

SENSOR-BASED ADAPTIVELY CONTROLLED ROBOTIC SYSTEMS

S.K. Tso

Because Hong Kong industry lacks sophisticated automation, a programme has been initiated to develop more interactive, adaptive, and easy-to-use robotic and industrial vision systems. Most industrial robots in use today have little or no vision or other sensory capabilities. It is our intention to integrate more sensor functions into high-performance robots to extend their applicability and control flexibility in the manufacturing industry. In addition to the interface problem between the sensor and the task environment, attention is being given to speedier processing of the sensor data as well as to the problem of more effective interpretation of the data to aid task planning. Since the accurate tracking of specified trajectories is important for high-speed operations, work is also being carried out on the adaptive control of the multi-joint dynamic robotic systems. Hybrid control of force/torque and the location of the end-effector is being studied in order to improve the assembly capability of industrial robots.

HYDRAULICS AND THE ENVIRONMENT

J.H.W. Lee and A.W. Jayawardena

INTRODUCTION

To a civil engineer, many problems in the aquatic environment are concerned with hydraulic processes. It is generally accepted that, unless the effects of water pollution can be quantified satisfactorily, it is not possible to manage our environment effectively. Inasmuch as the effect of pollution on a river, estuary, or ocean is determined by local pollutant concentrations which vary both spatially and temporally, there is a need to understand mixing and transport processes in the water environment. A sound understanding based on both theoretical and experimental modelling work can be gainfully used in pollution control.

This paper outlines the scope and motivation of some research projects in the environmental hydraulics area. An attempt to understand the environment often leads to interesting hydraulic research of basic importance.

FLUID MECHANICS OF WASTEWATER DISPOSAL

Mixing of a Round Buoyant Jet

To control local pollution conditions within acceptable levels, wastewater is often discharged in the form of a number of submerged buoyant jets at the bottom of the ocean or coastal water. Fig. 1a shows a 1:11 undistorted scale hydraulic model of a single-port section of the submerged multiport sewage diffuser serving Wah Fu Screening Plant. By preserving densimetric Froude similitude and ensuring a jet Reynolds number in excess of 2000, the dominant turbulent mixing process of the buoyant jet can be modelled. It can be seen that the turbulent round jet, inclined at 20° to the horizontal, spreads linearly near the discharge, but curves rapidly upwards when the initial jet kinetic energy is dissipated and buoyancy forces become dominant. The momentum and buoyancy-induced entrainment cause the mixing of the wastewater with the uncontaminated surrounding fluid; the wastewater is thereby diluted. The degree of dilution in stagnant ambient water, of the order of 100 for many outfalls, can be predicted reliably using mathematical models founded on rigorous fluid mechanical principles. Fig. 1b shows a comparison of predicted vs measured centerline dilution for different

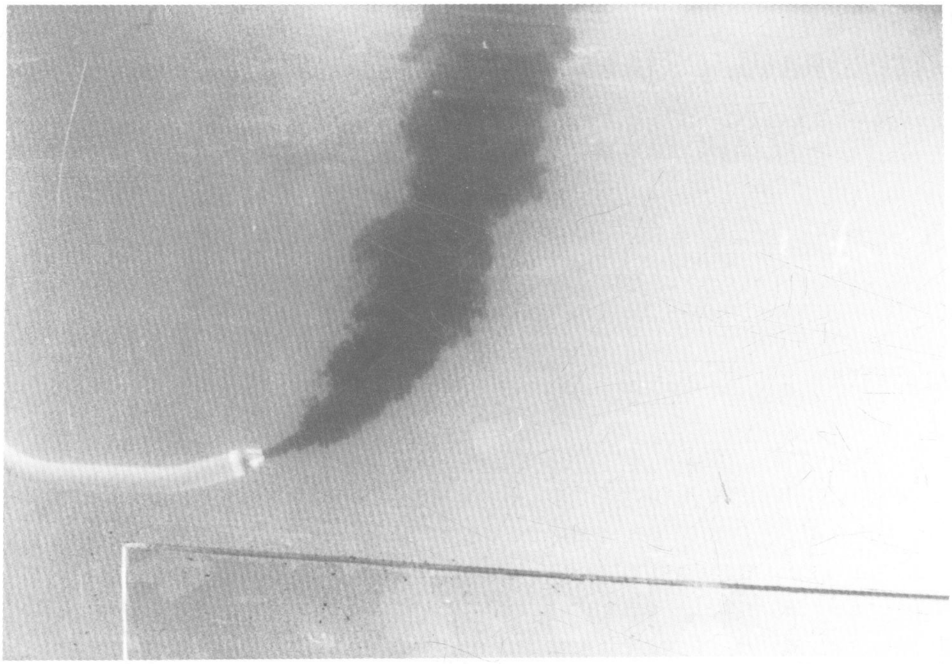


Fig. 1 a) Buoyant jet effluent issuing from a 1:11 hydraulic scale model of the Wah Fu sewage outfall. Jet velocity = 0.74 m/s, jet diameter = 0.1 m, relative density difference = 0.014. Densimetric Froude number = 6.3.

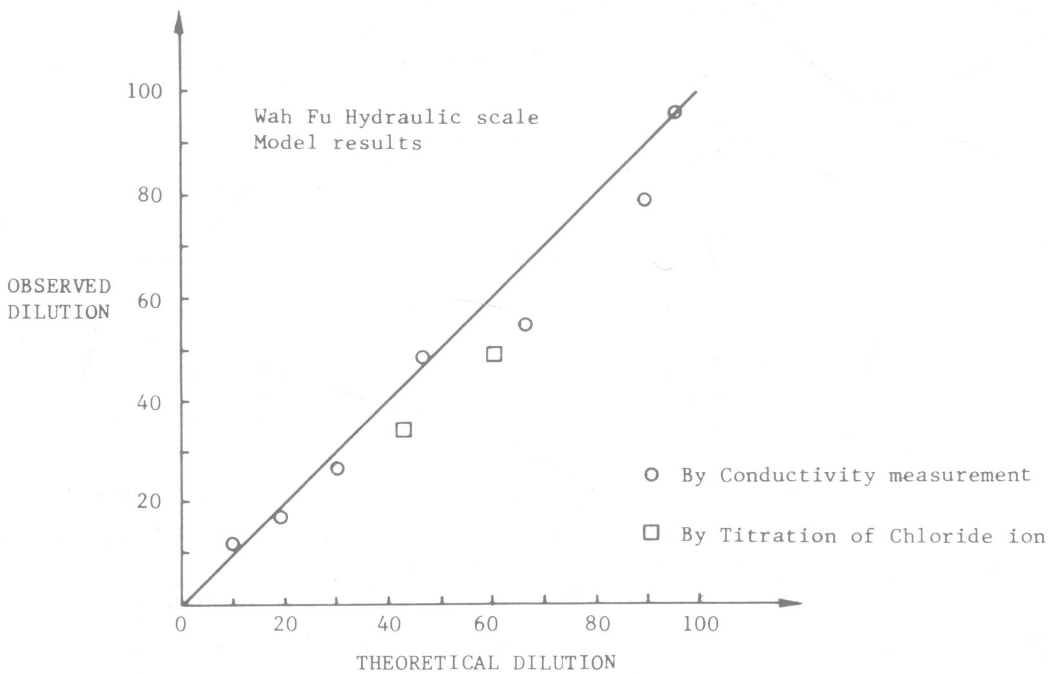


Fig. 1 b) Comparison of theoretical prediction of minimum surface dilution with experimental data - Wah Fu model study depths in the Wah Fu study. Fresh water, with 600 ppm sodium chloride added as a tracer, is injected into sugar solution that simulates the same relative densities as between effluent and ambient sea water. In general the initial dilution, inferred from the measured tracer concentration, can be predicted to within 10 per cent; the discrepancy usually increases for larger dilutions, when the relative experimental error is also larger. The observed trajectory and width of buoyant plume are also in excellent agreement with the theory. A general integral jet model can also be developed to handle a row of arbitrarily inclined and spaced round jets, including the merging of the buoyant plumes at some distances above the discharge and the subsequent essentially two-dimensional vertically rising curtain of sewage. Fig. 2 shows for example a calculation for the Kwun Tong outfall -- both the jet width and centerline dilution are indicated for representative depths. These calculations provide useful estimates for outfall design. The model predictions are often supplemented by intensive hydrographic and water quality field surveys carried out to better define the coastal current structure and background water quality at a chosen outfall site. A field survey planned in conjunction with a mathematical model can go a long way in understanding the field performance of outfalls and water quality control in general, with a view to effecting better designs and getting some clues to the answers to some important questions - e.g. the effect of tidal flushing on the initial dilution actually achieved in relatively enclosed waters like Tolo Harbour, or the mixing of a buoyant effluent in a relatively weak ambient current.

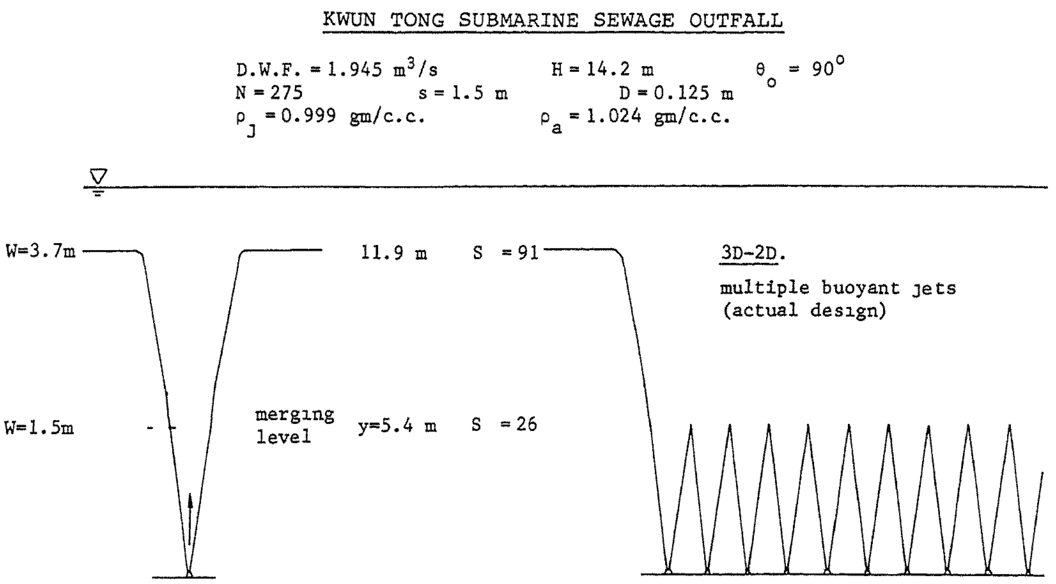


Fig. 2 Computed results of a general integral jet model for the 256 port Kwun Tong submerged sewage diffuser. Both the jet width (W) and centreline dilution (S) at the level of plume merging and the base of the surface wastewater field are shown.

Initial Dilution Prediction in Moving Water

Whereas the initial dilution achieved by buoyant wastewater discharges in still water can be predicted reliably, there appears to be no universally accepted method of predicting initial dilution in moving water. In view of the fact that a tidal current is always present in many coastal locations, it is highly desirable to take into account the effect of an ambient current in outfall design. The development of predictive methods has proceeded along two lines:

a) correlation of field data or laboratory data of experiments designed to closely simulate prototype conditions: equations for initial dilution have been proposed by many investigators in the U.K. and North America; however, there is significant discrepancy among the various theories; predictions can differ by a factor from 3 to 10;

b) development of relatively sophisticated mathematical models founded on fundamental fluid mechanics principles: here the effort has not met with the same success as in the stagnant ambient case.

Both model development and verification have been hampered by the highly complicated flow geometry of a deflected turbulent buoyant jet in a cross current. Further, comparisons of laboratory data with theoretical predictions have been limited primarily to high-momentum discharges in weak currents. In view of these deficiencies, prediction of initial dilution in moving water has for some time been regarded as the weakest link in an outfall design.

The above discrepancies have been to a large extent resolved in a recent study with the aid of mathematical models and a length scale analysis. All available field and laboratory data of initial dilution in a moving current were successfully interpreted in a single framework by this new method of analysis. Simple equations for initial dilution prediction were arrived at; the results, endorsed by the Water Research Centre, show that significant increases in initial dilution can be obtained even in a weak ambient current. Fig. 3 shows an example of the collective correlation of field data for plumes in a full "current-dominate" regime; the design implications and the statistical variability to be expected in the field have also been reported. More detailed studies on the mixing of a buoyant jet in a cross flow are currently under investigation.

Plane Buoyant Jet in Stratified Fluid

If the receiving water is stratified, the buoyant wastewater may entrain enough of the denser fluid in the lower layers that it never reaches the

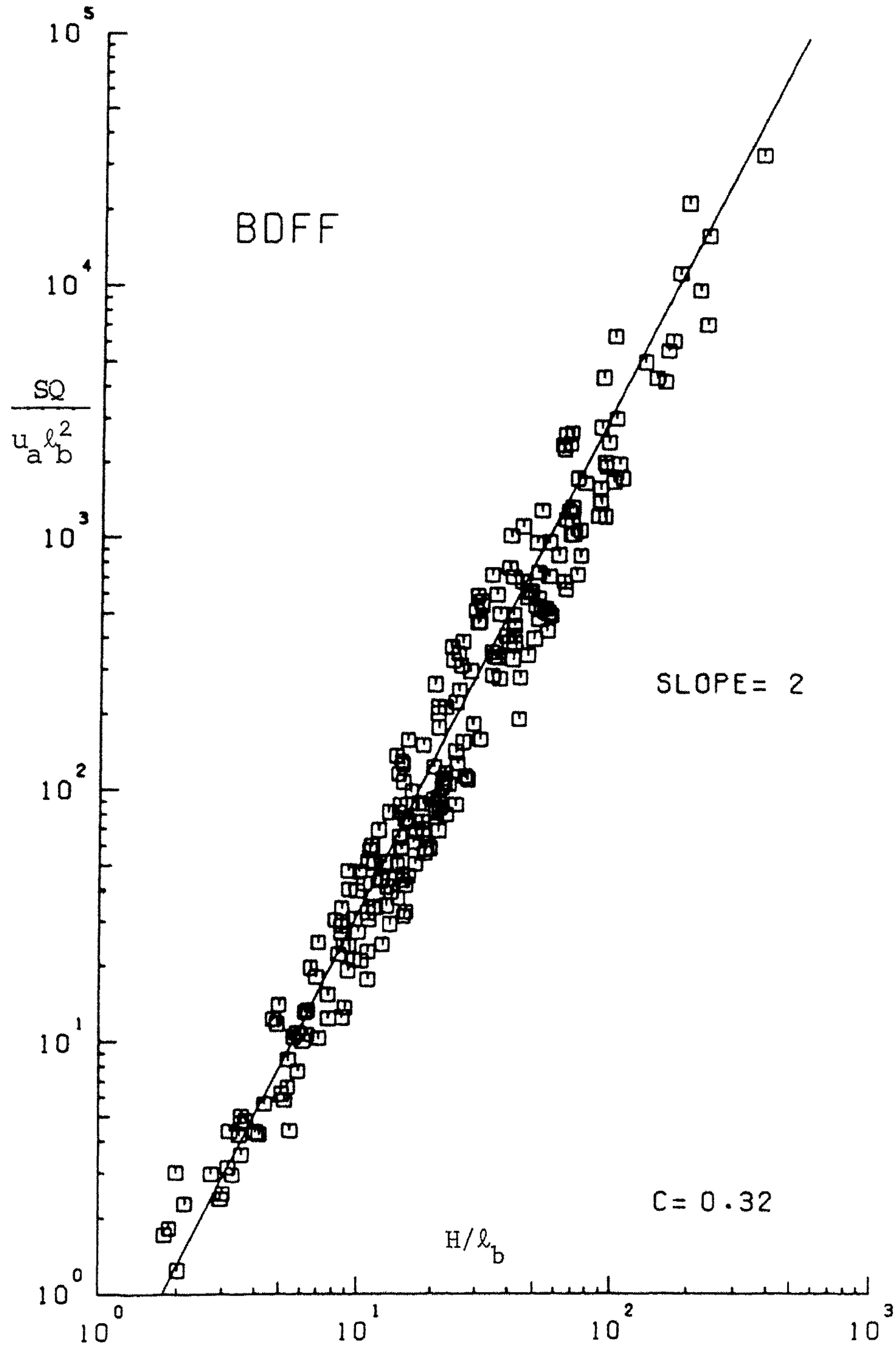


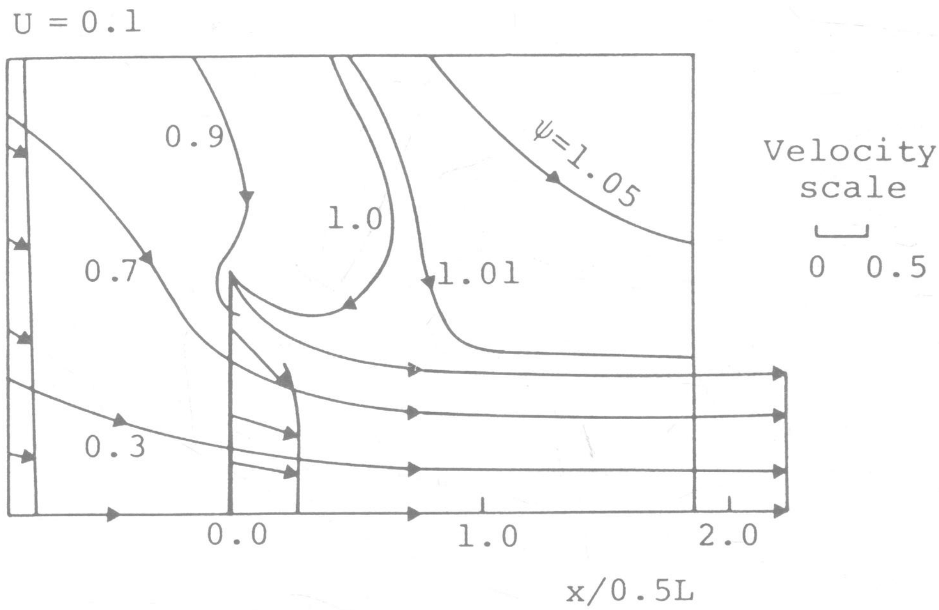
Fig. 3 Correlation of in situ measurements of initial dilution in moving water at a number of sea outfalls in the United Kingdom. Analysis is based on the use of length scales formed from the dynamic discharge momentum and buoyancy fluxes. S is the minimum surface dilution measured in the sewage boil, Q = discharge volume flux, u_a = ambient current speed, $\ell_b = B/u_a^3$, where $B = Q(\Delta\rho j/\rho a)g$; $\Delta\rho j/\rho a$ is the discharge relative density difference, and g = gravitational acceleration.

surface. The mixed buoyant effluent "finds" the level of its own density, overshoots a little, and finally settles to a submerged spreading layer. The submergence of the wastewater field presents certain advantages from the environmental point of view: surface recreation waters are protected, the wastewater effluent is subject to weaker wind-generated currents, and hence longer travel times before any pathogenic organisms are carried to nearshore areas of biological importance. In moderate to large depths with a stable stratification, this situation can be engineered to occur. Unlike round buoyant jets, there is scant basic experimental data on the maximum height of rise of a plane buoyant jet (which simulates the wastewater effluent beyond the level of merging of the adjacent jets), and the distribution of concentration within the spreading layer. The experimental technique required for this delicate and elaborate experiment has been developed.

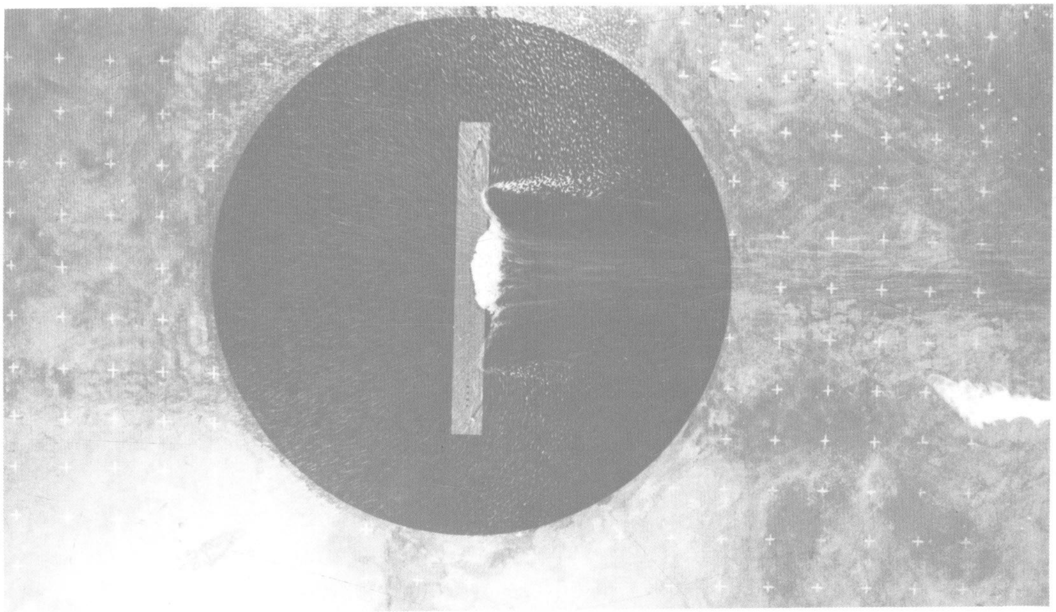
Multiple Weakly-buoyant Jets

Compared with sewage discharges, thermal effluents from once-through cooling systems of steam-electric power stations are characterized by much weaker buoyancy and much higher velocities. For a typical heated effluent with 8°C excess temperature, the buoyancy is about an order of magnitude less whilst the velocity is about an order of magnitude greater. Consequently, the near-field flow induced by such multiple submerged buoyant jets is primarily driven by the large momentum imparted to the receiving water, so entirely different predictive techniques from the ones described above have to be used. The mechanics of such a momentum-induced flow has been explained and computed by an exact inviscid vortex model. The basic theory has been verified for different ambient currents and lateral boundary conditions by extensive point velocity measurements in a specially designed 11 x 6 m shallow water basin in the Peel Laboratory of HKU. Fig. 4 shows an example of a computed flow induced by the multiple-jet group in a co-flowing current, together with a flow visualization for the same condition in an experiment. The resemblance of the inwardly-directed flow character near the ends on the multiple jet group is evident. The theory has been extended to study the effect of a shoreline boundary on the mixing performance of such a water-quality control device. A numerical and experimental investigation of the practical situation of multiple jets discharging in a perpendicular cross flow has recently been completed.

In contrast to submerged sewage discharges, condenser cooling water is often discharged through a surface or near-surface conduit at the coastline. Fig. 5 shows such a heated surface discharge from the 1500 MW Tsing Yi power station. With a maximum cooling water (CW) flow of 71 m^3/s, the high velocity surface jet can entrain up to ten times



(a)



(b)

Fig. 4 Computed and observed flow induced by a line of submerged shallow water jets in a weak coflowing current. All the jets discharge in the same $(+x)$ direction: a) computed streamlines for the upper symmetrical half of the flow field; b) observed flow field made visible by paper chips; the length of the streaks indicate the relative magnitude of the velocities. Note the significant reverse flow in front of the multiple jet group even in a forward current.

its own flow within 200 m from the discharge point; the ambient flow pattern is hence significantly modified by the discharge. A 1:150 schematic physical model was designed to examine the waste heat distribution in the vicinity of the thermal outfall. Fig. 5 shows the surface excess temperature field in a steady ebb current of 0.3 m/s. Supported by theoretical considerations and field measurements, it is seen that this high-momentum surface buoyant jet is attached to the downstream shoreline, with temperature rises in excess of 0.5°C around the intake area. The model has also been used to assess the thermal field and intake temperature rise under different conditions.

MATHEMATICAL MODELLING OF TIDAL CIRCULATION AND FAR-FIELD POLLUTANT TRANSPORT

All of the previous studies apply to the near field, a region which is close to and dynamically affected by the introduction of the discharge. For understanding pollutant transport on a scale much larger than the water depth, numerical modelling of long wave propagation and advective transport in coastal areas using both the finite element and the finite difference methods have been carried out. Emphasis was placed on studying the stability, accuracy, and efficiency of time-stepping numerical schemes, as well as on model verification. Fig. 6 shows an example of computed maximum flood currents in Tolo Harbor. A knowledge of the intra-tidal time variation of water levels and currents can aid greatly towards understanding water quality. In addition, a capability of predicting astronomical tides based on an extended harmonic analysis of a long or short series of tidal records at a given site has been developed. A time history of water levels can be forecast to within 0.1 m accuracy. Such a capability is essential for understanding the performance of tidal circulation models. Fig. 7 shows an example prediction of tide levels at North Point.

The water quality one observes in coastal waters is the result of a complicated interaction of water movement, turbulent diffusion and shear flow dispersion, and biochemical processes. The predictions of tidal currents provide a useful input to water quality models which simulate the response of coastal waters to pollution inputs and environmental factors. A current research project funded by the Croucher Foundation aims to develop modelling methodology for predicting marine water quality. In particular, a dynamic oxygen budget model has been developed in collaboration with the Agricultural and Fisheries Department for describing the ecological system in local fish culture zones. The dissolved oxygen level is modelled by quantifying the interactions of a number of biological and physical factors including: photosynthetic production and respiratory activities of the marine biota, light intensity, water temperature, tidal flushing, and wind speed. A

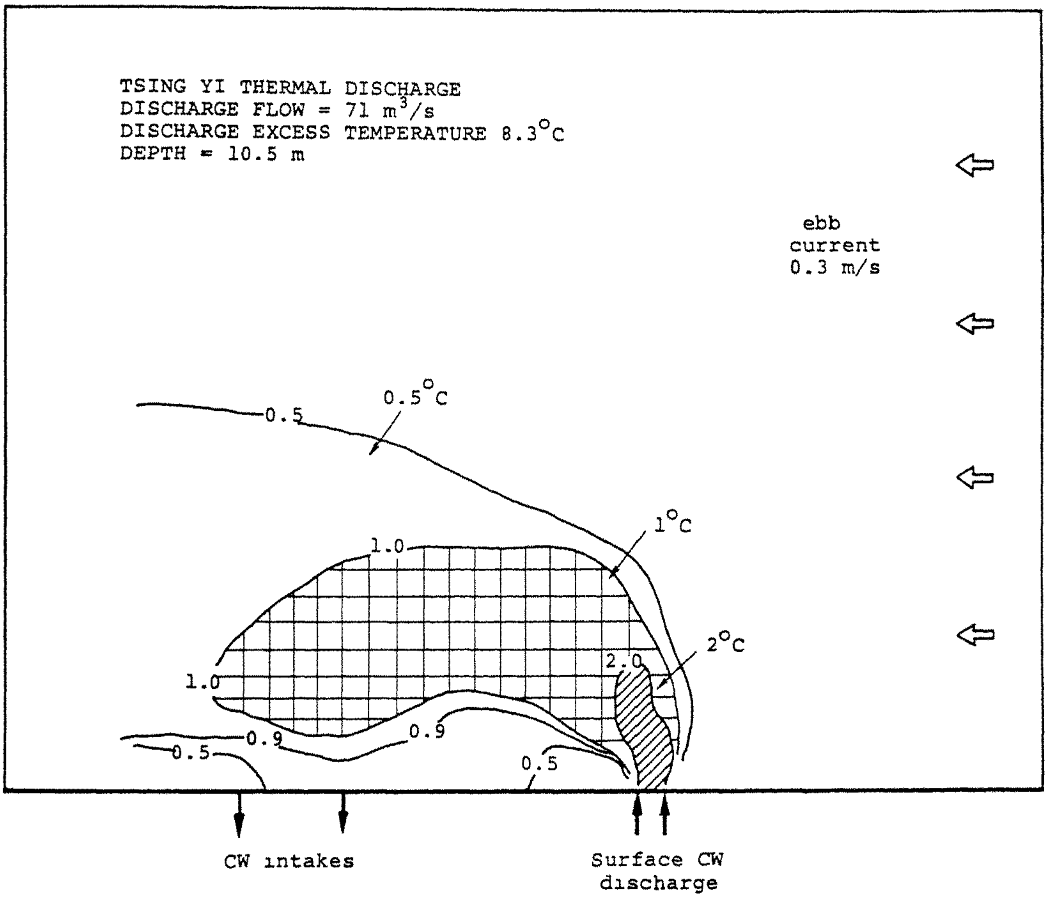


Fig. 5 Experimental results in a 1:150 schematic physical model of the Tsing Yi thermal discharge. Measured surface temperature field (isotherms refer to temperature excess in °C above the background temperature) in the vicinity of the power station in a relatively strong ebb current. Note the plume attachment "hugging" to the downstream shoreline

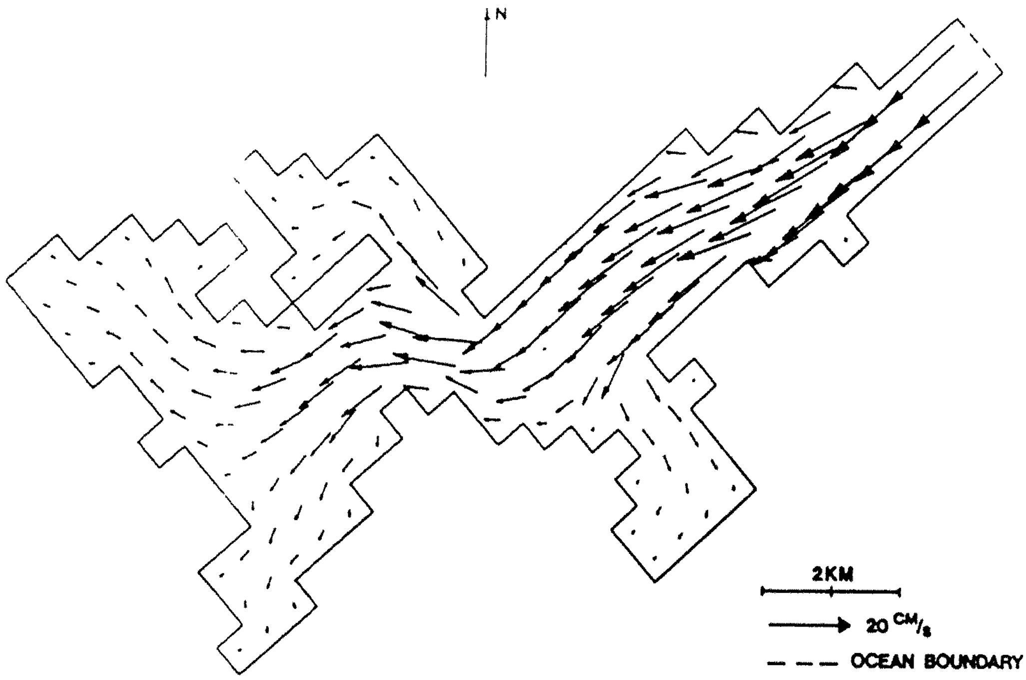


Fig. 6 Example of computed flood currents in Tolo Harbour

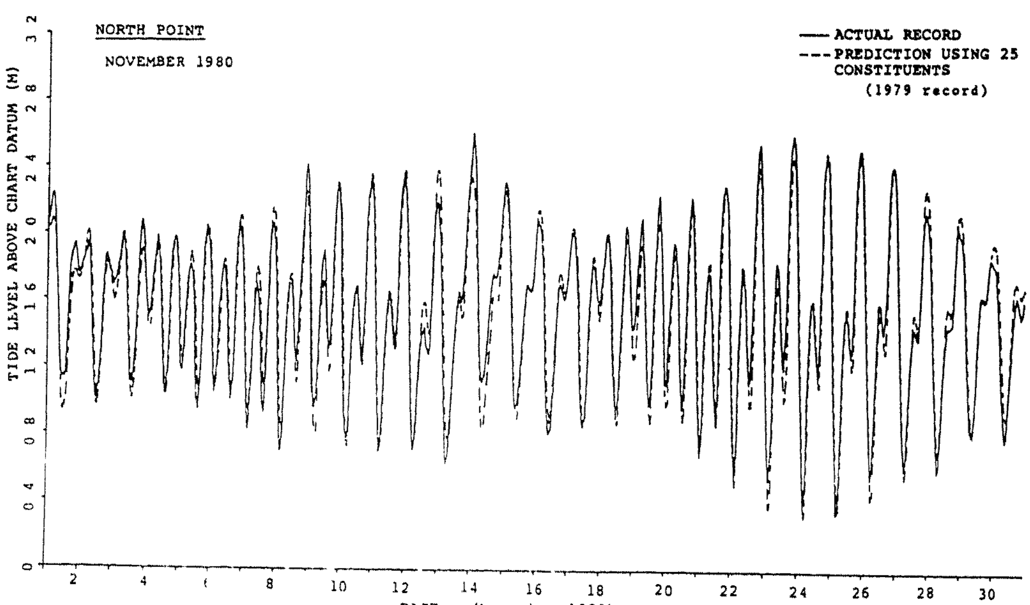


Fig. 7 Example of tide prediction at North Point

series of intensive 26-hour field surveys have been carried out to supply the necessary data for model calibration and verification. Fig. 8 shows an example of the dissolved oxygen variation during an algal bloom. The carrying capacity of a water body in relation to organic loading and fish stocking can be determined from such a model. The model can also be used to forecast severe oxygen depletion conditions, when major fish kills may occur.

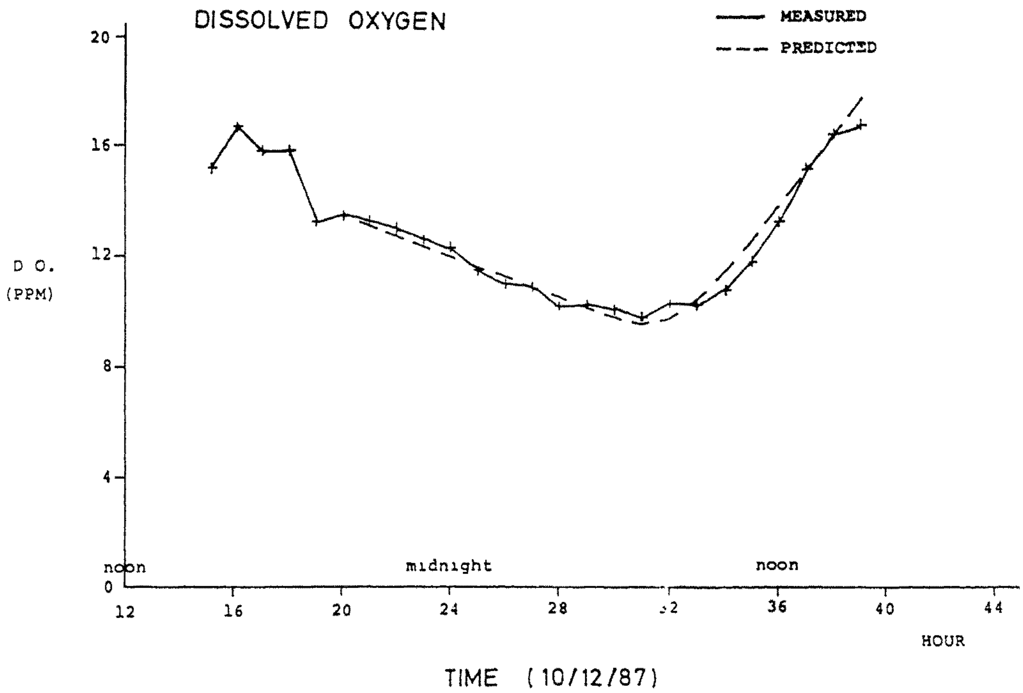


Fig. 8 Diurnal dissolved oxygen variation during an algal bloom in December 1987, Three Fathom Cove

LONGITUDINAL DISPERSION IN STREAMS

Longitudinal dispersion plays an important role in the response of a stream to the discharge of pollutants. With an ever increasing number of industrial wastes coupled with the lack/inadequacy of proper disposal facilities, pollutant releases to local streams are on the increase. A clear understanding of the mechanics of dispersion is essential for predicting the concentration profiles resulting from routine/accidental release of pollutants into water bodies; for taking appropriate measures during emergencies such as, for example, in the case of an accidental spill of a toxic substance; for setting limits for releases of common waste; and for overall management of the water environment. The Civil and Structural Engineering Department of the University of Hong Kong has been actively involved in studying the various aspects of the dispersion problem since the later 1970s. A brief qualitative description of the work done is given below:

Mathematical Modelling of the Dispersion Process

Dispersion prediction involves three problems. Firstly, the physical/chemical/biological processes that take place when a pollutant is discharged into a water body must be identified and quantified. They must then be simplified to make practical sense. A computer-oriented solution free from numerical instabilities must then be developed to solve the resulting equations.

The advective diffusion equation which describes the longitudinal dispersion process in terms of bulk flow parameters is applicable only after an initial period -- often known as the "convective period" -- has elapsed. The dispersion coefficient which is the most important parameter in the equation depends on flow and geometrical parameters and can also be considered as dependent upon time during the initial stages of mixing. Following this idea, a relatively simple model in which the dispersion process is considered as consisting of three stages has been proposed in some of the early work carried out by the Civil and Structural Engineering Department. After extensive laboratory experiments, the parameters of the model structure have been established. Tracer studies were later carried out in some selected streams in Hong Kong using sodium chloride in streams where the water quality was good, and Sulphorhodamine B in streams where the background pollution level was very high. Estimated dispersion coefficients using the proposed three-stage model were found to be in satisfactory agreement with measured values. The concentration profiles obtained by the proposed mathematical model were also found to be in reasonable agreement with measured data (Fig. 9).

Dispersion through Porous Media

Relatively less attention has been given to the pollution of sub-surface water perhaps because it cannot be seen. The response to sub-surface water contamination is very slow, giving a long lag time between the cause and the effect.

Infiltration of rain water through contaminated soils is one cause of sub-surface water pollution. This occurs to some extent in controlled tips. The solutes travel through the unsaturated soils and may reach the water table. A solution to the moisture movement problem must therefore be first obtained and used in the solute transport problem.

Initial studies on the moisture movement in unsaturated soils carried out in the Civil and Structural Engineering Department have been using reconstituted soils under laboratory conditions. These include the determination of the soil hydraulic parameters which have very high degrees of non-linearity with respect to the soil moisture content, mathematical model development, and application for prediction. Similar work on the solute transport problem has also been carried out under laboratory conditions. The results are satisfactory. Fig. 10 shows the similarity between the volumetric moisture content and the solute concentration when plotted against a function of depth and time. A field monitoring programme to measure various soil hydraulic parameters and parameters of hydrodynamic dispersion has also been initiated at the Kadoorie Agricultural Research Centre.

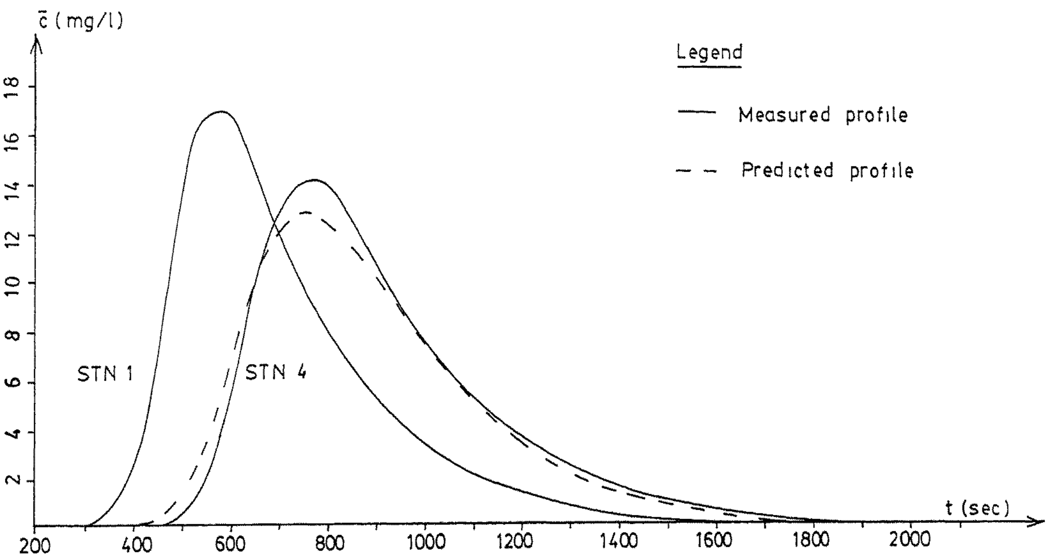
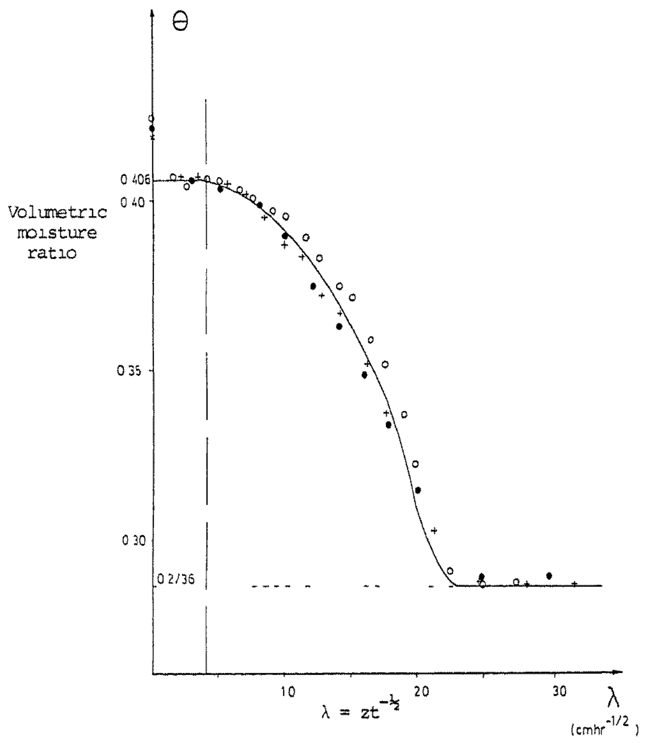


Fig. 9 Comparison of predicted and measured concentration profiles using field data
Test No. 3 - Tung Chung Stream

STOCHASTIC MODELLING

For planning and design purposes, it is often necessary to understand the long term behaviour of a system. The environmental variable is then considered as consisting of a deterministic component with an outcome which can be determined with some degree of certainty and a stochastic component with an outcome attributed to chance and which can therefore only be described in probabilistic terms. The historical data, usually in the form of a time series, are decomposed into trend,



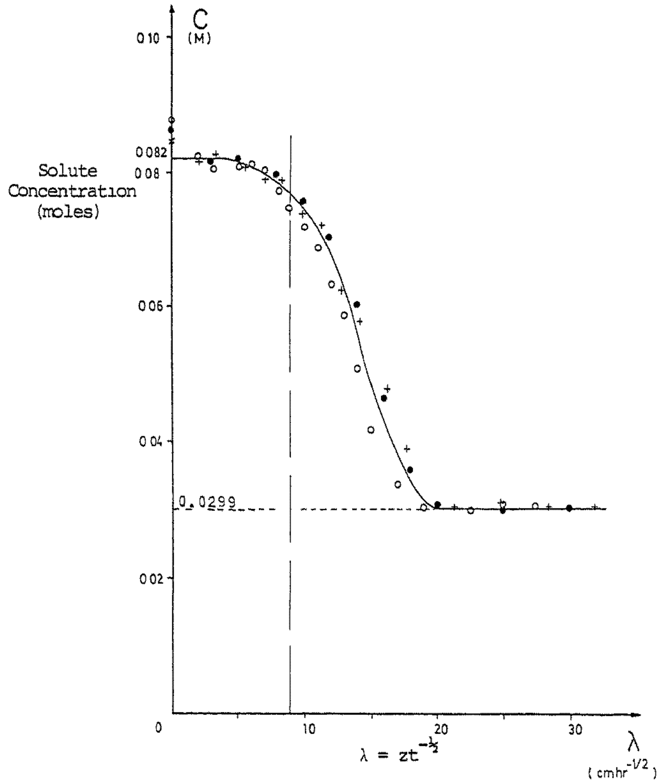


Fig. 10 Predicted and observed volumetric moisture content θ and the solute concentration (moles) versus depth and time, $\lambda = zt^{-1/2}$. The three different symbols correspond to 1, 2 and 4 hours since infiltration commenced

cyclic, dependent, and independent components and then synthesized by working in the reverse sequence, starting from a newly generated sample of the particular probability distribution function which fits into the independent component.

Research in this area of study commenced as a result of a UNESCO-sponsored project in which several teaching modules for strengthening the postgraduate curriculum in Environmental Engineering were developed. These were backed by several software packages which included stochastic modelling. The work has subsequently been extended to water quality time series modelling and forecasting using ARIMA and Fractional Differencing type of modelling.

For more technical details the reader is referred to the papers listed in J.H.W. Lee, A.W. Jayawardena and K.T. Chan, "Mathematical and experimental modelling of some environmental problems", Hong Kong Engineer, Vol. 15, No. 6, pp. 33-45, June 1987.

HYPERCUBE SUPERCOMPUTERS

C.C. Lau

A hypercube supercomputer consists of many computers arranged in a parallel processing network that results in a very high throughput, usually measured in MIPS (Million Instructions Per Second). In a hypercube, each computer shares part of the computation load and, interacts with its neighbours via respective communication links. A computer and its associated communication links form the basic unit of a hypercube, usually called a node. The number of nodes and the connection between nodes in a hypercube can be varied by its users to cope with different applications.

The development of hypercubes relies on the development of Very Large Scale Integration (VLSI) chips and software packages with the following features: (1) high computation power, (2) fast node-to-node data transfer, (3) efficient use of node memories, (4) optimal task decomposition and distribution, (5) efficient task synchronization, and (6) efficient fault detection and recovery. Commercial VLSI products specially designed for implementing hypercubes are few. Up to now, only two families are available from the market, namely: Transputer developed by Inmos and M88000 developed by Motorola. Researchers and users of hypercubes often have to construct their own systems using general-purpose microprocessors or custom chips. Among about 100 hypercubes in the United States, many are constructed using 8086, 80286 or 68020; examples include Waterloop/64, System 14, and Butterfly, ... etc. A few are constructed using custom chips such as NCube/ten and Connection Machine. Almost all of them use serial links for node-to-node communication. Most existing hypercubes are being used by research institutions or government laboratories.

Constructing an experimental hypercube, using high-performance general-purpose microprocessors and supporting chips off-the-shelf, is also a cost-effective way to collect experience for designing more mature hypercube hardware and software in the future. Using chips off-the-shelf, one can ignore some useless functional units inside a chip and supplement new functional units using off-chip logic. The new combination of on-chip and off-chip logic will lead to the design of new hardware, with its compatible software developed in parallel.

Staff and students of the Department of Electrical and Electronic Engineering have also pursued the development of hypercubes using special-purpose microprocessors (TMS32010), and general-purpose microprocessors (MC68000), respectively. The general-purpose hypercube will be upgraded to a 68030-based one this year. The new design divides a large hypercube into smaller sub-cubes. Sub-cubes communicate with neighbouring sub-cubes via serial links. Each node in a sub-cube contains two 68030-68881 pairs. Processors in a node can access their local memory and memories in neighboring nodes via a switch matrix which, in turn, is controlled by a decentralized arbiter, one in each node. Reconfiguration can be done by changing the physical links between nodes or sub-cubes or by programming the arbiter in each node, which keeps part or all of the switches in a matrix open, isolating a node from part or all of its neighbours. Resource sharing and processing-synchronization logic is implemented in each node in a small mailbox which is always accessible by all neighboring nodes at high speed. Accessing other areas of neighbouring memories is controlled by the resource-sharing logic which is also programmable.

IMPACT MICRO-VISCOMETRY

P.L. Wong and S. Lingard

Part of an ongoing programme of research in tribilogy in the Department of Mechanical Engineering is a project aimed at developing a technique for the determination of the rheological properties of liquids at extremely high pressures. The significance of the topic is perhaps best appreciated from the fact that lubricants in high performance gears and rolling bearings can operate at pressures up to 2 GPa (about 300,000 lbf/in^2). The flow characteristics of liquids under such conditions are largely unknown because conventional viscometers are unable to sustain pressure intensities which exceed the mechanical strength of most structural materials. A method of measuring and observing flow at elevated pressures is therefore of considerable novelty and interest.

The technique employed is based on experiments in optical elasto-hydrodynamics carried out at Imperial College in the 1970s, when it was observed that a steel ball dropped on to a glass plate in the presence of a liquid film causes a small reservoir or dimple of fluid to be trapped between the two bodies (Fig. 1). Subsequent flow of the fluid may be observed and recorded by optical interferometry. The experimental arrangement is shown in Fig. 2. Twin beams from a He-Ne laser are used to generate interference images which are recorded using a video camera and processed in digital form in a micro-computer system. The use of two beams enables the refractive index and density of the fluid to be determined as well as the film shape, and results in simultaneous dual images as illustrated in Fig. 3. The ability to record and process the optical data on a real time basis is essential to the fulfilment of the project objectives because simultaneous solution of the equations of elasticity and hydrodynamics for the whole flow field at successive time intervals is necessary. However, the flow is axi-symmetric and a solution for any radial path, once found, provides viscosity data for a wide range of pressures varying from atmospheric at the edge to perhaps 1-2 GPa at the centre. The length of the flow path is of the order of 0.1 mm and its thickness of the order of 0.0001 mm, so that the quantity of fluid required is only the merest droplet.

Results have been obtained for a number of fluids, using strikers of glass, steel, and tungsten carbide of different radii to suit the pressures and viscosities needed. The accuracy of the technique has been established by comparison with existing data obtained by other methods at relatively low pressures. At very high pressures some interesting features are observed. With certain fluids for example, flow rates are negligible in the high pressure regions and evidence suggests that a glass transition and, to all intents and purposes, a liquid-solid phase change has occurred. In most cases the effective viscosity of the fluid is shown to vary with time (Fig. 4), a phenomenon which is difficult to explain.

Efforts have been directed towards analyzing the flow in the light of the time-dependent behaviour which have culminated in the development of a new non-Newtonian fluid model. The validity of the model is under investigation by assessing its ability to adequately predict other characteristics of concentrated contact film behaviour, the explanations for which have long been controversial.

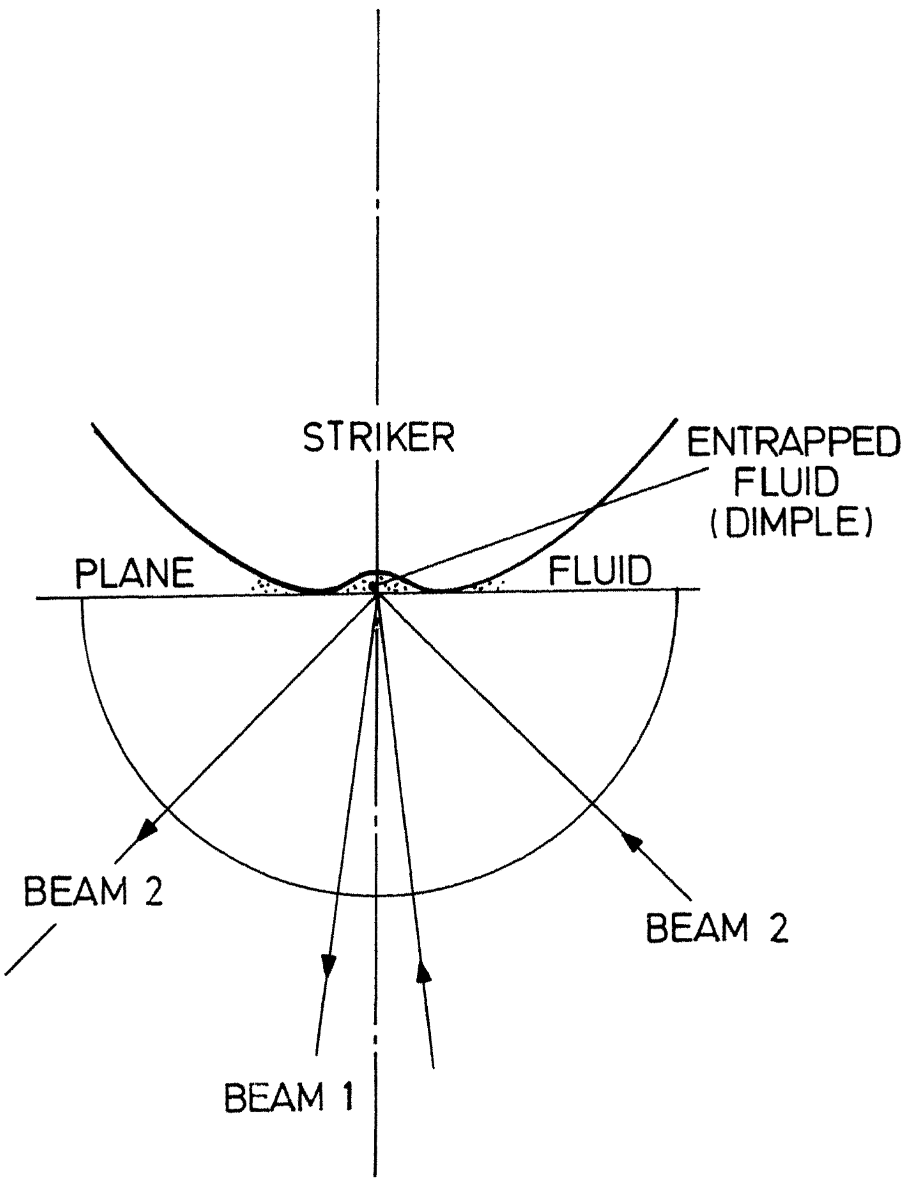


Fig. 1 High pressure entrapment

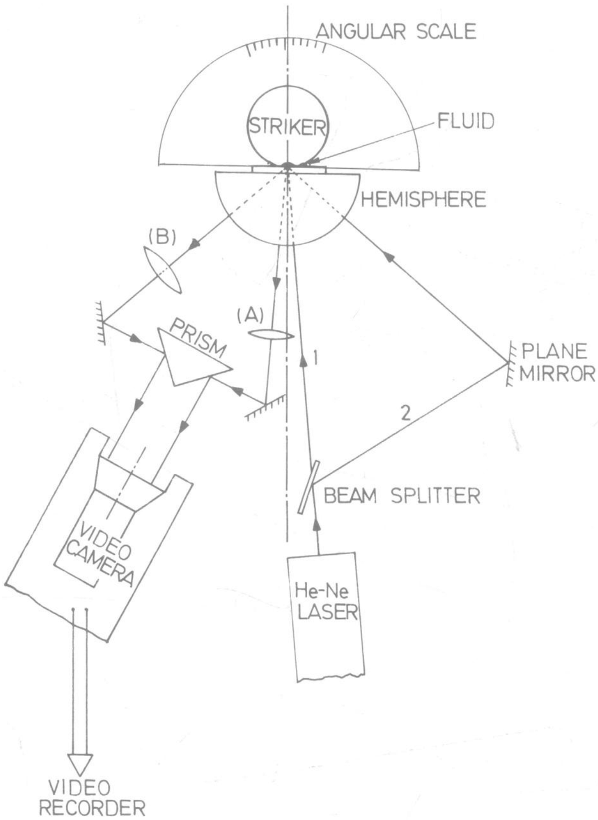


Fig. 2 Optical arrangement

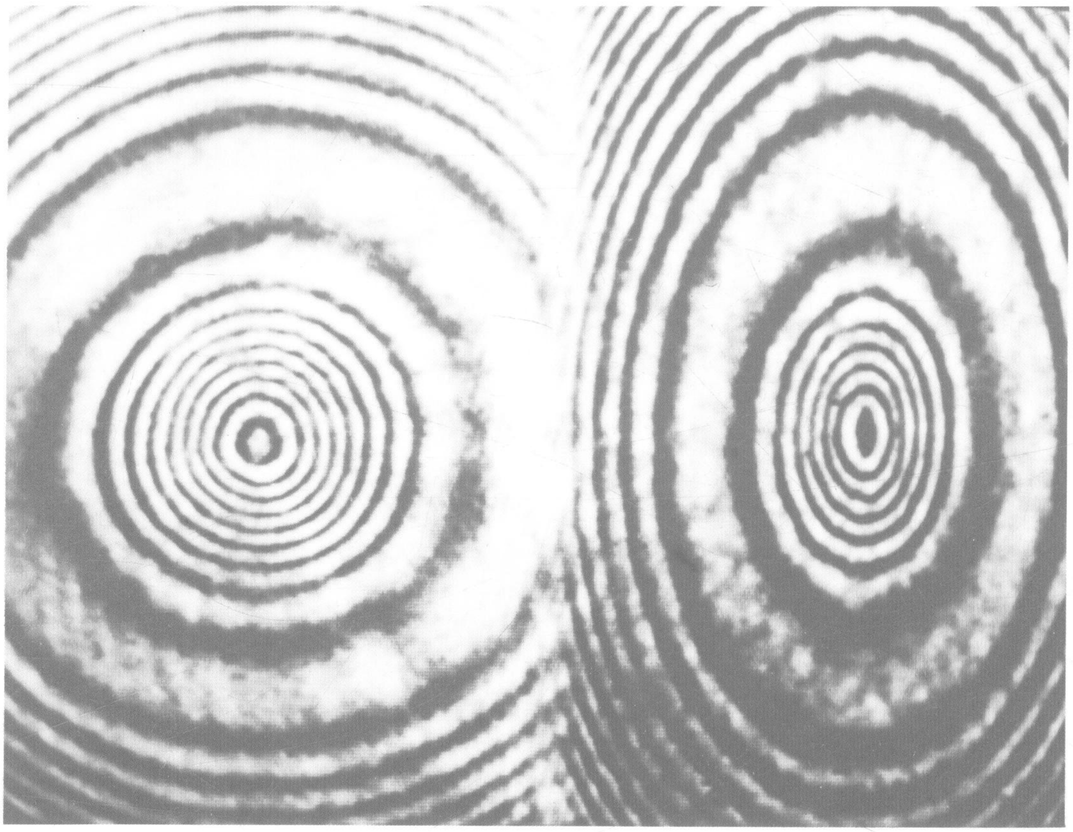


Fig. 3 Interference images (2 beam angles)

EFFECTIVE VISCOSITY AGAINST PRESSURE, LVI 260

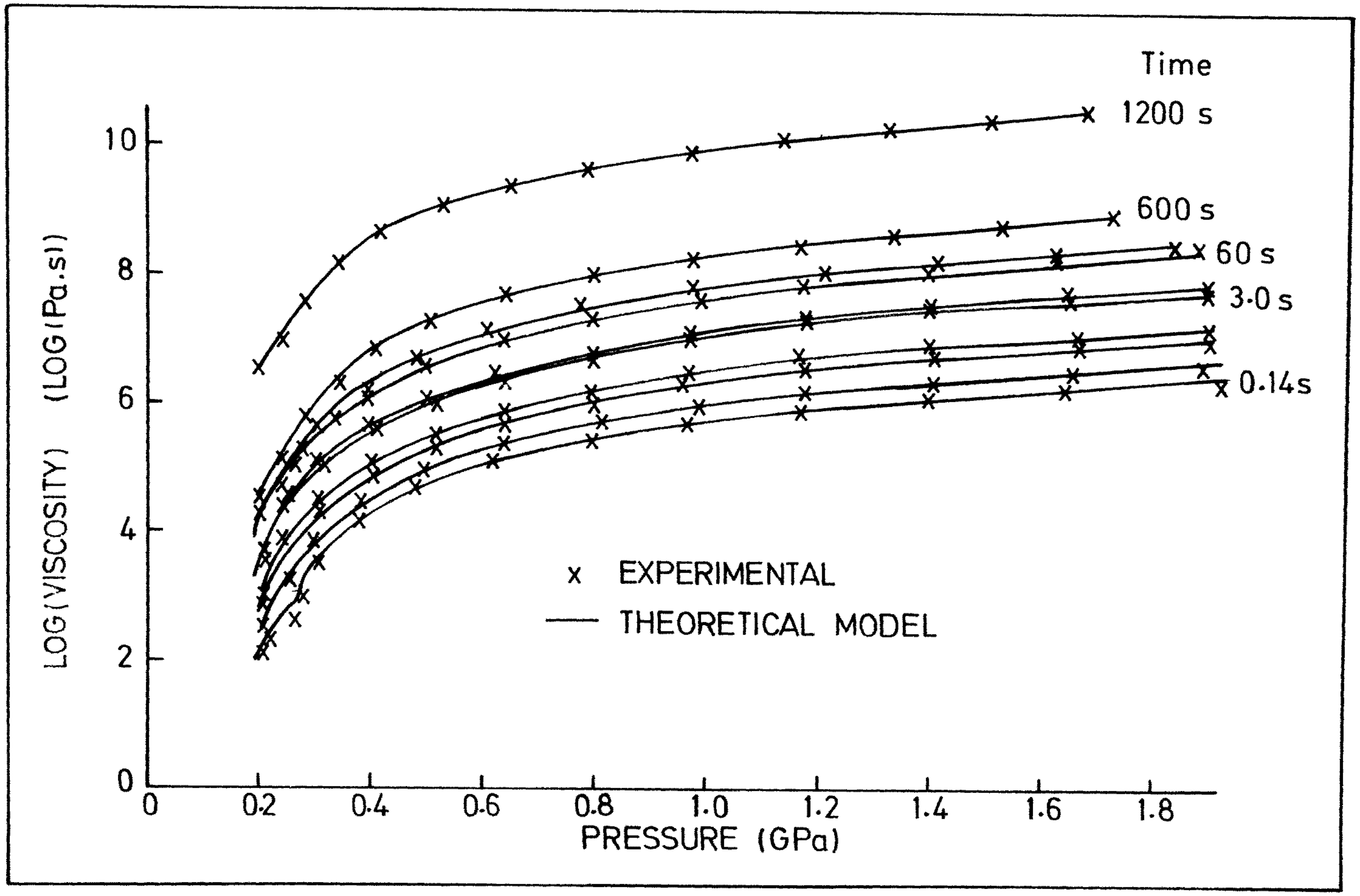


Fig. 4 Variation of effective viscosity with pressure

INTERNATIONAL COLLABORATION IN CIVIL AND STRUCTURAL ENGINEERING

Y.K. Cheung

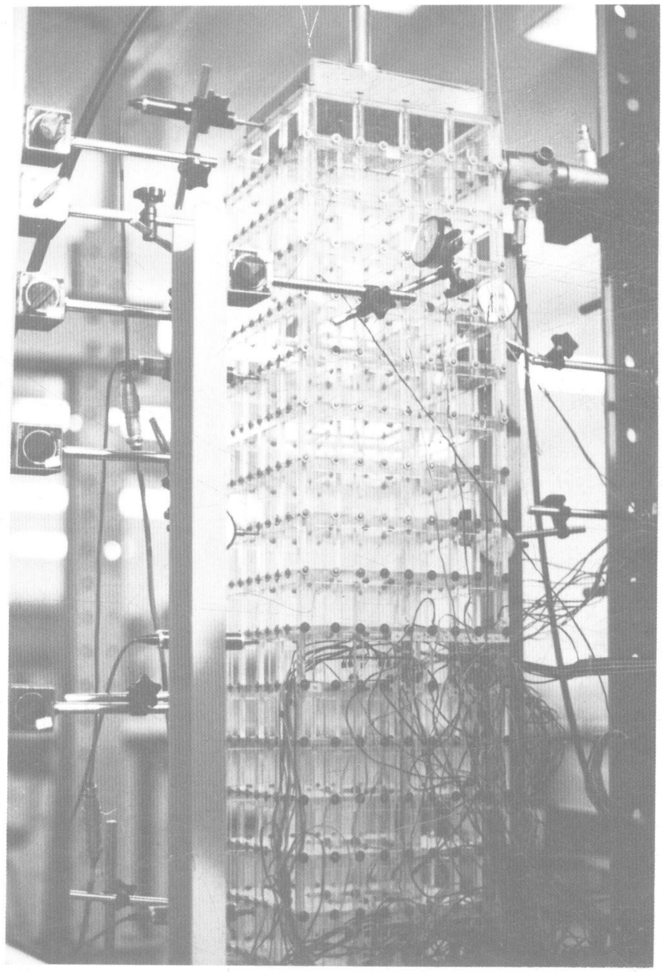
The Department of Civil and Structural Engineering has a long history of undertaking both collaborative and externally-funded research which has enhanced its reputation internationally. Below is a summary of three projects which are currently being undertaken; others are highlighted elsewhere in the publication.

RESEARCH ON TALL BUILDINGS

Tall buildings construction can be divided into two sections. There is the section above ground which provides living space for the flats or offices for which it was built. This top part sits on a pile cap which is a base slab of reinforced concrete. Supporting both of these are pile foundations penetrated into the soil to reach underlying bedrock or a stiffer layer which supports the total or most of the loading of the building. Up to now the pile cap has always been considered and designed as rigid and the upper and lower parts of construction have always been considered separately. However these existing methods very often overdesign the structure as a whole and under-estimate the local stress at the joints.

The present investigation includes ways of giving the present rigid bases of high rise buildings some sort of flexibility as a result of making them thinner and using less material, a development which could result in considerable savings in building costs. Further research involves observation of actual buildings, the force present in the piles, and the interaction between the soil and the foundation slab. The aim of the project is to develop a unified numerical model which will allow for the interaction of the foundation, the pile cap, and the superstructure.

This project is carried out in conjunction with the Soil Mechanics and Foundation Engineering Division, Tongji University, Shanghai and is funded by the Croucher Foundation.



Model showing the interaction between tall building and its foundation.

STEEL FRAMES WITH IMPROVED MASONRY INFILLS

It has been known for sometime that the stiffness and strength of steel or reinforced concrete frames are greatly increased when the frames work compositely with the concrete or masonry infills. The concept of using infilled frames to resist wind and earthquake has been recognized and accepted for about two decades. However, conventional masonry infills have many inherent weaknesses, and a continuation of research in this field using non-conventional improved masonry is highly desirable in order to expand knowledge and to promote confidence to a significant level for practical applications, e.g. in restoration of damaged buildings and in strengthening of existing buildings for various reasons, apart from designing new buildings against strong wind and earthquake.

The aim of this research is to employ, or modify if necessary, the methods of improving the properties of conventional masonry in order to incorporate the improved masonry in the infilled frame. The general characteristics of such improved masonry infilled frames are to be established through experimental work and theoretical study. A second aim of this research is to develop methods for prediction of the lateral stiffness and strength of the improved masonry infilled frames by means of experimental work and theoretical investigation.

This research programme involves the co-operation of the Department of Civil Engineering, University of Edinburgh, one of the leading centres in the research of masonry structures and is funded by the Croucher Foundation.

CROUCHER FOUNDATION GRANT, LEE HYSAN FOUNDATION GRANT, AND PUI HUA FOUNDATION GRANT FOR VISITING ACADEMICS FROM CHINA

Since 1984 the Lee Hsyan Foundation (1984 & 1987), the Pei Hua Education Foundation (1984), and the Croucher Foundation have all made substantial grants to enable visiting academics from China to participate in joint research in our Department on a short-term basis. This scheme has been running successfully with about two to three academics from China visiting the Department annually. The visitors have come from Zhongshan University, Institute of Mechanics of Chinese Academy of Sciences, Tongji University, Jiangsu Institute of Technology, Dalian Institute of Technology, Zhejiang University, and Beijing University.

MOIRE INTERFEROMETRY FOR DEFORMATION MEASUREMENT

A. Asundi

INTRODUCTION

Moire, as understood by engineers, is the pattern resulting from the superposition of two slightly dissimilar geometric patterns. For deformation measurement the geometric patterns are usually a set of dark and bright uniformly spaced lines called gratings. Two gratings are commonly used: a specimen grating printed on the specimen surface and a reference grating. Initially the two gratings are identical. On applying a load, the specimen and hence the specimen grating deforms. Superposition of this deformed specimen grating and the reference grating results in a moire pattern which represent contours of the displacement component perpendicular to the lines of the reference grating -- the *isothetics*. The sensitivity of the method depends on the spacing between the lines on the reference grating -- the pitch of the grating. Until recently, the smallest pitch was 0.025 mm, which restricted the use of moire to fairly large deformation measurement. The technique of moire interferometry has made it possible to measure deformation with a sensitivity of the order of the wavelength of light (0.0005 mm).

This article describes the application and development of moire interferometric systems for analysis of adhesively bonded joints, deformation in composite materials, vibration analysis, and fracture mechanics.

IN-PLANE DISPLACEMENT MEASUREMENT

For complete 2-D strain determination, displacement components along two mutually perpendicular directions are desired. Thus the specimen grating is generally a cross line grating. The pitch of the gratings used in these studies was either 0.00083 mm or 0.00167 mm, or in other words the gratings had 1200 or 600 lines/mm. Printing of the grating on the specimen is quite routine and simple. The reference grating was created by optical interference and is referred to as a virtual grating since it is not physically present. The pitch of the reference grating is chosen to be twice that of the specimen grating. Thus the displacement sensitivity is 0.00083 mm/fringe for a 600 lines/mm specimen grating.

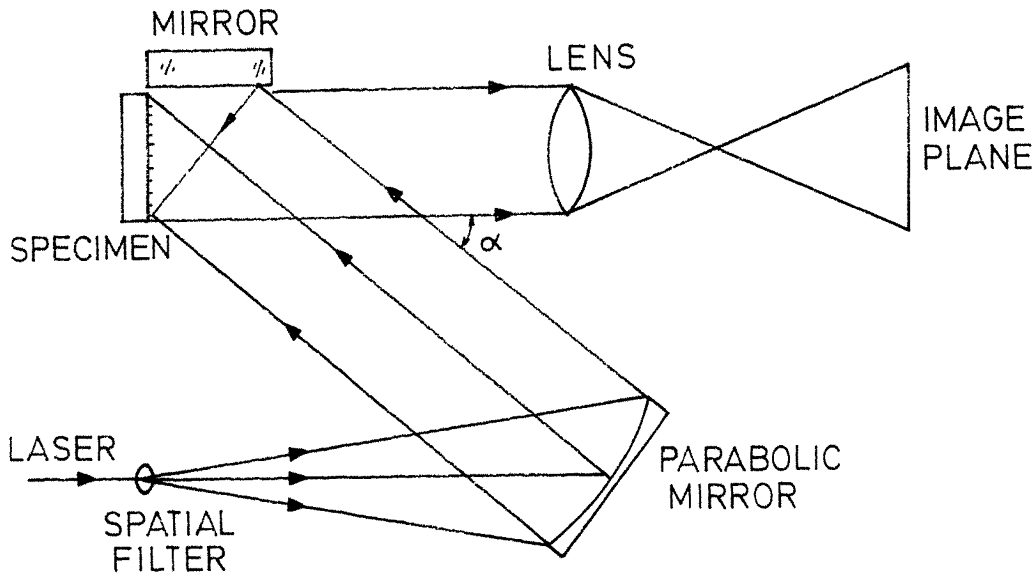


Fig. 1 (a) Set-up for moire interferometry

A schematic of the experimental set-up is shown in Fig. 1(a) at an angle α, while the other half reflects off the plane mirror and is incident on the specimen at a symmetric angle α. These two beams interfere to produce a virtual grating whose frequency f_v is governed by the diffraction equation

$$f_v = 2 \sin \alpha/\lambda$$

where λ is the wavelength of the laser.

The virtual reference grating so created has lines only in one direction and hence will interrogate only the corresponding grating on the specimen. An alternative scheme to simultaneously obtain both the in-plane displacement components is shown in Fig. 1(b). Beams A and D interfere to create a virtual grating with lines parallel to the x-direction and along with the corresponding specimen grating produce the u-isothetics. Similarly beams B and C create a virtual grating in the y-direction and interfere with the corresponding specimen grating to yield the v-isothetics. Fig. 2 shows the u and v isothetic patterns used in a study of the deformation around an adhesive layer bonding two quasi-isotropic graphite-epoxy members under bending. Each fringe represents a displacement of 0.000417 mm.

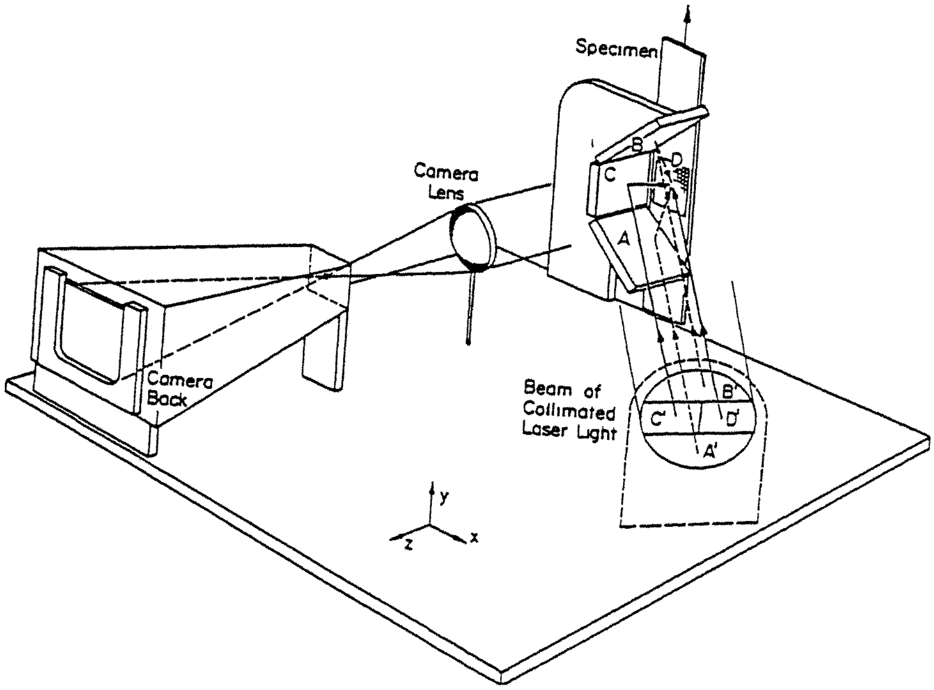


Fig. 1 (b) Schematic of set-up for simultaneous measurement of both in-plane components

APPLICATIONS

Adhesive Joints

Moire interferometry has been used to determine the strains and stresses within the thin (0.3 mm - 0.7 mm) adhesive layer in a bonded lap joint (Fig 3(a)). A typical u-isothetic pattern is shown in Fig. 3(b). The fringe sensitivity is 0.00083 mm. It was quite obvious that the gradient $\partial u/\partial y$ was by far the largest within the adhesive layer. In fact it was found to be an order of magnitude greater than any of the other gradients. Thus the shear strain is the most significant component. Further it can be seen that this gradient and hence the shear stress drops significantly towards the centre of the joint.

Composite Deformation

Moire interferometry has also been used to detect small localized irregularities in the complex deformation of composite materials. Fig. 4 show the u and v isothetic patterns in a $+45°$ 8-ply graphite epoxy composite tensile specimen with a central hole. Clearly defined bands of deformation are observed along the fibre direction. The strains can be quantified both in this damaged region and the surroundings. In

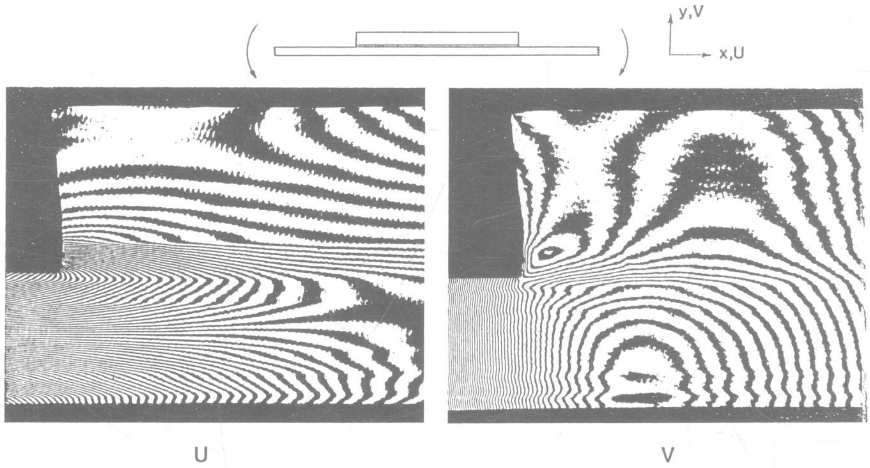


Fig. 2 In-plane isothetics around the adhesive layer bonding two composite plates

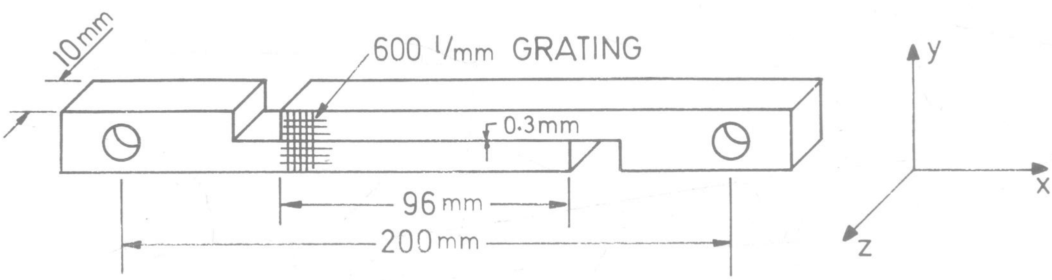


Fig. 3 (a) The adhesive lap joint used in the study of stresses within the adhesive layer

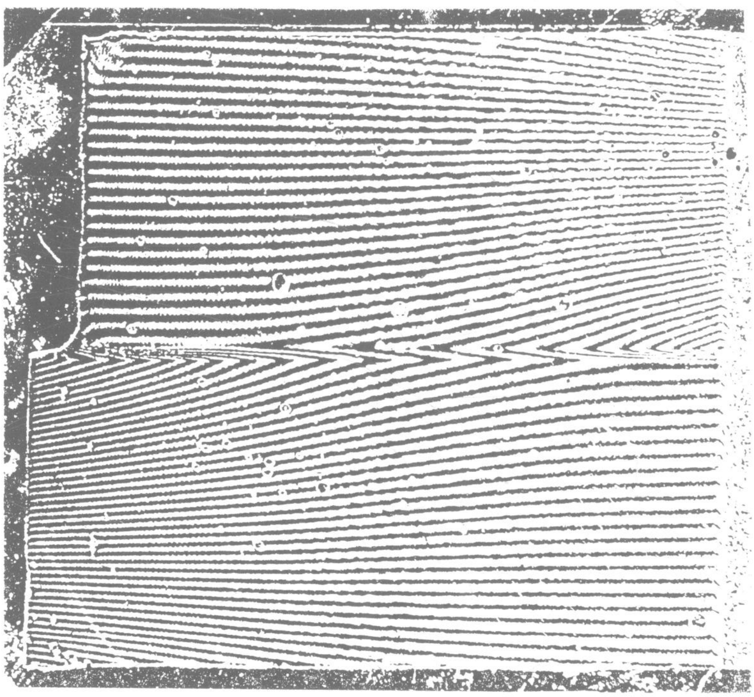


Fig. 3 (b) A characteristic u-isothetic of an adhesive lap joint some instances the uniform part of the strain overshadows the small non-uniformities. Fig. 5(a) is an example of the displacement component along the loading direction of a glass fibre woven composite plate with a small hole subject to tension. Close inspection of the fringe pattern reveals the non-uniformities as small variations in the numerous uniformly spaced fringes. These non-linearities are enhanced using moire of moire interferometry as evident in Fig. 5(b).

OUT OF PLANE DISPLACEMENT MEASUREMENT

The moire interferometric set-up was modified to yield contours of out-of-plane displacement with the same high sensitivity. The set-up of Fig. 1(a) is altered as follows: the specimen and specimen grating is replaced by a high frequency real reference grating, and the specimen whose surface has to be specular replaces the plane mirror. For this case the specimen does not have to be imprinted with a specimen grating. In this case the virtual grating deforms due to the out-of-plane displacement of the specimen. Moire fringes are thus formed by the interference of the deformed virtual grating and the real reference grating. Since the object is not recorded normally, the imaging plane has to be suitably inclined to correct for this distortion. Fig. 6 is the modified version of Fig. 1(b) to simultaneously map all three displacement components. The reflective grating C doubles as a plane mirror for in-plane measurement and a reference grating for out-of-plane displacement mapping.

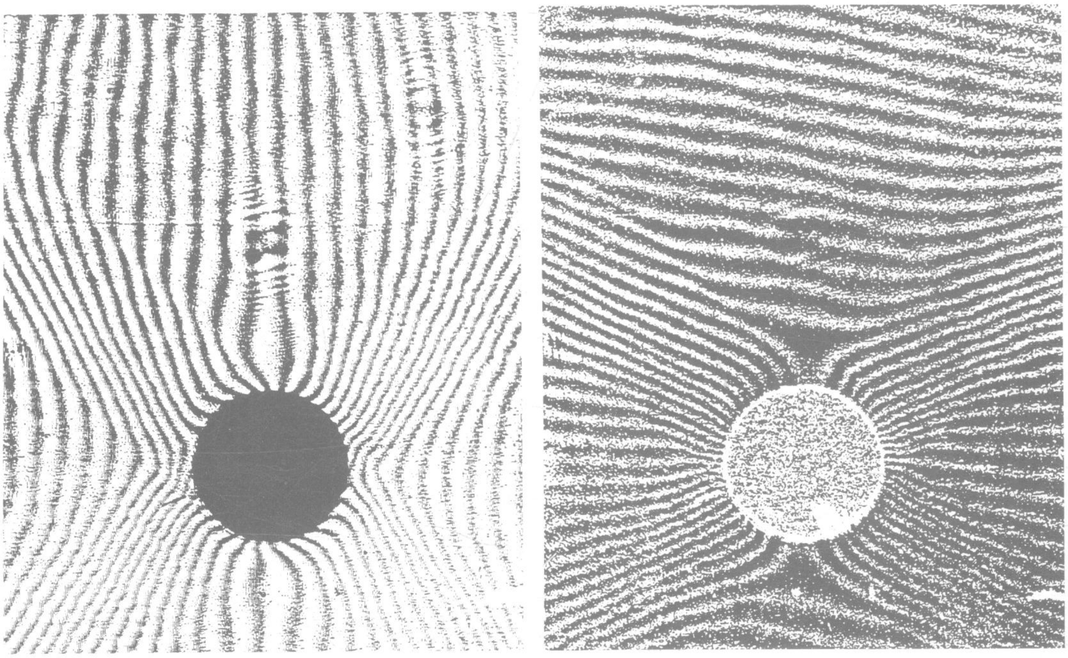
APPLICATIONS

Fracture Mechanics

This new technique was used to map the topography around a crack tip with a view to determining in the first instance regions where linear elastic fracture mechanics is not applicable. Fig. 7(b) shows that the deformation is not unbounded as predicted by theory.

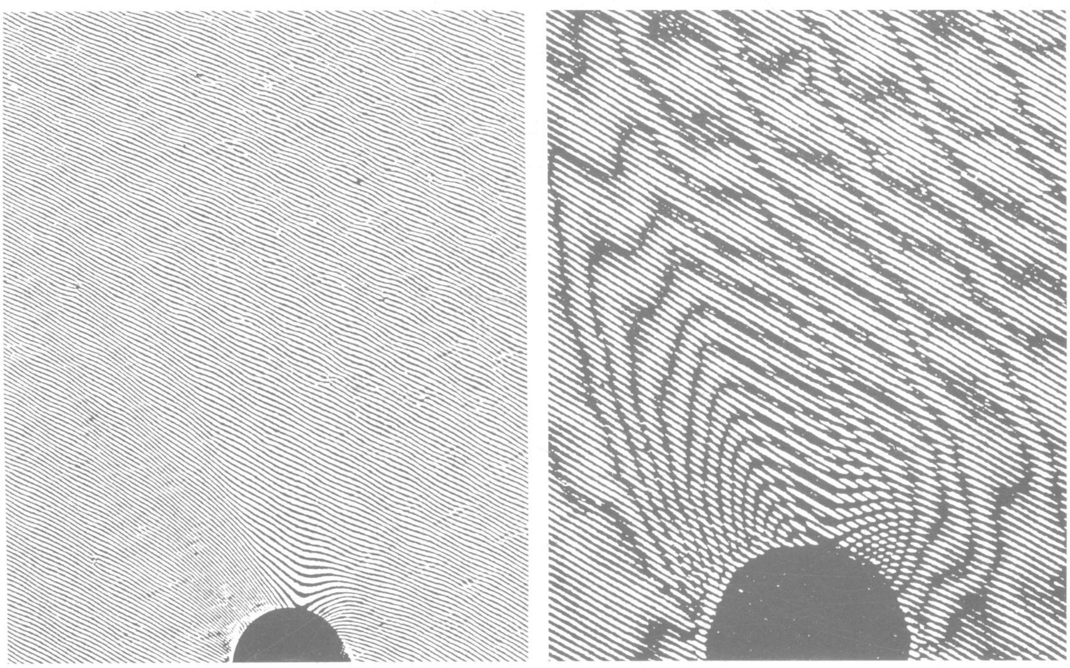
Vibration Analysis

The technique has also been shown to be capable of locating nodal regions and measure the amplitudes of vibration of sinusoidally vibrating plates. Fig. 8 shows the time averaged moire interferometric patterns of a square plate (only half the plate is shown) vibrating at frequencies ranging from 1kHz to 8kHz. The brightest fringe (or fringes) are the nodal areas while the vibration amplitudes at other areas can be deduced from the other fringes.



(a) (b)

Fig. 4 (a) u and (b) v isothetics on a +45° graphite-epoxy composite plate



(a) (b)

Fig. 5 Subtraction of the uniform part of the strain from (a) to enhance the non-uniformities as in (b) using moire of moire interferometry

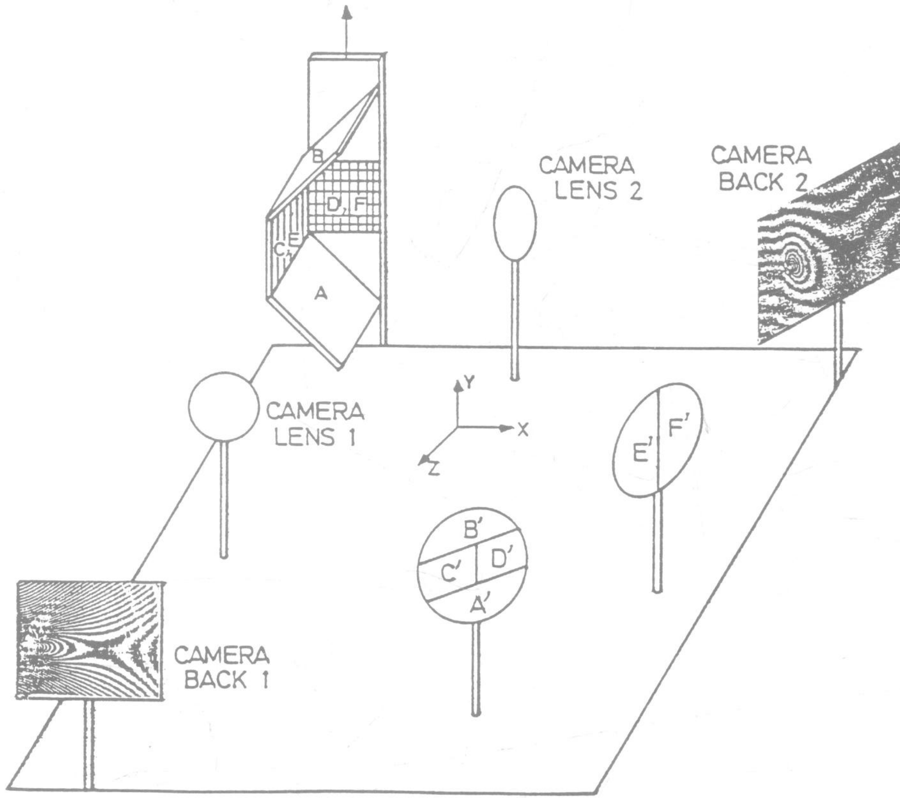


Fig. 6 Schematic of set-up for simultaneous measurement of all three displacement components

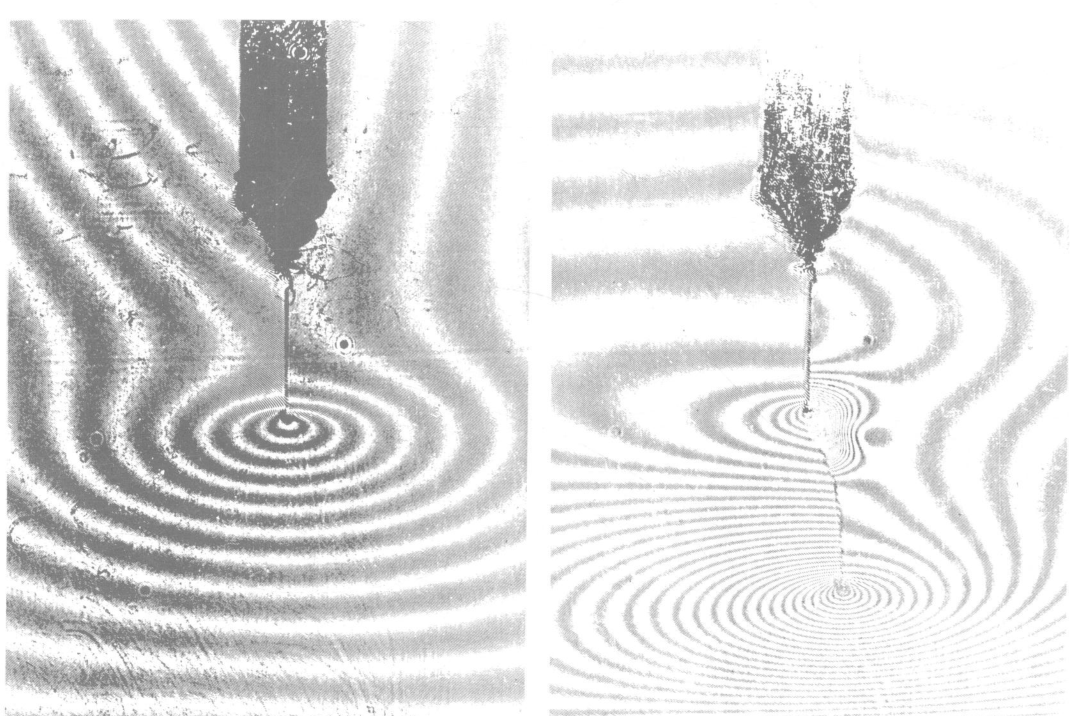


Fig. 7 (a) Out-of-plane displacement contours for a compact tension specimen before and after crack propagation

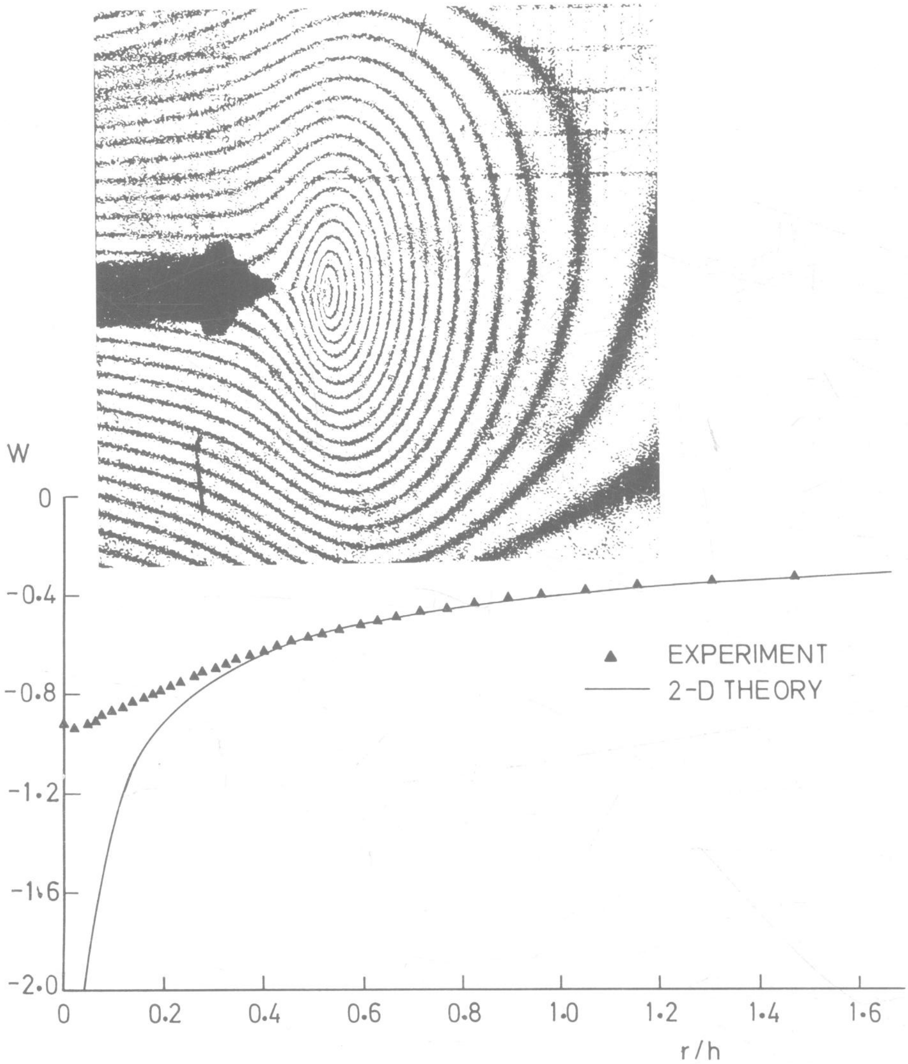


Fig. 7 (b) Out-of-plane displacement ahead of the crack tip -- comparison of theory and experiment

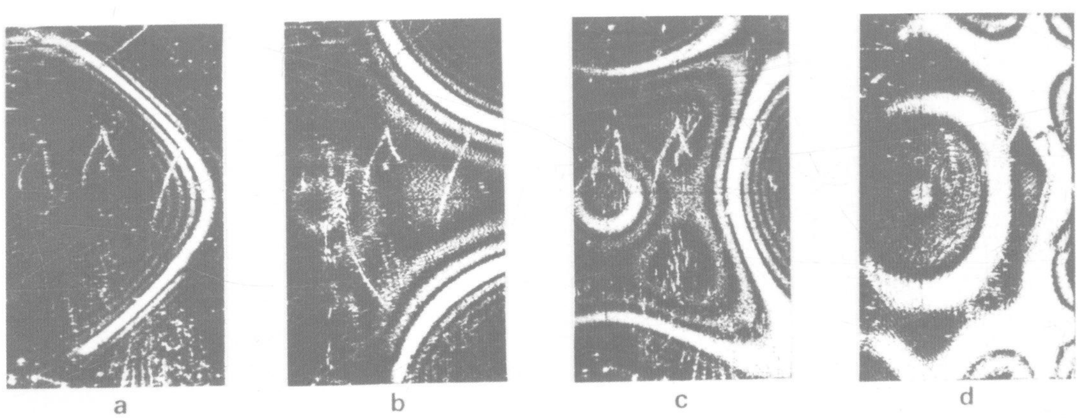


Fig. 8 Time-averaged patterns of a square plate vibrating at different frequencies

MONITORING OUTPUT PERFORMANCE OF MOTORS

Leung Wai-sun

INTRODUCTION

The torque-speed characteristic is the most important property of a motor. It determines not only the output power and speed of the machine but also the type of load the machine is capable of driving. Although there are design equations whereby the torque generated in an induction motor can be calculated at any speed, the validity of the theoretical torque-speed relationships have to be verified experimentally as there are nonlinear relationships, empirical formulae, and stray quantities in the design equations. Conventionally, to measure the motor torque, a range of loads are applied to the motor and the steady-state load torque is measured for each load. The motor torque is then obtained as the sum of the load torque and an estimated frictional torque. This method of measuring torque cannot be applied to the induction motor very well because its steady-state operation is unstable over about 75 percent of its speed range. While there are computational and experimental methods of obtaining the torque-speed characteristics, these methods are indirect and therefore less accurate. This paper presents a direct method of monitoring the motor's output characteristics. The method is based on a modification of a patent (UK patent no. 2127549) held by the author.

MONITORING TORQUE AND SPEED

The torque to be measured is the static motor reaction torque. The special feature of the transient motor torque monitoring system lies in the way in which the test motor is placed on the test stand. Fig. 1 shows the test stand in the form of a turn-table. There is a rubber pad on the top of the table to provide the necessary friction between the table top and the motor, which rests freely and vertically on the table as shown in Fig. 2. For single-phase induction motors, whose starting torques are relatively small, the friction between the rubber pad and the motor is sufficient to prevent the motor from turning relative to the table top. For three-phase induction motors, whose starting torques are larger, the motor is mechanically mounted on to the table. The table top, which rests on a bearing, can rotate relative to the table legs; however, the table top is prevented from turning by a strain gauge which has one end fixed to the table top and the other end fixed to the table leg as shown on the right side of Fig. 1. A flywheel is mounted on the shaft of the motor as shown in Fig. 2. The function of the flywheel is to stabilize the motor during the test and to increase its starting time. The motor's speed is measured by an optical sensor not shown in the figures. By the action-and-reaction principle, the strain gauge will experience a static torque which is equal and opposite to the motor dynamic torque. The test on the motor is performed during the starting period of the motor when both the motor torque (sensed by the strain gauge) and the motor speed (measured by an optical sensor) are monitored.

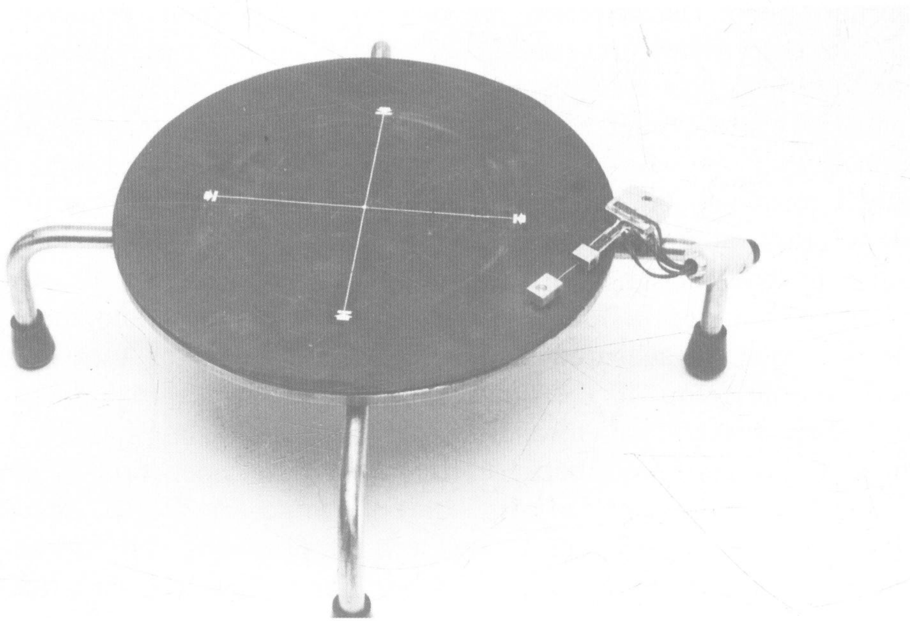


Fig. 1 Turn-table (transducer on right)

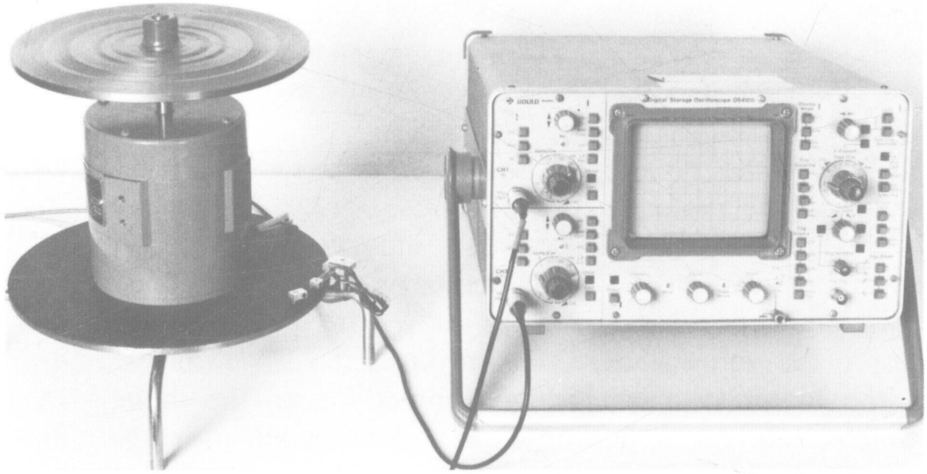


Fig. 2 Test system (optical sensor omitted)

The strain gauge forms one of the four arms of a standard strain gauge bridge. It is important that there is no temperature difference among the four strain gauges. For this reason, the four strain gauges are located close to each other and are housed in an enclosure for protection from any air current generated by the motor's motion. Also, the test strain gauge has to be thermally isolated from the motor. The output signal of the strain gauge bridge is fed to a strain gauge amplifier whose common-mode voltages are removed to overcome the problem of common-mode rejection. The negative input terminal voltage is always held at zero. A circuit for minimizing the noise in the output of the strain gauge amplifier is provided and any bridge imbalance is compensated. The output of the strain gauge amplifier is fed to an operational amplifier whose output voltage is a measure of the motor toruqe. The voltage is filtered and connected to a high-impedence analog voltmeter or a digital voltmeter via an analog-to-digital converter. Alternatively, it is connected to an oscilloscope or X-Y plotter to obtain the torque-time or torque-speed characteristics of the motor.

Since this is a measurement of a static force by means of a strain gauge, the calibration of the measuring system is relatively simple. Standard weights are hung by the strain gauge located at a known radius from the center line of the motor shaft and the readings of the output voltage from the strain gauge amplifier are calibrated directly to read the motor torque. The accuracy of the torque-voltage relationship is ensured by making use of the linear portion of the output range of the strain gauge and of the amplifiers. The accuracy of the transient torques measured will, however, be affected by the presence of the system response, whose effect has to be minimized.

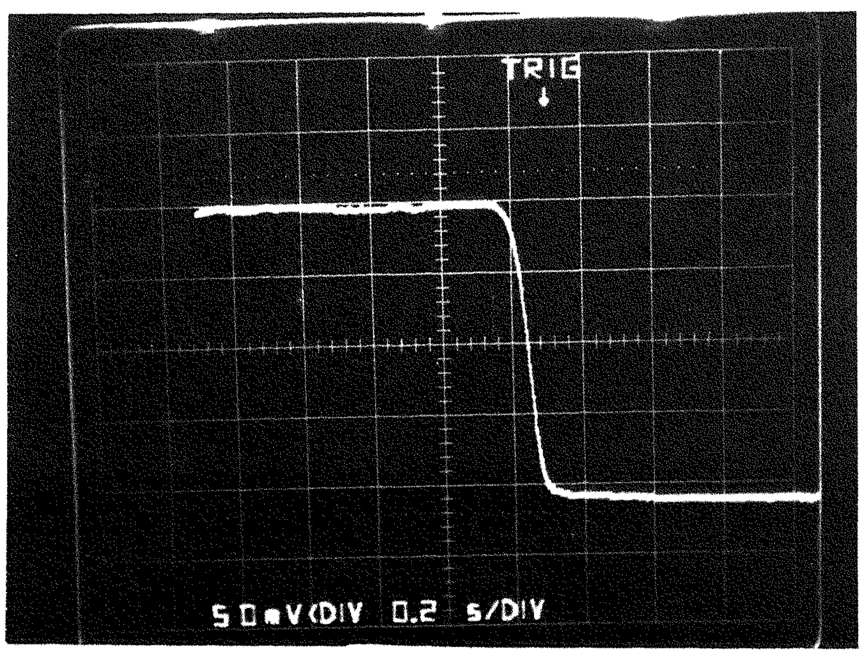
ACCURACY

The starting time of an induction motor is relatively short, and even on-load it can be as short as a fraction of a second. At the instant when the motor is switched on, the torque instantaneously changes from zero to the value of the starting torque. In the torque-time and torque-speed characteristics, this will appear as a step function. In practice, the curves traced in the oscilloscope and X-Y plotter cannot have a vertical gradient owing to the response of the overall measuring system. The falling curve in Fig. 3 shows the response of the torque measuring system to a step-function fall of voltage with the oscilloscope. It takes about 0.1s to attain the new voltage level. The response of the torque measuring system to the same step-function fall of voltage with the X-Y plotter takes about 0.25s owing to the presence of the inertia of the plotting mechanism. The extent to which these responses affect the accuracy of the torque-time and torque-speed characteristics of the motor is dependent on: (i) the starting time of the motor, and (ii) the rate of change in the transient torque. Moreover, there is also the switching transient when the ac motor is switched to "on" from "rest". The torque variations due to the switching transient can be removed from the transient torque characteristics in the measurement by holding the motor momentarily stationary while the motor is switched on and then by releasing it to plot the torque characteristics of the motor on the oscilloscope or X-Y plotter. In this way the motor will be started after its starting current has reached its steady-state conditions and the switching phenomenon will no longer be present. The accuracy of the transient torque characteristics of the motor will increase with an increase of the starting time of the motor. It is estimated that for the accuracy normally expected from a curve in an oscilloscope or X-Y plotter, a motor starting time of 4s with the use of an oscilloscope and that of 10s with the use of an X-Y plotter will be sufficient. The lengthening of the starting time of the motor is achieved by providing the motor with a flywheel.

EXPERIMENTAL RESULTS

The torque-speed characteristics of three single-phase capacitor motors are shown in Fig. 4. They are obtained by releasing the motor to start running after its starting current has settled to its steady-state value. The curves in Fig. 4 show the comparison between the output performances of 4-pole, 6-pole, and 8-pole capacitor motors of the same core diameter and core length.

Voltage



Time

Fig. 3 System response

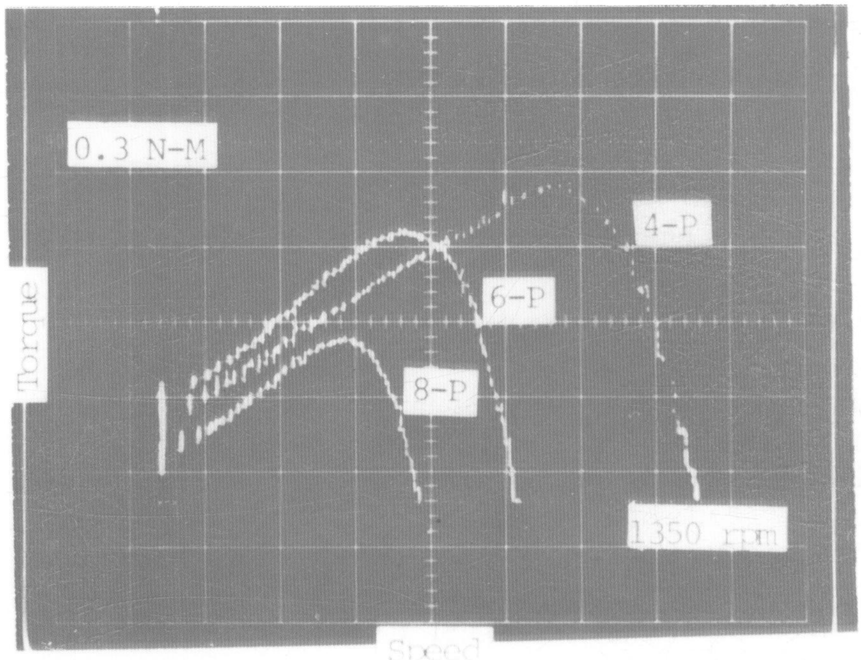


Fig. 4 Torque-speed curves of induction motors

CONCLUSIONS

The special features of the monitoring system are: (i) it measures the transient torque rather than the steady-state torque; and (ii) it measures the motor torque rather than the load torque. Coupled with the fact that it measures the static reaction torque in lieu of the dynamic torque, the method presented offers a convenient, simple, direct, and accurate method for obtaining the motor torque over the full range of speeds of the motor. The accuracy of the transient torque characteristics are ensured by calibrating the torque measurements using standard weights and by making the response time of the measuring system negligible compared with the starting time of the motor. The torque measuring method presented in the paper is particularly valuable for obtaining the torque-speed characteristics of motors whose operation is unstable over a wide range of their speeds.

SELF-TUNING CONTROLLERS

C.W. Chan

INTRODUCTION

There has been a growing interest in recent years in the application of modern control theory to industrial processes. For many years the industrial application of modern control theory has lagged far behind the development of the theory largely because of its very mathematical nature. This has presented a communication barrier between theorists and practical engineers. However, the gap is beginning to be filled by a special breed of engineers who in their basic training have extended their discipline into the mathematics of modern control theory. Coupled with this has been the development of cheap and powerful microprocessors and micro-computers which are able to handle the necessary mathematics on-line. There remains the major problem of sensor development but even here the availability of cheap computing power is helping the control engineer to infer a measurement from a number of other related measurements.

In regulating a process, the main concern is to minimise the deviation of the output from the set-point. There are two approaches to the design of the regulator. The first is to design a regulator satisfying a set of specifications such as to make the closed-loop system less sensitive to disturbances in the process. Proportional-integral-derivative (PID) controllers are the most commonly used controllers in this category. The second is to design a regulator using optimal control theory involving the optimisation of a criterion involving the output, the control, the set point, and other relevant variables. A common criterion simply involves the variance of the output errors and the square of the control. It is interesting to note that a common feature of these two approaches is that the system dynamics of the process to be controlled has to be available before the controllers can be designed. It normally involves performing experiments on the process and from data collected the behaviour of the process is established. Clearly, if the process characteristic changes or if there is a change in the operating conditions the regulator should be redesigned or retuned so that the performance of the controller is maintained. Retuning a controller is a tedious procedure. Furthermore, it is often uncertain when retuning is required. Consequently, it is not uncommon that controllers are disconnected from the control loop due to deteriorating performance, and manual control is resorted to. To overcome this difficulty adaptive or self-tuning controllers are derived. As it turns out, self-tuning controllers have become the most useful work product of using modern control theory.

A self-tuning controller (Fig. 1) consists of three parts: (i) a model of the process, (ii) a recursive parameter estimator which continuously updates the parameters of the process model, and (iii) an optimal control law

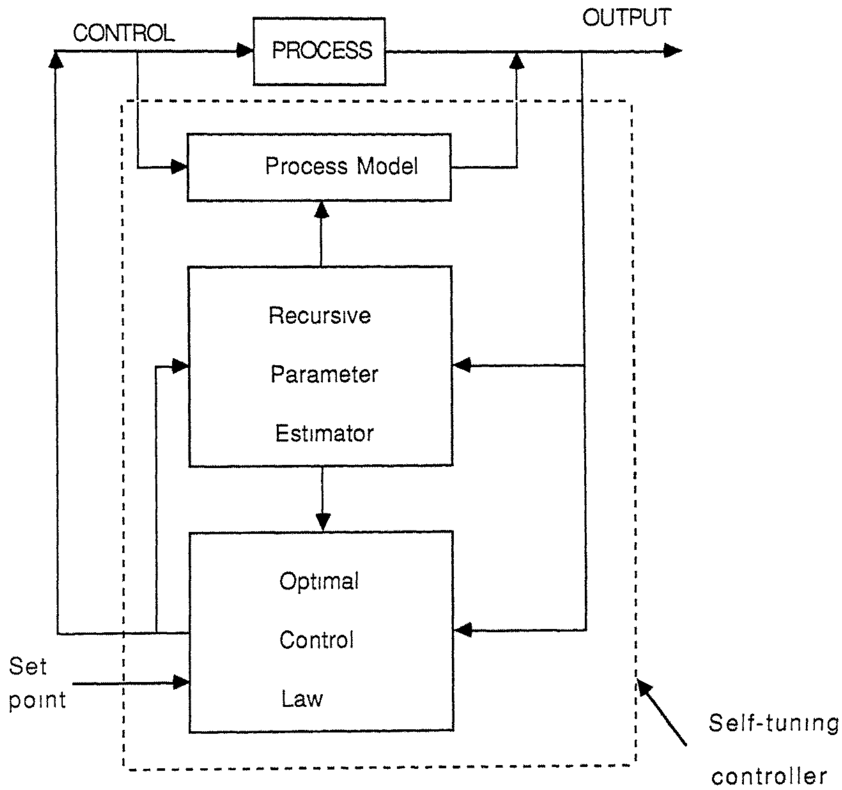


Fig. 1 Schematic diagram of self-tuning controllers

The advantages of self-tuning controllers over conventional PID controllers are as follows. First under normal conditions a self-tuning controller can be self-starting, and requires only a fraction of the time for tuning a conventional PID controller. Secondly, the built-in capability of continuously updating the parameters of the process model implies that it can handle slowly varying processes. This is a major advantage over the PID controller which cannot adapt. Thirdly, the complexity (that is the number of parameters) of a good controller depends on the order and the transportation delay of a process. In a PID controller the number of parameters is limited to three whilst in self-tuning controllers there is practically no limit. Fourthly, the self-tuning controller is implemented digitally on a computer and experiences can be programmed into the controller to make it more flexible and, most of all, more robust.

It is not difficult to see that self-tuning controllers are the controllers of the next generation. They can out-perform conventional PID controllers readily. In addition one can change over from a PID controller to the a self-tuning controller readily.

The aim of this article is to present the basic concept of self-tuning controllers and to compare their performance with that of conventional PID controllers using a process simulated on an analogue computer.

THE THEORY OF SELF-TUNING CONTROLLERS

An important prerequisite in any control problem is that the process can be described by a mathematical model. In self-tuning controllers, a linear discrete model is assumed. The optimal control law is derived by first defining an auxiliary output function consisting of the output, the set-point, and the control, and a cost function representation of the one-step ahead prediction of the auxiliary output. The optimal control is obtained by minimizing the cost function, yielding the smallest one-step ahead prediction error. The optimization problem is solved by separating the auxiliary function into two components: one that is predictable given historical data and the other, the unpredictable component. The one-step ahead prediction is minimized if the predictable component is zero, giving the optimal control law. Various control laws, such as the generalized minimum variance, the k-incremental, and the integrating controllers have been derived to handle various control applications.

The self-tuning ability of the controllers is achieved by introducing a recursive parameter estimator in the controller. Recursive least squares estimator is the most commonly used algorithm. Another form of the algorithm that has become more popular because of its robustness is the one derived from the Kalman filtering theory.

THE IMPLEMENTATION OF SELF-TUNING CONTROLLERS

The implementation of self-tuning controllers involves programming the optimal control law and the recurisve parameter estimator on a digital computer. A number of self-tuning control algorithms such as GMV, k-incremental, integration, pole-placement, etc., have been programmed and incorporated into a process control package on a digital computer.

The initialization of self-tuning controllers involves choosing the following variables: (i) model order, (ii) pure delay, (iii) weighting function Q, (iv) initial parameters and the associated variables in the recursive parameter estimators. For practical applications, the model order is normally chosen below three. The pure delay can be determined from physical consideration of the process. The choice of the weighting function Q and the initial parameters needs more thought since their choice affects the stability of the closed-loop system. A systematic approach in choosing these variables has been developed by the author and a research student in the Department of Mechanical Engineering. Now, the initialization of self-tuning controllers is more or less a routine procedure.

EXAMPLE

To illustrate the effectiveness of self-tuning k-incremental controllers, the following process is simulated on an analogue computer:

$$G(s) = \frac{5(1.25)^2}{(s + 0.35)^2 + (1.2)^2}$$

The open loop response of the process subjected to a step input of 0.8 unit is shown in Fig. 2. The process is controlled first by the following PID controller,

$$C(s) = 0.5(1 + 0.6s + \frac{1}{2s})$$

The control is implemented discretely on a digital computer, with a sampling interval of 0.2 second. The closed-loop response when there is a step change of four units in the reference input is also shown in Fig. 2. The process is controlled next using a self-tuning k-incremental controller, with $Q=5.5(1-z^{-1})$ and a sampling interval of 1 second. For ease of comparison, the corresponding response using the self-tuning controller is also shown in Fig. 2. Note that it is assumed that the controller parameters have converged to their optimal values. From Fig. 2, the steady-state value of the process under open loop conditions turns out to be 4.1, instead of the theoretical value of 4, illustrating the sensitivity of open loop control to parameter variation in the process. It is observed that the self-tuning controller gives smaller overshoot and undershoot than that using the PID controller. Also the commission time of the self-tuning controller is much shorter.

CONCLUSION

The self-tuning controllers described here have been under development since early 1970s and most of the practical problems have been solved. The work in the Department on the initialization of self-tuning controllers reduces further the commission time of self-tuning controllers, and turns the commissioning process into a routine procedure. As shown in the simulation example, the performance of the self-tuning controller is much better than that of the PID, apart from its advantages of being able to track changes in the process characteristics. Self-tuning controllers have now been developed to a stage that is ready for industrial exploitation.

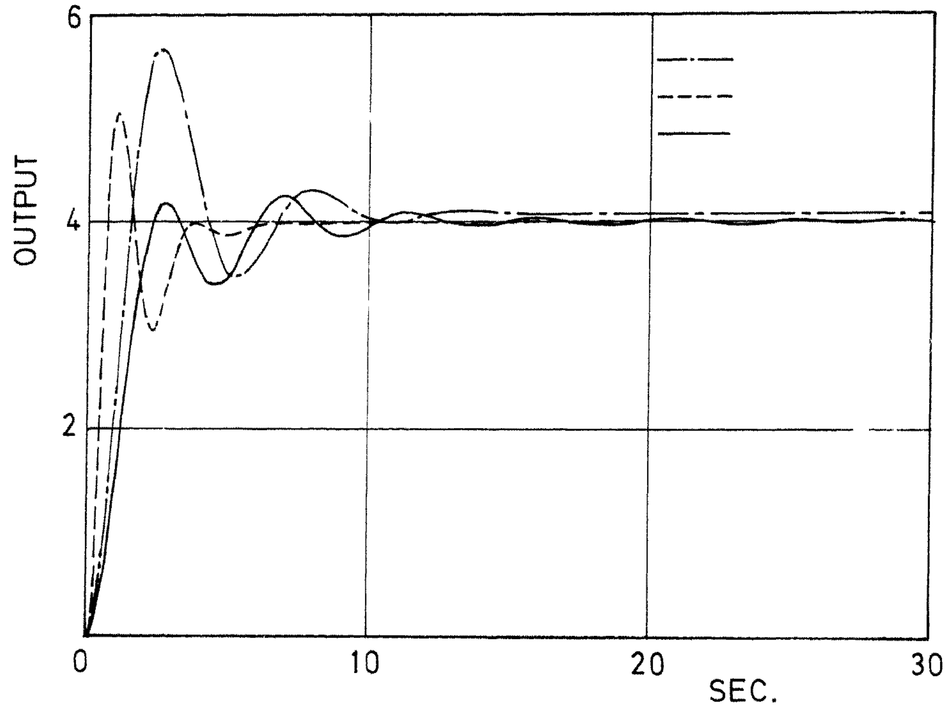


Fig. 2 Output of the simulated process with and without control

THE SIMIAN PROJECT

John B. Evans

MODELLING BY COMPUTER

In the SIMIAN project our aim is to design a language for specifying models of dynamic systems in the computer. The purpose of building models in the computer is to given an investigator, who may be a manager or a planner, the opportunity to subject the model to experimentation, involving tests, workloads, or stresses of various kinds and to examine the effects and responses of the modelled system. Experimentation with models is a familiar methodology in all aspects of engineering, but computer models have the advantage of being informational, non-destructive, inexpensive, and safe. Eventually, the SIMIAN project will provide the manager with a comprehensive model-building language incorporated in a total programming environment, linking up with other software packages, enabling him to specify and experiment with computer models in a simple and interactive way, without the need of an intermediary to write programs.

In order to pursue this aim, we must first consider exactly what we mean by a *model*. The word has two distinct meanings: when we speak of a model student or a model village we are indicating something that serves as an ideal, a form towards which we should strive; on the other hand, we may consider a model in the form of a wooden mock-up representing say, the structure of a bridge. When an engineer wants to design a new structure, the model must combine both meanings: the model must incorporate known properties of real materials and structures together with a specification of desirable properties which the ideal system should possess. Then the designed system can be simulated in order to prove to what extent the system responds to the kind of pressures it might be expected to meet in reality.

The first task of a language of modelling is obviously that it should be able to *represent* the designed system. This in itself presents a considerable challenge to language designers. Basically, the language must transform the dynamic of the system into the control flow of a program. Most real systems are composed of parallel flows, whether of material, production, or people, whereas the computer is essentially controlled by a single sequence of instructions. The transformation will therefore involve sequentialisation, and provide an opportunity to check out the basic validity of the system, as it is described. In fact the subjection of a system description to the rigour of a computer language will often show up unexpected omissions or redundancies in the design. Above all, we require our language to support a *declarative* style, by which we mean there should be nothing hidden in the internal mechanisms which could affect the meaning of the system. Clearly, a simulation language will be different from the familiar computer-programming languages used to specify algorithms.

SIMULATION OF SYSTEMS

There are two approaches to specifying dynamic models: we can treat reality as undergoing either continuous change or a succession of discrete changes. Dynamics of the first kind lead to a specification in terms of differential equations, while the most general kinds of discrete systems are discrete-event systems, in which a model advances through a series of state-changes which take place at discrete instants of time. Broadly speaking, most natural systems are modelled as continuous systems, but because of the computer's digital nature, differential equations must first be discretised in order to be solved by computer. So discrete-event systems can embrace both approaches.

While our mathematical training may incline us to think most naturally in terms of continuously-deformable structures, the first paradigm of discrete-event simulation assumes that *all* significant changes occur at discrete instants of time. Perhaps surprisingly, a large number of man-made systems fall into this category. Furthermore, as opposed to the discretisation procedure for solving differential equations, we are not required to propose a minimum time quantum -- the duration between instants is determined quite naturally by occurrences in the model. This acceptance of this paradigm has the great advantage of enabling parallel flows to be described on a sequential computer.

The working out of sequentialisation -- which is the central task in the implementation of any simulation language -- relies upon the adoption of a particular *strategy* for execution. Recent theoretical developments (see Evans, J.B., *Structures of Discrete Event Simulation: An Introduction to the Engagement Strategy*, Ellis Horwood, Chichester, U.K., 1988) have made it possible to design a new strategy, called the *engagement* strategy, with certain consequences for the nature of the interaction between modeller and computer. As a result of applying this strategy, a simulation program resolves itself into three separable domains, each of which is capable of independent specification:

$$\text{simulation} = \frac{\text{engagements}}{\text{data-probes}} + \text{allocation}$$

This, the second paradigm of discrete-event simulation, shows how a simulation need not be considered as a monolithic program for which any change, however slight, would require recompilation. Instead, the broad strokes of the system are described as a pattern of *engagements* between entities. An engagement is formed when entities enter into activities, either individually or jointly. The rules governing which entities are chosen for advancement at any instant is then the subject of *allocation*, a separate program domain which operates at a superior level, supervising the details of specific state-changes. Thirdly, measurement of the time-evolution of the model can be made by the insertion of *data-probes*, which function analogously to probes inserted into an electrical circuit. They are placed around particular activities which comprise the bottleneck under investigation.

The second paradigm also gives great flexibility to simulation modelling. For instance, two systems may be compared under identical conditions of measurement and allocation policy by amending just the engagement pattern. Similarly, many kinds of allocation policy may be tried out with respect to the same system and, at the same time, different kinds of response may be examined, without requiring the re-compilation of the whole program.

As a by-product of the second-paradigm analysis of the SIMIAN program, a DEVNET network is produced which is an abstract form of the engagement pattern. It functions as an activator of the program, in much the same way as a tree-structure activates an algorithmic program. It is an implementation of a precisely defined activity-cycle diagram, which can also have other uses in the initial description of the engagement pattern.

SIMULATION ENVIRONMENT

In order to take advantage of these developments in discrete-event system, an interactive and intelligent programming environment is needed. We should incorporate flexible, interactive handling of program editing, and a means by which the SIMIAN system can request clarification from the simulationist.

As an example, let us consider a basic model of a ship entering a harbour. A ship arrives and requires the services of a tug and the reservation of a berth. In addition we must ensure that the tide is high before entering. Then the ship enters and unloads. Before exiting, a tug and high tide are once more required. The SIMIAN program for this model is shown in Fig. 1, and its expansion into a DEVNET is shown in Fig. 2. The DEVNET is a diagram with arcs connecting *places* (circles) with *transitions* (bars). The dynamic is represented by a transition *firing* under certain conditions, which has the effect of moving tokens from one place to another. One way of understanding the diagram is to regard it as a board game, with tokens positioned on places to indicate the occupancy of states by ships, tugs, and other entities, and the movement of tokens indicates the passage of these entities through the system.

```
                GEN ship;
wait_in:        ACQ tug | ACQ berth | AWAIT tide IN high;
                TIME enter;
                REL tug;
                TIME unload;
wait_out:       ACQ tug | AWAIT tide IN high;
                TIME exit;
                REL tug | REL berth;
                NEG ship
***
                FOR tide
                DO CYCLE
high:                   TIME next_tide;
low:                    TIME next_tide
                OD.
```

Fig. 1: SIMIAN code for a simple harbour simulation.
*** denotes a process divider.
. denotes the end of the program.

There are some features of the SIMIAN program which would be difficult to obtain using other languages. Firstly notice that the description is very concise. Use of the high-level ACQ-REL statements for acquisition and release of resources allows a lot of general resource behaviour to be automatically assumed. Also, the program refers only to the engagement pattern -- allocation and data-probes are specified separately. For simplicity we have not specified any data structure for the ship, but most likely in practice it would be important to know details of the cargo and maybe also the stowage configuration. The policy by which ships were allowed to enter the harbour would naturally depend on such attributes.

Since the main impetus in management planning is to obtain the maximum utilization of resources and to reduce idle waiting, the critical measurement of interest would be the time spent by ships in the "wait_in" state. Statistics on this could be obtained by a statement:

```
MONITOR ships IN wait_in
```

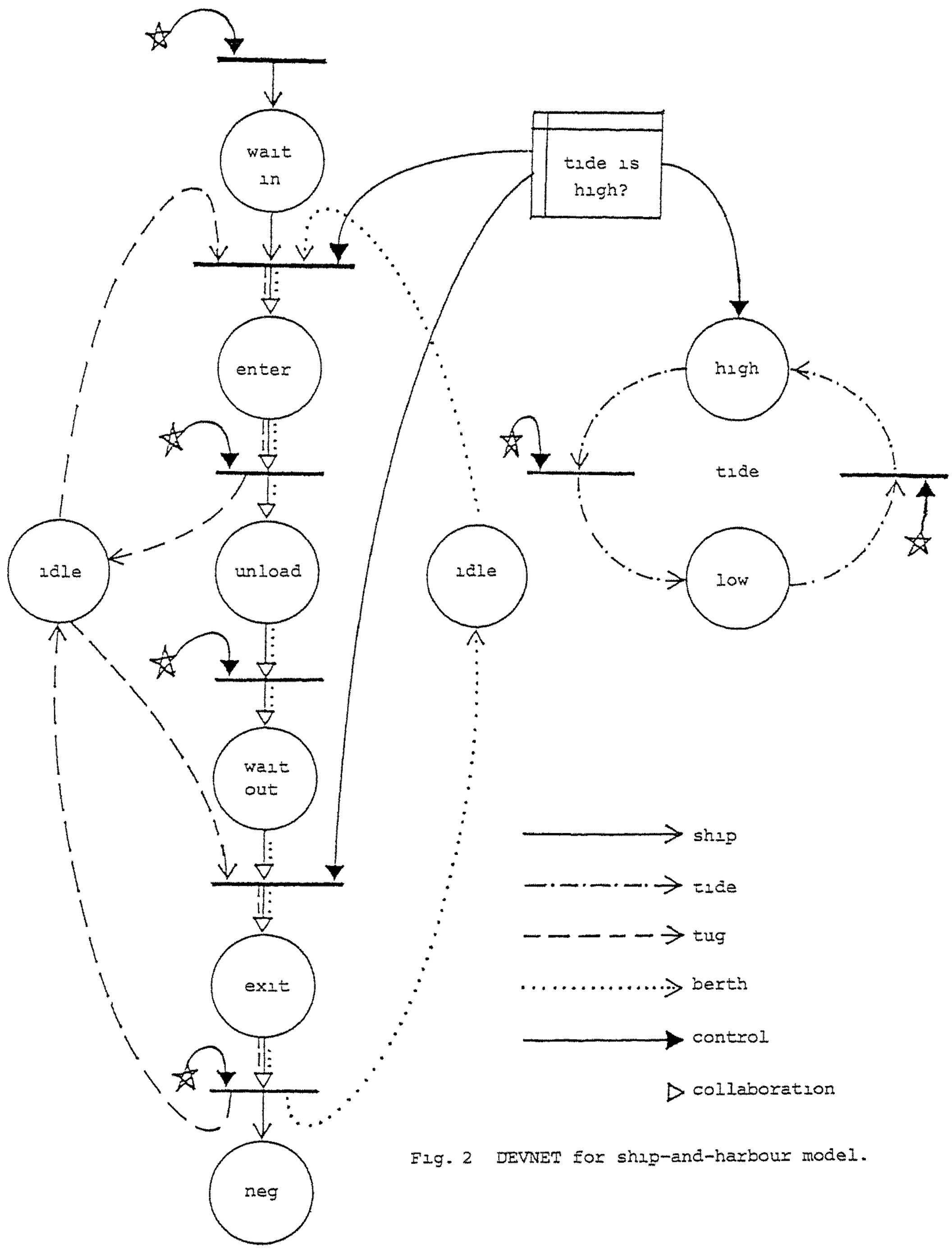


Fig. 2 DEVNET for ship-and-harbour model

which would automatically insert data-probes around the "wait_ in" activity and produce performance data at the end of the run, in any desired format. Such monitoring statements can be made and withdrawn at any time to suit the requirements of the simulationist.

Notice that the acquisition of the tug and berth and the awaiting of high tide are pursued in no particular order, as indicated by the use of the | operator. However, many simulation languages would insist that a specific order were imposed on these requirements. Such insistence prevents the system from reflecting the behaviour of a real system and can lead to a specification of a system which deadlocks.

From the diagram (Fig. 2) we can see that the system is loosely specified in as far as when a tug becomes "idle" it may be required to assist ships in either entering or exiting. If there are ships waiting to perform both activities, with which should a newly released tug engage? This quandary can be seen by observing that there are two possible routes leading out of the tug's "idle" place. No guide has been given in the program to resolve this dilemma. Most simulation languages would go ahead and perform the option which was more implementationally convenient, but the SIMIAN system, pursuing its declarative maxim, would draw the simulationist's attention to the situation, and request a resolution. If the user wishes to indicate "it doesn't matter" then the system will make a random choice each time there is a decision to be made.

What would be the purpose of such a simulation? The system clearly represents a transportation bottleneck -- there is not much point in speeding through the ocean if the ship must wait for long periods at the entrance to a port. Thus a judicious allocation policy to assign priority to certain ships waiting to enter (which may also depend on the current state of the tide and the cargo carried by the ships, etc.) could be of great advantage. How can we evaluate a given policy? Does it work? How can we compare one policy with another? It would be unwise to try out a new policy without subjecting it to rigorous checking beforehand. In a SIMIAN simulation, the policy is simply the allocation logic which applies to the firing of the transition following the "wait_ in" place. By running the simulation under likely conditions, and maybe also under extreme conditions, respective policy benefits may be directly compared.

4. APPLICATION AREA

As we have already remarked, many types of designed systems fall into the category of discrete-event systems, and can therefore be simulated in a similar way. In general, any system involving waiting for resources can be cast as a discrete-event system -- another description is a "resource-limited" system -- and waiting usually represents lost opportunity. Typical applications include all kinds of service systems, transaction processing, container terminals, stock control, financial planning systems, transport, jobshop scheduling, etc., in fact most systems which involve management decision-making.

We have frequently mentioned the managerial applications of simulation, and it should come as no surprise that the origins of the technique are closely tied up with solving management problems of capital-intensive manufacturing plants, especially steel works. Management decision-making is the crux of the business enterprise and many computer systems concentrate on the handling of data to expedite these decisions. But historically each application has developed along separate, individual lines. What is needed now is more integration with other computer systems, such as those concerned with finance, personnel and inventory. We intend to consider the closer integration of simulation with software for decision-support, planning, and computer-integrated manufacturing (CIM) more closely in the future.

The simulation technique has suffered somewhat from being a pioneer in computer applications to management, and many simulation languages in common use today hail from the 1960s. Simulation software has been slow to adapt to the micro-computer: although simulation may be carried out in Basic, Pascal, etc., it still remains a hit-or-miss affair. In the absence of a declarative style, no one can be sure of the extent to which a such simulation *really* models a system. In the past, simulation has been traditionally associated with long run-time. This was in order to obtain results valid for a steady-state/operation, but it has now come to be realized that steady-state solutions are not so important as those for a finite horizon. Few managers are interested in eternal truths.

Now that the underlying concepts of the engagement strategy have been formulated, we are ready to exploit recent innovations. In the SIMIAN project, we are about to move to the next stage, which is the implementation of the concepts into a prototype system, to be followed by field testing with realistic applications. Anyone with interests in this field is welcome to get in touch.

STRESSES IN METAL CUTTING

N.N.S. Chen and W.K. Pun

This research is a fundamental investigation on the deformation mechanism of work material in the vicinity of the cutting edge and wear land. Measurement of the force acting on the wear land under various cutting conditions revealed that the deformation was elastic in nature and obeyed Amontons' laws of friction.

Another aspect of the investigation was the study of the cause of wear land stress. It is generally believed that the wear land is due to the elastic recovery of the machined surface which has been compressed by the stress inside the cutting zone. However, investigation showed that this was not the case. Calculation of the internal stress inside the tool by series solution method indicated that swelling of wear land due to loading on the tool rake was also a major cause of wear land stress. The results also indicated that the elastic recovery of the machined surface was independent of the change in stress inside the cutting zone. On the other hand, investigation on the work material behaviour close to the cutting edge by slip-line field construction revealed a layer of stagnant metal covering the cutting edge as well as the sticking zone on the tool rake due to material separation in front of the tool edge. The thickness of the flow layer was built up gradually on this layer of stagnant metal. The shape of the flow layer was found to be governed by the radius of the cutting edge instead of by the friction of the sticking zone on the tool rake.

Stress analysis of the material in front of the cutting edge showed that although the stress acting on the work material would change rapidly from tensile to compressive when the material approaches the cutting edge, the stress would change from compressive to tensile again on leaving the tool edge.

TRENDS IN THE TELECOMMUNICATION INDUSTRY

Yuk Tung Ip and Tse Kai Wing

Our society is moving toward an information-intensive culture built around the exchange of information. To support this, the telecommunication industry is developing the integrated services digital network (ISDN) to provide a low-cost integrated digital access to the customers. In the past few years, there have been many field trials of ISDN throughout Europe, the United States, and Japan. In some countries, ISDN is expected to be fully implemented by the 1990s. By that time, many new services such as shopping and banking from the home could become a reality. In Hong Kong, the Hong Kong Telephone Company is also planning the introduction of ISDN in the near future.

A brief introduction to ISDN is presented below together with a description of the development work at HKU on the ISDN system and in other data communication areas.

INTEGRATED SERVICES DIGITAL NETWORK

The ISDN is an international standard, the basis of which is a network that provides users with end-to-end digital connectivity that can support a wide range of voice and non-voice applications in a single network. A key element of service integration for an ISDN is the provision of a range of services using a limited set of connection types and multipurpose user-network interface arrangements. The network will support switched (circuit-switched and packet-switched) and non-switched (leased-line) connections. The network will also contain intelligence to provide service features such as maintenance and network management.

Some of the main features of ISDN are end-to-end digital connectivity, common integrated access, out-of-band signalling, and clear channel capability. These features are examined in what follows.

The present arrangement for accessing services of different nature will typically require different access interface equipment, involving high cost and inconvenience. Also, since most of today's customer terminals are still analogue, using the public switched network to transmit digital data requires a modem which is limited in data rate. Following the introduction of the Integrated Digital Network using the advanced technologies of digital transmission and switching, ISDN is one more step towards providing end-to-end digital connectivity up to the customer's premises. Considerable cost saving can be gained with the digital technology. The other feature of ISDN is that it brings together a number of independent networks (e.g. circuit, packet, private-line, signalling) to provide a common integrated access interface to the users. Through this integrated access, the users can be provided with a variety of services including voice, facsimile, teletex, videotex, etc. To the network provider, it is more economical to operate, maintain, and administrate the single ISDN network.

ISDN ARCHITECTURE AND PROTOCOL

The ISDN standard has identified at the customer-end four reference points (R,S,T,U) and the functional groups between them as depicted in Fig. 1. These functional groups can be implemented in one or more pieces of equipment. The network termination 1 (NT1) provides the physical line termination at the U reference point, maintenance and performance monitoring, and isolation of the user from the loop technology. Network termination 2 (NT2) provides the terminal controller functions for the ISDN terminals (TE1) such as multiplexing and switching. Non-ISDN terminal (TE2) is connected to the ISDN reference point S and T through the use of terminal adapter (TA).

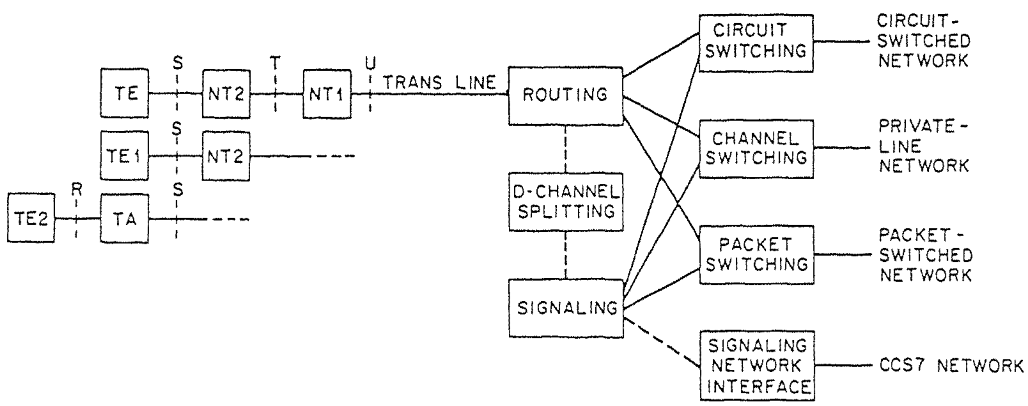


Fig. 1 ISDN reference configuration of the user-network interface

There are several types of channels defined in the ISDN which form the building blocks for the user network interface:

B Channel	64 kbits/s
D channel	16 or 64 kbits/s
H0 channel	384 kbits/s
H11 channel	1536 kbits/s
H12 channel	1920 kbits/s
H4 channel	135.168 Mbits/s

The B, H0, H11, and H12 channels support clear transmission with unrestricted bit patterns, which differ from the present digital transmission facilities having a limit on the minimum one's density and the maximum number of consecutive zeros. These channels may be used for circuit-switched voice and data, and packet-switched data. The D channel is for signalling or packet data. Two major interfaces are:

> Basic rate interface (BRI) which operates at 144 kbits/s comprising 2B+D channels (D channel operates at 16 kbits/s).
>
> Primary rate interface (PRI) which operates at 1.544 Mbits/s (North America and Japan) or 2.048 Mbits/s (Europe) comprising, respectively, 23B+D or 30B+D channels (D channel operates at 64 kbits/s).

Fig. 1 also illustrates a generic architecture of an ISDN interface on the network side. The first task of the interface is channel routing. The B channels are routed appropriately to either the circuit-switched network, packet-switched network, or private-line network. Since the D channel may contain both data and signalling, it must first be split into its two logical subparts. The X.25 data channel is routed to the packet-switched network. The signalling information is directed to a call processor which communicates with the switching function to route the B channels. If signalling across the network is required, the information is forwarded to the signalling network interface.

The networking protocols used in the ISDN follow the layered approach in the Open System Interconnect reference model. The lowest three layers are defined. Their main characteristics are discussed below.

The BRI physical layer uses the time compression multiplexing and the echo canceller hybrid techniques to provide a high data rate bidirectional transmission of 192 kbits/s in the two-wire local loop which cannot be attained by a modem. For the PRI physical layer the line coding techniques of Bipolar With 8 Zero Substitution and Zero Byte Time Slot Interchange are considered by CCITT to provide the clear channel capability.

Layers 2 and 3 are specified for signalling in the D channel. The layer 2 protocol LAPD is a data link layer protocol based on the link access protocol of the X.25 packet switched network, except that it allows for two logical links -- one for signalling and one for data. It provides functions such as error detection, flow control, sequencing, and multiplexing. Layer 3 specifies the call control procedures for the establishment, maintenance, and termination of both the circuit and packet switched calls. The signalling approach in the D channel is out-of-band signalling where the signalling and user information are transmitted in separate channels. This can provide saving in the network transmission and switching facilities by the more efficient call processing capability. It also provides flexibility and more efficient use of the information channel.

DEVELOPMENT WORK

A project on the design and development of a small ISDN PABX system is currently underway. The goal is to search for an optimum configuration of the ISDN PABX and the appropriate structure of the ISDN terminals.

The system overview of the PABX at the present stage of development is illustrated in Fig. 2. The master control unit is the central controller of the PABX whose tasks include the provision of network layer functions and services, supervision of call processing, maintenance and management of system resources. The central switching matrix provides non-blocking switching of 256 channels of 64 kbits/s each. The digital line interface provides the U interface between the network and the users together with the implementation of the data link layer functions. For testing purposes, a public network interface and the digital phones are also implemented.

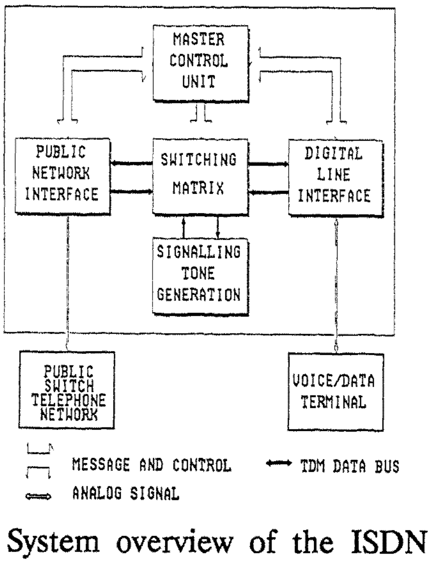


Fig. 2 System overview of the ISDN PABX

The design of the ISDN PABX architecture has been geared for system flexibility and expandability so that future upgrading of services or addition of users is possible. Various function cards are connected by two buses. The ST-Bus is a 2.048 Mbits/s bus that holds the 64 kbits/s channels in a TDM fashion. The other bus is for control signalling and the passing messages of messages between the processors in the function cards. Several design characteristics are highlighted below:

Modularity - the system is partitioned into well-defined functional modules so that replacement or upgrading of outdated modules does not affect the entire system.

Distributed Processing - each functional module (e.g. a line card) has its own processor to perform some of the call processing functions off-loaded from the master controller processor, so that the real-time requirement can be attained.

Common Bus Structure - a common backplane bus is used as a standard interface between the master control unit and other functional modules for passing control messages, so that the addition of functional modules is made easy.

Semaphore and Mailbox Interface - this technique provides an efficient communication interface between the processors so that it greatly simplifies the handshaking procedures and can act as a buffer between the processors.

Future work on the project will be to complete the software development of the data link layer, and to design other interfaces such as the S interface and the terminal adapters for non-ISDN terminals. Other information transmission such as image data is also planned at a later stage.

A second activity in the area of data communication at HKU is the development of an integrated services local area network (ISLAN). Signals such as voice and data can be transported in the same LAN. The main goal of this project is very similar to the ISDN, i.e. the integration of different networks in a local site that have traditionally supported different media of communications with different characteristics. A key advantage is that it has only one wiring plan in the local site. For voice communications, ISLAN functions as a traditional PABX. For data communications, ISLAN functions as a traditional local area network. A token ring has been selected as the experimental network since it supports synchronous operation that can satisfy the real time constraint of the voice signals.

INDUSTRIAL TRAINING FOR UNDERGRADUATES

INDUSTRIAL TRAINING FOR ENGINEERING UNDERGRADUATES

G.W. Greene

This is a brief statement regarding industrial training undertaken by undergraduates. It includes points that may promote a more positive and beneficial approach to industrial training by all parties concerned.

As part of their degree requirements all students are required to complete periods of practical training during the academic year and during the summer breaks. Various programmes have been developed to suit individual departmental needs. Each department should be contacted directly for specific details.

Some first year students take basic workshop practice sessions of three hours duration during the academic year. Further sessions are taken during the summer at the University, VTC training schools, and the Hong Kong Polytechnic, depending on the subject being covered. Students compile training logbooks which are assessed as coursework for the second year.

After the second year degree examinations in June, students spend from eight to twelve weeks in industry. Companies provide an allowance and organize different forms of industrial experience. Clearly there is a wide range of topics and approaches which are possible and the experience of students varies considerably. The companies also find the response of students varies quite a lot.

Students lack experience so cannot make specific contributions quickly. They need some introduction and guidance but normally respond very well when given a defined project to undertake. If a proper supervisor (preferably a professional engineer) is assigned by the company to be responsible for the relevance and challenge of the training, the end result can be beneficial all round. Most students who work on specific tasks find the experience more challenging and interesting and the companies are more pleased with the performance of the students.

Unfortunately in some companies students are simply moved between different departments and told to observe. In some others, they are given very simple or repetitive tasks to do including preparing engineering drawings for components that are already in production, making tea, doing messenger work, and filing papers or drawings.

Cheap labour is not a good reason for taking undergraduate trainees during the summer. The reaction of students to careers in industry may be strongly influenced by this training period. If we want to encourage able students to be interested in engineering careers, this initial contact with industry is a good way to do it. Furthermore companies benefit more directly if students are given closely defined and well supervised projects to do.

Some companies treat the period as an interview with a potential employee that lasts several weeks. By giving the students realistic problems and challenging them, the companies can evaluate the capabilities of the student very well. An increasing number of students have gone on to work for summer vacation employers because they have had a good training experience and made a favourable impression on the company.

Some students have previously been assigned tasks like:

a. investigation of a particular problem that the company would like to look at more closely but cannot justify the deployment of full time staff;

b. assessing material flow within a factory or setting up a better stock control or work schedule;

c. design, build, and test a jig or adapt some aspect of a production line;

d. actively participate in the commissioning of a new machine or system;

e. computer programming of software for a specific in-house application including preparation of user documentation.

There are questions that remain which should be directed to the University departments:

1. Has enough effort been made by the departments to encourage good training experience?

2. Do the departments issue good guidelines to companies regarding the type of training desired and provide good examples?

3. Should the department assist individual firms in drawing up feasible and worthwhile programmes?

4. Should there be closer contact between the company and the academic staff during the training period?

5. Are students sufficiently prepared before they start their training? Do they recognize the importance of the contact with industrial staff and the interpersonal relationships they will need to establish?

If your company could make positive use of some undergraduates for eight to twelve weeks during the summer, contact either the Engineering Training Officer, c/o the Faculty of Engineering, or the head of a specific department. Arrangements are normally finalized in April so plan ahead if possible.

For the moment it is appropriate to acknowledge and give thanks to companies who have provided training places to undergraduates in the past and more particularly during the past five years.

List of organizations which have offered placements for industrial training in the years 1984-1988

Agri Business Ltd.
Astec International Ltd.
Atico International Ltd.
Arco Industries Ltd.
Ampex Ferrotec Ltd.
ASM Asia Ltd.
Analogue Technical Agencies Ltd.
Automation Machines Co.
APP Engineering Pte. Ltd.
Architectural Services Department
ASM Assembly Materials Ltd.
A S Watson & Co. Ltd.
Aoki Corporation
Amstrad Microtronics (Mfg.) Ltd.
ASM Assembly Automation Ltd.
Arnhold & Co. Ltd.
Almart Manufacturing Co. Ltd.
Apple Computer International Ltd.
Automation Manufacturing Ltd.
Automation Systems Hong Kong Ltd.
Agriculture & Fisheries Department
BRC Sterling Ltd.
Boly Metal Mfg. Ltd.
BICC BOSCHERT Ltd.
Bound Brook Engineering Ltd.

Building Development Department
Building Ordinance Office (Buildings & Lands Department)
Binnie & Partners International
Brightmond Co. Ltd.
Bondwell Industrial Ltd.
Cable & Wireless (HK) Ltd.
Caltex Oil Hong Kong Ltd.
China Light & Power Co. Ltd.
Clipsal Asia Ltd.
Cummings Engineering Co. Ltd.
Civil Aviation Department
Civil Engineering Office
Civil Engineering Services Department
Ching Ngai Metal Product Ltd.
Changi International Airport Services Pte Ltd. (Singapore)
Capital Automation Co. Ltd.
Chen Hsong Machinery Co. Ltd.
Chung Hing Engineers Ltd.
Chung Wah Shipbuilding & Engineering Co. Ltd.
Co-Bond (Resources) Holdings Ltd.
Cathay Pacific Airways
Celestial Electric Mfg. Co. Ltd.
Commodore Electronics Ltd. (HK Branch)
Connectics (HK) Ltd.
Chit Wing Enterprises Co.
Computer Products Asia Pacific Ltd.
Data General
Denholm Ship Management (Overseas) Ltd.
Daniel Clayton Ltd.
Dodwell Hong Kong Ltd.
Digital Equipment HK Ltd.
Design Future Computer Products Ltd.
Det Norske Veritas (Singapore)
Data-Products Components H.K. Ltd.
Elec & Eltek Co. Ltd.
Electronic Devices Ltd.
Electrical & Mechanical Services Dept.
Electronic Sales Ltd.
Electronic Ind. Ltd.
Engineering Development Department
Esso H.K. Ltd.
Engineering System Ltd.
Earth Science Asia Ltd. (Geotechnical Consultant Firm)
Eastern Time Ltd.
Electrical & Electronics Ltd.
Environmental Protection Department

Franki Contractors Ltd.
Freeman Fox (F.E.) Ltd.
Flextronics Manufacturing (HK) Ltd.
Forward Engineering Co.
Fireman Auto Service Centre
Fugro (Hong Kong) Ltd.
Franki Kier Ltd.
Gilman Engineering Ltd.
Gammon (H.K.) Ltd.
Geotechnical Control Office, E.D.D.
Gamma Misrek
Grey Wong & Associates
Geotechnical Instruments (HK) Ltd.
Guangdong Water Conservancy & Hydro-Power
Engineering Development Co. Ltd.
Gammon Construction Ltd.
Gotech Engineering Ltd.
Hong Kong Telephone Co. Ltd.
Hong Kong Aircraft Engineering Co. Ltd.
Hong Kong Oxygen & Acetylene Co. Ltd.
HMT Consort (HK) Ltd.
Harris & Sutherland (Far East)
Hong Kong Housing Authority
Housing Department
Highway Office
Haven Automation (HK) Ltd.
Herald House Ware Ltd.
Hitachi Electronic Components (Asia) Ltd.
Hong Kong Post Office
Hewlett-Packard Hong Kong Ltd.
Hong Kong Electric Co. Ltd.
Herald Datanetics Ltd.
Hong Kong CAD/CAM Services
Hightech Information System Ltd.
IBM Turk Ltd.
IBM World Trade Corporation
IBM Asia Ltd.
IBI (Asia) Ltd.
Island Navigation Corp. (Ship Management) Ltd.
Intermarket Manufacturing Ltd.
Industrial & Offshore Computer Services Pte. Ltd. (Singapore)
Integrated Display Technology Ltd.
International Quartz Ltd.
I. Kryger A/S
Johnson Controls H.K. Ltd.
Jardine, Matheson & Co. Ltd.

J. Roger Preston & Partners
Johnson Electric Ind. Mfty. Ltd.
Kowloon-Canton Railway Corporation
Kulicke & Soffa (Asia) Ltd.
Kumagai Gumi (HK) Ltd.
Kajima-Keppel Joint-Venture
Keystone Electronic
Krups (Far East) Ltd.
Kier Hong Kong Ltd.
Kwan Ng Wong & Associates (Hong Kong) Ltd.
Kwong Wah Industrial Co.
Lambda Tele-Equipment Ltd.
L & M Prestressing Pte. Ltd. (Singapore)
Lee Kim Tah Pte. Ltd. (Singapore)
L & M Prestressing Pte. Ltd. (Singapore)
Laser Imaging Systems
Management Investment & Technology Co. Ltd.
Mass Transit Railway Corporation
Mattel Toys (HK) Ltd.
Meyer Manufacturing Co. Ltd.
Motorola Semiconductors (HK) Ltd.
Motorola Asia Ltd.
Mobil Oil H.K. Ltd.
Mott Hay & Anderson Hong Kong Ltd.
Meco Engineering Ltd.
Micro Electronics Ltd.
Meyer Aluminium Ltd.
Manhattan Electronics Ltd.
Micor Engineering & Consultant Ltd.
M.C. Packaging (HK) Ltd.
National Semiconductor H.K. Ltd.
New Territories Development Department
Nypro Chen Precision Moulding Co. Ltd.
New Bright Industrial Co. Ltd.
Netas (Turkey)
Nice Look Co. Ltd.
Outboard Marine Asia Ltd.
Ove Arup & Partners (HK) Ltd.
Office of the Water Authority
Olivetti Singapore Pte. Ltd. (Singapore)
Orient Overseas Management & Finance Ltd.
PRO - Power Manufacturing Co. Ltd.
Pechiney H.K. Ltd.
Possehl H.K. Precision Machining Ltd.
Presco Pte. Ltd. (Singapore)
Pan Abrasives Pte. Ltd. (Singapore)

Panint Enterprises Ltd.
PepsiCo. Inc.
Quality PCB Ltd.
Radofin Electronics (Far East) Ltd.
Radio Television H.K.
Royal Observatory H.K.
Robert Chiang & Associates
RCL Semiconductors Ltd.
Reuters Asia Services Ltd.
Raymond Industrial Ltd.
Robert Vart & Associates Ltd.
SAE Magnetics (HK) Ltd.
Sime Darby Hong Kong Ltd.
Sonca Industries Ltd.
Standard Telecommunications Ltd.
Sunciti Manufacturers Ltd.
Shui On Construction Ltd.
Scott Wilson Kirkpatrick & Partners
Schlumberger Overseas S.A.
Starphoto Products Mfg. Co. Ltd.
Seapower Consortium Co. Ltd.
Swire Haden Ltd.
Smartfield Ltd.
Safer Electrical Manufacturing Co. (F.E.) Ltd.
Shun Hing Electric Works & Engineering Co. Ltd.
SFE Systems Ltd.
Shui On Group Ltd.
Societe Generale d'Entreprises pour le
Batiment et les Travaux Publics (SGE-BTP HK)
Shinryo Corporation (Japan Co. Air-Conditioning)
Sino Estate Management Co. Ltd.
Swank Int'l Optical Ind. Ltd.
Swire Magnetics Ltd.
S.Megga Telecommunications Ltd.
The General Electric Co. of Hong Kong Ltd.
The Jardine Engineering Corporation, Ltd.
The Kowloon Motor Bus Co. (1933) Ltd.
The Royal H.K. Jockey
The Hong Kong Electric Co. Ltd.
Testconsult Cebtp (F.E.) Ltd.
Tileman (HK) Ltd.
Tridant Engineering Co. Ltd.
The Shell Co. of H.K. Ltd.
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