Proceedings

of the

First International Conference

of

Women Engineers and Scientists

1964

SWE

FOCUS FOR THE FUTURE

Developing Engineering and Scientific Talent

Sponsored by the
Society of Women Engineers
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JUNE 15-21, 1964
United Engineering Center
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New York City

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DEDICATION

This volume is dedicated to the memory of

MRS. PEARL FRANKLIN CLARK

Honorary Member of the Society of Women Engineers who believed that a better world for all people must be brought about by men and women, with their special qualities, working together, and who predicted that one day the SWE would have its National and International Headquarters not in a building separate and apart, not in competition or with any emphasis on differences, but in professional association and cooperation with all technical Societies in the United Engineering Center, so favorably placed overlooking the United Nations Plaza and the East River with its international traffic.

MESSAGE FROM THE PRESIDENT OF THE UNITED STATES OF AMERICA

to the

FIRST INTERNATIONAL CONFERENCE OF WOMEN ENGINEERS AND SCIENTISTS

(Received June 17, 1964 in a telegram to Dr. Beatrice A. Hicks)

I am happy to greet participants in this First International Conference of Women Engineers and Scientists. You will be focusing attention on the new contributions which Engineering and Science can make to all problems of hunger, disease, disability, and lack of individual opportunity.

In focusing attention on the untapped potential and ability of talented women to participate in these professional activities, you and your colleagues are performing a distinguished service in our society. The United States has lagged behind many European countries in its utilization of the abilities of women in the professional fields, particularly scientific research, engineering, law and medicine.

We take pride in noting that two American women have won the Nobel Prize, and the National Academy of Sciences has elected five women members. But the energy and determination of our American women must not stop here. Our citizens must use their unique qualities of mind and character to meet the challenges which face our Nation in this changing and increasingly technological world. More can and must be done to develop a public understanding of the untapped potential of our women.

I extend to this Conference every good wish for a successful and productive meeting.

LYNDON B. JOHNSON

MESSAGE FROM LADY BIRD JOHNSON

(Conveyed in a telegram to Margaret R. Fox, Chairman, Technical Program Committee, on June 19, 1964)

How sorry I am to miss the opportunity to join in the First International Conference of Women Engineers and Scientists -- I know it will be a most informative and rewarding experience. In this challenging time women are meeting today's needs and preparing for the future as never before, and it is gratifying to realize that in such highly technical fields as yours women are devoting their great talents and abilities.

Please extend my very best wishes for the success of the Conference.

Sincerely,

Lady Bird Johnson

STATE OF NEW YORK
EXECUTIVE CHAMBER
ALBANY

NELSON A. ROCKEFELLER
GOVERNOR

I am happy to have the privilege of sending a hearty welcome to all present at the International Conference of Women Engineers and Scientists.

We are delighted to be host to so distinguished a gathering of women engineers and scientists from all over the world -- and are proud of our New York Chapter for initiating and "engineering" this First International Conference. We are well aware of the contributions which members of that chapter are making -- they work in every scientific area from undersea to outer space. And we are particularly happy about what they -- and all of you -- are doing in those engineering areas that make for better living for our citizens.

In fact, the program of this Conference impresses me above all by one dominating attribute -- its concern with the people of this earth. Your program indicates that each of you has come -- not primarily to increase your own know-how or improve your own situation -- but to help humanity in general.

In this connection, I have a few figures -- and since, being in the profession you are, you are not dismayed by figures -- I will mention them:

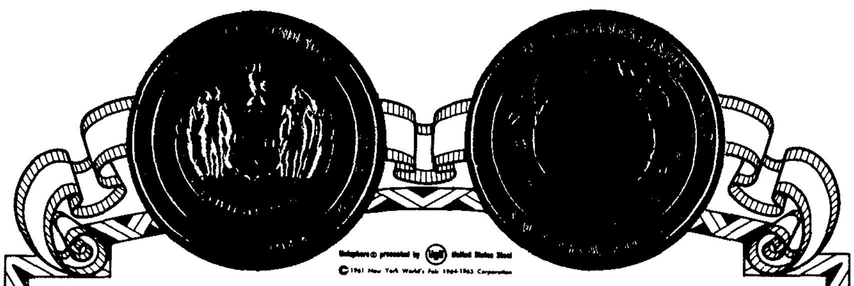
In 1961, 2,999 young New Yorkers took BS degrees in engineering -- and 1,171 took their engineering masters. Even better, presently, in New York State colleges, 19,806 students are enrolled in courses leading to an engineering degree -- and 6,147 more are studying for engineering masters. This is the largest number of any state in the country. I like to think, too, that some of it has been made possible by an expanded educational opportunity system inaugurated here a few years ago -- a system which insures that any New York girl or boy who has talent and ambition need not be prevented by lack of funds from the full development of that talent -- even through graduate studies.

This state is keenly aware of the crucial part that science and engineering play in today's progress and tomorrow's economy -- and we devote considerable attention to fostering a climate encouraging to them. Eighty-eight thousand engineers and scientists are now exercising their know-how in the industries of this state and in the 1,007 research laboratories that serve our business. Incidentally, more laboratories than any other state in our nation, I am proud to report.

I am delighted that this First International Conference of yours takes place in New York City while our great World's Fair is in progress. I also hope that as many of you as possible will take advantage of the opportunity to see some of the historic landmarks and superlative scenes of beauty throughout the Empire State.

With best wishes for a happy and a fruitful conference,

Sincerely,



New York World's Fair
1964-1965 Corporation
Proclaims
June 15, 1964
to be
Women Engineers & Scientists Day
and extends
a most cordial welcome
on behalf of the Officers
of the Fair Corporation,
our Exhibitors and Participants

ROBERT MOSES, President

PRE-CONFERENCE PROGRAM

MONDAY, JUNE 15, 1964

WORLD'S FAIR DAY

General Motors Futurama

Behind the Scenes at Socony Mobil Exhibit

Bell Systems Exhibit

International Business Machines Exhibit

General Electric Exhibit

Luncheon at Little Old New York

Parade of States and Roll Call of Nations, Federal Pavilion

Mistress of Ceremonies: Blanche H. Dow, National President, American Association of University Women

Greetings from New York World's Fair: General Seymour Potter, Chief Engineer

Dinner at Rathskeller at Belgium Village

TUESDAY, JUNE 16, 1964

PROFESSIONAL TOURS DAY

Tour and Briefing of new Research Center, International Business Machines Corporation, Yorktown Heights, New York

Luncheon as guests of International Business Machines Corporation

Tour of Consolidated Edison Co. of New York, Inc., Atomic Energy Plant, Indian Point, New York

or

Tour and Briefing of latest facilities of Bell Telephone Laboratories, Holmdel, New Jersey

Luncheon as guests of Bell Labs.

Tour of Sterling Forest

BOTH TOURS:

Dinner at Patricia Murphy's Candlelight Restaurant, Yonkers, New York

Informal Entertainment - International Song Fest

PREAMBLE TO THE PROCEEDINGS

of the

FIRST INTERNATIONAL CONFERENCE OF WOMEN ENGINEERS AND SCIENTISTS

The opening session of the Technical Program featured Dr. Lillian M. Gilbreth, world renowned Management Consultant and Industrial Engineer, who set in perspective the Conference theme "Focus for the Future - Developing Engineering and Scientific Talent" with her Keynote Address. The outstanding success of the Conference is a well deserved tribute to her and to the other international speakers who completed the program.

The first session developed the requirements in scientific and technological manpower for meeting the challenge of sustaining the expanding population of the world. The next three sessions established the specific types of scientific and engineering talent that will be needed by describing the state of the world in the several major areas of basic human needs: food and water, clothing and shelter, heat and power, communications and transportation, etc.

In the fifth session international reports on the current status of engineers and scientists, based primarily on information provided in response to requests to some 120 countries, were presented, with emphasis on the present and future status of the women engineer and scientist as members of the technical team. The sixth and final session, a Symposium on Developing Engineering and Scientific Talent for the Future, provided not only an opportunity to review and comment on the previous sessions, but also to discuss various approaches to the problem. The nucleus of the open forum was a group of eminent scientists, engineers and educators representing the disciplines so vital to the progress of humanity, augmented by the active participation of Delegates representing many countries.

The Technical Program Committee is deeply appreciative of the gracious contributions in time and talent of those who accepted the challenge of participating in this pioneering effort, in particular the authors of the technical papers, and the Session Chairmen, Moderators and Summarists of Technical Program Sessions I through IV; and the Panelists of Technical Program Sessions V and VI. Acknowledgment and gratitude are also given to those who provided Statements and Special Feature Contributions, and to the several Delegates who offered additional papers, some of which are included in this Proceedings.

Margaret R. Fox, Chairman
Technical Program Committee

Wednesday, June 17, 1964

FOCUS FOR THE FUTURE--DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

WELCOME AND OPENING MESSAGE--Ruth I. Shafer, Conference Chairman, Design Engineer, Gibbs & Cox, Inc., New York, New York

OFFICIAL OPENING OF CONFERENCE--Aileen Cavanagh, President, Society of Women Engineers; Member of Bell Telephone Laboratories, Inc., Whippany, New Jersey

WELCOME AND INTRODUCTION OF KEYNOTE SPEAKER--Beatrice A. Hicks, Conference Director; President, Newark Controls Company, Bloomfield, New Jersey

CONFERENCE KEYNOTE--Lillian M. Gilbreth, Management Consultant and President, Gilbreth, Inc., Upper Montclair, New Jersey

TECHNICAL PROGRAM SESSION I

Spotlight on Engineers and Scientists

Chairman: Margaret R. Fox, Technical Program Chairman; Electronic Engineer, Information Technology Division, Institute for Applied Technology, National Bureau of Standards, Washington, D.C.

Moderator: Patricia L. Brown, Immediate Past President, SWE; Technical Information Consultant, Corporate Research and Engineering Division, Texas Instruments, Inc., Dallas, Texas

REQUIREMENTS FOR ENGINEERING AND SCIENTIFIC MANPOWER-- M.H. Trytten, Director, Office of Scientific Manpower, National Academy of Sciences, Washington, D.C.

TECHNICAL SERVICES NEEDED IN SUPPORT OF ENGINEERS AND SCIENTISTS--Ira Rischowski, Dipl. Ing., Technical Writer, Elliott Process Automation Ltd. (Elliott Bros. Ltd.), London, England

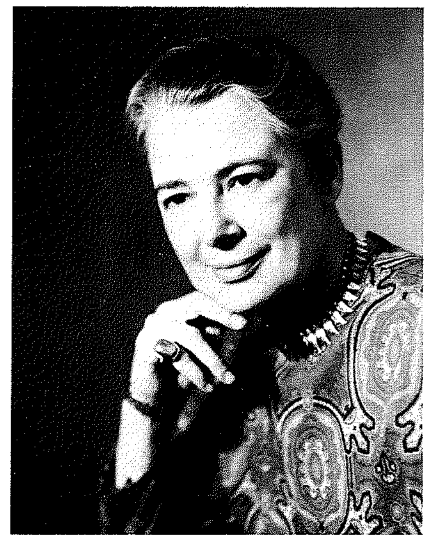
Summarist: Isabelle F. French, President-Elect, SWE; Member of Bell Telephone Laboratories, Inc., Allentown, Pennsylvania

12:00 Noon - WELCOME LUNCHEON

Presiding: Ruth I. Shafer, 1964 SWE Convention Chairman.

WELCOME FROM THE SOCIETY OF WOMEN ENGINEERS--Aileen Cavanagh, President.

WELCOME FROM THE CITY OF NEW YORK--MESSAGE FROM MAYOR ROBERT F. WAGNER, presented by: Bradford N. Clark, New York City Commissioner of Public Works.



Miss Ruth I. Shafer
Chairman
Conference Operations Committee

OPENING MESSAGE

Good morning, ladies and gentlemen. It is my good fortune to preside at the initiation of the more formal part of the First International Conference of Women Engineers and Scientists. During the course of the next several days, you will be officially welcomed by the Society of Women Engineers, the City of New York, the State of New York, and the President of the United States of America. You have already been welcomed by the New York World's Fair and by your hosts on the several tours--the International Business Machines Research Center, Consolidated Edison's Atomic Energy Plant, and the Bell Telephone Laboratories.

This is my personal welcome to you as Chairman of the Conference Operations Committee. I am glad you are here. I hope that this Conference will be a rewarding and heart-warming experience for each of you and that I can get to know you personally before it passes into history. As you have already been informed in the Program and its Preamble, the first Session will develop the requirements in scientific and technological manpower, and Sessions II, III and IV will establish the types of talent needed in support of the several major areas of basic human needs. Session V will present an overview of the status of the world's supply of such talent, and Session VI will provide the opportunity for discussing how to develop scientific and engineering talent for the future.

I urge you to participate in these Sessions to your fullest capability.

Miss Aileen Cavanagh, President
SOCIETY OF WOMEN ENGINEERS

Dr. Lillian M. Gilbreth

Dr. Beatrice A. Hicks

OFFICIAL OPENING

of the

FIRST INTERNATIONAL CONFERENCE OF WOMEN ENGINEERS AND SCIENTISTS

by Miss Aileen Cavanagh
President, Society of Women Engineers

Welcome, ladies and gentlemen, on behalf of the Society of Women Engineers, over which it has been my privilege to preside during this historic year, 1963 - 1964.

We are meeting at a time when most people have come to realize that their own integral worth as human creatures is inevitably dependent on the ability of the human race to mature, both by self-recognition and by self-discipline. In this changing environment, this First International Conference of Women Engineers and Scientists has been an ambitious but much needed undertaking.

It has been needed because the place of women professionals in the fields of engineering and science has been debated without the benefit of facts for far too long, most often by people -- including both men and women -- who have never met a woman engineer or scientist. You will meet and have the opportunity to converse with many women engineers and scientists here, and they have come from all over the world. I am certain you will find them both charming and sociable, and with only one head apiece!

This Conference has been ambitious, as is any attempt to find rational perspective in a controversial issue. In nation after nation, poverty, selfishness and ignorance have created severe economic problems. Today, determined to maintain world peace, the many nations of the world are striving to feed, clothe, house, educate, transport and communicate with their peoples, no matter how large their numbers may become. While these nations are seeking responsible ways to govern their expanding populations without destroying family life, the world is trying to enter a new era of human understanding and international cooperation.

Its peoples seek to eradicate national prejudices, formed under past economic and social stress, by reciprocal communications and by sharing cultural and technical knowledge among the many nations. In this work to bind the world together, many engineers and scientists -- men and women alike -- are looking to the future needs of humanity; some are striving to conquer outer space and attempting to unlock the mysteries and vast resources of the oceans and the bowels of the earth, while others are working daily to nurture the hopeful spirit of life among the world's peoples.

This Conference, as its sessions unfold, will open to you and to us even broader engineering and scientific career vistas for the future. You will see, as we have seen, that technical progress properly applied can be a strong force for good, acting to increase human dignity and to ease the burdens of hunger, ignorance, and despair that afflict so many of our fellowmen throughout the world today. You will recall my opening statement: That we live in a time when our worth as individuals depends on the ability of the total human race to achieve the maturity of self-recognition and self-discipline. We feel that without that maturity a blind and undirected pursuit of technology for its own sake could destroy human dignity and thus become a force for evil.

And so we shall try in this Conference to look at the future technological needs of a peaceful world and to define those areas of endeavour in which our scientifically inclined and inventive youth of today -- boys and girls alike -- can find their opportunities for service to their fellow men of tomorrow. As Delegates it will be our responsibility during the several sessions to formulate resolutions and guidelines that young people can use for inspiration and guidance in choosing their own cultural and educational patterns, and in setting their own life goals.

As we approach this task, let us try to recognize and understand some fundamental and well justified differences in the underlying interests of the groups you Delegates represent. We women want more women engineers and scientists because we know more women want to become engineers and scientists; industry wants more women engineers and scientists in the high demand fields to fill its deficits, thus stabilizing supply and demand, so it can gain a more even distribution for its engineering and development costs; education wants more women students so it can meet industrial and governmental demands for the most highly qualified graduates, and so it can maintain and expand its plant in the face of stable male enrollments; and government wants more women so it can both develop a strategic manpower reserve in critical categories and stabilize the costs of its engineering requirements. These are not necessarily harmonious objectives, and thus we must all look deep into our own motives before we can hope to achieve the essential balance in human values which is one of the major objectives of this Conference.

And so, ladies and gentlemen, with these comments I hereby formally open the First International Conference of Women Engineers and Scientists, and the Fourteenth Annual Convention of the Society of Women Engineers. May we be guided rightly in our work.

W E L C O M E

TO THE

FIRST INTERNATIONAL CONFERENCE OF WOMEN ENGINEERS AND SCIENTISTS

Dr. Beatrice A. Hicks, P. E.
Conference Director
President, Newark Controls Company
Newark, New Jersey

It is my great privilege to be able to welcome you to this First International Conference where we will consider the present and future opportunities in engineering and science and how we may encourage women to use and to enjoy these opportunities, and thereby to serve the progress of all peoples.

This Conference has brought together men and women to exchange information and to create new patterns and new plans for the activities of women in enginee ing and science. We represent over 30 Nations and all 50 of the United States of America. We represent education, government, industry, professional guidanc personnel placement, and management, as well as engineering and science. But most important, we represent those people who recognize the need for progress and unselfishly give of their time and their means toward these goals.

I should like to pay particular tribute to those men who have contributed so largely to the progress leading up to this Conference. To realize and under stand the foresight and concern with human needs of outstanding men from the major technical societies, the International Program of the Engineers Joint Council, many of our major engineering schools, the foundations concerned with education, and important sections of industry has been one of the most rewardi experiences of our years of work.

I sincerely welcome each of you to this history-making Conference. We hope that you will receive from it information and inspiration, that you will make new friends and that you will contribute to it your own experiences and suggestions. We hope that you will enjoy this week and that it will live in your memory as a symbol of progress in the work we are trying to accomplish.

Our Keynote Speaker is herself a symbol of progress. As a world renowned management consultant, she has spent her life in the studies, planning and activities that create the opportunities for progress.

Born in Oakland, California, in 1878, and educated at the University of California and Brown University, Dr. Lillian Moller Gilbreth pioneered with her husband, Frank Gilbreth, in the field of motion study that became the profession of Industrial Engineering. Through the ensuing years she continued to work for progress in the engineering management areas.

In 1954 she was the first woman to receive the Washington Medal, awarded for her outstanding contributions to engineering and scientific management. Among her many honors she holds the Gantt Medal, the Wallace Clark Award, the Award of the National Institute of Social Science, The Gilbreth Medal, and ove twenty honorary degrees.

This last September the XIII Congress of the Comite' International de l'Organisation Scientifique awarded her a special scroll for outstanding leadership in the international management movement.

She is especially generous in responding to the requests of all who need her. We are deeply appreciative of her work as a consultant to this Conference.

Today she continues to FOCUS FOR THE FUTURE: our beloved Dr. Lillian Moller Gilbreth.

FIRST INTERNATIONAL CONFERENCE OF WOMEN ENGINEERS AND SCIENTISTS

FOCUS FOR THE FUTURE

Conference Keynote and Foreword
by

Dr. Lillian M. Gilbreth
Management Consultant and President
Gilbreth Inc., Upper Montclair, New Jersey

In selecting this theme for the First International Conference of Women Engineers and Scientists, the Society of Women Engineers has concentrated its attention on a service project. We have come together to focus our attention on the future needs of the world. We shall try, through pooling our diverse experiences, to estimate what these needs will be and then to consider ways in which we can best contribute to these needs.

It is no new thing for this group to approach a project in this analytical fashion. In the beginning, before SWE was organized, the need for such a society was carefully weighed and its membership requirements clearly defined. The Certificate of Incorporation and the Bylaws of the Society are evidence of its standards. As a Technical Society, we accept the Code of Ethics and Canons of Ethics of the engineering profession.

In a Conference such as this, we have representatives from many Countries. We shall be able to compare and evaluate our experiences, and to help one another focus on our aims for the future.

What is the engineer expected to do? To "utilize the resources of nature and of human nature for the benefit of mankind." We must both know the resources and put them to use. Known resources are reserved sources of supply, to be used when needed. A benefit is something that provides well being. Every engineer is expected to follow this code. This implies knowledge, dedication, and life long learning.

The engineer has obligations toward mankind, as have all professional men and women. He has obligations to further the growth of his profession; to accept, maintain and, if possible, raise its standards; to recruit for its organizations; to help educate and train its members, both before and after they join its organizations.

The profession has world-wide membership. Every engineer must recognize this and the responsibilities it brings to every engineering organization, and to every member.

Why women engineers? And why a Society of Women Engineers? Because the profession needs women, and because they need the opportunities for work that the profession affords. Because people with a common interest need the feeling of group solidarity that an organization gives. Because young women need knowledge of the opportunities in science and engineering, and help in being tested, educated and trained providing they have interest and the necessary aptitudes. Because many women, young and old, need the opportunities the profession gives.

Our First International Conference gives us a timely opportunity to think and plan together - to recognize and evaluate our likenesses and differences. The future demands that we utilize both. If we are to work together effectively, we should recognize that, while each of us is different from every other person, our likenesses are of great importance. This applies both to skills and to satisfactions. The interdisciplinary researches going on prove this.

We must come to know each other better, world wide. This means better communication, definition of words to make sure they have the same meaning to all, and better interpretation and translation. This means more travel and exchange of experiences, more opportunities to know one another internationally, not only through books and all the library can bring us, but in our meeting, our work places, our social life, our homes.

One of our resources is what has been called "management," which makes it plain that people everywhere have similar responsibilities. Everyone everywhere must learn (1) to manage himself, (2) to participate constructively in home and family life, (3) to be a good citizen, (4) to be a helpful volunteer, and (5) to earn one's way by doing a job that needs to be done. Our success in our engineering job is affected by our success in our other four jobs, and vice versa.

We have much to be thankful for, much to appreciate. Women engineers and scientists have welcomed and helped newcomers in the profession. Men engineers and scientists have helped us get education, training, jobs, promotion, and membership in organizations. SWE has special gratitude to express for our welcome into the United Engineering Building and for freely given help, where this was needed. I am sure that engineering women from other countries are grateful for similar help.

The sharing of experiences in our First International Conference should help us to focus more effectively on the future and to go forward into it together, courageously and in the spirit of service.

REQUIREMENTS FOR ENGINEERING AND SCIENTIFIC MANPOWER

By Dr. M. H. Trytten
Director, Office of Scientific Manpower
National Academy of Sciences, Washington, D. C.

INTRODUCTION

It is surely fitting at the outset, in speaking to this epoch-making convocation, to congratulate those whose vision, devotion, and assiduous effort have now been translated into successful reality. There are others who, possessed of more intimate knowledge of the persons who have borne the brunt of the labors, can single out those who have most merited just applause. Anyone in the slightest amount familiar with the enormous effort and talent such a ground-breaking event calls for will feel as I do, that the leadership which gave rise to this event and saw the planning through to conclusion deserves high praise.

I am interested in the fact that by the self-assertion which characterizes this event, women have declared their maturity as a component part of the professional labor force in a field not long ago almost conceded to men. In doing so, it seems to me women engineers have done themselves credit and have done a real service to their sex, to the profession, and to the nation. We have spoken much in the past of the untapped reservoirs of talent in our population. A large part of the greatest unused potential in our society in regard to scientific and engineering talent is that of women. There should be no doubt that the very fact of this meeting will contribute to a better understanding that women are not to be ignored as a potential force in science and technology, and that engineering will become an increasingly accepted profession, open and hospitable to women.

It is with these thoughts in mind that I must express an especial sense of privilege and honor in being asked to participate in this the first international conference of women engineers and scientists.

The subject of my remarks you have listed on your programs. To do complete justice to the subject one should have a higher degree of clarity of pre-vision than I possess. I believe any one whom I know who has concerned himself with the problem of future needs for scientists and engineers has learned how full of uncertainties is this process of prognosis.

THE INFLUENCE OF WORLD WAR II

We have been involved in this concern over future manpower resources for science and technology in our nation since the early days of World War II. I can recall no similar concern prior to that time. It is important, I believe, to recognize this unique situation. Education in our society has always been a personal and a local or parochial concern. Our secondary schools have been controlled locally and have reflected local interests, including the opportunities provided for each student to make the most of his latent potential. The benefits to the nation and to society of a well-trained and well-educated people were generally much more vaguely understood and poorly expressed.

The special significance of trained personnel in the professions and disciplines, including the sciences and engineering, particularly in a world racing into the scientific revolution, should have been understood and clearly articulated much sooner than it was. Indeed, the transition into a technologically based economy in our country was enormously accelerated in the decades between the wars. But the fact of the economic depression which clouded the economic skies in the fourth decade of the century obscured from clear view and understanding many otherwise obvious trends and tendencies.

When the crisis of World War II precipitated and this nation found itself literally without the instrumentalities of war, the technological mobilization promptly occurred. The resulting effort furnished probably the most spectacular demonstration of the power of organized technology in history. It has always seemed to me that we in the United States have understood the miracle of the mobilization of technology in World War II less than the many nations which observed it from the sidelines. The fact is that between 1940 and 1945, a scant six years, our almost complete state of unreadiness was changed to that of the possessor of the most powerfully equipped force of global dimensions ever previously seen.

But it also spotlighted the significance of highly talented and highly trained manpower in the disciplines concerned and, in fact, in all disciplines relevant to modern life. Since the close of the war and to the present day, the lessons of that time have led us to try to understand this wholly new dimension in our systems of economic and social values. It has been baffling, both in the quantitative and qualitative dimension.

Perhaps in the long run the most interesting and promising dimension will be the qualitative one. There are evidences that very bright boys and girls, given optimum opportunity and guidance, can achieve a working and creative mastery over a larger segment of science or engineering than would a few years ago have been thought impossible. One needs only to attend a final showing at some competition, such as that of the Westinghouse Talent Search, to be impressed.

On the other hand, highly talented people are not always necessarily productive. People in the last analysis remain people, and act in a very human way. They are not interchangeable parts like pieces on an assembly line.

REQUIREMENTS: A QUANTITATIVE QUESTION

I have mentioned these things because we are concerned here with the future and its requirements for engineers and scientists, largely a quantitative question. It is necessary to recognize immediately that there are inherent limitations in our capacity to read the auguries in this matter. We have only had a few years to try to improve methodology. We are handicapped by the fact that our problem is in substantial measure qualitative, with no good ways to measure or recognize quality except in a limited number of cases.

Nevertheless, we have made efforts and some strides in our understanding of the quantitative dimension. It is an important dimension, as every nation today understands. Perhaps the first step in this paper, as far as a quantitative presentation is concerned, should be to indicate the findings of the latest National Science Foundation-Bureau of Labor Statistics report, now several months old, but still the most current survey on this issue.

It may be well to describe briefly the methodology of this report, because in many ways it is a crucial document in this matter of manpower in engineering and science. It is the second in a series of surveys, the first carried out in the late Fifties and concentrating primarily on methodology, although predicting some concrete figures of demand for personnel in the sciences and engineering. The present study is to be considered an attempted refinement on both methodology and predictive forecast of demand.

In any attempt to predict demand the assumptions underlying the statistical findings must be established. In this case, the assumptions include relatively high levels of economic activity and employment and a steady increase in gross national product, assumptions which must be considered to have been approximated up to now as they affect the type of manpower here considered.

The second assumption is that space and arms expenditures and others commonly thought of in the context of "security" will rise somewhat. The third assumption is that the heavy expenditures in research and development will continue and grow, and finally that the economic and social patterns of the nation will not undergo any great changes.

The methodology of prediction included basically two elements, one a careful analysis of historic trends, such as the ratio of professional employees to general employment overall, and by sectors of the economy, as well as by industries in certain cases. More accurately,

> "In brief, the trends in the use of scientists and engineers in each sector of the economy were examined in relation to total employment and economic activity in that sector, and these trends were projected on the basis of expected changes in total employment and economic activity. In this way, developments in each sector could be examined separately to estimate future changes.
>
> In more specific terms, the steps were as follows:
>
> (1) Ratios of scientists and engineers to total employment were established for each sector of the civilian economy - including private industry, government, and colleges and universities - for the base year 1960 and for all previous years for which data were available.
>
> (2) Trends in the ratios were projected to 1970.
>
> (3) The projected ratios for each industry were then applied to independent 1970 projections of total employment by industry to yield first approximations of scientific and engineering manpower requirements for 1970. The independent projections of total employment used are preliminary data from a new economic model, prepared by the BLS staff, showing actual 1960 total employment and 1970 projected employment for all sectors of the economy in considerable detail.
>
> (4) The first approximations of 1970 scientific and engineering manpower requirements developed in (3) were then examined in detail and analyzed for reasonableness.

> Projections of requirements for engineers and for chemists, physicists, and each of the other scientific professions were derived by applying an estimated 1970 distribution (based on past trends and other information) to the above described projections of total requirements for scientists and engineers in each industry in the economy. As in the preparation of the projections of total scientific and technical manpower requirements, anticipated supply was not taken into account in estimating future requirements by occupation."

The same general procedure was followed in developing 1970 projections for government and for most other major sectors in the economy. A somewhat different approach, however, was necessary in developing the 1970 projections for engineering personnel in the universities. Here separate projections were developed for personnel in administration, in teaching, and in research. Numbers of personnel in teaching and administration were a function of projected enrollments. Projections of personnel engaged in research were based on past trends in the increase in this activity.

The projected net manpower requirements indicate:

> "...a 69 per cent increase in requirements for natural scientists and engineers in the United States over the 1960 decade - nearly 800,000 more than the 1,157,000 employed in January 1960 to a projected need for 1,954,000 in 1970. These increased requirements are expected to result from continued economic growth, expanding research and development activities and exploitation of the resulting discoveries, growing complexity of new products and process for civilian and military use, expected expansion of the space program, and the continued high level of defense expenditures.
>
> "In engineering, a growth in requirements of nearly 553,000 is indicated - from 822,000 employed in early 1960 to the 1,375,000 projected need by 1970, a 67 per cent increase. This compares with a nearly identical growth in engineering employment between 1950 and 1960, according to preliminary data from the 1960 Census of Population. For scientists as a group (including mathematicians), the increase projected is 73 per cent or almost 245,000 - from 335,000 in 1960 to 580,000 in 1970. The need for technicians is projected to increase at about the same rate (67 per cent) as that for engineers - from 775,000 to 1,297,000 for an increase of about 522,000 between 1960 and 1970."

I have gone into considerable detail over this particular report for the reason that, in terms of comprehensiveness, of design, of sheer expenditure of funds for its execution, and for the experience from which it has benefited, it should be as authoritative as the present state of the art permits. And yet there arises in certain quarters some skepticism with respect to the validity of its findings. It would seem to be important to consider some of the questions and opinions which have been heard since the advent of the NSF-BLS report.

CHARACTERISTICS AFFECTING VALIDITY OF PROJECTED REQUIREMENTS

Perhaps one of the points which should be made is that inquiries of industries as to their projected manpower needs face certain hazards. Industry is not always organized to answer such questions. The persons to whom inquiries go are not always current with long-range developments or prospective trends in their own organization. What is more important is that new technological breakthroughs can not be added into their calculations.

Secondly, psychology has much to do with the matter. An apparent temporary reduction in employment for engineers seems at one to generate a still further reluctance to hire. A temporary acute shortage of engineers seems to cause a stampede into the marketplace to hire engineers. Perhaps this is merely a manifestation of the human characteristic which is causing the hoarding of silver dollars today and other examples of the psychological syndrome over scarcities.

It is, however, peculiarly apparent partly because of the public attention which seems to be focused on the matter by the press whenever an occasion arises. These occasions do arise more often because of the volatility of the marketplace in manpower as a result of the sudden large shifts occurring in the so-called defense industries. Sometimes contracts calling for large numbers of engineers and scientists may be let or cancelled with equal abruptness. If a few hundred engineers are displaced it affects the market much more than commensurately. The vast bulk of the labor force in these fields, of well over a million professional personnel of specialization, is unaffected in employment. Much of the evidence, both for shortages and overages, is much more apparent than real. The ripple on the top of the pond does not affect the water below the surface very much.

Nevertheless, the skepticism with regard to the predictions above goes beyond what may be explained by transient changes in the labor market and their conspicuousness. If shortages were to occur in the middle of the present decade of the magnitude expected, they should presumably be more conspicuous.

There are a number of comments which have been made in this regard that are quite worth recalling. One of these relates to the fact that the pace of change has enormously increased in our time. Technological innovations of a fundamental sort may emerge from the laboratory and enter into commerce, greatly affecting employment, all within a space of time short compared to the decade covered by the referenced survey, and shorter still compared to the time required to train a modern engineer or scientist from the time of decision to become an engineer or scientist through high school, college,and graduate work, and subsequent apprenticeship. The point of this remark is that manpower strategy in a nation must of necessity be long-range, even though the transient effects in the marketplace may be turbulent.

FLEXIBILITY OF THE TECHNOLOGICAL COMMUNITY

Perhaps the most obscure phenomenon may be the most significant in this matter of the apparent relationship between our needs andour supply of specialized personnel in these categories. This is the enormous flexibility of the technological community to adjust to shortages and overages, so that indeed neither one seems in reality to occur in any challenging degree. This flexibility may be at the same time a protection and a safeguard, on the one hand, and a deceptive reasurrance, on the other.

The nature of this flexibility is complex. In our educational system, the pattern of education is by no means fixed and unchanging as one goes from college to college, and from department to department. There is a wide variation both in quality and quantity of training which is represented by a degree at the baccalaureate level in the science majors in colleges and universities, and even to a degree in engineering schools. Besides this fact, there are many training and learning opportunities in industry and on the job. The net result is that there exists in our society a not inconsiderable number of persons of less than professional grade or training who in cases of need and shortage can be drawn into work for which they are only marginally qualified. Sometimes they grow into the stature commensurate with the challenge of the new responsibility. Frequently they do not. But in any case, the professional labor force is in a sense extensible along the axis of qualification requirements.

There is another type of flexibility which is by no means so clearly observable in its operation. This is the adjustment of the technological work load to fit the available supply. During World War II most of the technological competence of the nation was shifted from its peacetime pursuits and focused on the needs of those critical times. In most cases this represented a sharp departure from the nature of the work which was for the time being abandoned. What happened to these abandoned vineyards? During the war they remained abandoned in large part. After the war the return to status quo ante-bellum was much in evidence psychologically. At the same time there arose a substantial shift of academic personnel into entrepreneurial activities to capitalize on new war-born technologies. Many of the leading firms now in existence were founded post-war.

However, after the Korean episode most of these companies were drawn into the new emphasis on "defense research and development." There has been much less fallout from defense research into commerce and industry, probably in no small measure due to the fact that much of the most creative leadership is now in the complex of defense research activities. If high quality leadership were in long supply, no doubt the progress in the non-defense technological domain would step up sharply. Flexibility in the deployment of manpower in science and technology may be in this case not always to the long-range benefit of the nation.

Having sufficiently hedged about the business of prediction with these comments, let me return to the NSF-BLS report, and state that, in spite of all that has been said, its findings will probably be largely borne out by the events of the rest of this decade.

It should be pointed out that several events have conspired to raise the questions that are prevalent today with respect to this report. In the first place, the Congress has for the first time begun to inquire more deeply into the affairs of federally funded science. It is also an election year, with its accent on economy, both in the executive and legislative branches. The research and development expenditures of the government seem to be approaching a plateau, although this is due more to the fact that major capital expenditures seem to be declining, and not necessarily accompanied by declining demand for personnel. With the psychological effects of these events added together, one might expect a considerable softening of the market for personnel. There has been some effort, but no pronounced change. For example, the findings of placement counsellors are always of interest in this connection, since indeed the fact of employment or unemployment is a very real circumstance in the view of any individual. For the present graduating class it is too early either to have the facts in completeness or to assess their meaning. This may be done in another month. However, for the class of 1963 fairly good information is available from the Journal of College Placement, where studies by Everett Teal of Lehigh University are reported. Teal's results are always viewed with interest and respect.

His findings of interest here, based on a national sample of over 50,000 graduates, show that as of June 30, 1963, all but 1.8% of engineering graduates were committed either to a job or to graduate school. Among engineering graduates 71% of the women and 18% of the men were expecting to enroll in graduate school. The high percentage of women engineers planning on graduate study is a particularly notable development.

THE NONQUANTITATIVE ASPECTS OF REQUIREMENTS

Perhaps it is time now to move away from the quantitative aspects of this problem. At the very best, it is a somewhat unsatisfactory approach. At the worst, it is of little meaning unless one can define and measure many elements in the quantitative picture which as yet are imprecisely known. The problem is far too important to be left to bookkeeping. I have indicated my confidence that the statistical forecasts indicated earlier in this paper are reasonably good predictions. The difficulty is that much more is involved than can be covered by the assumptions underlying the statistical predications.

The fact is that we are trying to adjust our ideas to the changes occurring in this the most dynamic decade perhaps in the history of the world. We are trying to adjust to the scientific revolution and to all the other major changes in the world, including quite unprecedented political, economic and demographic convulsions. Each of these is capable of affecting profoundly the equations of our present concern.

Generally, our methods of prediction are based primarily on extrapolation of the past. We shall continue to do so, but hopefully we shall be wise enough to realize that extrapolation has its limitations. We need, in addition, a sense of the nature and significance of the profound movements of our time. We need to achieve a perspective which can guide us in meeting the needs of these impending times. For it is true that changes can be sudden and great, and it still takes a dozen years to train a scientist or engineer.

It is perhaps at this point to be noted that the problem we are here concerned with may be thought of primarily in personal or public terms. In a personal sense, it finds its expression in the decision of the growing youth and his parents as to what his future shall be. In public terms it finds its expression in the manifold steps society takes to support education, training, and the development of science.

For most people, whether they are parents whose children are about to decide on a career or the young people themselves, the former is the burning issue because it is immediately personal in its application. However, it is the issue of public policy with respect to the further development of science and technology and the corollary problem of manpower in national terms that we are here concerned with. In treating this problem we, like most nations in the world, are seeking a national science policy. In one sense, this search is new in the extent to which it is for a consciously recognized need. In another, it is old, since to a degree the search has been in the minds of some thinkers since the advent of the scientific method.

From the assertion by Bacon of the scientific method, there have been those who have stressed the almost unlimited power of the method, if properly applied to the problems of man. There have been in general two major areas of science in which the public support of research has been unrestricted by notions of impropriety as a concern of the federal government. These are in the fields of agriculture and public health. In both cases the social benefits have been enormous. Probably these benefits can not be measured in dollar values or in per cent return on investment. Attempts which have been made come up with values such as a return of 100% per year on money spent on agricultural research to date. Suffice it to say here that such returns are very great indeed.

Perhaps one major problem in arriving at national science policy is that of determining the proper role of government. In our zeal to leave to private initiative the latitude to pursue research for private purposes, a wholly laudable objective, it is possible to lose sight of reality. The federal government is already focusing a large part of the prime scientific leadership on certain specific targets, and in so doing it is limiting the power of the technological competence of the nation to focus on other needs. Also there is no natural guarantee that the most interesting and socially useful or desirable inquiries should parallel profitable economic opportunity. It will probably be more and more the case as time goes on that the pressing need for research to meet major problems will not be matched by economic opportunity sufficiently attractive to trigger off private initiative. The problem is one of the major reasons for the search for a national science policy.

It is necessary to call attention to this point in looking to the future. It is easy enough to point to needs, many of them compelling, for new directions of technological effort. Whether these will eventuate will depend on the degree to which we understand and properly use the power of scientific inquiry in the interests of the common good.

Much of the methodology of prediction of future needs must of necessity presuppose a certain continuity of past trends. In the case of manpower needs in science and technology, this must also be the case. Much has been said lately of the need for the new engineer, the man whose base in science is broader and deeper and whose role will be at a higher intellectual level than has been the case traditionally. This seems destined to be the case, but the transition will not be immediate. Not all industry, but indeed much of it, will continue to hire for the traditional role. Concomitant, therefore, with the growing need for the "new" engineer is the growing need for the "standard brand." Eventually perhaps a somehwat elevated curriculum for the technical institute may provide the needed high grade technician who can take over much of what many engineers now do. But the time is not yet.

In the meantime, competition in the international technical world is sharply increasing. Remarkable strides are being witnessed abroad, for example, in transportation research, in the design of rail transport, and ocean vessels. This is a challenge which must be met.

Many functions carried out by scientists and engineers are related to the magnitude of the population. With the phenomenal growth of the population the corresponding levels of needed services also rise. This applies to power facilities and service, transport, housing and a host of other needs. Some of these needs increase not linearly but logarithmically, for example, the problem of transportation. There are many situations in our sprawling metropolises where it is almost impossible to get from one point to another by public transportation in any faintly reasonable time. Meantime, the automobile is in greater and greater danger of being forced out as the answer to public transportation by the sheer weight of the problem.

The need for fresh innovation in industry is patent. The enormous thrust in expenditures for research and development in recent years has left a legacy of scientific findings for which there is as yet no proper way of systematically exploring its usefulness in the civilian economy. Furthermore, those most knowledgeable about it are continuing to focus on other goals and creating new knowledge. Fresh innovation, while greatly needed, can only be achieved with available talent of a high order.

The "defense" aspect of our technological effort needs no particular comment. However, it may be noted that while there is at present a slowing down in the rate of growth of expenditures in space research and development, in comparable military technology and in atomic energy, the aggregate demand in these categories will remain very high for the rest of the decade at least.

NEW NEEDS OF THE FUTURE

The needs of the future will not substitute for these demands, but will be new in many ways. Perhaps the most pressing problem of our day is that of the emerging and developing nations. Most of them have a combination of circumstances which promise precarious years ahead. In most of them, population is running ahead of any means of supporting it, and the peak of the problem is not far ahead. In one country recently visited, the average age is below fifteen. The impact of the burgeoning flood of young people on the labor market can be visualized.

There is no apparent solution except for the more advanced nations to assist in developing a technological base which can support a working population. This will take manpower for export in a level of flow not yet even visualized in our country, if indeed this will not be one of our greatest lost opportunities.

In our own land the need for adjustments to our own technological civilization is beginning to be more insistent. We have alluded to the critical need for a new and massive program to meet the transportation demands of an urban society such as the area from Boston to Richmond in a belt at times up to 70 miles wide. The automobile will be crowded out, as it is now in Manhattan. But many other problems grow out of the same causes. Recreation facilities, which at one time were the natural birthright of us all, with lakes and beaches, playgrounds, woods and fields not too far away or too crowded, now must be created for an ever-increasing and concentrating population in areas where need for them has not previously been recognized.

On the negative side, we must learn to deal in a wholly new way with destructive elements growing in proportion to population and technological change, such as pollution of air and water, chemical and biological agents of destructive capability beyond their purpose. For most of these new needs, public recognition of the relevant problems is very recent. We start late on many of these matters, and the pace must be swift to catch up to our needs.

One of the aspects of the problem of adequate manpower for the future that has always interested me is that any planning that is done must of necessity recognize that we are looking ahead a dozen years at least. The decision to move in the direction of the sciences or engineering is commonly made or foreshadowed in the early high school years or earlier. But from then until the youth has grown to maturity, passing through high school, college and apprenticeship, whether in graduate school or on the job, a full twelve years has normally passed. But today a whole technological revolution may have occurred in that time.

The rise of nuclear technology was mainly a matter of less than a decade, as was that of semi-conductors, jet propulsion and anti-biotics. New sudden surges in other branches of technology are probably inevitable. We need to be ready to move into such new areas with competent man- or womanpower, in order to capitalize on the new frontiers opening up. Here the need is not only for a deployable portion of the labor force, but for flexibility in their competences permitting the degree of migration into new scientific phenomena called for.

EMPHASIS ON EDUCATION

This again throws the spotlight of attention on the educational institutions of our land. In the uncertain years ahead, nothing is more essential than strength in the institutions from which our trained personnel come. As the rising tide of young people surge in upon our institutions of learning in science and engineering, we should have teachers in quality and quantity who are able and eager to teach not only the subject matter relevant to a changing technology, but the nature of the rapidly changing world these young people must serve. Probably no single need will be so great or so unlikely to be met, if one speaks generally of all institutions of higher learning or, indeed, of the secondary or preparatory schools as well.

One of the categories which may well be of considerable need in the future is that of management. Perhaps one might also include public service at a high administrative level. There are few management functions today where some fairly intimate understanding of the nature and processes of technology would not be a clear and, indeed, perhaps an indispensable asset. The trend is apparently in this direction. It is sometimes possible to acquire the technical expertise on the job, but it is apparently much easier for the person with technical knowledge to acquire administrative skills if he desires to do so and has any bent in that direction. Not all management personnel require this background, but it seems likely that in the future a steadily rising percentage should, and will, have it.

Many of the problems mentioned above have their strong element of human involvement. The behavior of people is an increasing factor in many of the problems which will preoccupy policy makers in the coming years. The impact of a swiftly moving technology has destroyed the way of life of many people, changed living habits and environments and created new problems and situations with which people have to struggle as an element of daily living. Increasingly, scientists and engineers have to deal with problems and situations where the technical element is only a fraction of the problem, the rest being the human element. Examples are the location of highways, the creation of new transportation systems, the location of recreation areas, the conservation of resources and areas for parks and wild life, the control of pollution, etc. The scientist or engineer here must lend his assistance and understanding to that of the social scientist in the public interest.

It may be commented here that our problem for the future is not to determine what our needs for persons trained in science or engineering may be. The probability is high, it seems to me, that if we were to attempt to meet all the challenges facing our nation we could not find enough competent youth to train for the purpose. Our problem is rather so to structure our society that we find proper ways of supporting the work that must be done.

There never has been in our minds a thought that a person could be trained to a level of competence which we would think too high. Nor would we think it likely that if our most able youth were really to be trained to their maximum potential, we would need to be alarmed. We have abiding faith in trained ability. What we need is more abiding faith that if such trained personnel were turned loose on the major problems of our day, the social benefits would parallel those in agriculture and public health. We should have faith that there is no over-supply of ability or talent, but only under-utilization.

So far in my discussion I have maintained a lofty unconcern with the relationship of the sex difference in employment opportunity or professional choice. Partly this is because in all my teaching career in physics I never noted any clear difference between men and women as far as academic performance was concerned, once they had been enticed into the classroom. There is a lot of evidence, statistical and otherwise, that sex does make a difference in the probability that a woman will enter the classrooms of science and engineering.

Miss Pauline Tompkins, Executive Secretary of the American Association of University Women, has said that such "discrimination against women in employment is in part a reaction to the lack of career planning by women. In turn, job discrimination and inadequate career planning can be attributed to a considerable degree to our cultural mores regarding the role of women, the professions 'suitable' for them, etc." The needs of society will probably be the urgent force which will provide a change in the relationship of women to the career and job picture in our country in the near future. Miss Tompkins predicts a job revolution for women, and quotes from an article in the March issue of the journal of the AAUW by Professor John B. Parrish, Department of Economics at the University of Illinois, who says "Strong economic and social and technical forces are now working to bring about fundamental change in the demand for and supply of women workers. These forces are proceeding with such rapidity as to be revolutionary rather than evolutionary. They will bring the first major occupational upgrading of women in the nation's history."

Noting the likely need for increased numbers of persons in the disciplines we are interested in today, Professor Parrish states also that the variety of jobs and levels open to trained womanpower is greater. The changing nature of jobs opens more opportunities for women. Dr. Parrish says:

> "The application of mathematical techniques and computer technology to production processes, the shift in emphasis from production to research and development, the development of automated systems of information search, storage and retrieval have combined to bring about a change in employment from shop to office, from the practical to the theoretical, a context more favorable to women."

A case in point is engineering. Not long ago this profession was among those deemed least suitable for women. Today there are at least enough women to constitute a beach-head, probably over 7,000 active. Even so, percentage-wise this is not impressive; it seems probably that Professor Parrish may be vindicated in the future. Certainly the general picture is one of women flooding into the labor force in volume. The most recent bulletin of the Population Reference Bureau has a somewhat current review of the situation.

Nearly three-fifths of the growth of the labor force in the Fifties occurred among women, although they were only one-third of all workers. Women 45 years of age or over accounted for 58% of the growth. In this same decade, the female labor force expanded by 4.8 million, whereas the male labor force expanded only 3.5 million. Over half of the female labor force were working wives. The number of single women in the labor force actually declined.

The inference from these remarks seems to be clear. A combination of economic need and present mores, including circumstances conducive to work in our modern highly gadgeted society, are drawing more and more women into the labor force. The changing technology of our day is demanding more people with higher skills and professional competence. But up to now the professional level at which women enter the labor force is well below what it might and should be. The missing element has been appropriate guidance and career planning.

Women's organizations and other interested groups will need to face the realities of intermittent employment, for family raising, for example, on the part of women, and plan accordingly. Concerted action to conserve womanpower and to foster the best use of professionally competent women will be necessary. Steps have been taken in the recent past to bring out rational programming for women, by such organizations as the AAUW, and the Carnegie Corporation cooperating with Mills College, the American Council on Education, and others. Programs for retraining women have been organized, for example, at Rutgers-Douglas, at Radcliffe, and at the University of Delaware. However, so far the efforts have fallen short of the considerable need for action.

For years, those who have written and thought about manpower problems in the technical fields have been unanimous in urging more use of womanpower. There seems a considerable consensus that no substantial resistance to hiring exists in types of employment where the nature of the job is not inhospitable to women. It would seem a particularly propitious time for concerted action which could penetrate to the heart of the problem. This is at the level of family attitude, community mores, and in the practices of counselors and guidance officers. There is, it seems at present, a favorable time for an effective push for more women in the professions of engineering and the sciences. Perhaps one should say here that as far as womanpower in science and technology is concerned, there is likely to be no over supply, but there is definite under-utilization.

TECHNICAL SERVICES NEEDED IN SUPPORT OF ENGINEERS AND SCIENTISTS

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INTRODUCTION

The Oxford Dictionary defines an engineer as "one who contrives, designs or invents" and a scientist as "a person learned in one or more of the natural sciences", whilst science itself is defined as "systematic and formulated knowledge." This latter definition could be extended and formulated as follows: "A scientist is a person who observes phenomena, systematizes his observations and draws general conclusions, which allow predictions of future events to be made, and who formulates these findings so that they are accessible to others."

To illustrate the definition of an engineer, it may be said that what distinguishes the first man from his animal ancestors was that he was an engineer. Not the fact that he used tools - the higher apes are quite capable of using sticks and stones as tools and weapons - but the fact that he fashioned them! He deliberately worked flints to a preconceived pattern in order to shape handaxes, knives, arrows, spearheads and the like. He contrived and designed and produced.

One cannot, however, say that he was a scientist. Although he certainly must have observed the shape and color of natural flints in order to find them, must have found out under what conditions they occurred in his environment, must have observed time after time the way the flakes shaped under different conditions, and must have drawn conclusions which allowed him to predict how the flakes would shape if he attacked a certain piece of flint in a certain way, still this cannot be called science in the sense of the definition, as the laws deduced from these findings were not formulated.

In considering prehistoric man, one fact stands out. That is that not one man - or woman - invented or developed the techniques which allowed mankind to survive, but that it was the community as a whole, the contribution of countless individuals over many generations, who brought about the means to warm, feed and shelter all the members of the community.

In the earliest recorded historic times, we already find a high degree of specialization, although by and large every man or woman, or at least the small rural unit, as for instance a peasant family, was still able to survive on their own. This was because they were still able to master almost all the crafts and techniques necessary for their daily lives, and were in possession of the necessary knowledge to predict the seasonal events on which they depended.

Perhaps the earliest specialization and the most important one was metallurgy and mining. Within this industry - one can already give it that name - a fairly high degree of dividion of labor appears. Also a large corpus of knowledge, both theoretical and practical, was amassed, and whilst the manual skills were transmitted from father to son, the theoretical knowledge was formulated and recorded, mostly in temple libraries, and thereby became true science.

As other technologies developed - pottery, textiles, building of houses, roads, bridges, canals, irrigation systems, navigation, and astronomy to name only a few, an increasingly higher degree of specialization and of division of labour became inevitable. Gone were the days when one man could know everything that was knowable or put his hand to any task that required doing.

One consequence of this growing complexity of the structure of the economic life was the growing interdependence of all of the branches of science and technology. During the last centuries this development has become more rapid and more pronounced. The differentiation of skill and knowledge takes place both in a horizontal and vertical direction. Increased specialization is accompanied by an increase in the mutual influence of one discipline on the other. To an increasing degree all men are dependent on all other men for survival and development.

EXAMPLES OF DIFFERENTIATION

A few examples may illustrate this point.

Medicine today is unthinkable without X-ray apparatus and techniques, designed and developed by engineers.

Control terminology has been adopted to a large extent by physiologists, whilst on the other hand many physiological concepts have stimulated the evolution of the theory of information. The term "Cybernetics" covers both the technical and physiological science of automatic control.

The heating and ventilating engineers require the biologist to tell him that Ozone may be as poisonous as Chlorine, and that the admixture of Ozone in an air conditioning plant must be carefully supervised so that the safe concentration is not exceeded.

In the control of machine tools by computers, one of the newest additions to production techniques, classical machine tool engineering, general electrical engineering, control engineering, and data processing theory and techniques must be combined.

This collaboration of the various disciplines in science and industry can perhaps best be illustrated by analyzing a major industry. Consider, for instance, the construction and running of a modern power station.

Civil engineers and architects are responsible for the buildings and foundations for heavy machinery. The supply of the fuel, say coal, either by rail or by water, requires the construction of sidings or docking facilities, and coal and ash handling plant are products of the heavy engineering industry. Water Intake and Effluent Discharge are specialized civil engineering work.

The boiler requires the collaboration of structural engineers with heat engineers, who must have special knowledge of thermodynamics, heat transfer, flame propagation, etc. The ceramics industry supplies the firebrick lining of the boiler. Boiler tubes and drum are produced in steelworks and forges.

Water treatment requires the help of chemists; supervision of effluents is the task of biologists. A great number of pumps and fans is required, the design of which is based on hydrodynamic and aerodynamic principles, metallurgy and constructional engineering.

The turbine is the product of another specialized branch of engineering, involving such subjects as metallurgy, casting, machinery, lubricating, and bearings, quite apart from the theoretical design considerations.

The electrical industry contributes the generator and all the motors that drive the auxiliaries, pumps, fans, and lubricating oil pumps. Another branch of the electrical engineering industry supplies the transformers; yet another the switchgear. Cooling of generators with hydrogen gas is an application of physics.

The necessary supervisory instruments come from various specialized firm in the instrument industry; the panels on which the instruments are mounted are produced by another set of firms.

Automatic controls are provided by the control industry. They may be either pneumatic or electronic, and are usually either pneumatically or hydraullically powered, even if the signal transmission is electrical, and therefore compressor plant and oil pumps are required.

Electronic data logging and computers begin to make an appearance in the modern power stations.

The safety of the plant calls for elaborate alarm equipment. Some parameters require the attention of chemists for their supervision. The power station must have an extensive workshop in which maintenance is carried out.

Many auxiliaries can only be briefly mentioned, for instance, valves, dampers, attemperators, cooling towers, closed circuit television and many others, which all come from separate fields of engineering and all require design and development work, based on scientific researches.

DIVISION OF LABOUR

The personnel required to staff a power station will come from widely varying fields. Among them, there will be electricians, mechanical engineers, instrument engineers, chemists, and biologists; and their qualifications will cover a wide range.

Such vertical division of labour will be found everywhere in industry. There is a great complexity of structure; levels of skill and knowledge are differentiated from the unskilled labourer to the highest executive.

At this point it seems necessary to enlarge the definitions of the engineer and scientist, with which this survey began. It may conceivably be possible to give a clear definition of a scientist in the functional sense, as somebody who holds a University degree in some science, whilst those that do not hold such a degree are called technicians. Even here the borderline would be rather fluid. There are technicians who have acquired such wide knowledge of their subject and are so gifted that they are capable of undertaking original research just as well as fully qualified University graduates.

Looking at engineers, there does not even seem to be a borderline. Engineers with University degrees, B.Sc. or Ph.D. or Dip.Tech., may be working side by side with engineers who have no paper qualification. It may even happen that a man who has only "practical experience" to his credit is in a superior position and in charge of University graduates. This is partly a consequence of the British system of training and education, which will be mentioned in more detail later on. When one talks of engineers, therefore, one cannot classify them by their qualifications, but must define their functions.

With the increasing specialization of knowledge and experience required, particularly in the new sciences and industries, as for instance in electronics and spacecraft, or in chemistry and allied branches, there arises now a growing tendency for management to insist on paper qualifications for the higher grades of appointments. Whilst the passing of exams as such does not necessarily imply that a man (or, of course, a woman) is of higher calibre, it at least gives proof that he or she has acquired a certain minimum of knowledge in the chosen field.

Therefore, a majority of engineers with University degrees now hold the more influential and managerial posts, whilst those without these or with lesser qualifications fill the more routine posts of technicians, draftsman, service engineers, and the like.

MATHEMATICIANS

Mathematicians are in a class by themselves. Mathematics of course, is standard equipment for both engineers and scientists. Here again specialization has reached such a pitch that it is hardly possible for either of them to master the mathematical science fully, and for many branches of work specialist mathematicians are needed.

During the last hundred years or so mathematics has developed enormously and in itself has become differentiated. There are problems, particularly in research, which will yield solutions only to mathematical treatment, and special mathematical techniques have been evolved for these problems. This applies particularly to pure Physics research, which is unthinkable without mathematicians.

Application of Servo Theory makes aircraft control possible and is used in many types of defense work, e.g., in guided missiles and, at a further stage, in spacecraft. The shot to the moon required extensive use of mathematics provided by mathematicians of the highest qualifications and originality of thinking. Astronomical calculations are done by mathematicians of physicists with a special aptitude for and knowledge of mathematics.

In nuclear physics, innumerable calculations have to be undertaken, and whilst some of these, by now, may have reached an almost routine stage, the development of the theories and their mathematical formulation can only be undertaken by mathematicians.

Mathematicians are employed in telecommunications, where they perform the complicated network calculations for telephone and telegraph cables, filter design, etc.

In the production field, large use is made of statistics, a specialized branch of mathematics, in data sampling, sample testing and bulk testing. Quality control is based on statistics.

Data processing, used to an increasing extent for the supervision of complicated processes, e.g., in the chemical and petroleum industries, as well as in large power generating plants, rests on a mathematical and statistical basis.

Man; involved calculations nowadays are done on computers. Apart from the fact that the conception of computer design involves special extensions of mathematical methods, the translation of engineering and research problems in physics, chemistry, biology and other fields into formulae suitable for solution by computer is in the first place the job of a mathematician, working in conjunction with the engineers of scientists who are undertaking the research.

THE AUTOMATIC COMPUTER

A great deal will have to be said in this survey about computers. They are the newest tools at the disposal of engineers and scientists and constitute a large step forward. Their introduction has been called a revolution, and although some forms of computing are almost as old as recorded history - think only of the abacus - this is almost justified. It has been hailed by some as being endowed with almost superhuman powers. There have been visions of a world in which the humans can almost retire to a time of infinite leisure, whilst all the work is done by electronic robots under the control of electronic "brains". This is not only quite phantastic and fictitious, but is an unhealthy approach, which can only have harmful effects on future developments. One cannot be too emphatic on this point.

A computer cannot, fundamentally, solve any problem that could not be solved by a good engineer or scientist, given the necessary time and manpower. What the computer can do is to solve problems immeasurably faster and with greater accuracy.

As far as controls by computer are concerned, where necessary information is missing, as for instance, when at some point in a process there are no detectors or analysers available, or where the theoretical correlations between phenomena are unknown, then no computer can give an answer to the problem or give instructions for the correct carrying out of the process. If a working hypothesis can be formulated, then the computer can, by an enormous number of calculations in which all the known variables are permutated, sometimes arrive at a possible solution on which decisions could be based.

Within these limitations, however, the computer is an immensely powerful tool that can give great relief from tedious work and enable accuracies to be achieved which could not be reached by means of "hand calculations". It thereby leaves the engineer and scientist free from repetition and drudgery, and in that sense one might be justified in calling the computer a "robot".

A few examples may serve as illustrations.

In transformer design even an experienced designer must calculate perhaps ten different preliminary designs in order to arrive at one which will satisfy his requirements. The computer will produce an optimum design out of a much larger number of calculations in a fraction of the time the designer would have needed by manual methods. After the basic design has thus been settled, a great many further calculations have to be made, most of which are time consuming and not very interesting. The computer can be fed with a flow diagram, and starting with the control data at every stage. Where there is more than one possibility for proceeding, all the possible ways will be tried and the optimum will be selected.

This may entail several repetitions right from the start, with some new data gained in the process. Even so the whole calculation will not take longer than some hours, and the designer can then consider a whole set of output data. The speed and accuracy of the operation will allow the designer to reduce the size of transformers by enabling him to use the lowest possible safety factors. And since designs can be produced within days rather than weeks or even months, it is now possible to consider several alternatives and to submit them within a very short time after having received an enquiry.

The same considerations apply, of course, to the design of motors and generators.

It is also possible to simulate performances and thus gain data which could otherwise only have been obtained after long trials. The performance of Diesel Electric Locomotives can thus be simulated. Data representing gradients, curves, speed restrictions, engine characteristics, and so on, are fed into the computer. The output will then indicate the optimum running time for a given journey, the fuel consumption, and other relevant data.

In the field of telecommunications, the General Post Office can, for example, obtain the life expectancy of transistorized repeater amplifiers used on underwater cables which have to be operative without maintenance on the sea-bed.

In chemistry, computers are used to determine the physical properties of chemicals in an attempt to relate some characteristic data such as boiling point, critical temperature, vapour pressure, etc., to their structural formulae.

In petroleum research, direct performance tests are carried out both in the laboratory and in vehicles on the road. One can then determine the effects of the composition of the product on its performance.

Again with the help of the computer it is possible to determine the temperature and pressure profiles down a pipeline, which can then be used to determine how much pumping power is needed and where to place pumping stations.

The determination of the underlying rock strata is essential for operation in the oil industry. This is done through analysis of seismic data with the help of computers.

In biological research, the time saving can be even more spectacular, when experiments are simulated that normally would take years. In chicken breeding, for instance, in order to improve egg production and chicken quality, programs are worked out representing biological phenomena such as cell division, reproductive cells and cell fusion. By combining a number of such programs it is possible to simulate the development of a chicken population. The genetic make-up of the parent birds is estimated, and a likely genetic make-up of the offspring is then produced by the computer. Taking into account the chicken's environment, the biologist can then estimate the bodily characteristics fairly accurately. Actual experiments would yield comparable results in about ten years time, whilst the computer provides the data in some hours.

It is strikingly obvious that the saving in time in such a case is not even the greatest advantage. The greater continuity, the freedom from tediousness, will allow the scientist to concentrate on the essentials and, by enabling him or her to repeat and vary such tests, to discover perhaps unsuspected fundamental relationships.

Yet another example from the field of biological chemistry is the control of yeast production. Yeast passes through a number of vessels in each of which a nutrient is added in such a way that in the final vessel the concentration of nutrient absorbed approaches a known optimum. The feed schedule is formed by superimposing a number of basic schedules and optimizing the results by special techniques.

This brings us into the field where computers are used not only for analysis and data processing, but for control of processes. One of the best known examples is, perhaps, that of production control. It can be applied as well to continuous or flow line production as to batch production and even to jobbing production. The objective is to organize both manufacture and stockkeeping in the most economic manner, so that orders are fulfilled on time whilst stores are kept at the minimum safe levels.

By using the computer memory, incoming information can be stored with a minimum of paperwork, and instructions to the shop can be given at the right time based on up-to-the-minute information about orders, stocks, work in progress, shop lay-out, shortages, etc. Shop loading can be optimized to a certain extent. Management can be provided with reliable feedback information, and any unforeseen events can be quickly taken care of, so that necessary changes to the established program can be made in good time. At the same time past performance can be analysed, and sales forecasts can therefore be much more accurate and closer to reality.

All sorts of book keeping operations also can be carried out, e.g., pay roll, stock lists, costing records and others, but these belong to the commercial field and need not concern us here.

A further field of control in which the electronic computer now begins to appear is that of automatic boiler control. Pneumatic analog computers have been used in this field for a very long time and may still be preferable, for instance, in fire hazard areas. Their great advantage over the electronic digital computers is the ease with which integral and derivative terms can be incorporated. However, where lines of communications between the detecting instrument and the processing and indicating instruments become very long - as is invariably the case in modern large steam pressure and power generating plants - then electrical transmission has obvious advantages.

The choice between pneumatic (analog) and electronic (analog or digital) computers will be partly determined by the ultimate aim. If the final link in the control loop is a valve or damper, which has to be positioned, then the choice would be a pneumatic computer. If, on the other hand, a set of data is required, then the digital computer can do this with greater ease. Whichever is chosen, it will be possible to run the plant much nearer to its possible maximum efficiency and with far greater reliability than if it were left to human operators.

This does not, however, mean that the human operator becomes superfluous. He is relieved of menial tasks and the tediousness of having continuously to observe indicating instruments. His task becomes truly supervisory. It requires a higher degree of theoretical knowledge. He is able and available to deal with any deviation from standard performance, an indication of, which will be a function of the computer-operated data logging and monitoring equipment. Only the class of operating personnel has changed; instead of stokers, maintenance engineers are now required to attend to complicated and delicate instruments.

It seems obvious from these examples that not only a great number of computer programmers and operators are required, but also that at least programmers have to have a high degree of specialized training in order to be able to communicate the problems arising to the computer. They will have to work closely with the mathematicians, as explained before, who evolve the mathematical formulae in which scientific and technological problems must be expressed in order to be solvable by computers.

Today the use of computers is greatly facilitated by the development of internationally agreed computer languages, e.g., ALGOL 60. This language is sufficiently similar to every day language to make it comparatively easy to acquire. This means that on some calculations the designer or researcher can dispense with the programmer and write his own programmes. This has sometimes the advantage that intermediate results may prove to be unsuspectedly useful to the designer or researcher, whilst they would be meaningless to the routine programmer, who could only be expected to produce the final answer.

However, as a rule, the services of highly qualified programmers will be required in increasing numbers.

TECHNICIANS AND LABORATORY ASSISTANTS

Workshop and laboratory technicians are equally indispensable. Every research laboratory, both in pure research and even more so in applied research and production, has normally a workshop in conjunction with it, in which the special apparatus required by the experimenter can be constructed or maintained. These instruments and apparatus, which are often very makeshift - a sort of string and sealing wax affair, are built by the workshop technicians from sometimes very vague sketches and instructions. A very high and specialized skill is therefore required and a very intimate knowledge of what the instrument is supposed to do. Such skill and knowledge can only be acquired by years of experience.

There are many different activities to be performed that require special manual skills, e.g., glassblowing, which is often needed in chemical or biological research. Technicians operate microscopes and electron microscopes. The cutting of the sections of biological specimens is almost an art, which can only be learnt by long practice.

Routine testing is usually left to the beginners, who thus acquire familiarity with the equipment which may later enable them to use it on original research.

Most laboratories and experimental workshops are staffed with an army of experienced and specialized technicians, without whose aid successful research and development could not be carried out.

DRAWING OFFICE, PLANNING AND WORK STUDY

Drawing has been rightly called the language of the engineer. The drawing office, or drafting room as it is known in the United States, is the core of every project. There are many types of drawing offices. In general production there will usually be one or more design drawing offices, a works drawing office, jig and tool drawing office, and so on. In smaller firms these will probably be combined. Each drawing office is usually divided into various sections, working under a section leader. These will deal with specialized aspects of the product of the firms. For instance, one section will be occupied on panel design and lay-out, another will deal with, say, valves, and yet another with arrangement drawings. Or in the case of machine tools, one section will specialize on gearing, another will design the bedplates, and so on.

What distinguishes the designer from the draughtsman (draftsman) is, apart from experience, a fertile imagination. He must be able to visualize a complex whole and to subdivide this entity into parts which can be handled by the individual sections. Within the section, the subassemblies will be still further subdivided until eventually a detail draughtsman can deal with one single part. Even for the design of a small part, a great deal of knowledge is required by the draughtsman. He must know what materials to use; he must be familiar with workshop practice in order to judge how and to what limits the parts have to be machined - if the limits are too fine, the part will become too expensive; if not fine enough, fitting may become difficult and, therefore, again expensive. He must take into account under what conditions the part will have to work and allow for possible heat expansion. Heat treatment has to be specified; surface finish, friction and backlash have to be considered; and so on.

The draughtsman has to be familiar with existing standards, and wherever standarized parts are available, these will have to be usedin preference to new designs, unless for very good reasons they are considered unsuitable. Where off-the-shelf mass-produced parts can be used, this will have to be done. The draughtsman, therefore, must familiarize himself with catalogs and advertisements, and generally consult the available technical literature. He may have to choose between several alternatives, each requiring a different lay-out or at least different fits in the part he is designing.

All this time the section leader has to watch that the detail fits into the subassembly for which the section is responsible. He must bear in mind how the parts will fit together and how the design of any one part influences the design of any other part. He has to watch the clearances, must see that it is possible to assemble the different parts, and must check on limits and generally supervise the drawings made by the detail draughtsman.

At the same time he has to coordinate the subassemblies drawn in his section with those produced by other sections. Frequently, the design of one or more details will have to be modified, as the design of other parts or subassemblies proceeds.

If the design is not for a prototype but for production, the jig and tool drawing office will soon have to be called in. Here jigs, fixtures, tools, handling equipment, gauges and other inspection aids have to be produced for every single part. The jig and tool designer has usually also to do the planning, although in some firms a separate planning department is in existence. Here the sequence of operations is laid down for every item. The planner must have a thorough knowledge of the machine capacity available and of the shop layout. Often the sequence of operations for some part has to be modified in order to get better shop loading, and this in turn may have repercussions on the design of the part. A slight modification may sometimes mean that a number of operations can be undertaken by one machine and thus cut down handling time.

If it is a case of mass production, the jig and tool designer can go all out, as the cost of the tooling will be small compared with the quantity produced and the shop lay out can be arranged to suit the product. Every second saved on any one operation will result in really big savings. This is, of course, where the moving belt was first introduced and all automatic transfer equipment started. Jigs and tools then become special-purpose machinery.

In the case of batch production with comparatively short runs, the situation is much more difficult, as the cost of the jigs and tools has to be absorbed in the price of the finished article and if the runs are not very long, it may not be worth while to shift heavy machinery to suit a proposed sequence of operation. This will then have to be adapted to existing shop lay-out. This is a case where the technique known as "Work Study" will pay particular dividends. In large undertakings there is frequently a work-study office, but in smaller firms this is usually done in the planning office or even in the drawing office. Work Study is a systematic investigation of all necessary steps to be undertaken in the production of part or equipment, considering all possible variations in materials, operational sequence, shop lay-out, available stocks, or off-the-shelf equipment.

An extension of Work-Study techniques, which has in recent years gained wide application, is what is called "Project Evaluation Review Techniques", abbreviated PERT, also sometimes called "Critical Path Analysis". This method adds time estimates to the job breakdown and enables the critical activities to be pointed up so that special attention can be focussed on them. This ensures a much closer control of the progress of a project. A computer can be used to evaluate alternatives in the proposed process, and it is thereby possible to optimise the project to a certain extent. This technique can obviously be applied to projects of any size, from the production planning of a machine to large building projects. It was developed in the first instance for monitoring the progress of the Polaris Missile Program. It has become a very sophisticated tool for the designer and production engineer.

It is thus apparent that draughtsmen, planners, and work-study engineers are all working to enable the designer to accomplish his task more efficiently.

LIBRARIES AND TECHNICAL LITERATURE

It is essential for every engineer and scientist to have access to the records of the achievements of the past. These are collected in the technical literature, that is, publications and periodicals. While the fundamental knowledge required for every branch of technology or science has been acquired during training, the mind should not be cluttered up with details which can be found in books and tables. To know what has been done in the past to solve a set problem saves a lot of time and unnecessary effort.

It is equally important to keep abreast of new developments, reports of which are usually published in magazines and periodicals or in catalogs.

Information is published, for instance, by learned and professional Societies, of which there are about 800 in England. Much of this is publication of original work, as for instance the bulletins of Research Institutes.

There are also popular scientific papers aimed at the laymen. The importance of these will be discussed later. The Government issues publications, mostly in the form of reports. Lastly, there are commercial publications, such as scientific books, journals, journals issued by private firms, containing reports of research and achievements.

There are catalogs and advertisements, giving information on the products of individual firms. Universities publish theses produced by their graduates. Then there are the publications of the British Standard Institution, laying down standards and Codes of Practice, and lastly the publications of the Patent Office.

To put all this information at the disposal of the user, there are the libraries. First, there are the large Public Libraries, as for instance in England the British Museum Library and in the United States the Library of Congress, which receives a copy of every publication that appears. There is the Patent Office Library, the libraries kept by the major institutions, e.g., the Institution of Mechanical Engineers or the Institution of Civil Engineers, to name only a few, and of course the University libraries.

Some large firms like the I.C.I. or Shell also keep extensive libraries. Practically all firms keep libraries of varying size, which are normally stocked with the literature relevant to the products of the individual firm. It can also be assumed that every department in every firm keeps its own library, even if it only contains a number of handbooks and catalogs.

Librarians, particularly in smaller firms, have a very difficult task. How to make available the accruing information to all concerned is an almost insoluble problem. In very small firms, periodicals are usually circulated, with all the advantages and disadvantages attached to this procedure. In theory, it means that every member of the staff gets every periodical, magazine, catalog, etc! In practice, of course, most people do not find the time to read all this literature quickly and pass it on. This means that the more interesting material is kept back by the first readers, or even taken home for reading at leisure, and it may then never get back into circulation. Even if it does, it may reach the man who requires it most urgently after such a long time that it may be antiquated and superseded by more recent information.

In larger firms, therefore, periodic bulletins are issued enumerating the new acquisitions, preferably with a precis or even digest of the contents. This puts a very heavy task on the librarian and his staff - if he has any staff! It requires a very intimate knowledge of the subject matter and a very great general technical knowledge.

The organization of even a comparatively small technical library demands great administrative skill. The librarian has also to keep in close contact with other libraries, certainly with the public libraries, but also with the libraries of allied firms whose products are being used by his own firm and who are, therefore, likely to have in their library specialized information useful to his readers. The librarian must read the publications issued by commercial and public libraries, giving information about their new issues, so that he can advise his readers on what information is available. He should be sufficiently familiar with every publication he receives to enable him to lay his hands on the relevant information if he is asked for his advice by one of his readers.

In short, the librarian should ideally be omniscient, a teacher, advisor and friend.

For the individual engineer or scientist it is a problem of frightening dimensions to follow the technical literature. It is an all-consuming task to read even a small sector of the publications concerning one's own field of activity. Looking for some specific information is like searching for the proverbial needle in the haystack.

Librarians can at best catalog the available literature under broad headings. This problem is growing all the time as the output of scientific and technological information increases. It is, on the other hand, absolutely required not only to remain familiar with the more essential newly appearing information in one's own field of activity, but also to acquire some knowledge about happenings in neighboring and allied branches. Indeed, it is desirable to have some idea also of apparently quite alien and unconnected fields.

Many great inventions have been inspired by the sudden realization of unsuspected similarities between widely differing branches of science and technology, or of unknown relations between phenomena occurring in fields hitherto considered quite unconnected. It is here that the popular scientific papers are important. Although they are frequently aimed at the layman, most engineers and scientists are hardly more than laymen in fields not directly related or allied to their own field of activity.

The problem is aggravated by language difficulties. It is impossible even for a very good linguist to be able to read more than a few languages, and translation of articles is still a slow process. Besides, the choice of what to translate is left to the translator who may not necessarily have made the right selection.

Of course, we know that efforts at developing methods for translation by computer are being pursued. A byproduct of these studies may be a better understanding of the formation and development of speech and languages, which may in the end give us a new lingua franca, in which scientific and technical literature all over the world would be written.

Such new understanding of language formation may also facilitate automatic data processing methods to be applied to the card indexing of scientific and technical literature. We may perhaps end up with an electronic card index that will allow a researcher to feed into a computer all possible data he can think of in connection with some project, and the computer will eventually furnish him with a list of the articles and books from all over the world that are relevant to his problem.

In the meantime, most journals already classify their own contributions, and there are publications entirely devoted to publishing classified titles with a synopsis or even a digest of the content of the articles in a number of publications.

In the meantime it would be helpful if classification systems could be standarized all over the world and indices worked out, so that each author, or at least each publisher, would be able to classify each article published in a uniform way.

ADVERTISING

An important field in technical literature is provided by advertising. It is easier to cover, since the number of firms producing various articles is finite. But it remains a formidable task all the same to gather and classify advertisements -- quite sufficient to keep any librarian busy.

Technical advertising is an art. The advertisement must be sufficiently striking to arrest the attention of the reader, it must be really informative, and it must be pleasing. It must also be repetitive, so that the "image" of the producing firm becomes easily identified with the product advertised. But the operative word should be "informative".

EXHIBITIONS

Another source of information which may be mentioned here are Exhibitions. It is quite a different thing to see something in the flesh than to only read about it. Particularly for the young engineer and scientist and the trainee, a well organized exhibition can provide a quite unique experience. The wide variety of exhibits, even in a comparatively narrow framework in which an exhibition may be set, is awe-inspiring for somebody who sees it for the first time. To be able to see how many possible solutions there can be for the same problem, how each firm uses a different approach, to acquire first-hand knowledge of the feel and touch of various materials, to be subject to the different sales techniques employed by different sales representatives, to learn to ask the right questions which will elicit really informative answers, all these are thrilling and exciting experiences. The young engineer and scientist is less likely to forget a piece of equipment or machinery which he has seen in action or been allowed to handle himself, than to forget something he only reads about.

The stand attendants for an exhibition should, therefore, be very carefully chosen. The salesman who is only a good salesman may be successful in selling his firm's products to men who already know all about his products. But he will not be a success with the clients of the future, the young engineers and scientists, who mainly want information and knowledge. The same may apply to visitors from the developing countries, who, whilst they may have come to place orders for specific plant or equipment, at the same time wish to gain as much knowledge and information about the whole field of industry covered by the exhibition.

The salesman at the exhibition should therefore have a thorough knowledge of the products which his firm exhibits and be able to express himself clearly. Preferably he should be able to speak, or at least understand, several languages.

SAFETY OFFICERS AND INSPECTORS OF FACTORIES

Production Engineers are responsible for the safety of the work people in their charge. It is their duty to see that workshops are maintained in such conditions that accidents are not likely to occur. The Factory Acts lay down the conditions of safety and in Great Britain Her Majesty's Inspector of Factories and his staff, who form a department of the Ministry of Labour and have fairly wide powers, supervise the effective observation of these rules and regulations. Their job is to examine all workshops and factories at regular intervals.

The task of taking special care of the safety arrangements and supervising the observation of safety regulations is usually delegated to one engineer in the production department, who acts as safety officer and who cooperates with the factory inspector. One of his duties will be to make his workers safety-conscious. It is most distressing to see how frequently workers disregard the most primitive safety precautions, and unfortunately women are among the worst offenders. The safety officer's job will, therefore, to a large extent be educational. Among his most effective aids will be special films; also the Factory Inspectorate maintains a permanent "Safety" Exhibition in London.

SCIENTIFIC MANAGEMENT

Some aspects of what is known as "Scientific Management" must be discussed here. All technology and much of science are ultimately orientated towards production to satisfy the needs and wants of the community. It is in everybody's interest, producer, consumer, management and employees and labour force, that production should be carried out with the minimum of wasted effort, that is to say, as efficiently as possible. It should also be realized by everybody that human happiness and satisfaction are essential premises for efficient production as well as for the life of the community.

That a tired worker will work less efficiently, will make more mistakes, and have more accidents than a fresh one is today universally recognized. Time and Motion Study, which aims at eliminating unnecessary fatigue for manual workers is by and large accepted by all managements who lay claim to being called progressive. It is acknowledged that proper machine lay-out, flow of material and work, work routine, good lighting, convenient seating, well designed jigs and tools, in short, everything that makes work easier and diminishes the possibility of making mistakes, will increase output and productivity.

Ergonomics has been defined as "the study of the relation of man to the environment in which he works and the application of anatomical, physiological and psychological knowledge to the problems involves". In the application of these studies to the material environment, they will form the basis for Time and Motion Study. More especially must ergonomics be applied to studies of the convenience and purposefulness of equipment, for example, to the lay-out of observational instruments and controls. The distribution of instruments and controls on the dashboard of a car - or more strikingly on the much more complicated one of an aeroplane -- must ideally be such that any unnecessary movement of the eyes, the hands and arms is avoided. Instruments themselves must be of the right size, not too small - not too big, because there would not be enough room. They must be arranged in logical and unmistakeable sequence; background colors and lighting must be such that they stand out clearly and are easily legible and distinguishable without glare, so that any eyestrain or possible confusion is eliminated.

At the same time the ergonomics engineer must consider the possibility of fatigue by sheer monotony. This applies, for instance, to motor-way design. Anyone who has ever driven along a fast motorway as for instance the M.1, the connection between London and Birmingham, knows how difficult it is to keep awake on a completely straight road without any relief to attract attention. On this stretch of 70 miles, ergonomics was, unfortunately, not applied. On motorways built later in England, the lesson from this mistake has been learned. Occasional bends, graceful bridges and pretty views, far from detracting the drivers attention, keep him alert and thus prevent many an accident.

Another type of work where ergonomics should be applied far more than is done at present is the presentation and make-up of instruction books, accompanying machinery and installations. Clear subdivisions, annotated drawings, uniform and unambiguous cross referencing would make it far easier for the user to follow the instruction and avoid sometimes costly mistakes, which arise not so much because the instruction was not given but because it was too difficult to find it and comprehend it.

Time and Motion Study and ergonomics are now beginning to be applied also to offices. Office furniture can already be found that has been scientifically designed. The typewriter is being studied with a view to altering its familiar shape, as it has been found that the present design often causes sprained wrists in typists.

Filing systems are undergoing some modernization along scientific lines. The result is the elimination of a lot of frustration resulting from time and energy lost when looking for files.

There is another aspect of the working environment that the material one: If psychological knowledge is applied to the problems arising out of the reactions of man to man, then we enter the field of Industrial Psychology.

Unfortunately this is a field the importance of which is by no means generally accepted. The following quotation is from a publication of the Department of Scientific and Industrial Research (DSIR):

"Research into materials and products, processes and operations is commonly accepted by forward looking firms in industry as essential to technical progress. There is no such unanimity however on research in the human factor in production. While many firms call in technical experts to advise them on some new equipment - or on problems that arise in the operation of existing plant - few ever consider the possibility of seeking expert advice on problems concerned with the men and women who operate the machines or run the plant___".

And yet Industrial Psychology is not really a new science, and one should expect that it would by now be generally accepted. It springs from the recognition that manpower is the most precious raw material in industry, that its properties must be studied at least as carefully as the properties of all other materials used, and that it must be treated in accordance with the laws that these studies and investigations have revealed. Indeed, one could call Industrial Psychology the technology of manpower.

It is, of course, a much more difficult subject that the technology of other materials, as its constituents, men and women, are very much more diverse and complex than the constituents of other materials. Nevertheless, the studies into the reactions of human beings, in particular the reactions of groups of men and women to situations that are by large recurrent, have been successfully investigated and analysed for quite a long time.

Like so many other new researches, these started in the U.S.A. certain laws have already been deduced from these investigations, and if these are disregarded, stresses and strains appear in the labor force, relations between management and workers becomes unsatisfactory, and at best production falls. At worst, constant labor unrest, rapid labour turnover, absenteeism and frequent strikes will be the consequences of the wrong treatment and wrong attitude to men and women.

The reason why it seems difficult for management to appreciate the fact that manpower must be treated scientifically is probably historical. During the beginnings of industrialization, manpower was so plentiful that it appeared to be an expendable commodity. This situation still exists in most developing countries and even in some European countries. However, in Western Europe and in the U.S.A. labor,particularly trained labor, has become so scarce that it is quite incomprehensible that managements still do not seem to appreciate that it has to be husbanded, that research has to be expanded on it just as much as on any other rare material, and that it has to be treated according to the findings of such research.

Here is a quotation to show how much these points are still disregarded. In a pamphlet on production control we find the following sentence:

"...one of the secrets of efficient production control is to restrict the amount of work made available to the shops so that the number of jobs which have to be scheduled and progressed in detail is reduced to a minimum. This also limits the freedom of shop floor personnel to choose between different jobs - a very worth while limitation in view of the fact that many production hold-ups are caused by misguided initiative based on incomplete knowledge of the whole situation..."

This statement disregards completely the fact that human initiative is one of the rarest and most desirable qualities. If initiative is misguided because of incomplete knowledge, then this is an indictment of the management concerned. Breakdown of communications - worse, no attempt at communication - is one of the primary causes of bad labor relations.

Introducing computer control into production also raises problems of the responses of the people concerned. The shop supervisor, the foreman, even the chargehand, automatically have to forego a great deal of their responsibility, since many decisions are no longer their responsibility, but are automatically made by the computer. They therefore lose status.

Unless management becomes far more aware of the importance of these problems and much more thought is given to the implications deriving from the science of Industrial Psychology, the description "Scientific Management" remains a misnomer.

In this context labor relations officers must also be mentioned. This job is frequently done by the Welfare Officer, or some member of the management team is charged with taking special care of the labor force. These men or women are not, as a rule, engineers but have some training in the social sciences. They have to keep in close contact with trade union officials and shop stewards. They can have a very great influence on the smooth working of production.

TECHNOLOGY AND SCIENCE IN SOCIETY

Technology and Science cannot be considered in isolation. They can be understood only as phenomena in the context of the society in which they exist. To the same extent as these disciplines have influenced and changed the environment, so they are being moulded and influenced by it. Without the social background to which technology and science are adapted and which feeds them, their future growth and development, their very existence would be impossible. It is essential for engineers and scientists to be aware of these connections and to foster such awareness.

Technical and scientific concepts and ideas must be made familiar to the general public in order to create a responsive atmosphere and a climate suitable for scientific and technological development. The writers of popular scientific and technological literature aimed at the laymen are of the greatest assistance in building up such an atmosphere. Particularly valuable is literature of this nature addressed to children. There are many excellent magazines and journals suitable for even quite small children, which fascinate boys and girls alike, as do some radio and television programs.

Science fiction may also be mentioned here, and there can be no doubt that writers of science fiction like Jules Verne or H.G. Wells or Max Eidth, to name only a few, have greatly contributed to the development of a technically conscious climate in the Western World. Whether the more phantastic and lurid type of science fiction makes any really valuable contribution to the understanding of scientific and technical problems appears to be highly doubtful. The existence of this type of literature seems to be more symptomatic of the extent to which science and technology have captures the imagination of children and adults.

EDUCATION AND TRAINING

Education of engineers and scientists is provided by society. In the United Kingdom the attainment of professional status is usually indicated by membership of one of the senior Institutions, as for instance the Institution of Civil Engineers or the Institution of Mechanical Engineers, the most senior one being the Institution of Civil Engineers. Membership is conferred only on those who have acquired the qualifications laid down by these Institutions. The standards set by the Institutions are, therefore, of the utmost importance for the level of technology and science.

The course of studies leading to these qualifications normally goes via a University, ending with an Engineering or Scientific degree, or via a College of Advanced Technology, finishing with a Diploma of Technology, the Dip. Tech.

It has been estimated that each scientist or technologist requires the assistance of at least five technicians and it is, therefore, essential that appropriate training and education is provided to meet this end. Technical Colleges and similar Institutes offer full-time and part-time day and evening classes in a great variety of technical and scientific subjects, and a number of routes leading to various levels of attainment. A completed course of study will give the student either a certificate or a diploma, enabling him or her to find employment in industry.

Practical training, which is an essential requirement at all levels, is almost entirely provided by industry itself. It is usual for firms, who train young engineers for their own use, to pay for the technical education of these students. The courses are arranged either on the "sandwich" system, i.e., alternating college education and workshop training, or for day release for attendance at classes. Frequently firms pay the fees for those of their employees who attend day release or evening classes.

Those students who attend full time at college obtain awards from their Local Education Authority, which are given statutorily if the student has the necessary qualifications to be accepted at college. During their practical training in industry these students receive payment from industry.

Some large firms have excellent training facilities and well planned training schemes. In many small firms, however, training may not be well planned or may not be sufficiently comprehensive to be really adequate. There is, therefore, a growing tendency for small firms to organize their training in groups. Large firms employ special training officers, and where group training schemes exist a Group Training Officer will be responsible for carrying out the scheme.

There are, however, many firms who still have no regular training schemes and rely for their intake on young people either trained by others or with no formal training at all. These acquire their knowledge by experience in the day-to-day business of their employer and may supplement this by attendance at evening classes, if they have sufficient perseverance and stamina to stand the strain.

The recently introduced Industrial Training Bill aims at eliminating some of the disadvantages of this situation by setting up Training Boards who are entitled to impose a levy on all firms, whilst the Government will give training grants to those firms whose training schemes are considered adequate. Also the number of Government Training Centres will be considerably increased and thus supplement the training provided by industry.

In most small and medium firms it is still possible for a gifted man - less so for a woman - to rise from the ranks to the top by their own efforts, by length of service, or by sheer brilliance. Some may acquire paper qualifications on the way, but often these are not demanded.

However, this opportunity is fast disappearing. The requirements for more systematic and wider knowledge become more and more imperative in more and more branches of industry. It becomes, in fact, increasingly necessary to train more people more systematically to a higher level, and to compress training time. Training by exposure, as the old method has been called, is very time-consuming and not very effective.

The British system of education and training has hitherto been quite unique in its flexibility. It has permitted transference from one stream of education to the next higher one, so that it was quite possible for a talented and ambitious young engineer starting at the bottom level to end up with full professional status and membership in one of the Institutions. It is very much to be hoped that the present attempts at simplifying and streamlining the system will not lead to rigidity by blocking the way from one level to the higher ones.

There is, in fact, a growing shortage of trained and qualified engineers and technicians on all levels. Also it has been found that there is a tendency for young people to choose scientific education in preference to technological training. This tendency is so marked that grave concern has been expressed by some leading autorities in the educational field at the resultant shortage of engineers and technologists. Some of the reasons for this tendency are that science carries a higher status rating than engineering and that it is sometimes better paid. Unless this trend is halted, a situation may arise where technological posts will have to be filled with scientists rather than engineers. These would not really be suitable as their training and education are aimed at a different application. It should be the task of enlightened management to draw the proper conclusions and, by increasing the remuneration of engineers and giving them a higher status, to provide the incentives for more young people to choose a career in engineering.

This applies to an even higher degree to women, who are in general not encouraged to enter engineering. It is more difficult for them to obtain the required training, and those who have taken that hurdle still have a very much restricted choice in the employment open to them and much less opportunity for advancement.

TRAINING WITHIN INDUSTRY

There is in general in industry a lack of skilled supervisors, and even high executives are frequently deficient in the art and science of getting the best results from the manpower under their leadership. To compensate for such deficiencies at all supervisory levels, specialized training courses are organized within industry under the auspices of the Ministry of Labour.

Such training schemes originated during the war in the U.S.A. when it was of vital importance to obtain maximum efficiency from the then available man and woman power. They proved so successful that they were retained and adapted to peace-time conditions. The aim of these courses is to train supervisors on all levels - from chargehand to top executive - in the basic supervisory skills, to enable them to discharge their duties with greater efficiency.

The training comprises three courses: The first course, Job Instructions, underlines the necessity for, and the systematics of, clear instructions at every stage. The second course, called Job Relations, tries to teach the application of the fundamental principles of Industrial Psychology to the relations of a supervisor to those working under him. Again these applications are systematized. The third course, Job Methods, is basically an instruction in work-study methods.

Although training on these lines has been modified and adapted to prevailing conditions in industry, the basic rules still apply. Such training is now continuous throughout industry on all levels and has certainly paid dividends in increased production efficiency and improved labor relations wherever it has been applied.

The task of organizing and often of conducting these courses usually falls to the Education Officer in larger firms, or to the Group Training Officer in the case of smaller firms where these have organized themselves in groups for group training schemes.

FURTHER TRAINING

In order to keep abreast of new developments, engineers and technicians must be given the opportunity of attending courses and special lectures, arranged frequently at Universities and Technical Colleges, or by the Professional Institutions or by larger firms or groups of firms. Attendance at conferences will, of course, always be stimulating and fruitful, but is available usually only to the selected few.

There is much need for research into new training methods in an endeavour to shorten training time and increase the output of trained personnel. The growth in the body of knowledge to be acquired at Schools and Universities makes the fulfillment of a syllabus a source of constant concern. Visual aids of all kinds, Radio and Television, simulation, teaching by computer, are all being experimented with. This is a field of research where very valuable contributions to science and engineering can be expected in the future.

TECHNICAL ASSISTANCE TO THE DEVELOPING COUNTRIES

Some comments must be made about the technical assistance given to the developing countries. There are two main ways in which this aid is given, and in both engineers and scientists play an important part.

There is first the direct aid in the form of plant and equipment sent to these countries. Almost always these will have to be accompanied by engineers and technicians to install them, commission them and service them. These engineers and technicians must have special qualifications if they are to be of real assistance to the people concerned. That they have to be fully qualified technically to do their job under sometimes very difficult conditions goes without saying. But they must also be able to communicate an essential part of their knowledge and of their attitude to technology and science to the future users. If they are able to learn the language of the people with whom they are dealing, then that will be a great asset. They must also have teaching abilities, which will imply a great deal of patience and understanding of a frame of mind that is not used to technical concepts.

It must be borne in mind that technology and science can only thrive in a congenial atmosphere. Where this technical climate does not exist, it has gradually to be built up. The engineers and scientists who go out to these countries in order to install plant and machinery must, therefore, be regarded as missionaries, whose aim at least in part must be the "technisation" of the native population.

The second way, and the more important one, is the direct training and education of the peoples living in the developing countries. A very serious drawback will be encountered here. Whilst on the one hand many young men and women are given, and will take, the opportunity to be trained and educated in the Western World, these will, for obvious reasons, be either members of the upper classes in their countries, the offspring of the aristocracy or the very wealthy, or they will be exceptionally brilliant young people who are considered suitable for scholarships and grants by their governments. In both cases these people are destined for the upper echelons in the industry and science being built up in their countries.

At the other end of the scale, there are the hewers of wood and drawers of water, who have to be trained on the spot for the so called unskilled and semiskilled jobs. It has been proved to be a not too difficult task to overcome the initial awkwardness of untrained workmen.

What is lacking, however, is the industrial middleclass, which in the Western World has developed over the centuries from the class of craftsmen and which still retains many of the traditional craftsman's attitudes. Particular attention will, therefore, have to be paid to the experience and traditions of the craftsman class, which can be found in every culture, however atrophied it may have become by the impact of western technology. For here will be found the nucleus of the technicians, supervisors, foremen, draughtsmen, and so on, without whom a self-contained native industry could not develop and without whom a climate of technically conscious thinking could not grow.

A beginning has been made in establishing technical training schools for craftsmen, supervisors, foremen and technicians, staffed, to begin with, by western teaching and training personnel. It is envisaged that these teachers will train native teachers and trainers to take over these task in due course. In the meantime, the engineers and scientists who go out to do this work are fulfilling an eminently worth-while job of assistance to engineering and technology in the service not only of the countries in which they work but of the whole of mankind.

SUMMARY AND CONCLUSIONS

To summarize, an attempt has been made in this survey to show that in modern society industry and science are differentiated in both a horizontal and a vertical direction, and that the consequence of this division of labor is a total interdependence of all disciplines of science and technology, none of which can exist without all the others. The same applies to the hierarchy of skill and knowledge in each branch of science and technology.

Some of the ways in which the technical needs of engineers and scientists are being satisfied have been discussed in some detail. Mathematicians, Computers and Computer Programmers, Technicians and Laboratory Assistants, Draughtsmen, Planners, Work Study Engineers, all enable Engineers and Scientists to make fuller use of their capabilities. Libraries and Exhibitions bring the experience of the past and the newest developments to their knowledge. Safety Officers and Factory Inspectors assist them in discharging their responsibilities towards the workers in their charge.

In this short survey, it was emphasized that manpower is the most precious ingredient of science and industry, which must never be wasted and must never be considered cheap, however plentiful it may appear to be in some parts of the world. It must, therefore, be the endeavour of society to employ this precious resource to the best advantage, by giving every man and woman the opportunity for training and education to the limits of their capacities and by using trained men and women in the most efficient way to enable them to use their potentialities to the fullest degree. Thus more opportunities will be provided for more people to be of assistance to engineers and scientists for the benefit of mankind.

Summary of Session I

SPOTLIGHT ON ENGINEERS AND SCIENTISTS

Isabelle F. French
Bell Telephone Laboratories, Inc.
Allentown, Pennsylvania

In Dr. Trytten's talk he has told us that historically in the United States education in general has been of personal and local concern, and only vaguely understood as a benefit to the Nation. In addition, the facts are that the United States which was changing to a technologically based economy following World War I was quite hurt by the depression, and that plus the artificially induced acceleration in technological developments during World War II are factors that have also handicapped making predictions on future requirements of engineers.

The National Science Foundation and the Bureau of Labor Statistics have recently made their second report of a series in which the demand for engineers and scientists is predicted. Certain assumptions were prerequisite for these predictions. They assumed a continued relatively high level of economic activity which includes high government spending for space and arms, heavy expenditures for research and development, and no great change in the economic and social patterns. These predictions were based on historic trends and on cycles of the economy.

The projected manpower requirements indicate a 69% increase over the 1960 level, to give a total of almost two million engineers and scientists that will be needed in 1970. Of these 1,375,000 will be engineers which is an increase of 67% over 1960. During this period there will be fluctuations in the needs with the changes of the economic cycle and Defense efforts. There is, however, a flexibility in the supply of technological personnel which is accomplished through the use of the marginally qualified and through shifting engineers from less urgent projects as new needs arise. Fears of an over supply of engineering graduates can be allayed by the statistics on the present employment situation as reflected in the fact that in 1963 there were 50,000 engineering graduates, and by June 30, 1963, all but 1.8% were committed to a job or were going to go to graduate school. Of practical interest to us is the statistic that 71% of the women and only 18% of the men were planning on graduate school.

Predictions are based on the past. Today changes can be sudden and great, but training of an engineer takes time. Significant here also is the fact that there is still a personal decision of the parents and young people to choose the lightest career training. We have not yet formed a clear-cut national science policy in the same manner as we have in such fields as public health and agriculture. Dr. Trytten closed his remarks with the statement that the engineer of the future must deal with the sociological problems of the times, such as transportation in our sprawling metropolises and providing jobs for people in a developing nation.

If we properly trace the history and evolution of engineering from the primitive man to the specialist of today, who is dependent on many others in different disciplines, Mrs. Rischowski notes that of these the mathematician is one on whom the engineer is very dependent for solving his problems. Also mentioned were the uses to which the computer has been applied, to such tasks as the synthesis and control of processes as well as the routine every-day problems of the engineer and management. Other members of the technological community on whom the engineer must depend are the skilled craftsmen who produce the models, the technicians who perform the experiments, and the draftsmen-designers who translate the ideas to a working drawing.

A supporting device for the engineer is the technical library which maintains collections of technical literature from current publications to the latest scientific treatises. Often a library service will include literature searching and translation services, but in all cases it is a broad source of technical material. Two other sources of technical information are the trade magazines and professional periodicals with their advertisements, and the trade shows to which they may go to learn the latest tools of their trade. A necessary adjunct to the industrial operation is the safety engineer who protects the interests of both the employer and the employee where safe operating procedures are concerned.

Today in planning a production operation, it is not only necessary to have the best tools and designs, but thought must also be given to the best psychological presentation to prevent fatigue and to facilitate the operation itself. The engineer is provided an awareness of his entity by his participation in the technical societies. In the United Kingdom, engineers are trained both in the colleges and through on-the-job training. There are obvious differences in the level of competence between those trained in the small firms and those trained in the large firms, but recent legislation has been introduced to try to eliminate these discrepancies. In addition, methods familiar to those of us in the United States are being used to keep the engineer up to date on the latest technological knowledge.

With the new machinery that is being sent to developing countries, it will also be necessary to send engineers to teach the people how to use the equipment. This will require the formation of new concepts within those countries and these will be a challenge to the engineers involved. The engineer is an integral part of Society and must also be of benefit to mankind.

WELCOME FROM THE CITY OF NEW YORK

By Bradford N. Clark
New York City Commissioner of Public Works
(Presented at the Welcome Luncheon, Wednesday, June 17, 1964)

The origin of engineers is that they were men of war. How fortunate that times have changed! And for international flavor, I'd like to add a hearty "Vive la difference!"

Those original men of war, through the development of formal education in the humanities and the arts, found refinements, initiated conveniences, and have been joined with other professions in cultural and scientific advances that make our modern society and our mode of living, and this at the national and international level, as well as at the level of the community and in our own homes and offices.

Ad Adam was joined by Eve, it is natural that distaff engineers and scientists should emerge as helpmates in the profession, as well as being housewives in our homes. And I find that the woman's touch in many fields of engineering has been a terrific boost in the accomplishment of our mutual aims, to make our world a far better place in which to live.

And while we have common aims, we face the common problem of a shortage of qualified engineers, and, of course, scientists. Our educational institutions are aware of the dearth of qualified graduates eagerly sought by industry, consulting firms and municipal agencies in the field of public works; yet they have been unable to come up with a formula to swell the ranks of undergraduates whose numbers have been declining steadily these past ten years or more.

Studies sponsored by professional service groups such as the A.P.W.A., as well as college service groups, have failed to hit upon a solution to this growing problem. Here we are, engineers and scientists, unable to resolve one of our own most critical problems. Perhaps we need, again, the woman's touch: that infinite patience in planning, tinged, I'm inclined to add, with some degree of scheming or call it what you will - providing that it produces results.

More seriously, however, let me say that society is suffering in part from drop-outs at the secondary school level, but the drop in professional school enrollments is one of our principal problems. I am hopeful that you here at your first international conference will accept the challenge of aiding us in industry, in engineering-consulting and in the public works program--on a world-wide scale, for that matter--to replenish the professional reserves on which the future of our society so largely relies.

As Commissioner of Public Works you might properly assume that I am more accustomed to dealing with engineers and other consultants of the male variety. Therefore I find it a particular pleasure to have been designated by Mayor Wagner to welcome you here today, in the city of the United Nations, the city of the World's Fair, and the city at the crosswalk of the world.

In furtherance of the Mayor's wishes, I take this opportunity to read to you his proclamation--

Office of the Mayor

CITY OF NEW YORK

Proclamation

Whereas: THE SOCIETY OF WOMEN ENGINEERS WAS ORGANIZED MAINLY TO ASSIST AND INFORM YOUNG WOMEN, THEIR PARENTS, COUNSELORS AND THE PUBLIC IN GENERAL OF THE QUALIFICATIONS AND ACHIEVEMENTS OF WOMEN ENGINEERS AND OF THE OPPORTUNITIES OPEN TO THEM IN THIS GREAT PROFESSION; AND

WHEREAS: DELEGATES FROM FORTY COUNTRIES AND FIFTY STATES WILL ATTEND THE WELCOME LUNCHEON OF THE FIRST INTERNATIONAL CONFERENCE OF WOMEN ENGINEERS AND SCIENTISTS AT THE UNITED ENGINEERING CENTER IN NEW YORK CITY, ON WEDNESDAY, JUNE 17, 1964; AND

WHEREAS: FIVE HUNDRED REPRESENTATIVES FROM EDUCATION, INDUSTRY, GOVERNMENT AND THE PROFESSIONS WILL MEET IN A WEEK LONG CONFERENCE TO STUDY THE QUESTION OF INCREASING THE CAPABILITY OF OUR SCIENTIFIC MANPOWER THROUGH THE ENCOURAGEMENT OF WOMEN TO USE THEIR TALENTS IN THIS FIELD,

NOW, THEREFORE, I, ROBERT F. WAGNER, MAYOR OF THE CITY OF NEW YORK, DO HEREBY PROCLAIM JUNE 15 - 21, 1964, AS

"WOMEN ENGINEERS WEEK"

IN NEW YORK CITY, COGNIZANT OF THE RECORD OF ACCOMPLISHMENT OF WOMEN IN THIS HIGHLY SKILLED AND IMPORTANT PROFESSION, SO NECESSARY TO MEET THE EXACTING NEEDS OF OUR MODERN CIVILIZATION, I DO EXTEND THE CITY'S GREETINGS AND WARM WELCOME TO OUR VISITORS TO NEW YORK AND I DO FURTHER EXPRESS VERY BEST WISHES FOR A MOST SUCCESSFUL CONFERENCE.

IN WITNESS WHEREOF I HAVE HEREUNTO SET MY HAND AND CAUSED THE SEAL OF THE CITY OF NEW YORK TO BE AFFIXED.

Robert F. Wagner

MAYOR, THE CITY OF NEW YORK

Wednesday, June 17, 1964

2:00 P.M. - TECHNICAL PROGRAM SESSION II

Requirements of the Individual's Standard of Living

Chairman: Katsuko Saruhashi, Research Chemist, Meteorological Research Institute, Tokyo, Japan; Society of Japanese Women Scientists

Moderator: Lillian G. Murad, Past President, SWE; Textile Consultant, Oyster Bay, New York

THE PLANETARY WATER PROBLEM--John D. Isaacs, Professor of Oceanography, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California (Presented by Mr. Walter R. Schmitt, Research Geophysicist)

CLOTHING--A BASIC REQUIREMENT--Young Sun Lee, Lecturer, Department of Textile Engineering, City College of Agriculture, Seoul, Korea

THE ESSENCE OF SHELTER--Consuelo M. Hauser, Project Engineer, Hauser Research and Engineering Co., Boulder, Colorado

FOOD--ITS PRODUCTION, PROCESSING AND DISTRIBUTION--Jointly prepared by SWE Members Mary H. Malone, Naomi J. McAffee, Margaret Ann Pritchard and Joan T. Sullivan (Presented by Joan T. Sullivan, Staff Member, Arthur D. Little, Inc., Cambridge, Massachusetts)

Summarist: Isabel H. Hardwich, Conference Representative in Great Britain, Research Physicist, A.E.I. Power Group Research Laboratory, Manchester, England

5:30 P.M. - ENGINEERS JOINT COUNCIL RECEPTION

Courtesy of Engineers Joint Council and its memberbodies, in recognition of their International Relations Program.

THE PLANETARY WATER PROBLEM

by John D. Isaacs
Professor of Oceanography
Scripps Institution of Oceanography
University of California, San Diego

INTRODUCTION

In this present day we are likely to form our opinions of the world's problems through newspaper and magazine coverage, and we are often misled. Engineers and scientists are often misled along with the lay populace, for they frequently are searching for important problems on which they believe that they can aid. They are sparked by some popular account and subsequently concern themselves with only the technical aspects.

Thus we are frequently greeted with the sight of some honest scientist bursting from the laboratory to reveal to the world that by his years of toil he has discovered a process by which sea water can be made fresh, and at some trivial cost, perhaps $2.00 a ton. He believes that he has solved a basic human need, and awaits acclaim.

What a shock awaits him! He is soon to find out that although water is most precious, it is yet the cheapest of all the substances that man utilizes. No trash, no dirt, not even the air is as cheap as the $1.00 per 3,000 tons that the Sacramento River farmer pays for his water; the one cent per ton that Southern California irrigation districts pay for theirs; or the seven mills that about limits the marginal value of a ton of agricultural water around the world. So no one wants his $2.00 per ton water, not even for domestic purposes on a desert coast!

Now, this is no way for society to treat and to dissipate the honest efforts of its members. Thus for some years I have attempted to elucidate and to identify the water problem.

I have been asked to address this conference on the "general topic of supplying, controlling and conserving water as it relates to the requirements of the world population, including corollary information on the kinds of scientists and engineers needed now and in the future to cope with this gigantic task."

This is a large order, and I am going to be capable of filling only a small part of it, for this assignment is complex and associated with curious, generally held but obscure, misconceptions that obfuscate understanding. I could spend the entire day speaking merely on the problems of desert water supplies without covering very much of that manifold problem. In addition, the water problem is larger than the assignment, for, as I hope to point out, the water problem stems from the problem of food for the world's peoples, and here there exists a wide range of alternative actions.

Thus, rather than attempting to cover the conventional idea of the water problem as it is popularly held about the world today, I plan to present the human need for water in some rather more general terms of the water regime of this planet. I will also discuss some of the scientific and engineering research that can apply.

THE AGRICULTURAL WATER PROBLEM

Like many others, I have found the matter of water particularly intriguing It is treading a well-worn path to go over the basic nature of the water substance. From grade school we learn of water's peculiar properties, its power as a geological and meteorological element, its fundamental functions in living organisms, and we learn of the uniqueness of this world--the watery planet--in the possession of a great hydrosphere and an abundance of water in all of its physical states.

We also learn of man's early civilizations along the great water courses of arid regions. The Nile, Tigris and Euphrates, and the Indus formed more than vast alluvial valleys. They gave rise to profound and unprecedented social forces, challenges and opportunities that underlie our entire western culture. Indeed, among the earliest preserved writings are instructions for the culture of irrigated crops.

The dimensions of the fresh water regime of the world are impressive. Annual evaporation from the oceans is of the order of one meter. Some one-third to one-fourth of this annually falls on the land surface. By conventional agricultural standards, this rainfall is in total about adequate for optimum watering of the entire earth's land surface. The total world-wide annual precipitation on land is thus of the order of 100 acre feet (that is, over 100,000 tons) of fresh water per world inhabitant, or some 30 times the water necessary to supply food for the human race by conventional agriculture. But, of course, the operation of this natural distribution system is spotty and capricious.

Apparently the natural distribution has not always been so varied. At this particular time in geologic history the great equilibrator of heat and rainfall, the oceans, is prevented from exercising its full moderating influence on the world's climate. At this moment our arctic region is isolated in a curious circular ocean, and our antarctic on an equally curious discoidal continent. In addition, our geologic period is typified by great mountain elevations that greatly impede the low level atmospheric circulation. Thus we have the great dessicated deserts, humid tropics, cryogenic arctic, as well as the small regions of temperate and subtropical grasslands and forests from which we have derived our unirrigated agricultural lands.

At the present stage of the world's geography, the categories of the world's climates and vegetation forms are allotted as seen in the single world continent of Figure 1, which is also otherwise categorized in the

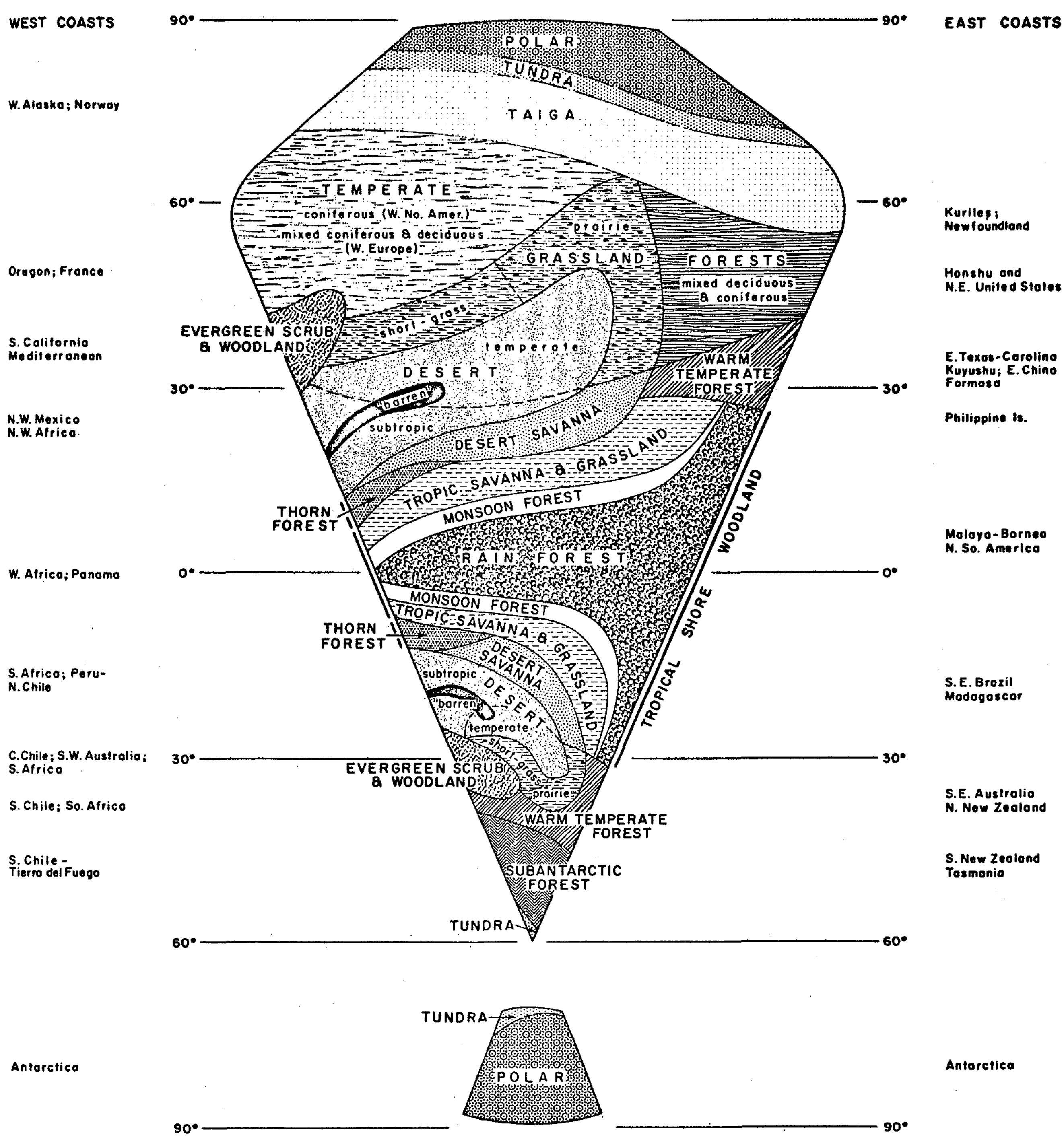

Figure 1 Idealized distribution pattern of vegetation

table in Figure 2. Some 11 percent of the world's land surface is now cultivated or pastured. There is an additional 7 percent, mainly in Africa, that is cultivable by present technology. Uncultivable with present technology are several groups of land and vegetation forms that are each of much greater area than all that is now cultivable.

Thus, it is apparent that there are available great areas for the expansion of agriculture, each with its particular limitations and advantages. Of the list the principal expansion of agriculture has been into the desert (that is, deserts of heat) by irrigation. There are many reasons for this. Growing seasons are long, topography is usually no barrier, soils are often fertile, and, importantly, existing crops and agricultural methods are immediately suitable to these areas. In some regions, there is more than this also. Irrigation works are monumental and hence politically appealing!

This development of desert agriculture is undertaken and carried on with only some evidence that it can be sustained perpetually. Actually there is much evidence that perrenial irrigation agriculture by canals in arid regions rapidly engenders a syndrome of problems that are difficult to correct. Probably the most serious of these is the accumulation of salts in the soils, in the aquifers and eventually in the ionic composition of the minerals of the soil substance. This latter condition is irreversible for all practical purposes unless there are strong economic compulsions for its correction.

The scientific advisor to the Government of Pakistan, Dr. Salam, has pointed out that in West Pakistan the syndrome of canal irrigation, coupled with primitive agricultural methods, results in a very low productivity. West Pakistan holds one percent of the world's population and one percent of its cultivated land (which is mainly irrigated and thus constitutes 12 percent of the world's irrigated land!), and yet in recent years has been unable to feed itself adequately. We can hardly conceive of an example that would question the perpetuity of canal irrigation more strongly than this immense deterioration in Pakistan.

There is little question in my mind but that the problems of desert agriculture will be solved by a concerted scientific, social, and technical attack. Yet we should remember that the problem of expansion into desert agriculture is only initially that of obtaining a water supply and soon involves the extremely serious problems of salination, waterlogging, etc.

I believe that this watering of deserts is one aspect that has been pursued in response to our ancient cultural development and that vast other areas of possible development receive scant attention because of this single-minded approach to the nutritional needs of the race.

What of the great rain forests of the world--15 percent of the world's land area. It is a curious matter that man has made so little progress in

FIGURE 2

CHARACTER OF THE ENVIRONMENT OF THE WORLD'S LAND SURFACE (36.7×10^9 ACRES)

Cultivated land	11%	4.1×10^9 acres
Potentially cultivable with present technology		
from forests	2%	0.7×10^9 acres
from grasslands	5%	1.8×10^9 acres
Uncultivable with present technology		
Lakes and rivers	2%	0.7×10^9 acres
Humid lands		
Wetlands	2%	0.7×10^9 acres
Tropical rain forest	13%	4.8×10^9 acres
Temperate rain forest	2%	0.7×10^9 acres
Forest, conif. and decid.	12%	4.4×10^9 acres
Grasslands	4%	1.5×10^9 acres
Semi-arid grasslands	13%	4.8×10^9 acres
Deserts		
Heat	15%	5.5×10^9 acres
Frost	18%	6.6×10^9 acres
Altitude	1%	0.4×10^9 acres
	100%	

their reclamation. Here the problems are diametrically opposite to those of the desert. Productivity in the wild state is very high, both in temperate and tropical rain forests, and is estimated to be 15 to 60 tons of dry organic matter/acre/year, or above the productivity of the most productive of agricultural lands. However, conventional agricultural methods are almost completely unsuccessful in these rain forest regions. Only a thin humus layer overlays the acid, highly mineral soils. Destruction of the organic material and erosion is an immediate result of cultivation. Fertilizers suitable for conventional agriculture are rapidly leached away. You might argue that these regions are poor places to live and hence it is not reasonable to develop them. But modern agriculture is developing in a direction that does not require a population to live where its food is produced. Rather only a few people are needed to tend the machines that raise our food!

In our own United States, agriculture in the humid regions of the eastern, north-central and southern states is decreasing. Vast areas are returning to their native cover. This is spoken of as "worn out" land. This abandonment is to a degree the result of competition with similar crops grown under irrigation in the arid regions, and to some significant extent, this abandonment does not represent the workings of a free economy.

It is difficult to conceive of spectacular and monumental engineering works to deal with the problems of the overwatered lands. Perhaps this is one of the reasons that the problems of the overwatered lands receive neither the attention nor the subsidy that is devoted to desert agriculture. Some have said that desert crops in the United States have been subsidized to their full market value at the time they are removed from the ground. I believe that this is an exaggeration. However, in many western areas the subsidy, in the form of overcharge to non-agricultural users of water, income tax exemption and non-repayment features of water development financing) government construction, research, engineering, and aid, constitute significant subsidies of the desert agriculture, not to speak of the direct subsidies of the crops.

It is with the benefit of such subsidies that much of desert agriculture competes with the virtually unsubsidized humid land agriculture in the product market, and competes with industry and cities in the "water market." Thus some have said that we are subsidizing ourselves into a water problem.

It is not my purpose to criticise society's action in this, but to point out that such hidden support of any agriculture misleads us. It engenders a misunderstanding as to the total economic benefit, and as to the comparative benefit of alternative uses of the available water, such as for industry. We also are misled in judging the feasibility of alternative sources of water. An economically complete estimate may show a discouragingly higher cost for new sources of water than the apparent cost of present sources, where these latter costs are reduced by obscure subsidies. We also are misled into neglecting the problems of alternative types of agriculture.

You will note that I have been discussing the water problem as though it were entirely one of agriculture. Perhaps some of you are wondering about the other water needs of the human race. Let us diverge for a moment and put these other needs into perspective.

NON AGRICULTURAL WATER REQUIREMENTS

The general public and even legislators in the Southwest seem to believe that we are soon to suffer from a lack of water to drink! Thus we are greeted with cartoons that portray the compassionate housewife sadly sweeping up the dusty remains of the stranger, who has crept up the back steps, slivers in his protruding tongue, to beg a drop of water - <u>if the water problem is not solved</u>! In like fashion in this wonderland, lovers on the beach guard their half-filled canteens from one another, and the highway patrolman angrily issues a ticket for a fatal traffic accident that damaged a radiator, as an irresponsible consumptive waste of water. It is seriously suggested that a brick be placed in the supply tank of each water closet to reduce water use. (A brief calculation shows this latter to be an excellent investment: The cost of the brick (ca. 8 cents) is returned in water savings every two or three years.)

The hyperbole is not mine, and to return to fact, the annual per capita use of water in the United States is of the order shown in Figure 3.

To picture this in somewhat different terms, again consider the meter of water which annually evaporates from the great hydrosphere of our planet. The <u>total water</u> that the human race has used for drinking <u>throughout its entire history</u> cannot be more than a 3 millimeter layer from the ocean surface (long since returned, of course), but the <u>agricultural use of water represents</u> a 40 millimeter layer annually!

The same arithmetical disparity in cost as seen in consumption is shown in Figure 4.

We see that providing drinking water by <u>distillation with present technology</u> is a trivial 30 cents per year apiece! - that providing all domestic, municipal and industrial water by such distillation is an added per capita cost about equal to that of smoking cigarettes, whereas providing for agriculture in this way would at least quadruple the cost of food.

In conclusion, water for all essential uses other than agriculture can be economically provided by any technologically competent nation. And although the costs may be initially high, technological improvements will certainly reduce costs of desalination by half an order of magnitude at least. I will mention some of the possibilities for research in this area later.

FIGURE 3

ORDER OF ANNUAL PER CAPITA USE OF WATER (UNITED STATES)

	Drinking and Cooking	Domestic Industrial and Municipal	Agricultural and Silvicultural
Tons	1	200	> 5000
Acre feet	0.0006	0.16	> 4

FIGURE 4

ORDER OF ANNUAL PER CAPITA COST FOR WATER (UNITED STATES)

AT VARIOUS PRICES

	Drinking and Cooking	Domestic Industrial and Municipal	Agricultural and Silvicultural
$12/acre foot (approx. SC wholesale)	$0.01	$2.00	$48.00
$36/acre foot (predicted desalination)	$.03	$6.00	$144.00
$360/acre foot (present Navy stills)	$0.30	$60.00	$1,440.00

Thus I submit that the agricultural use is the only significant essential use of our water supply, excluding aesthetic and recreational uses, which can also be large. Even including water for agriculture and aesthetics (and hence, most recreation), Nathaniel Wollman points out that the United States has adequate water supplies for a predicted population of 329 million in the year 2000 A.D. with shortages in only a few areas.

Perhaps I have now confused you entirely. Am I saying that there is no water problem? What I am saying or trying to say is that there is in this world a serious, vital and profound set of problems associated with water, but also that the problems are basically quite different from the usual concept, and involve antiquated water laws, confusion, subsidy of odd directions of development, adandonment of adequately watered regions, salinity and water logging, and an obfuscation of the basic opportunities to meet human need. It is not merely a problem of desalinating sea water, for as often has been pointed out, if the sea were fresh water only a few problems would disappear.

THREE APPROACHES TO MAN'S WATER NEEDS

Perhaps I can now serve the purposes of this convention most effectively if I stop taking the water problem apart and start putting together what in my mind are some of the types of opportunities for contributions to the general problem from engineering and scientific research and development.

Considering only agriculture and natural waters, man has three general approaches to accommodate his water needs:

1. He can change the natural distribution either through climate and weather control, or by direct physical transport of water,
2. He can develop agricultural techniques that are successful under a greater range of conditions, and
3. He can demineralize saline water.

I will thus continue with a collection of short discussions of single aspects of these general approaches.

Salinity.

This world-wide affliction of canal irrigated arid lands must be solved. In some cases salinity could be controlled to some extent at the source by the elimination of small, highly saline tributaries. The Colorado apparently possesses some very small, very saline tributaries that contribute about 4,000,000 tons of salt annually. This is enough salt to destroy production of conventional crop plants on 100,000 acres each year. Tracking down these small saline tributaries is a surprisingly difficult task.

Underground storage in aquifers rather than in reservoirs and other evaporation control in general can aid in the salinity problem. The varying results with cetyl alcohol as an evaporation control on free water surfaces are far from being completely understood. The Australians report much better success than do we, and they believe that very small quantities of branched chain impurities undo the advantages of the cetyl alcohol film.

In all areas, saline-tolerant crops would be highly advantageous. Thus, the development of salt-tolerant plants is receiving attention, but this mainly is concerned with the selection of existing crop plants for salt tolerance. But these plants are probably genetically limited, and only a highly improbably extraordinary mutation could give rise to varieties with more than marginal improvements in salt tolerance. Yet nature has bequeathed to us a group of higher plants representing some 50 or more species that <u>live</u> in the highly saline waters of salt marshes, where in some cases the salinity exceeds that of sea water.

Certainly these plants possess the genetic material that can be used to "teach" more useful plants to tolerate salt. Amont these salt-tolerant plants, the halophytes, are grasses, sedges, composites, legumes and many others. Thus there should be possible numerous breeding experiments, yet I can find essentially no record of work on the breeding and very little even on the physiology of these plants which grow so robustly in the sale marshes of the world. This is a large, important, and virtually untouched field and this particularly knowledgeable D NA is a major resource of this planet.

It seems to me that we (who know only how to use <u>degraded</u> solar energy) are naive indeed seriously to propose solar stills for desalinating water for agriculture when plants can carry out a conversion by sophisticated enzymes using solar energy at a high energy level.

Some ordinary crop plants apparently can be raised on irrigations of sea water when this is supplied in very deep, extremely coarse soils. The mechanisms of this are by no means clear, but apparently involve evaporation and condensation within the interstices of the gravelly substratum.

Understanding the manner in which biological systems handle water and salt may provide vital clues to many aspects of these problems. For example, it is probably that vastly superior osmotic membranes could result from biological investigations, or microorganisms can be developed to absorb salt, or produce cetyl alcohol.

<u>Fertilizers</u>.

Fertilizers and soil conditioners that are especially adapted to rain forest soils, together with engineering solutions to rain forest problems, could secure a food source for any foreseeable human need. No one has studied a vast (and monumental and politically appealing!) program to convey some substance (such as vermiculite) to the great laterite areas for the permanent improvement of humid soils and to obtain the immerse quantities of free agricultural water consequently available for the supply of human needs. There is an interesting relationship of this with the following subject.

Desalination of saline water.

Conventional stills, as pointed out earlier, can now solve any non-agricultural problem in any technologically competent nation, but only the very largest nuclear-powered desalination plants hold any promise of significant aid to agriculture. A projected ten to one-hundred million thermal kilowatt reactor may produce fresh water at $36. an acre foot. Water at this price would be of marginal use even for the most valued crops, but would supply agricultural water for regions of high economic development any any industrial or municipal needs.

By definition, the sea and deep ground waters hold many of the minerals that have been leached from the soils. Thus it is no surprise that some of the byproducts of demineralization include materials that are valuable to rain forest agriculture.

There are many important research areas related to desalination. I already have mentioned an outre one - the development of salt accumulating plants. In addition, besides the engineering problems of heat exchange and materials, there is research into the clathrates, these strange ices that water forms at near ordinary temperatures upon the addition of small quantities of simple chemicals. The efficiency of all sea-water distillation processes is limited by the temperature of scale formation. New heat transfer inventions (as by immiscible liquids or metal spheres) could possibly greatly improve the efficiency of distillation by simplifying the scaling problem.

New electrodialysis membranes, reverse osmosis processes, or some other development could constitute a breakthrough.

Demineralization of saline ground waters may be more valuable than desalination of sea water. After all, the ground water is more likely to be close to the need. In addition the chemicals in ground water may have components that constitute particularly valuable byproducts. We should know much more about the ground waters of the world, an opportunity for hydrological research.

Most desalination processes require large energy inputs. The thermal gradient of the ocean constitutes one of the greatest energy reservoirs in the world, probably 2,000 times the total hydroelectric potential. No one, I believe, has investigated the implication of new materials (plastics, stainless steels, etc.) to a sort of modified Claude type desalination using this great energy source.

Geothermal energy is increasingly attractive and even underground nuclear explosions to release this geothermal energy appear feasible.

Bold transportation.

The largest tanker in the world can hold less than $1,000 worth of fresh water at present Southern California wholesale prices. However, new materials may permit the construction of huge (10 billion ton) containers for the transportation of water from regions of plenty along the great streams of the oceans to arid coasts. After all, an entire Southern California annual supply of fresh water drifts by her door each week from the discharge of the great rivers of the Pacifici Northwest. Unhappily at this time, it is only represented by a slight salinity minimum in the California Current. Several people are considering immense containers for slow oceanic transport of water from such sources. Ocean wave propulsion is possible for these large containers. Transport of the antarctic icebergs can almost certainly supply the arid regions of the Southern Hemisphere with vast quantities of fresh water. A single secondary antarctic iceberg is worth $100,000,000 at present wholesale water values.

The coastal deserts of the world are located along the great cold equatorward currents of the sea. Thus, in the Southern Hemisphere at least, the great antarctic bergs are poised at the entries to natural highways that lead to the deserts. Indeed, some bergs find these routes by themselves and journey to the tropics.

Atomic PLOWSHARE harbors may emancipate man from his present limitation in marine transport.

Storage.

I have already mentioned that underground storage in aquifers has many advantages over ordinary reservoir storage. Evaporation is reduced, land is not taken out of production, etc. The storage capacity of these aquifers is sometimes immense. The great Mangla dam, for example, will have a capacity of only about 6,000,000 acre feet, whereas the aquifer of West Pakistan has at least 100 times this capacity.

The problem of aquifer recharge is curious, however, for recharge wells do not function satisfactorily. In some cases it has been shown that aquifer recharge is best carried out by maintaining a leaky canal system. The reasons for the poor results of aquifer recharge from prepared beds are obscure. Silt and possibly gas bubbles apparently are responsible. A study of these might improve canal sealing, also. Air bubbles in the canal waters might be investigated. Some highly sophisticated canal sealants are under investigation now, but air bubbles would be far cheaper and, of course, unobjectionable.

EVAPORATION AND TRANSPIRATION CONTROL, PRECIPITATION CONTROL, ETC.

There is a host of possible ameliorations of the water problem that require a deep insight into the nature of the water substance, into the manner in which other substances, salts and surface active materials, are associated with it, and into the hydrologic regime. As you know, water is a strange and remarkable substance, and we understand all too few of its properties, particularly considering the importance of the substance to man.

Basic research on the nature of solutions, of water droplets, on the manner in which water is associated with soils, and on the way it is handled in living organisms will give us needed insight into the water problem.

I have barely touched on a vast area of needs. I would like to have developed some ideas on alternatives to conventional agriculture and on climate control. I have not touched upon the use of waste water, on withdrawal vs consumptive use, on solar energy, on silting of reservoirs and the associated coastal erosion, and a many other important aspects of this complex melange called the water problem. In recompense for this deficiency I have given you some references to research opportunities in this field.

What I hope I have accomplished is to persuade you that there are many entrees into the problem; that there are great and exciting opportunities; that there is much need for insight and understanding derived from a far wider range of engineering and science than that devoted to a mere boiling of sea water; and that the water problem is merely a part of the food problem which itself, of course, is a portion of the problem of human numbers.

The planet on which we live possesses a great hydrosphere. By the time there are 30 billion inhabitants, each individual will still have a share of naturally desalinated sea water much more than sufficient for his needs. To use this adequately will require bold steps in agriculture, marine transport, biology, and law. Water must be redistributed, and also reused.

We consider the problems of the space voyagers, and how they must allocate and reuse their supplies. But as Dr. Roger Revelle has said, the sooner we realize that this earth is the best space platform that the human race is ever likely to own, and when we start treating it so, we will begin to make progress on distribution, conservation and use of the world's bounty.

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CLOTHING - A BASIC REQUIREMENT

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INTRODUCTION

One of the three important requirements for the human being is clothing, the other two, of course, being shelter and food. Clothing might be defined in a narrow sense as those things which cover the main part of the body, but in a broad sense, it includes the things which cover not only the main part of the body but also the head, the feet and the hands.

From the archeological point of view, evidence of the wearing clothing by the human being can be traced to the paleolithic age. However, then the purpose of clothing was simply to protect from the heat in one season and the cold in the other season. It consisted of raw skin or fur and raw plant fiber without any treatment before its use.

Nevertheless, as the general knowledge of mankind advanced, the demand for and supply of textile fibers was so increased that clothing was worn not only for avoiding cold or heat, but also for improving their appearance. Clothing thus changes in order to meet the needs of the times; this change is made for the people to look attractive when people enjoy economical prosperity, but sometimes this change is made in response to practical and economical needs, when the emphasis is on its strength and toughness rather than its appearance. Thus the extent of choice is very much widened.

We are now facing the problem of an extraordinary increase of population and a wide variety of national interests. If the present population is kept constant, the current state of development of processing methods for fibers will meet the needs and desires of this generation to some extent, but the estimated population of 8 billion by 2,000 A.D., or double the present population of the world (calculated on the basis of 2% increase per year), poses the real problem which we engineers and scientists must tackle within the common research body. We must, therefore, look into the status of available textile fibers and the methods of production.

First of all, the basic requirements of textile fibers are as follows:

1. They must be solid.

2. They must be resistant to chemicals.

3. They must be stable and nonconductive of heat.

4. They must have stability as a chemical compound.

5. They must have strength, elongation, elasticity and plasticity.

6. They must be fine and even in texture.

7. They must have some length.

8. They must have spinnability.

9. They must have hygroscopicity.

TEXTILE FIBERS FOR CLOTHING

We shall now introduce the following fibers from which material for clothing is made: cotton, stem bark fibers, silk, wool, regenerated fibers and synthetic fibers.

Cotton

Cotton holds the first position not only among seed fibers but also in its production and demand in the world. Cotton is cultivated in broad districts from parallel 40° north to parallel 30° south. However, the quality of that produced in the tropical region is inferior to that of the fiber of the subtropic region. The principal regions are North America, India, Egypt, Soviet Russia, Peru, Brazil, China and Africa. The proper conditions for its cultivation are 20° - 30°C of temperature, much moisture, and soil rich in potassium and calcium.

Sea Island Cotton is the finest of the cotton fibers and is mostly cultivated in the southeastern coast areas of the U.S.A. and its near-by islands. The cotton which is grown in Florida and Georgia has long, soft and tough fibers and it has cream-like or white color as well as luster.

Egyptian Cotton is next to the Sea Island Cotton and is cultivated in the region along the River Nile in Africa. This kind of cotton is white or light brown in color, and it is suitable to be made into sewing yarn, shirts, merias, and sovon.

American Cotton is the cotton grown in the United States, excluding the Sea Island Cotton. This cotton amounts to half of the whole production of cotton in the world, and it controls the cotton market of the world. It is mostly cultivated in the states of Louisiana and Texas. This cotton is generally white, and the length of the cotton fiber is even. At present this kind of cotton has been transplanted in Africa, South America, India, China and Korea.

Indian Cotton is produced in approximately the same quantity as that of American Cotton. The quality is somewhat inferior to that of America, because the fiber is short and thick.

Chinese Cotton is next in quantity of its production to that of the Indian Cotton, and it contains much moisture and a lot of impurities. It therefore requires much care in handling.

Brazilian and Peru Cottons are fine and tough, but not even, so they are suitable for mixing with wool.

These cottons are fibers consisting of glucose particles in cellubiose state. Cotton is widely used and in various conditions and placed. The fibers can be easily dyed, and the final finishing can produce various effects.

In addition to the several varieties of cotton fibers, Kapok and Simal fiber may be included in the seed fibers.

After the cotton bolls are picked, the seeds and fibers are separated. Then the fibers are graded according to quality, and in accordance to the proposed use and cost, they are mixed and opened through the opening machine. Through these processes the fiber is made into lap, that is, bundles of fibers, and even and thin bundles are produced. The draft and twisting is done by spinning machine and yard is made up. The yarn is then starched, gas treated, and bleached.

Production increased by 5 billion pounds during the nine years from 1951 to 1960. And as production increased, so the demand increased. Moreover, the demand increased more than the increase in production in 1959. But after that time, the demand decreased because of periodical business confusion and the competition between man-made fiber and cotton. It is thought that man-made fiber threatens the demand for cotton, but the reason for the decrease in the demand for cotton is not only this but also the technical changes of cotton weaving industry. The amount of consumption of cotton per individual occupies first place in the entire consumption of all kinds of fiber. But this situation can not be maintained because the area for cotton cultivation is limited.

Stem Bark Fibers

Among the stem bark fibers there are flax, hemp, jute, ramie (China grass), nettle fiber, Sunn hemp, Chinese jute, ko hemp, gambo hemp, and sovon.

The production regions of flax are North and West Europe, North Africa and East Asia. It does not matter about the weather, but mainly it is cultivated in the strip between 48th and 55 north parallels. Flax is strong, glossy and beautiful compared with cotton. All stem bark fibers including flax are heat conductive; hence, it is suitable for summer clothing because it is cool feeling and it is also suitable for handkerchiefs, coats, etc., because of its property of absorbing and discharging moisture.

Hemp is produced in India, Persia, Russia, Italy, Spain, France and North America. This fiber has strength and durability, but lacks pliability and elasticity. Therefore, it is used for the warp of carpets and sewing yarn instead of fine goods.

Jute is produced in South America, Africa, and Iran, and has the name Calcutta hemp. The subtropic region is suitable for producing hemp. The main composition of hemp is the ligno cellulose, a compound of cellalose and lignin. It is low in strength and durability compared with flax and hemp. The dyed yarn of this fiber looks like sheep's wool and is combined with wool to produce a mixed wool fabric.

Ramie (China grass) is produced in China, India, North Africa, North America and Australia. These are the strongest fibers among the plant fibers, having three times the strength of hemp, and they have luster and toughness. Thus this fiber is a favorite for use in summer clothing, lace, curtains, napkins and handkerchiefs.

Another of the plant fibers, known as leaf fiber, has a small consumption. Among the leaf fibers, there are New Zealand flax, Manila hemp, Sisal hemp, Mauritius hemp, Pita fiber, Pineapple fiber and Pandanus fiber. New Zealand flax is produced mainly in New Zealand, and is as strong as hemp. It has the possibility to be improved as good as the flax, even though it is weak in water properties. Manila hemp is produced in the Philippine. It has luster and is tough, so it is used for ropes and braid for hats. Sisal hemp is mainly produced in Central Asia, West India and Florida. As it is tough, it is used for tooth brushes and rope. Pineapple fiber is mainly produced in South America and Mexico. In addition to its durability, it has fineness and keeps its toughness with absorption of water.

There are many methods of producing stem bark yarn depending on the kinds of stem bark. In general, the stem bark fiber is obtained by various retting methods such as peeling off from the trunk of the plant and by cutting them into fine pieces longitudinally.

If we look briefly into the supply and the production of stem bark fibers, we can say that the rate of production has been gradually decreasing, but not very much. The fibers are strong even though the mother plant grows under the influence of all types of weather and its process of retting is also under the same all-weather influence. The production of sisal hemp has almost doubled the production in 1935 in Tanganyika, Haiti, Mesico, and Madagascar, but its production in Cuba, Indonesia and Salvador has decreased. Production of hard fiber among stem bark fibers ranges from 820 thousand tons through 28 million tons a year. Export of this fiber has been low in comparison with that of its production, for it is not popular due to its disadvantages of low pliability and high heat conductivity. Therefore, this means that it is consumed only in specific areas.

Silk

Silk can be divided into three categories, that is, domestic silk, wild silk, and special silk. The wild silk includes Tussah, Chestnut, Yamanai, Moonga, and Eria silks, and the special silk includes Anaphe, Bysuss and Spider silks.

Domestic silk is produced mostly in Asia and Central Europe. Silk is the fiber which is got from the silk worm cocoons. It is a fiber which is composed of coagulated proteins such as fibroin and sericine, that are the secretion of the silk worm. At the time of scouring and reeling, the sericine is dissolved and the fibroin remains as fiber. Silk is pleasing in appearance, is soft, has good natural luster and long fibers, and the processing is convenient. It has the defects of color fading in the sun light and of becoming weak from the sweat and sebum of the human body.

Silk has a brilliant natural luster which results when the sericine is dissolved. The surface of silk is smooth and reflects a great deal of the light. Silk is not used widely on account of the difficulty of processing and handling thereafter and its high price.

Next let me describe wild silk. Tussah is a fiber which is made by the worm living on the caster leaf. Tussah silk feels rather hard, and it is tough and very resilient. Therefore it is used in making brushes and in mixing with wool fiber. However, it has the defect that when it is dipped into water, it shrinks and loses its luster.

And last I will describe special silk. The Anaphe silk is made from the silk cocoons of the groups of insects that are found in the district of Uganda. The Bysuss, sometimes called sea silk or fish wool, is produced in the sea around the Island of Sicily in the Mediteranean Sea. The quality of this fiber is strong, but it feels soft and has a brilliant luster, and therefore it has a high price.

After sorting the cocoons, the silk yarn is made through cocoon cooking and reeling. Cocoon cooking weakens the cohesion of the sericine particles and makes the reeling easy. The quality of the silk yarn differs according to the degree of the sericine excluded.

Now I shall discuss the supply and demand of raw silk. In the U.S.A., since the production of synthetic fibers, the silk industry is carried on as non-professional occupation, and so the demand for raw silk has decreased. However, an after-finishing chemical has been invented in the U.S.A. which can be applied to the silk material to make it crease resistant and spot resistant. This makes for easy handling in washing and dry cleaning.

In Europe, the demand for Japanese silk has decreased while that for the Red Chinese silk is increasing. For example, in France the import of raw silk has decreased 40% in comparison with that of 1960. But the import of raw silk from Red China has increased a little. This tendency can also be found in Switzerland, Italy and West Germany. In Switzerland, their silk goods is 20% higher in price than that of Red China and Japan, and it seems that she will also impose protective control on the yarn and fabrics of the

South and Eastern Asia.

But when we examine the world status of raw silk, the demand for raw silk has decreased. On the other hand, we see the increase of 35% in production since the year 1951 to 1960 with the annual fluctuation of increasing and decreasing. Though raw silk is not suitable for practical use, it has gracefulness. And it is believed that we can predict its continuance of demand if we introduce the study and method for improving its processing and its quality. Even though the production of raw silk has increased, the individual demand can not be met because of the increasing population. One of the reasons for the decrease of demand for raw silk is the fact that the inclination of people is changing as the world progress.

Wool

Wool fiber comprises sheep wool, goat wool, apaca, mohair, cashmere, camel, angola fur, common fur, cow hair, horse hair, recovered wool, etc. The main producing regions are scattered throughout England, Australia, Canada, North America, Spain, Asia and Europe.

Sheep wool consists of fiber protein, the so-called keratine, and is a compound of amino acid which has rather a more complex structure than that of the fibroin of silk. The quality of wool depends on the kinds of sheep, the physical condition of the sheep, and the properties of their feeding grass. However, because of its desirable properties of strength, plasticity, and elasticity, the property of air entrainment ensures the warmth which makes it suitable for clothing. And scale, one of the characteristics of this fiber, accures the possibility of felting into wollen goods, felt hats, and so on. Nevertheless, the property of felting results in some difficulties such as shrinkage and the felting tendency of woolen clothing in washing.

Hair fiber is not the type of wool which will be supplied for woven goods, but in any case this fiber is utilized for particular clothing which emphasizes some inherent property of this fiber. For instance, glossy mohair comes from the angora goat, and the main production regions are Asia, Turkey, South Africa and North America. The characteristic of the fiber is stability which is favorable for brush fabrics for furniture, blankets, jackets, etc.

Cashmere hair comes from Cashmere goat, and main production regions are Tibet and North India. It is classified into soft and hard hair. Soft hair is mainly utilized for fabrics that feel soft to the touch.

Camels are mainly raised in the Asia desert,and the camel hair for fiber is supplied mostly from the Bactrican type of camel with two humps in the areas of China, Afghanistan and South Siberia. Its chief use is for high grade overcoats.

The alpaca lives in the Andes Range of South America, and alpaca hair is glossy and of high quality. Vicuna, llama and guanaco are also found along with the alpaca. Vicuna among them is of high quality in delicacy and feeling.

Rabbit hair comes from two types, the Angora rabbit and the common rabbit. Angora rabbits which are also classified into rabbits and hares breed rapidly. This was especially fortunate after French women started to spin Angora rabbit hair about 100 years ago. The common rabbit is found mainly in France, Russia, Japan and China. Rabbit hair is used in woven or knitted goods and for hosiery and gloves.

Fur fiber is the pelt of animals which bear hair or wool, and pelt-like fur need not be treated mechanically as spinning and weaving fibers and still has durability.

Remanufactured wool is reproduced from the Mungo, which is the reworked wool from felted wollen goods, from Shoddy which is reworked from unfelted wool of serge and flannel, and from extracted wool which is recovered from wollen and worsted goods mixed with cotton, such as cotton pockets of garments, by carbonization.

The feathers of the ostrich, goose, and duck have the multipurpose of providing warmth and for flying, and they are used mainly for packing, paint brushes, decorations, brushes, feather yarn, and so on. Particularly for packing, no felting is required due to their elasticity and light weight.

Wool as a material for clothing consists of worsted fabrics and woolen fabrics, and attention should be directed to the fact that at present the demand for woolen fabrics is increasing more than that of worsted fabrics. Such a trend in demand was caused indirectly by the development of artificial wool which is mixed with pure wool. Thus the amount of consumption of wool per person is decreasing, and yet the amount of production of pure wool is increasing according to the statistics of production year by year; from 2,356 million pounds in 1951 to 3,184 million pounds in 1960, an average annual rate of increase of slightly more than 3%.

On the other hand, the consumption rate in North America was 75% in 1959 compared with that in 1951; in the Western Europe there was a little increase in Portugal, Ireland, and Austria but no essential change in the other areas; in Eastern Europe, there was a marked increase in Bulgaria, the U.S.S.R., and Hungary; in Latin America and the Far and Near East, there was no essential change at all; and in Africa, there was almost half the increase in all areas except Algeria and Tunisia. After all, the rate of consumption of wool per person merely increased from 0.43 Kg in 1951 to 0.47 Kg in 1959.

Therefore, we reach the conclusion that countries in which wool consumption has been low have the tendency to consume more and more, while consumption per person is increased in a world-wide sense, for the country which consumes less wool has a high rate of increase in population, while the country which consumes more wool has a lower rate of increase in population. No matter how the consumption of wool varies among nations, the rate of consumption of wool will continuously increase due to its superiority in providing warmth, in absorption of moisture, and in easy fabrication by using scale.

But any effort to increase the production of wool in the areas most suitable for raising animals does not mean much without reducing the cost and without a substantial quantity compared with the synthetic man-made wool. Somehow or other, the rate of consumption of wool increases continuously, and the rate of consumption of wool will continue to increase, but it is doubtful whether it will meet the increase of population.

Regenerated Fibers

Regenerated fiber is the artificial fiber which has the appearance of natural silk. Generally the natural materials are the principal stuffs of this fiber which are treated with chemicals.

Nitro cellulose, cuprammonium, and viscose are among the cellulose regenerated fibers. To make regenerated fiber, linter and sulphurous acid pulp are used as stuffs, and especially the viscose rayon is made from the stuffs of various pine trees. The regenerated fiber sometimes has too much luster, poor strength and elongation, and is heavier in weight than natural silk.

Acetate rayon is regarded as a semi-synthetic fiber. It has the same specific gravity as wool, and it is elastic and strong. It has good warmth characteristics. As special artificial silk, there are dull luster rayon, lumen rayon, multi-filament rayon, high tenacity rayon, colored rayon, etc. The above-mentioned rayons are all spun as filament, and sometimes they are cut and mixed with other fibers according to objectives of various kinds. The cut fiber is called staple fiber.

Protein fiber is of two kinds, botanical protein fiber and animal protein fiber. The botanical protein fibers are made from the soybean, peanut, ground nut, monkey nut and corn. The animal protein fiber is made from milk, casein. Soybean protein fiber is sofe and has a pearl-like luster, and is cut to be mixed with wool. The peanut, ground nut, and monkey nut are made into ardil which has the defect of light yellow color, but is has the merit of absorbing moisture and other bodily secretions and is used for undershirts. Corn protein fiber is called vicara, and this vicara is the best of all the regenerated protein fibers. Vicara is soft and warm, and it is very suitable for making women's and children's wear, and knitting goods. Animal protein fiber is called lanital, which has the quality of being crease-resistant like wool and is used to be mixed with wool.

Glass fiber, slag wool, and rock wool are included in the mineral fibers. However, mineral fiber is seldom used for clothing.

Artificial silk yarn is made by passing the spinning solution of raw material treated by chemicals through a spinning nozzle and dipping it into the coagulation bath. By drawing the fiber during coagulation, the fiber is made strong.

The demand for and supply of rayon and acetate have increased since 1950. This increase has now reached 6 billion pounds.

Production of glass fiber has decreased because nylon and tenacity rayon have been made available. This has been primarily because of the unstability of glass fiber. Rayon and acetate are the oldest artificial fiber in production and represent the greatest production capacity in advanced countries. In fact, it seems that they are over-produced in them.

On the other hand, developing countries such as India and Red China are inclined to devise import protection policies for their industries. Therefore if the advanced countries want to export these fibers, they must develop new and highly developed techniques to devise new products. Under this situation, rayon is most produced and most consumed in America, England, Italy, West Germany, France, Japan and Brazil. At any rate, artificial fiber production is not limited to specific areas, and it will hold an important position in solving the problem of clothing.

Synthetic Fibers

Synthetic fibers are synthesized chemically by the high molecules which compose the fibers, and its kinds are poly amide, poly ester, poly acrilic, poly vinyl chloride, poly vinylidene chloride, poly vinyl alcohol, poly urethan, poly ethylene, poly propylene and poly styrene. These synthetic fibers are resistant to harm from inserts and are warm. In poly amide, which is the copolymer of hexa methylendiamine and adipic acid, there are Nylon 6, Nylon 11 and Nylon 66. Nylon is mainly used for sheer fabrics, lace, shoes, socks, gloves, rain coats, covering of wire, and filter cloth. And the monofilament is used for tooth brushes, fishing net yarn and medical yarn.

The poly ester fiber is the fiber produced by the poly ester of ethylene glycol and terephthalic acid, and has the common name Dacron, Terylene, Tetoron, and so on. It has the advantages of pliability and resistance to friction, and is often used in combination with other material.

Poly vinyl alcohol is a compound of high molecules of vinyl alcohol, and in order to obtain the fiber we must apply the treatment of heating and formalin chemicals to it. This fiber is light and warm, and it is friction resistant and moisture absorbent compared with other synthetic fibers. It is utilized to make socks, merias, uniforms, blankets, etc.

There are various kinds of poly vinyl chloride:

1. Simple poly vinyl chloride such as Rhovyl and Teviron.

2. Pe Ce Fiber such as poly vinyl chloride treated by chloride.

3. Vinyon such as copolymer of vinyl chloride and vinyl acetate.

4. Dynel (Vinyon N, Kanekalon) such as copolymer of vinyl chloride and acrilonitril.

Teviron is light and soft, and hard to absorb moisture. It can be mixed with rayon staple in weaving. As it has the merit of providing warmth, it is utilized in making knitting yarn, the fiber of blankets. But it has the defect of being weak to heat.

Pe Ce fiber is also weak to heat and is easily melted at 100°C (212°F). It is used to make fishing nets and water-proof clothing.

Poly acrilonitril is mostly found in copolymer fibers composed with acrilonitril and other materials. Orlon, Acrilan, Dynel, Exlan and Vonnel are the various material of this fiber in the market. The characteristics of this fiber are high bulk and softness. It is used to make merias, sweater, jersey, blanket pile fabrics, etc.

Saran or Velon is the copolymer of vinyliden chloride and vinyl chloride. It is very resistant to acid and mildew, and is difficult to dye. It is utilized for sheets, anti-insect nets, and furnishings such as carpet.

The total amount of production of synthetic fiber in the world has amounted to 1,800,000,000 pounds. In the percentage of production of synthetic fibers, that of filament was 78% in 1950 and 59% in 1960, and that of staple fiber was 22% in 1950 and 41% in 1960. It shows that the percentage production of filament decreased while that of staple fiber increased. In fact, the staple fiber was consumed not only in clothing but also in articles other than clothing, and the real percentage is 70% to 30%. Among all the synthetic fibers poly amide fiber has the biggest percentage, that is, 56%. We can enumerate the percentages in the order of consumption as follows:

Poly amide fiber	56%
Poly acril fiber	17%
Poly ester fiber	16.8%
Others	10%

The U.S.A. shows a decrease in the production of synthetic fiber, but this is because there arose many new countries that could produce synthetic fibers. However, U.S.A. holds the first position which indicates 40.7% of the world production in 1963, and Japan is second with 18.4%, followed by England and Germany. In these principle countries intensive study is carried on in order to develop the qualify of these fibers and better methods of dyeing and mixed weaving. These facts show it is an important task engineers and scientists have to accomplish. If we note the quantity of consumption per person per year, U.S.A. shows 3.04 pounds, Canada 2.0 pounds, and the other countries consumed 0.2 pound on the average. But the consumption of these synthetic fibers will vary greatly according to their peculiarities.

Textile fabric products are made in the form of felt, woven goods, knitted goods, lace, and net. Felt is made by adding heat, pressure, chemicals and rubbing from wool in free state. Woven goods are made to interconnect warp and weft; while knitted goods, so called Merias, are the cloth made by connecting loops and keep the heat due to the property of air entrainment.

The cloth which is woven in this way may be whitened with bleaching or fluorecence bleaching in addition to any alteration of structures itself. After that the dyeing or printing is applied. As the development of resin synthesis advances, desirable properties such as anti-crease, anti-shrink, wet-strength, shower proof, dye fastness, non-slip, rot proof, mildew proof, anti-felting, etc., can be provided. In addition to the above-mentioned external effects, each fabric may be flocked or embossed in accordance with their characteristics.

CONCLUSION

So far we have looked into all kinds of fibers, the methods of fabrication and the present state of needs in connection with fibers. Beyond the extent of our imagination, the rate of increase in population, i.e., 2% a year, predicts doubling the present population after 35 years, with simple calculation. From 1951 through 1960, based on 1951, rayon increased 144%; synthetic fibers, 700%; raw cotton, 128%; wool, 135%; and silk, 140%. These figures indicate the importance of various fibers, but their increase in production does not mean much. Instead the important fact is that the production of cotton is changed from 71% (of the total production of important fibers in the world) in the year 1955 to 67% in 1961; wool, 10% (no change); man-made fiber, 17.1% in 1955 to 17.7% in 1961; non-cellulosic fiber, 1.9% to 5.3%. Natural fiber has been increased step by step and will increase regardless of the local demands.

Due to the increase of population, the land area usable for planting fiber materials and for feeding animals is limited. This indicates that the production of the natural fiber will meet the demand for a while, but sooner or later, cannot increase compared with rayon or synthetic fibers. After all, the synthetic fibers must be produced more and more according to the demand. Anyway, the fiber which has popularity will survive; otherwise, it will be substituted by other fibers. At that time, engineers and scientists have to develop new methods of production.

It is an important problem for us engineers and scientists to contribute to the increasing population. At the present stage, first of all, engineers and scientists have to discover ways of processing which can eliminate the defects of natural fibers to encourage the use of natural fiber in spite of the appearance of new fibers. In the second place, the engineers and scientists have to develop new man-made fibers and industrialize the methods of production in order to meet the demands of the increasing population.

The man-made fiber is the one on which we can anchor our hope, for it is not affected by the weather, it does not require large areas of land, it can be adjusted in production, and so on. However, the development of man-made fiber depends almost entirely upon developed countries which have plentiful and economical power, while the development of man-made fiber in the under-developed countries is so poor that they will suffer a shortage of clothing in the near future, in addition to their low economical power. Some countries are suffering from an unstable supply of raw fibers, and in these countries, we must identify even the raw materials which are scattered about their countries which will produce the fibers. We can say the problems are these: (1) how to develop new fibers from available raw materials, and (2) how to gether the interested engineers and scientists.

We propose the establishment of an international research center where we can develop new textile fibers which are specific to some areas and then the new methods to industrialize this fiber. Next, this center may have a branch for each country, and may be supported by supplying the research equipment and the research engineers and scientists.

This proposal would ensure the development of new fibers and new methods of production. Next, in the developed countries, engineers and scientists would concentrate on the study of the improvement of fiber quality and the development of suitable fibers for various purposes. On the other hand, in the under developed countries, engineers and scientists have to keep up with the advance of knowledge which has already been achieved in the developed countries and to find possible new fiber sources which are locally plentiful.

Furthermore, when the underdeveloped countries suffer from a lack of supply of raw materials for producing fibers, engineers and scientists must be aware of the local fiber which is chiefly consumed in those countries and try to discover ways of mixing the existing materials in order to overcome the crisis.

Particularly to women engineers and scientists, processing of clothing is one of the stimulating fields because it is a natural interest of women.

THE ESSENCE OF SHELTER

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INTRODUCTION

In 3000 A.D. an archaeological party landing on the planet Earth will begin excavation at the site of some interesting ruins identified in Earth literature as Cape Kennedy, one of the first space ports. Going through the huge mounds of concrete rubble and corroded metal, they will probably grin in amusement at the gigantic amounts of building material that Twentieth Century scientists and engineers used to shelter and launch those early spacecraft which resembled huge pregnant cigars.

Completing their exploration, they will hop into their small spacecraft, turn on the anti-gravity field and maneuver to sufficient altitude to switch on the nuclear-powered motors. Meanwhile, the large complex of Cape Kennedy will sit silently in the light of the sun, a huge monument and graveyard of remains, commemorating the Stone Age of space flight.

This look into the future is a rather whimsical way to preface a talk on present, past and future types of shelter for mankind and his work. However, as we now somewhat humorously view the large stone pyramids that the ancient Egyptians built to shelter their dead, so future generations will chuckle at that towering Cape Kennedy structure, the 524 ft. (48 stories high) Vertical Assembly Building built for sheltering the operations of assembly, launch, and checkout of our Moon vehicles, the Saturn V rockets.

The purpose of this session has been to cover four basic human needs: water, food, clothing and shelter. It would be possible to write a definitive tract on each of these topics, encylopedia-sized, in attempting to cover the broad spectrum of all their engineering aspects and developments--historical, present, and projected future. To use a phrase much beloved by technical writers, such a treatise is "beyond the scope of this paper." Instead, I will aim at the goal of trying to create in you a sense of awe at the kaleidoscope of change that has come about in man's forms and modes of shelter. Another impression I would like to leave with you is a happy feeling that--by the grace of God--nothing is impossible. If we find ourselves living in a weightless condition in plastic bubbles 200 miles above the earth, why then "hurrah!" and "what a grand adventure this is!"

As a materials engineer, I have had a lot of fun sitting in a front seat and watching the Materials Age dawn on the horizon. Some call this the Space Age, but there is the reminder that previous Earth epochs have worn the titles of the Stone Age, the Iron Age and the Bronze Age.

The Materials Age has irrevocably changed our way of life and the roofs over our heads--living quarters as well as the industrial and commercial buildings in which we work. Educated as a civil engineer, I began professional work with design in standard materials such as reinforced concrete and steel. Gradually methods of design evolved to include new changes in these materials such as precast concrete, the application of limit design in reinforced concrete work, new design methods for new light-weight steel and aluminum alloys, and changes that were brought about by the incorporation of prestressing concepts into the U. S. engineering picture.

Rapidly though, new materials were bringing about a swift evolution in the building construction industry here in the U. S. Plastics have made heavy inroads into all types of standard home construction. In industrial and commercial building design the picture of such rapid change is similar to that in home construction. I now find myself working with structural materials that were undreamed of 10 years ago--such as thin-walled titanium alloys for pressure vessels, epoxy compounds used for rock solidification in tunnel bores, and plastic pipe reinforced with strands of glass fiber.

OUT OF THE CAVES

To really appreciate today's housing technology, we must look back in time to see where we came from, however much we may disdain historical reviews. Such a backward glance will also produce in us grateful shudders that we are rid of much of the filth and germs of our ancestors. (It was said of many European cities in the 1700's that travelers could smell their stench 10 miles away.)

Originally shelter was sought in caves by primitive man simply to get out of the rain. In some cases, a cave was indispensable to keep a hungry dinosaur from taking a nip out of one's hide, since the bulk of such mammals denied them access to small spaces.

As man got smarter or, at any rate, as his brain capacity increased inside his skull, the early cave was abandoned for other types of shelter as he roamed over the face of the Earth and adapted to different climates and geographical conditions. In the desert areas, where food was sparse and men banded together in nomadic tribes, tents of skins and coarse woven cloth made an appearance. In the northern areas, primitive families learned to construct crude houses, first of stones and then later of shaped mud bricks. In the tropical regions, construction materials consisted of readily available items such as bamboo, grass thatching and rough lumber from trees.

In the last two centuries man's living and working quarters have split. The single shelter in which the family's crafts and agricultural pursuits were coupled with living accommodations has been replaced by separate shelters for commercial and industrial activities and shelters which house the family unit. These two types of shelter have undergone interesting variations in design and appearance, particularly within the last 50 years, which has been a time of stepped-up scientific pursuits and technological developments.

Let us first consider the factory and commercial buildings of 50 or 60 years ago. Industrialization was just getting up a full head of steam. The average industrial building was merely a structure to protect some rather expensive machinery from the elements. For most of us U. S. citizens who are old enough to remember, the industrial section of town was a series of brick buildings which were said to be on the other side of the railroad tracks. This connotation carried a picture of barn-like structures with tremendous brick chimneys and a minimum number of windows which invariably were filthy from accumulated smoke particles and grit. Coal-burning locomotives and supply trains with their belching stacks contributed to the grimy picture. Inside the factories, narrow aisles and dingy working quarters provided an almost untenable working atmosphere for workers who put in a 12 to 16 hour day.

Homes and living quarters generally provided much pleasanter surroundings than the working quarters of those days. For the families who could afford it, there were large and individually designed houses with high ceilings and large windows. Victorian "gingerbread" which consisted of ornate roof trimmings was quite popular. Gables, cupolas mansard roofs, fancy balconies and gazebos were employed by Nineteenth Century architects to make their house designs more stylish and gentile. The more rooms a house had, the more affluent your family was said to be.

For the middle-class working man, the row houses which are still seen on many streets in New York, Philadelphia, and other eastern cities had just become popular. Indoor toilet facilities, running water, and the wall telephone were new luxuries. These row houses were considered the last word in elegance if they had marbel entry stairs.

TO THE PRE-FAB HOUSE

From the grace and gentility of the last century, we arrive on the scene of today where automation and streamlining are characteristic of both homes and factories.

Here in the United States, house construction is becoming rapid and simple, since whole prefabricated units of dwellings are factory-assembled and shipped to the construction site--everything from modular wall units to interior plumbing. One large Eastern contracting firm boasts that it can ship all the prefabricated units for a complete house and finish erection in one day, if foundation and utility connections are ready.

Prefab panels used for construction of small factory and commercial concerns are also finding an increasing market. With modular dimensions, these components are made with built-in insulation of glass fiber, styrofoam, built-in self-sealing strips of vinyl, or other elastomeric materials and with finished interior and exterior walls of thin-gauge aluminum and steel. Many panels are made of inexpensive sandwich construction such as a phenolic-impregnated kraft paper honeycomb interior bonded to plywood or hardboard exterior surfaces.

New coatings and paints which permit factory-finishing are also helping this commercial impetus of the prefab panel. Acrylic paints and thin films of such materials as polyvinylchloride and polyvinylfluoride are being used. The PVF film bonded to wood and metal panels and marketed under the Tedlar trade name by DuPont is said to provide maintenance-free surfaces for up to 25 years.

The ultimate in prefabrication possibilities will come about when a house can be completed in the factory and then shipped intact to its permanent location by helicopter. Presently, there are construction helicopters such as the Sikorsky S-64 which are capable of lifting 10 tons. If this payload can be increased, the factory-to-site transfer of a whole house may soon become possible.

The light-weight concrete block unit is the backbone of much of today's house construction. Brick and stone masonry are still popular, but the concrete block has spurted far ahead of these competitors. As a conservative estimate, 300 standard sizes and shapes of the concrete block are now on the market. Building codes are somewhat restrictive on the uses of this type of building unit. For example, maximum compression valves allowed by codes run from 85 to 300 p.s.i., while some tests have indicated such blocks have a potential strength of as high as 6000 p.s.i.

THE 'QUICK CHANGE' FACTORY

Particularly worthy of note are modern trends in industrial and commercial construction. Building a factory is no longer a simple job but an extremely complex undertaking.

Today when a corporation considers building a new factory, their entire administrative staff must consider a variety of different factors. Should the plant location be in a large city, close to readily available transportation and utilities, or should it be located in an urban area which is more attractive to potential employees? Are there adequate utilities at the site? What is the available manpower in that area? For tax considerations, will site A prove more profitable than site B? Is room available for rapid expansion? Can the plant be designed for optimum working efficiency?

So important have these considerations become that in March of this year a U. S. business publication, Dun's Review, devoted an entire supplementary issue to a phenomena called "The Advent of the Quick Change Factory." In their introduction, the editors wrote, "traditionally it (the factory) is slow to change. Nevertheless the factory today is undergoing one of the biggest changes that has come over it since the beginning of the industrial revolution......the hard fought competition of marketing today and the pell-mell rush of technological advancement have caught up with the production line."

The question naturally arises, why all the fuss and bother over factory design when only a few years ago the factory was merely a box which sheltered machinery.

Part of the answer to this question is the result of the efforts of large corporations to create a favorable image in the eyes of the public. Modern design of any item, whether a consumer product or building construction, leans towards such factors as simplicity, clean lines, and a generally pleasing appearance. Large manufacturing concerns like their offices and factories as well as the appearance of their products to impart such a public image.

The rest of the answer, as Dun's Review states, is based on the fact that the economy of the United States can no longer be said to be based on increased production of the same items, but instead is based on the production of items that continually change. This transition is mirrored in the rapid technological evolution of all machinery, tools, and equipment. Equipment manufacturing concerns are constantly designing new and better machinery to more effectively do old jobs. The Review cites the instance of the case of cutting a hole in a piece of metal. At present there are 25 different ways to accomplish this. Such rapidly occurring changes in manufacturing tools and products are the major factors in industrial plant design today.

Adaptability is another important criterion. A New York architectural firm cited the example of some industrial buildings in California that they had designed, which in ten years had changed hands four times, in some instances with a radical change in type of industry.

Employee morale is also a heavily-weighted design factor. Pleasant surroundings including attractive color combinations, adequate restroom facilities, air conditioning, canned music, and comfortable seating arrangements have been found to markedly increase employee production and cut down on absenteeism as well as reduce the number of rejects from the production line.

Thus, to answer all these needs, the factory structure is evolving toward a large, high-ceilinged box construction placed on a large plot of land close to convenient transportation. Interior walls are of non-load-bearing construction that can be moved or knocked out when needed. Utility lines are channeled underground or, when located overhead, are painted by color to allow easy maintenance. Exterior walls of curtain wall construction of plastic aluminum and steel composition are another market item which allow rapid erection of prefabricated buildings.

All of this home and industrial shelter design revolution describes conditions here in the United States. Europe and Asia are also experiencing rapid changes similar to ours.

In Great Britain, plans are on the board for a large-scale urban renewal project for an area lying within a hundred-mile radius of London. Much of the construction is planned for the 1970's and calls for three new cities, two new towns, and expansion of four existing cities and twelve towns. It is hoped that this massive scale building will reshuffle some of the 18 to 20 million people who live in the London area and thus alleviate crowded conditions.

In the past two years major emphasis in construction activities in

Russia has switched from apartment house building to heavy industrial construction, particularly hydroelectric power stations. Use of precast concrete members is characteristic of all types of construction in the U.S.S.R. even to the extent of pouring large concrete blocks weighing up to 200 tone as units for dam construction. Precast concrete methods have proved a blessing to Russian construction in several respects. The long interval of winter weather, characteristic of most of the Soviet lands, prohibits in situ placement of concrete. A serious shortage of skilled construction workers in certain areas is another factor. In still other areas, dress lumber for form work is extremely scarce.

TO PLASTIC BUBBLE HOUSES

Before attempting to assess man's requirement for future accommodations, we should first take a long hard look at man himself and his own evolution. A new branch of engineering covering this development is called human engineering. This science is a combination of many other disciplines such as psychology, medicine, biology, neurology, and engineering. In recent years the object of much of the work of this new science has been to determine man's capabilities under many types of environment and under adverse psychological conditions.

In discussing the crew requirements for an orbiting space station one authority has stated "man poses a serious problem; because unlike materials, which have a specific yield point at some given stress, the human being is composed of a combination of organic and inorganic materials and a mental component which decrees a variation in the ability of the various specimens to take combined stresses." This very briefly describes man in terms of other materials; if subjected to too much psychological stress, he will crack--like the experimental mouse in the maze.

Another factor is man's efficiency as a machine. It is a recognized fact that mankind functions at only a fraction of his potential. Various estimates have been made that we are only 15 to 20% efficient in accomplishing the work of which we are capable. If our energy levels could be stepped up to raise this figure to even 30 or 40% and in the process also give our bodies the capability to keep up with our mental processes what an interesting bunch of people we would turn out to be!

Aldous Huxley has said "what we need is.....an entirely new kind of society--durable but adventurous, strong but humane, highly organized but liberty-loving, elastic and adaptable." To attain such a society by natural processes of evolution would take more centuries than we would care to devote to the matter. It is thus reasonable to expect that at some time within the near future we will begin adaptation of our own species in the same manner as we are now creating biological revolutions with more simple forms of life.

This change in man's basic psychological and physical nature will be accompanied by similar changes in his functions in daily life. A case in point here is the present function of housewives and mothers. Since many of us at this Conference are housekeepers and have children, we have seen this evolution in our own lives gradually taking place. Our own mothers were occupied with duties which have been made obsolete for many of us here in the United States. For this we have many modern appliances to thank such as garbage disposals, automatic dishwashers, automatic clothes washers and dryers, refrigerators, and a very wonderful array of cleaning and polishing agents including detergents and waxes and solvents.

All of our modern home appliances are leading to a dust-free, germ-free environment in tomorrow's home. Already on the scene are ovens which cook by ultrasonic means thus shortening the time required for cooking an average roast to a fraction of the present time. It is conceivable that dust in the house of the future will be disposed of by electrostatic precipitation methods. Disposable clothes may eliminate washing. Many of our manual functions today in cleaning will become a matter of push-button technology.

If all this comes to pass, what is going to happen to tomorrow's women? Again we see trends in today's living. Here in the United States the part of the working population represented by married women is steadily increasing, despite the fact that they have homes and children. Women are taking a much more active part in civic and government affairs. The wife and mother of tomorrow will probably spend close to 90% of her waking time either in a profession or representing the family in community activities, as the family business manager and as her husband's and children's companion. What we consider major housekeeping functions of today such as cooking, washing, and ironing will probably disappear and may be pursued as hobbies. Speaking personally though, it is difficult to imagine any woman scrubbing floors joyously for purely recreational purposes unless perhaps she's trying to cut down on her weight!

Dr. Lillian Gilbreth, our keynote speaker for this session, herself has been instrumental in bringing about many of these changes not only through her professional practice but as an example from her personal life.

These transitions in woman will someday equip her psychologically to set up housekeeping elsewhere in the universe away from our planet Earth. A migration of mankind away from Earth may be necessary if, as statistics show us, our planet's population explosion will result in 50 billion people by the year 2026 A.D. (only 62 years from now). This figure is, of course, barring war or major epidemics. This would be an average of 10,000 people per square mile, an amount that could not be supplied by our present world food resources.

<u>UNDER THE SEA</u>

One solution to this overcrowding in the future may be found in human colonization of the bottom of the sea. As another possibility, we may farm the bottom of the sea and have our living quarters orbiting around the earth in an artificial satellite. Mass migration to the Moon may become a plausible answer.

Living and farming at the bottom of the sea are certainly not new ideas. Back in 1907, the British Admiralty established the fact that men could live and work well under a pressure of 2 earth atmospheres. More recently, there is evidence that man can function under pressures up to 100 atmospheres, although experiencing rapid respiratory fatigue.

Last year Capt. Jacques-Yves Cousteau headed an expedition from the Oceanographic Museum in Monaco which worked and lived in a small village six fathoms under the Red Sea without coming to the surface for a month. Future expeditions headed by the same man are planned for living and working quarters submerged to 600 feet.

OUT IN THE UNIVERSE

In leaving our natural Earth environment we only need step into outer space to realize that God has indeed given us a nice little planet with a comfortable atmospheric cocoon. In laying out design allowables for housing accommodations for men on the Moon, U. S. engineers have had to face a number of new environmental conditions. Summarized briefly these include (1) a different lunar gravitational field; (2) nonexistent atmosphere; (3) wide temperature variations; (4) provision for protective shielding against cosmic radiation; (5) meteorite bombardment; (6) lunar earthquakes; and (7) foundation soils.

The first of these conditions does not at first glance seem to be much of a problem. Lunar gravity has one-sixth the earth value, which would seem to result in lighter and more economical structures. This asset is compromised by earthquake probabilities, since scientists now hypothesize that the interior of the moon still consists of molten magma which is cooling and shrinking. Due to the low density of the moon, it is probable that the outer crust is extremely thin compared with that of earth and that considerable contraction and shifting within the crust are still going on. Living quarters may thus be designed for seismic vibrations greater than we have experienced here on earth. Most of the early lunar simulators used for research purposes here on earth have been designed with a spherical shape or some other type of curved shell.

To live in the vacuum-like atmosphere of the moon all buildings will have to be pressurized to tolerable levels for human life. A human being can live in a pressure as low as 5 p.s.i.; however, 10 p.s.i. is considered to provide durable working conditions.

The problem of temperature differential from 280°F. in the lunar day to -150°F. in the shade will probably be countered by extensive use of heat reflecting coatings and paints which are in the process of being developed now. The outside shell of lunar housing will probably consist of a sandwich construction made up of an outer and an inner skin which are separated by ring stiffeners or a honeycomb core material. It is probable that a liquid cooling fluid may be used between the skins.

A sandwich construction such as this would also be advantageous in countering the hazard of meteor impingement. The outer skin will be designed to resist meteoroids up to 1 1/2 to 2 inches in diameter. Statistics say there is a 1 in 10,000 chance of the Apollo lunar craft meeting a meteoroid large enough to pierce its external surface.

The extent and amount of cosmic and solar flare radiation which will be met on the lunar surface are still open questions. It is hoped that data from future U. S. Ranger and Surveyor flights will give more information on these items. The required amount of shielding for living and working accommodations on the moon will depend upon these answers. It is possible that a portion of the shielding may be accomplished by the coolant fluid mentioned before.

Detailed knowledge of the moon's topography is still scarce. A malfunction of Ranger 6 in early 1964 was a sad disappointment, since at the time it had been hoped that close-up pictures would provide some lead as to whether the lunar surface consists of a fine dust or a light porous surface rock. The presence of a fine dust would mean design of a raft-type structure which would "float" on its surface.

Another one of the engineering problems involved is designing to keep weight and space requirements of the missile payload to a minimum--the size of these manned capsules could produce claustrophobia for the average person. John Glenn and Scott Carpenter had only 50 cubic feet in their Mercury capsules. The co-pilots of the Gemini capsule will have even less leg room--about 35 cubic feet apiece. The Apollo command module will seem roomy by comparison with 75 cubic feet per man. As a measuring stick, these figures might be compared to the coffin size required for the average U. S. male--28 cubic feet.

These are a few of the overall design problems. More detailed questions for the engineer which have to be considered are the effects of the lunar environment on materials. As an example, the variation in temperature will, in the case of structural metals, reduce their tensile and compressive strength, and possibly cause thermal stress fatigue. Lunar structures such as described will probably be fabricated out of units which have been shipped in. It will not be possible to use conventional methods to weld parts together because of the lack of atmosphere. However, welding will probably be done using helium or argon for aluminum alloys coupled with a neutral gas jet to lessen the possibility of stress concentration around the weld area. Cold welding, in which the raw surfaces of two parts of the same material are joined together in a vacuum atmosphere, also presents interesting possibilities.

Another problem of great importance caused by the Moon's lack of surface atmosphere is that ordinary materials evaporate or sublimate. This phenomenon is called "outgassing". In tests conducted on insulated wire for cables attached to the Surveyor unmanned lunar landing craft, only a few types were found to be suitable under the 10^{-12} mm. Hg vacuum and 280^{o}F. to -315^{o}F. temperature conditions. A special alloy wire coated with a special tetrafluorethylene polymer will probably be the best bet.

All of this analysis of lunar accommodations for man leads to the natural question that instead of providing such a sweet little cocoon for mankind, why don't we take the economical approach and make the changes in the people themselves. Unfortunately our technology in human engineering has not yet advanced that far. I have no doubt that someday we will be the ones to adapt to the unfriendly environment rather than trying to carry our own environment with us.

....AND THE PEOPLE WHO WILL DESIGN THEM

If changes as outlined in this paper occur in man as well as his sheltering environment, what kind of an engineer will we have in the future?

First of all, he or she will likely be an extremely adaptable individual with a highly versatile mind. The mongoose is a small animal of India that is a lethal snake-killer. It has a rather queer dancing gait that allows it to fly off at any tangent to dodge the quick poisonous darting of its enemies. In many respects, future engineers will assume mongoose-like traits--particularly in their ability to quickly cope with the unexpected and unusual problem.

Since, even today, "Knowledge keeps no better than fish," as one philosopher expressed it, tomorrow's engineer will be dedicated to keeping himself educated on all new developments within his field. Education has become a never-ending process and the effort to keep up-to-date will prevent an engineer from letting himself become obsolescent.

The future engineer will also find himself one of a team of specialists who offer interdisciplinary services. The day of the "loner" is over, and the really effective engineer or scientist will be the one who can communicate well with fellow workers and work in harmony with them.

We have been told frequently in recent years that 90% of all the scientists who ever lived are alive today. It is an exciting age in which we live and even if the world's population of engineers multiplies like rabbits, there will always be more and bigger and better scientific and engineering riddles waiting to be solved. Our housing accommodations in outer space will be not the least of these.

In conclusion, the art of shelter technology has advanced rapidly from the "home on my back" concept of the snail to the plastic house for the man of the future which will float in a gravity-free condition around the earth. Brief sympathy must be given here to the saddest housing problem of all--the termites in a yo-yo who keep going round and round on the same string all day long.

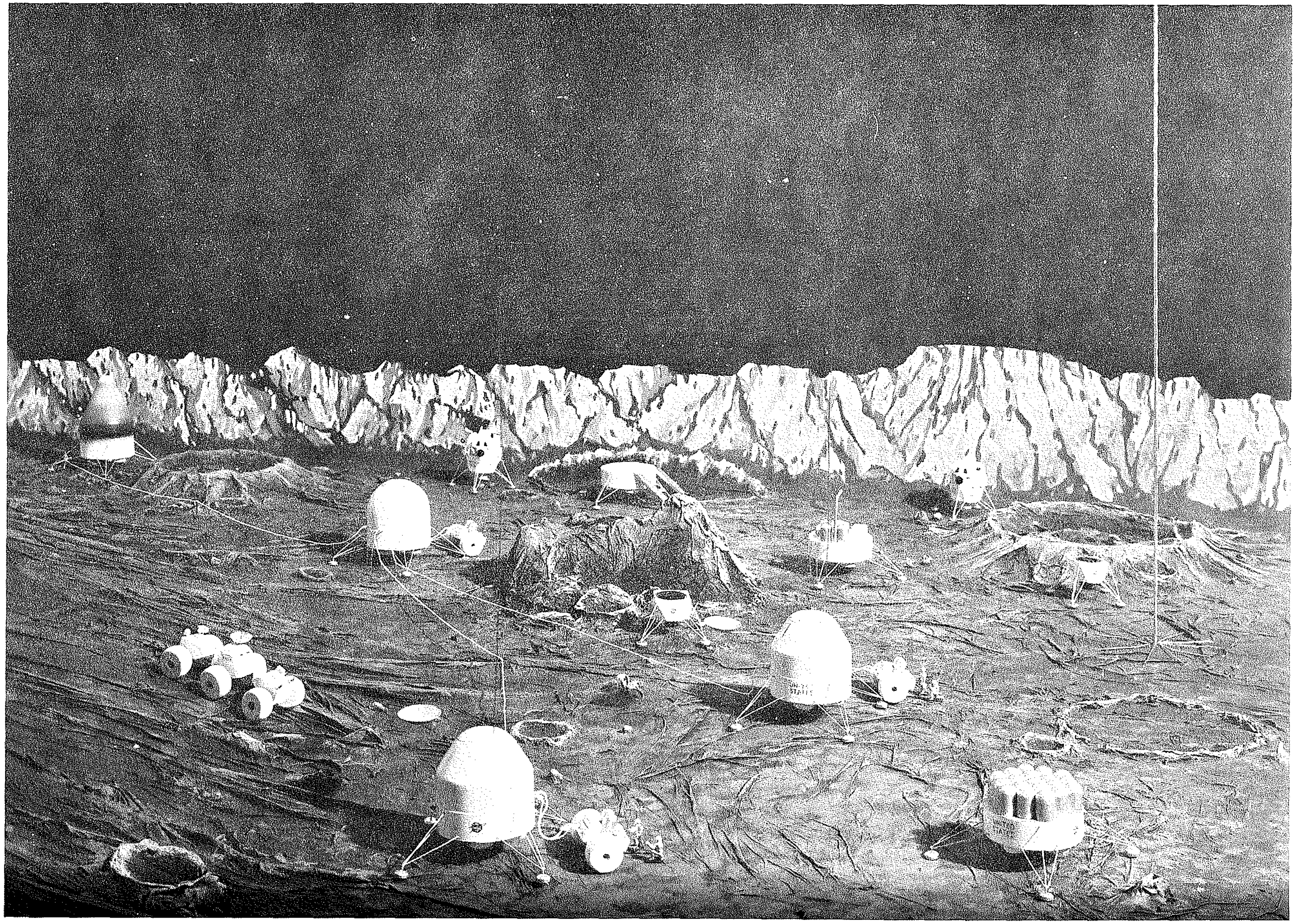

Figure 1. A model of a lunar base concept proposed by the Systems Operation Division, Westinghouse Electric Corporation. Such small "villages" would provide shelter for both men and scientific equipment in the early days of exploration of the moon's surface.

FOOD--ITS PRODUCTION, PROCESSING AND DISTRIBUTION

by Miss Mary H. Malone, Lincoln Laboratories Massachusetts Institute of Technology, Boston, Massachusetts; Mrs. Naomi J. McAfee, Westinghouse Electric Corporation, Baltimore, Maryland; Miss Margaret Ann Pritchard, Portland General Electric Co., Portland, Oregon; and Miss Joan T. Sullivan, Arthur D. Little Co., Cambridge, Mass.

It is a paradox that today, despite the great progress made in science and technology, Society still faces the same problem -- how to feed its hungry people. There are approximately 3.5 billion people to be fed in this world, and the number increases by about one million a week. Too many of these people do not have the essential of life -- their daily bread.

In this age of space travel, millions of people, nearly half the world population, have a diet that fails to meet the energy requirements of a normal existence. Ill health and ignorance follow in the footsteps of hunger. These, in turn, lower the productivity of the people or nations so affected.

The successful industrialization of the developing countries depends primarily on improving the efficiency of their production and utilization of food. The contrast in efficiency is enormous: On the one hand, although three-fourths of the population of underdeveloped countries are employed in agriculture, they cannot supply enough food for their needs. On the other hand, in highly developed countries, huge surpluses of food result from the farming efforts of only one-tenth of the population.

FAO, the Food and Agriculture Organization of the United Nations, estimates that to satisfy the food requirements of the world in 1980, production must be doubled; by the year 2000, it must be tripled. Can this increase in production be met?

The solution of this problem involves not only an increase in the supply or production of food but an improvement in the processing and distribution of this supply. This means improved agricultural technology, with emphasis on (1) the development of higher yield disease-resistant varieties of crops and livestock, (2) better planting and cultivation practices, (3) more efficient tools and implements, (4) optimum use of fertilizers, (5) safe and effective pesticides, (6) enrichment of nutritional value, and (7) better methods of preservation, storage and shipping.

Food technology has been practiced for centuries. Man learned to cultivate the soil to suit his needs -- when to sow, when to reap. Man learned to use animals and developed tools to conserve his energy. During the past two centuries, great strides have been taken in food technology with the application of discoveries in biology, chemistry, and mechanics.

Experience indicates the inadequacy of blindly increasing farm acreage. Such a program depletes the land. It becomes marginal, with crop failure being the rule rather than the exception. According to Professor Nevin S. Scrimshaw of the Massachusetts Institute of Technology, "highly developed countries have not increased the number of acres under cultivation but on the contrary have abandoned their marginal lands and steadily reduced the proportion of the population engaged in farming".

Crop rotation has been used successfully, but is not applicable in all cases. This method may be inapplicable for many reasons, one of which is that the farmer himself may be unwilling to employ it. Other techniques the farmer can use are the use of fertilizer, the use of additives, the control of insects, forcing early sprouting, and reconditioning the soil.

Advances in biology and chemistry have increased the efficiency of food production. New foods containing necessary proteins are still to be taken from the ocean. What is now considered as inedible may one day be enjoyed as a delicacy. Progress in the field of mechanics has contributed to the fact that the highest developed nations enjoy the luxury of producing more food than required by their own peoples.

The employment of machines to reap and sow not only conserves the energy expended by man in producing food, but also releases acreage formerly needed to feed work animals. This results in an increase in food grown for human consumption. Other mechanical improvements are irrigation systems, terracing and contour farming.

Proper breeding has increased the production of highly desired proteins in both cereals and livestock.

The necessity of preserving food so that it is available for man at all times resulted in the development of techniques for smoking, canning and freezing. Modern science and technology have produced, among other methods, the irradiation process for preserving certain foods for short periods.

As my father says, "There are two philosophies -- either one can eat to live or one can live to eat". In some of the more productive countries, food is wasted without much thought. For example, how many of you here today did not finish eating the fruit salad and sandwiches either because you were in a hurry or simply because you did not want to. This wasted food could well be used by some starving family.

On a global basis, production in the field is 120% of the food required by the world population. Losses resulting from such factors as harvesting, processing, storage, preservation and transportation result in 85% of this supply reaching the table.

Unequal distribution of the world's agricultural resources and production have been studied by the FAO. The Far East has more than 50% of the world's population, but it has approximately 15% of the world's agricultural land and less than 30% of the world's agricultural production. Europe, with less than 25% of the world's population, has approximately 20% of the world's agricultural land and 31% of the agricultural production.

Today the highly developed countries are concerned with the people of the developing countries. Concern for feeding the hungry is worldwide and is reflected in the Freedom from Hunger Campaign conducted by the Food and Agricultural Organization of the United Nations.

Emergency measures are to be commended, but in the long run the developing nations must provide for their own freedom from hunger. This will require a concerted effort on the part of these countries to follow, and perhaps surpass, the example set by the developed countries.

Improvement will come about through education, research, and the development of careers in agricultural technology. There must be a closer union of the social, agricultural, and health sciences if the problem of feeding the world is to be solved successfully.

The world's food problem is everyone's. Conferences such as this -- people sitting down together to discuss their problems and the means to effect a solution -- are part of the answer. It is within your grasp -- reach for it!

REFERENCES:

1. Scrimshaw, Nevin S. "Food". SCIENTIFIC AMERICAN 209:3 (September 1963) 72-80.

2. The Rockefeller Foundation, President's Review, 1963, p. 5-7, 38, and 39.

Summary of Session II

REQUIREMENTS OF THE INDIVIDUAL'S STANDARD OF LIVING

Mrs. Isabel H. Hardwich
A.E.I. Power Group Research Laboratory
Manchester, England

I have a feeling that all our speakers must have been consultants to "Futurama". In their papers, Mr. Schmidt (for Professor Isaacs), Mrs. Lee, Mrs. Hauser, and Miss Sullivan have discussed matters of immediate concern to all of us as individuals.

The required standard of living has been, is, and always will be very variable from individual to individual; and when all of us have reached a reasonable standard of living, it will be most interesting to see whether we shall settle back and work just sufficiently to preserve this standard or whether we shall continue to work as hard as ever in order to improve our standard still more. Already, there is a detectable trend towards sitting on our laurels, but these papers have shown us that we are as yet in no position to indulge ourselves as the explosion in world population is calling us to make ever harder efforts. We must supply more water, more food, more clothing, and more housing.

Mr. Schmidt emphasizes how important it is to be quite certain that we truly understand what our problems are before we try to solve them. Thus it is indeed certain that the majority of people believe that the industrial and domestic supply of water is threatened and they fear a shortage of drinking water. However, Mr. Schmidt points out that only 4% of our water goes in these purposes and it is the supply of sufficient water for agricultural needs which is the problem. He cheers us by assuring us that the world has ample water and tells us that we can get this water by methods other than the obvious one of desalination of sea water. He suggests that maybe, after all, it is not more water which we require but rather more suitable methods of agriculture in now undeveloped lands or the development of crops which thrive in saline water. His figures show us that more than twice the present world cultivated area could conceivably be brought into use.

Mr. Schmidt has also emphasized that we must tackle our water problem in the right frame of mind, i.e., as a world problem needing a world solution without any pressures from specialized groups and without any thoughts of political advantages.

This world-attitude of mind has also been emphasized by Miss Sullivan in her heart-felt cry to us at the end of her talk and by Mrs. Lee who calls for an international organization to solve the clothing supply problem. In her careful survey of all the world's fibres under the headings of cotton, bark fibres, silk, wool, regenerated fibres and man-made fibres, we have a clear indication of nature's astonishing bounty to us and also of our own ingenuity in processing these materials to supply ourselves with garments. Once again we are told that we do not generally appreciate the true world problem. This is not just finding better fabrics with special properties but rather it is finding enough fabrics to alleviate a world shortage. The world supply of all these materials increased in the ten-year period up to 1960. Cotton increased by 128% and synthetic fibres by 700%, while all the time cotton formed about 70% of the total output and although demand per head for individual fabrics varied and occasionally decreased, the increase in the number of individuals to be supplied was such that the supply of textiles still did not meet the demand.

Mrs. Hauser, too, anticipates a problem due to the world population explosion. This time it is a housing shortage, and she discusses the problems inherent in her solutions, which are the setting up of a colony on the moon or full-time living in space bubbles. It is interesting to find an apparently serious consideration of these ideas, as experience shows that once an idea has germinated on a sufficiently grand scale, we have always succeeded in bringing it off. As Mrs. Hauser has said, nothing is impossible. However, before we get too excited, we should perhaps ponder Mr. Schmidt's declaration that this planet is probably the best space platform that the human race is ever likely to own.

Mrs. Hauser's major developments depend greatly on the development of new materials, and new materials are also essential in the clothing field, where synthetic fibres are rapidly closing the demand-supply gap, and in the water-supply field, where they are needed for anti-corrosive equipment for the desalination of water, and in the food supply area, as new fertilizers for the hot wet soils or as new chemicals for the specialized treatment of plants.

Mrs. Hauser finds that woman coping with her prefabricated home will have much more time than she has now to play a part in the world as distinct from her family and will be able to use to great advantage her infinite capacity for adaptation in the world of engineering. That there will be plenty to be done in the future by both scientists and engineers is well shown by the multitude of possible fields of endeavour which have been mentioned in the four papers as necessary for solving the problems.

To sum up the papers, we have these common points:-

1. Practically all the problems of this afternoon's session arise from the world population explosion.

Assuming that the problems cannot be solved by curbing this frightening population increase, then

2. It is essential that we define our problems most carefully and exactly and approach them with a world-wide and not with a parochial attitude. We are considering world-wide shortages; we must combat them on this basis. And we must note that poor distribution is one of our present major failures.

3. It is essential that we do not automatically look for the purely obvious solution and so miss alternative routes of attack. Mr. Schmidt has suggested alternatives to literally increasing present water supplies, and I should like to add another approach which might solve both water and food problems: the complete abandonment of agriculture and its replacement by factory-made synthetic foods. Similarly, maybe we do not need to increase our world supplies of fabrics but should really be concentrating on the manufacture of paper throw-away clothes.

Returning to our summary:-

4. New materials including those not yet developed have a great part to play in future developments.

5. Engineers and scientists will be needed in all fields of endeavour if the required individual's standard of living is to be met.

6. Women, with their easy adaptability, should make most suitable engineers for these future projects.

Thursday, June 18, 1964

9:00 A.M. - TECHNICAL PROGRAM SESSION III

Focus on Industrial and Social Needs

Chairman: Lorna N. Millan, President, Women Chemical Engineers of the Philippines

Moderator: Beatrice M. Williams, Treasurer-elect, SWE; Design Draftsman, Lockheed-California Company, Burbank, California

TRANSPORTATION IN THE WORLD OF TODAY--Monique Vuillemin, President, Association des Anciennes, Eleves de l'Ecole Polytechnique Feminine, Paris, France and Monique Barbe, Ingeneure au Commissariat a l'Energie Atomique, Paris, France

ENERGY SUPPLIES FOR AN EXPANDING DEMAND--J. Cicely Thompson, Senior Engineer, The Nuclear Power Group, Knutsford, Cheshire, England

ENVIRONMENT POLLUTION AND CONTROL--V.E. Anneli Hattari, Chief of Laboratory, Printal Oy, Helsinki, Finland

COMMUNICATIONS--Olwen A. Wooster, Ground Communications Superintendent, Trans Australia Airlines, Victoria, Australia

Summarist: Jacqueline Juillard, Ingenieur Chemiste, Battelle Institute, and Free-lance Journalist, Geneva, Switzerland

12:00 Noon - NEW YORK LUNCHEON

Chairman: Anna Longobardo

WELCOME BY THE NEW YORK SECTION OF THE SOCIETY OF WOMEN ENGINEERS: Alva Matthews, Section Chairman

WELCOME FROM THE STATE OF NEW YORK WOMEN'S PROGRAM: The Honorable Guin Hall, Deputy Commissioner, New York State Department of Commerce, Woman's Program

ADDRESS: THE UNIVERSITY AND THE ENGINEER--Clifford C. Furnas, President of the State University at Buffalo, New York

TRANSPORTATION IN THE WORLD OF TODAY

by Madame Monique Vuillemin
President, Association des Anciennes Élèves
de l'École Polytechnique Feminine

and
Mademoiselle Monique Barbe
Metallurgy Division
Commissariat à l'Energie Atomique
Paris, France

INTRODUCTION

We must turn back to the first ages of intelligent man-kind if we wish to try to find a logical series -- a normal evolution -- in the appearance and growth of transportation. The word "transport" itself is inseparably connected to the word "movement," whether of human beings or of merchandise. So by finding the origin of this movement or of travel, we find the origin of transport.

Thus, leaving aside prehistoric times, we note that mass movements (tribes or whole peoples) were occasioned above all by necessity; the necessity of grouping themselves in fertile, mild regions, of defending themselves against a natural or human enemy, and of working together on productive property belonging to a single man. Hence the appearance of serfs, or in other words, the first requirement for labor.

The fact must next be pointed out that the means were created by the needs - the migration of peoples is a fact in itself which results primarily from vital considerations: Water, for example, an element which is indispensible for life, exerts just as much attraction on present-day primitive populations as at the very beginning of humanity. Thus, in desert areas there is an instinctive concentration of people in the vicinity of wells or water sources.

Tribe migrations were also determined by other reasons. One was the need for escape, which existed as early as the first tribes who separated from the main groups and picked up men and customs as they went along. The need to survive by one's own means led to regrouping about new centres of interest, energy sources: wood, coal, and later iron. Finally, we must mention the mass exodus of those who were fleeing wars.

Means of transport slowly became more common, and as time went on travel for pleasure began: on local feasts in honour of the Spring and of the harvests; on trips to artistic and intellectual events, to festivals and conventions, and to sports events; and even at the time of religious celebrations on such as pilgrimages. These are, of course, group displacements, but to these will also be added individual travel for the sake of business and especially touring, the two being interdependent without it being clear which is more important. Means of transport must then be safe and benefit from a certain number of perfections.

The wheel, <u>the</u> great human invention in the realm of transport, has become indispensible and is used in all modern transport including aviation. Through it, all forms of escape become possible: the chariot, the cart, and the coach, and then bicycles, automobiles and trains. Thus there immediately arises before our eyes every craft related to means of transport and to the competition to perfect them with respect to sturdiness, propulsion and comfort.

LAND TRANSPORT

On land, it was the horse that reigned in transport for a very long time. For man this was a practical way of making the most diverse trips. Moreover, the fact of being able to take a known itinerary in order to reach a given point lead to the creation of a route, which subsequently was improved by whatever means existed. Then again, the concentration of groups of human beings near energy sources required the exchange of fuels and foods, thus leading to the utilization of natural waterways at first and then artificial waterways, i.e., canals. Later on, the invention of the wheel, which through its various uses enabled people to circulate, brought us chariots, wagons and then coaches.

We have now reached the age when travelling was an adventure which could be dangerous; it was an expedition on which one wished for luck, and begged for divine protection! Though the motive force of steam was recognized about 1615, we must wait until the Nineteenth Century before it was used on the first locomotives in 1811. The Manchester to Liverpool line was in nearly regular operation in 1830. In France, the first attempts began in 1837, and from that point on the great development of railroad networks across Europe took place.

The attempt was made, however, to become free from the dependence on rails, and the few existing roads were very tempting for the steam machine that did not run on rails. In 1873, we finally saw the appearance of the first steam car, and in 1891 rapid progress brought the first automobiles with an explosion engine, though they still operated somewhat timidly. Within a short period of time, their development led to increased transportation of the raw materials used in building them and in propelling them, such as oil, iron and rubber.

WATER TRANSPORT

On the sea, ships were freed from coasting and great sea explorations were made possible by the use, as of about the Twelfth Century, of the compass and the adoption of the rudder. A splendid proof of this is the discovery of America in the Fifteenth Century. By using the steam engine for navigation and doing away with the sail, or at least relegating it to a secondary position, ships managed to do without the only motive force known up to that time, the wind.

This engine gave navigation its full scope, but we are now in the Nineteenth Century. It is now that the great migrations took place to the little populated lands of North and South America, Australia and South Africa. This enormous mass upheaval brought about the flourishing of sea transports: the two continents must be joined, and it was no longer possible to spend months doing it. Passengers were travellers who had paid for a service.

In 1864, one hundred years ago, the "Washington" connected LeHavre to New York in twelve and one-half days with sails and paddle-wheels: it scudded along at 12 knots. And over a period of 100 years, from 1820 to 1920, some 34 million Europeans emigrated to the USA. To transport these masses the very interior of Europe must be drained; the French Line established recruiting agencies there and special trains raced toward LeHavre.

A large-scale movement in the opposite direction took place between 1900 and 1914. Emigrants expulsed by poverty returned to Europe in ships on which entire decks were reserved for them. They found Europe at war, or nearly at war. And so movement to and fro became steady between the two continents; it would soon be replaced by touring.

It is now 1936: "France," "Paris," "Il de France," and then the "Normandie" crossed the Atlantic in 5 days at 30 knots. The two opposite streams of traffic were then balanced, thus making the ocean lines profitable; in 1938 they transported 700,000 voyagers. It was not until the Second World War that sea transport fell back into second place behind air transport.

AIR TRANSPORT

In the air, transport was late in getting under way, and we may indeed say that poor Icarus, though he may have been a forerunner, was nonetheless never a promoter. It was again steam which makes a shy appearance, and Ader made his first successful flight in an aeroplane in 1897. But the age of the explosion engine has already arrived, and although no categorical statement is given, we feel that the air will soon be conquered by a product from beneath the earth, oil. War, experienced altogether too often, alas! is directly responsible for progress. Everyone seeks to find protection or flee from destruction, working tirelessly to make improvements. The great growing European catastrophe of 1914-1918 became ripe and international at the same time.

Aviation was born, used, and was effective; the plane, the engine of war, became the automobile of the air. In the years 1919 and 1920, we note the establishment of the first air transport lines: the needs for communication grew very quickly and led to the intense, simultaneous development of research and actual results. Speed, altitude and, in short, everything which at this time is still making a record give a clue to the simple day-to-day reality of the near future.

In 1939-1945, there was another catastrophe. Through the private and national efforts of the United States, air transport was made more rapid, and thereby more flexible and effective for defense. This gigantic effort, which produced 47,000 airplanes in 1945, collapsed suddenly at the end of the conflict. In 1946 only 1330 planes were built. A civilian outlet must be found for this industry, and it was found in the appearance and increase of regular air lines along with improvements made in speed, silence and comfort. Propulsion by propellor was next pushed aside by jet propulsion, without, however, being entirely replaced by it.

But aviation, though its development seemed to have reached the asymptotic stage, was only a first stage in the race to the moon. The rocket, also born of war, and used first as an engine of destruction, in turn became an instrument of research and of possible links with other planets. It provided access to interstellar space, inhabited only by infrequent space pilots, and the earthly route of the earliest times of the world today stretches out into the unknown of space.

Here then, we have a brief summary of man's means of transportation and their development up to the present. However, we must not neglect the existence of the transporting of goods, either as a special aspect of passenger transport, such as lorries and trains; or in static forms such as pipelines, oil and gas lines replacing transport by river and sea, as well as rail transportation whose cost is higher. These different types require the creation of specialized industries having special competency for research, manufacture, installation and supervision. Thus products and subproducts of some of these are not simply delivered, but brought right into the home without recourse to any vehicle, without circulating in traffic and all the disadvantages it represents.

BYPRODUCTS OF TRANSPORTATION

At the outset, the chief problem of transportation was that of creating them: The need for collective transport was added to that of individual transport: the wagon was attached to the horse. Then, when large-scale migrations took place, the problem was no longer the creation of transports, for the ships existed and circumnavigated. The difficulties are now only those created by their number, their time tables, and their capacity and, most particularly, by the way the traveller lives during his voyage. Foods and medicines must be stored, patients must be cared for, life on board must be organized; in short autonomy with all the comforts and conveniences.

Today these problems no longer exist. We go to sea for personal pleasure, to get away from things. We seek rest, hope for a change of scenery and sometimes adventure. That is what the tourist cruise is. We nearly even hope for uncertainty in the timetables for the first crossings. Commercial exchanges, on the contrary, cannot tolerate this tranquillity, this calm. Things must be done quickly: the airplane is there, waiting to take you to the other side of the earth to consummate a deal personally within twenty-four hours.

It must be acknowledged that a tete-a-tete conversation is more effective than a letter or a telephone call for giving the necessary explanation or the specific change in plans. The same observation is still more valid when it is a question of colloquiums, conventions, or various meetings or assemblies. The means of transport is an integral part of daily life, and today no one is amazed by it. The resulting promiscuity, interpenetration of characters and ideas, the collision, even if only momentary, of all these personalities, is often beneficial.

Sometimes encounters made travelling are forgotten and leave no trace, and sometimes the contact that has been made continues, thus creating new relations, particularly in the business world. During tourist travel, great exchanges of ideas may take place between people of varying countries. Likewise, other exchanges take place between people - exchanges of ways of living, of languages, and so on. Countries avidly study one another. Sports and politics have followed business in international rendezvous at which people are not longer foreigners, but simply neighbors.

The result is greater understanding among countries and races, and this should lead to the abolition of the notion of nationality; however, we are still far from that. But efforts have been made leading to actual steps to make several nations a single market commercially. From the moral standpoint, frontiers have disappeared, and attractions and affinities are no longer hindered by the obstacle of distance interfering between men and consequently between different peoples. Transports have broken down a wall, the barrier of ignorance of others or of the misery of some. Solidarity can and has been manifested quickly when the need arose. In politics likewise, there is no longer the excuse of isolation to justify disregard of the voices of other countries. The certain possibility of explaining oneself in person gives greater chances for better understanding.

It we do away with the word "transport," and the value that it represents, the world would be inert, emptied of the blood circulating in its arteries! Would it be possible to be a human without legs? Would it be possible to remain without transport? Whatever was once an obstacle has been brought under control -- tamed. We now have fairly good knowledge of the earth and the resources it can offer us, but what do we know of the sea and especially space? In other words, what do we know of other worlds?

SPACE TRANSPORT

Five centuries after Christopher Columbus, the epoch of great discoveries is beginning again, and man, eager to learn, is striking into the unknown. What role will our techniques play in this search? The questions are still unanswered. What do we need? What form will our action take? This is all premature, indeed, but if the future resembles the present, everything will need everything.

The more man's task is out of proportion with him, the greater will be his eagerness to accomplish it. Daily applications and refinements are considered details of secondary interest. What counts is what is unknown, and that is where we find the human task, the task given by God from the earliest awakening of mankind: "Invade the earth and enslave it." Nothing stops man in his pursuit: a goal reached becomes a new starting point.

How could problems be separated from one another in a life in which all activities are intermingled, in which particular techniques become basic general techniques an hour later? How can transportation techniques be isolated, when all sciences, all modern and future industries are used in them? Transports have become one of the cogs of a human society which is no longer national or international. They are ranged among the "absolute necessities," along with bodily or intellectual nourishment.

Innumerable cogs, the names of which were unknown yesterday, are created every day, and are mutually produced by a common need for the victory of man over himself. The constant movement of peoples, which is increasing every day, gives to some the possibility of intellectual enrichment, to others that of giving their knowledge and their products; but in our opinion, nothing moves fast enough. Engineers are wanted throughout the world, but in parts of the world even the absolute minimum necessary to maintain human life is lacking; by what means will just this minimum be brought to those who need it, if not by transportation?

Every means will have its justification, but those who survive will have no pity for their ancestors. In France, where are the little railroads of local interest circulating along the edge of the road? And in this madness for speed, how can this agitation be controlled and sanctioned, how can each one be given his place, his movement, his justification? What will become of our excellent specimens of electronic signal controls, with their heaps of wires? What wave will be sent out to dominate that meteor that is orbiting the moon?

If it is true that one of the problems seems solved, nothing proves the validity of the system once our skies are as cluttered up as our present-day terrestrial routes.

Perhaps we feel that this is going a little too far? But as little as 50 years ago, who could have predicted the extent gained by speed, the complexity of transports, the efficiency of all the current forms of transport? By the end of the Twentieth Century, it will be impossible for a group of human beings to live in isolation, outside the passage of time, remaining on the sidelines of a progress that pushes them in spite of themselves.

A society which is to survive must circulate, must live as a whole, and must therefore make sure of its communications, hence its transports; these transports are today criticized because of their slowness and their high cost. But how can they be speeded up by putting new techniques to use? Perhaps one day the wheel, that element which right down to today has remained indispensible, will disappear as a means of locomotion. We are, in fact, already witnessing the appearance of vehicles on air-cushions. They run on water, but we may well see them come into use on land tracks before long.

In any case, attempts have already been made at operating a train car on a special rail and propelling it with an airplane propellor. The rocket has proved itself as a vehicle since its appearance in 1944. Filled with explosives, it arrived at its destination with greater or lesser success, but always efficiently; once perfected, it was sent higher to cover greater distances. The rocket is in a medium position between aviation and the missile; it can be radio controlled and can carry very heavy loads.

Extensive and active research is still being done on the fuel problem, but also in the case of human transport, certain questions concerning acceleration and deceleration must be given a practical solution. There is no reason for not believing that the trip from Paris to New York will shortly take an hour or even half an hour. The questions blocking realization are no longer in the field of transport alone, but rather problems of human resistance. The problem is to reproduce, in the rocket, a normal atmostphere for human beings. Is this the special field of transport engineers? We do not think so. But we feel that, in its realization and its use, the transport problem affects the whole realm of engineering.

In this field, women will play the same part as in other areas, a role just as complete, just as active, and just as efficient. The age of men's superiority has been long outdated, and even large-scale road operations are directed by women. In spite of many areas that remain empty and unknown, the earth seems too small to our research scientists. It is with good reason that space attracts them, and they need space vehicles suited to their task, which is still one of observation.

However, their road may soon become a main artery to another world in which people will settle and live, which it will therefore be necessary to supply with food and with men, until some production returns to our earth by the same means. The first thing to do will be to design, and then to produce, the necessary vehicles and their fittings. What will they be like? What obstacles will have to be overcome in this unknown space, in order to perpetuate life in it? All these are questions in which we feel the presence of an unknown world full of possibilities for all, and we must gain victory at any cost.

To sum up, how is it possible, in the midst of such a seething of minds and masses, to live in isolation, to work in an isolated laboratory, far from the world and contact with its people? How can we go to the source, to seek and to see, and to exchange ideas and products? Transport. How can we get large masses of raw materials, bring in the precious metal that is still too rare? Transport. How can the results of which we are proud be presented to mankind? Transport. How can one attract the working masses in order to produce, at first, and deliver afterwards? Transport. How indeed can we slow down for a moment and rest in the bosom of tender but powerful Nature, in order to meditate? Transport. How can we, in order to face the future, know ourselves better, prepare for and carry out our lives' work -- how can we organize a world congress? Transport.

This is the way of the world; we can no longer remain indifferent to anything, and if we do not dominate, we must be resigned to follow! But our choice is made by the role we have decided to play in world society. We live at too rapid a pace to be able to stop and dream. The alternative of resignation is impossible. We would be condemned by it to disappear with no return. Our destiny requires us to dominate matter; we must get ready for new tasks, and at the same time our current sciences will need to be perfected in a vast number of ways. Will we know the secrets of known sources of energy before others crop up?

Research and production on the one hand, and use on the other, are tightly interdependent, mutually creating one another. Working together as a whole, they participate in the transporting of masses or individuals through the utilization of modes of energy thus obtained. In every energy source, we must look at what way it affects transportation. The world is such that every scientific effort at any point on the globe has an immediate however remote repercussion over the rest of the earth. Any need for labor or any discovery of a natural wealth creates an immediate requirement for transportation, whether the discovery is of tourist, scientific, or industrial nature.

Transports do not always concern human beings, but often consumer products or production goods. The atomic age, which is so rich in potential application but not yet completely under control, is full of opportunities. What new means will be created by it? We do not yet know, but we must be alert in order to gain the upper hand over problems and exploit their symptoms. What do we mean by being alert? It may mean having sufficient general and specialized knowledge gained first of all by studies, and subsequently in daily experiences, so that nothing that can be turned to use may escape. A specialist's work is not fruitful unless nothing escapes his investigations, and whatever is not included in his field must be taken up by another specialist so that nothing gets free from our examination and perhaps our future exploitation.

Who can define what needs, what sciences will govern our future life, or what orientation we must give to it? The answer is as valid in the field of transports as is known in the others: every branch of science can be utilized, and the future that awaits us will need each and every one of our specializations. The regrouping of our sciences will see its crystallization into a new transport system, itself created in order to make new explorations easier. Nothing will ever stop in the search for and conquest or subjugation of energy.

Only a new catastrophe, perhaps, set off by a force out of human control, could wipe the world out of existence. This time, the sorcerer's apprentice would have nowhere to turn; everything would be over unless, on the other hand, everything began again if any seed of life were left in the world! All would start up again, no doubt, with new beginnings, and with all the intellectual wealth and the joys that science makes available to the world for its greatest possible benefit.

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ENERGY SUPPLIES FOR AN EXPANDING DEMAND

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INTRODUCTION

It is exactly 40 years since the supply of, and demand for, energy in relation to the resources available first began to be systematically studied on a world-wide scale. The organization responsible for stimulating these studies has been the World Power Conference which held its first meeting in London in June 1924. By means of papers presented at the four-yearly Plenary Conferences and at the intermediate Sectional Conferences, and by the publication of collected statistics, the Conference has brought about a great increase in knowledge of energy resources, energy needs and energy usage.

Since 1952 the United Nations Organization has also been active in this field and since 1959 the World Power Conference has ceased to publish statistics relating to the production and use of energy as these figures are well represented in the 'J' Series of Statistical Papers issued by the Statistical Office of the U.N. In preparing this paper, publications from both sources have been freely drawn on and, together with other published information, have provided the statistics and particular data on which it is based.

An ample supply of reasonably priced energy is at the base of all material wealth, and economists have shown that there is a broad relationship between a country's energy consumption and its Gross National Product. In a world aiming at an expanding economy, therefore, there must at the same time be an expanding energy consumption. However, even if the target were no more than to maintain the status quo in per capita energy consumption, the gross consumption would rise by reason of the rise in world population.

It will be seen from Tables 1A and B that the anticipated rise in world population is 32% by 1975 and 119% by 2000 compared with 1960. The two factors of expanding economies and population rise combined will indeed lead to dramatic increases in energy consumption in the future.

In Table 1A and in all other similar statistical tables except Table 1B, the areas of the world have been grouped in accordance with the method adopted in the U.N. Statistical Papers Series J6, except that "Countries N.E.S." has been split into "Eastern Europe", "U.S.S.R.", and "Asia N.E.S."

ENERGY PRODUCTION AND CONSUMPTION TODAY

It is customary to divide the main users of energy into four groups: domestic, industrial, transport and agriculture. Taking each in turn: domestic use includes energy for space heating and air conditioning, lighting and cooking, and power for domestic appliances; industrial use includes energy for steel-making and the other metallurgical industries, process heating of every kind, power for machinery, and factory space heating and lighting. Energy for transport is almost all used as power for road and rail vehicles, ships, and aeroplanes, and for pipeline pumping systems. Energy used in agriculture may be for irrigation and drainage, for tractors, for grain drying and for a very wide variety of other specialized purposes.

The division between groups is not absolutely clear cut, but borderline cases are allocated by convention to one group or another. By far the largest consumer is industry with the domestic consumer second. Table 2 shows for 1952 the way in which the main primary sources of energy were finally used by the four groups of consumers.

The main primary sources of energy are hydro electricity and the fossil fuels, i.e., coal, oil and natural gases, although minor sources such as draught animals, wood and dung are important in underdeveloped areas. Table 3A shows the total world energy consumption in 1961 and its source, excluding all minor sources. World figures for 1951 are also included. It will be noted that there are very wide differences in per capita energy use, the average varying from 7,824 kg.p.a. in North America, to only 262 kg.p.a. in the Far East, a ratio of approximately 30 to 1.

A fraction of this disparity is being met by the minor sources of energy. An investigation made by the Indian National Council of Applied Economic Research and reported by them in "Domestic Fuels in India", 1959, gives the figures shown in Table 4 for the source of energy for domestic purposes. In India all except a small percentage of domestic fuel is wood or dung which together are equivalent to just over 200 kg. of coal equivalent per capita. It is therefore probable that the per capita figures for energy consumption given in Table 3A for underdeveloped areas should be increased by some such figure to account for other fuels. Adding 200 kg. per capita to the Far East average consumption brings the ratio, as compared with North America, to 17 to 1, but even so the disparity between major energy consuming areas and the rest is very striking.

Tables 3A and B also show the outstanding position held by solid fuels, which today account for 50% of all energy supplies, though a comparison with the 1951 figures shows that the consumption of liquid fuels is rising relatively faster and in a few years may equal or overtake that of solid fuels. This may in part be due to the greater convenience and versatility of liquid fuels, since for most purposes there is a choice between the different forms of energy. Local conditions of price, convenience, and availability then determine the selection, although in certain fields a particular form of energy is a necessity or has overwhelming advantages, such as coal for steel making, oil for road and air transport, and electricity for lighting and electronic equipment.

To provide energy in the form in which it is needed a large proportion of primary energy, particularly the solid and liquid fuels, is transformed in some way before final use. For instance, as shown in Table 5, in 1958 in the O.E.E.C. Countries 479.4 x 10^6 tons hard coal were consumed, of which 186.4 x 10^6 tons were consumed directly and 293 tons were first transformed into electricity, coke, gas, or briquettes.

ENERGY RESOURCES

In a paper on "Evaluation of Foreseeable Energy Requirements" given at the U.N. Conference on the "Application of Science and Technology for the Benefit of the Less Developed Areas" in 1962, it was pointed out that in any area the structure of energy supply, in particular the relative importance of electricity, is broadly correlated with the basic pattern of natural resources available. It is therefore appropriate at this stage to consider the amount and distribution of the energy resources available to mankind, for the present taking account only of the major, or "conventional", fuels already mentioned in the last section.

Fairly comprehensive estimates of reserves of these fuels have been made throughout the world, and statistics are published by the World Power Conference. The figures given in Tables 6 and 7 are taken from the World Power Conference 1962 statistics, but these tables can only be regarded as giving a very general picture of the distribution of these fuels. In the first place, although the World Power Conference do their utmost to obtain estimates on a common basis, this is not always possible. Secondly, depending on the local conditions, although a reserve may be accurately measured, it does not by any means follow that it is economic or even possible to extract and use the whole of it. Thirdly, there is a very large margin of error in the amount of "indicated or inferred" reserve which is added to the "measured" reserve to give the "total" reserve. Lastly, there are still large areas where adequate surveys have yet to be made.

From Tables 6 and 7, the total measured world energy reserves of the conventional fuels can be found to be equivalent to more than 10^{12} metric tons of coal, which, at the 1961 total energy consumption of 4,300 million metric tons coal equivalent, would mean exhaustion in about 250 years. The total reserves, of course, are considerably more, but on the other hand it has already been mentioned that consumption is likely to rise rapidly.

The reserves of conventional fuels are not evenly distributed and the actual availability of fuel in any particular country is a complex political, economic, and technical problem, so that in fact in many countries there is a definite energy shortage.

FUTURE ENERGY NEEDS

It has already been pointed out that there are likely to be massive increases in the use of energy in the future as the world population increases and as efforts are made to raise the standard of living, particularly in the present underdeveloped areas. Methods of estimating future energy needs have been refined in recent years and are succinctly described in the paper on "Evaluation of Foreseeable Energy Requirements" mentioned earlier, as follows:-

"Methods of arriving at future energy needs in an economy where production of goods and services is rising may be reduced to the following:-

(a) Direct extrapolation of rates of change in requirements based on analysis of past experience;

(b) Extrapolation from functional relationships between two or more variables, one of which is that to be forecast;

(c) Extrapolation of requirements per unit of product applied to planned or expected production;

(d) Evalation of a development trend from comparative study of its homologues in different countries".

Depending on the availability of statistics of past energy consumption and production and information relating to plans for future economic expansion, these methods can be used singly or together to provide detailed or overall estimates for future energy needs. A great many such surveys have been made, but only two examples of detailed forecasts are given in Tables 8 and 9 where the growth of demand in India and W. Europe is compared. The explosive growth of the Indian demand, characteristic of a developing country, is in sharp contrast to the slower, though still considerable, growth in W. Europe which has a long history of industrial development. Even so, with populations roughly comparable, the total Indian demand in 1975 is still only about one third of the European demand, so that there are clearly further increases to come in later years.

The Canadian Nuclear Association in 1961 gathered together energy forecasts from as many sources as possible and these are reproduced in Table 10. In order to arrive at a world total for 1980, crude estimates have been included for the three areas not given in the Canadian report. The world total for 1980 then becomes approximately 8,800 tons or 8,900 metric tons of coal equivalent, which is already more than double the actual 1961 consumption.

All the estimates given above are for energy consumption referred to the primary sources, but as has already been noted earlier, a substantial proportion of primary energy is transformed in some way before use, in particular, into electricity. In Table 5 it can be seen that in 1958 in the O.E.E.C. area, 22% of all hard coal consumed was used as electricity. The corresponding percentage for 1948 was only 17%, although the total hard coal consumption was much the same. In fact, over the period 1948 to 1958, the electricity consumption in the O.E.E.C. area doubled whilst total energy consumption only increased 40%. Similar factors of 4 to 1 in the rates of increase of electricity and total energy consumptions have been experienced in countries at such diverse stages of development as the U.S.A. and India. In assessing future world needs, therefore, the increasing importance of electricity must be remembered.

UNCONVENTIONAL ENERGY RESOURCES

Brief mention has already been made of some unconventional energy sources which are in use in various parts of the world and such sources are further discussed below. "Unconventional" for present purposes may be taken as meaning "contributing only a small fraction of the world's energy consumption today", and this will explain the otherwise strange justaposition of wood fuel and nuclear energy.

Vegetation and Organic Wastes

In underdeveloped countries with a large rural population there is a heavy reliance on wood fuel and dung for domestic energy supplies and for rural industries. From the figures given in Table 9, it can be seen that in India 94 m.t.c.e. (68%) of the country's energy demand was supplied from these sources in 1955 and they are still expected to be supplying 88 m.t.c.e. (22%) in 1975. Wood fuel lacks versatility and is usually burnt with low efficiency, and agriculturalists would prefer to see the dung used to increase soil fertility.

A modern approach to these traditional fuels may be provided by the "digestion" process used for purifying sewage, in which the action of anaerobic bacteria converts organic waste into a fertile sludge and methane gas. Sewage works using this process expect to supply all their own power demands from engines or boilers using the methane produced in the system and find a ready market for the sludge as fertilizer. It is feasible to design units in which methane production rather than sewage purification is the primary object, starting from one or more of a wide range of organic substances.

Alternatively, specific vegetable crops may be cultivated for eventual fermentation for the production of power alcohol.

Estimated fuel yields from various organic materials in these two processes are given in Table 11. Either of these methods offers a means of converting solar energy through the agency of vegetation into a convenient and versatile fuel capable of efficient use.

Solar Energy

The use of solar energy either directly or for steam raising has received a good deal of thought in the last two decades. The mean radiation intensity external to the earth's atmosphere is 1.98 cal./sq.cm/min. but it is reduced by a third or more at the earth's surface due to atmospheric conditions. There is a lack of reliable data covering different countries and the varying seasons, but the figures shown in Table 12 may be taken as a guide to the energy available directly from the sun.

Solar radiation collectors are of two types, either with or without mirrors for concentrating the radiation. In the first type the absorbing surface is fixed and the losses from the large surface area required to collect the low intensity radiation inevitably limit the upper temperature which can be reached. In the second type the mirrors and absorbing surface move to follow the apparent motion of the sun and with a very high degree of concentration very high temperatures can be reached.

Fixed surface type collectors can be used successfully for water heating and distillation, and over 100,000 units are said to be in operation in Israel and over 350,000 in Japan. Mirror type collectors have not so far been used on a similar scale, though there are examples ranging from a simple solar cooker, to a 2-5kW power unit designed by the National Physical Laboratory of Israel and the 70kW metallurgical furnace at the Laboratory for Solar Energy, Montlouis, in the South of France, in which a temperature of 3,000°C can be attained.

Nuclear Energy

Nuclear energy is still in its infancy, but in the 22 years since Enrico Fermi made the first reactor it has already made remarkable progress. Nuclear reactors are essentially heat sources, and since they are uneconomic in small sizes they are used for large-scale electricity generation. The commercial reactors in use today mostly fall into one of the two groups; (1) those using natural uranium as the fuel, gas cooled and graphite moderated; and (2) those using enriched uranium as fuel, water cooled and moderated. Power reactors of the former type with a total electrical output of 1,800 MW are operated in Britain, France, and Italy, whilst there are enriched uranium power reactors of the latter type totalling 900 MW electrical output operating in the U.S.A., Germany, and Russia.

Intensive research is being undertaken into other types of reactors, including breeder reactors, which not only produce power, but convert fertile material into further supplies of fissile material. This is very important since the proportion of fissile U235 occurring naturally in uranium is only 0.7%, the rest being non-fissile U238, which can however be converted into fissile Pu239 in a breeder reactor. Fertile thorium (Th 232) can be converted similarly into fissile U233 which does not occur in nature in appreciable amounts.

The known reserves of fissile ores are given in Table 13. When it is remembered that even without breeding, there is a factor of the order of 10^4 between a ton of uranium and a ton of coal in available energy content, it will be seen that these ores represent a very large energy reserve.

Just as energy is released during the fission of heavy atoms, it is also released during the fusion of light atoms, but no one has yet produced a power reactor based on the fusion process. When they do, the hydrogen of the earth's oceans will be available as a vast energy reserve.

Geothermal Steam and Windpower

Other unconventional sources of energy make only a small contribution to the world's resources and the scale is unlikely to change.

Geothermal steam is produced in some of the world's earthquake areas and has been successfully used for electricity generation in New Zealand and Italy.

Wind power is used widely on a small scale for drainage, irrigation and other agricultural purposes, but attempts to use it on a larger scale to generate electricity have not proved economic.

IMPROVING EFFICIENCY

A very large proportion of the fuel used today is effectively thrown away due to low efficiency in the energy-using appliances. Table 2 shows that on an average about 35% of the thermal energy in the original fuel source ends up as useful energy. The life of the world's fuel resources could be substantially extended if the efficiency of use was improved.

It has already been noted that a large and increasing percentage of energy is used as electricity. Electrical energy can generally be used with efficiencies between 80% and 100%, but today the best efficiency of generation is only about 40% and the average is appreciably less, due to the limit imposed by the Carnot cycle efficiency when energy is transformed first into heat and then into electricity.

There is, therefore, a great deal of research in progress into methods of improving efficiency by direct generation instead of by first raising steam.

Fuel Cells

Fuel cells are essentially another form of the familiar battery with fuel being supplied continuously to enable the cells to give a continuous output. Efficiencies up to 80% have already been achieved with an output of 6kW.

The hydrox cell is perhaps the most advanced and two alternative forms have been developed by the General Electric Co. of America and by F.T. Bacon at Cambridge. The former design uses hydrogen and air at ambient temperatures with polymeric ion-membrane electrodes. The latter uses high purity hydrogen and oxygen, and operates at approximately 600 p.s.i., 200°C. American firms are also working on carbox cells which will use carbonaceous fuels.

In both these types of cell the fuel is also the working medium, but it is quite possible that the final answer may be a closed-cycle regenerative fuel cell in which highly reactive chemicals from the working media in the cell and the reaction products are regenerated externally by the fuel. This possibility opens the door to a wider range of fuels including nuclear energy.

It appears equally possible to develop fuel cells for the large-scale public electricity supply and for small package units for transport and similar uses, and it seems probably that a commercial fuel cell of some kind will be working successfully within the next decade.

Magnetoplasmadynamic Generation

The conventional electrical generator today consists of a copper conductor and a magnetic field in relative motion. However, at very high temperatures (of the order of 2000 - 3000°C) gases ionize to a degree at which they become conductors of electricity and can be used as the conductor of a generator. This is the basis of magnetoplasmadynamic generation.

Theoretically, this method is very attractive for large-scale generation, either on its own or as a "topping" unit to a conventional plant, and some particularly ingenious schemes have been proposed for using nuclear energy in this way. However, the high temperatures required represent a formidable barrier, and although generators have been built, none has yet operated for more than an hour without failure.

Thermo-electric Generators

Very small thermo-electric generators have already long been used, of course, as thermocouples for temperature measurement. With the advent of p and n type semiconductors has come the possibility of designing a practical generator in any size that may be required. However, present day semiconductors lose their positive or negative characteristics at high temperatures and since hot junction temperatures of at least 500 - 600°C are necessary to obtain worthwhile efficiencies, much research into suitable materials has still to be done before this type of generator is available for large-scale generation.

Thermionic Generators

Provided that the temperature of the cathode is high enough and the space charge between the electrodes is small enough, a diode can become a reasonably efficient power converter.

In 1959, a plasma diode was demonstrated in a test nuclear reactor at Los Alamos and the electrical output was made to light a 30W bulb. Since then 90W output at 10% efficiency has been obtained in another plasma diode at the General Atomics Laboratories. Higher efficiencies are already known to be feasible, and ultimate efficiencies of about 40% are predicted.

Photo-electric Cells

Silicon photo-electric cells are capable of producing small voltage and current outputs from incident light. Even where direct sunlight is apt to be erratic, silicon cells may be combined with batteries to provide reliable small power supplies for unattended equipment, such as micro-wave repeater stations or light buoys.

Direct Generation Problems

For high efficiencies, such as would be required for large-scale operation, four of the methods of direct generation discussed here require operating temperatures appreciably higher than those encountered in a conventional large generating plant today. Table 14 gives an interesting comparison with various flame temperatures and refractory properties. New materials or improvements in the properties of existing materials are needed before direct generation can be achieved on a large scale.

However it is also interesting to note that these methods can be adapted to use nuclear energy.

SUMMATION

Before considering their implications in regard to manpower, it may be useful to gather together some of the salient points from the previous sections:

(1) The consumption of energy varies widely but is rising rapidly.

(2) Almost all of today's demand for energy is met from nonreplaceable sources.

(3) Exhaustion of the world's fossil fuels could occur within the foreseeable future.

(4) Nuclear energy vastly increases fuel reserves.

(5) Replaceable energy resources such as solar power and vegetation could be exploited more effectively.

(6) The efficiency of fuel use is lamentably low.

Perhaps the three most important problems in the energy domain today are to make energy available and cheap in the areas where consumption is low and to improve the efficiency of use where it is high.

TECHNICAL AND SCIENTIFIC MANPOWER

In order to produce, transform and distribute energy a complete cross-section of technical and scientific manpower is required, from geologists to electronics engineers, from mathematicians to fuel technologists. As more energy is used, more trained persons will be needed in all these varied pursuits, more mechanical and electrical engineers, more chemists and physicists, more metallurgists and architects. Whatever type of trained manpower used now will be required in still greater numbers to meet the greater energy demand of the future. The need will be so great that it is more than likely that a more efficient use of the trained personnel will be inevitable with each person taking greater responsibilities than his counterpart today.

However, the sources of energy of the future will not be entirely the same as today. Already a change from coal to oil is in progress, and another change can be foreseen from fossil fuel to nuclear energy. Moreover, a larger proportion of energy will be transformed to a more convenient or efficient product before use, such as vegetation to gas or alcohol and fossil fuels and nuclear energy to electricity. All such changes will demand great versatility in the technical and scientific manpower engaged in the energy field and an ability to change with the circumstances.

Taking into account these changes, the wider individual responsibility and the greater flexibility, it would seem that the initial training of these scientist and technologists should be weighted in favour of fundamental principles rather than a specialist field or current technology. An emphasis on fundamentals should tend to eliminate the differences which at present exist between, say, civil, electrical and mechanical engineers, and between physicists, chemists and mathematicians, and so on, so that the differences exist more in the job being done and less in the training beforehand.

CONCLUSION

The working life of engineers and scientists starting today will cover an immensely exciting and challenging period in the domain of energy production and use. There is a need and there will be scope for all the knowledge, skill and inventiveness which can be attracted into this field.

TABLE 1A

World Population in 1960

	Area 10^6 hectares	Population 10^6 persons	Average Density Persons per 100 hectares
World		2,861.82	
N. America	2,151.5	197.1	9
Caribbean America	414.48	65.11	16
Other America	1,534.18	114.86	8
Western Europe	385.02	325.90	84
Eastern Europe	101.77	97.23	95
Middle East	669.65	113.26	17
Far East	735.889	864.43	118
Oceania	853.8	15.17	2
Africa	2,159.64	183.56	9
USSR	2,240.9	216.2	10
Asia N.E.S.	956.1	669.0	70

Note: These figures are approximate since the census date varies slightly from 1961 to 1958 and in a few minor cases to 1953.

Source: "World Power Conference Survey of Energy Resources", 1962

TABLE 1B

Estimated Population by Continent, 1975 - 2000

Year	1975 10^6 persons	2000 10^6 persons
World	3,828	6,267
Africa	303	517
N. America	240	312
Latin America	303	592
Asia	2,210	3,870
Europe (including USSR)	751	947
Oceania	21	29

Source: "The Future Growth of World Population", United Nations, 1958

TABLE 2

World Utilization of Energy in 1952

	1000 million Mwh electricity equivalent		%	
Production		29.0		100
Losses and diversions		18.8		65
In processing plants	3.6		12	
(petroleum refineries)	(0.8)			
(coke and gas plants)	(0.5)			
(electric power plants)	(2.3)			
In transmission	0.1		1	
In use	14.0		48	
Other	1.1		4	
Effective use (heat and power)		10.2		35

	Heat	Power	Total	%
In agriculture	-	0.3	0.3	1
In transportation	-	0.8	0.8	3
In industry	5.2	0.6	5.8	20
In households, etc.	2.9	0.4	3.3	11

Source: "Peaceful Uses of Atomic Energy", 1956

TABLE 3A

World Energy Consumption

million metric tons of coal equivalent and kilograms per capita

	Solid fuels	Liquid fuels	Natural & imported gas	Hydro & imported electricity	Total Aggregate	Total Per capita
1961						
World	2,174	1,393	672	90	4,329	1,400
North America	370	652	527	32	1,581	7,824
Caribbean America	4	60	18	1	83	911
Other America	7	50	5	3	65	514
Western Europe	532	276	19	29	856	2,602
Eastern Europe	275	22	17	1	315	3,180
Middle East	5	31	2	0	39	272
Far East	133	87	6	10	237	262
Oceania	29	18	0	1	48	3,024
Africa	44	16	0	1	61	310
USSR	383	168	78	7	636	2,921
Aisa N.E.S.	392	13	0	2	407	528
1951						
World	1,640	705	318	47	2,710	1,075
World increase 1951 - 1961	534	688	354	43	1,619	325

TABLE 3B

World Energy Consumption

per cent

	Solid fuels	Liquid fuels	Natural & imported gas	Hydro & imported electricity	Total Aggregate	Total Per capita
1951	60	26	12	2	100	100
1961	50	32	16	2	100	100
World increase 1951-1961	33	42	22	3	100	100

Source: United Nations Statistical Papers Series J No 6 "World Energy Supplies 1958-1961".

TABLE 4

Domestic Heat Consumption in India 1956

million tons (of 2240lbs) coal equivalent

	Urban	Rural	Total
Coal[a]	2.0	-	2.0
Electricity	0.2	-	0.2
Kerosene	0.3	-	0.3
Dung	4.0	35.0	39.0
Firewood[b]			
Solid	8.5	23.5	32.0
Waste	5.0	18.5	23.5
Total	20.0	77.0	97.0

[a] including coke

[b] including charcoal

Source: "Domestic Fuels in India", National Council of Applied Economic Research, 1959.

TABLE 5

Final and Total Consumption of Hard Coal in the O.E.E.C. Area

1958

million tons (of 2240 lbs)

Direct use by		
Iron and steel industry	8.4	
Other industry	53.7	
Railways	26.4	
Other transport	1.7	
Bunkers	1.0	
Domestic and miscellaneous	79.6	
Total direct use		170.8
Mines' own consumption		15.6
Transformed in		
Power plant	106.5	
Coke ovens and gas works	169.9	
Briquetting plant	16.6	
Total transformed		293.0
Total consumption		479.4

Source: "Towards a New Energy Pattern in Europe", O.E.E.C. 1960

TABLE 6

Coal and Water Power Reserves

	Coal million metric tons		Brown coal and lignite million metric tons		Water Power MW
	Measured	Total	Measured	Total	Total installable
World	Over 569,000	Over 8,067,000	Over 192,000	Over 1,960,000	Over 840,000
North America	114,000	1,700,000	21,650	430,100	Over 147,600
Caribbean America	30	Over 342	U	U	19,074
Other America	858	2,734	Over 356	Over 5,380	39,560
Western Europe	204,828	415,395	71,826	Over 24,308	Over 101,288
Eastern Europe	75,798	Over 141,693	4,339	Over 50,800	1,250
Middle East	489	1,298	438	882	Over 3,800
Far East	6,094	Over 79,340	Over 293	Over 4,199	Over 47,785
Oceania	1,841	13,003	40,019	98,063	Over 7,555
Africa	26,154	Over 75,905	U	U	Over 11,735
U.S.S.R.	143,688	4,630,050	56,820	1,349,630	465,000
Asia N.E.S.	U	1,011,000	U	700	U

U = Unknown

Source: "World Power Conference Survey of Energy Resources", 1962

TABLE 7

Oil and Natural Gas Reserves

	Petroleum million metric tons		Oil in Shale & Bituminous Sands million metric tons		Natural Gas million cubic metres	
	Measured	Total	Measured	Total	Measured	Total
World	Over 43,000	Over 107,000	Over 23,000	Over 135,000	Over 6,537,000	Over 54,000,000
North America	14,700	76,600	Over 23,070	Over 135,470	83,329	Over 28,300,000
Caribbean America	2,786	Over 2,786	U	U	1,203,089	Over 1,203,089
Other America	1,880	2,440	Over 60	Over 60	300,762	537,440
Western Europe	Over 99	Over 163	Over 894	Over 894	242,160	Over 242,160
Eastern Europe	Over 151	Over 174	U	U	U	U
Middle East	Over 22,320	Over 22,320	U	U	712,000	Over 712,000
Far East	Over 1,255	Over 1,255	U	U	Over 722,389	Over 1,220,807
Oceania	U	U	Over 5	Over 32	U	Over 3,000
Africa	Over 1,000	Over 1,000	U	U	1,275,800	Over 1,275,800
U.S.S.R.	Over 3,300	Over 3,300	U	U	2,000,000	23,700,000
Asia N.E.S.	Over 70	Over 70	U	U	U	U

U = Unknown

Source: "World Power Conference Survey of Energy Resources", 1962.

TABLE 8

Estimate of Demand of Energy by Sectors 1955 - 1975

	INDIA						W. EUROPE (O.E.E.C. Countries)					
	Indices (1955 = 100)			As percentages of totals of each year			Indices (1955 = 100)			As percentages of totals of each year		
	1955	1965	1975	1955	1965	1975	1955	1965	1975	1955	1965	1975
Industry:												
Iron & Steel)	100	353	942	14	30	43	100	150	206	13	15	17
Other)							100	130	167	28	29	30
Transport:												
Railways)	100	206	364	9	12	13	100	84	58	7	5	3
Other)							100	160	228	9	11	13
Domestic and)	100	120	153	77	58	44	100	115	133	39	36	33
Miscellaneous)							100	132	181	4	4	4
Ocean bunkers)												
Total	100	159	266	100	100	100	100	126	157	100	100	100

Sources: "Demand for Energy in India 1960 - 1975", National Council of Applied Economic Research, New Dehli, 1960

"Towards a New Energy Pattern in Europe", Organization for European Economic Co-operation, 1960.

TABLE 9

Estimate of Demand for Energy by Source 1955-1975
million tons (of 2240 lbs) of coal equivalent

	India			W. Europe (O.E.E.C. Countries)		
	1955	1965	1975	1955	1965	1975
Coal)	36	97	227	505	450-540	440-555
Lignite)				30	45	60
Oil	6	17	44	159	290-340	430-550
Natural gas	0	0	0	7	30	60-135
Hydro-power	3	16	40	56	95	140
Nuclear Energy	0	1	8	0	15-20	30-90
Other forms of energy	94	99	88	20	20	20
Total	139	230	407	777	945-1090	1180-1550

Notes: (1) For India "Other forms of energy" are almost entirely fuel wood and dung; for W. Europe they include fuel wood, peat and geothermal energy.

(2) The figures quoted for W. Europe are actually "Potential Supplies" and the total of the mean of the estimates is therefore in excess of the mean estimated demand by 0.5% and 3.0% for 1965 and 1975 respectively.

Source: "Demand for Energy in India 1960 - 1975", National Council of Applied Economic Research, New Delhi 1960

"Towards a New Energy Pattern in Europe", Organization for European Economic Co-operation, 1960

TABLE 10

Forecast of World Energy Consumption for 1980

million tons (of 2240 lbs) of coal equivalent

	Oil	Gas	Coal	Nuclear	Hydro	Total
North America	1,171	907	646	94	70	2,888
Caribbean America	165	25	5	1	6	202
Other America	130	15	10	4	15	174
Western Europe	740	75	615	110	82	1,622
Eastern Europe						600*
Middle East	95	35	10	3	1	144
Far East	305	10	224	39	30	608
Oceania	70	2	39	6	4	121
Africa	100	5	74	8	7	194
USSR						1,200*
Asia N.E.S.						1,000*

* Author's estimate

Source: "World Energy Consumption 1980", Canadian Nuclear Association, 1961

TABLE 11

Power Alcohol: Yield from Typical Vegetable Material

Material	Total Fermentable Carbohydrates per cent	Average crop yield ton/hectare	Yield of 95 per cent Alcohol 1/ton by weight	Yield of 95 per cent Alcohol 1/hectare by area
Cereals				
Wheat	65	1.23	376	472
Barley	60	1.61	341	551
Maize	67	1.73	391	674
Rice	76	1.06	386	416
Tubers				
Potato	18	1.61	95.50	1540
Cassava	30	2,22	168.00	3710
Roots				
Sugar beet	15	3.46	95.50	3320
Residues				
Molasses:				
Sugar cane	58	-	332	-
Sugar beet	50	-	300	-

Secondary Methane: Typical Yield from Organic Material of Vegetable and Animal Origin

	Average crop tonne/hectare	m^3/tonne	Average gas yield 6230 to 6760 kcal/m^3 m^3/hectare
Fresh crops			
Potato Haulms	25.1	279 to 446	6995 to 11200
Sugar beet top	35.1	335 to 502	11760 to 17620
Straw	-	209 to 307	-
Vegetable waste	-	279 to 418	-
Animal wastes			
Cow dung	-	209 to 279*	-
Pig manure	-	558 to 697*	-
Abattoir wastes	-	279 to 837*	-

* Yield will depend on proportion of organic solids.

Source: "Thermal Energy from Indigenous Vegetation" H.A.S. Gotherd, British Power Engineering, July, 1961.

TABLE 12

Comparative Solar Radiation Intensities

Country	Daily average over a year cal./sq. cm.
N. Europe	210-240
Mediterranean Countries	370-515
Sahara	545
Central Africa	380-540
South Africa, Desert	600
Central High Veld	490
Coastal Regions	400
India and Pakistan	450-540
Australia	370-500
Japan	280-360
U.S.A., Northern States	330
Southern States	500
Canada, North	200
South	305

Note: These figures are an approximate indication only, as no single figure can be used to represent the radiation for a whole country.

Source: "New Developments in the Use of Solar Energy", H. Heywood, Journal of the Royal Society of Arts, 1961.

TABLE 13

Reserves of Fissile Ores

metric tons

	Uranium Oxide U_3O_8		Thoriun Oxide ThO_2	
N. America	Over	535,000	Over	263,000
Caribbean America		-		-
Other America		U	Over	200,000
W. Europe	Over	1,102,662		U
E. Europe		U		U
Middle East		U		1,670,000
Far East		27,276	Over	555,904
Oceania	Over	15,700	Over	8,300
Africa	Over	227,570	Over	25,000
U.S.S.R.		U		U
Asia N.E.S.		U		U

Source: "World Power Conference Survey of Energy Resources" 1962.

TABLE 14

Operating temperatures for large-scale direct generators, compared with certain flame temperature and refractory properties

Generator	Temperature	Flame	Material
	8,500	Oxygen-cyanogen	
	7,800	Hydrogen-fluorine	Hafnium carbide melts
	7,000		Carbon evaporates
	6,000	Oxygen-acetylene	
Magnetoplasmadynamic	5,000	Oxygen-hydrogen	Alumina melts
Thermionic	(4,000 to	Blast furnace	
	3,000	Kitchen range	Iron melts
Thermoelectric	2,000		
Fuel cells	(1,800 to		
	(1,500		
Modern steam turbine	1,200		

Source: "Electricity without Dynamos" J.W. Gardner 1963

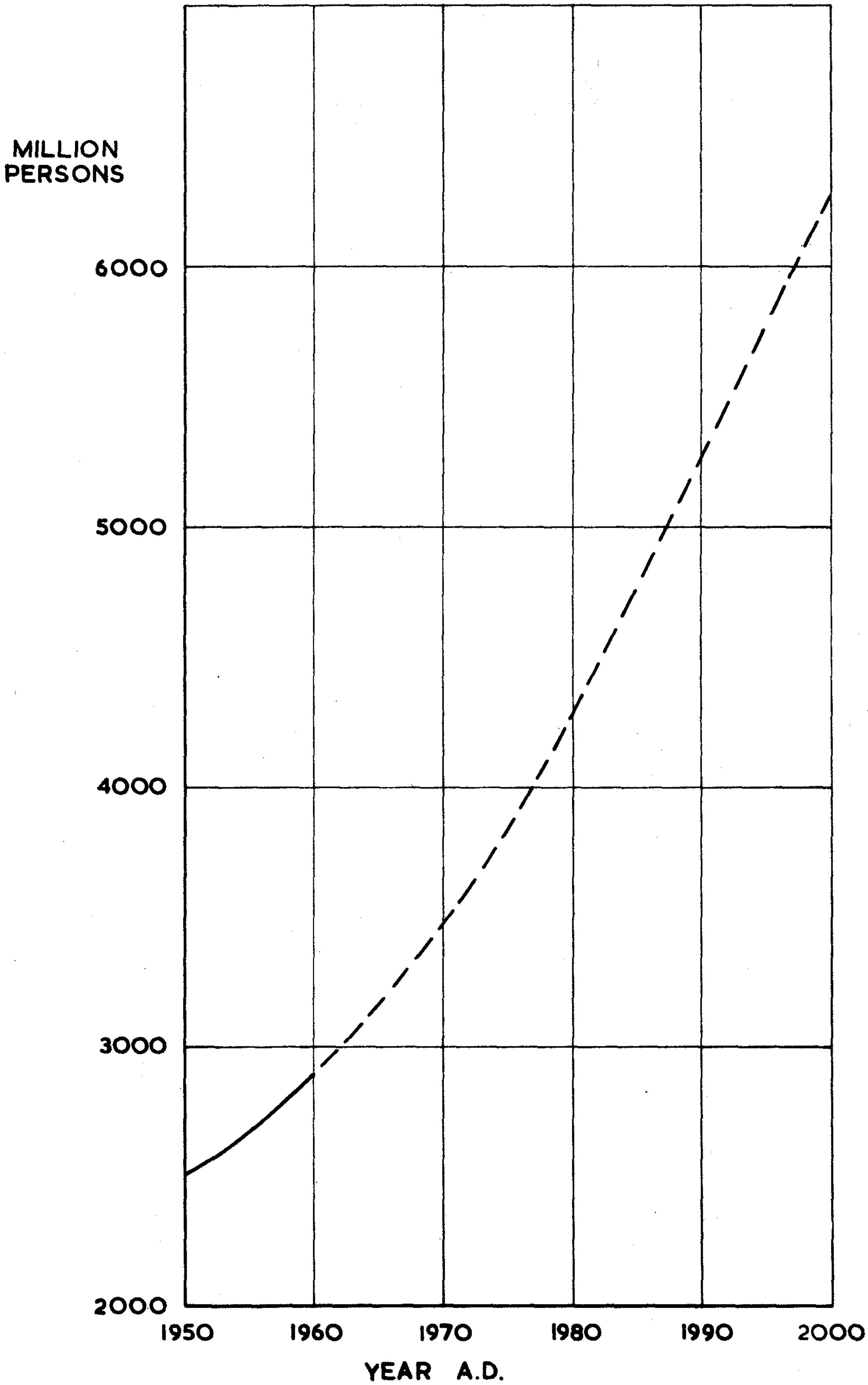

FIG. 1. ESTIMATED FUTURE WORLD POPULATION

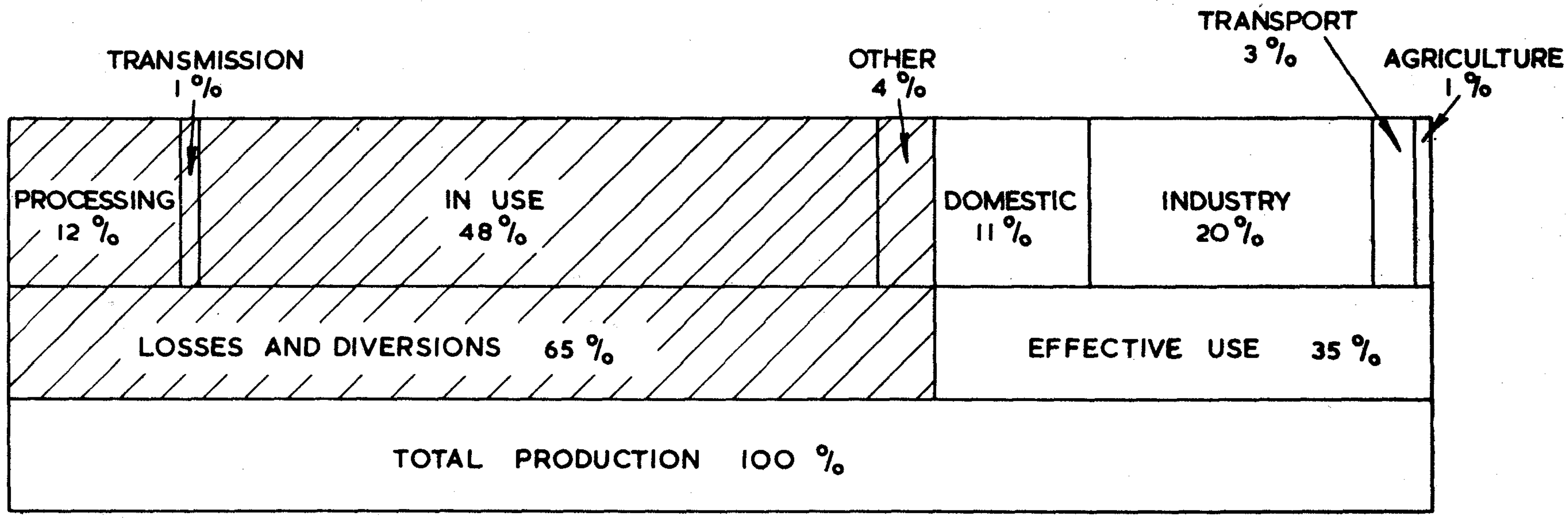

FIG. 2. WORLD UTILISATION OF ENERGY IN 1952

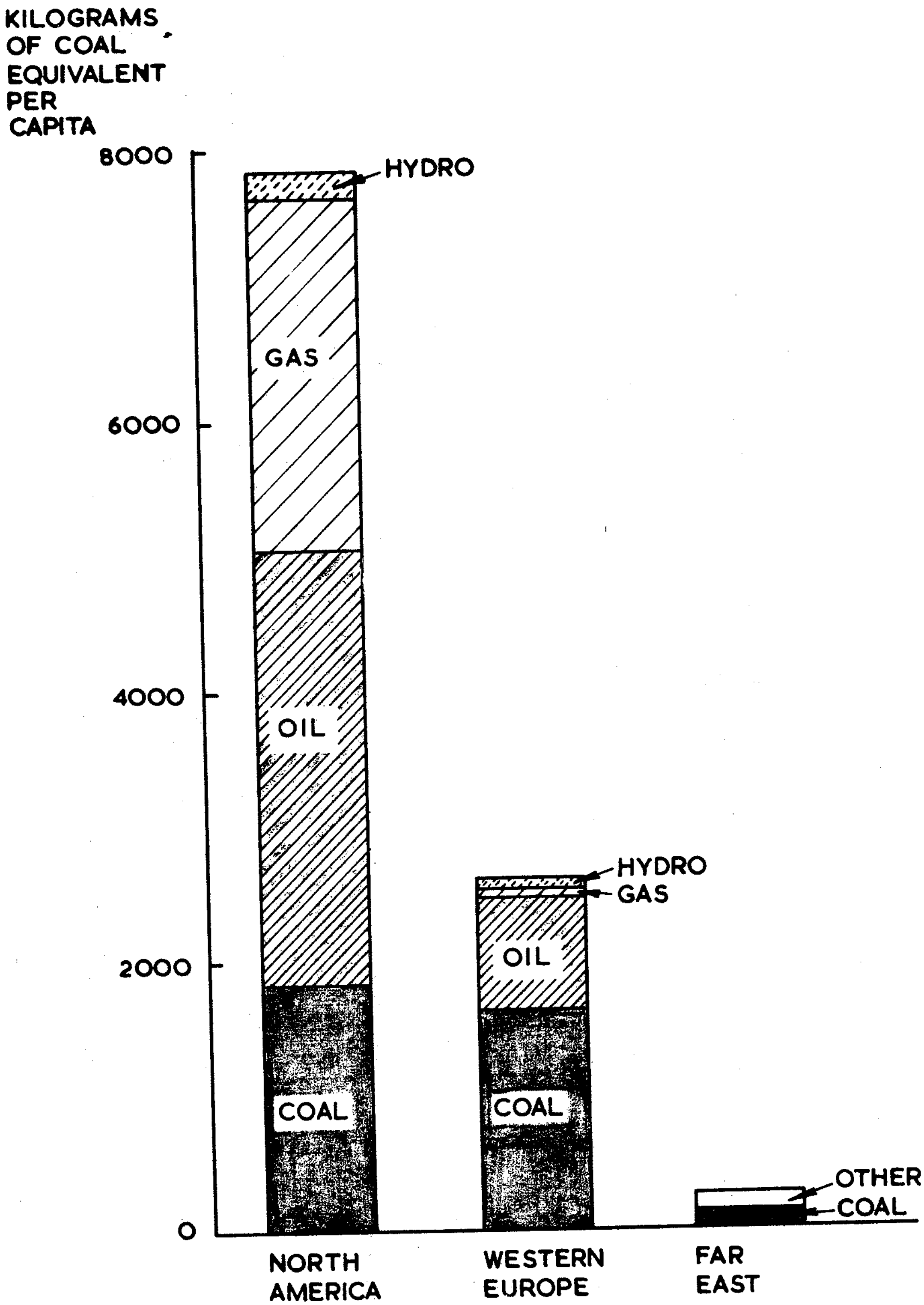

FIG. 3. ANNUAL ENERGY CONSUMPTION - 1961

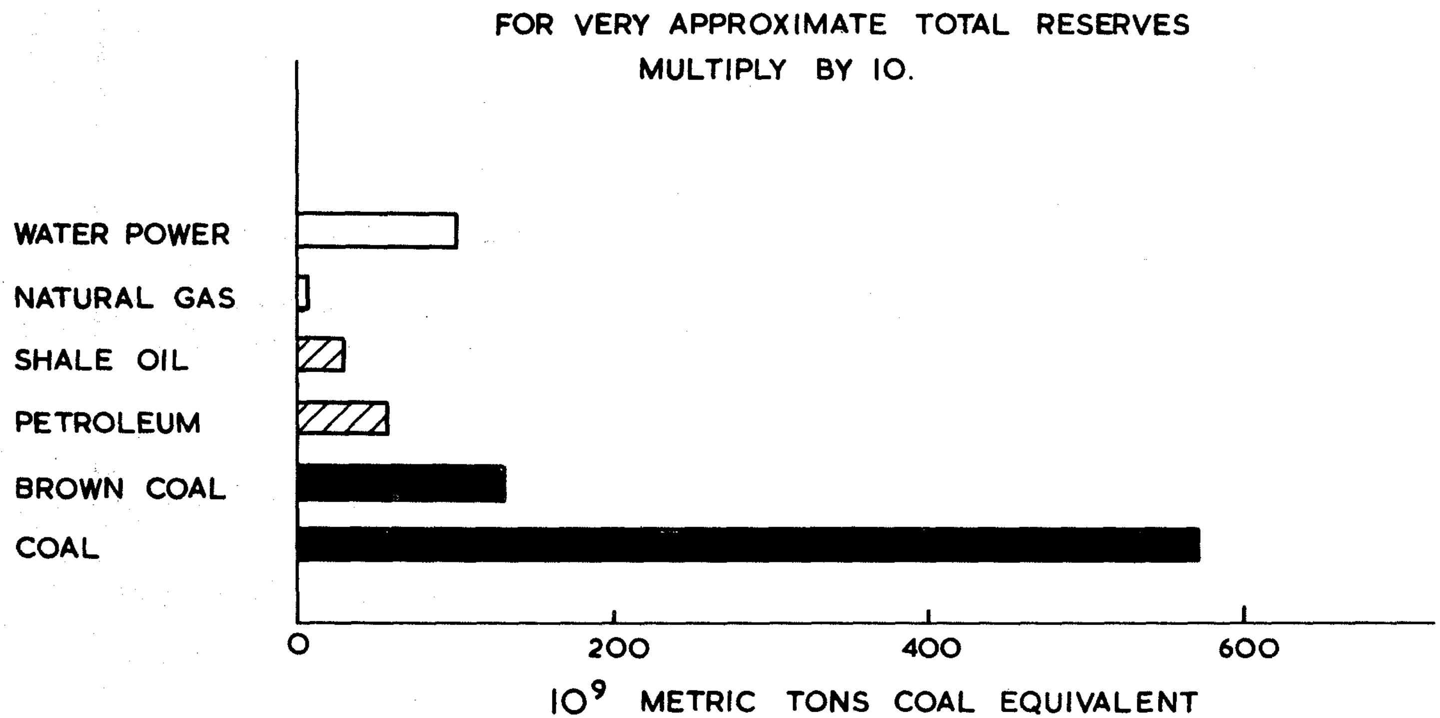

FIG. 4. MEASURED WORLD ENERGY RESERVES.

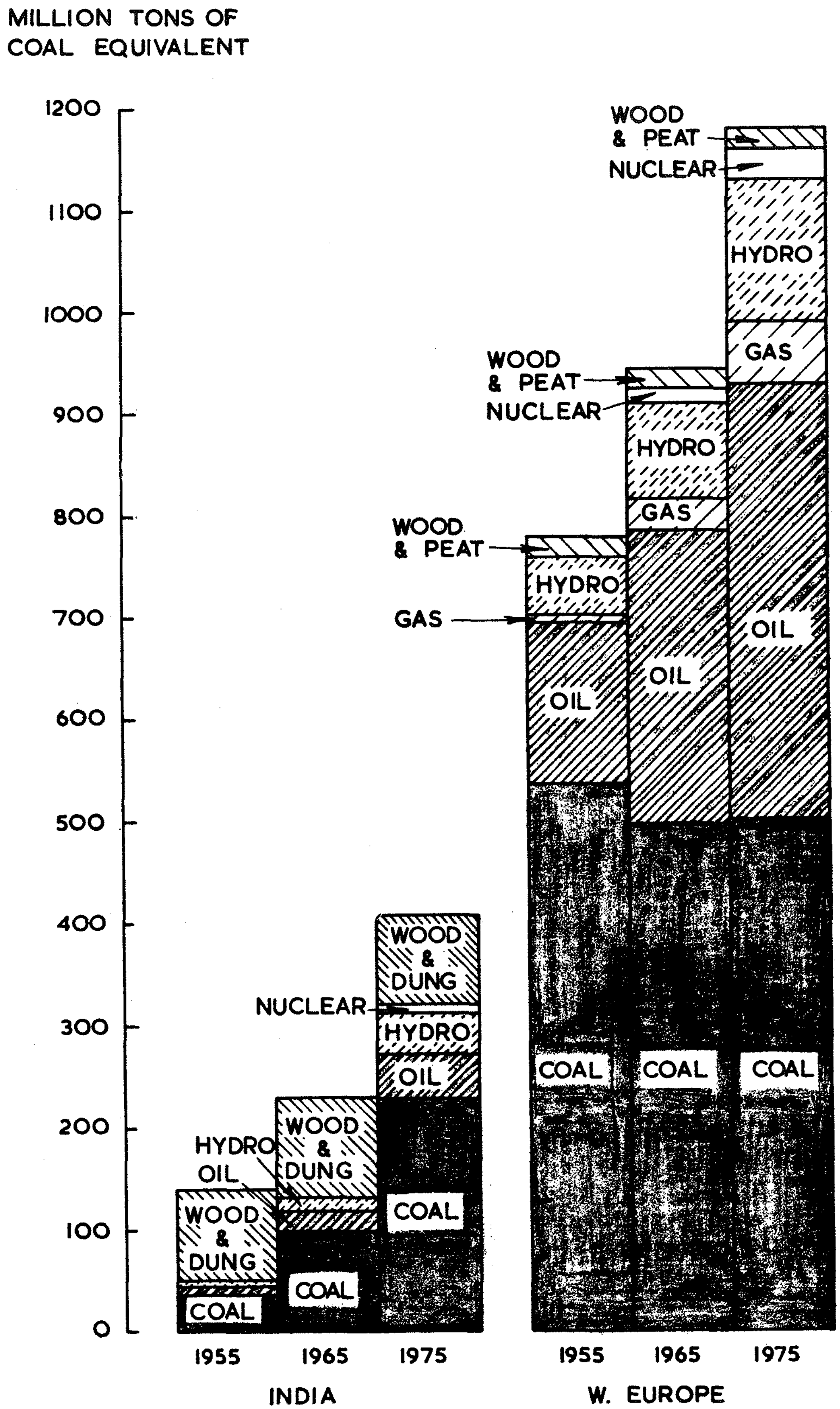

FIG. 5. ESTIMATE OF DEMAND FOR ENERGY IN INDIA & W. EUROPE.

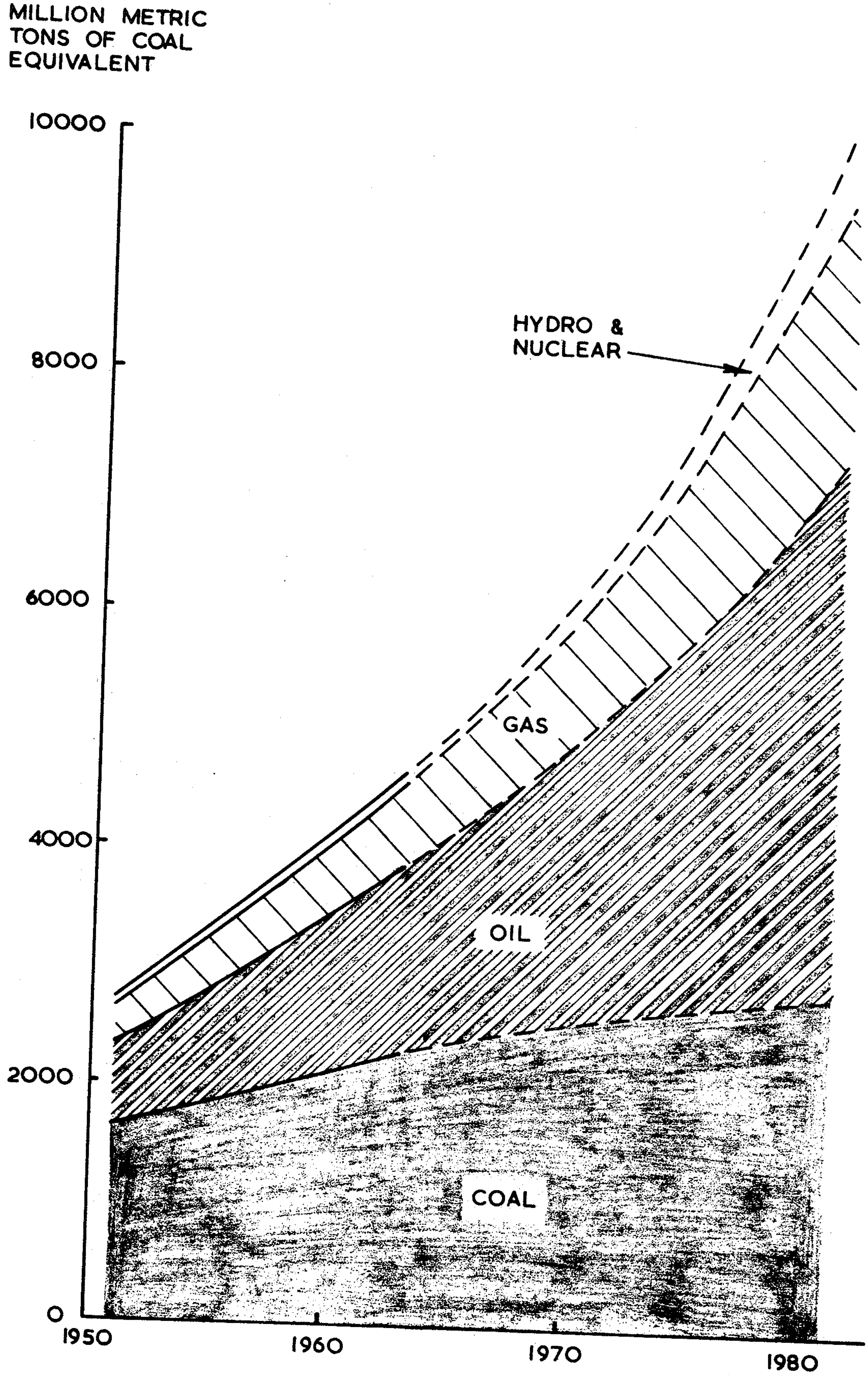

FIG 6 ESTIMATED WORLD FUTURE ENERGY DEMAND.

ENVIRONMENT POLLUTION AND CONTROL

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INTRODUCTION

During recent decades, a tremendous amount of development has been observable in every field of endeavour. Science and engineering have achieved results, of which preceding generations could not even dream. We have learned how to vanquish deadly diseases, to augment the yield of the soil, and to develop an ever-increasing number of products, designed principally to maintain the pulsating rhythm of life of the people of today and to make living easy and comfortable. The standard of living has risen at breath-taking speed.

Nevertheless, the triumphal march of development has proceeded at the cost of pollution of our environment. Watercourses have to accept large amounts of industrial and residential waste waters, oil, chemicals and other waste materials. Factories and centres of population hurl huge amounts of smoke and fumes into the air. Nuclear tests pollute the atmosphere, soil and water with radioactive fallout. Hundreds of thousands of tons of various chemical pesticides are scattered each year in fields, gardens and forests, as powdered or sprayed material or as injections. Diversified products such as finely divided aerosols are sprayed in the air.

What have we done, and what must we do, to prevent the pollution of our environment? Attention has been drawn to this regrettable fact only within recent years. Prohibition of pollution of the environment and its control have become a matter of general interest to public health and agriculture authorities, to chemists and physicists, to lawyers and to the whole community. It has been realized that the life of the people of today, along with that of the coming generations here on earth, is possible only if the essential conditions of our living, the water, the air and the soil, are preserved in a serviceable condition, and are contaminated as little as possible.

WATER

Of our natural resources, water is one of the most valuable. More than 70 per cent of the surface of the earth is covered by water. However, despite this superabundance, we suffer from a shortage of water. The major part of this substance which is so abundantly present in our environment contains salt and, as such, is unfit for use in agriculture, in industry, and by the individual consumer.

The greater part of humanity exists with an actual shortage of water, or at least under the threat of water shortage. Even in those territories where abundant water is available, the human being has by his activities induced a wavering in the availability of the continuously protected supply of this essential condition of its existence by the contamination of his environment.

Water Pollution

The pollution of water is no new phenomenon, but it was not until after the Second World War that the situation become catastrophic in some places. The rise in the standard of living has in general occurred at the expense of natural water systems. Society with its high level of development, large centres of population, huge industrial plants, radioactive materials, along with an ever-increasing use of chemicals, has multiplied many times the amounts of "nonnatural" water.

Thus the waterways have to accept large amounts of organic and inorganic matter, with the result that many inconveniences become apparent even to the senses: They have a disagreeable odor, the water becomes muddy and grass-grown, and algae and waste floats are formed. The bacterial content may also be increased to such as extent that the health of the people is subjected to hazard.

All over the world, the serious nature of the situation has been realized, and immediate measures have been taken to protect the supply of natural water. Legislation on water protection has been passed, industrial plants have been obliged to acquire apparatus for waste water purification, informative and educational work has been carried out among the public in large, and systematic research work is more and more engaged in. The protection of water has become a matter of public interest. It has been recognized that prevention of water system pollution is not merely a matter that concerns the people of today, but also that the possibilities available to coming generations to live and to gain their livlihood on this planet depend on it.

In consideration of the means of protecting the water supply of a city or other centre of population, the first concern is the protection of the waters of the region concerned against the pollutant effect of the sewerage system. This is easy to understand, as industial and residential waste waters, which are often conducted in sewage to the water systems, constitute the worst enemies of water purity. However, such waste waters are not the only consideration in this respect; many other hazards, such as liquid fuels, radioactive materials and chemicals, may contribute to the pollution of water systems and even completely spoil the water supply.

Quality specifications for water

The quality of water is commonly defined by the purity or impurity of the water. Nevertheless, natural water is only rarely quite pure. Before it becomes a part of the ground water or water systems, rain water may contain large quantities of mineral substance or atmospheric gases dissolved in it. Ground water and surface water which do not contain any particular pollutants are to be considered as pure water. It is therefore more practical to talk about the usability of water for the purpose concerned than about the purity of water.

Water can be divided into the following categories according to use: household water, which includes drinking water; water for industrial use; farming water; swimming water; and fishing water. Each category has particular specifications as regards quality.

The following quality specifications apply to household water:

1. It may not contain anything which causes disease.

2. It may not contain toxic or factors otherwise dangerous to human beings.

3. As regards taste, odor, color, brightness, hardness and temperature, household water has to meet moderate requirements.

The standards stipulated for drinking water vary slightly from country to country; for instance, Finland has not as yet any official standards. As the best recommendation for the quality of drinking water, there can be proposed the standard of the World Health Organization (WHO) given in the Table 1, which lists the substances that cause hazards to health if they occur in large concentrations.

It is not possible to give common quality specifications for industrial water, as the requirements for the quality differ, dependent on the field of production and the methods employed.

The quality specifications for household water are mostly valid for the water to be used in raising livestock, although it may be pointed out that the qualifications are not as strict for drinking water for cattle and for irrigation water as those for drinking water.

The hygienic point of view is most important in evaluation of the quality of swimming water. The bacteorological quality, waste waters and epidemic conditions must be taken into consideration in determining whether water is suitable for swimming.

Fishing water may not contain toxic substances, such as copper salts, cyanides and free chlorine, in such amounts that they exercise a poisonous effect on fish. The oxygen content of the water must be sufficiently high to ensure that the stock of fish can thrive there. In the search for elucidation of the reasons for the mass death of fish which have occurred in some waters, it has most frequently been found that the supply of oxygen is inadequate; the fish have simply suffocated because of lack of oxygen.

Table 1

Standards for Drinking Water Recommended by WHO

(ppm = parts per million)

Substance	Permitted Amount	Amount which causes hazard to health
Color Pt/water ppm	5	50
Turbidity (turb. Units)	5	25
Taste	-	-
Odor	-	-
pH-value	7.0-8.5	>6.5 or >9.2
Solids content ppm	500	1500
Iron Fe/water ppm	0.3	1.0
Manganese Mn/water ppm	0.1	0.5
Copper Cu/water ppm	1.0	1.5
Zinc Zn/water ppm	5.0	15
Calcium Ca/water ppm	75	200
Magnesium Mg/water ppm	50	150
Sulphate SO_3/water ppm	200	400
Chloride Cl/water ppm	200	600
Magnesium sulphate + sodium Sulphate ppm	500	1000
Phenol ppm	0.001	0.002

Pollution of water

The pollution of water can occur either suddenly or gradually. Unfortunately, attention is drawn to such pollution only when the water is already unfit for use, and the maximum capacity of the water is exceeded at that stage. The most common sources of water pollution are organic waste substances, acids, toxic substances, radioactive fallout, and various causes of disease.

Waste materials.--Organic waste materials principally enter the water with waste from chemical plants and through sewerage systems. If the amount of these materials does not exceed the normal maximum capacity of the water, they are not harmful, since natural purification operates in the water. Certain bacteria, small underwater organisms, act to serve the people by taking organic wastes into their biological process of production. They decompose high-molecular organic compounds into short-chain compounds, and convert them into matter than can be utilized for the production of new organic matter. Thus, substances which are initially dangerous to the human being are evolved into living organisms, become the food of larger animals, and might in their entirely end up, say, in the form of fish on the dining table.

If the concentration of organic matter in waste water is so large that the normal maximum concentration is exceeded, then the decomposition by the bacteria becomes the dominating biological action in the water. The amount of organic matter to be decomposed is so large that the oxygen balance of the water becomes disturbed, and the oxygen may even be exhausted. Microbiological action then continues under anaerobic conditions, which result in the development of odoriferous compounds such as hydrogen sulphide. Fish disappear or die en masse. The water is unacceptable, even as drinking water for cattle, and can become dangerous even to the health of man. As oxygen is continuously being dissolved from the air to water, under summer conditions the whole oxygen content of the water cannot be exhausted. In winter, under the cover of ice, or in summer, under luxuriant surface vegetation, however, an excessive load in the water may result in the complete exhaustion of oxygen.

Occasionally, acids and toxic materials enter water systems, causing injury to living beings in the water and even introducing hazards to man's health. The most common toxic materials which enter water systems through the agency of waste waters are compounds of arsenic, lead, chromium, copper and cyanide. In handling these compounds, the greatest caution is necessary, as even small concentrations may bring about serious effects. Table 2 presents the maximum allowable amounts of toxic materials in waste waters to be conducted to water systems, as recommended by WHO.

It is obvious from this table that the maximum allowable amounts are very small. For example, only less than 0.1 part of cyanide per million parts of water is allowable in waste waters which are discharged into running water. Cyanide compounds are very effective poisons and are in general so stable that they are not decomposable in the normal treatment of waste water.

A typical effect of cyanide is that it retards normal biological actions. In large amounts, it may kill all the effective organisms in biological waste water treatment plants, and for this reason, cyanide must be removed from the waste water separately before the waste water is conducted to treatment plants. In polluted waters, where the oxygen content is also reduced, the effect of cyanide compounds is more poisonous than in nonpolluted waters. Similarly, the poisonous qualities rise in virulence with an increase in temperature.

Prevention of the effects of pollutants.--It is an easy matter to present a list of the demands imposed on water if it is to make life pleasant, but the question of how all these demands are to be fulfilled in practice is another matter. Simple as it would be to prohibit all the activities which induce pollution of the water supply, in practice putting such an order into effect would be a difficult task. In addition, the application of such an order could bring about a situation which would disturb economic development as such and which would be opposed to the interests of society.

Table 2

WHO Recommendation for Maximum Allowable Amounts of Toxic Materials in Waste Waters Entering Water Systems

Substance	Water with Biological Clarification	Running Water System
Acidity, pH-value	6.5 - 8.5	6.5 - 8.5
Insoluble solid residue, ppm	upper limit fixed separately	10 to 30
Aluminium	should not be conducted	pH value no limits
Ammonia, ppm	20	5
Lead, ppm	1	1
Cadmium, ppm	1	1
Chlorine, ppm	none	0.2
Chloride, ppm	500	800
Chromium II, ppm	0.5	0.5
Chromium IV	none	none
Cyanide, ppm	1	0.1
Iron, ppm	-	0.1
Fluoride, ppm	2	2
Copper, ppm	0.2	0.2
Nickel, ppm	0.5	0.5
Nitric, ppm	20	0.5
Suphate, ppm	200	none
Suphite, ppm	20	1
Zinc, ppm	5	5
Temperature ^{o}C	35	25

Though the protection of natural water entails strict prohibitions and restrictions as a matter of values which must be preserved, the general objective of protecting water systems can not be so absolute that all other interests must be subordinated. With close cooperation between groups working for the improvement of public health and those who aim at improvement in the process of production, it is possible to achieve satisfactory results.

With certain limits, prevention of the effects of pollutants is practicable by purification of the water to be utilized. In the treatment of both household water and water for industrial purposes, the same methods are in general used. The most important of these are aeration, clarification, filtration, coagulation by either chemical or biological means, disinfection and chemical balancing. One or several of these individual operations may be used in the purification of water. Iron and manganese, for instance, are often removed by the application of aeration, clarification and filtration. Humus is removed by chemical coagulation and filtration, and for the removal of corrosive carbonic acid, there is applied aeration or chemical balancing with lime and caustic alkali, and so on. It is obvious that all kinds of water treatment and purification involve expenditure of an amount which depends on the quantity of water to be treated and the demands imposed on water quality.

Control of Water.--The need for fundamental research as regards water is appreciable, and can be divided in two groups. Examination is necessary of various methods of purification and the measures that can be adopted to prevent the polluting effect exerted by waste waters on fresh water. The other area for investigation is concerned with examination of the water itself, to clarify the changes made by waste waters in natural water systems. Only after interpretation of the effect of these changes can we achieve an understanding of the dynamics of acceptable water, the basis for evaluation of the quality and the amount of waste water, and consideration of the principles underlying the correct treatment and outlet for wastes. Thus, only by means of close cooperation between those with limnological backgrounds and the technologists will it be possible to treat waste water in such a way that it can without any risks be channeled into natural water systems.

By means of analytical methods evolved in water research, it will be possible to introduce continuous control of the quality of natural water systems and that of usable water. The main points for examination comprise radioactivity, acidity or pH value, conductivity, oxygen content, amount of organic matter, and toxic or otherwise harmful matter in the water. Similarly, by means of biological methods, the effects exerted by waste waters on the life in water will be under continuous control, and such examinations will establish new opportunities for the testing and the removal of the deleterious elements in water.

In parallel with these examinations concerning pollution and purification of water, scientists and technicians all over the world are endeavouring to formulate methods to increase the scanty water supplies of the world. Artificial lakes have been constructed, and plants for the removal of the salt in sea water are under development. With some satisfaction and a feeling of security, we realize that measures designed to ensure the protection of natural water systems and to increase the world's water supplies are many in number and nature, and that the importance of this question has been understood and good results already achieved.

AIR POLLUTION PROBLEMS

The rapid increase in traffic, the substantial expansion of industry, and the enlargement of power and heating centers have meant that air pollution has become a problem which has gained increasing attention especially in recent years. One of the essential conditions of our life, the air that we breathe, has to accept diversified impurities in the form of gas, vapour, mist, or dust, impurities which may all be dangerous to out health. The ambient air in large cities and other centres of population, particularly in industrialized districts, may bring about considerable health problems. Much more difficult, however, is the situation in closed air spaces, such as in mines, in cement and metal factories, and in chemical plants. Continuous control of the air and research in the field, together with protective means, are matters which demand serious attention throughout the world.

On occasion, there have been acute cases of air pollution, as if to remind us of the importance of control of the air. In December, 1952, "lethal smog" killed about 4,000 persons in London, and in 1957 about 1,000. Most of these people were old and were suffering from chronic heart or lung diseases. Similar sudden disasters, although on a smaller scale, have taken place elsewhere, e.g., in 1930 in the Meuse Valley, Belgium, and in 1948 in Donora, Pennsylvania, U.S.A. Fortunately these phenomena occur but seldom.

Air pollution resulting from nuclear weapons and from radioactive fallout is for us people of the atomic era the newest and most alarming form of danger. Nevertheless, it is so extensive and many-sided in its effects, that it deserves more detailed and separate explanation than other air pollution.

Sources of air pollution

In consideration of pollution of the air around us, two main groups are to be observed: (1) natural air pollution and (2) cultural air pollution.

The most important natural sources of air pollution are granules of pollen, virus and pathogenic bacteria, causes of disease originating in flying inserts, and other factors which arise naturally. Industrialization and other human activities may increase the amount of atmospheric natural pollutants. As an example, there may be mentioned the pyrethrum used as an active agent in insect powders.

The most important sources of cultural air pollution are to be found in heating and power plants, traffic and industry, especially in metallurgical, cement, iron and steel factories, in chemical plants, and oil refineries. In discussing air pollution, a distinction is drawn between indoor and outdoor air pollution. The effects of outdoor air pollution or general air pollution are in general more far-reaching problems than those presented by indoor or local air pollution.

Composition of clean air

Before entering upon a detailed discussion of atmospheric impurities, it might be helpful to study the chemical composition of air. Dry clean air is a gasous mixture which consists of nitrogen, oxygen, rare gases, carbon dioxide, and hydrogen. The concentrations of these gases are given in Table 3.

Table 3

Composition of Dry Clean Air

Gas	Concentration ppm
nitrogen N_2	780000
oxygen O_2	209500
argon A	9300
carbon dioxide CO_2	300
neon N	18
helium He	5.2
krypton Kr	1
hydrogen H_2	0.5
ksenon X	0.08

Outdoor air pollution

Atmospheric air however, contains a substantial quantity of hundreds of inorganic and organic particles and gases. The amount and character of air pollution vary greatly in accordance with the topographical and meteorological characteristics, and the nature and extensiveness of industry, traffic, heating and other human activities. The measurements of dust fall have varied from 5 tons to 62 tons per square mile per month within the limits of some cities of the U.S.A. In some large industrial cities, considerably higher values were noted; for instance, in Pittsburgh 291 tons per square mile per month. In Helsinki, Finland, in 1959, according to examinations carried out by the Institute of Occupational Health, the amount of dust falling with the air amounted to 5.6 to 30.5 tons per square mile per month, whereas the corresponding value in a typical Finnish rural district was no more than 0.1 to 1.8 tons.

The most common inorganic pollutants in outdoor air are:

- nitrogen compounds (NO, NO_2, NH_3)
- oxygen-containing compounds (O_3, CO, CO_2)
- sulphur compounds (SO_2, SO_3, H_2S)
- halogen compounds (HF, HCl and its salts)
- carbon, silicates, phosphates etc.
- alkali-, earth alkali- and earth-metal compounds

These contaminants exist in air partly in the form of free gases, partly dissolved in water, and partly in water-insoluble form. The number of organic impurities in outdoor air is also large. The most common are methane and some other aliphatic hydrocarbon compounds, and mercaptanes.

Table 4 presents the ranges of concentration of gaseous pollutants gathered from several cities in the U.S.A.

Table 4

Ranges of Concentrations of Gaseous Pollutants
Gathered from Several Cities in the U.S.A.

Pollutant	Range of average concentration ppm	Range of maximum concentration ppm	Maximum allowable concentration ppm
aldehydes (as formaldehyde)	0.02 - 0.2	0.03 - 2.0	5
ammonia	0.02 - 0.2	0.05 - 3.0	100
carbon dioxide	2.0 - 10.0	3.0 - 300	100
hydrogen fluoride	0.001 - 0.02	0.005 - 0.08	3
hydrogen sulphide	0.002 - 0.1	up to 1.0	20
nitrogen oxides	0.02 - 0.9	0.3 - 3.5	5
ozone	0.009 - 0.3	0.03 - 1.0	0.1
sulphuric dioxide	0.001 - 0.7	0.02 - 3.2	5

The table indicates that the maximum allowable concentrations of impurities of air are exceeded only occasionally.

Indoor air pollution

In places of employment, thousands of various materials have been found contaminating the air which workmen have to breathe. The amounts of pollutants may be present in the local factory atmosphere in such concentrations that they exert injurious effects on workmen, work efficiency drops, and, when polluted air is breathed year after year, workmen's health may even be affected. Such pollutants include solutes such as benzene, tri- and perchlor ethylene and carbon tetrachlorids; gases like chlorine and sulphuric dioxide; and metals such as mercury, lead and arsenic, to mention only a few.

Hazardous effects of aur pullutants

The question which occupies our thoughts is concerned with the kinds of hazards to which peoply may be subjected by polluted air. The health problems brought about by air pollution mostly relate do the lungs or through the lungs to the blood, and in this way all over the body. The most well-known disease occasioned by dust is silicosis, a disease peculiar to workmen who have to breathe stone dust from year to year. Well-known occupational cases of poisoning are ascribable to metals, solutes, and gases. The reasons for an alarming increase in allergies and cancer are also partly to be found in impurities in the air. Flue gases generated in burning coal may have a strong corrosive effect. Sheet-iron roofs and the aluminium facades of buildings corrode, and within a few years white-washed walls become grimed in cities and other centers of population.

The pollutants most harmful to vegetation are toxic gases such as sulphur dioxide and chlorine, together with tarry contaminants. The injurious effect of gases mostly affects the green parts of plants, i.e., the leaves and needles; this causes disturbances in assimilation. Even in small concentrations, toxic gases may exert fatal effect if continuously present.

Evergreen trees are as a rule more sensitive than foliage trees to the harmful effects of gases. The tarry materials prevent the access of light to the chlorophyl of the leaves and needles in the cells, or fill up the air cavities; this results in prevention of the normal action of oxygen and carbon dioxide, assimilation stops, and the plant withers. Fir is the most sensitive tree as regards the effects of tarry materials, and is thus as a rule the first tree to wither in newly settled areas and centres of population.

Control of air

In the most densely populated industrialized regions, legal restrictions are in force with respect to the maximum allowable amounts of dust, ash and gas which can be released into the air. In those countries which have no direct legal stipulations for the prevention of air pollution, it is possible entirely to avoid such inconveniences or to minimize their effect, if purposeful scientific and technological activity enables the exercise of control of the amount and quality of pollutants released into the air. The research and development of methods of analysis of pollutants in the air, the realization of their dangerous effects and their prevention, as well as improvements in air conditioning systems, are well worth study.

In this connection it could be mentioned that though the pollutive effect of carbon dioxide is no new phenomenom, its beneficial effects on plants were not known until recently. It has viz. been noted that carbon dioxide can also be utilized for augmenting the yield of crops; this may be regarded as the most important invention in the field of agriculture in recent years.

RADIOACTIVITY

Development in the nuclear field has made tremendous progress. Hundreds of nuclear reactors are in operation in different parts of the world, producing atomic power and radioactive isotopes for peaceful purposes. Nevertheless, radioactivity has become a frightening and menacing word since that day on which the first atomic bomb was prepared about 20 years ago. Great powers have competed in an armaments race; hundreds of nuclear-explosion experiments have been made.

Increasingly more frightful nuclear weapons have been created, weapons which strike terror to people's hearts, principally because they lead to the creation of ever more destructive nuclear weapons, but also because of the radioactive fallout which penetrates to every corner of the earth and of which the destructive effects are diversified and partly shrouded in mystery. What is this radioactive radiation? Where may people and other living creatures be subjected to it? How can its dangerous effects be prevented, and how can protection from it be achieved?

The radiation of radioactive materials may be composed of three kinds of rays, viz, alpha-, beta- and gamma-rays. Gamma-rays are similar to roentgen rays, while beta-rays are electrons which move at high speed. Alpha-rays are heavier particles than both the other two kinds: their mass is about four times that of the hydrogen atom, and as a result of this mass they possess high kinetic energy. By their powerful effect, the atomic nucleus, which was earlier regarded as unchangeable, may be decomposed, thus releasing the latent energy in the nucleus which is millions of times greater than the energy involved in even the most vigorous chemical reaction.

Human organs may be subjected to radiation either from radioactive materials external to the body, that is to say, outer radiation (A), or inner radiation (B), originating in radioactive materials which have entered the body by the agency of air, food or drink.

The sources of <u>outer radiation</u> include various items of apparatus used in industry, instructional work, or science, generating ion radiation, and radioactive substances whose use has widely increased in recent years, as well as the fallout from experimental nuclear weapon explosions. In our everyday environment, there are artificial sources of radiation, probably to a greater degree than we can even imagine, such as television receivers, self-luminous watches, and so on; however these present no real danger to people.

<u>Inner radiation</u> is very dangerous, because the control of this kind of radiation is difficult if not impossible, and also because its effects are long in duration and generally unexplained. Cattle feed becomes contaminated, and the radioactive foodstuff chain is initiated: radioactive fallout - land plants - animals - foodstuffs from the animal kingdom - man's alimentary canal.

If the direct destruction brought about by an atomic bomb exploding is omitted, the radiation of group A is not so fatal to people as that of group B. This is because in group A the means of control and protection are generally good, and are based upon legislative enactments. Against this, the control of inner radiation sources is difficult. Radiation doses contained in the body are not determinable by simple measurements, although they can be restricted by keeping a check on the amounts of radioactivity in man's environment and in his food.

Radioactive Fallout

Let us examine in greater detail the radioactive dust and its effects on living nature, especially human beings. Radioactive dust is composed of radioactive particles which have found their way to the outer layers of the atmosphere, stratosphere and troposphere following the explosion of nuclear weapons. These particles gradually fall to the earth in the course of an indefinite period of time. This falling process occurs more rapidly near the poles than around the equator, since the path around the globe which the particles must pursue is shorter, and because the lowest layer of atmosphere there is lower than that near the equator. The small particles which fall to the earth at a distance thousands of kilometres from the site of the explosion are as such not dangerous to people; but danger is inherent in the radioactive particles which enter cattle feed, foodstuffs and finally people via milk, meat, vegetables and fruit.

Although the radiation dust which originates in the explosion of nuclear weapons contains about 200 various nuclear particles, of which the radioactivity lasts for various periods, only five of them are supposed to subject people to risk. The other types are non-biological, plants do not absorb them, and they do not become absorbed in the tracts of men or animals. The most dangerous of these five types of radioactive particles are the radio isotopes of strontium (Sr) and Caesium (Cs), 90 Sr and 137 Cs.

Radio-strontium is the one most feared, as it is closely related to calcium (Ca), behaves in a similar way, accumulates in the bones, and generally acts like calcium in the metabolism. In addition, it decomposes very slowly and has a long half-life. As a criterion of the hazardous character of food-stuffs as far as radioactivity is concerned, there is generally employed the relation of radioactive strontium to one gram of calcium to be found in the foodstuff concerned, i.e., the relation 90 Sr/g Ca.

Radio-caesium is related to potassium. Because potassium is indispensable for the action of cells, both of them spread over the whole body. Radio-caesium decomposes to half, or loses one-half of its activity in about 30 years, viz., has a thirty-year half-life. As the human body gets rid of one-half of it within six months, radio-caesium does not in general have time to exert a large amount of radiation, in spite of the magnitude of its concentration.

Radio-active iodine accumulates quickly in the thyroid gland, which is known to be an iodine collector; no more than a few minutes after eating, iodine is in the thyroid gland. It thus localizes its radiation, which increases its effect. Similarly, the effect of radio-iodine is augmented by its rapid decomposition; the half-life is about eight days. The short half-life has the advantage that the greater part of its radioactivity is exhausted before the fallout reaches the earth.

Immediately after the first nuclear explosions, intensive research began throughout the world with the objectives of examining the effects of radioactive fallout and of protecting society from the fatal consequences. It was realized that satisfactory results could be achieved only by means of close cooperation between public health officials and farm officials, chemists and physicists. It was noted that the dangerous effects of radioactive fallout might be reduced by the use of correct methods of cultivation, feeding, storage and treatment. Regular measurements of the radioactivity in the atmospheric air and drinking water were begun in many countries, and there was initiated the control of foodstuffs with respect to its radioactivity.

Radioactive residues in milk

Milk and milk products constitute the main sources of calcium in the average diet of many European and North-American countries. A direct consequence of this fact was that the study of the radioactive residues in milk became the object of intense interest during the period of experimental nuclear explosions. This also applied in Finland, where according to information compiled by the Food and Agricultural Organization of the United Nations (FAO) the consumption of milk is about 0.8 litre per person per day, the highest average consumption of milk in the world.

This quantity of milk contains about one gram of calcium, or an amount which is sufficient alone to cover the calcium need of man. The necessity of calcium to man, the close relationship between calcium and strontium, and the possible contamination of the most important source of calcium, milk, through the agency of feed eaten by cattle were things which alarmed the people living in the northern hemisphere. The result was a rush on the chemists' shops, calcium pills were eaten in unreasonable amounts, and calcium was even added to the baking soda in pursuance of the belief that radio-strontium cannot penetrate people saturated with calcium.

However, food and milk investigations brought very reassuring information to milk drinkers. It was observed that the most important source of milk was in the happiest situation as regards the receipt of calcium; this finding was based on the cow's organs being able to remove strontium, a foreign substance to the animal, to a greater extent than calcium; consequently, the relationship of active strontium to calcium in milk becomes small. This kind of strontium-straining occurs to such an extent that 90 Sr/Ca in milk amounts to only one-tenth of the corresponding ratio in the feed. The use of milk is further facilitated in that only a small proportion of the racioactive matter in milk is in the fatty part, e.g., only two percent as regards 90 Sr. Butter prepared from contaminated milk thus contains no more than a small proportion of the fallout isotopes in contaminated milk.

Radioactive residues in reindeer meat

Another interesting object of investigation which has attracted appreciable attention is reindeer meat. These investigations had as a foundation the observation that plants exert potent discrimination against strontium; only a few kinds of plants favor it. One of these few exceptions is lichen, the principal food of the reindeer, which seems to collect radio-strontium in it. Man eats reindeer meat and the chain is thus closed; man absorbs the radioactivity originating in nuclear explosions.

A natural result of the experimental nuclear explosions carried out in the northern hemisphere was that investigations were initiated into the effect of radioactive fallout among the most typical population and fauna of the northernmost part of the world, Lapps and reindeer. Lapps constitute a small population, about 36,000 in number; about 22,000 of them live in Norwegian Lappland, 10,000 in Sweden, about 2,000 in Finnish Lappland, and the remainder in the Kuolla peninsula. Reindeer meat is an important item in the Lapp diet.

Studies among the Finnish Lapps have been in progress since 1959, under the leadership of the Chief of the Radiochemical Laboratory of the University of Helsinki, Dr. Jorma K. Miettinen. The objective of the studies has been that of acquiring information on concentrations of 90 Sr and 137 Cs in the vegetation, animals and people of Lappland, as well as the nutritive chains of the nucleus, i.e., the circuit from radioactive fallout through plants and animals to man, with a view to making a prognosis of and outlining protective measures to cope with catastrophic situations. An investigation concerned with radioactive caesium was of great interest, as this substance accumulates in meat used as food by man. Such an investigation to be conducted among people is not easy of accomplishment. It is not sufficient to make nuclear analyses of foodstuff and feed; accurate knowledge of the consumption of the foodstuff is also necessary before any conclusions can be drawn from the analysed results.

Amongst the Lapps, such an evaluation was not overwhelmingly difficult, since the Lapps, living as they generally do far from the centres of population, provide food supplies for three to four months at a time, and can accordingly tell the amounts of foodstuff to be consumed during the course of a lengthy period. Furthermore, the whole of the activity of some people subjected to tests was measured by the aid of a special apparatus in which he sat. Above his body a sodium iodide crystal served as indicator, and diagrams were obtained in which the radioactivity of the person was indicated at each energy level.

One result of these studies was that the radioactivity of the Lapps, people who eat substantial amounts of reindeer meat, was little higher than that of the people of southern Finland, and there was no reason for anxiety. There need be no fear associated with the eating of reindeer meat; it is still safe. Though a one-sided diet of reindeer meat increases the inner radiation, it does not do so to an extent which warrants alarm.

Investigations made in various places have led to the conclusion that the radioactivity in our environment has not yet attained values which are considered as dangerous to man. Nevertheless, the effect of radioactive materials assumes many aspects and is long in duration. It may lead to disastrous consequences for generations to come, as its effect on the genes is still a matter for conjecture. Accordingly, the people of today must strive by all possible means to prevent the dangers inherent in radioactivity. Good results may be achieved only with purposeful research, with continuous examination of the air, water and foodstuffs, and close cooperation in our endeavours.

AGRICULTURAL CHEMICALS

In consideration of environment control, there remains one source of possible danger to the health of man, that concerned with chemicals for plant protection. The enormous increase in the use of synthetic pesticides has induced the late well-known American biologist, Rachel Carson, to take up her pen and write a disturbing account of how we shall before long poison ourselves with these chemicals. Dangerous poisons accumulate in the soil, make their way into water systems, and end up in man's foodstuffs. "Silent Spring" is an impressive novel, which will quite certainly make many readers believe that the only way to save the whole of mankind is to abandon the use of pesticides and allow the primeval balance of nature to regulate the injurious micro-organisms.

Nevertheless, the situation is not so disturbing and dangerous as is described in this book, provided these chemicals are utilized reasonably, their use controlled effectively, and field research is carried out. They may bring about serious effects when used in the wrong way; however, advantages achieved by their use are remarkable. With the aid of insecticides malaria, for instance, has almost disappeared from the world, and the pesticides have made it possible to augment the yield of the soil by 10 to 20 percent.

The figures which record the increase in production of synthetic plant protection chemicals are in fact high. For instance, in the U.S.A. their output has increased five-fold in 14 years--in 1947 it was 124,250,000 pounds and in 1960 it had increased to 637,666,000 pounds. The selection of products has simultaneously increased; more than 200 base chemicals have been developed and put into use to exterminate various injurious organisms. These products have been marketed under thousands of names, and are administered as injections, dusts, or aerosols in fields, gardens, and forests.

There are two main groups of synthetic insecticides; the first of these includes chlorinated hydrocarbons and the second the organic phosphorous compounds. Typical representatives of the first group are DDT, or dichlordiphenyltrichlorethane, and lindane, and of the other group, parathione and malathione.

Experts in agriculture and health officials agree that some of these chemicals may be dangerous to human beings if used carelessly. For example, if parathione is sprayed without protective clothes and mask being donned by the operator, he may be poisoned. Thus the essential condition is that these compounds should be treated with caution, and the directions given for use should be followed.

What then are the activities aimed at obviating the concentration of these chemicals in foodstuffs in amounts which involve danger to people? In many countries, there is legislation which stipulates the maximum allowable concentrations of pesticides in foodstuffs. In addition, each of these compounds has its own time-safety limit, which entails that for each pesticide the time elapsed between the last treatment with the particular compound and harvesting is characteristic and determined in each individual case. In many countries, such as the U.S.A., Germany, and the northern countries of Europe, similar time-safety limits are to be observed; for instance, the time-safety limit for parathione, lindane, and DDT is two weeks, and for malathione only one week.

As regards determination of pesticides in foodstuffs, research and the development of methods of analysis have been in progress during recent years. The most interesting of the methods of analysis include chromatographic and biological ones. The principle involved in the latter is that foodstuffs thought to contain these chemicals, either in the form of an extractive made of it or in the crushed form, come into contact with test-organisms or insects in their area of feeding and movement, and the living capacity of the test organism is studied in its environment.

How long then are the pesticides preserved in the soil, and are they accumulated there? There are compounds with short and with long half-lifes. Lindane, for instance, has still been found in the soil 15 years after its use. Similarly, the half-life for dieldrine, a pesticide which belongs to the chlorinated hydrocarbons, is 7 years. The farmers should be instructed in the use of pesticides so that instead of pesticides accumulating in the soil, those which become easily decomposed are to be used.

AEROSOL PRODUCTS

In addition to the environment control of a general nature outlined above, I cannot keep from touching briefly upon the field of my present activity, a field which is the concern of all women, that is to say, the use of perfumes, hair lacquers and aerosols in general. Aerosol packages, from which the effective product under pressure, dissolved in the appropriate solute in very finely divided form, may be sprayed in the air, have rapidly gained popularity throughout the world. In 1961, the total output of aerosol products exceeded one billion production units.

The most diversified products, such as hair lacquers, insecticides and pesticides, deodorants, air fresheners, and so on, are available in a handy form within the reach of everybody. It is therefore no wonder that any possible injurious effects on health are a matter of constant interest. Certain newspapers have published alarming news items on the alleged detrimental effects to the health resulting from the use of hair sprays. It was even stated that in a couple of cases death ensued as a consequence of continuous breathing of hair lacquers. However, the majority of investigators and experts are of the opinion that such reports are misleading and over-hasty, and that we can without hesitation use hair lacquers and other aerosol products, provided the directions prescribed are observed.

CONCLUSIONS

During recent years, the standard of living has risen at breathtaking speed, thanks to the development in every field of endeavor, and especially that of the chemical industry. Nevertheless, this triumphal march of development has proceeded at a cost to our environment. We should therefore not close our eyes to the hazardous effects of contaminants in our environment. On the contrary, we should realize the importance of questions concerned with preservation of the essential conditions of our living, the water, the air and the soil, in a serviceable condition and as little contaminated as possible.

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The high point in my career occurred in 1957, when the Society of Women Engineers honored me with their Annual Award for Engineering Achievement for my work in high temperature metallurgy and nondestructive testing. I can still feel the thrill of that night in Houston, when Dr. Gilbreth gave such an inspiring talk, and everyone was so wonderful to me.

Failure analysis, or "trouble-shooting", has been one of the really fascinating phases of my job. I remember one time when I reconstructed a jet engine from over 6,000 broken fragments! And learned why it blew up, too -- the cause was clear, once the pieces were identified and arranged.

Another engrossing subject is that of nondestructive testing, to establish the quality (or lack thereof) of parts without precluding later use. Nondestructive tests vary from simple raps to hear the tone produced, to sophisticated, automatic ultrasonic inspection. Each test has its special advantages and its limitations, and new ones are developed every day. It would keep me fully occupied just to read of all the advances!

The longer I study materials and work with them, the more interested I become in the subject of materials engineering. Every day brings new inventions, new discoveries in processing and treatment, new opportunities to learn. Increasing my knowledge and using it to make better parts for the missiles which defend our country is my life work - stimulating, demanding, and, I feel, very worthwhile. I wish I could live to be 150 and keep studying and working all the time.

COMMUNICATIONS

by Miss Olwen A. Wooster
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By his ingenuity, his brain and his skill, the thinking man has made communications instantaneous, global, and a vital nervous system of the modern world. Notwithstanding this remarkable technological explosion, some of today's primitive societies have not advanced beyond the gesture, the signal, and the spoken word. The vast economic disparities among the nations are related to their educational standards. On a global basis, therefore, we have the less developed, the developing, and the developed nations to consider, each with government or privately owned public telecommunication networks and all with varying degrees of complexity.

By definition, telecommunications is the emission, transmission, and reception of signs, signals, writing, images, sounds, or information of any nature by visual, wire, radio, or other electromagnetic systems. Of itself, it does not create power and will not, but it does increase the possibility of obtaining it. An analogy can be made between the relationship of a human being and the human nervous system, on the one hand, and civilization and its means of communication, on the other hand. The human nervous system is most complex. Its function is to integrate the parts of the body into one whole. The nervous system is not concerned with what the body does; it is not important in itself, but only as a tool of the human being. Similarly, the means of communication, facinating though they are, are not important in themselves; they are only important as a tool of civilization. The important question concerns the use that we are going to make of it.

In a growing nation, the spread of industry and population takes place rapidly, and when new communities are created, communications are essential. Sometimes this takes place in the urban areas, sometimes in hitherto sparcely populated regions. Unfortunately, the pattern of development is not easy to predict. Providing services to new areas is not always an economic proposition; there are problems too of terrain. However, if denied, growth is inhibited. Telecommunications therefore help to develop new industries, open up new areas, and break down the isolation of remote villages and towns, and thus make contact with the world outside.

The population explosion, substantial growth of primary and secondary industries, together with administration, commercial and social needs, have all created conditions in which there are continuing pressures for expansion of telecommunications service. This is one of the real problems right through. With regard to the telephone network and the world automatic telephone network, not only has there been tremendous growth with, for example, the number of telephones in the world increasing from 70 million in 1950 to 133 million in 1960, but also rapid mechanization has occurred bringing new concepts in speed and range of connections.

Manual switching functions at most local exchanges have gradually been replaced by automatic systems using varying switching equipment ranging from the operator and step-by-step trunking to crossbar equipment and today to the electronic exchanges. Developed nations have applied automatic techniques to the trunkline system as long-distance dialing has become possible, and most trunk services now use highly mechanized systems, some using the unisilector switching under operator control, while others have advanced to the fully automatic nationwide system.

The numbering plan is something that we have got to take into account. The numbering plan for an automatic telephone system must be designed to serve two main purposes: Firstly, it must provide the basis for the directory information to enable any caller to establish connections to other stations in the system. Secondly, it must provide information in the digital form required by the automatic switching equipment to carry out its functions of setting up the connection to the wanted station and of applying the appropriate charge. The directory information must be as simple as possible to understand and to use so that the automatic system is attractive to subscribers, but also to avoid unproductive usage of expensive plants due to inaccurate dialing. The human problem comes into this consideration quite a lot.

THE WORLD AUTOMATIC TELEPHONE NETWORK

All numeral presentation of world telephone numbers will be used based on a dial designated from 1 to 9 through to 0. This suits the majority of world telephones and corresponds to the dialing used in Australia. The principle that applies to linked numbering will be applied, and each nation's telephone system or an integrated telephone system serving more than one country will be designated by a unique destination code. The subscriber's world number, consisting of the continental or country code plus the subscriber's national number, would be unique and would be dialed to call a subscriber in any other country of the world.

A boundary condition proposed is that the world number not exceed 12 digits in length, with the additional recommendation that wherever practicable, the administration should endeavor to plan their national systems so that for 25 years or more their world numbers will not exceed 11 digits in length. This limit is prescribed to simplify the immediate problems of world-wide operation for countries such as America, where a large investment exists in switching equipment with limited storage capacity, and also to keep down as far as practical the maximum number of digits which the subscriber will encounter in world dialing. The two components of the world number, the continental or country code and the national number, will therefore be variable in length. For example, a country cared for adequately by an eight-digit national numbering scheme could have a three-digit country number or code, while the U.S.A. and U.S.S.R. with ten-digit national schemes would each be identified by a single-digit code.

The technical means of providing the world-wide automatic system are available already. National systems are being mechanized rapidly, generally in forms suitable with little change in the world system. Suitable signaling and switching systems and large-capacity submarine cable systems are available, and the feasibility of satellite communication systems has now been proved as a means of providing the number of circuits required in an automatic network. The world-number scheme will be implemented progressively. During the next decade, development should be rapid, and semi-automatic operation using the world numbering schemes should become wide-spread in the world system. It is possible that within this time subscribers will dial world numbers directly on some routes.

Now the International Telecommunications Union, designated ITU, is the world forum for international discussions on such matters, although international links are currently provided and operated by national and international bodies, either government or privately owned. Generally speaking, all members of the United Nations are members of the Union, but when we are dealing with global communications we need somebody to be the administrator on a world-wide pattern because we are thinking world-wide now.

CONTRAST: THE OUTPOST RADIO SYSTEM

Now changing from the world-wide scene--the large global pattern--back to outback sparcely populated regions: I have chosen here to talk a little bit on one of the unique systems in use in Australia which is world renowned now and which I feel is of interest here at this conference. In the outback sparcely populated regions of Australia is the outpost radio system. This was initiated primarily to assist in the provision of medical aid and advice to residents in these locations, but it now operates and enable telegrams to be passed to the public telegraph network and conversations to be held between outposts. For instance, one can send a telegram from New York and it will be automatically handled right through to the outpost radio station; from there it will be put over the radio to a little outback station in the "back of beyond" in Australia.

This system which was started by the Royal Australian Doctor Service was the vision not of an engineer or scientist but a Minister of Religion, the Reverend Dr. Flynn. For several years he had the vision of air transport and communication, but this was about 1914. Planes were not so efficient then; communications were not so efficient; one could not get long-distance radios in that area without power supplies and other things. He insisted that he would not go on until such time as he could get the radio. He influenced a man by the name of Alftraga in Adelaide to design a small unit that had a high-tension generator. He assembled a series of gears and spindles and set up bicycle pedals--you may have probably heard of our pedal radio--and they bolted it to the floor and that is how they generated the power to produce the signals. In the early days they had a keyboard, just a normal typewriter keyboard, that produced the Morse symbols. Later it was replaced by voice and so it has developed.

From that system, developed back in 1927 (the first base opened in 1928 in Cloncurry), they now have something over 2,000 small sets which cover 400 to 500 miles on comparatively light power supplies, mostly home generating units. There are also quite a number of air ambulances operating throughout the world, the Highland and Ireland services of Northwest Scotland, Air Ambulance Schemes of Canada, the Swedish Air Force. However, we believe that they are essentially emergency service and they all lack the radio link, but our service provides not only medical service with the person in his own home being able to talk to a doctor something like 200 miles away--the comfort that that person might get over just a simple illness of a child is something that, I believe, and we all believe in Australia, is keeping the people, particularly the women, living in the outback areas--but also the fact that she can use the radio to talk to a neighbor some 100 miles away which gives peace and contentment to her.

The radio is helping in the development of those outback areas, and they are something like two-thirds of the area of Australia or 2 million square miles of country. We have "School of Air" as well to help with the education of the children, and all results from the vision of one man, who was not a scientist or an engineer but used the technology created by them.

In New Guinea also we have problems. We could not use Alftraga's radio equipment there, and this is much the same as it would affect Africa and other developing countries. We have terrain, tropical conditions, and many other problems to overcome--the radio conditions themselves. These are some of the things we have to look at both for our developing countries and also our development into space.

TELEGRAPH NETWORKS

To get back to the general subject, the development of the telegraph networks falls into three categories. There is the public telegraph service handling public telegrams (some administrations again going into the automatic stages of various sophisticated designs). In Australia we use the electro-mechanical storage and retransmission system known as "trace" whereby the message originates at, say, Perth and arrives in Cairns in North Australia untouched by human hands all the way through. The further development from that, of course, is its development into a world-wide scheme. Then there are the leased private-wire systems, with which I am directly concerned, which are operated by subscribers, for example, airlines, weather services and various forestry commissions and forestry groups. All lease their own services and operate their own systems.

We have been doing quite a lot of work with the International Air Travel Association in integrated systems--that is, integrated world systems, looking at formats, to get this operating and working, now that the compact cable provides linking around the world. The cable from Europe to the East Coast of America, microwave across the continent, and cable again from the West Coast to Australia thus gives us a way of doing these things immediately. Satellite communications will further develop that system as well.

The Telex system is another form of telegram service that provides a direct switching teleprinter exchange network, the public network for interconnecting teleprinter subscribers. It functions similarly to the automatic telephone service mentioned earlier, except that a call is made direct from A to B. Instead of being switched through, a subscriber can automatically talk from, say, a place in New York to Sydney in Australia.

That will be coming now through the compact cable. This international telex is not as yet, but it will come. There will be dialing, a similar sort of dialing of codes that were mentioned for the telephone system.

Data transmission is now coming well into the field. The ability to process commercial data rapidly on a computer has emphasized the need for facilities to transmit the basic facts and figures to the computer. In many organizations this means collecting the pertinent information from area offices, factories, warehouses and other locations remote from the data processing center. One of the simplest and cheapest methods of doing this, where the quantities of data are small, is to use the existing public telex network. Where this might prove too slow, data transmission units that operate in conjunction with the public telephone service can be employed. Most progress in this technique has been made in America where several magnetic tape to magnetic tape and microwave radio data transmission systems are now in operation. With the aid of an efficient data transmission network, more effective control of a commercial organization can be exercised.

The creation of local or national communication systems which can gather the raw data and disseminate the results quickly and accurately follows as a natural consequence of processing information on computers. With the advent of Telstar the construction of ultra-high-speed international communications systems for business purposes becomes practical. The airline systems, again here in America, have done quite a lot to advance the real-time computer system. Now we are finding that computer switching techniques are coming in with integration of the two systems.

Looking back again to the less developed countries, for effective global communications, at whatever stage, by whatever means, the information to be transmitted must not only be received but it must be understood. The recipient must be able to read the signal, translate its code, its language, and nowadays transform invisible and inaudible ethereal vibrations into words or pictures. Where such skills are lacking, effective communication is impossible. So for a global network, the first requirement it literacy. We must have a command of foreign languages; then we must have mastery of today's electronic techniques. This is all essential for a world-wide communications network. Beyond this, it still remains to understand the content of the transmitted message to comprehend the topic; therefore public education is needed for mass communication. In many of these less developed countries, the first essential is to have a good internal communications system. When you realize that in places like New Guinea there are several hundred languages in that country alone, before electrical communications is possible, there must be good communications within the country itself. These are some of the local problems in the general field of communications.

The next part that communications can play in this is in the world of broadcasting of sound and image. One of the most effective means of reaching the people and building a modern nation is the braodcasting of sound and image because it can reach large segments of the population. It can leap over the barriers of illiteracy and can adapt to the multiplicity of languages that often hamper national unity. It is not only an instrument of social development, but it is also an effective means of direct education within and outside the schools. It is essential to both agriculture and industrial development. It is the sole medium for a world-wide network of weather-observation stations and of weather forcasts for shipping, aviation transport, and agricultural interests. It provides an important service to medical aid and rescue work in some countries.

Because of the need for schooling in the less developed areas, the most pressing problem is probably the shortage of qualified teachers in the face of phenomenal numbers to be educated and the rapid increase of these numbers by high rates of population growths. Instruction by radio and television, either as a supplement to the efforts of the teachers or in the complete absence of a teacher, has been used in some countries to counteract the teacher shortage through the efforts of a comparatively small number of competent broadcasting personnel and trained educational experts. Where a school system is not yet developed, where building equipment and teachers are lacking, both radio and television are cheaper than the rapid establishment of the conventional school system, and they are able to provide immediate educational services to a wider audience.

There is an acute shortage of radio receivers in Asia and Africa. This was mentioned at the scientific and technological conference of the United Nations in Geneva last year, the main reason for this shortage being their high price, the nonavailability of electric power, and the inadequate coverage of broadcast programs. The ITU, in cooperation with UNESCO, is now studying the two recommended specifications and their design using transistors on a large-scale production. The aim is to produce these in the less developed countries, and so expand industry in these countries as well.

Why have there been such rapid advances in the science and technology of communications? What has brought it to the present degree of excellence? It has not been sheer inventiveness and imaginative engineering entirely. It has been by the determined effort to understand the nature of communications, the qualities in man that lead to the ability and need to communicate, the basic laws of nature, the government communication systems, the solid state components with their reliability and miniaturization, these all tend to improve our efficiency. Problems associated with the limiting rate of communications, the noise factor, distortion, attenuation, all these problems that have constantly been under examination in the laboratories.

Other problems that have accelerated development have been the rapid population growth, the constant need, the constant pressures all the time, and the complexity of it all. These have all led to the development of modulation, repeaters, all sorts of long-distance equipment, multiplexing techniques, coaxial cable, microwave equipment, satellites, new wave guides on our cables, the time assignment, speed, and all techniques possible to get the ultimate capacity out of the one length of line because our high frequency radio spectrum is so crowded. With these developments, no part of the globe is inaccessible. It is therefore up to the scientists and the engineers of the future to bridge the gap between the developing countries as we advance, if we are to establish global communications and mutual understanding in the world of tomorrow.

Now, what of the type of engineers? The vast bulk of engineers and scientists needed now differ little from their prewar forebears except that they would be required to operate in more specialized or functional fields in common with other strata of society. They require a higher standard of academic qualifications, higher mathematics, specialized knowledge of computer programming, data processing and other techniques. Outstanding intellects among the younger professionals will require experience in several fields to equip them for senior positions with an overall appreciation of the facets of network or systems engineering which I have not mentioned very much. All these will be essential. The lowest specialist levels will become increasingly concerned with precision engineering, while executive levels would be concerned with problems of coordination and balance of activities as a whole. That is the communications situation as I see it.

Summary of Session III

FOCUS ON INDUSTRIAL AND SOCIAL NEEDS

Mrs. Jacqueline Juillard
Free-lance Journalist and Scientific Documentalist, Battelle
Delegate of the Swiss Society of Engineers and Architects (SIA)

We have heard four international colleagues speak about industrial and social needs; it is evident that such needs could not, nowadays, have been examined otherwise than on a world-wide basis. For, if it is true that in the past frontiers would have hindered development in this field, this is more and more so today with the need for international cooperation amongst engineers, scientists and many other specialists to further such developments.

Transportation and communication are as old as man himself; he makes wide use of both for social contacts as well as for economic and industrial development. However, neither transportation nor communication would have reached the breath-taking pace it has today, if power, heat and light had not been developed concurrently, while pollution is an unfortunate consequence of this general rise in the standard of living. The latter is a heavy toll to pay, and this field has therefore become a vital new activity for scientists, engineers and economists the world over.

Madame Vuillemin and Mademoiselle Barbe from France have given us a bird's eye view of the transportation development through the ages and its problems in the near future. Personally, I would have welcomed a few figures to emphasize some facts here and there. However, two essential "motors" (taken figuratively) of transportation have well been put in evidence: they are the WHEEL and the ENERGY. Without these, transportation such as it is today would not exist.

While the wheel is not essential for communication, energy is. This energy is of course in the form of electricity to power the various equipment required in communication. Our Australian colleague, Miss Olwen Wooster, describes communication as "a vital nervous system of the modern world", which is a very good representation of the importance of this field today. An emphasis was given to telecommunication which represents a link between communities through electromagnetic systems, and the International Telecommunication Union (named as such in 1932) was mentioned. But we must not forget that before Edison and his followers, communication existed in an ordinary written form carried to and fro between communities, but taking sometimes months instead of seconds. As a matter of fact, the Universal Postal Union was founded in 1875. However, in the future we need still more direct and rapid contact with other human beings wherever they may be. World systems are therefore to come about soon -- with what I would call the home and office world-dialing system with world numbers -- through the development of Telex services, that of data processing and dissemination as well as with systems of image and sound transmission to alleviate, for instance, illiteracy and to sometimes substitute for the schools themselves. Miss Wooster pointed out that among the main technologies that have permitted or will help to bring about such developments are the coaxial cable, microwave techniques, and transmission by satellites, as well as computer switching techniques. But, however advanced these techniques may be, without energy we could not use them.

If I may generalize: we know that energy is one of the essential keys which has opened the door to our present standard of living; -- so much so that the energy resources of our earth and its surrounding space are a constant preoccupation to the economist of today, while the necessity of research into the various means of converting these resources into usable supplies such as power, heat, and light spurs the imagination of engineers and scientists into conceiving a great variety of developments. These two aspects of this problem, energy resources and energy supply, were brilliantly examined by our English colleague, Miss Cecily Thompson, with a detail of facts, figures, and references that rejoice my down-to-the-earth technical mind. The subject was thoroughly examined and terminated with a conclusion on our future manpower needs as well as on the standard required for engineers and scientists. Her opinion on this quality is very near to what I myself have been thinking for some years now; I shall emphasize it in my conclusion of this summary.

Last, but unhappily not least, is the very important problem of environmental control examined by Mrs. Anneli Hattari from Finland. In two main chapters, water pollution and air pollution, all aspects of this burgeoning problem of the 20th Century were examined, including the so feared artificial radioactive fall-out, although no mention was made of the natural radioactivity which has always existed. I would also have liked to hear about the important international cooperation this pollution problem has brought into highlight over the last decade. For this is a development that again has no frontiers, so that analytical and measuring devices as well as control means must be thoroughly standardized in order to be effective in this field, and more so than in any other one. The types of engineers and scientists needed should be mentioned: apart from the devisers of analytical and control equipment, the future men and women active here will consist essentially of chemists, biologists, zoologists, botanists, etc. In other words, they will consist of specialists dealing mainly with nature and not so much with heavy machinery or electronics, although the civil engineer, sometimes called sanitary engineer, dealing with sewage and waste disposal must not be forgotten.

Now if we consider our ability to develop in the future the four aspects of industrial needs examined here this morning, I think there is one main problem in common: the <u>scientific education</u> of the world's future engineers and scientists, and <u>what is the best way</u> to bring about an effective and adaptable education in the vast and varying fields of science and technology of today? In this respect, I entirely agree with

Miss Thompson. Forming scientists and engineers at the college and university level should be emphasized in fundamental principles, and I would add culture, rather than in specialized fields of technology. We must find a way to upgrade the general level of the scientific and engineering world; colleges should offer more education towards maturity and less professional training.

The latter is the next step and is automatically accomplished and acquired in the professional life with much better results if based on good sound fundamental scientific and engineering education. This is in my mind EDUCATION and not TRAINING, for we must have people capable of understanding problems in their broadest perspective, able to foresee the implication of problems and solutions. This has always been one of the endeavors of our old Europe, though culture is lacking today to some extent. However, this is possible only if these, let us call them highly educated men and women, can base their professional activity on solid technological assistants or industrial middle class, built up by a wide net of technicians, draughtsmen and specialized workers. Such a basis, for instance, is greatly lacking in countries being developed, but it is well in operation in my country, Switzerland, as well as in the Western World. Our future engineers, if they want to be so called, must therefore be technicians.

I would like to conclude by adding a very personal thought: while I was at school learning, as a very young girl, about past scientific and technical discoveries and inventions I always thought I was born too late, everything had already been invented. But since then, and today especially, the generation of my three daughters has yet an unknown and thrilling supply of experiences to live for. It is the duty of the men and women of our generation to guide this next generation intelligently towards these experiences.

WELCOME FROM THE STATE OF NEW YORK WOMEN'S PROGRAM

By The Honorable Guin Hall
Deputy Commissioner, Woman's Program
New York State Department of Commerce
(Presented at the New York Luncheon, Thursday, June 18, 1964

On behalf of the Woman's Program of the New York State Department of Commerce, I am happy indeed to welcome participants in this First International Conference of Women Engineers and Scientists. Among the responsibilities of the Woman's Program is that of encouraging girls and young women to make full use of their brains -- and this impressive gathering of women who work as engineers and scientists all over the country and the world is a splendid example of what women <u>can</u> do and an inspiration to women and girls everywhere.

One reason the Woman's Program encourages girls to aim toward the best career of which they are capable is that most of them will, at some time, work. It is a trifle difficult to convince a high school girl that even though she marries her Prince Charming the chances are 6 in 10 that she will sometime <u>have to</u> or <u>want to</u> work. In New York State, 2 1/2 million women, more than one-third the total work force, are gainfully employed. (I am happy to report that the number who earn over $10,000 a year is double the national average.)

Another reason we want our girls to achieve their greatest professional potential is that, being part of a Commerce Department, we are aware of the careful planning and preparation essential to meeting the demands of the state's continual development. New York is a busy state -- it leads in almost every economic measure: 16% of all manufacturing establishments in the country, 14% of the wholesale firms, a tenth of the nations's retail stores are here. We produce over one-third of all apparel and furs, and lead in production of photographic equipment, printing and publishing. Industrial giants whose names and trademarks are recognized throughout the world are located here.

Research, scientists, and engineers are a necessity in a state as industrial as New York. Many authorities -- including yourselves -- have emphasized that men alone cannot fill the great need in these fields -- that it is essential for <u>girls</u> capable of being engineers and scientists to enter these careers. The Society of Women Engineers is to be greatly commended for their outstanding work and accomplishments in encouraging talented girls to enter the engineering field. Dr. Beatrice Hicks has pointed out that every thousand women entering the labor market must take with them enough engineers and scientists to support their participation in the work force. So, both from the standpoint of the state's economy and progress, and in the knowledge that girls are being helped to realize their full professional potentials, we heartily endorse your Society's excellent work.

Actually, it would seem to be engineers and scientists who prod the world into progress. Monday, many of you visited the World's Fair. Twenty-five years ago another World's Fair occupied that exact site. What were its marvels - not yet reality? A television set, mock-ups of highways with clover-leaves, a computer -- all products of scientific and engineering knowledge and vision -- and all, by now, a casual part of everyday life. Judging from this present World's Fair, your engineering marvels will, in twenty-five more years, have us in undersea hotels, in jungle motels made possible by a tree-eating pavement-laying monster, and we'll probably be flying to the moon in super-supersonic planes!

I hope, now that you are here, that you will visit other parts of New York State because, although it is an industrial and business giant, it also has large open spaces -- mountains, lakes, seashore, farmland, and vineyards. As the map in your kit shows, there are roads leading everywhere; our 500-mile Thruway, the world's greatest superhighway, leads to the nation's biggest big of its kind: Niagara Falls.

May I say in closing that although I am sure not one of you here is at all concerned about public appreciation for your achievements -- since I know each of you finds in her work the deep satisfaction derived from doing what you like to do and doing it well -- you all must enjoy the sense of accomplishment inherent in building forward, building new. But we do appreciate your accomplishments, and for prodding the world into progress, thank you.

THE UNIVERSITY AND THE ENGINEER

By C. C. Furnas
President, State University at Buffalo, New York
(Address presented at the New York Luncheon, Thursday, June 18, 1964)

It is commonplace now to characterize the latter half of the 20th century as the time of the Second Industrial Revolution, or the era of the new Science and Technology, or by other trite phrases. Whatever the labels, there is no question that the application of new research findings during the past 25 years has had a profound effect upon our whole industrial and economic structure. The shock waves of the new technology are just beginning to be felt and the significance is just beginning to be realized.

A number of the impacts are very evident and their significance is profound. I would classify the most important ones as follows:

1. In quantity as well as in importance, research and development activities have swollen beyond all predictions of a generation ago. The amount of effort expended on research and development in the United States, as measured in constant dollars, increased by some twentyfold between 1940 and 1962. In that same period, the amount of research carried on in universities has increased by some fifteenfold. In the field of national defense the corresponding figure was a one hundred fiftyfold increase since 1940. The amount of money which will be spent on research and development during this fiscal year in universities, research institutes, government laboratories and industry will total approximately $19 billion. This is a huge mass of scientific nutriment to be swallowed in 24 short years, much less properly digested. In short, research and development is now Big Business, throughout all of our institutions, and will probably continue to be so. At the moment it appears that expenditures may be in a leveling-off part of the cycle, but this may only be temporary.

2. There has been a steady and striking increase in productivity per man-hour in industry, brought about in no small measure by the sweep of automation.

3. Scientific information and mechanical devices have been brought to bear upon that most ancient of occupations, farming. In our country only about seven percent of the labor force are engaged in farming. At the time of the American Revolution, less than 200 years ago, probably 90% of the population were living on and getting their livelihood, such as it was, from the farm.

4. There has been a massive and continuing movement of the population toward the great urban complexes of the world. This, of course, brings about a few social problems, particularly those of unemployment among the uneducated and unskilled.

5. The major engineering and industrial tasks are far more complex than they ever were in the past. They are, for the most part, of interdisciplinary character. The former rigid walls between the traditional disciplines are now permeable membranes. The electronic engineer works with the physiologist to develop a minute instrument for the improvement of human health. The nuclear engineer burns the midnight oil over the same desk with the physicist to develop improved power plants for domestic use. The mathematician who has specialized in operational research, the sociologist and the civil engineer team up in a university institute to determine a valid approach to urban redevelopment. The engineer, if he is engaged in the constructive work of pushing technology forward, must have much more scientific background than he ever had before. He must also learn to work with scientists and vice versa. However, the engineering function is still basically the same as it has always been--that is, organizing complexities, taking information from various sources to produce a device or material or a system that will perform in an optimum manner. That is the design function.

6. Because of the very rapidly swelling and ever-changing reservoir of basic science knowledge, and the increasing complexity of its application, the traditional educational background in science and engineering becomes inadequate or obsolete very rapidly. It is this point that I wish to emphasize in my remarks.

There are some outstanding examples in this country of districts or regions which have been in the forefront, or on the crest of the wave if you prefer, of the new science and technology. The economic benefits to such regions have been striking and great. There are at least three famous examples, all centered around high-powered university nuclei. They are: (1) the Boston area, closely coupled with the Massachusetts Institute of Technology and Harvard University; (2) Southern California, with its California Institute of Technology, University of California at Los Angeles, and an able assist from the University of Southern California; and (3) the peninsula of the San Francisco region, bounded on one end by the University of California at Berkeley and on the other by Stanford University at Palo Alto. These three regions are currently outstanding because they are the foci of amazing vitality within the framework of the technological revolution.

For at least two decades it has been very fashionable for major industries to give at least lip service to the idea that their well-being and their future depend upon a sound research and development program. Even the Wall Street operators have begun to feel that there is probably something to the idea.

The three regions I have mentioned have been closely observed under the economic and industrial microscope in the past few years, and the idea has been repeatedly advanced that a strong university, or university complex, is at the heart of flourishing industrial communities. Hence, many draw the immediate conclusion that the only thing that is required to assure industrial, and hence economic, health is to establish a strong university. Then industry will flourish as the rose, and life will be beautiful and prosperous.

Unfortunately, the matter is by no means as simple as that. If one examines the three regions that I have mentioned, he will find that there are four very important and necessary variables:

1. At the nucleus is a strong university structure devoted to the advancement of human knowledge.

2. Each is in the midst of a medium to large urban complex (industry does not develop in a vacuum).

3. Substantial, varied and continual applied research and development activities are vigorously pursued in the geographical area, more or less closely linked to the university's faculty and graduate school.

4. Financial support for industrial growth has been made available through government financing, through risk capital for industry and/or through enlightened long-term investment by existing industries.

In the Boston area the bridge of application was built around the MIT Radiation and Instrumentation Laboratories during World War II. Subsequently the Lincoln Laboratories, the MITRE Corporation, and several others provided the strong links of the chain.

In Southern California the solid rocket work at Cal Tech led to the formation of Aerojet Corporation. The Jet Propulsion Laboratory is a continuing source of applied research ferment. There are many other and continuing collaborations between the universities and the various aerospace industries.

Along the Berkeley-Stanford axis nuclear and high-energy physics and sophisticated research on electronics during the war blossomed into a multitude of applied research and subsequent industrial developments.

At least to a certain degree these three regions I have mentioned have indicated the direction and at present are certainly setting the pattern for those who are doing serious planning for encouraging the growth of modern industry. It is to be noted particularly in these cases that the spectrum of activity goes the distance from basic research in universities on through the collaborative phase between scientists and engineers to the ultimate end of production development, which is largely in charge of the engineers.

It would not be appropriate for me to seem provincial in addressing an international conference but I do have a certain amount of regret that up to now New York State, as a whole, has not adapted its industrial pattern as well as it might to the newer technologies. This may be the case because of accidents of history, or there may have been other reasons. At least the situation is worthy of a brief analysis.

New York State certainly has the basic ingredients for the front position in the new industrial era. It has great cities, great national industries and an extensive matrix of great institutions of higher education. In the academic year 1963 to 1964, some 70,000 degrees were conferred by the 202 institutions of higher education in the state, including 13,000 masters and 1,700 doctoral degrees. New York State has consistently led the nation in the number of bachelors, masters and doctoral degrees conferred. In the decade of 1950-60, New York State institutions gave 16% of all the doctorates awarded in the United States even though we have less than 10% of the population.

A recent study indicated that there are approximately 150,000 scientists and engineers in New York and an equal number of supporting personnel in technical occupations. There are almost 1,200 research and development laboratories in the State, many of which are utilized by smaller business concerns which do not have full-time research facilities of their own. According to the latest nationwide directory, there are almost as many industrial research laboratories in New York as in the next two leading states combined.

With all this background, why isn't New York in the fore on <u>all</u> fronts? I do not insinuate that New York is doing poorly within the framework of the new technology--I am only suggesting that it should be able to do better. In the parlance of the great American game of baseball, it needs to 'bunch its hits'. We have been a little slow in developing that strategy.

Now, however, there are some examples which indicate that a new era of foresightedness is beginning, particularly in spots of close cooperation among universities, government and industry. New York State may well furnish a fine case history for the future of what vigorous self-help can accomplish.

Four years ago the Polytechnic Institute of Brooklyn established a graduate division at Farmingdale, Long Island, and is working in very close cooperation with the aerospace and electronic industries in that area. For several years Rensselaer Polytechnic Institute has been giving higher educational assistance to the sister state of Connecticut through its graduate division at Hartford. New York University is building up a research park activity, in close cooperation with industry, at Sterling Forest, some 40 miles north of New York City.

In 1958 an Office of Atomic Development in the Executive Branch of the State Government was established. In 1959 this agency, which had contract authority, supported the University of Buffalo on a matching fund basis to establish the Western New York Nuclear Research Center on the University campus, the principal research tool being a modern one-megawatt research reactor. This activity has been progressing very successfully ever since.

Directly and indirectly, because of this Nuclear Research Center, a major new industrial development is going forward in the western end of New York State. A new agency, the Atomic Research and Development Authority, was established for the purpose of actively promoting the peaceful use of atomic energy through the structure of private industry. As a result, a new private corporation was formed--Nuclear Fuel Services Inc.--a wholly owned subsidiary of the W.R. Grace Company and American Machine and Foundry. That company is now in the process of building a $30 million industrial plant in Cattaraugus County for reprocessing nuclear fuel from research installations and industrial power plants. This is the first example of private industry entering into this extremely important activity which will mean so much for the peaceful use of atomic energy. Prior to this time, all the fuel reprocessing has been done at Atomic Energy Commission installations.

In addition, the Atomic Research and Development Authority has recently established a complete Space Technology and Atomic Radiation (STAR) Center at Malta in Saratoga County. It is also planning a nuclear-powered desalinization plant for Long Island, which will produce electric power as well as fresh water.

During its Spring 1964 session, the New York State Legislature accomplished the following by the passage of three important bills:

1. Established two truly top-level Regents Professorships with supporting funds of $200,000 annually. These are to be known as the Albert Schweitzer and the Albert Einstein Chairs. Either public or private institutions may be chosen as recipients. Over a five-year period, the program will be expanded to include ten such chairs.

2. Funded the newly-formed New York State Science and Technology Foundation with $500,000 so that organization may make a modest beginning in supporting important new research.

3. Established a small fund for a pilot plant project for the study of the development of regional scientific libraries. In anticipation is a centralized network of machine-processed library operations for evaluation, machine-coding, storage and retrieval of scientific information among a large number of libraries. Such a system will greatly increase the effectiveness of research and higher education.

These are merely samples of fermenting activities which may produce a very potent brew in the future.

In my opinion, the combined activities of universities, industry and certain arms of the government will prove highly beneficial within the next few years, not only to the economic well-being of certain regions but also in continually pushing forward the frontiers of knowledge, both basic and applied. However, this cannot be accomplished if the pattern of higher education simply stands still and only adheres to the structure of the past. It is of ever-increasing importance that there be an enlarged pattern of so-called "continuing education" in order that the engineer in the industrial plant, or the Ph.D. who got his label some ten years ago, does not find himself suddenly outdated and obsolete. Continuous contact with the wavefront of advancing knowledge and ready means of updating are obviously going to be necessary for those engineers and scientists who hope to stay in important spots in the forward thrust of technology.

The necessity for ready availability of continuing education has become very evident indeed to the defense and space industries, particularly during the last decade. A few of the larger national corporations are, within their own framework, providing such continuing education, but this fills only a small fraction of the need. Even in the case of those national industries, there is still call for close cooperation with the very best university faculties. Small and medium sized corporations have entered into the picture but very little, if any. The process is expensive and complicated, and it takes full cooperation of universities and government, as well as industry.

It is interesting to note that the Sloan Foundation recently made a $5 million grant to MIT to set up a pilot plant, or experimental operation, in continuing education for high-level scientists and engineers in order to arrive at the optimum pattern, not only for the type of education needed for updating scientists and engineers, but also for the best cooperative pattern with industry and with government. In the Spring of 1964, Polytechnic Institute of Brooklyn carried out a successful, intensive, three-week refurbishing course for middle-management engineering and scientific executives.

In 1959, Governor Rockefeller established the New York State Advisory Council for the Advancement of Industrial Research and Development. This organization, the members of which are appointed by the Governor, comprises some 45 leaders of State Government departments, New York State industries, and universities. It has been exploring the possibilities of continuing education through a series of conferences. One of these was held at Sterling Forest, another at the Graduate Branch of the Polytechnic Institute of Brooklyn at Farmingdale, a third one was held at Columbia University last fall, and the next one will be held at the University of Rochester in November. No specific definitive action has come from these conferences as yet, but certainly these meetings have been very valuable in preparing the seedbed for a number of continuing education activities which I anticipate will be forthcoming in the not distant future.

A great deal of national attention is being paid to the role of education in our economic well-being, particularly since President Johnson declared his War on Poverty. However, nearly all the attention (perhaps rightly so at this juncture of our economic history) is being paid to the plight of the high school dropout, the craftsman who has lost his job because he has been replaced by a machine, and the educational obsolescence of those at the lower technological levels. However, it appears to me that in the long run it will be necessary to have greatly increased emphasis on and support for major participation by universities in cooperation with industry to develop comprehensive and widespread continuing education programs for our higher level scientists and technologists, in such places and in such a manner that they can take full advantage of it without stopping their professional careers.

In my opinion, this must become a major responsibility of state government, particularly state universities. In New York State we have a unique opportunity, in the not distant future, for carrying out a major program. This is because New York State has a quite young State University which is in the growing and viable stage.

Curiously, for reasons which may now be obscure, New York was the last state in the nation to establish a State University. This event took place in 1948. At the present time State University is not a single institution, in the tradition of the Midwest states; rather it is a wide-spread federation under a single board of trustees embracing some 58 different educational institutions ranging from two-year technical institutions to liberal arts colleges to teachers colleges to medical schools. Four major graduate centers, built around large and comprehensive undergraduate bodies and professional schools, are in the plan--one at Stony Brook, Long Island; one at Albany, New York; one at Binghamton in the Southern Tier; and one at Buffalo, New York. The one at Buffalo came about by the merger in the Fall of 1962 of the then private institution, the University of Buffalo, into the State System. The official name of the institution is now State University of New York at Buffalo, and it is the only comprehensive university in the State University system to date.

State University at Buffalo is starting this Fall on three small pilot continuing-education programs for industrial scientists and engineers, supported by and in close collaboration with individual industries. These three programs are as follows: at Corning, New York, supported by the Corning Glass Company; at Wellsville, New York, supported by the Worthington Corporation and the Air Preheater Company; and at Buffalo, supported by the local chapter of the American Society of Mechanical Engineers and the Bell Aerospace Company and the Cornell Aeronautical Laboratory Inc.

These programs will involve intensive work at the graduate level, particularly tailored for the group, to bring the various individuals involved as up-to-date as possible in the newer funds of applicable knowledge. Naturally, it is my hope that this activity will expand and that before many years it will receive major attention and substantial support from public funds. Such programs should be carried out not only in State University institutions but also--perhaps on a matching fund basis--at private institutions throughout the State.

If this trend toward intensive continuing education is successful in New York, it could well be copied, with appropriate modification, in other regions of the country and should eventually be of inestimable benefit to the whole nation. Perhaps experience here could serve as a model for similar experiments in other lands.

I felt it was particularly appropriate to point out these trends and to emphasize the importance of continuing education to this conference of women engineers. I note that one of the four principal objectives of the Society of Women Engineers is "To assist women engineers in readying themselves for a return to active work after temporary retirement." I assume that the 'temporary retirement' refers, more often than not, to the initiation and initial rearing of a family, which is a noble and necessary objective. However, we must face the fact that no matter how brilliant and capable a women engineer may be, if she withdraws from active participation in the profession for an interval of five to ten years, she then has a major handicap to overcome in getting back into the mainstream of affairs. This is particularly true now when the fund of knowledge is advancing and changing with extreme rapidity.

I feel it is a matter of major importance, not only to individual women engineers but to the profession, to industry and to the nation, that something be done in a major way through the structure of public and private universities so that those who have been in 'temporary retirement' may have the opportunity to renew and update their fund of knowledge. Thus many women engineers would be enabled to continue to be happily engaged in constructive work and also make major contributions to our scientific, industrial and economic advancement. As long as the present figure holds, that less than 1% of our engineers are women, it is obvious that there is a crying need. I feel that State University of New York can, and by all means should, give serious thought to and provide adequate support for such a program for women engineers which would probably need to be tailor-made. The special character of the program would make it all the more interesting and all the more important.

Thursday, June 18, 1964

2:30 P.M. - TECHNICAL PROGRAM SESSION IV

Needs of the World's Standard of Living

Chairman: Dorothy M. Cridland, President, The Women's Engineering Society, London, England

Moderator: Ivy M. Parker, Research Engineer, Plantation Pipe Line Company, Atlanta, Georgia

URBANIZATION FOR THE FUTURE--Elizabeth J. McLean, Traffic Engineer, Department of Streets and Sanitation, Chicago, Illinois

MANAGEMENT OF OUR NATURAL RESOURCES--John H.M.S. Miller, Deputy Director, National Research & Technology Study, Dublin, Ireland

THE IMPORTANCE OF LANGUAGE AS A MEANS OF COMMUNICATION FOR SCIENCE AND TECHNOLOGY--Dorothy U. Mizoguchi, Consultant for Scientific Documentation and Chief, Cancer Chemotherapy, Information Center, Cancer Institute, Tokyo, Japan

THE OCEAN--CRADLE OF LIFE AND CHALLENGE TO SCIENTISTS--Zinaida A. Filatova, Professor and Oceanologist, Academy of Sciences, Moscow, U.S.S.R.

Summarist: Shirley A. Holmgreen, Aerodynamicist, Airplane Division, The Boeing Company, Renton, Washington

URBANIZATION FOR THE FUTURE

by Mrs. Elizabeth J. McLean, P.E.
Department of Streets and Sanitation
City of Chicago, Illinois

INTRODUCTION

This paper on "Urbanization for the Future" has been prepared for the First International Conference of Women Engineers and Scientists. Its essential purposes are (1) to illustrate the job opportunities in fields concerned with providing an adequate urban environment for the ever increasing demand; (2) to indicate the present and future challenges in solving the problems of the world's cities; and (3) to stress the importance of training persons who can skillfully cope with all areas of development and redevelopment of urbanized areas.

Observations, conclusions and recommendations, are based primarily on the author's experiences in planning for the City of Chicago her participation in community activities, and her residence in an urban renewal project.

The views expressed herein are the author's own and do not necessarily reflect those of organizations with which she is associated.

THE STATE OF URBAN CENTERS

The urbanization of society is the most important single phenomenon of the 20th Century. In the first half of the century, the urban population of our globe became a majority of mankind. In 1900 40% of the 76 million people living in the United States lived in urban areas; by 1960 the population had increased to 180 million with two-thirds living in urban areas. It has been estimated that by 1980 the United States population will be in excess of 245 million, 75 percent of which will reside in urbanized areas.

The urbanization of the world has brought with it social, cultural and economic progress. It has meant a more urbane way of life, better education, more comfort, and increased leisure time for the vast majority of people. It has also generated a desire for the enrichment of the amenities of the urban scene.

The urban population has expanded more rapidly than the ability or inclination to accommodate it at standards acceptable to an increasingly sophisticated populace. Chicago, for example, in the 100 years from 1850 to 1950, grew from a city of 30,000 to a metropolitan area of 6.2 million people. Estimates now indicate that we may expect a metropolitan population of 9.5 million by 1980.

The early stages of development of the United States were based on a desire for freedom, the struggle for survival and a quest for happiness. The years have brought an astronomical increase in population, technological wonders, cultural advancement, educational opportunities for all, unsurpassed income level and purchasing power, availability of luxuries to almost everyone, more leisure time, extensive systems of communication, and the congregation of the majority of the people into great urban centers.

These advancements have generated an evolution of objectives from the attainment of basic essentials to a desire for comforts, opulence and excellence. The goals of society have changed, and so has the wherewithal for realizing them. Skillful manipulation and conservation of our resources can result in an approximation of excellence which generations before us never dreamed of. This is our challenge!

Many aspects of the urban scene must receive attention if we are to provide "excellent" urban living for the present city dwellers and for the anticipated future increases.

Housing

One of the most important is housing. By present day standards, more than one-fifth of the people in the United States live in substandard housing. Of our 58 million dwelling units 15.6 million do not meet minimum acceptable condition criterion. More than 1.5 million dilapidated structures have been eliminated from our inventory in the last 10 years, but this rate must increase. In addition to eliminating substandard dwellings, the market for homes is increasing. It has been estimated that during the 1960's two million new housing units will be needed annually. The largest area of housing shortage is at the lower middle income level. Construction costs for housing for this large group have risen faster than incomes. Housing for the elderly also is a growing need augmented by the lengthening life span.

Recognition of the importance of housing has been illustrated by our government's legislative action and policy statements. The Declaration of National Housing Policy from The Housing Act of 1949 states: "The Congress hereby declares that the general welfare and security of the Nation and the health and living standards of its people require...the realization as soon as possible of the goal of a decent home and a suitable living environment for every American family". President Johnson, in his 1964 State of the Union message said in part "...and seek as our ultimate goal in our free enterprise system a decent home for every American family".

Corollary to housing is the post-war phenomenon, creation of suburbs. Each year more than one million acres of land in the United States are being urbanized. Exploding suburbia has been the subject of many studies, much conjecture, philosophical discussion, and dissertation. Criticisms have been many: Unethical real estate speculators have sold the unsuspecting market poorly constructed houses in communities lacking necessary public facilities. Poor site planning has resulted in deterioration of the countryside. Lack of public transit and low densities have made the private automobile the only feasible mode of transportation, thus increasing transportation costs and aggravating the traffic problem.

Unhealthy social conditions are caused by the economic, racial, educational and age segregation which exists in new suburban developments. Improvements to inadequate sewers, school systems, water supply systems, etc. necessitate tax increases which young families cannot afford. But it is likely that the demand for suburban type homes will grow. Young families desire new single-family houses with private open space at monthly payments within their means.

Recent new construction in central cities generally has been either for the very rich or the very poor. Public housing units are constructed for the very low income level family. High density apartment buildings and townhouses are built at prices which only the upper middle income or high income family can afford. Present financing practices dictate that the purchase of an old home in the central city requires a substantial down payment and a short mortgage with high monthly payments. Steps should be taken to assure that the best use is made of the existing housing supply, to see that new communities are provided with every feasible amenity, and to encourage urbanization patterns in which social values are recognized.

Population increase and emphasis on education have created problems for the school systems of most cities. Classrooms are crowded, buildings and facilities are obsolete, and proficient teachers are scarce. Costly improvements and additions are being made to most school systems, and more will be required to meet future needs. More than 40 percent of the Cook County real estate tax collected in Chicago in 1963 was allocated to the Board of Education.

Transportation

Second to housing, transportation is the urban problem receiving the most public and governmental attention. Vast quantities of federal funds have been earmarked for the Interstate Highway System which is now under construction. The popularity of the private automobile has increased traffic volumes on our streets and highways, and decreased patronage of mass transit lines. Transit companies can no longer operate their equipment and finance capital improvements to maintain attractive service unless they are subsidized with funds from other sources than revenue from passengers.

While vehicular speeds on most urban streets and highways are faster now than ever before in history, the public is demanding more efficiency so that the trafficways will reflect the capabilities of the modern automobile. Urban streets must accommodate not only moving vehicles but also the storage (or parking) of them in areas which were developed before the magnitude of the parking problem could be anticipated.

The transportation system can do more than any other single factor to influence the development and vitality of an urban area. Most experts in the field agree that a city's transportation system should be a balance between streets, expressways and mass transit facilities. There is no definitive agreement, however, on the quantitative emphasis which should be given each of these facets. The automobile is an unbeatable invention, but if the present trends of ownership and usage continue it could mean strangulation of most large urban centers. It has been estimated (based on trends) that the vehicle miles of travel in the Chicago area will double by 1980. This dictates an enormous highway construction program, mode transfer, or a combination of the two.

The automobile age and the growth of suburbia have supported the construction of large shopping centers, sited in park-like settings and surrounded by ample parking spaces. The shopping center boom has been to the detriment of the Central Business District of the central city and to the old neighborhood shopping streets. The resultant is a decrease in retain sales in the core city, vacancies in stores along strip commercial streets, general deterioration of old commercial structures, and loss of tax revenue to the core city.

Many cities are attempting to revitalize their downtown areas and their neighborhood shopping complexes. Plans include off-street parking, landscaping, modernization of merchandizing methods, and special mass transit service. It is generally agreed that strip commercial street development, as it is presently recognized, is obsolete. The transition from strip commercial to concentrations of shopping establishments must be properly controlled so that future shopping facilities are adequate to serve their planned market area and so that vacated strip commercial lands are redeveloped appropriately.

Automation and technological advances have rendered many of our cities' industrial buildings obsolete. The shift from employee transit riding to automobile driving has created parking problems which companies located in densely developed urban areas cannot solve. Central cities have lost many industrial concerns to suburban areas where inexpensive vacant land can be purchased in quantities sufficient to provide plant expansion, storage and off-street parking. The move to the suburbs has injured the tax base of the central city, and it has not always been the panacea for the industry. Labor forces are not readily available in suburban areas, choice of transportation methods and routes is limited, and taxes are frequently higher.

Most American cities are concerned about the exodus of industry and are attempting to develop methods for attracting new industry and retaining the existing. In Chicago, the Mayor has appointed a Committee on Economic and Cultural Development which has solicited requests for help from industries that have problems. In many cases through the cooperative efforts of several City agencies, parking problems can be alleviated, streets can be vacated or rearranged to provide expansion space, zoning problems can be solved, or neighboring industrial companies can be organized to work on joint solutions to their problems. This activity, though relatively new, has been instrumental in keeping several companies within the City of Chicago.

Recreation and Aesthetics

Recreational and public open space are of concern to those who are interested in creating urban areas that will satisfy the aspirations of the future city dweller. Automation and efficiency have decreased working hours, increased leisure time, and increased income available for recreational activity. Population increases will bring about requirements not only for more recreational space but for more varied types of activity. Parks, zoos, boat mooring space, picnic areas, fieldhouses, and the like are already overcrowded. Urbanization and educational levels have given rise to a demand for more cultural facilities. It is particularly important that public open space be set aside in outlying vacant areas where future urban development is expected.

Urban aesthetics defies definition and legislation, and has been grossly neglected by city builders. We have allowed our cities to become cluttered with gawdy billboards, exposed utility lines, row after row of unimaginative identical housing units, run-down stores and unsightly factories belching air pollution. As more and more land becomes urbanized, some form of aesthetic control becomes imperative. While taste cannot (and should not) be legislated and while both design freedom and variety are desirable, some of the common and basic unsightliness, such as overhead electric lines and dilapidated commercial structures, should be eliminated through legislation and enforcement.

Concern for human relations has become more obvious in recent years. Civil Rights Bills, open occupancy legislation, freedom rides, and racial riots are the subject of frequent front page newspaper stories. Of particular concern is the Negro problem. Negro population in the large northern cities is increasing while the White population decreases. The Negro middle class is growing at a rapid rate, but the White middle class with which they might assimilate is drifting off to the suburbs. It has been almost impossible for the middle class Negro family to obtain housing in White suburbs. "Panic peddlers" and fear by the White middle class families have resulted in little integration of inner city neighbors. However, several middle income urban renewal housing projects are serving as examples of the harmony which can exist when middle class White and Negro people share the same neighborhoods.

Acclimation of low income minority group families to urban living is even more difficult. Many poor Negro and Spanish speaking families have never been exposed to the ways of the city. Modern sanitary facilities, cleanliness and social laws are not understood by the first generation of city dwellers. Lack of regard for property and exploitation by slum landlords keep these families in overcrowded slums at unreasonable rents they cannot afford. Diminution of jobs for the unskilled means many minority families are at the mercy of welfare subsidies. Public housing projects have provided safe sanitary homes for many low income families, but the problem is larger than the availability of funds, and even housing cannot make the situation ideal. Education for useful work and for acceptance of higher values, equal freedom of choice of housing and neighborhood, and equal opportunity for advancement are necessary before the racial problems of urban areas can be solved.

Automation and efficienty have decreased the manpower required to produce the necessities and luxuries that will supply our market. Unemployment is the resultant. The unskilled labor class is, of course, hardest hit. It is paradoxical that unemployment exists while there are still such shortages in technical, scientific and professional fields. Many cities are now initiating programs to train the unemployed for skilled jobs. Industrial concerns are working with schools to provide work-education programs for high school dropouts. Expanded educational opportunities for all are also exigent.

Taxes assessed against real estate are steadily increasing in most American urban areas. Public facilities in older cities need replacement, improvement, and/or extension. The booming population of most suburbs necessitates new facilities or enormous expansion of existing facilities. As the population grows, the number of employees required to serve the public must also increase. Construction costs and wage levels are much higher than they have been in the past. All of these costs must be paid by the urban tax payer. Municipalities must seek to balance their economic bases by attracting and retaining healthy industry and commerce as well as variety in residential facilities. Tax payers must realize that their quest for improved public services means payment of commensurate taxes.

City government has become increasingly more complex as urban populations grow and urban problems are augmented. To perform its duties within a budget which will be accepted by the tax payers requires that city government be one of the most skillfully managed organizations. In fact, considering the obstacles to be faced, most city governments are indeed better managed than many large corporations. The City of Chicago government includes some 50,000 employees involved in such diverse activities as city planning, street sweeping, budgeting, garbage collection, air pollution control, traffic engineering, building maintenance, police protection, bridge design and construction, fire fighting, building code enforcement, water distribution, tax collection, urban renewal, education, licensing, zoning code enforcement, electrical wiring, airport construction, architecture, youth welfare, public health, street paving, sewer construction, office management, forestry, public safety, purchasing, human relations, law, libraries, mapping, movie censorship, port development, parking, rat control, relief payments, social work, and many more.

Maintaining a competent staff of public servants, especially at professional levels, has been difficult in most American cities. Salaries have been low, and the exaggeration of political corruption and inefficiencies have discouraged many talented people from accepting employment with a governmental agency. Improved general awareness of political processes and more widespread appreciation of the tasks required of public agencies have begun to change the image of the public servant. In addition, salary schedules are being revised to be more competitive with private industry. There have always been able city employees who have dedicated their services to the public in spite of existent obstacles, and changing conditions are resulting in an improved government service image which now attracts employees.

Effective city government requires the understanding, confidence and cooperation of the residents of the community. Execution of public affairs is everyone's responsibility. The masses must realize the importance of their role, and expend the time and energy necessary to participate. Public agencies, on the other hand, must accept much of the burden for educating the public concerning the rationale behind public objectives, methodology of accomplishing goals, and, procedures for participation by residents of the community. Much effort must be expended for this cause. Only its success can bring effective public programs which are actively supported, understood and appreciated by the citizens of our urban areas.

Urban renewal in American cities is presently a fashionable but not always well understood process. "The Federal Government first became interested in slum clearance in 1892, when Congress appropriated $20,000 for an investigation of slum conditions in cities having more than 200,000 population. Forty-five years later Congress passed the United States Housing Act of 1937, which contained limited slum clearance provisions. The Act provided for assistance to cities to build low-rent housing for low income families and included an "equivalent elimination" requirement under which cities had to remove one slum dwelling for every new low-rent public housing unit erected. The Housing Act of 1949, a bipartisan legislative action, broadened the authority of the Federal Government to help cities remove slums and blight and rebuild in accordance with sound planning. Since 1949, this legislation has been extensively amended and broadened in every instance with the support of both Democrats and Republicans, regardless of which party was in control of Congress or the White House. Throughout the country, more than 600 communities have undertaken some 1,300 urban renewal projects under the Federal assistance program."[1]

Since 1949 urban renewal with its subsequent modification has become one of the nations most vital urban programs. The objectives of urban renewal are to prevent slums through neighborhood conservation and code enforcement, rehabilitate structures and neighborhoods, and to clear and redevelop structures and neighborhoods. Through these objectives, cities hope to slow down the exodus of middle class families from the city and attract middle class families. Urban renewal is a locally planned and

1 From "20 Questions and Answers on Urban Renewal by U.R.A.", Housing and Home Finance Agency, Washington 25, D. C., February 1963

executed community improvement program using private and public resources including assistance from the Federal Government. Several types of renewal projects have been used to advantage in American cities:

1. Clearance of blighted residential structures for the construction of public housing units for low income families;

2. Clearance of slum areas for resale to private developers for residential construction in compliance with an urban renewal plan;

3. "Conservation areas" where public facilities are improved, buildings which cannot be rehabilitated are cleared, and property owners are encouraged to rehabilitate and/or maintain their buildings;

4. Clearance and conservation projects for commercial, institutional and industrial uses.

The urban renewal program has added millions of dollars of tax base to urban areas. In Chicago, for example, 19 million dollars in new assessed valuation has been added to the tax base through urban renewal. While urban renewal is concerned primarily with the provision of standard housing for urban dwellers, it has also provided the opportunity for amplifying other assets. Important traffic improvements have been made possible through widening rights-of-way in clearance areas. Rebuilding of neighborhoods has allowed revisions from obsolete street systems to modern efficient patterns. Parks and school expansions have been provided in renewal areas. Obsolete strip commercial areas have been eliminated, and commercial and industrial concerns have been provided with more compatible environs.

In spite of the many advantages, urban renewal is not always favorably accepted. Relocation of displaced persons presents many hardships. Property owners resist selling their properties for the better good of the public. Many residents are suspicious of public action and will resist any change of existing conditions. These problems are particularly obvious in "conservation areas" which are required by law to have active community organizations which must approve the renewal plan before it may be executed. Acceptance by the community means that many individual desires must be compromised and a plan must be devised which will get majority approval. This is usually a long and difficult task.

In addition to community involvement in urban renewal planning, the democratic process requires that each level of government thoroughly review, amend, and finally approve each urban renewal plan before any rebuilding action can take place. Governmental delays, administrative complexities and endless red tape frequently mean many months, even years between initiation of a project and execution. Urban renewal is and undoubtedly will continue to be the most effective means for rebuilding and/or improving our cities. It provides a vehicle for the coordination of improvement to public facilities, clearance of slums, and rebuilding of neighborhoods through public and private enterprise. Urban renewal philosophies and procedures will be revised in the future as they have been in the past. If the citizens of the city are to constructively participate in the rebuilding process, they must be allowed and encouraged to become more sophisticated concerning the needs of the urban area.

THE JOB TO BE DONE

Considering the tremendous growth of urban population and the momentous advances in technology, cities have done a remarkable job at keeping pace with demands. But anticipated growths and augmented expectations and standards will command vast revisions to the present urban setting.

It is expected that by 1980 the population of our major metropolitan areas will have increased by more than 70 percent. An estimated demand of about two million new homes annually will be needed to house this population increase. The proportion of young married families and the proportion of elderly will rise while the proportion of couples in their thirties, the suburban market, will decrease. Emphasis must be given to special housing for the aged and to moderate rent family housing.

Moderate income housing has been a neglected field. It was not until 1961 that the U. S. Housing Act was amended to provide incentives for the construction or rehabilitation of housing with rents appropriate for families in the $5,000 to $10,000 income bracket. This program is getting under way slowly, and an effort should be made to strengthen its provisions and to lessen the governmental delays involved in it.

Real estate developers have been reluctant to construct middle income housing, especially in the central city. This is due to the demand for high rent housing, high construction costs and the restricted use of new and different building materials. The area of new building materials and new construction material needs much exploration by those who are concerned with meeting future urban needs. In many instances, restrictive building codes have deterred much experimentation with construction methods, and this situation should be rectified as soon as possible.

The field of home financing must receive attention if the urban housing market is to remain fluid and healthy. Present practices favor the new suburban home to the detriment of resale housing, especially housing in excess of 20 years of age located within the central city. Minimal down payments and mortgage periods up to 40 years are big attractions to the home buyer in suburbia. Conservative mortgage houses must be convinced that investment in old neighborhoods is sound policy.

The enforcement of standards through building codes can do much to insure maintenance of residential units and eliminate exploitation of the underprivileged by slum landlords.

The future will require replacement or improvement of obsolete public facilities, extensions to existing services to meet the needs of the growing population, and additional public facilities to satisfy aggrandized standards. The successful accomplishment of this aspect of future urban needs will demand the ultimate of initiative and skill of those concerned. To establish an efficient and economic program for public services requires intelligent projection of needs, coordination between the various disciplines affected and modern flexible financing methods.

Transportation systems, for example, influence and are influenced by the patterns of residential, commercial and industrial development. The construction of transportation facilities can be much more economical if land use needs can be forecasted or controlled than if the facilities must be constructed to solve problems that arise after areas are developed. Transportation networks cannot be treated on an individual neighborhood basis, but must relate to entire regions if adequate communication is to be maintained. If, for example, an expressway is to collect traffic from an outlying suburb, the expressway must connect with other trafficways which lead to the desired destinations of the suburb's residents. If the work trip takes the suburb's labor force to the central business district of the central city, the necessary terminal facilities, such as parking lots, must be available. If too many outlying suburbs must rely on the private automobile for transportation, the central business district will run short of space for parking lots. Resultants, such as this oversimplified one, must be realized before committments are made concerning isolated portions of the transportation network.

Many transportation decisions must be made immediately if efficient, safe and convenient movement of people and goods is to be realized economically. What should be the balance between mass transit and private automobile usage? Should tax revenue be spent for subsidies for mass transportation? Should action be taken to encourage changes in the physical locational relationship between home and work so that the magnitude of the rush hour traffic movement is reduced? Can streets and highways be designed so that they are not detrimental to the neighborhood through which they run? And many more. Once agreement is reached on these matters, a program must be developed for construction. The program must be determined by coordination with land use development, priorities based on anticipated needs must be assigned, and funds must be made available.

The same sort of intricate relationships exist in the consideration of public open space, water supply, sewers, schools, fire and police protection and all other public services. Therefore, it is mandatory that the urban area have a comprehensive framework within which these facets may develop. The comprehensive framework, or the city plan, must reflect foresight concerning expected growth; it must be realistic so that it can be translated into action programs which will be supported and financed by the public; it must be detailed so that it will be an effective guide for public construction agencies and private developers; it must be authoritative so that it controls development in accordance with desired goals, and it must be flexible enough to allow revision as conditions require. These are the goals for our city planners.

One of the biggest problems facing urban areas is that of coordination. Most metropolitan areas are composed of many separate municipalities, each with its own government. In addition to the municipal administration, the County, the State and the Federal Governments have varying degrees of responsibility. Coordinating these activities plus private action is essential to the orderly development of the urban area. There are those who have proposed establishment of one super-government to replace individual municipalities. It is doubtful that this could be realized in the near future in most metropolitan areas. It is also doubtful that it would have as many advantages as proponents claim. Realization of and emphasis on the need for coordination eventually will result in the development of a vehicle for accomplishing the goals. All of us are responsible for seeing that it happens before the lack results in chaos.

There is evidence that urban renewal will play an increasingly dominant role in the future of our cities. We have long since passed the time when our old cities with all their problems could be abandoned in favor of building new centers of urban activity. Therefore, our alternative is to improve the existing physical plants. Urban renewal provides the opportunity for making many of the necessary improvements to urban neighborhoods. Renewal projects bring with them a concentrated expenditure of public funds to be used in revitalizing worn-out section of cities. The public expenditure in turn provides the incentive for private investment and civic pride. President Johnson has strongly recommended the establishment of a cabinet level post for the coordination of research, experimentation and action in the field of urban problems. It is likely that many revisions will be made to present urban renewal methods. One of the most important determinants of a successful program is a widespread understanding and realization of its importance.

Urban renewal was never conceived as the remedy for all urban ills. It provides cures for the deficiencies in the physical surroundings and as such acts as a catalyst in removing many social ills, but separate and concentrated effort is needed to solve such problems as juvenile delinquency, unemployment, lack of respect for property, etc. Human renewal must receive attention similar to that given customarily recognized urban renewal.

Aesthetic and cultural amenities of our cities will become more important as leisure time increases and as the population becomes more sophisticated. It is important that city builders and rebuilders seriously consider open space, landscaping, art, and other cultural activities. Even though complete facilities cannot be built now, land should be set aside for ultimate development for these purposes as the urbanized areas expand into the countryside. The automobile has brought with it the defacement of highway frontages with billboards and drive-in commercial establishments. While good taste cannot and should not be legislated, some action should be taken to control urbal developments so that some visual amenities are available to future generations.

The problems of intergroup relations, especially in the area of racial differences, is indeed overwhelming today. Current variant opinions indicate that arriving at a solution will be lengthy and difficult. On the other hand, progress is evident and two generations hence probably will see the elimination of discrimination in housing and in the use of public spaces.

Satisfactory building and rebuilding of urban areas will require the best efforts of everyone, not only those involved directly through professional associations, but all residents of urban and suburban communities.

HELP WANTED!

Rebuilding our cities so that they will accommodate a high standard of living and increasing the capacity of our urban areas to facilitate the rapidly expanding urban population will require the dedication of many people, both professionally and privately.

There are present shortages of city planners and engineers. For example, there are now 6,500 traffic engineers in the United States; there is a demand for more than 7,800. This situation will become even more critical as demands are augmented, unless more and more young people are encouraged to pursue these professions. We who are already engaged in urban rebuilding and those of us affiliated with related professions should assume the responsibility for "selling" city building careers to qualified persons.

Urbanization for the future requires talents in many fields. City planners, statisticians and researchers must predict future needs, establish goals and develop a framework with necessary controls for future building. Lawyers skilled in legal tools for city development must prepare zoning laws, building codes, urban renewal and housing bills, and other ordinances which will help insure the orderly building and rebuilding of our urban areas. Economists and experts in finance and marketing must relate city building programs to tax revenues and market conditions.

Engineers, architects, designers, landscapers and contractors must develop plans and designs, and construct the many new public and private services and buildings that will be necessary in urban areas of the future. Sociologists and welfare workers must initiate and execute programs for the underprivileged, unemployed and uneducated so that as many people as possible can become useful happy citizens. Experts in fields related to recreation and leisure time must innovate programs for satisfying the demands that will result from more free time.

Educators must develop broadened programs for teaching the intricacies of city building, and also for general education of the public concerning the ways of urban life. Politicians must be cognizant of urban problems if plans for the future are to be translated through voter action into reality. Community organizers will play a critical role in the future of urban areas as urban renewal becomes more common and as city changes require comprehension by organized resident groups.

The education and training of people for these professions should be our prime concern. More programs for the education of city planners, for example, are needed. And these programs should include the practical tools related to city rebuilding and improvement. The education of engineers and architects should be broadened to include aspects of the relationship between design and construction and the operation of an urban area. Amplification of citizen participation programs will require comprehensive education of community organizers as well as continuous public educational or training programs.

Professional organizations can play an important role in improving future urban conditions. Societies such as the American Society of Civil Engineers, American Institute of Planners, Institute of Traffic Engineers, American Institute of Architects, National Association of Housing and Redevelopment Officials, American Society of Planning Officials, and the Society of Women Engineers can contribute to research in the fields of urban building and rebuilding through their committee activities. They can stimulate coordination and cooperation between the various disciplines by sponsoring joint projects or conferences. They can foster general understanding of urban problems through articles released to the press and public exhibits.

"Urbanization for the Future" is everyone's responsibility. Those of us in professions concerned directly with urban problems must strive to improve the quality of our contributions. Those in related fields must endeavor to coordinate their activities so that the tremendous job of keeping pace with urban demands can be done as efficiently as possible. Those whose professions are not related to urban construction should, as citizens, keep abreast of urban affairs and requirements, and contribute by intelligently guiding those with authority for making policy which determines the future of our urban areas.

MANAGEMENT OF OUR NATURAL RESOURCES

by John H.M.S. Miller
Director, Research and Technology Survey
Dublin, Ireland

"From the beginning of civilization, every nation's basic wealth and progress has stemmed in large measure from its natural resources.-------
-----Our entire society rests upon--and is dependent upon--our water, our land, our forests, and our minerals. How we use these resources influences our health, security, economy, and well-being."

President J.F. Kennedy, Feb. 1961

DEFINITIONS

Resources can be defined and classified in many ways, but basically, and in simplified form, they are commonly considered to fall into two main categories, material and human. As a rule, however, simple classifications are not very satisfactory. Our society and our technologies are far too complicated for such classifications to be completely valid.

Resources are more than things. The soil, for example, becomes a resource only when it is used. Up to then, it is only a potential resource and the more we know about the potential resource itself, the greater value that potential resource becomes, i.e., it increases as a resource. Thus, resource includes the potential resource, the skills in using it, and the knowledge about it. Resources, therefore, include material and human factors, and combinations of both.

Material resources can exist without man, but not vice versa. Yet without man the material resources are, from man's viewpoint, worthless and sterile. Thus, human resources are the key resources which must be developed so that material resources can be unlocked and made useful for man. Knowledge and resourcefulness are paramount in the management of our natural resources. These qualities enabled the Dutch to reclaim deltas and push back the sea, thus actually creating vast material resources. The lack of these qualities influenced many of the nomadic races of the past, and a few of the present, to wander over continents, picking at material resources as they found them, often dissipating them wastefully.

But now we are living in an age in which, in the developed countries, knowledge and resourcefulness are at a premium in industrial and agricultural businesses and in which, for profit motives, productivity, efficiency and therefore, indirectly, conservation of human resources, materials and energy are features of society. Even in the developing countries the importance of these factors is becoming recognized.

Yet, by themselves, economy and efficiency applied in business enterprises will not necessarily lead to the development and management of resources as instanced in the Netherlands. The activity of individual firms and companies may lead to better, more efficient use of a particular material resource in a very localized sense, but in two ways this activity may be too limited for overall national development.

First, the development of any local material resource has some side effects, many of which are beneficial, but some of which, if ignored, may be positively deleterious to other resource user, and even to man's well being. Examples of these side effects are atmosphere and water pollution, surface and ground water modifications, creation of wastes, and depletion of one resource while another is being exploited. There are very many well-known examples of the foregoing, and it is self-evident that it is in the national interest for governments to exercise some control over these side effects in a positive manner, e.g., by providing or encouraging national and local planning bodies. Their function would be to study and assess side effects, to provide or encourage research into them; to help conservation of resources where it is outside the scope of the industry concerned, and to guide the industries in their activities to limit any deleterious side effects.

An interesting and unusual example of local activity which, perhaps in ignorance, may be wasting a vital national asset, is in natural gas production in the United States. It had been reported that some of this gas contained helium which had not been extracted, and where extraction was carried out, a high wastage occurred. Helium is finding increasing use in some important industrial processes with a very marked effect on them. Protection of these particular helium resources may be of national importance and yet of little direct interest to the natural gas industry itself.

The second limitation of isolated local development lies in those fields where large-scale resource development is beyond the means of private investment in any particular country and set of circumstances. Certain national air, transport and power corporations are examples, by type, of this. A specific example is the industrial peat development of Ireland where nearly 200,000 acres of waste bog land, spread over about 20 different rural centres, have been drained and exploited to produce fuel for power stations, industry and the home. Some peat for horticulture and special industrial uses is also produced.

This development has been an economic venture and is in itself a sound business proposition. Its beneficial secondary effects, however, have scarcely been less important, in creating new village centres, revitalising declining ones, and upgrading the technical and cultural level of rural communities. Different countries, of course, have different situations regarding the potentiality of private investment and the need for State enterprises.

Time and space does not allow the full development of this theme, but it is suggested that sufficient evidence exists to show (a) that resources include potential material resources, human resourcefulness and knowledge; and (b) that good management of resources requires proper planning by industry, local government authorities, and the State, separately and jointly. The emphasis in this planning must lie on science (including statistics), technology and economics but it seems apparent that it should include sociology.

It does not follow from this that the developed countries are in a stronger position than the developing ones in all aspects of resource development. Developed countries have extra knowledge and experience which adds to that knowledge. They have extra and superior support services including educational institutions, primary, secondary and higher. But they may have some disadvantages from the planning point of view. Long established practices of industry, local and national governments may well be more difficult and certainly more complicated to adapt to any external planning requirements. Where these practices are less firmly fixed, or in an early stage of development, as in some developing countries, more flexibility may exist to accommodate the requirements of planning.

PUBLISHED INFORMATION

Two of the most comprehensive sets of papers have been published on the subject of Natural Resources. One, on Scottish Natural Resources, is a collection of over fifty papers presented at a remarkable symposium held in Edinburgh in 1961. The papers include reports on the economics and the mechanics of Resource Development, and on Administration, Management, Education and Strategy (for Scotland). The material resources discussed were soil, water (sea, land surface and underground), minerals, fuel, biological wastes (peat, seaweed, etc.), wildlife and recreation.

The second is a Summary Report on Natural Resources, with seven supporting studies, published by the U. S. National Academy of Sciences, dated November 1962. This report surveyed the national resources of the United States with reference to the influence on them of the world situation. It also included a number of recommendations on major courses of action by the Federal Government as a basis of a national program of resources research. The resources reported upon were renewable resources (food, fibre and forest products), water, minerals, energy, marine, environment, social and economic. The definition of natural resources used in this study is as follows:

> "A natural resource is any naturally occurring element, product, or force that can be utilized by man in his contemporary environment. So defined, a natural resource is inseparably related to the condition of the society that uses it; its study cannot be confined to the objective realm of the physical sciences and their derived technologies, but must embrace social and cultural values as well. Although economic and geographic considerations generally dominate any assessment of resource needs, considerations of esthetics and political and military necessity must also be taken into account."

Both of these sets of papers are worthy of study by anyone connected with resource use or development. They show the complications and interrelations of many resources. Too often resource development is considered in isolation. The study of different resources may require different combinations of specific science and technological disciplines, but in principle it is desirable to have a team consisting of scientific, technological, economic and social disciplines. See references

SCOPE OF THIS PAPER

The sponsors of this conference asked for papers in some depth to provide a measure of career guidance for engineers and scientists. They also proposed the titles of the paper. Fortunately for this paper they transferred a number of natural resources to other papers and sections of the conference. These are food, water, energy, natural and synthetic clothing (fibre), and environmental control which it is presumed will cover both pollution and recreation. The main resource, therefore, left to discuss is minerals. The general question of resource management will also be included.

MINERALS

The stages of development of resources are not very different for any material, whether it be mineral organic deposit or soil. First, the facts of the resource must be established by surveys. Secondly, site preparation and development must be carried out, including a gradual build-up of technical services and administrative facilities. Thirdly, development mining (including excavation and drainage) must be undertaken, leading gradually into early stages of production. Fourthly, the full production stage is reached. A most essential aspect, which begins even before the decision to develop the resource is reached and which develops parallel to the technological stages, is the economic, commercial and marketing study.

For mining technology these stages include the following operations but not necessarily only in the order given:

1. Survey;
2. Exploration and sampling;
3. Development;
4. Drilling and blasting;
5. Size reduction;
6. Materials handling and loading;
7. Transportation;
8. Ground support and control;
9. Drainage;
10. Ventilation;
11. Health and safety.

These operations apply to metal and non-metal mining, e.g., metal mines, sand and gravel pits, and stone quarries (including limestone, granite, marble, sandstone, slate, etc.).

While mineral development methods may be similar, their processing is extremely variable, depending upon the mineral involved. In some cases the products of these mines are processed locally. This applies frequently in the case of the non-metal minerals. Metal ores are often trans-shipped to processing and refining plants.

It is not proposed to deal with the processing of non-metal minerals in this paper. The range of sands, gravels, and non-metal rocks is extremely large, and their uses are multifarious, covering roadstones, cements, marble and granite veneers, ceramics, refractories, foundry sands, fertilisers, rare earth uses, abrasives and very many more important uses. However, the principles that are recommended in the management of natural resources apply equally for the foregoing materials.

SURVEY

Finding out the facts about natural deposits is usually a costly operation. In the case of underground deposits and in rock masses, expensive and time consuming operations are needed to drill, sample and analyse. If a deposit is to be exploited, the general volumetric shape of it, with data on the variations in its quality and purity, is needed. In order to save costs, surveys are usually carried out in stages;

1. Reconnaissance Survey--initial data collection to locate resources.
2. General Survey--data collection to indicate size of resource.
3. Exploration Survey--data collection to establish economic and commercial potential.

The function of National Geological Surveys may not be the same in all countries; generally speaking they do confine themselves to reconnaissance and some general survey, but do not as a rule carry out exploration surveys. The latter are best dealt with by consulting geologists or by the firms who intend to carry out the exploitation. Geological Surveys can provide a flow of information leading to the construction of maps from which more detailed surveys can be made.

Exploration surveys require an actual knowledge not only of mining practice, but also of the commercial products which may be obtainable, their value and the technology of their use. A 4-inch coal seam, for example, of high calorific value and low ash, may be of less economic value than a 20-inch seam of lower calorific value which has a high ash content. A mining engineer in collaboration with a fuel technologist can decide this question. It is too specialized a question for normal Geological Survey teams.

Another important and highly specialized question is that of scale of exploitation in relation to economic production and life of the deposit. If too high a rate of production is selected, the purity of the product may fall below an economic price and the project may fail. There are many facets of this aspect and it must be considered during the exploration stage by specialists, not general geological surveyors.

The importance of joint specialist team work cannot be underestimated in the exploration surveys. Even in surveys of water or potential water resources this applies; e.g., in recent years the Jabel Marra area in West

Sudan was surveyed to find:

1. How much water was available,
2. When and where it falls,
3. How it could be collected, and
4. How it could be used.

The exploration team consisted of geologists, an ecologist, a forester and a hydrologist. The example is interesting also because it used (a) steroscopic air mapping followed by (b) ground work using helicopters for transport, before making final analyses and mapping the data. The use of air photography in geological studies is not new, but application of this technique is by no means fully developed and new uses of this method are frequently arising.

In recent years the development of new geophysical instruments has brought about a new method of geological survey, airborne geophysics. This involves magnetic, electromagnetic and radiometric methods of survey. There are a number of different types of these instruments, but in principle the magnetometers measure components of the earth's field and particularly locate anomalies which are attributable to mineral deposits. Electro-magnetometers record variations in ground conductivity, and scintillation counters record radio-active emanations.

Apart from its application in surveying for radio-active ores the latter method is used in oil surveying, as the presence of oil sometimes influences the radiation flux over the area. These techniques have in recent years either been instrumental in, or have strongly supported, such findings as iron ore in Ontario, Venezuela, Libera and Missouri. They also led to copper discoveries in Quebec and Ontario, lead deposits in Missouri, bauxite in Surinam and Venezuela, apart from a very large nickel deposit in Manitoba.

The example quoted earlier of the water survey in West Sudan indicates how air borne methods are rapidly applicable to the developing countries. The methods are costly and also may be best suited to clear weather conditions when air photography can be applied about the same time. The latter is not essential, but in underdeveloped areas surface mapping may be as important as mineral discovery. Generally speaking, this type of survey applies best to relatively large areas. Apart from reducing the cost per unit area, there is much to be said for large-scale surveys to obtain a geological framework into which detailed local surveys can be subsequently fitted. Aeromagnetic surveys provide information not only from the surface, but in depth.

Geophysical methods are also now used in ground surveys but a new tool is the geochemical method, which analyses samples of soil, water and vegetation (including peat) for traces and concentrations of metals which might be deposited in the area. This method is of particular value in surveying for sulphide ores, e.g., copper, lead and zinc, but this range has been widening appreciably.

The advent of new tools leads not only to new methods in any technology, they often bring new complete processes. The new tools in geological survey are having such a radical effect on this very old technology. Different combinations of aerial photography, aeromagnetic surveys, reconnaissance field work, photo mosaics, mapping, drilling, pitting, trenching, geochemical and geophysical ground techniques provide survey teams with a powerful array of data collection methods. By using teams of a number of specialists and by covering large areas, the cost can be reasonable for a large amount of information.

The magnitude of the task of providing world coverage of survey can be appreciated when it is realized that even in a developed country like the United States only 70 per cent has been topographically mapped and only 20 per cent mapped geologically. This leaves out of account the enormous areas of the world's continental shelfs which are beginning to receive survey attention by methods using echo-sounding, underwater photography, radiation measurement, sampling by grab and drilling, seismic and geophysical methods.

The prospect before us to-day, in the field of minerals, appears to be one of very much isolated information on reserves scattered widely over the earth. Large-scale surveying using the new techniques may not only construct great frameworks round this information and reveal more surpsising deposits, it could lead to more fundamental knowledge on the nature and classification of geological occurrences. This in turn may well lead to new tools and survey methods. The prospect appears good.

METALS

We are informed by chemists that half the weight of the surface layer of our planet consists of oxygen. Eight other elements make up another 48%: silicon (26%, as rock silicates); aluminium (7%); iron (4%); calcium (3%); sodium (2 1/2%); potassium (2 1/2%); magnesium (2%); hydrogen (1%); others (2%). Much of the oxygen is useless to man, being strongly combined with other elements. The affinity of metals for oxygen has resulted in rocks and ores containing metal oxides which have to be processed to remove the oxygen and concentrate the metal.

Iron, which is still the most important metal, is the lowest cost because (a) mass production is possible due to the high percentage of iron in ores (20% would be quite good, up to 70% maximum), (b) a cheap reducing agent, e.g., coke, may be used, and (c) the process is workable in large-scale units.

Aluminium, which on the average is more plentiful as an element, is mostly present in common clay, and no commercial process is yet available to remove it. The process of removing aluminium from the other main source, bauxite, involves a large number of small electrolytic units and uses large quantities of electricity. Even though bauxite contains about 25% aluminium, the foregoing factors make it much more expensive than iron. Yet while the world production of iron is at several hundred millions of tons, and aluminium is in the tens of millions range, the former is now increasing in developed countries only in the tens of percent and the latter by several hundreds of percent per annum. Practically all metals are increasing in use at a very much faster rate than iron, but the latter will obviously remain the most important metal for a very long time to come. Among some important competitors for steel, the main product of iron, are aluminium, prestressed concrete, magnesium, titanium and plastics. High grade steels such as, for example, manganese steel, vanadium and chrome steels, by economizing in iron and using other admixtures, are also affecting the demand for the iron raw material.

The basic metallurgical reaction for removing oxygen from metal oxides remains at concentrating the metal by heating the ore using a reducing agent, e.g., carbon in the form of coke; gaseous carbon dioxide is formed leaving the metal. The temperature required varies for different metals, e.g., about 1500°C for iron and about 1200°C for copper. But the long established blast furnace used for reducing iron oxide to pig iron (about 4% carbon) and the subsequent Bessemer (or Thomas) and Open Hearth processes for processing iron and scrap into steel (0.15 to 1.5% C) may give way to new continuous processes from "ore to steel castings". The Open Hearth process will probably retreat slowly because of its advantage in being able to process scrap as well as pig iron and its superior ease of control. Partly for this reason and also because in its own right it is becoming an advanced piece of equipment, the blast furnace is likely to remain with us for many years to come.

One new continuous process uses a rotary kiln furnace for partial reduction of the ore, and the final smelting and refining to steel is carried out in electric furnaces. This is suitable obviously for countries where low cost power is available. These processes are not as yet continuous in that the separate stages of reduction and refining are carried out in separate plants, but by modifying the old processes it has been possible to combine them in one steel making department using the hot and molten material throughout the processing.

To illustrate the range of technologies applied in metallurgy, the following processes are of interest, as many of them apply in principle to all metal ore processing and some apply also to non-metal mineral technologies:

<u>Preparation of ores</u>:

1. <u>Concentration and blending</u> of lean ores, e.g., physical processing by <u>mineral dressing</u> including mechanical separation say of fine sand and oxide particles (cyclones and fluid columns), washing, etc.; <u>rotary kiln heating</u> (Krupp-Renn process) to concentrate the iron oxide; a <u>chemical process using hydrochloric acid gas</u> to purify iron oxide. Where silica is present as an impurity, the chemical bond with iron and some other metals is very strong; research is needed in this field to find more commercial techniques. <u>Sintering</u>, which is used mainly to agglomerate ore fines, also has the effect of removing moisture and carbon dioxide so that some concentration

of oxide is effected. Where the ore is not an oxide, e.g., a sulphide or carbonate, roasting in the presence of air removes the sulphur or carbon in the form of a dioxide leaving the metal oxide.

In addition to the standard grate furnaces, new fluidized bed roasting ovens have been evolved in recent years. Where the metal particles are embedded in rock (gangue), beneficiation is obtained by froth flotation. After size reductions the rock/ore fines are treated in dilute chemical vats and separation occurs. The ore particles are skimmed off with the froth. The process is repeated many times to increase separation. In the case of metal, clay, slime combinations, a hydrometallurgical process using flocculating reagents is used to precipitate the metal bearing solutions. Many new flocculating reagents have been found in recent years to increase the efficiency and speed of separation. These are organic substances, instead of the old glue reagent. They are characterised by water soluble substances of high molecular weight. Moisture removal is often necessary as part of ore concentration, perhaps by rotary drum vacuum driers.

2. Crushing and screening applies to practically all metal and non-metal minerals. In some cases such as sand and gravel, cleaning by washing while screening is not uncommon. At one time these processes were considered simple and obvious, but in recent years fundamental studies using mathematical and statistical methods are being undertaken as it is realized that size reduction and screening are complex processes.

3. Agglomeration and sintering (to coalesce under heat without liquefaction) apply to fine particle ores. Agglomeration may be by pelletising, nodulising, or briquetting, using rotary drums, inclined rotating pans and presses. Additives such as coke breeze and lignite (even peat has been considered) may be used to aid bonding. Sintering may follow agglomeration and this is appearing to have advantages, as it results in a more uniform size of material for the blast furnace. Alternatively agglomeration may occur rather haphazardly during sintering of fines of ore with coke and sometimes with the addition of a flux agent such as limestone. In the development of blast furnaces it is increasingly obvious that a more uniform size of sintered or agglomerated ore produces a more uniform and controlled flow of gases through the furnace bed.

Sintering is sometimes applied to refined metals; for instance, tungsten may be sintered in a hydrogen atmosphere (to avoid oxidation) to prepare the metal for extrusion and shaping.

Transport and handling.

This technology is common to practically all processes in industry. In steel making, in which 50 percent of costs are carried by raw materials and fuel, the latter two items contain high transport charges. This is a field particularly suited to operational research studies to delineate specific subjects for applied research and development.

Reference has already been made to the other processes of ironmaking and steelmaking. Needless to say, a tremendous amount could be said in detail about all of the foregoing, but only indications of technology type with some trends are possible in this paper.

Electrolytic processes.

The basic metallurgical reaction to use carbon to separate oxygen from a metal oxide cannot be applied to aluminium since this metal has a greater affinity for oxygen than carbon. Thus an electrolytic process has had to be evolved. This has lead to high costs in that about 5 tons of coal and 20,000 units of electricity are required per ton of aluminium metal. This compares with about one ton of coal to convert iron oxide to 1 ton of iron. The process using bauxite is mainly two-stage: Iron oxide impurities are separated by dissolving the aluminium oxides in alkalis, and the refined bauxite is dissolved in molten cryolite at about $1000^{\circ}C$ and the molten aluminium set free at the cathode of the electrolytic cell.

Zone refining.

This is an interesting development for obtaining metal of exceptional purity for special applications, e.g., in transistors and conductors. Metal rods of high purity are suspended in a heating tube containing a hydrogen atmosphere to avoid oxidation. At a certain plane or zone across the tube, high frequency electric heating is applied until a band of the metal begins to melt; relative to the metal the tube is moved down slowly so that the melting zone moves at the same rate. In this way the metal melts and cools so that the impurities move with the refining zone leaving metal of very high purity in its wake.

Ion-exchange separation.

Recovery of metal oxides from some wastes and effluents is possible first by separation, using ion exchange resins (a type of absorption process), removal by strong nitric acid and concentration by evaporation. A further purification can be obtained by solvent extraction, followed by further distillation. A rare metal Technetium is being recovered in this way from solutions of waste nuclear fission products. This type of process may be at an early stage of application to a wide variety of industrial wastes. It is an example of the wide range of technologies which touch the metal industry.

The following examples further amplify this point: (1) A waste slag was produced in a Japanese plant which produced nickel from garnierite. The slag was a fused mixture of ore, limestone, silica, gypsum and coke. By substituting phosphate rock for limestone as a flux, a calcium magnesium phosphate slag is produced. This byproduct is a good grade fertilizer for some soils. (2) By mixing zirconium hydride with molten aluminium it is possible to produce a foamed aluminium which has good insulating properties and is even lighter than aluminium.

These cases illustrate an important requirement of all our modern technologies, namely, to obtain a high degree of cross-fertilisation of ideas and knowledge of processes and products between different technologies. The scope for development and consequently for better uses of our natural resources by such cross-fertilisation of ideas appears to be enormous. It is not an easy activity to organize but seems to be worthy of exploration.

MINERALS IN THE FUTURE

A lot of expert opinion has been expressed about the trends and future in mineral technology. The answer depends upon the amount of information available. Taken seriously, it is a question that requires careful research. The indication from resource survey data, especially since the advent of the new tools, is that many reserves of high grade ores remain to be discovered.

Iron is undoubtedly the basic metal of modern technology. Aluminium and iron are the two most common metal elements, and it seems reasonable to assume that whatever limitation they have in cost or characteristics can be overcome by research and developing techniques, so that these metals may remain our most important. It is even conceivable from a very long term point of view that rare metal uses may have to be replaced eventually by the more common ones. As energy sources develop, sea water may become an important mineral resource and this could change the trends again.

At present, plastics are in greater production by tonnage than all except the five most common metals and by volume are near the top, but these are dependent largely on carbon sources. Carbon compounds can be derived from renewable resources such as vegetable plants.

The type of metal used will affect the annual demand. Steel without protection has a fairly short life. Protections are imperfect and badly maintained; therefore steel demand is higher than it need be, apart from wear and stress considerations. Titanium is almost immune to corrosion and is highly heat resisting. Zirconium has similar good properties. Titanium is widely dispersed and diffused, yet it accounts for about 0.6 percent by weight of the earth's crust.

These considerations support the point of view written by Julian Feiss in the September 1963 issue of Scientific American:

> "In spite of the accelerating drain on the world's mineral resources it is now becoming recognized that they will never really be exhausted. Just as advances in technology have made it possible to exploit today ores so lean they would have been considered worthless only 50 years ago, new advances will make it possible to extract metals from still leaner ores in the future. In effect technology keeps creating new resources".

But 'technology' advances rarely come by accident. It was argued at the beginning of this paper that human resources are the key resources which must be developed so that material resources can be utilized. Applied to minerals, this means that the future of our mineral development depends on the development of our science and engineering disciplines in mining geology, mining engineering, metallurgy, civil engineering and mechanical engineering, but not only these. It depends more and more upon proper decision, making using statistical techniques. It depends also upon the proper use of research as a tool to maintain awareness of possibilities, as well as to reveal innovations.

It depends upon training in our schools and colleges in the application of the fundamental sciences to the future needs of mining and metallurgy, as well as proper orientation towards existing industrial requirements.

These things are important, but in the proper management of our natural resources, they should not be taken in isolation. As the next and last part of this paper proposes, they would be better as part of an overall plan of management of these resources.

MANAGEMENT OF OUR NATURAL RESOURCES

It has been suggested earlier in this paper that our resources can be considered to consist of potential material resources, knowledge and human resourcefulness. In the development of the potential material resources, knowledge is needed not only in the form of survey data but in the form both of educational knowledge of scientists, technologists, economists and administrators, and of know-how. Human resourcefulness is brought to bear in this development by the organization of the team and the work involved in the development.

Knowledge.

This involves education in relation to resources, which is a vast field but it is considered worth mentioning a few important facets of the subject which have a particular bearing on the question of resource management. A scientist or technologist may receive a higher education which is (a) oriented towards the requirements of particular technologies, e.g., industrial requirements, (b) oriented towards fundamental science, (c) oriented towards a high degree of specialization, (d) oriented towards a general science field, (e) oriented towards research, (f) oriented towards production activity, or (g) a combination of some of these.

A recent criticism of science education in Britain was that graduates were too "out of touch" with industry. Another made in the United States was that graduates were "too much" in touch with industrial requirements and too little in touch with fundamental science. The answer to the real requirements of science and technology education appears too complex, and there may be many answers in different countries. The importance of this question has been recognized and is the subject of research in some countries.

Enough is known, however, and has been written on the problems of industrial (and resource) development to record that industrial activity requires scientists and technologists in all its sections, i.e., in research, in development, in production, and in sales and marketing. Moreover, these sections must work smoothly together for optimum industrial activity. Smooth working requires understanding and knowledge of the other's activity and an intelligent adoption of policies and programs in each section which does not unnecessarily raise problems in another. The point of this argument is the need in education to prepare graduates for effective communication among the different spheres of industrial activity.

This can be aided and brought about by training in operational research and by the adoption by industry of operational research methods. It also requires industry to staff its departments with scientists and technologists who are capable of using the work of other departments in a positive way. Too much specialization in higher education for people who intend to go into industry may not be a good thing at this stage of their life's work, because knowledge in one field illuminates that in another.

Whatever emphasis is placed on the higher education of scientists and technologists, it is particularly important, especially in developing countries where techniques have to be evolved, to place great stress on scientific method in all science and technological activity and especially on the necessity for statistical design and analysis of investigation. Engineers are particularly lax in using this technique, and decisions involving the loss of many hundreds of thousands of dollars have been made, based upon inaccurate information, as a direct result of bad methodology. The ground nuts scheme in Africa is a classical example of this type of situation.

There are very few technical decisions where the statistical method has no application, although in simple cases this may be applied almost subconsciously.

Development of a resource.

The development of a particular resource should include the following activities:-

1. Data collection, e.g., by survey in any number of necessary stages,
2. An analysis of these data,
3. A decision on development, or on research for development, including a plan for development.
4. Development, including preparation for production and leading into the early stages of production.
5. Parallel with 1 to 4, an economic and marketing study leading to market development.
6. A means of making innovation, using research and technical information the nature and extent of each of which are defined by the size

and subject of the resource development.

7. The use of operational research techniques as a guide in management decision making, the extent of which will also depend upon the size and subject of the industry.

Leadership.

Much has been written and discussed about the need for and role of leadership in any sphere of activity. There is little disagreement that a good leader is necessary in any project. Many potential material resources have become useful resources because of the good leadership of one man, often against opposition from many who had no faith or belief in possible success. Good leaders usually have some support from a Board or even a Minister in the case of a state development, and this may be their strength, but not always so. They need also clear objectives, a plan and the human resources to carry it out. The development of peat in Ireland, limestone in Nigeria, low phosphate iron ore in Iran, and phosphate in Israel may be good examples illustrating how resources can be economically developed against odds through good leadership. It is the author's belief that if a leader can inspire in the team confidence in the project and engender healthy and balanced enthusiam, the best conditions will be created for success.

Statistical Methods.

The importance of using statistical design of investigation has been mentioned several times, and it cannot be overstressed. It applies particularly in the first two activities listed above, data collection and analysis. The accuracy of the analysis will affect the soundness of the decision to undertake, or how to undertake, the subsequent development. Some judgment in these decisions is still required, but the responsibility and extent of judgment in decision making based on survey data which has not been statistically planned in its collection method, or statistically analysed after collection, may be so great as to be almost instinctive.

Adaptability.

The ability of staff and particularly of technologists to adapt to the changing situations arising during a resource development are very important. They can be aided very materially in this requirement by periodic technical meetings from which information and decisions evolve. These decisions affect the micro-planning within the overall project plan and are a guide as to the adaptability required by staff and organization. In an organization which evolves into a large body, departments such as research, development, production and sales may be formed. At this stage, a very crucial one, divergence of the departments is unfortunately a natural tendency and it is of the greatest importance to offset it.

Most people agree about this, but not on how to avoid this divergence. To talk of cooperation between departments only stresses a need, not a method of obtaining it. Meetings between department personnel may only mean the presentation to each other of prepared points of view, not an objective attempt to resolve a problem. The progress or general manager may chair such a meeting and select an answer based on his judgment of the issues, but both formal and informal training of technical staff in methods and aims of cooperation between departments should be attempted to aid management decisions.

Management of Innovation.

The organization of research and its development into production has become known as the management of innovation. This involves a wise choice of subjects for research and development, and preferably some attempt to assess the economics of research and development.

Research into methods and techniques of the management of innovation is badly needed. It involves education of personnel and also their training in industry. It involves management techniques, economics and the phsychological problems of moving innovation into production operations where the production manager is concerned only with achieving a target output at the lowest cost.

NATIONAL STRATEGY FOR RESOURCE DEVELOPMENT

It was proposed earlier that good management of resources requires planning by industry, local authorities and the State, separately and jointly. In the foregoing section the type of planning required by industry has been indicated. The following factors are examples of those which generally fall wholly or partly outside the scope of private industry:

1. Side effects of resource development, such as air and water pollution
2. Surface and ground water modifications
3. Utilisation of wastes
4. Conservation of one resource which may be depleted while another is being exploited
5. Large-scale resource development (e.g., forestry, irrigation, etc.)
6. Town and country planning development
7. Marine and continental shelf exploitation
8. Provision of national aids such as education, research and technical information services.

These must, therefore, fall into a national management framework.

Very many of these factors affect others so that planning is essential. A strategy must be evolved to include planning, clear objectives, financial and economic assessments linked to priorities so that a practical national budget is followed, research, surveys, and a good organization and management structure.

In principle, there appears to be little difference between a local and national development strategy for resource exploitation, although the latter may be more complicated. As for local development, the first stage is probably in all cases a data collection stage followed by analysis. Statistical methods are quite unavoidable here and, in the case of national surveys, they will complicate into systems analyses since so many factors and systems will be affected in most national questions. The whole process of decision making in these national resource development problems requires research and study, and time must be taken in this vital development.

Cybernetics.

We appear to have reached a stage in the development of society when not only is planning recognized as an essential part of our activities, but also the study and effect of decision making on these activities. Moreover, it is becoming widely realized that by carefully observing the effects of decisions new decisions can be planned and made to deliberately modify those effects.

This process whereby actions are modified by the knowledge of results is known as cybernetics. Nature embodies many "feedback" mechanisms in living things. It seems logical to apply this technique in technological activity. In a crude way this has been done by man in most of his actions, but the positive application of the process in complicated technologies is very involved and is worthy of more research.

DEVELOPED AND DEVELOPING COUNTRIES

Knowledge has been shown to be an essential requirement of resource management. This implies education in science, and at once the developing countries are at a disadvantage. One of the most comprehensive papers on this subject of science in underdeveloped countries is that by Dr. Stevan Dedijer "Underdeveloped Sciences in Underdeveloped Countries". He discusses a range of decisions which should be made by these countries to progress into the scientific age, including political, educational, research and development decisions.

Two points of principles on this subject are worthy of suggestion, however, as they have a particular bearing on resource development. First, the priority for development of resources might best be arranged from the less to the more sophisticated projects, in that order, e.g., the drainage and re-seeding of grassland may be a better economic project and lead to a more educative development of a country than building a colossal nuclear power station or a huge steel mill. The stage of sophistication can be advanced in a planned way, side by side with education. Once the breath of real advancement is felt, people seem to have the ability for stimulating their own rapid progress after that.

Secondly, the control of these projects should as far as possible lie completely with the indigenous population although foreign expert advice may be essential. This is an education problem as well as one of development. When one learns something, one has to begin at the beginning, e.g., one learns to walk by crawling not by trying to run a four-minute mile!

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THE IMPORTANCE OF LANGUAGE AS A MEANS OF COMMUNICATION FOR SCIENCE AND TECHNOLOGY

by Dorothy U. Mizoguchi
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That science and technology are important to life in the modern world is understood by all. There is no "WHY" to that. As has been emphasized time and again, our knowledge and skill in science and technology have made tremendous progress since the World War II. This unfortunate experience of modern times has tried natural resources and human resourcefulness to the utmost, and man has emerged triumphant with the weapon of modern technology. The youngsters of today do not realize the marvellous gifts they are now enjoying in their daily lives.

Not only the youngsters but we ourselves are apt to forget the gifts we enjoy and take them just for granted--solid buildings, sanitary food, clean and neat clothes, radio, television, automobiles, aircraft--all these are the products of modern technology which our ancesters did not enjoy to the extent that we do. Of course, there are two sides to it. The modern technology has also produced deadly weapons, e.g., atomic bombs and missiles, but we are certain that the scientists and engineers will strive to put these inventions to a peaceful use, a use by which the human race will be able to enjoy clean and profitable living.

Progress of modern industry has posed another problem--pollution the atmosphere surrounding us. It is no longer possible to enjoy clean air and clean water when they are fouled by fumes from chimneys or waste liquids from factory pipes. These problems must and will be solved by engineers and scientists.

Take the matter of transportation and communication. The development of aircraft has extremely shortened the distance (in terms of time) between different parts of the world. When the first Ambassador of Japan went to America, it took a good part of three or four months on the old-fashioned wheel boats with sails. To the members of his delegation, the American continent appeared as far away as the moon appears to us now. Today, thanks to modern aircraft with its high-powered jet engines, one can eat breakfast in Tokyo and have dinner in New York or Paris. The distance (in terms of miles) has not changed, but in terms of hours the distance has shrunk to a more sizable length. To quote Dr. M.H. Trytten, transportation has increased by a logarithmic scale.

This increase in transportation is in terms of both size and number of vehicles and things being transported. Technology has produced material that can withstand the drastic use to which such vehicles are put and has provided the roads which must bear the burden of such transportation on land. Congestion of traffic has been alleviated to some extent by the use of aircraft which utilizes the space unused till this day. More marked is the progress in the construction and launching of satellites and spaceships which are going to provide a means of transportation unaffected even by the earth's gravity or atmosphere with its constant changes in weather that try the aircraft of today. There are still numerous technological problems that must be solved in order to make space flights as popular as modern air travel, but knowing the progress science and technology has made in the past half a century, we may safely expect engineers and scientists of today and tomorrow to provide theory and materials that will make such flights feasible.

COMMUNICATIONS-MEDIUM FOR TRANSFER OF IDEAS

This brings us to the matter of communication. From the early and prehistoric use of sounds as a means of communication, we have arrived at the stage where intercontinental television is almost at our door. What distinguishes *Homo sapiens* from *Pithecantropus erectus* is said to be speech--a means of communication through a series of formulated sounds. However, modern cultural anthropology has revealed that some species of apes and gorillas have a certain set series of sounds by which they seem to communicate with each other. This may reflect early forms of communication which took the route of mouth-to-mouth or man-to-man contact.

As soon as men developed a written form of expression, communication of abstract ideas became possible. Development of symbols started in different parts of the world--Egypt, India, China. Expression of ideas in written form has made it possible to extend an idea started by a person. Thus, accumulation of knowledge developed astronomy and mathematics in Egypt, India, and China. This was early technology in its budding form. Egyptians built a huge pyramid, an extremely large house for the dead. In building pyramids and places of worship, the Egyptians used their technological knowledge and skill. The star Sirius is seen squarely from the south passage opening of the Great Pyramid at Ghiza on the day of equinox to this day. This calculation was, is, and will be valid as long as we do not put the earth out of its orbit.

Although a great deal has been said about the development and progress of technology and science, few people realize that such development and progress would have been impossible without the expression of our ideas in a written form. Crude conception develops into highly skilled knowledge when it can be communicated from man to man through written expression. The early forms of such expressions were made on stones and wood, but a crude form of paper was soon produced. A light-weight material like paper can be carried a great distance--unlike the heavy stones and bulky wood. The knowledge written on a paper was carried miles and miles, by hand, on a horse's or camel's back, and by ship.

An idea started by a person in Egypt might take root and be completed in Greece. An idea expressed by a person in India might be carried over thousands of miles and used in China. And *vice versa*. From such exchange of written ideas emerged the core of our modern communication system. If one wanted a letter to reach the destination in a hurry, one used the means of faster-moving vehicles. Man-on-horse was the fastest means of communication until wheeled vehicles were invented.

As soon as man invented a written language, a language even in crude form, his knowledge and skill made a tremendous advance. However, without the means of communicating this knowledge, it was almost the same as though it had never existed. The knowledge of science and technology, before the invention of a means of communication, died with the man who thought up such ideas. The next person who thought up the same idea had to start from scratch. He had no means of knowing that someone had already thought of the same idea. And the idea died with him again. There was no progression of ideas, no build-up of known facts.

Letter-writing as a means of communication helped develop ideas among people in far-away places. One could start from a nearly-completed concept and work it out further. It was imperative for the progress of science and technology that a means of communication should develop. Individual letter-carrying soon developed into postal or mail systems on a national and international basis. Invention of postage stamps and affixing stamped seals made it easier to distinguish between paid and non-paid letters. Faster means of transportation was utilized. Galloping horses made way to motor trucks and trains. Aircrafts began to carry trans- and intercontinental mails.

Invention of printing was the other means of communication with a wider distribution of ideas. Communication of scientific knowledge relied on personal letters between individuals for a long time. Printing, a means of duplicating characters and images, worked magic in dissemination of knowledge. Distribution of printed matter through the mail helped all kinds of scientific knowledge to be placed in the hands of people in remote corners of the earth.

Soon, photography worked its way into our lives as a means of communication of ideas in visual form. Without the means of photography, it would have taken years of effort on the part of scientists to understand certain ideas or forms of ideas. Today, photography is being utilized in reproduction of large and small objects, from the stars beyond our galaxy to the chromosomes in the cells of a tiny fruitfly, to give two extremes.

The telegraph started the era of faster communication and thus helped develop wireless telegraphy or radio. Verbal communication by a telephone, storage of the vibration of sounds on grooves on a solid disc for playback on the phonograph, and recording of sounds on a magnetic tape were all means of communicating or storing knowledge, scientific or otherwise. Electric and electronic engineering have helped to develop these mechanical devices of communication until, as I said earlier, intercontinental television or personal telephones with television-like image of the other party seems to be almost at our door.

THE INFORMATION EXPLOSION

Although printing and photography have been a great help in the dissemination of scientific knowledge, we have been almost deluged with a flood of scientific and technical literature that have been printed and distributed during the past 15 years since the end of World War II. Growth of Engineering Index will indicate how much literary material has increased in the engineering world. Since its start as the Engineering Index in 1934, the number of abstracts printed in the E.I. was around 25,000 from 1934 to 1953. The number increased to 25,500 abstracts in 1954 and the estimated number for 1964 is around 50,000. This is a doubling of the number in 30 years.

In the field of chemistry, in which I am more familiar, Chemical Abstracts is taken as a measure of the amount of chemical literature. When the C.A. started printing abstracts of the world's chemical literature in 1907, the number of abstracts was little more than 7,900. In 1963, C.A. printed some 175,000 abstracts from about 8,000 journals in fine 6-point type. Just to give you an idea of the enormous size of chemical literature--the section on Analytical Chemistry has the largest number of abstracts, comprising about 4.15% of the whole. If all the abstracts in the Section on Analytical Chemistry for 1 year were printed in a straight line in the fine 6-point type, it would go up and down the Empire State Building 17 times.

Faced with such an inundation of printed work, the scientists and engineers put their knowledge and skill into solving the problem. Although we are still far from solution, there has been a great deal done in the way of storing and using the stored knowledge. Our visit to the IBM and Bell Telephone Laboratories has given us a narrow glance at what might be forthcoming. Computers would be a help in storing and retrieving knowledge--to a certain extent. As yet, little has been done to solve this problem at the roots--how to write the idea effectively for a more effective use of literature. Writing a paper is never an easy task, but this is neither here nor there in today's program and I shall not dwell on it.

But, and this is a big BUT in capital letters, men had to go and invent a different language in different parts of the world. If the peoples of the world had but one language, how easy and pleasant it would have been. There would be no headaches of translation from one language to another in either oral or written form. (I am not trying to put simultaneous translators out of work.) Translation is always a difficult business and is never a satisfactory means of communication for the simple reason that a translation is not the same work written in another language.

A language of a nation is peculiar to that country--it grew with that country, with her people and their traditions. A thing expressed in the language of one country cannot be expressed exactly by the language of another country; only an equivalent meaning can be expressed. Perhaps some of you who are bilingual have often found yourself searching for an exact expression of the word (in one or the other language) which would express what you wanted to say but have not been able to find that exact word. That is what I mean when I say that exact translation is difficult or well-nigh impossible.

UNIVERSALITY OF THE LANGUAGE OF SCIENCE

Failure to make exact translation is not satisfactory or desirable in science. Science is not limited to one country or another--it is universal. Anything scientific expressed in one language must have the same meaning in any other language, and this should be feasible. We find such a universal language in numbers--100 is 100 everywhere on earth, in atomic symbols of elements, barring a few, and symbols denoting physical constants, and mathematical operations. Chemical formulae are perhaps evidence in favor of international notation for all scientific communication. H_2O is water whether written in Japanese, English, Russian, Arabic, or any other language. A scientist looking at that symbol will know that it stands for water and no other thing.

A great stride has been made in the past 10 years on international standardization of units and this should also be a help in furthering international communication of scientific ideas. Most European and Asian countries have adopted the metric system. Yet the engineers still adhere to the yard-pound units, which is not a decimal system. I almost jumped out of my seat when the thermometer in the airplane was registering 72 degrees, thinking I was being half boiled, before I realized that the Fahrenheit scale is used here. Perhaps the units of measurement could be standardized before long and engineering specifications could be used without translation.

The reason why the matter of translation was taken up is because translation requires manpower--a highly skilled and technical person who can be otherwise employed for industrial production. The use of manpower for something that can be eliminated poses a question on the future activities of scientists and engineers, although I must admit that some women with knowledge of science and engineering make ideal workers in this field. The use of manual labor also detracts from the speed of processing a scientific and technical literature. Before a translating machine can be elaborated and used, it might become possible to write a scientific and technical paper in such a form that a translation would become unnecessary or even useless.

THE OCEAN--CRADLE OF LIFE AND CHALLENGE TO SCIENTISTS

By Mrs. Zinaida A. Filatova
Professor and Oceanologist, Academy of Sciences
Moscow, U.S.S.R.

I am pleased to have this opportunity to greet you, women engineers and scientific workers from many countries, who are gathered together for the first time at this forum to discuss many questions that interest us all.

OCEANOLOGY AND ITS POTENTIAL

I have the pleasure to represent a very rare speciality for women -- oceanology, the science of studying the ocean. It is well known that seas and oceans cover two-thirds of the surface of our earth, surrounding all the continents. The world ocean is so immense that perhaps our planet could justifiably be called the "Ocean" rather than the "Earth".

The ocean is such an organic part of the life of our planet that it represents one of the most important factors in nature. Thanks to the presence of such a mighty water layer (hydrosphere), the existence of an air layer around the earth (atmosphere) also became possible. The ocean and the atmosphere, in their turn, made possible the origin and development of life itself on our planet. The regions of dry land and of ocean populated by living organisms are called the "biosphere" or "living sphere" of the earth. The ocean is justly called the "cradle of life"; because of its remarkable characteristics the sea water is extremely favorable for the development of life.

There are more than 30 chemical elements dissolved in sea water, the greater number of them being necessary for the existence, nourishment and respiration of everything that is alive. Sea water heats up gradually and gives off warmth gradually; it easily penetrates the tissues of animals and vegetation. All of these characteristics make it much easier for organisms to exist in sea water. The ocean, in fact, determines all the conditions of existence on the earth's surface. All the varied changes in the weather, the humidity of the tropics and the dryness of the deserts, the destructive typhoons, the ice of the Arctic and Antarctic -- all that, after all, is determined by the interaction of the ocean, the earth's atmosphere and solar radiation.

So it is obvious how immensely significant is the study of the ocean. Oceanology is the study of the water layer of our planet -- the world ocean. Studying at first the different aspects of the nature of the ocean -- physical, chemical, geological and biological -- and then pooling the results obtained, this science considers the ocean as a whole, as one natural phenomenon, studying the processes going on in it in all their complexity and interaction. For a correct understanding of the general picture of our planet and all the processes taking place in it, in the present, the past, and the future, it is impossible to proceed without deep study of the ocean which covers the biggest part of the earth. Only in such a case can a forecast of the direction and intensity of these processes and their aim -- man's control over them -- be possible.

Many sides of human endeavour are closely associated with the presence of the ocean, and every day new and more complicated tasks arise which demand a detailed knowledge of the nature of the ocean to solve them. While the dry land which occupies only one-third of the earth's surface supplies man with enormous stores of mineral and organic raw materials and material for the generation of power, it is easy to picture what boundless stocks of them are hidden in the remaining part of the earth's crust which is covered by its water layer or hidden in the depths of the world ocean. There is a tremendous amount of albumen, fats and carbohydrates in the form of living organisms and also chemical elements and vitally important vitamins and other things useful to man in the ocean but which are still not fully used by man. So far, the energy produced by the movement of the ocean waters (tidal and ebb movement or breaking of waves) remains unused.

However, one often realizes that our knowledge of the ocean is still very poor. Even today new deep trenches on the ocean floor, huge dead volcanoes and whole chains of mountains are still being discovered. For instance, there was a long deep trench discovered by the English expedition near the shores of Australia, its depth in places being over six kilometers; and an enormous chain of underwater mountains was discovered by our Arctic expedition several years ago, which crosses the Arctic Sea in a long line and has been named after Lomonosov. Another example is the mighty current, a real "river" in the ocean, running across the Pacific Ocean.

While the necessity to study the fish and also the non-fish products of the sea in shallow water regions is clear to everyone, the question of why we study the great depths of the ocean, spending much time and labor and organizing expensive expeditions, may not be clear to everybody. The oceanographic work carried out by many countries during the International Geophysical Year and the International Cooperation Year, as well as the results of the first International Oceanographic Congress, have shown how immense are the problems involved in a study of the ocean which are confronting the oceanographer and how important it is to unite the efforts of all the people for the solution of several most pressing tasks in the study of the ocean and tapping its resources.

The need to use the animal and mineral resources and resources of material for the generation of power which are to be found in the oceans and seas has grown tremendously during the last ten years and now sets completely new tasks before the scientists. That is why the science of ocean study is now in the stage of progress and rapid development. What was only a dream yesterday becomes reality today. With the aid of special equipment or vessels such as the bathyscaph, man physically penetrates the tremendous depths of the ocean more than 10,000 meters deep, which is a new stage in the study of the ocean.

In concluding my short description of the subject of oceanology I must touch upon one other side of ocean research, the geology of the ocean. The sea deposits which comprise a great layer on the ocean floor, its bottom sediments or soil, are a remarkable chronicle of all the events of the ocean's history that have happened in the atmosphere or in the ocean, the traces of which are preserved in these deposits. Here one can find traces of the changes in vegetable or animal worlds. When man penetrates to the bottom of the ocean and drills the whole thickness of the bottom layers that settled there over many millions of years in the life of the ocean (such attempts are being made), then it will be possible to learn what events, where and when, took place on earth.

U.S.S.R. RESEARCH IN OCEANOLOGY

In the past ten years Soviet scientists have been making an extensive and thorough study of the world ocean with the aid of large well-equipped oceanographic vessels which are in fact whole floating research institutes. These were built and fitted out by the state and then handed over to the Academy of Sciences and other research institutions. At present the "Lomonosov", a big ship belonging to the Hydrophysical Institute, is working in the Atlantic; in the Antarctic the oceanographers have two powerful icebreakers, the "Ob" and the "Lena"; and in the Indian and Pacific Oceans the "Vityaz", which belongs to the U.S.S.R. Academy of Sciences Institute of Oceanology, has been carrying out research work over the past 15 years.

The Vityaz is justifiably considered the flagship of the research fleet of our country; it has a displacement of 5,600 tons and is excellently equipped, having the equipment necessary for carrying out all kinds of work at any depth. It has many spacious laboratories with facilities for 65 scientists and technicians to work at the same time. There are comfortable cabins, well fitted out for both rest and scientific work, a library well-stocked with reading material for work and for leisure, an attractive recreation room and two big lounges in which people can enjoy themselves when they are not on the job. Film shows are organized in the evenings.

Usually work goes on for 24 hours a day and is very intensive, but because there is a well arranged schedule of duty and off-duty periods people do not get tired. The scientists on the Vityaz love to work and wholeheartedly enjoy their leisure. The Vityaz is well known in countries bordering on the Pacific and Indian Oceans -- in New Zealand, Australia, Tahiti, Zanzibar and Madagascar. When the Vityaz puts in to a port thousands of people usually visit the ship to have a look around, to see the scientific collections and to hear talks about the latest work of the expedition.

There are many Soviet women scientists -- and this is one of the main points I want to stress -- working in various spheres of oceanology, taking a most active part in all stages, from gathering the material at sea and doing experimental work in the laboratory to writing scientific works. The names of many of these women who have devoted their lives to their beloved work are well known not only in our country but in others too.

At present there are about 2,000 women in the Soviet Union working in oceanography. Seven hundred of them are scientific workers on the staff of institutes and research stations. Many of them have the scientific degree of M.Sc. and 12 of them have doctorates. A considerable number of the girls graduating from higher schools each year take up post-graduate courses or start work on their Master's thesis while working at oceanographic institutes or at universities. The geographical, physics, geological and biological faculties of universities of the U.S.S.R. are the main training grounds for specialists in oceanography.

For the sake of comparison I should like to point out that the only woman who was studying the seas at the end of last century was a zoologist, Sofia Pereyaslavtseva. She proved herself an outstanding scientist and became head of the Sevastopol Biological Station on the Black Sea. Today quite a number of women scientists occupy similar posts.

THE ROLE OF THE WOMAN OCEANOLOGIST

The difficulties arising from long periods away from home and family naturally limit the possibilities of women working in this sphere. But despite this, quite a number of Soviet women who have made oceanology their subject are working enthusiastically taking samples from the sea, reporting on the work done and drawing scientific conclusions. In addition to the scientists there are students and laboratory assistants who work on the ships during expeditions and in on-shore laboratories as technical personnel.

During expeditions the women take their watch at the instruments and carry out chemical, physical and biological analyses of the material collected, sorting, mounting and preserving samples, make entries in the records, and do many other things. Naturally the heaviest work is done by men. It goes without saying that a researcher who is deeply interested in his work prefers to take part in gathering the material he is later to work on. No records, not even the most detailed logs, can replace his own personal observations. This is why all the oceanologists, among them the women, try to take a personal part in the most strenuous stage--gathering material during an expedition.

I consider my speciality, oceanology, one of the most interesting and absorbing of the sciences concerned with the earth. I started my independent research work in the sea after graduating from Moscow University. I had no doubts about my choice of a profession, and now, as I look back, I realize I was right. Like most of the students graduating from universities, who are led by their interest, inclinations and ability into a certain work, to their particular profession, an immense field of activity lay before me.

Every sea demanded study, every sea was a mass of interesting problems and questions. Then the day came to work on our wonderful Vityaz, probing the depths of the Pacific and Indian Oceans. Every expedition brought solutions of some questions and brought new questions. After I had presented my doctor's thesis, on which I had spent four years of serious and satisfying work, I devoted my time and energies entirely to the study of the deepest parts of the oceans, which I am still working on today with a group of my colleagues.

In what spheres of oceanology do the more famous Soviet women scientists work? One of the most eminent specialists in marine geology in our country is Professor Marya Klyonova, who more or less founded this science at the beginning of the thirties. She is the author of several books and scientific works on marine geology, is head of a laboratory of the Institute of Oceanology, and has many pupils. She was the first woman scientist to go to the North Pole and to the Antarctic, where she went on an expedition on the icebreaker Ob. The first woman geologist, Tatyana Gorshkova, devoted her life to the geology of the seas of the Soviet Union. She has worked in high Arctic latitudes and on Franz Josef Land.

The biggest research center in Leningrad, the U.S.S.R. Academy of Sciences Zoological Institute, has a whole galaxy of distinguished women scientists who carry out research in connection with sea fauna. The most famous of them is Professor Guryanova who has carried out research into the coastal waters of the Soviet Union and of other countries which share the same seas. She has written more than 200 scientific works. She is a brilliant lecturer at Leningrad University and is extremely popular with the students.

There are many women on the staff of the Institute of Oceanology and its branches on the Black and the Baltic Seas and the Sea of Japan, working in various spheres of oceanology, meteorology, hydrology, physics, chemistry, geophysics, geochemistry, geology, and biology. A group of biologists from the Institute of Oceanology is doing complex and demanding work investigating life at great depths in the Pacific and Indian Oceans; scientists collect the material needed from on board the Vityaz, with the aid of various instruments and after that the samples are processed in Moscow. This group, which includes Masters of Science Nina Vinogradova and Marina Sokolova, is the first to have compiled a chart of the biological zones of the ocean, the quantitative distribution of life at the bottom of the ocean at a depth of 4 to 6 kilometers, and has established a number of laws governing life at that depth. Until quite recently it was thought that the Pacific Ocean bed was almost entirely without life. The unsoundness of this hypothesis has been demonstrated by this group of biologists.

Extraordinarily interesting and valuable work to change the fauna of our seas and the pattern of species found in them is being done at the laboratory headed by Professor Alexandra Karpevich (Institute of Fishing and Oceanography). She was directly concerned in the large-scale experiment to transplant a number of creatures from the Black Sea to the Caspian with the aim of improving food supplies for valuable kinds of fish. The experiment was a great success.

This list of names could be continued, and I could name many more talented and tireless women oceanologists of many specialties of different generations who are passionately devoted to their work. But even the examples I have already quoted are enough to show how successfully and fruitfully women are working in all spheres of science, what wide possibilities are open to them in our country and how much attention is paid to training oceanologists of both sexes. Undaunted by the complications of long sea voyages and the difficulties of studying little-known material relating to the great depths of the Pacific, our women are working enthusiastically and devotedly in this complex sphere of the science of the Earth. They are all united by a selfless devotion to and love for their job, the study of the nature of the ocean for the good of man.

Friday, June 19, 1964

9:00 A.M. - TECHNICAL PROGRAM SESSION V

Reports on the Current Status of Engineers and Scientists

Chairman-Moderator: Katharine Stinson, Past President, SWE; Chief, Procedures Section, Federal Aviation Agency, Washington, D.C.

AFRICA--John O. Ilukor, Graduate Student at the University of Rochester, Rochester, New York. Soroti, Uganda

ASIA--Midori Yamada, Lecturer, Industrial Chemistry, Nihon University, College of Science and Engineering, Tokyo, Japan

AUSTRALIA--Esther Kaletzky, Senior Research Officer, Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia

EUROPE--Anna E. Amour, Director of Rassegna Technica ENEL Torino, Torino, Italy

NORTH AMERICA--Josephine R. Webb, Consulting Engineer, Rockford Bay, Idaho

SOUTH AMERICA and CENTRAL AMERICA--H.E. Francisca Fernandez Hall, Ambassador Extraordinary and Plenipotentiary of the Republic of Guatemala to Israel, Guatemala City, Guatemala

Summarist: Naomi J. McAfee, Fellow Engineer, Aerospace Division, Westinghouse Electric Corporation, Baltimore, Maryland

1:45 P.M. - UNITED NATIONS TOUR AND BRIEFING

Carmel Marr, Advisor on International Organization and Legal Affairs, with the United States Mission to the United Nations, will speak on "Women in the United Nations," scheduled from 3 P.M. to 3:45 P.M.

2:00 P.M. - SWE COUNCIL OF SECTION REPRESENTATIVES

4:15 P.M. - RECEPTION--COURTESY OF UNION CARBIDE CORPORATION

REPORT ON THE STATUS OF ENGINEERS AND SCIENTISTS

by Mrs. Naomi J. McAfee
Westinghouse Electric Corporation, Aerospace Division
Baltimore, Maryland

INTRODUCTION

An attempt has been made to determine the number of engineers and scientists throughout the world and their relative professional status, and further to determine the percentage of women engineers and scientists and to evaluate their relative status within the engineering and scientific profession. To accomplish this, letters were sent to all of the countries which have diplomatic relations with the United States of America, requesting that they supply information on the numbers and status of engineers and scientists within their countries. Specific information was requested on the relative status of women engineers and scientists.

This report, of necessity, will be a cursory review of the current status of engineers and scientists. For ease of grouping, the information is summarized by continent, and the primary emphasis is on women who for cultural, religious, or traditional reasons have only recently begun to practice extensively in the scientific and engineering fields:

> "We have by no means done enough to strengthen family life and, at the same time, to encourage women to make their full contribution as citizens... Women should not be considered a marginal group, to be employed periodically, only to be denied opportunity to satisfy their needs and aspirations when unemployment rises or war ends." President John F. Kennedy, December 1961.

AFRICA

To describe the status of engineers and scientists in the giant continent of Africa, which consists of approximately 35 countries, would appear to be very difficult because of the expected diversity of social, economic and political development. However, such is not the case, for in these rapidly developing countries there exists a serious shortage of qualified engineers and scientists. Hence, unemployment for such a qualified person is out of the question. In fact, in terms of salary, this group of professionals is among the continent's most highly rewarded employees.

Until quite recently, engineering was considered to be a man's domain, even though there are some women doctors and science teachers. There are no known women engineers practicing in Africa, but to quote the Moroccan Commercial Attache "with the increasing number of engineering and science schools we hope to be able to deny this fact in a few more years".

ASIA

Far East

Many countries in Asia which acquired their independence after the Second World War are making great efforts to expand their educational systems so that future industrial and cultural needs will be fulfilled. These programs have paved the way for many women to enter the scientific and engineering fields. The participation of women in these fields is increasing year by year, but even so the problems to be encountered by an over-abundance of engineers are of tomorrow rather than today.

Women are actively engaged in all professional fields. In Indonesia, there are over 10,000 women engaged in technical professions; in the Republic of Korea, there are 35,000 women engaged in technical professions. Table 1 shows the number of workers in engineering and other professional fields in the Philippines. It is easily seen that the majority of women are employed in the medical sciences while only a small percentage is engaged in engineering. To help overcome this imbalance, the Women Chemical Engineers of the Philippines (WOCHEP) was organized, and it must be pointed out that the ratio of women to men in professional jobs and higher education is higher in the Philippines than in any other Asian country.

In Japan, there are 1,750 women engineers and scientists, which is approximately two percent of the total engineers and scientists. In 1958 the Society of Japanese Women Scientists was established to promote scientific activity and friendship among women scientists in Japan. To date the Society has approximately 150 members. The number of women members of academic and technical societies is shown in Table 2 (compiled by the Society of Japanese Women Scientists).

Middle East

Only recently has higher education been open for women in the Middle East countries of Afghanistan, Iraq, Iran, Israel, Jordan, Lebanon, Pakistan, Syria, and Turkey. Since the Second World War, a campaign has been underway in these countries to eliminate poverty and ignorance by extending industrial and educational opportunities. Women who had the capabilities and desire were brought into the limelight, and their potentialities and talents utilized in social services and educational opportunities.

Women have not only progressed in social and educational endeavors, they have also shown an interest and aptitude for scientific and engineering subjects. Table 3 shows that the number of women entering the engineering and scientific fields is increasing from year to year. This will aid in offsetting the acute shortage of engineers and scientists that exists in these countries.

It is interesting to note that in the Middle Eastern countries women engineers and scientists are accepted on an equal basis professionally, helped and encouraged to enter engineering by men, and have the same positions and salaries as men.

Table 1. Number of Registered Professionals in the Philippines by Profession and Sex: 1960 and 1961

Profession	1960 Total	1960 Male	1960 Female	1961
Certified Public Accountant	6,421	5,163	1,258	7,088
Architect	1,351	1,244	107	1,409
Chemical Engineer	1,287	1,001	286	1,383
Certificate of Proficiency	118	118	---	118
Chemist	1,287	633	654	1,429
Chemical Technician	163	150	13	163
Civil Engineer	6,005	5,934	71	6,316
Certificate of Recognition	1	1	---	---
Custom Broker	54	53	1	56
Dentist	8,480	708	7,772	8,790
Professional Electrical Engineer	781	781	---	828
Associate Electrical Engineer	363	363	---	420
Assistant Electrical Engineer	783	781	2	917
Master Electrician	716	716	---	840
Professional Mechanical Engineer	709	709	---	845
Mechanical Plant Engineer	1,508	1,508	---	1,679
Junior Mechanical Engineer	3,573	3,573	---	4,278
Certified Plant Mechanic	2,872	2,872	---	3,052
Master Plumber	141	141	---	178
Marine Engineer	---	---	---	4,278
Marine Officer	---	---	---	5,097
Mining Engineer	456	456	---	465
Certified Mine Foreman	211	211	---	217
Certified Mill Foreman	82	82	---	82
Certified Quarry Foreman	8	8	---	9
Nurse	15,772	878	14,894	17,303
Dental Hygienist	6	---	---	6
Dietician	---	---	---	73
Optometrist	1,207	660	547	1,473
Pharmacist	14,397	1,581	12,816	15,186
Physician	16,580	12,741	3,839	17,450
Midwife	8,108	---	8,108	9,207
Sanitary Engineer	111	109	2	131
Surveyor (Private Lands)	1,408	1,401	7	1,574
Cadastral Land Surveyor	111	111	---	119
Mineral Land Surveyor	129	129	---	143
Veterinarian	411	411	---	422
Lawyer	23,745	---	---	24,590

Note: This registration includes the unknown dead and those who are in foreign countries. No breakdown by sex is available for the 1961 registration and for lawyers in 1960.

Table 2. Ratio of Women Members in Various Japanese Academic and Technical Societies (1962)

Name of Society*	Total Number of Members	Women Members	
		Number	Percentage
Chemical Society	26,500	940	3.57
Analytical Chemistry	5,000	131	2.60
Pharmaceutical Society	4,800	133	2.80
Physical Society	4,240	73	1.70
Agricultural Chemistry	3,300	89	2.60
Biochemical Society	2,650	221	8.40
Nutrition and Food Sciences	2,000	280	14.00
Vitaminology	1,600	84	5.20
Physiology	1,500	87	5.80
Botanical Society	1,370	644	4.70
Mathematics	1,900	56	2.95
Documentation	240	12	4.60
Mechanical Engineering	37,000	5	0.01
Architecture	19,757	150	0.76
Electrical Engineering	14,180	3	0.02
Civil Engineering	1,600	2	0.13
Illumination	2,753	13	0.50
Television	4,237	1	0.02

* Designation 'Japanese' or 'of Japan' omitted.

Table 3. Ratio of Women Engaged in Academic and Engineering Professions in the Middle East.

TOTAL STUDENTS

Country	Total	Women	Per Cent	School Year Beginning
Iran	19,815	890	4.5	1960
Iran*	14,065	2,521	17.9	1963

PRACTICING ENGINEERS

Country	Total	Women	Per Cent
Iran	4,000	60	1.5
Syria	1,200	80	6.6
Turkey**	3,000	150	5.0

STUDENTS IN ENGINEERING

Country	Total	Women	Per Cent	School Year Beginning
Iran*	1,788	105	5.9	1963
Syria***	1,000	130	13.0	1963
Turkey**	4,000	400	10.0	1963

* University of Tehran only
** Approximate figures
*** University of Allepo only

These do not include the 15,000 students studying abroad who are, for the most part, studying science and engineering.

First woman engineer in Iran -- 1952

First woman engineer in Syria -- 1950

All women who have received an engineering degree are working in their profession. When a woman receives a degree and then does not actively pursue her profession, she can be accused of preventing a man from obtaining an education because of the limited facilities and shortage of teachers in the universities and colleges. The major problem in these countries is a general shortage of engineers and scientists which can only be solved by more extensive educational opportunities.

AUSTRALIA AND NEW ZEALAND

The total number of practicing engineers and scientists in Australia is unknown. However, there are at least eight practicing women engineers. The educational requirements for being designated an engineer are similar to those in Europe, and equal educational opportunities exist for both sexes. There is a strong professional engineers society whose aims are to enable professional engineers to attain a standard of living and status in keeping with the needs of professional people, to encourage professionalism and to improve the standards of the engineering community.

There are no practicing women engineers in New Zealand; however, there are two girls in undergraduate work. In 1962, there were 2,612 persons engaged in scientific work, of which 217 were women. The status of engineers and scientists is comparable to that of other wage earners, but there has been no change in their relative salary status in the last six years.

EUROPE

In all countries of Europe, there are engineering associations or institutions to which those who have a university degree and those who have followed technical careers after some years of practical experience and demonstration of their technical and scientific preparation are admitted. The general criterion used to evaluate the quality of engineers is to specify the school where they were granted a degree. For many tasks, the State Departments require an academic degree.

Throughout the continent, there are no general legal definitions or dispositions on the exercise of the engineering profession. Any person, enterprise, or business can enter the engineering field without restriction.

In some countries, for example Italy, to be called an engineer, it is necessary to have a doctoral degree from the University or from a Polytechnic Institute in one of the 12 engineering branches, or an equivalent foreign degree, and to have passed the State Examination for the right to practice the profession and to be listed in the Albo of the Order of Collegio of Engineers of the Provinces.

Women who choose to enter engineering as a career are admitted to the technical schools, universities and polytechnic institutes in all countries. When they start to work, they are subjected to the rules and dispositions of their respective countries on equal terms with men. The status of women engineers in all European countries is very similar; they are accepted, not without some skepticism, but are not asked or encouraged to enter the engineering field. The working conditions encountered are initially the same as those for men, but they have to demonstrate their professional ability to their employers to a much greater degree than men before the original skepticism is overcome.

Access to industry does not appear to be equal for men and women. There are no women engineers on the boards of large engineering companies, and a woman has to be much better than her male colleagues to obtain equal recognition. This attitude is clearly stated in the report of the British Women's Engineering Society: "A few employers are noted for their generous attitude towards women in deciding whether or not to train a woman .... . There is much talk by employers on the financial risk involved in training women, and some of them exclude women from training schemes or accept them only at a lower rate of pay".

This is why there are so few women in the engineering field as indicated in Table 4. However, these few have taken the opportunity to enter many branches and activities of engineering and have demonstrated that they are capable of contributing to engineering progress.

Table 4. Women Engineers in European Countries

Country	Number of Women Engineers
Austria	*
Belgium	*
Cyprus	*
England	149
France	1,500
Germany	*
Ireland	3
Italy	313
Netherlands	*
Norway	900
Switzerland	3
U.S.S.R.	*
Sweden	*

* These countries stated that they have women engineers but gave no numbers.

NORTH AMERICA

According to an Engineers Joint Council study made in 1962, there were 615,400 engineers employed in industry in the United States of America. The 1960 census reported that there were 7,000 women working as engineers. However, a survey of the universities and colleges which teach engineering recently conducted by the Society of Women Engineers indicates that there are approximately 2,000 women who have actually received engineering degrees. This discrepancy can be explained partially by the fact that there are many women who have received degrees in the physical sciences, i.e., chemistry, physics, and mathematics, who are doing engineering work.

Prior to 1963, the Society of Women Engineers had made several studies pertaining to the professional status of its membership. However, it was felt that these were not broad enough, and that it would be useful to know how all the women who studied engineering have fared since graduation. To do this, the Deans of Engineering at all of the engineering schools in the United States were asked to provide a list of all their women graduates in engineering, specifying the degree and year granted and present address. Of the 150 schools that replied, only 15% have no women graduates, and only 10 of the schools are all-male institutions. The Deans' replies yielded approximately 1,800 women graduates to whom the Society of Women Engineers mailed a brief questionnaire. Some 600 questionnaires have been returned and analyzed, as follows:

- 43% are employed full time.
- 10% are employed part-time.
- 47% are not employed (most of these have small children).
- 20% are single.
- 80% are married (with an average of two children).
- 55% of those married have husbands who are also engineers or scientists.
- 39% have done graduate work.
- 40% belong to professional technical societies.
- 10% are Registered Professional Engineers in the states in which they practice.
- 5% are Engineers in Training in the states in which they practice.
- 68% of those not working expressed interest in re-training programs.

Of those who are working, when asked whether they feel that they have every opportunity for professional advancement, 70% answered yes and 30% answered no. The types of work being performed by these women engineers are shown in Table 5.

Table 5. Employment of Women Engineers in the United States by Type of Position

Executive, Management positions	3.4%
Research and development	22.0%
Design, production, application engineering	28.0%
Information, technical writing, technical librarian	8.0%
Government (city, state, federal) engineering	11.0%
Teaching	10.0%
Consulting - private practice	6.0%
Technician level work	5.0%
Miscellaneous, non-technical work	6.0%

It can be seen that approximately 50% of the women who received degrees in engineering are working at their profession, and about 50% are staying home to rear families. Of those working, 50% are in research and development or design and application engineering. Only 3% are executives and only 6% are in private practice, and very few settle for less than engineering level jobs.

SOUTH AND CENTRAL AMERICA

Only in the last 30 years have women been accepted in the engineering and scientific professions, and the number of women considering engineering as a serious vocation is limited. Girls obtain a degree, get married, have children, and as mothers do not actively pursue a profession. Even so, women engineers are no longer considered to be the exception in their own countries.

To be recognized as an engineer in South and Central American countries, a course of study culminating in an engineering degree at a recognized university must be completed. Upon graduation the engineer is registered in the College of Engineers and may practice engineering. The demand for engineers is so great that any qualified engineer is assured employment with a high position in either government or industry.

Several of the countries, e.g., Nicaragua, Honduras, Paraguay, and Jamaica, do not have women engineers. However, the countries that are known to have practicing women engineers and the number in each are shown in Table 6.

Table 6. Women Engineers in Central and South America

Country	Number of Women Engineers
Ecuador	1
Venezuela	
Civil	70
Industrial	1
Chemical	6
Petroleum	1
Forestry	5
Geological	5
Architects	6
Brazil	
Engineers	300
Technicians	150
Bolivia	100
Argentina	150
Guatemala	3

CONCLUSION

Before the status of engineers and scientists can be accurately stated, further study is obviously required. Specifically, those countries that are not included in this study must be contacted and the status of engineers and scientists determined. The Society of Women Engineers has undertaken a continuing effort to determine the status of engineers and scientists throughout the world.

Generally the status of engineers and scientists is quite high and compares favorably with that of other professionals. Women appear to have the same educational opportunities as men. In Africa, the demand for engineers is quite great and engineers and scientists are highly rewarded; however there are no women engineers. In Asia, women are accepted professionally on the same level as men and are encouraged to enter the engineering and scientific fields. All women who have received a degree are working at their profession in the Asian countries. On the other hand, in Europe, women are not encouraged to enter the engineering and scientific fields and are not accepted without a great deal of skepticism. In Australia and New Zealand, the status of engineers and scientists is comparable to that of other professionals. In North America, the report contains information only on the status of women engineers and scientists in the United States. The status of women engineers is comparable to that of men; women appear to be quite happy in their work. In South America, women have only recently entered the engineering field. However, women in engineering are no longer considered the exception, and they have the same status as men.

Saturday, June 20, 1964

9:00 A.M. - TECHNICAL PROGRAM SESSION VI

Symposium on Developing Engineering and Scientific Talent

Chairman-Moderator: Lydia I. Pickup, Engineer Designer, The Boeing Company, New Orleans, La.

PANELISTS

Anna E. Amour, Associazone Italiana Donne Ingegnere Architette (for Emma Strada, First President)

Constance Arregger, President, British Federation of University Women

M. Bruce Barton, Vice President, Careers, Incorporated

Tania P. de Cano, Facultad de Ingenieria, Universidad de Buenos Aires

Lewis K. Downing, Dean of the School of Engineering and Architecture, Howard University

Helen E. Hale, President-elect, The National Science Teachers' Association

Evelyn Harrison, Deputy Director, Bureau of Programs and Standards, U.S. Civil Service Commission

Euphemia L. Haynes, Education Committee Chairman, Sigma Delta Epsilon

Jlse Knott-ter Meer, VDI, Nurnberg, Germany

William E. Lear, Division of Mathematical, Physical and Engineering Sciences, National Science Foundation, Washington, D.C.

Amy C. Spear, SWE Professional Guidance and Education Committee, and Senior Member of the Technical Staff, Radio Corporation of America, Aerospace Division

Magdalena Alde Templa, First President of the Women Chemical Engineers of the Philippines; Senior Research Scientist in Engineering, National Science Development Board, The Philippines

SPECIAL FEATURES

Bertha Jeffreys, Director of Studies in Mathematics and Mechanical Sciences, Girton College, Cambridge, England

Maria Telkes, Director of Research and Development, Cryo-Therm, Inc., and Consultant, Allentown, Pennsylvania

(The Statements that follow were graciously contributed as the basis for discussion for the Symposium.)

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Miss Virginia R. Allan, President
National Federation of Business and Professional Women's Clubs, Inc.
Washington, D. C.

I am very happy to have this opportunity to stress the importance of preparing our youth today for careers best suited to their abilities. Certainly there are many young women whose capabilities meet the requirements of engineering and science which have so many areas of specialization.

As many of you know, the National Federation of Business and Professional Women's Clubs, Inc. has 170/000 members organized in 3,500 local clubs under 53 state federations, including the District of Columbia, Puerto Rico and the Virgin Islands. It is the largest national organization offering membership to all women who work in business and the professions.

This year the Federation has launched a "Partnership With Youth" program, as we have come to realize that those of us who have risen in our businesses and professions share an indebtedness to the oncoming generations of young people whose responsibilities to society in this fast-moving world increase moment by moment.

We know from the findings of the President's Commission on the Status of Women that there are places at the top for trained women in every field of endeavor. In response to President Johnson's challenge to find women to place in key positions, the National Federation is conducting a talent search for women to fill top positions, not only in the Government but also in business and industry.

We know that there are many able girls who graduate from high school but who do not go on to college. It is here that we feel our membership can be helpful in person-to-person contacts with those young people who need the benefit of counseling from experienced, trained women.

Those who do graduate from high school and go on to college tend to gravitate to the characteristically feminine areas of study -- education, social sciences, English and journalism. The Commission report bears out the fact that -- as we look to 1970 -- there is a tremendous gap developing between women's qualifications and the requirements of the jobs that offer the greatest potential for well trained people. The figures on women who go on for their Ph.D's are somewhat alarming. The number of Ph.D recipients declined from 1920 until 1960 -- for the natural sciences from 11% to 5%. For other fields the drop was from 15% to 11%.

It would seem to add up to informing our young women of today -- letting them know what the job potential is in the field -- in this instance, engineering and the sciences which have had, for so many years, a "male only" tag on them.

Evidence of the interest of the National Federation of Business and Professional Women's Clubs in the promotion of science as a career for women is an article which appeared in the February 1964 issue of our magazine -- The National Business Woman. Entitled "A New Trend: More Women in Sciences," the article outlines the academic requirements for a career in all of the sciences and the salaries which can be anticipated in each field.

We are all aware that many of our young women today head for a career as they map their college programs. Many of them, however, with sheep skin in hand, go on to lose themselves in the career of marriage and family, not realizing that 70 per cent of them will work 25 years of their adult lives. All of which bears out the absolute necessity for the establishment of specific vocational goals for all young people. Opportunities for continuing education must be made available for every adult. The world of today demands highly skilled and highly educated manpower.

It is our hope that, with the emphasis we are placing on youth-power in our "Partnership With Youth" program, our members who are engaged in careers in science and engineering will make themselves available for counseling and guidance assistance in youth programs.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Mrs. Constance E. Arregger, President
British Federation of University Women
Bromley, Kent, England

Our age is different from all that have gone before due to the rapid advance of science and technology. The educator, at all levels, is treading new ground. What he learned at school and college is not what he must now be teaching. This presents many problems but most of all the problem of providing citizens with a suitable background for living in a changing world involving (a) basic education for all in which science is one part of a general cultural background, and (b) selection of young people with special talent in order to give them the opportunity to develop their gifts in the direction most suitable for them.

Law givers, politicians, and business men should all have an appreciation of science and technology, and particularly of how scientists think and work but, at present, there should be emphasis on offering openings for scientific training to as many able boys and girls as possible, remembering that the young person with good general excellence is often equally able to specialize in arts or science.

Speaking especially from the point of view of the United Kingdom there has been, during the last few years, a great outcry for scientists and technologists for work at home and in the emerging countries. Steps are being taken to increase the size of the science and engineering faculties in the universities, to build new universities, new technical colleges and new school laboratories. Boys, rather than girls, tend to specialize in science and there must come a time, with the demand for increasing numbers, when young men of the highest mental ability are no longer available resulting in a decrease in average capacity.

This is not the case with girls, of whom only a small fraction become scientists and a minute number engineers. Here there is a pool of ability tapped to various degrees in different countries. Studies have shown that influencing factors are many, including parental attitudes, childhood toys, early concentration on home making, mental development at different ages from boys requiring special educational treatment in adolescence, prejudices of headmistresses in favour of arts and classics, job availability and prejudice of employers due to the life pattern of a woman which does not fit in to an industrial machine geared solely to the life pattern of a man.

Studies are being made and there is need for more. Probably only a major need such as a war, or an utter shortage of manpower, will give birth (and equally painfully) to a new system. However, the pattern of shorter working hours which will be made feasible by the instroduction of automation, if approached wisely, can make the complex problems associated with the employment of professional married women much less difficult.

In addition there is the problem with both sexes of the choice of pure science or applied science and engineering as a career. In some countries, particularly U.K., the status of the scientist is high, while the engineer, who can be trained either in the University or by part-time study while working, has a lower status so that able young people who can choose take up pure science with a hope of entering the research field leaving the less able to engineering. This needs combatting vigorously since industry needs the most able brains.

One excellent weapon would be a large increase in pay for graduate engineers and the better use of engineers including the provision of sufficient assistance at technician level. Another would be a greater spread of information to young people in schools on the fascinating work done in technology.

The educator in planning his work to be of most help for the future must consider now the future pattern of the lives of both men and women. Automation of industry and commerce means that life will be divided into short intense periods of activity for which intense specialized training will be required and longer periods of leisure which, if they are not to be complete blanks, causing frustration and conflict, must be the goal of the general education program mentioned earlier.

A further consideration must be how to keep the practicing technologist up to date in his chosen subject and its allied fields. Here, the educator must provide refresher courses and the industrialists must face the need to give leave of absence for study. These courses can also include those women returning to work after absence from their professional work spent in raising a family.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by The Rt. Hon. Sir Edward Boyle, BT., M.P.,
Minister of State for Education and Science
United Kingdom

There are few if any countries which do not need to produce more engineers and scientists. The United Kingdom is certainly not among them. As a densely populated small country, it has to depend for its living upon its skills and its ability to sell its products overseas. The technological basis of these products must be such that they are competitive in world markets.

Because of the rather special position of the U. K. (perhaps paralleled only by that of Japan) the Government has paid great attention in recent years to the development of many more scientists, engineers and technicians. Since 1956 the achievement has been striking, particularly in the output of scientists. By granting additional funds and stimulating building the Government encouraged the universities and technical colleges to work towards doubling their output of professional scientists and technologists by the late 1960's. The results to date are impressive. In 1955/56 there were some 18,000 full-time students in science and some 11,000 in the applied sciences in universities. The total of nearly 30,000 has by now risen to 46,000 and by 1966/67 it will be 67,000. A decade from now, we hope within the total university population there will be over 80,000 students in pure and applied science.

This advance has been paralleled within the technical colleges. Ten of the colleges doing a considerable amount of advanced work have since 1956/67 been nominated as Colleges of Advanced Technology and the number of their advanced students is nearly 12,000 compared with 4,700 in the base year. These Colleges are due under recent decisions to acquire University status and the facilities for full time and "sandwich" courses are to be expanded to 21,000 places. In addition, there are the 25 regional Technical Colleges doing work up to and beyond degree standard.

On the other hand the over-all picture is not fully satisfactory. Despite some improvement, the U.K. is likely to be lacking a considerable number of qualified scientists and engineers by the end of next year. The gaps are most apparent in the fields of mathematics, and electrical and mechanical engineering. One of the factors giving rise to this is a deep-seated attitude in this country in favour of pure as opposed to applied science. A recent study by the Department of Scientific and Industrial Research brought out the fact that in Britain the school leavers of the top flight do not regard engineering as a sufficiently exciting subject for a career.

So marked a bias is peculiar to Britain - when compared with other advanced countries - and the Government is using its influence in all ways possible, including continuous publicity, to rectify the position. The framework of Government policy in this matter was indicated recently by the Secretary of State for Education and Science, Mr. Quintin Hogg, as follows:-

"The function of Government in this field is not to usurp the functions of management but to provide the conditions in which management can function properly.

For this purpose five conditions are essential:

(1) An educational system which provides the requisite number of applied scientists and engineers.

(2) A climate of public opinion which encourages an adequate proportion of our best young brains to use this educational system and seek in engineering and applied science the satisfying career that they offer.

(3) A system of taxation and an economic climate favourable to scientific innovation and investment.

(4) Financial inducements and grants out of public funds, and research and development in Government laboratories where these are appropriate.

(5) An adequate service for the retrieval and dissemination of information."

And what of the position of women in the fields of science and technology? The census of 1961 revealed that of the 287,000 qualified scientists and technologists in the U.K. some 32,000 or 1/9th were women. On the other hand nearly all these women were working in various branches of science and only 1/60th of them were employed in engineering. From recent studies made it appears that many more girls in the U.K. would be capable of the mathematical basis which is essential for technologists and that more needs to be done to bring to their attention the career opportunities which they could secure. The report on higher education produced last year by the Committee under Lord Robbins, which has attracted world wide interest, said firmly "In particular it is desirable to encourage more girls to read applied science. At present very few girls in this country seem to be attracted to a career in applied science and the contrast with some other countries, notably the Soviet Union, is very striking."

I should like most warmly to endorse these words, and I welcome the fact that there is, in Britain today, an increasing recognition of the part which science ought to play in the general education of girls of secondary school age.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by The Honorable Anthony J. Celebrezze, Secretary
U.S. Department of Health, Education and Welfare

The Society of Women Engineers is to be commended for sponsoring the First International Conference of Women Engineers and Scientists. The opportunities afforded by this meeting to share ideas and knowledge across national boundaries will contribute to the progress of your professions and help to enhance international understanding.

Although we live in an age of unprecedented technological achievement, this is only a beginning. With further advances in science and engineering, the world of tomorrow will be as different from today's world as today's world is from yesterday's. Some of the changes ahead, such as those that will result from advancing automation, can be foreseen. Others will be revealed only with the passage of time and the unfolding of human events.

It is imperative that the engineering and scientific professions continue to receive infusions of new talent. This will occur only if bright young men and women in adequate numbers are attracted to these professions and then are sufficiently interested to devote their lives to them. That more and more women are choosing technological and scientific careers is an encouraging sign. To realize our full potential for material and spiritual well-being, we must develop all of our intellectual capacities and apply them in ways that will produce the maximum benefit for peoples of all races and all circumstances.

In the final analysis all human progress depends upon a vigorous and versatile educational system, one that enables each individual to equip himself to the fullest possible extent, both to assure his own advancement and to contribute to the advancement of his fellow human beings. Through your professional organizations, you have a splendid opportunity to work with schools and teachers and students to help in the development of young people whose minds incline toward science and technology. Such youngsters are being identified in increasing numbers in the schools, and many financial barriers to their education are being removed. But many need the advice and encouragement of professionals such as yourselves in order to catch something of the excitement and importance of the world you have made your own.

Yours is important work indeed. Never before in history has mankind had such spectacular opportunities for an abundant life. But to seize those opportunities, men and women of good will, with minds highly trained for work in science and technology, will be needed in ever increasing numbers throughout the world.

From your symposium on developing engineering and scientific talent should come the kind of imaginative and creative thinking needed to assure that our human resources are developed to their highest potential.

I wish you every success.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Dr. Watson Davis, Director
Science Service, Inc. Washington, D. C.

Women are people. In these times when there is a great deal of discussion about integration of the races, the recognition that in many activities sex has no bearing should be more widely recognized. We need sex desegregation.

Women have always done a great deal of the work of the world but in earlier epochs it has been largely domestic or unskilled. Now there is higher education and technical training for women. There is increasing willingness of industry to recognize that leave and time off for child bearing is a useful and economical procedure. This makes it possible for women to undertake professional work, not competitively but cooperatively, with men during a good portion of their effective adult lives.

The scientific manpower of the world could be increased by thousands of scientists and engineers. Womanpower should be included more effectively in the term "manpower." Perhaps we should refer to "workpower." Intelligent and highly trained women should be encouraged to work part-time, both before and after raising families.

The Russians have made greater use of women in science, medicine and technology than the U.S. More than 76% of Russian doctors are women, contrasted with about 6 per cent in the U.S. But the U.S. is far ahead of many countries in utilizing the skills and intelligence of the fair sex. In a nation like Japan, the scientific professions include very few women.

In the U.S., educational opportunities are equal for both girls and boys. As for brains, they are equally distributed. Obviously, there are some psychological differences between men and women, but many of those that once were thought to be innate have been found to be the result of home environment or tradition. It was once thought that it was not "natural" for a girl to possess scientific talents, as it was for a boy. Now girls are taking an interest in science to a greater extent than ever before, putting aside their dolls for microscopes.

One indication of this trend is the high percentage of girls -- about half as many as boys -- entering the local science fairs all over the country. Even in the stiff competition for the National Science Fair, many of the winners are girls.

And in the Science Talent Search about 25% of the entries are from female teen-agers in their senior year of high school. The Science Talent Search picks the country's top young scientists each year. A survey of 31 women who participated in the first and second Science Talent Searches of 1942 and 1943 showed that only three did not hold college degrees 15 years later, and even these three followed their scientific interest into some form of science after high school training. Of the 28 who finished college, more than half hold degrees beyond the bachelor's and almost one-fourth have achieved the doctorate.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by William A. Douglass, President
Careers Incorporated, New York

A great question mark hangs over the career of the scientist and engineer today. The "shortage," which has been one of the cliches that has been taken for granted for the past six to 10 years, is suddenly being questioned. Since the recent cutbacks in defense appropriations, since last December's "freeze" on the hiring of technical personnel by NASA contractors and subcontractors, since the switch from the cost-plus-fixed-fee to the incentive contract by the Defense Department, many people are suddenly wondering if maybe we actually have an oversupply of engineers and scientists.

All of these things are causing some people to wonder whether we have put too much emphasis on engineering and science as a career for young people. New questions are being asked. Maybe we should forget about Federal aid aimed at scientific education? Maybe we should be hesitant about recommending a technical career to our young people?

In my opinion these are dangerous thoughts. Just as the alarmists were overly dismayed by the "shortage" during the past five years, now these same alarmists are unduly fearful of an oversupply of technical people. I think what has been lost sight of in both instances is a balanced appreciation of what this country should offer a scientist or engineer and what an engineer and scientist should be prepared to offer his country.

From my own observation, which includes an intimate acquaintance with the technical personnel requirements of most of the major employers in this country, there is absolutely no slackening of demand for men and women of ability. Nor is there any reason not to have complete confidence that this nation will need an increasing number of engineering and scientific people in the decades ahead. The panicky attitude which resulted in an attempt to substitute quantity for quality is on the wane, and I, for one, cannot help but feel that this is all for the best.

However, I feel that the full advantage of this calmer approach to the technical manpower problem will never really be capitalized upon unless we take a good hard look at the scientific manpower inventory of this country and make a determined effort to seek out scientific and engineering talent where the talent is. It is far better to concentrate on this group than to try to mold a heterogenous mass of raw material, many of whom are not necessarily the best prospects for a scientific education.

Let me give just two examples of what I mean:

First, there are in this country thousands of people with engineering degrees, who are underemployed because their training is out of date or in the wrong discipline. These people have already made a commitment to the engineering profession, and I think that one of the most important things both industry and government can do is to try to find ways of up-dating their skills so that we might once again make use of their talents. The Sloan Institute at the

Massachusetts Institute of Technology has made a start in this direction, but much more needs to be done.

As far as women are concerned, I feel that the future now holds more promise for the truly able and dedicated woman scientist or engineer than ever before. If the present equilibrium in technical manpower holds, women will find themselves competing on the basis of ability rather than becoming part of a national nose count. The result should be to encourage the best women to enter the field. This, plus the generally high level of employment for talented people, should provide them with a successful and challenging future.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Dr. Blanche, H. Dow, President,
American Association of University Women
Washington, D. C.

Three factors essential to the discovery and development of engineering and scientific talent among young women - as in every other area of occupational or professional achievement - are interest, motivation and training. If a serious and lasting interest in science is to be awakened and developed in the young student, she must be made aware of the world of science, its nature, its fascination, its demands and its rewards, the opportunities which are open to persons trained in science, and the recognition and esteem which are accorded the true scientist.

Formal education or training of the future scientist must be followed by training and development which come with the job. But without motivation, neither the formal education nor the practical training will produce the scientists.

In the past, the inequality of job opportunities for women and for men may have contributed to the seemingly stronger motivation of men. The fact that as students men have had opportunity to meet engineers and scientists who have reached the top of their professions has been a great source of their inspiration and motivation. Not only have fewer women achieved preeminence in scientific fields than men, but women students have had little or no contact with those who have achieved.

The National Science Foundation through its grants, as other agencies and foundations, has awakened an interest in science in today's students at an early age. The number of young persons studying science and engineering has increased, but the number of women preparing for those fields is still regrettably small although the best education in science and engineering in this country is and has been for many years open to women. Women may compete for the many scholarships and fellowships now available for students of science. For many years the AAUW has offered fellowships to women, usually without restriction as to subject although several are definitely for women in science. Today women receive appointments to interesting and well paid positions in engineering and science in universities, industry, the federal government and the national laboratories. To the women who pioneered in science, it must seem as though Utopia had arrived.

Why then are not more young women entering these fields? There is no lack of ability, no lack of interest on the part of women students. Is there a conflict between the demands of the scientific world and the responsibilities that are peculiarly a woman's? Women are marrying young, usually without professional experience. With the great emphasis on the rapid development of science young women may think that the responsibilities of mother and homemaker are incompatible with those involved in a career;

that it would be all but impossible to be out of science during the years of child-bearing and rearing and then return to science even with a retraining program.

Why, we ask, could not part-time jobs in science and engineering be created for such women to fill? What programs are available to help the woman trained in science to keep step with the newer developments so she might return to science after an absence of ten to fifteen years? Programs which offer women an opportunity to retrain prior to their return to the scientific world are available in a few sections of this country, but more are needed.

Women engineers and scientitst have an important role to play in developing engineering and scientific talent by motivating young women through the inspiration of their achievements; through their interest in the young women with scientific aptitudes; by assisting able well-trained scientific women to good positions that will deepen and strengthen their scientific knowledge; by helping to change the climate of public opinion about women in science; and by providing opportunities for the young married woman with family responsibilities to keep abreast with science. This is a challenge that cannot and should not be denied.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Miss Helen E. Hale
President-Elect, The National Science Teachers Association
Supervisor, Senior High School Science
Baltimore County, Maryland

The nation's science and mathematics teachers, particularly those in the high schools, have a plain responsibility to uncover and begin to develop the scientific and engineering talent which our country needs. And they are in a unique position to accomplish the task! They meet and work with 100 percent of the future scientists and engineers, teaching these students at a time when their intellectual interests are becoming clarified. For it is in high school that most young people settle on their life's work; it is in high school that boys and girls get foundation courses in mathematics and science; and it is largely in high school that students learn either to appreciate or to depreciate the total scientific and technological enterprize.

What Is Being Done

Are high school teachers encouraging young people to enter scientific and technical professions? In my opinion, they are doing a number of constructive things toward this end. First of all, they are teaching science and mathematics better than they ever have before. The improvement in instruction discernible during the 30 years I have been in the teaching profession is certainly heartening. During the past six or seven years the general up-grading of high school science and mathematics has been particularly noteworthy, with major curriculum developments in all courses and greatly improved training and competence of teachers. Because teachers themselves have a better understanding of the theoretical aspects of their disciplines as well as more skill in presenting them than heretofore, students gain a truer picture of the conceptual nature of science and mathematics and are given, as well, opportunities to "act like scientists" by carrying out elementary investigations.

To be sure, high school science and mathematics teachers have been favored and given many opportunities to extend their competencies through special programs sponsored and paid for by governmental and private agencies. It is to their credit, however, that they have accepted these opportunities enthusiastically and reaped so much benefit from them. It is also to their credit that they have willingly helped to administer the various informational and incentive programs designed for high school science and mathematics students. Thousands of boys and girls have been introduced to practicing scientists and engineers, either in person or vicariously, through seminars, science fairs, lecture series, industrial and laboratory visits, student summer institutes, summer and after-school employment, science camps, scientists-visits-to-classrooms, and career-information media including posters, films, pamphlets, and interviews. Some of these students have subsequently chosen science or engineering as their life's work.

A few years back most of these programs were sponsored by agencies outside the school--professional societies, academies of science, business-industry groups, colleges and universities, and the foundations. High school teachers cooperated with the agencies, in some cases helping to design the programs, but usually merely operating the programs in their schools. Today many school systems have incorporated incentive and career-informational activities into the total program, and the schools are no longer completely dependent on outside agencies for this kind of service.

What More Is Needed

Do the high schools need to do anything more? One thing is certain: More programs, as such, are not needed. The number of special activities, at least in the urban areas, has nor proliferated to such an extent that there is not only considerable overlap but also insufficient time to accommodate all of the worthwhile programs which are available. The need now is for the schools to be selective and for the teachers to make better use of existing programs. Closer coordination of activities with the school's guidance and curricular programs is also desirable.

An example of a commendable effort in this direction is the SPICA (Scientist Participation in Classroom Activities) Program developed cooperatively by the Westinghouse Corporation and the Baltimore City and Baltimore County School Systems. In SPICA twenty scientists and engineers work closely with high school physics, chemistry, mathematics, and electronics teachers. They study the high school curriculum bulletins carefully and then visit the schools, observing the regular teachers with their classes and conferring with them about the best ways to use the special knowledge of the industrial representative. The teachers, in turn, visit the Westinghouse laboratories. When the scientists and engineers return to the school to work with classes for one, two, or three-day sessions, their presentations are made at a suitable level of difficulty for the students and are meaningfully tied to the regular classroom study.

It goes without saying that the best way to continue to enlist talented young people for the scientific professions is to keep on improving the curricular offerings in science and mathematics. There is a real need for surer techniques for imparting the excitement of science and for developing investigative and thinking skills. A closer articularion between science and mathematics courses is also in order. Possibly, some restructuring of the courses themselves will become desirable; for example, a genuinely integrated physical science course might well replace separate offerings in physics and chemistry.

Something should be said about the school's responsibility for helping to develop a climate of opinion under which science can continue to flourish in a way which will attract able young people into the profession and which will insure general support for the scientific enterprise. Perhaps we have been spoiled by the present emphasis on science and technology, and have become over-confident about the public's interest in this area. It could be that we have passed the crest of public support. In any event, the high school must give all students a reasonably sophisticated understanding of what science is, and what it can and cannot do for our society. If this is done, our future citizens will be in a position to provide intelligent support and adequate controls for scientific and technological activities.

A Special Word about Women in Science

Not being an ardent feminist, I find it difficult to make a special plea for women in science. I know that women make good scientists, engineers, and science teachers. I think of eminent women scientists from my home town -- Janet Howell Clark, Rachel Carson, Florence Sabin, Helen Taussig, Florence Siebert, and Helen Dodson. I work with many outstanding women science teachers, and I accept without question that one of the best science laboratory aides I employ is obviously female, having produced 12 healthy children. At the same time I am realistic enough to know that women engineers, physicians, and scientists are not accepted everywhere without discrimination. High school teachers and counselors must, therefore, give special encouragement to girls who show interest and talent for science and mathematics, and must do their part in helping to break any psychological barriers against women which still exist in their communities.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Dr. Euphemia L. Haynes, Chairman
Committee on Education, Sigma Delta Epsilon
Washington, D. C.

The Recognition Committee of the Engineer's Council for Professional Development has given the following definition of Engineering: "Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind."

It would seem, therefore, that one very strong factor, given as evidence of potential for success in the profession of engineering, is the ability to recognize problems wherein mathematical and scientific knowledge is applicable and practical in their solution and the ability to solve these problems.

This would seem to imply two things. The first is the ability to achieve in mathematics and science, i.e., the ability to think quantitatively and relatively, critically and objectively; the ability to withhold judgment until all factors involved have been considered. The second is the ability to recognize in these sciences the appropriate tools for the solution of a problem as well as the ability to use these tools effectively.

Hence, the program of education must provide not only the necessary learning experiences; it must assure an understanding and appreciation of what has been learned, why it has been learned, as well as where and how it may be used. Moreover, this attitude toward learning must be habitual.

This attitude toward learning should be the objective of all teaching mathematics and science. In order that it may be a habit of thinking as the student moves into the secondary school level, he should be led early in the elementary grades to see his materials as tools with which he may resolve a very real need.

This type of approach has these advantages. Potential for further study in science and eventually in the field of engineering is measurable, to some extent, at any point along the line of preparation. Moreover the student engaged in purposeful activity is working with satisfaction, knowledgeable with respect to his ability and, perhaps, his ultimate objective.

The student must be able to find value in his learnings. Early in the Junior High School years students are frequently lost to the field of mathematics and science precisely because they see no practical value there for them. They drop out of school and have little chance to return to the field. Therefore lost to the profession of engineering is probably a large group of potential engineers. Evaluation of potential and careful guidance are both extremely important at this point in the educational program. Equally important is the availability to the student of the technical problems within his world which offer for him the opportunity for solution.

With increased knowledge in mathematics and science, the student gains day by day a greater understanding of the technical problems which surround him and a greater interest in them. As his horizon widens, his new world of technology becomes more familiar and more challenging, and he approaches the field of engineering not only with increased potential but with familiarity, self-confidence and enthusiasm.

It is true that care must be taken to provide the girl with the opportunity to attain understandings of the technical world which are readily apparent to the male student. The girl must find those experiences through which she too will develop that self-assurance so necessary to move into unfamiliar areas. She must be led to see her opportunities. There must be publicized opportunities for success, growth, and advancement for women. Training for the field of engineering must hold the same standards for men and women.

Until the talents of youth, regardless of sex, are channeled toward engineering and scientific careers, and until the professional world of technology confidently anticipates quality and quantity of preparation independent of sex, that "untapped national resource" referred to by President Lyndon B. Johnson will remain a reality.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Dr. Leland J. Haworth, Director
National Science Foundation
Washington, D. C.

Imaginative and creative scientists and engineers provide one of our great national strengths. To an increasing extent during recent decades they have stepped out of the background of academic and industrial life in order to play a critical role with respect not only to the national economy and security, but also in terms of the national health and welfare and the national prestige as well.

Because this is so, the development and training of adequate numbers of scientists and engineers cannot be left to chance. Our Government has found it to be in the public interest to take positive measures that will insure a steady flow of these highly skilled professionals into teaching, into basic and applied research, into industry, medicine, government, and all other areas where their talents are needed.

The National Science Foundation supports a number of programs designed to further these objectives. A wide variety of fellowships in science and engineering is available for students at all levels of graduate training and for certain categories of faculty as well. Because effective teaching is vital to the training process, colleges and universities conduct a number of Foundation supported institute programs for teachers of science, engineering, and mathematics. Along with measures to make teachers more effective is the concurrent effort to revise and bring up to date course content and curricula. Students in many of the nation's secondary school are now enjoying the benefits of the new courses in physics, mathematics, chemistry, and biology. Similar efforts are under way for engineering; during 1963 the Foundation awarded grants totaling approximately $1,315,000 for course improvement in engineering. The American Society for Engineering Education has a Foundation grant for a comprehensive study of the current status of, and future directions in, engineering.

The Foundation's programs of research support include both engineering and the sciences; and these programs, in addition to providing needed support for the research itself, also contribute in an important way to the training of young scientists and engineers. Other programs are directed toward the provision of needed research facilities, laboratories, and equipment.

These varied efforts are some of the ways in which the Foundation, and other agencies of the Federal Government, are meeting what they feel to be an important responsibility for the educating and training of scientists and engineers. The Government should not, however, and indeed cannot shoulder the entire burden. Important impetus must come from the local community in creating a climate of opinion that encourages and furthers the sustained intellectual effort required to attain mastery in the fields of science and technology. Such encouragement must take the positive form of active support for the educational institutions of the community and of attitudes that stimulate better teaching and better students.

Women have repeatedly shown that when they enter in a serious way those professions that have long been dominated by men, they can be as successful as their male colleagues in attaining professional competence and recognition. The question of sex difference really is not germane, therefore, except to the extent that far too little has been done to persuade competent women students with appropriate aptitudes to apply their talents and their abilities to the fields of science and engineering. I am confident that if the emphasis is placed where it should be -- on proper motivation and recognition -- women will contribute in a significant way to our total resources in scientific and technical manpower.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by W. Scott Hill, President
Engineers Council for Professional Development
United Engineering Center, New York

Our real concern in these times when change seems to be the password is to provide opportunity for our young people to receive the maximum amount of preparatory education in relation to their capabilities, and to put in place educational programs for the continued development of professional personnel. When these opportunities are available, the numerous professions should be able to attract the necessary people to provide leadership in their respective areas. Today's environment exacts a higher level of intellectual thought and objectivity than at any time in our history, and the future will be even more demanding.

This is why it is necessary to make certain that we do not allow prejudice or lack of human commitment to prevent the development of our best brains and leadership in all of our people irrespective of race or creed. The role of women in our professions, particularly in engineering and science, has been seriously neglected. But changes in our social environment, and even more so in the nature of engineering work, are offering greater acceptance and rewards which broaden the potential contributions for this group of people.

There are approximately 7,500 women engineers in the United States, ten times the number in 1940. Yet, women represent only one per cent of the engineering profession at a time when the nation is coping with a serious shortage of engineers. In the scientific field, 11 per cent of the scientists are women.

According to reports from engineers and other sources, women have successfully demonstrated their ability in these fields. In elementary and high school, girls are as frequently outstanding science students as the boys, but all too often are not given the same encouragement to acquire a technical education. There are certain social prejudices and attitudes held by both sexes which prevent women from becoming engineers and scientists in greater numbers.

Engineering is no longer entirely a "nuts and bolts" profession carried on in a factory atmosphere and involving physical as well as mental exertion. The majority of engineering jobs in this technological era are desk or laboratory jobs and are directed toward problem solving. This type of specialty requires a high degree of analytical competence, prevalent in both sexes, and offers a challenge to either men or women. By overcoming these prejudices and attitudes with a more realistic, challenging image of engineering and by offering encouragement early in the high school to girls who show an interest in the aptitude for technical and science subjects, more talented women will be channeled toward engineering and science careers.

The Federal Government is promoting engineering as a career for qualified women. The Executive Office of the President of the United States has arranged conferences in which college faculties, technical industries, and members of the Society of Women Engineers meet to discuss ways of attracting women to the engineering profession.

This activity by the government is commendable, but the engineering profession itself has the responsibility to initiate and implement programs to emphasize to our young women the exciting challenges which exist for those who enter this field. The contribution of chemistry, mathematics, biology, physiology, psychology, economics, and other of the diciplines are uniting with engineering to provide greater service to mankind than ever dreamed of by earlier generations. This service should have a tremendous appeal to women who possess such a compassion for humanity.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Dr. Elmer Hutchisson, Director
American Institute of Physics

I am please to have the opportunity of commenting on the need for channeling the talents of our young people toward careers in science and particularly toward careers in physics. This problem of interesting our youth in science is clearly part of a very much larger problem; that of arousing the interest of people both young and old in the potentialities of science as a leading factor in building up the intellectual fiber of our nation as well as its economic strength. In this task, there is an unusually important role for women to play which makes it an altogether proper subject for discussion in the First International Conference of Women Engineers and Scientists.

The science of physics has two quite different aspects. On one hand, it is an essential part of our culture to be studied by all educated persons. It is as fundamental as "reading, 'riting and 'rithmetic." It represents the finest example of the power of the human mind to observe nature, to arrange these observations in an orderly fashion, and from them to build the magnificent intellectual edifice which as a unified whole so clearly portrays the physical universe in which we live. Fortunately, the building of this intellectual edifice will never be quite complete. Each new generation is given the opportunity of adding something of significance and thus increasing the strength and magnificence of the entire structure.

Just as in the Middle Ages the rich and the poor each contributed their bit to build the great cathedrals and to partake of the high satisfaction of having made the world more beautiful, so now in our day can those both poorly and richly endowed in science contribute their bit to this modern edifice that so eminently characterizes our age and culture. This one aspect alone of the science of physics or of "reasoning" from observed facts justifies adding it as well as other science as a fourth "r" to the curriculum of even our most elementary schools. Throughout the ages, the substitution of reasoning for witchcraft and magic has been the hallmark of a civilized nation.

The study of physics, like that of other sciences, has, in addition, a second and very practical aspect. With a comprehensive and detailed understanding of the forces of nature comes also the possibility of harnessing these forces for the good of mankind. Science, by enhancing man's physical strength and his sources of energy, provides him with material riches far beyond the dreams of men only a few decades ago. Yet only a beginning has been made. New science is enhancing his mental powers even more than science a short time ago enhanced his physical powers. The future opportunities for improved health and freedom from hunger and drudgery are limitless. These opportunities are open not only to men but equally to women.

Women have a great power to influence our youth and to turn their limitless energy into useful channels such as those represented so well by those modern-day women engineers and scientists attending this First International Conference. The Conference, in dramatizing the opportunities ahead, will contribute significantly toward tapping this great "untapped national resource" of women in the growing force of engineers and scientists in America.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Dipl.-Ing. Jlse Knott-ter Meer, VDI
Nürmberg, Germany

As in most other countries, there are only a few women engineers in Germany, but more and more are wanted. Because of the progress in all technical fields more engineers are wanted everywhere and women engineers can help fill this need and can do so by performing very important work. Another matter is notable: Looking at Russia it is interesting to see that there a lot of women engineers are employed, and they consider it very important to give many women a good technical education.

In Germany we have women who came in different ways into their profession: There are Diplo-Ingenieure (Dr.-Ingenieure), those who have completed baccalaureate-examina at the Technical Universities; We have women engineers who got their education at Technical Schools or Schools for Engineers; We have women who learned their technical skills on the job in different factories or laboratories and were employed later as engineers; We have women who had to take over the engineering work in their own firm by illness or death of their husbands.

To discover and to develop the technical talents of girls and women it is very important to inform them of how women are working today in technical fields and to let them have contact with these women and women engineers. So it is necessary to publish news about these women and their work. It is also important that the teachers of the youth get acquainted with these matters.

To provide the opportunities to publish such information we in Germany have arranged meetings of women engineers in connection with the "Deutschen Ingenieurtag" which take place every two years in different towns. Thousands of engineers, also some from abroad, take part in these Conferences.

In 1960 on the "Deutschen Ingenieurtag" in Hamburg, we had a first meeting of women engineers. There were about 30 women engineers; they spoke together and each of them told of her education, her work and also of her difficulties. In 1962 at the Deutschen Ingenieurtag" in Karlsruhe, we had a meeting of Women Engineers, and papers were given concerning: (1) the work of a women engineer in the Deutschen Patentamt (Patent Office), (2) possibilities for women in the engineering profession, and (3) a business women as technical manager of a factory for electrical appliances. This year we shall have the Deutsche Ingenieurtag 1964" at Munich; there we shall have three papers by women engineers. One of them is occupied in the Chemical Industries, the second one at IBM, and the third is a textile engineer.

Another matter is important. After marriage the women engineer or scientist should try not to lose connection with her profession. During the years she has to spend most of her time and energy on her family or her children, she should try to continue her studies; then later she will have the possibility to return to her profession and to do good and satisfying work.

So we consider it very important that the "First International Conference of Women Engineers and Scientists" is taking place and we are very thankful to the members of the Society of Women Engineers that they have arranged it.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Mrs. Esther Peterson, Assistant Secretary
Director of the Women's Bureau
U. S. Department of Labor

I am delighted that women of so many countries have united in scheduling the First International Conference of Women Engineers and Scientists. The United States is honored to be host nation to such a significant gathering.

By emphasizing the importance of developing engineering and scientific talent wherever it can be found, you are underscoring a great need. By focusing attention on the potential role of womanpower in meeting this universal need, you are demonstrating outstanding leadership as well as vision.

The message which you have for young women of today should be disseminated to all who may influence their motivation and plans for the future. It takes on a particular urgency because engineering and science have not been considered traditional career fields for women. Yet, despite this attitude, some women have made great contributions in these areas of work. More could, in my opinion, if latent talent were identified and developed. One of the challenges facing us is the encouragement of talented girls to prepare for and seek to enter any profession for which they are qualified.

Your findings, your recommendations, and your subsequent actions will further the goals of every nation throughout the world, for many of our hopes for a better life and a better society are dependent upon engineering and scientific progress. Women can and will play significant roles in such a vital undertaking. Your conference will point the way.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement of A.E. Amour on the part of Emma Strada
President, Associazione Italiana Donne Ingegnere Architette, Italy

The problem of providing for the future growing demand for engineering and scientific personnel, needed for the development of industrial technology, has to be considered under three basic aspects. First of all is the availability of "raw material", that is to say, of young people endowed with good intellectual capacities for undertaking and successfully achieving the heavy curricula of engineering and scientific studies and the successive specialisations in different branches of engineering and science. Under this aspect, the problem is to find among young people a greater percentage of those who are endowed with mathematical and scientific aptitudes, with capacity for synthesis and analysis, with imagination and creative thinking. These are qualities which can remain at a more or less static state, if they are not developed and trained during early youth, that is, if young people are not given the opportunity to study.

The second aspect of the problem is exemplified by the farsighted spirit of social service of the Rotary Club of Milan, which has launched and supported the IARD Program. This program aims at the identification and encouragement of all boys endowed with good potential qualities, whatever may be their social status, to pursue studies in higher education. The selection is based on their personality and social environment, for therapy purposes, not for discrimination, aimed at developing them in the positive sense. The selection is made on the basis of three parameters: school marks, teachers' judgment and psychometric tests, essentially about their creative nonconformist thinking, by integrating the various results of IQ evaluation. The boys who are included in the ninth superior percentiles are offered the means to continue their study and eventually some assistance to their family.

This program is aimed also at showing that it is necessary to personalize and make more efficient scholastic assistance. It has to be added that in 1962 only 23 million lire were assigned out of 100 million lire available for scholarships offered by Municipality, Government and local Authorities. Significantly enough, the selection is operated only among boys, not among girls. That is, the Rotary (as many other organizations in Italy) do not yet plan to utilize the talent with which girls also are endowed by nature to satisfy the future request of engineers and scientists. Girls who are pursuing advanced studies can always apply for scholarships offered (the 100 million lire mentioned above) without discrimination.

Actually women in engineering schools were but 0.53% in 1960, while in the Scientific Faculties of Universities (Mathematics, Physics and Natural Sciences) women represent about 1/3 of students. After obtaining their degrees they engage in the teaching field (mostly of the secondary level), as also do a good half of women who reach the Doctor's Degree in the Engineering field. About 1/4 of them retire to take care of the family, and only the remaining 1/4 undertake professional activity, either as employees in industry or independently in the civil engineering field.

The number of women actively engaged in the profession represents only about 1% of the total number of registered engineers. This minimum percentage is a symptom characteristic of the third more vital aspect of the problem of developing engineering and scientific talent. A person has to be endowed with natural gifts of intellect, needs the financial means necessary to pursue studies, but more substantially any person wants to have incentives and motivations which can drive him along the career which are represented by the possibilities of succeeding in the professional field. These possibilities are not only represented by a high remuneration. The inquiries made in different countries of the world have shown that a high pay is not in the first place in workers' requirements. The value of the pay is relative; what counts most are work satisfactions and recognition of personal capacities.

Therefore, it is not enough to invite girls to enter the engineering fields of activity; it is also necessary to improve the actual perspectives of future achievements and working satisfactions and to be recognized in a technical and professional status, free from preconceptions, prejudices and privileges. The situation is comparable to the so-called "brains exodus" from Europe and more recently from the United Kingdom to the U.S.A. It is said that one of the reasons for the exodus is the high wages which are offered to scientists and professors in U.S.A. but the real motivation is probably the quest for better recognition of their contribution to the progress of science and for more freedom of activity in comparison to that offered within narrower limits and in a more rigid and subordinate position in their own countries.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Mrs. Magdalena Alde Templa
Director and First President
Women Chemical Engineers of the Philippines
Manila, Philippines

Greetings from the Philippines to the Society of Women Engineers of the United States and to the delegates from all over the world. We wish to congratulate you for your laudable move of holding this International Conference of Women Engineers and Scientists as it is of great significance and value, especially to countries like ours where the search for engineering and science talent is a necessity. While our women technologists, particularly the Chemical Engineers, are increasing in number, most of our men still refuse to accept or recognize the latent power that could be used to help in the industrial and economic development of our country.

As a pioneer and first president of the Women Chemical Engineers of the Philippines (WOCHEP), I wish to state that we organized ourselves five years ago patterned after the SWE. We had as the main objective the fostering of a congenial attitude in industry toward women chemical engineers and to guide them in their educational progress and the practice of their profession. We could at least say today that our efforts have not been in vain, as private industrial sectors as well as government agencies have started employing women engineers.

To avoid competing with men in matters of employment the WOCHEP has launched a program of guiding and training our women graduates in cottage industries, tapping our natural resources and putting emphasis in the rural areas. We have succeeded in training some of our women engineers who are now engaged in utilizing our agricultural raw materials and residues such as the coconut for food, construction materials and fuel, and local clay for ceramics, etc. With this approach to the use of our latent women power we feel that while we practice our profession for the development of the country we do not abandon our homes as wives and mothers.

This year a survey was conducted by the WOCHEP on the status of our women engineer members. Of those that responded, 52 per cent are working in government agencies, 20 per cent are in private industries, 4 per cent are pursuing graduate courses and 12 per cent are doing non-Chemical Engineering jobs. Most of those employed are engaged in research and development work and in the manufacture and quality control of products.

With your theme "Focus for the Future - Developing Engineering and Scientific Talent," which is the great need of the world, particularly of the undeveloped countries, I believe that all delegates to this Conference will profit greatly from the experience of each country on this problem.

Here is wishing the Society of Women Engineers a very fruitful and successful Conference. We, the women engineers and scientists of the Philippines, are behind you in this effort.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Dean Kurt F. Wendt, President
The American Society for Engineering Education

I would emphasize the rapid, almost bewildering, speed with which new knowledge is being developed and the ever-increasing rate at which old knowledge is being applied to solve increasingly complex problems. New technologies based on new discoveries of materials and processes grow up almost overnight. As a result it becomes essential, to a greater degree than ever before, for every engineer and scientist to plan a program for keeping abreast of his field and related areas.

How can he (she) do this? Reading the literature in the field, using effectively the trade and technical publications, and attending the meetings of appropriate professional societies all are important and rather obvious. But good as they may be, these measures are not enough. It is being recognized more and more that occasional, intensive study programs in which the participants literally "go back to school for a while" and in which study of a limited area can be pursued in depth are needed.

To be most effective the participant should be removed from his usual environment far enough and for a sufficiently long time (one to six weeks) to break away from old routines and office pressures, and he should be provided with an atmosphere, both physical and mental, which is conducive to study. It hardly seems necessary to point out that great care must be taken to select participants with relatively uniform qualifications and to provide for them the most stimulating and effective teachers possible. As an alternative, a series of two- or three-day institutes coming six to eight weeks apart has also been found moderately effective.

What are our actual needs in continuing education? What resources are now available to fill these needs? What can our industries, our professional societies, our schools do to supply additional opportunities? How can all of this be financed? How can the participant receive appropriate recognition for his efforts?

In the engineering field I have posed these very questions to our many interested groups in ASEE, and have further queried the National Society of Professional Engineers, the Engineers Joint Council, and the Engineers Council for Professional Development as to their interests, comments, answers, and plans. It is good to be able to report that we have agreed and have established a Joint Advisory Committee to coordinate work in this all important field, to develop a plan to get the answers, and hopefully to implement such a plan. Dr. Ernst Weber, President of the Polytechnic Institute of Brooklyn, has accepted the chairmanship of the committee.

Several effective studies directed at some of these questions are already under way. More are needed. Much high quality work is also being done by many schools and colleges, and by several of the professional societies in providing lecture series, short courses, institutes, and special on-campus programs of study. Again, more is needed -- much more.

Your symposium could well address itself with profit to the exploration of the most effective ways and means of providing for the young and not-so-young scientists and engineers the opportunities to stay at the forefront of knowledge in their respective areas.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by The Honorable W. Willard Wirtz, Secretary
U. S. Department of Labor, Washington, D. C.

This First International Conference of Women Engineers and Scientists should constitute a milestone in the development and utilization of human resources. It recognizes that peoples the world over have mutual problems and challenges. It focuses attention on the potential capabilities of women, referred to by President Lyndon B. Johnson as an "untapped National resource." The Conference derives its significance from still another factor: It is looking toward the future--toward the better life all of a Nation's citizens can enjoy through scientific and technological achievement.

Forecasts indicate excellent opportunities for those who seek careers in engineering and science. New scientific research and development work in atomic power, space exploration, electronics, solar-powered electricity, and aviation can be expected to create many more jobs for physical scientists, engineers, mathematicians, statisticians, and for assistants to the professional workers in these fields. Marked growth will continue in the medical and health services. Expansion is anticiapted in the teaching field. Clearly, if a Nation is to meet its need for qualified workers in these and other areas, the potentialities of women must be fully utilized. Such an action is in the national interest; it is in the tradition of our democracy.

The combined resources of educational institutions, professional societies, business and industry, and Government must be directed toward motivating able young women to develop their maximum potential. Society still clings to the tradition that some occupations are men's work and others women's work. The sciences and engineering, for example, long have been considered to be more appropriate careers for men than for women.

We can no longer afford such ill-conceived ideas. Young women who have the capacity and desire to prepare for such professions not only must be tolerated but actively encouraged. Serious attention also must be given to the proposition of continuing education for mature women. The President's Commission on the Status of Women, in its report AMERICAN WOMEN, labeled this need as a priority. We need every resource of skilled manpower and womanpower we can muster.

In considering the measures which must be taken to educate women for the fields of science and engineering, it is advisable that we examine the educational needs of the population as a whole. Within the reach of all Nation's youth must be good basic instruction, dedicated teachers, and adequate facilities--and, as adulthood is reached, the opportunity for individual fulfillment. Our goal is a higher quality throughout life, in America and the world. We can attain it only as we strive for it.

SYMPOSIUM ON DEVELOPING ENGINEERING AND SCIENTIFIC TALENT

Statement by Dr. William Wright, M.A., Sc.D., Ph.D., B.Sc., Director,
Graduate School of Engineering Studies
Engineering Schools, Trinity College Dublin, Ireland

There is a wealth of meaning underlying the title of a book published just after the War, "Ladies may now leave their machines," and it seems to say: "Thank you very much, ladies, but peace has broken out and you can get back to your knitting." Machines, and not only in the alliterative sense, are for men.

In English, the word "engineering" embraces a wide spectrum of meaning extending from the technician whose abilities are largely manual and manipulative to the theoretical research worker whose abilities are more cerebral and contemplative. Clearly, in studying the question of women engineers, attention should be focused on the second category. I am not thinking of brassy voiced hoydens screaming instructions at passing bulldozer drivers, nor of young Amazons dressed in oily dungarees wielding outsize spanners.

In Russia, nearly 80% of the doctors and rather more than 30% of the engineers are women. In this country, about 30% of the doctors and rather less than 1% of the engineers are women. This state of affirs is very hard to defend nowadays. When Brittania ruled the waves, it was all right if the mem-sahib confined her activities to making tea and polite conversation, but it won't do in the 1960s when our principal asset is trained manpower and womanpower.

Why then do we not have more women interested in careers in engineering? This question can be broken down into three parts. Firstly, are women coming forward in large numbers seeking to be trained in engineering? Secondly, is there any obstacle placed in their way in the engineering faculties of our Universities or Colleges of Advanced Technology? Thirdly, is there any prejudice against their employment in industry or elsewhere when they have been trained?

The answer to the first question is that there are few girls indeed seeking admission to courses of study in engineering, probably because of ignorance of what a career in engineering has to offer them, because of prejudice on the part of teachers and of parents, and because of inadequate preparation, particularly in the field of mathematics.

Turning to the second question, if large numbers of girls were clamouring for admission to our engineering faculties, would they be welcomed? By and large, I think that the answer is "Yes." Indeed all those who are qualified and who seek admission are welcomed at the moment, but the number is very, very small.

The last question concerns the attitude of prospective employers. Here the position is less clear and it is not easy to generalize. Firms engaged in older heavy industries such as steel and ship building would not, I feel, be expected to look on women engineers with much favour. The opposite view would be more likely to prevail in modern light industry, for example, in the electronic and aircraft fields. It is in just those industries and others whose embryos have not yet emerged from the research laboratories that the scope for expansion is greatest.

To view the problem from another angle, the work of an engineer can be thought of as ranging from theoretical research planning and design through development to practical production. Because of increasing automation in industry, a disproportionately large increase in demand for engineers at the research and planning end is to be expected. Indeed, it is already with us and again this is the end most appropriate for the employment of women engineers.

If the foregoing analysis is correct, it means that there should be increasing opportunity for the employment of women engineers in industry. Certainly in 10 or 15 years' time, with the present pace of technological change, a very strong demand indeed can be foreseen. I mention a period of from 10 to 15 years because, even if there were not to be a revolution in thinking on this question, it would take at least that period of time for women engineers to begin to percolate into the ranks of trained engineers and to take their place along side their male colleagues as real effectives. It must not be forgotten that with our present educational system, the age of decision when a child must select which academic stream to follow is about 13 years and that an engineer is not really effective and trained as such until he or she is about 25 years of age.

It must be admitted that a rapid and dramatic change in present attitudes on any scale is unlikely, given the present climate of opinion nourished as it is by out-worn and out-of-date prejudices. A more gradual change of attitude is surely to be looked for analogous to that which has slowly transformed and melted the prejudices against women doctors during the past 60 years or so.

Such a change will surely come for it must ultimately be most damaging to labour under a self-imposed handicap whereby half of the population is debarred from participating at the highest levels in the ever-expanding field of the application of scientific knowledge for the use and benefit of man, which is, I think, a good definition of the work of an engineer. This definition is not original as the wording closely follows part of the preamble to the Royal Charter of the Institution of Civil Engineers, our oldest professional body of engineers, which incidently has recently admitted its first woman to full membership. This action would, I feel sure, have been warmly approved by the first President of the Institution, Thomas Telford. As a Scotsman, I cannot forbear pointing out that they both came North of the Border.

Note: Acknowledgment is here given to The Scotsman, which has accepted Dr. Weight's statement as an article for publication.

SPECIAL FEATURE SECTION

of the

SYMPOSIUM ON DEVELOPING ENGINEERING AND
SCIENTIFIC TALENT

The contributions that follow are the generous responses of women of recognized eminence in Engineering, the Physical Sciences, and Mathematics to a request for an inspirational personal account of how each was motivated to choose her career and what had been especially outstanding and satisfying in her work experience.

Contribution of Mrs. Bertha Jeffreys

Director of Studies in Mathematics and Mechanical Sciences,
Girton College
University of Cambridge, England

Those of us who were born early in this Century had the good fortune to be at not too great a distance from the Nineteenth Century pioneers in women's education. Feminism is an unpopular word nowadays, and I would rather describe the atmosphere in which I grew up as one in which it was taken for granted that women should be self-reliant and able to think for themselves. The reason for this was simple: the distaff side was much more strongly represented on both sides of the family and I owe much to the encouragement and help that I received in my early education from my mother and aunts, several of whom were teachers in primary schools. After my father's early death, my mother returned to this profession and to my grandfather's home, so that my early formative years were spent very much among the previous generation.

The impetus towards Mathematics and Science came partly from a devoted aunt, who taught me Algebra and Geometry from being one jump ahead of me and who shared a possionate interest in Systematic Botany, and later from my headmistress, who established a very fine scientific side in the early years of a newly founded secondary school for girls in my native town of Northampton. We had excellent teaching from well-qualified graduates. It is a matter of very grave concern that at the present time there is such a shortage of women teachers of Mathematics and Science in our schools; this is due to the attraction of other careers than teaching, and in large measure to the early age of marriage among graduates.

I was taught Mathematics by two graduates of Cambridge University, both members of Girton College, one of the pioneer Colleges for women, and with the aid of scholarships I went there myself in 1921 and took the Mathematical Tripos. This was and is a strenuous discipline in Mathematics and Natural Philosophy--I use the old term, which embraces Applied Mathematics and Theoretical Physics. No formal courses in other subjects are required, but there is plenty of opportunity for widening of interests.

After this I studied Physics for a year, but the old Cavendish Laboratory tradition of making one's own apparatus was too much for me. When the question arose of my starting research, the one thing that I remember Lord Rutherford saying to me is, "They tell me you are not much good at experiment; you had better go and see R.H. Fowler". So I did, and had the good fortune to work under him for a Ph. D., which was then a very recently instituted degree in the University of Cambridge. He was by no means a "spoon-feeder", and his pupils were rather left to sink or swim, but I never went to see him without coming away inspired and stimulated.

At this time, the new Quantum Mechanics was being developed by Bohr, Heisenberg, Dirac and Schrodinger, the beginning of a new era in Physica. The same excitement was felt then about the resolution of problems of the extra-nuclear structure of the atom as is felt to-day about those of the nucleus itself. In my third year of research I went to Gottingen for a winter semester. I was then making some first steps in the problem of absorption of X-rays by the electrons of the atom in which they were emitted --so called internal conversion, a problem which has in fact needed the techniques of modern computers, and has more recently been so treated by Dr. Rose and his collaborators.

During this time I first met Douglas Hartree, who in 1929 became Professor of Applied Mathematics at Manchester University, where I was a member of the teaching staff for some eight years. I greatly enjoyed the work there, both teaching and research, and I retain a great affection for the large industrial city. Hartree was at this time producing his masterly series of papers on the atomic self-consistent field, and at his suggestion I made some steps in extending the method to the first order of the relativistic approximation. I also worked on the problem of absorption of radiation in white dwarf stars.

I was also one of the Honorary Secretaries of the Manchester Literary and Philosophical Society, a foundation going back to the Eighteenth Century and possessing a fine periodicals library. Its beautiful old house was bombed, but I am glad to say that a very satisfactory modern building has risen to the ashes and the Society plays a part more suited to the Twentieth Century.

In 1939 I accepted an invitation to return to my own College at Cambridge and I have been there ever since. I should mention that one of my first pupils there was Miss Cicely Thompson, immediate Past-President of the British Women's Engineering Society and one of our delegates to this conference. World War II came and this time men studying Science and Mathematics were allowed to continue their University course, though it might be curtailed, and it was only in the last years of the war that classes became smaller.

In 1940 I married Harold Jeffreys, geophysicist, astronomer and mathematician. We set up house, as we thought for a few months, in the only Thatched Cottage in the middle of Cambridge; in fact we stayed there till the end of the war. It was a real cottage, but it had been modernized on American lines and was extraordinarily convenient. It is now overshadowed by our new multi-storey car park. It did not occur to either of us that I should stop working and retreat into domesticity; in any case it would have been impossible in those war years. As we worked in different fields of theoretical physics, it occurred to us that we might work together on a book on Methods of Mathematical Physics. Looking back on it, I think how rash we were in entering on such a collaboration with all the strains it entails; however, we and our marriage survived it and the book came out in 1946 and is now in its third edition.

Music and languages have always been among my interests. In the last few years I have had much pleasure from learning Russian sufficiently to follow technical works and am rather proud of having had a translation of a monograph on Dynamical Astronomy published a year ago.

Since the war, my husband and I have had many occasions to travel together, several times to this country--to both sides, but in my case hardly ever to the middle. It is a platitude that the best way to get one's own work done is to go away from one's own University, and I should like to pay tribute to the stimulus that I always get from visiting departments here. For the last few months, my husband, now "retired", nas been working at the Lamont Geological Observatory of Columbia University; I am deeply grateful to the aeronautical engineers for making the time of travel so short, so that I shall be able to make two visits during the period.

My own retirement from my present appointment is only a few years off, but I hope to continue to work. Combining academic work with marriage is largely a matter of how much you want to do it and of the support that your husband gives. I wish that I could see it becoming really easier for the coming generation. We have no children and I realize that the decision on what is best for them is not easily settled. Although women engineers cannot do much in the way of providing an automatic children's nurse, they can do much in stressing the need for cheap and efficient labour-saving equipment in the home; but I believe the fostering of a public opinion that encourages the married graduate to use her training to be even more important.

Contribution of Dr. Desiree S. LeBeau

Director of Research, Midwest Rubber Reclaiming Company
East St. Louis, Illinois

As a kid, I had always had an interest in science in general and I liked to make all kinds of experiments, and mostly read books on general science, geology, biology, natural history, etc. I also had a considerable amount of talent in music, piano and voice, but hesitated to take this route because it might lead to teaching which I disliked. On the other hand I could not see myself spending year in year out in any office doing the same thing.

Therefore, after graduation from a secondary school in Europe, which would put me at about the level of two years of college here and which is a very necessary springboard in Europe, I decided to study Pharmacy because it would have taken only three additional years of study. However, my mistake I attended the lab course for chemists rather than for pharmacists. This course is much more extensive than the one usually taken by pharmacists. In due course, the subject matter of chemistry became more interesting and I switched to it completely, taking my Ph.D. in physical chemistry.

Jobs were scarce at that time. I also had a degree for teaching science, chemistry and mathematics in junior colleges, which I did for one year. After this year I found a job in the rubber industry and have been in the rubber industry ever since.

The satisfaction in my work comes mainly from being able to design new materials, improve processes, and above everything learn to understand the underlying principles for each phenomenon with which I am dealing. This of course is an age of progress in chemical synthesis and particularly in polymers; therefore, the work is exciting and satisfying.

Contribution of Mrs. Laurence Pellier

Senior Scientist, International Nickel Co., Inc.,
Bayonne, New Jersey

Progress in science and technology during the span of my life time has reached far beyond all frontiers that the imagination could conceive. The opportunity to witness even an infinitesimal fraction of this progress has thus been a most rewarding experience.

Throughout history, the practical demonstration of a few major ideas made progress advance suddenly by leaps and bounds out of long periods of conversative achievements. Persons my age have had the privilege to follow the burst of progress that such ideas have generated during the present century. As an example, I should like to consider briefly distances that it is now possible to survey directly. At one extreme, we have space travel. For centuries, travel was limited to the earth surface and, all of a sudden, during my life time, it acquired an immense third dimension when it was proved that machines heavier than air could be made to fly.

I remember very well when my mother used to take me, as a little girl, to an airfield near Paris; experts pointed to "biplanes" and "monoplanes", now museum pieces; flying across the English Channel was a most daring expedition, and many people nodded disapprovingly at the magnitude of the risk that fliers were taking. The following 50 years proved that the major step in aviation had already been taken. Many discoveries contribute, of course, to such a burst of progress, but they usually follow with logical rapidity from the major breakthrough. Perhaps I can illustrate this point at the other extreme of distances, that of microscopical dimensions, which have been opened to the scrutiny of man during the past decades.

For centuries again, the smallest dimentions, directly observable with light microscopes, had been limited by the wave length of light to a little over a tenth of a micron, or one thousand Angstrom units. It took great care and skill, with the best instruments, under optimum conditions of sample preparation, to achieve magnifications of some 3,000 diameters, far from the magnifications of over a million diameters necessary to resolve atomic dimensions and make them visible. Then, with the discovery of particles other than photons--such as X-rays, electrons, protons--and the understanding of the wave motion associated with them, the idea was conceived that the improvement in microscopy could come by a radical change in the nature of the illuminating beam rather than from mechanical improvements on the microscop body and optical improvements on its lenses, all improvements which had already reached such a high degree of perfection.

Electrons were first selected for illumination because they had all the characteristics required; they could be emitted from a source and accelerated by a potential field, they could be deflected by magnetic or electrostatic fields, and they could sensitize a fluorescent screen or photographic emulsions. A new microscope could thus be designed following the pattern of a light microscope, that is, an electron gun could replace the source of light, magnetic or electrostatic lenses could be substituted for the condensers, objectives and projectors--and were given the same names--, and an image could be observed and recorded.

The instrument was somewhat complicated by the use of vacuum to prevent scattering of the electrons, but it was essentially the same as a light microscope. The short wave length of the electrons, however, permitted, even with the original instruments, a resolving power of 30-50 Angstrom units, as compared with over a thousand Angstrom units with the best light microscopes; electron microscopes today can resolve a few Angstrom units.

Once the first electron microscopes proved workable, other microscopes and related instruments were designed in rather rapid succession. It was quite logical to use an illuminating beam of a different nature and proton and ion microscopes have now been designed. The sample itself can be made the electron emitter and in a very simple instrument, in which the sample is in the form of a sharply pointed filament, individual atoms have been resolved. Several instruments can be combined and synchronized, as in microprobe analyzers in which microscopy and elemental analyses can be performed over areas the size of a micron.

The first results of electron microscopy in biology promised to be spectacular: for example, it was possible to observe the molecular organization of viruses and, immediately cures for poliomyelitis and cancer were envisaged. In metallography, the first attempts were more arduous because the instruments were designed for transmission microscopy and bulk metals were opaque. Replicas techniques were developed and contributions began. The field of observation was cautiously extended to finer and finer microstructures, first fine carbides in steels, the presence of which was expected from years of systematic studies with light microscopes, then precipitates in hardening alloys in which evidence for their presence was much weaker.

Techniques for direct examination of thin sections of metals were next developed. By this time, microscopes had been improved: higher voltages had increased the penetrating power of the electrons and better condensers had increased the illumination intensity, so that it had become possible to see through representative sections of metals. Electron metallography had been won from light metal lography. Progress then took bigger steps.

In the physics of metals, for instance, it had been postulated and shown indirectly by X-ray diffraction analysis that metals were imperfect crystals and that their imperfections were responsible for the several orders of magnitude difference between their actual strength and that calculated theoretically. It was now possible to observe these defects. It had been shown theoretically that line defects, called dislocations, greatly facilitated slip in metals under stress; these dislocations could be observed directly, they could be made to move and multiply under the effect of mechanical or thermal stress applied directly to the samples in the microscope, their reaction with inclusions and grain boundaries could also be followed.

In other words, a wealth of direct evidence had become available for the formulation of mechanisms of deformation and fracture of metals. Such progress steps were perhaps minor when one thinks of the release of nuclear energy; they were enormous to a metallurgist whose field was not yet a science; they were fascinating to me when I had the opportunity to be an observer.

As a personal point, to fit in the theme of this program, I should mention that my own efforts were not associated with the designs whose outstanding character I have tried to convey in a few words. They were of a far less glamorous nature. I have often spent hours polishing, etching and replicating samples finally to lose the specimen when trying to place it in the holder for examination. Repeatedly, the tweezers would escape from my fingers and, although equilibrium and statistics would dictate otherwise, they always fell on their sharp points which were ruined. It was not rare to find me on four legs on the floor looking for an aperture or a fine screw, a very undignified attitude when VIP visitors came in unexpectedly.

Procedures, in this apparently highly scientific word, were sometimes questionable to me. For instance, it is customary to breathe on a replica before stripping it from the surface of the metal to loosen it. I have often been tempted to make a study of the effect of various diets, especially liquid diets, on the ease of stripping, that is replica stripping. In spite of all these hardships and incongruities, when a microstructure is revealed by the microscope for the first time, it is a joy that makes up for very many bad hours, and that, I believe, no one would wish to miss.

Contribution of Mrs. Laurel Roennau

Member, Board of Airport Commissioners
City of Los Angeles

Some years ago, while going through some scrapbooks which I had made as a child, I was astonished to find several clippings and articles describing the wonders of space travel. With this evidence, I must conclude that my interest in space exploration has been a life-long one. On the other hand, I have had many life-long interests--sports, music, philosophy, art, astronomy, animals (my secretary adds "men"), etc.--so one can hardly say that my present position is the result of any single, long-term, dedicated and consuming drive. Indeed, it would be quite accurate to say that my present involvement in bioastronautics and space exploration came about because this field offered the greatest opportunity to learn and continue learning in a great number of fields of personal interest.

If I were asked to advise young people toward the objective of working in my fields of professional experience, I would be quite unable to recommend courses of study or technical references which would prepare them for their chosen professions. Instead, I would be able only to encourage them to pursue <u>all</u> of the many interests which their young, uninhibited, curious and creative minds may suggest. The best equipment for effective contributions in the sciences has always been and always will be an imaginative and inquiring approach to life. Unfortunately, it is almost impossible to counsel toward such an objective in any specific way. One can only teach by example, and to this end I have tried to work extensively with children of every age group, kindergarten through college--an activity which in itself has added greatly to the gratification and enjoyment which I derive from my work.

From a historical standpoint, the first step leading to my present position was a trip to Nevada during World War II for preliminary training for the Women's Air Force Service Pilots (WASP) Program. When I ran out of money buying flying lessons, I took two jobs in Reno--trainee as a railroad switch tower operator (for future security) and shill in a gambling casino (for fun and money). When the WASP program was terminated, I managed to get a switch tower post within commuting distance of Berkeley (45 miles) and began work toward my engineering degree. The step from aeronautical engineer to design engineer for advanced spacecraft could have been predicted from my penchant for experimentation and exploration. The final step (so far) into bioastronautics is, of course, due to my desire to become personally involved in any activity which captures my interest and attention.

Most of the personally gratifying highlights of my career in bioastronautics engineering have been of an administrative and/or highly technical nature and consequently of little interest to the general public. Although the whole complex of problems associated with the successful exploration of space is fascinating and absorbing to those of us in the field, there has been only one project of mine which appears to have captured the interest of the general public. This was Project MIA (Mouse-in-Able) in which white mice hitchhiked rides to outer space and back in the nose cones of Thor-Able rockets.

In this project, heartbeats of the mice, Benji and Laska, were measured and telemetered to Earth. The launches provided information on the physiological effects of space flight and, because they were the first animal experiments above 100 miles in space, were direct historical forerunners of flights by American astronauts. The mid-1958 experiments disclosed that mice have normal heart rates during weightlessness periods of up to 40 minutes duration.

On each flight, the mice traveled at speeds exceeding 15,000 miles per hour, reached record altitudes of 1400 miles, and withstood decelerations well over 60 g's and nose cone skin temperatures of several hundred degrees Fahrenheit. Although the nose cones were not located by recovery ships, telemetry records proved that the mice survived their flights into space and returned to Earth alive and well.

This project typifies the type of experimentation which has special appeal to me, not only because of the numerous scientific disciplines which were involved but also because the basic concept was essentially a simple one which provided information from which future, more complex experiments could be developed. In other words, my basic philosophy of scientific research is not how to answer a specific question but rather to discover through experimentation what the right question would be to ask next.

At the present time (but certainly not permanently) I am no longer active in the space industry as such. I do, however, have three major projects which keep my schedule very full indeed. The first of these is lecturing. I feel very strongly that one of the major obstacles to the success of our space program is a lack of understanding on the part of the general public of our objectives and the benefits which will result. To help with this problem, I address women's clubs, student groups, and any other audiences which will listen, in the hope of imparting some of my enthusiasm for this greatest of all mankind's adventures.

My second occupation is Airport Commissioner for the City of Los Angeles, a post to which I was appointed in 1961. In this capacity, I have responsibility for the master planning, buildings, and engineering of the second and third busiest airports in the world representing a total value of 318 million dollars. This extremely challenging job is tremendously satisfying to me since it affords a unique opportunity to acquire knowledge in many fields which are foreign to my past experience.

The third project, and one to which I plan to devote at least 48 hours a day for the rest of my life, is the raising of my two young sons, now 7 months and 22 months.

Contribution of Mrs. Rebecca H. Sparling

Design Specialist, General Dynamics/Pomona
Pomona, California

It is only by happy chance that I got into engineering. None of my family or acquaintances were in technical or scientific work, but we were all great readers. As a child, I worshipped knowledge and used to dream of making great discoveries. But as I grew older, I found that I was not particularly creative or inventive. The ability I did have was that or organizing, analysing and applying data to the problem at hand. My curiosity about the world around me caused me to study chemistry and physics, and the application of these sciences to industrial production led me into engineering.

Metallurgy was a rather unusual occupation in the '20's, when I was in college. One day, I heard a guest speaker address our class on "The Romance of Cast Iron". He really knew his subject, and he tied in the development of cast iron centuries ago with the growth of cities, availability of fresh water supplies, and healthy people. He captured my interest and my career. I was so enthusiastic about iron and metals that I got a job in a cast iron pip foundry after receiving my Master's degree in 1931. And ever since, I have been "solid" on the importance and fascination of metals and metal processing.

My first jobs dealt with production of cast metal parts. Starting in the cast iron pipe foundry, I have worked on gray and malleable iron, steel casting, and special metals for specific service requirements such as high temperature, corrosive chemicals, or abrasive wear. As I learned more about service requirements I became more interested in the proper selection, treatment, and design of metal parts, and then of non-metallic materials as well.

In the late '30's, I worked on metals for guns and tanks and aircraft; then in 1944; I joined a company making gas turbine engines for aircraft. For the past 20 years I have been concerned with materials for jet engines, missiles, launching equipment, and spacecraft.

It is hard to select any one thing which has been especially outstanding. Every day has been interesting. Sometimes I've been tired, or frustrated, or discouraged when I could not immediately find the answer to a problem; but I have never been bored, and have never felt that what I was doing was unimportant. Whether it was a malleable iron brake shoe to stop a railroad car quickly, or a special alloyed iron to provide better service as an automobile cylinder block or a new superalloy blade to stand the heat of jet engines, my work has always given me satisfaction. And it still does.

The high point in my career occurred in 1957, when the Society of Women Engineers honored me with their Annual Award for Engineering Achievement for my work in high temperature metallurgy and nondestructive testing. I can still feel the thrill of that night in Houston, when Dr. Gilbreth gave such an inspiring talk, and everyone was so wonderful to me.

Failure analysis, or "trouble-shooting", has been one of the really fascinating phases of my job. I remember one time when I reconstructed a jet engine from over 6,000 broken fragments! And learned why it blew up, too -- the cause was clear, once the pieces were identified and arranged.

Another engrossing subject is that of nondestructive testing, to establish the quality (or lack thereof) of parts without precluding later use. Nondestructive tests vary from simple raps to hear the tone produced, to sophisticated, automatic ultrasonic inspection. Each test has its special advantages and its limitations, and new ones are developed every day. It would keep me fully occupied just to read of all the advances!

The longer I study materials and work with them, the more interested I become in the subject of materials engineering. Every day brings new inventions, new discoveries in processing and treatment, new opportunities to learn. Increasing my knowledge and using it to make better parts for the missiles which defend our country is my life work - stimulating, demanding, and, I feel, very worthwhile. I wish I could live to be 150 and keep studying and working all the time.

Contribution of Dr. Maria Telkes

Director of Research and Development, Cryo-Therm, Inc.
Consultant, Allentown, Pennsylvania

These are the days of the summer solstice, when the Sun's rays are usually the brightest and daytime is the longest. The overwhelming power of the sun can help you to understand why I have tried to "Reach for the Sun". Usually solar radiation is called "dilute", but the fact is that a plot of land covered entirely by horses, standing side by side, represents the solar equivalent of horsepower that falls on the same land area on a clear summer day. What power--to drive an entire field of horses!

I was only 11 when a simple school experiment, the melting of sulphur, made me intensively curious about chemistry. I purchased test tubes and chemical glass-ware, and a small garden-house became my "laboratory". My parents were amused and tolerant, even after a loud but harmless explosion. Avidly reading science books, I was "experimenting", in addition to the usual school science classes. Later as a freshman at the University of Budapest, I read a small paperback book by Kornel Zelovich, "Energy Sources of the Future". This was the deciding moment for me. The book explained that the usual energy sources have geographical limitations, especially in the less developed tropical regions, but the SUN IS DIRECTLY OVERHEAD in the tropics and you do not have to explore for it. The book described experiments, mostly conducted in the United States, and therefore this was the place for me, directly after obtaining my degree.

Dr. Godfrey Lowell Cabot, the prominent Boston industrialist, was the first to recognize the importance of systematic Solar Energy Conversion Research. He created a Foundation for this purpose at the Massachusetts Institute of Technology. I joined this group, being one of the relatively few women research associates at M.I.T. for the next 13 years.

During these years I lived an active "solar" life, developing what I regarded as potentially practical devices for the basic needs of human existence. One of the first projects was the conversion of sea-water into pure drinking water for the use of occupants of life rafts. Solar distillation is of great potential use to provide pure water for households in arid regions and on islands lacking pure natural water.

The use of the sun for house heating was another interesting project, leading to the development of heat storage methods to store solar heat on clear days to provide heat for the night and for cloudy days. Even if solar house heating is not "commercially popular" now, the heat storage principle, based on the heat of fusion of selected materials, has many practical uses. One of these is the stabilization of the temperature of shipping and housing containers for delicate instruments, such as the guidance systems of missiles and satellites.

The conversion of Solar Energy into electrical energy is the most challenging problem, which catapulated this rather neglected field into stratospheric importance. Solar cells are used to power the transmitters of practically all satellites and without solar power they could not communicate. Solar energy research projects for space application have also skyrocketed. At the present time work is in progress to design solar operated electric power stations to be built on the moon.

Less than ten years ago when I left M.I.T., solar energy conversion into electrical power was considered "too far out" and of little practical future importance. The sudden eruption of solar energy research for use in space has not been paralleled by a similar progress for the "peaceful uses of solar energy" on earth, at least not as yet.

The key-word of our Conference is FOCUS ON THE FUTURE, centering to some extent on the great "Untapped Potential", the brainpower of women in the scientific and engineering fields. We, assembled here, may be regarded as the already "tapped" potential. Would it be possible to appeal to you to turn with interest to our greatest "Untapped Energy Source", Solar Energy. After all, more than half of humanity lives in the Tropical Zone, with practically limitless energy directly over their heads, although very little else than their own muscular energy in their hands. The development of solar energy for these regions appears to be the most rapid and practical method to provide them with the basic necessities of energy.

It is most appropriate that our untapped potential should develop the untapped energy source for the greatest benefit of the least developed group of humanity. Perhaps there will be some of you who will also "Reach for the Sun".

Saturday, June 20, 1964

12:00 Noon - STUDENT BUFFET LUNCHEON

Chairman: Dr. Maryly V.L. Peck, Chairman, Student Activities Committee of SWE

INTRODUCTION OF AWARD WINNERS AND PAST PRESIDENTS

OPPORTUNITIES FOR WOMEN HOLDING THE FIRST LEVEL ENGINEERING DEGREE--Elizabeth Hinton, 1962 Gilbreth Scholarship Award Winner, degree in Mechanical Engineering, Auburn University, Auburn, Alabama, 1964. Employed by Esso Research and Engineering Company, Linden, New Jersey. Enrolled in Graduate School, Stanford University in Fall 1964.

OPPORTUNITIES FOR WOMEN WITH ADVANCED ENGINEERING DEGREES--Idele Pederson, degree in Chemical Engineering, Iowa State University, Ames, Iowa. Currently in Graduate School.

INDUSTRIAL OPPORTUNITIES FOR WOMEN ENGINEERS IN ELECTRONICS--Judith Anderson Atkinson, 1960 Gilbreth Scholarship Award Winner, degree from Northwestern University, Boston, Massachusetts, 1962. Employed by the Guidance Electronics Department, Space and Information Systems Division, Raytheon Company, Bedford, Massachusetts.

OPPORTUNITIES FOR WOMEN ENGINEERS IN AEROSPACE STRUCTURES--Phyllis S. Gaylard, First Gilbreth Scholarship Award Winner, 1958, degree from University of Southern California in Aerodynamics, 1964. Employed as a research and development engineer at Space Technology Laboratories, Redondo Beach, Calif. and is enrolled in Graduate School at University of California in Los Angeles.

PRESENTATION OF CHARTERS TO INCOMING STUDENT SECTIONS OF SWE

2:00 P.M. - SWE MEMBERSHIP MEETING, PART I

6:30 P.M. - RECEPTION IN HONOR OF THE RECIPIENT OF THE 1964 SWE ACHIEVEMENT AWARD: DR. GRACE MURRAY HOPPER

7:30 P.M. - SWE ANNUAL BANQUET

Sunday, June 21, 1964

10:00 A.M. - SWE MEMBERSHIP MEETING, PART II

SUMMARY STATEMENT

on the

FIRST INTERNATIONAL CONFERENCE OF WOMEN ENGINEERS AND SCIENTISTS

June 15 to 21, 1964

SUBJECT: FOCUS FOR THE FUTURE

More than 500 women engineers and scientists from 35 nations and all 50 States of the United States of America have shared experiences, plans and aspirations during this Conference. Women are making outstanding contributions to science and technology throughout the world. They have learned to know one another, what they do, and how they live.

Speaker after speaker pointed to the many ways in which science and engineering are contributing to improved world living conditions. The possibility of cooperation in achieving the outstanding potential of the future throughout the world was emphasized. Then, like a refrain, each speaker mentioned the inadequate supply of trained personnel to implement future world needs.

Statistics point to the scarcely touched resource of talented women.

The Conference therefore resolves:

(1) To encourage each participant to report about the Conference in her home country or region.

(2) To encourage women to increase their participation in the professional societies in their countries.

(3) To encourage women to enter the field and improve their qualifications not only during their student days but throughout their professional life.

(4) To maintain the central file of women engineers and scientists used for this Conference and enlarge it as much as possible.

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CONTRIBUTORS

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Worthington Corporation

APPENDIX

The papers in this section were submitted by Delegates to the First International Conference of Women Engineers and Scientists in addition to the formally scheduled program of technical sessions:

Brazil	Brazil, by Miss Sophia Machado Portella
Japan	Present Situation of Women Scientists and Engineers in Japan, by Dr. Katsuko Saruhashi
Mexico*	El Infiernillo Hydroelectric Power Plant, by Mrs. Angelina Perez Lopez
Philippines	Developing Engineering and Scientific Talent in the Philippines, by Mrs. Magdalena Alde Templa
Syria	Syrian Women as Engineers and Scientists, by Raja Jalaleddin
U.S.S.R.	Developing Scientific and Technical Talent in U.S.S.R., by Mrs. Galina N. Kadykova

* Recognition is also given to the two papers submitted in Spanish by Delegates from Mexico which were distributed at the Conference.

Architecture Supplementary to Toll Roads, by Mrs. Maria Luisa Dehesa de Millan, Architect

Highways of Mexico, by Inga Yolanda Basurto and Edith Nunez Tovar

BRAZIL

by Miss Sophia Machado Portella
Engineer of the Brazilian Bank of Economic Development
Professor of Electronics and Physics
College of Engineering, University of Brazil, Rio de Janeiro

ENGINEERS AND SCIENTISTS IN BRAZIL

As a Brazilian and a member of this most useful Conference, I shall naturally make some remarks on the problems of my own country. Brazilian living standards, in general, are very low. This is a terrific situation since the population has increased from 18 million inhabitants in 1900 to 64 million in 1960, with a forecast of 71 million for 1970.

Perhaps I am more interested in the problem of Education for I am professionally more concerned with Education. In this case Education means instruction so as to give every individual a means of acquiring a good standard of living, thus taking advantage of his own powers both intellectual and physical.

Primary Education

In the larger cities, such as Sao Paulo and Rio de Janeiro, with the latest developments in schools, practically every child learns how to read and write. But throughout our vast country of 3,290,000 square miles, the demand for manpower, especially skilled personnel, is urgent. The very small per capita income is surely caused by this lack of instruction: "Bread is insufficient when there is no knowledge of how to produce it".

Thus poor living conditions cause population movements from the country areas to the towns. Here unskilled and non-working classes remain outside the so-called technical progress. We must also remark that country life is not attractive, and its farming population increases the underpaid groups in the big cities (63% of the total of the Brazilian population). As to the activities which relate to industry, trade, transportation, etc., skilled personnel is required, individuals who have had at least their primary instruction.

Intermediate Instruction (High School)

Trade and teaching staff take those individuals who have finished their education in our 4,500 high schools. Of those students, only 2.8% work for industry and agriculture. There are only 120 institutions that prepare farmers, which is a very small number for the demands of the country.

Higher degrees are granted by our 272 institutions. However, with the impact of an expanding population, the number of universities and schools is far from meeting our urgent requirements. I must say that the number of candidates enrolled in the different institutions attain only three per thousand of the population. Brazilian youngsters are very keen in obtaining admission to higher education which, certainly, shows that in my country "human brains" has not been lacking, is not lacking, and will never be lacking. But, unfortunately, the means to make use of the intelligence of those youngsters is insufficient.

Figure 1 shows the higher degrees taken in Brazil through 1962. One of our targets must be an increase in qualified engineers and scientists. It is interesting to observe that only 22 women engineers were graduated in 1961 and only 26 in 1962.

REQUIREMENTS OF AN INDIVIDUAL'S STANDARD OF LIVING

As social requirements are an integration of individual needs, the factors hindering the attainment of these requirements are as follows:

(a) Difficulty to assimilate modern techniques,
(b) Difficulty to obtain capital for investment,
(c) Poor transportation (old railways, bad roads, etc.),
(d) Lack of know-how, and
(e) Political instability.

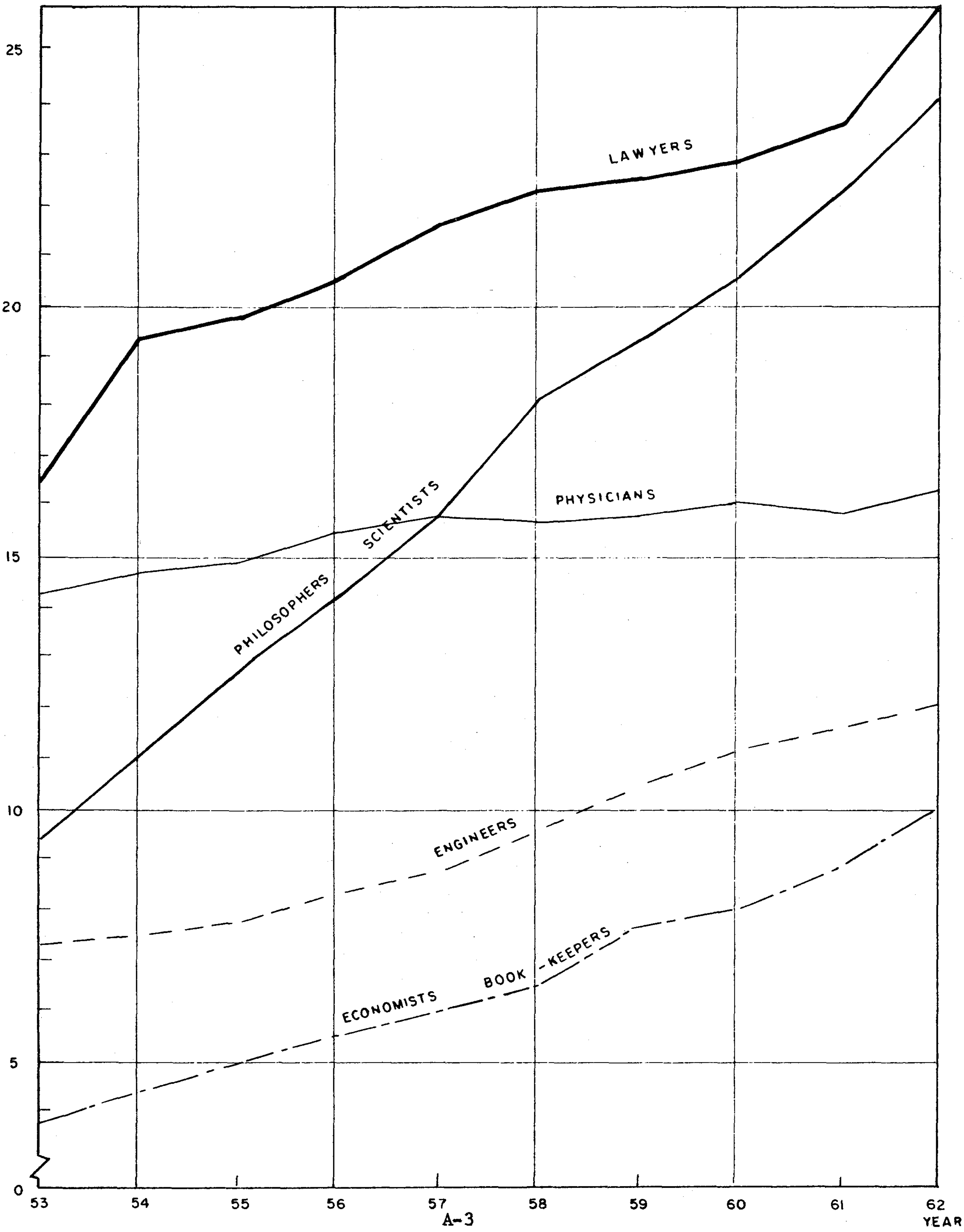
Measures for improving this situation are being taken by the Brazilian Bank for Economic Development and the Interamerican Development Bank, Alliance for Progress. The technical progress, as has happened in the United States, is a result of the combination of socialization, technology, and provision of incentives to individuals; the actions of the state and the universities increase the per capita production and income.

With international cooperation and with the help of the United States, our industrial park is becoming a reality. For example, during 1957 there were in Brazil 785,100 vehicles with only 30,700 produced in my country. In 1963 there were 1,595,900 cars with 831,000 made in my country. This and the opening of highways transformed distant undercivilized regions into new areas. The United States provided aid to Brazil in 1963 for hydroelectric plants, transport, water and food distribution, and technical assistance. Brazil received $43,000,000 from the United States Agency for International Development.

Nobody need fear any longer to be lost and forgotten in the wild country, where now the standard of living has become higher, and where commodities and requirements for comfort can be found nowadays. Here radio communication plays a great part. News flashes to spots where it took months to reach in the past. The distribution of products has become more even throughout our vast country, and education is becoming better and better. But we must realize that it takes time to develop a whole country as vast as Brazil.

The economists of the Brazilian Bank for Economic Development realized that they must award facilities to those who invest in education, and other new plans are actually being studied to increase the number of

FIGURE I. ANNUAL UNIVERSITY DEGREES



skilled personnel. May I quote Lincoln: "Capital is only the fruit of labor, and it could have never existed if labor had not first existed". As we know, "Labor is the tree of knowledge".

INDUSTRIAL AND SOCIAL NEEDS

The Brazilian hydrographic system needs to be controlled urgently. As it is known, forest reserves play an important role in the water system of earth. Many dry regions were formerly vast forests where timber was removed and used in railways, for cooking, for coal production, etc. Here again ignorance transformed rich regions into dry and inhospitable parts of Brazil. Our rivers, the Amazon, S. Franscisco, etc., are powerful (attaining 22 million horse power), but only a small part of this is profitable.

Other elements of living, such as food, clothing, and housing, surely with the rich soil and good cultivation will become sufficient. I am sure that a well planned agrarian reform should bring most important social and political improvements, and if the demand of the increasing population is satisfied, the standard of living of the rural population, as a matter of course, should also rise.

This must be accompanied by incentives to agriculture production, for example, (a) training personnel to more advanced techniques, (b) investing in land and implements, and (c) developing transportation means. As the growth of industrial and social needs is larger than the national productivity, inflation is lowering the acquisitive power of money. Here I would like to refer to our former Brazilian Ambassador to the United States, Mr. Roberto Campos, who is actually leading our economic problems. I am quite sure that he is capable of pulling my country out of the inflation spindle. In a short paper such as this one it is impossible to say what is being planned for solving Brazilian economic Problems, but I pray that the Almighty will peacefully make Brazil become as great and powerful country as our eldest sister of North America.

THE WORLD'S STANDARD OF LIVING

Here I can only talk about some ideas: It would be great if all the countries could cooperate to make humanity live happily and peacefully. The Act of the Atlantic signed in 1941 by Sir Winston Churchill and President F.D. Roosevelt and all allied countries proclaimed: "Great Britain and the United States will make efforts to open to all nations, big or small, winner or loser, access to raw material of the world, and to trade so as to make those countries economically prosperous". It is my sincere hope that this may be accomplished!

PRESENT SITUATION OF WOMEN SCIENTISTS AND ENGINEERS IN JAPAN

by Katsuko Saruhashi, Dr.Sc.
Meteorological Research Institute
Tokyo, Japan

After the Second World War, the number of women in Japan who have professional jobs increased rapidly. According to the census being carried out every ten years, the increase in the number of women who are dealing with secretarial and accountant businesses and other general affairs in offices is especially remarkable. While the total number of these jobs for women was 56,000 in 1930, it increased by 30-fold to 1,650,000 by 1960. The total number of teachers in elementary and secondary schools and nurses in kindergartens also increased from 90,000 to 260,000 in the same period.

Other than the above jobs, there are professions for women such as physical doctors, apothecaries, midwives and nurses for public health and in hospitals, artists, lawyers, licensed accountants, scientists, and engineers. Among them, the number of women who are engaged in medical jobs is 350,000 of which 9,000 are physical doctors, or 10% of the total number in the same occupation in Japan in 1960.

It is a rather difficult task to estimate the accurate number of women scientists in Japan. The total number of women who are listed as voters in the election of members of the Japan Science Council is 1,760 whereas the total number of voters is 80,000. Therefore, the number of women is about 2% of the total. Among the 1,760 women scientists, 180 are in the fields of basic research, 120 are engineers, 119 are agricultural scientists, and the largest number of 1,260 belongs to medical sciences. On the other hand, the number of women scientists who belong to the scientific societies is as follows:

The Chemical Society, 940 or 3.5%,
The Biochemical Society, 221 or 8%,
The Society of Analytical Chemistry, 131 or 2.6%,
The Pharmaceutical Society, 133 or 2.8%,
The Physical Society, 73 or 1.7%,
The Agrochemical Society, 89 or 2.6%,
The Mathematics Society, 56 or 3%,
The Mechanical Engineers Society, 5 or 0.01%,
The Electrical Engineers Society, only 3 or 0.02%.

The average number is 1.7% which agrees with the value estimated from the number of voters in the Japan Science Council.

The places in which most woman scientists are working in Japan are (1) institutes and laboratories in universities, (2) governmental institutions, and (3) private institutions in manufacturing companies. The number of woman scientists who work in governmental or semi-governmental institutions is increasing gradually because of the equality of terms for salaries between men and women. The total number is not quite clear, but it may be around 1,000 among which, however, only one woman has the position of research director, in public health research institute. The number of women who are in charge or the chief of laboratories or equivalent is somewhere between 20 and 30. The rest of them are researchers or research assistants in laboratories. The small number of woman leaders in research in Japan is mainly due to the short time that women have been engaged in scientific studies.

PRESENT SITUATION IN THE SCIENTIFIC AND ENGINEERING EDUCATION FOR WOMEN

After the war, the system of education in Japan was reformed, and coeducation was introduced not only in elementary and secondary schools, but also in colleges and universities. The number of girl students who are enrolled in higher education is increasing very rapidly year by year. In 1949 the number of female students was 46,766 which was 11.8% of the total. However, the number has increased to 184,083, which is 21.9% of the total number of students. Among girl students 40% are enrolled in junior colleges, whereas only 5% of boy students are attending junior colleges. The number of females in the four-year colleges or universities is 105,000, and this is 17% of the total. Among the students learning literature is 41.7%; education, 23.1%; home economy and nursing, 9.6%; medical and pharmaceutical sciences, 8.9%; natural sciences, 2.3%; agronomy, 0.7%; engineering, 0.5%. In 1961, 674 females entered into the graduate schools which is 3.8% of the females who finished undergraduate courses.

The activity of woman scientists and engineers largely depends on the political and economical situation of the country which requires scientific man-power and mental resources from women. It is needless to say that the level of women's activity in various advanced fields, cultural and industrial, is the reflection of the development of the society, and the higher the level, the more women's activity is requested.

In Japan, because we are now facing a shortage in man-power in science and engineering, my nation will have increasingly to depend on the contributions from women. For this, however, it may be necessary to improve the education system for women not only in the universities but also in elementary and secondary schools, to establish social protection for working women, and to develop understanding and recognition by the society as a whole of the necessity for women-power in science and technology. We should expect a greater contribution and more activity of woman scientists and engineers in the future, not only in Japan but also in the world, which will contribute very much to the welfare of mankind as well as the peace of the world.

EL INFIERNILLO HYDROELECTRIC POWER PLANT

by Mrs. Angelina Perez Lopez
Comision Federal de Electricidad (CFE)
Estados Unidos Mexicanos

The Comision Federal de Electricidad (CFE), an agency of the Government of Mexico, has developed an intensive program for the electrification of the Country by increasing the total installed capacity, both thermic and hydro, from 2,560 MW in 1958 to 5,560 MW in 1964. In line with this program, the CFE has built a rock-fill dam 148 meters high on the Balsas River at the El Infiernillo site, State of Michoacan. This dam will have a total capacity of 12,000 million cubic meters, power generation being the main purpose of its construction.

This hydroelectric plant is the biggest in the Country, and rates among the most important in the world due to several features, such as its large reservoir, the dimensions of both its dam and its powerhouse, and the power output of its units.

GEOLOGY

The rock in the zone for all structures of the plant is of very good quality. It is formed by a tertiary conglomerate heated and silicified by intrusion of a dioritic body with planes of fracture showing in localized zones having a general North-South bearing.

Dam

The dam is of the rockfill type and has a relatively thin impervious core made of compacted clay. Sand filters and gravel transition zones are adjacent to this core. The main body of the dam is composed of two rockfill shoulders. Each is divided into two zones, one of compacted material and the outer portion built in dumped layers two meters thick. The volume of the dam is 5.7 million cubic meters, 4.7 million of which are rockfill material.

At the time work was begun, it was the world's fourth in height among existing dams of the same type. Its principal dimensions are:

Crown elevation	180.00 m.
Maximum height	148.00 m.
Width at the base	608.15 m.
Height of upstream cofferdam	60.00 m.
Height of downstream cofferdam	58.00 m.
Width of crown	10.00 m.
Length of the crest	360.00 m.
Total volume	5,700.00 m3.

DIVERSION STRUCTURE

The full capacity of the diversion structure is 10,000 m3/sec. It is formed by three tunnels each with a 13 meter diameter (diameter: 15 m with no lining in the section between the entrance and the beginning of the plug), and two tunnels each with a diameter of 8 meters lined from the inlet to the deep outlet tunnels (numbers 3, 4 and 5), all located on the right river bank.

In the event of a maximum incoming flood of 10,000 m3/sec., discharge will be effected through the diversion structure reaching an upstream elevation of 105.78 meters and a downstream elevation of 76.50 meters.

SPILLWAYS

The spillway structure has been designed for a combined discharge of 12,000 m3/sec. corresponding to an incoming flow of 34,000 m3/sec. which will reach elevation 176.40 on the upstream side of the reservoir while elevation 75.00 will be the highest level on the downstream side. Each spillway will have three radial gates of 7.42 meters in width and 15 meters in height. Each spillway tunnel connects with each of the diversion tunnels 3, 4 and 5.

PRESSURE CONDUITS

The pressure conduit is formed for every two units by:

1. Intake, regulated by wagon-type servomotor operated 3.50 x 8.90 m. gates.

2. Simple concrete-lined pressure tunnel with 8.90 m. inside diameter (L=101.21 m.).

3. Concrete-lined pressure tunnel with steel lining of 8.50 m. inside diameter (L=130.98 m.).

4. Steel Wye imbedded in concrete with 8.50 m. of inlet diameter connecting to the branches.

5. Two branches of 6.0 m. inside diameter reduced to 5.75 m. to connect with tunnels to the entrance butterfly type valves (L=47.45 m.).

6. Coupling piping between valves and turbines with an inside diameter of 4.70 m.

7. Tailrace structures. Discharge from every two units flows into a concrete lined tunnel with an inside diameter of 13.00 m. The two tailrace tunnels work as an open channel under normal conditions. The average length of the tailrace tunnels from the control station is 219.00 m.

8. Surge tank. Upon arrival of a flood and the consequent discharge through the spillways, the downstream level in the tailrace tunnels goes up to the tunnels which work submerged. To insure operation of the units under stable conditions, given the above conditions, surge tanks were provided. The surge tank is of the chamber type with weir.

POWERHOUSE

The powerhouse is formed by two chambers excavated in the rock, one to house the entrance valves to the turbines and the other one to accommodate the generating units. The dimensions of the main chamber are an arch roof 21 m. wide by 127.95 m. long with 4.83 m. sag, lined with reinforced concrete 65 cm. thick. From the support of the crane and the generators floor, or a height of 9.77 m., the total dimensions are 19.30 m. in width and 121.15 m. in length.

This chamber houses the generating units, the mechanical shop and switchboard room.

On the turbine and cables floors (elevation 56.00 and 52.50) the dimensions become 19.30 m. in width and 86.00 m. in length. Below the turbine floor pits have been excavated, their dimensions decreasing as depth increases up to elevation 36.50. These pits accommodate the turbines and the draft tubes. Maximum height of the present excavation is 40.20 m.

ROCKFILL MATERIALS TESTS

In Mexico generally rockfill dam designs have been provided with a rather thick impervious core. El Infiernillo has a ratio of water head to thickness of about 1/5, which is not unusual when compared with several high dams in operation. Reasons for adopting a thin core for El Infiernillo dam were (1) an acute shortage of suitable materials in the vicinity of the dam site and (2) the availability of highly plastic and well graded soils at a valley 18 km. from the works. Rock of excellent quality was available within short hauling distances. However, materials for filters and transition zones had to be processed in order to comply with the requirements for this type of dam.

Notwithstanding that materials to be used for rockfills are hard sound diorite and silicified conglomerate, it was decided to investigate their shear strength in the original design if necessary. For this purpose, CFE has for the first time both in Mexico and the world built two triaxial apparatus for testing samples 2.5 m3 in volume, one designed for confining pressures smaller than 1 kg/cm2 and the other one for pressures up to 25 kg/cm2 and a maximum axial load of 1,600 tons. Preliminary test data have been obtained which are somewhat different from expectations.

Triaxial specimens were prepared having a cross section area of 10 cm2 and compacted in the laboratory with the average water content specified for placement in the fill. In order to study the effect of various types of covers for the sample, a smaller triaxial machine was built for specimens 20 cm. in diameter and 50 cm. high to be tested under confining pressures up to 50 kg/cm2.

An effort has been made at El Infiernillo to observe the performance of the dam by installing several types of measuring devices. Information yielded by these instruments is very enlightening thus far, particularly on the rockfill section of the dam. Data obtained as of May 1963 are still not complete enough to deserve detailed comments.

POWER TO BE INSTALLED

The system to which the Infiernillo plant will be interconnected when completed will have a total installed power capacity of 1,390,200 KW in 1964 of which 886,000 KW are generated by hydroelectric plants while the remaining 504,200 KW come from the thermoelectric power plants. The average yearly generation estimated for these systems will be 3,600 GWH.

The storage water capacity in the reservoirs of Ixtapantongo and Necaxa reaches 1,250 million cubic meters. Taking into account these data and having studied the future growth of the central zone of the country where a 50-cycle frequency is available, the CFE decided to build the hydroelectric plant of El Infiernillo with a great reservoir and to install a capacity of 500 MW or more. The plant was finally designed for a power capacity of 625 MW divided among four 156 MW units for a generation of 2,771 GWH.

On designing the Infiernillo power plant it has been considered that by regulating the flow of Balsas River through the use of reservoirs to be built upstream from the Infiernillo plant, two more units may be installed in the future. The project was made taking into consideration that investment should be the minimum possible. But installations should be such that operation of the plant will not stop if the future enlargement of the power house is advisable.

The Balsas River valley has a drainage area of 108,000 Km2. This river may be considered as the most important American river on the Pacific Coast. It is limited by the Neo-Volcanic range, the Western Sierra Madre and the Southern Sierra Madre. It starts at great altitudes in the counterforts of the Nevado de Toluca and Popocatepetl extinct volcanoes and discharges into the Pacific Ocean in the vicinity of the limits between the Mexican States of Michoacan and Guerrero. The great differences in level along the course of both of its tributaries and the main riverbed, as well as the yearly average volume of 14,000 million cubic meters flowing through its mouth, show that the Balsas River has a hydroelectric potential evaluated at 2,000 million KW.

The Infiernillo power plant is being built some 60 km. from the mouth of the Balsas River and will have a total reservoir capacity of 9,210 million cubic meters. The average flow at the Infiernillo dam site may be estimated at 454 m3/sec. Future operation of the reservoir provides for utilization of 79% of the pool if the four 156 MW units are installed. Upon determination of the maximum operation level, studies were undertaken to determine the power to be installed. A summary of the principal results obtained may be given as follows:

Installed capacity	624 MW
Power factor	0.5
Useful water capacity	6,910 million m3
Maximum power for peaks	624 MW
Minimum load recorded	83.47 m.
Minimum power for peaks	451.2 MW
Arithmetic mean	103.45 m.
Design head	101.00 m.

Power Generation

Generation recorded in normal period	2,530.5 GWH
Yearly mean secondary generation with power factor 0.85	221.4 GWH

The characteristics of the units are given below:

Number of units	4
Type	Francis
Shaft	Vertical
Rotation	Clockwise
Maximum net head	112.00 m.
Minimum net head	80.70 m.
Design load	92.00 m.
Design flow	193.90 m3/sec.
Normal speed	136.4 rpm
Race speed	270.0 rpm
Water level in tailrace with normal flow from fully loaded turbine	52.50 m.
Maximum turbine power	208.00 CV
Distance between units	20.00 m.
Elevation to axis of distributor	49.50 m.
Elevation to coupling flange of shaft with that of the generator	54.20 m.

Capacity:

208,000 CV with 92.00 m.	189 m3/sec

Characteristics of the generator:

Power factor	0.95
Normal capacity	164,000 KVA
Overload capacity	188,600 KVA
Voltage between phases	13,800 V
Frequency	50 cs
Synchronous speed	136.4 rpm

DEVELOPING ENGINEERING AND SCIENTIFIC TALENT IN THE PHILIPPINES

by Mrs. Magdalena Alde Templa
National Science Development Board
Manila, The Philippines

In behalf of the Philippine government, the Women Chemical Engineers of the Philippines and in my own, I wish to extend our sincere greetings to the Society of Women Engineers and to the international delegates to this Conference. My congratulations to the SWE for this successful attempt to gather all women of different parts of the world in this conference for a very worthy objective. This convention, I am sure, will be fruitful to all of us and will foster closer ties amongst all countries.

The Filipina woman of today is very different from her sister, the so-called Maria Clara of yesterday. While this Maria Clara was a reserved, quiet, and homey type of woman, the present Filipina is a medley, the result of various cultures that have pervaded Philippine history. Its 300 years of Spanish influence gave her the Latin ways. The 50 years of American occupation gave her the accent of the Western hemisphere. But all in all, she retains her Malayan culture, with all its traditions, and that is why the modern Filipina is more or less a product of the Asian, Latin, and Western influence.

The Philippines has a population of 30,000,000 people, about 50 per cent of whom are women. With customs and traditions that were quite conservative and the gradual transformation of her ways from the pure Malayan traits to that mixed with the Latin and Western influence, the Filipina is now a self-made woman who goes about with independence.

It was on June 18, 1949, that the New Civil Code, Republic Act No. 386, was enacted giving the Filipina her rights (her civil emancipation). Art. 115 N.C.C. provides that the wife may manage the affairs of the household. This is a "legal sanction of the popular and eminently sound idea that the wife is the queen of the home". Art. 117 N.C.C. gives the wife freedom to exercise any profession or occupation or engage in any business under certain limitations.

With this new Civil Code provision, the Filipina woman started being a professional and a career woman. At present, we have women lawyers, doctors, pharmacists, accountants, engineers, chemists, and others. But this emancipation has not been complete as of now. Our men have been used to seeing a Filipina woman the queen of the home whose job was to be a wife and a mother. Her place was the home. While some of our men have learned to accept this change in her, to date most of our men still revolt against this transformation. However, it is pleasing to note that while it is gradual, more and more of them realize that with mechanization of work in the home, the woman could be more than a mother and a wife. She could be an asset to the community and help hand in hand with the men in the economic and industrial development of the country.

Today we have all kinds of professional women working in government entities, private firms and industrial plants. They have been a part of all movements in the social, economic, and industrial functions of the country. While they have been increasing in number, there is a need for putting them all into use. The scientific and engineering groups are still wanting in recognition. However, most of them have been accepted in government entities and industrial plants.

The lack of science consciousness still pervades in our country. This is a move that is being undertaken by the National Science Development Board. A study of the scientific and technical manpower resources in the Philippines made by the NSDB reveals the following:

Enrollment in private university for courses leading to a Bachelor's degree in Engineering rose from 11,671 in 1949-50 to 29,203 in 1958-59, an average increase of 10.8 percent every year. From 1952-53 onward, Mechanical Engineers had the highest enrollment. Civil Engineering came next. These two courses alone covered practically two-thirds of the total Engineering enrollment. Others such as Chemical Engineering and Electrical Engineering had high enrollment also. In the University of the Philippines (State University) 567 students enrolled in 1949-50. The number increased to 1,380 in 1958-59 with a yearly average increase rate of 6.1 percent.

Graduate and postgraduate studies were few. In 1949-50 not one was reported studying for a Master's degree. One enrolled for his M.S. in Civil Engineering during the academic year 1950-51. This increased to 13 in 1951-52, 16 in 1952-53, and so on until 1956-57, when enrollment dropped to zero. With the trend and growth of industrial plants, however, the tendency was to enroll in Management Engineering, with 15 enrolled in 1952-53, none in 1953-54, and 13 in 1954-55, increasing up to 72 in 1955-57. These figures did not, however, indicate lack of interest to pursue postgraduate courses, but rather an apparent lack of universities that would offer the courses. This caused most of those who were interested to go abroad and pursue their studies there. About 72 students enrolled in the United States in engineering courses during 1957-58.

Table 1, as presented in the study made by the NSDB as reported by the Institute of Internal Education, shows that Chemical Engineering was the most pursued course in U.S. Universities in 1957-58. This must have been due to the chemical plants that have started coming up in the Philippines.

From 1950 to 1960, about 20,000 were graduated with the Bachelor's degree in Engineering, an average of 1,800 yearly (about 10% of the total Bachelor's degrees); 38 percent were in Mechanical Engineering, 35 percent in Civil Engineering, 14 percent in Electrical, 8 percent in Chemical and the rest in Mining, Aeronautical, Sanitary, Marine, etc. Very few pursued graduate studies in the Philippines, with only nine graduated from private universities and 12 from the University of the

Philippines during this period. Various scholarships awarded by the United Nations, Colombo Plan, NEC-ICA and other technical assistance programs were granted to about 280 Filipinos from 1948-1961.

Table 1: Engineering Students Enrolled in U.S. Universities, 1957-58

Field of Study	No. Enrolled
Chemical Engineering	44
Civil Engineering	27
Electrical Engineering	43
Industrial Engineering	5
Mechanical Engineering	39
Others	14
Total	172

As of December 31, 1961, a total of 27,030 engineers and professionals in related fields were registered in the Philippines, most of whom had passed the Board examination for their particular field. The number of engineers and professionals in related fields registered annually between 1950 and 1960 indicate an average of about 1,600, with civil engineers and mechanical engineers heading the list. A total of 19,453 were graduated with engineering degrees from private educational institutions and 909 from the University of the Philippines over the 10-year period. It is noteworthy that graduates from the chemical engineering course increased from 46 to 243, or 10-fold in 10 years. This has been concurrent with the country's industrial development when an outgrowth of industrial plants took place. It was also observed that the number of women engineering students and graduates increased tremendously as the 1962 figures shown in Table 2 indicate. The number of chemical engineers in 1962 almost doubled the number in 1961.

A survey was conducted by the Women Chemical Engineers of the Philippines (WOCHEP) on the present status of women chemical engineers. Of 2,037 registered chemical engineers, 25 percent are women; and of the 495 registered women chemical engineers, 60 percent are full-pledged members of WOCHEP. It was found that about 52 percent of these women are employed in the government; 20 percent are in private firms or industries; and 28 percent are teaching in the universities and high schools.

The Women Chemical Engineers of the Philippines (WOCHEP) has had as one of its objectives the utilization of its technical woman power. As much as the Philippines is a developing country and an agricultural one, the WOCHEP has conducted a program of training its women members on specialized industrial fields where it could use the local raw materials for useful industrial products for basic human needs.

An act was approved creating a Philippine Science High School designed to offer on a free scholarship basis a secondary course with special emphasis on subjects pertaining to the sciences with the objective of preparing its students for a science career. Educational television, where scientific films are shown, is promoted to bolster science consciousness.

Table 2: Total Registered Women Professionals in 1962

Architects	217
Chemical Engineers	497
Chemists	916
Civil Engineers	169
Electrical Engineers:	
Professional Electrical Engineer	2
Associate Electrical Engineer	2
Assistant Electrical Engineer	3
Mechanical Engineers:	
Professional Mechanical Engineer	-
Plant Mechanical Engineer	-
Junior Mechanical Engineer	-
Certified Plant Mechanical Engineer	
Mining Engineer	1
Sanitary Engineer	18
Surveyors:	
Private Land Surveyors	13
Cadastral Land Surveyor	-
Mineral Land Surveyor	-

The NSDB has as one of its programs the development of scientific manpower, which is a need in the industrial development of a developing country like ours. It has stressed the intensification of programs for the improvement of basic education in science. Summer science institutes for elementary science as well as for secondary science and mathematics teachers have been conducted. Studies have been made to improve the curriculum introducing science and mathematics subjects in elementary and high school levels. Scholarships have been awarded here and abroad to selected talented students to pursue science and engineering courses.

The NSDB has a program of training its own technical personnel and personnel of other agencies to upgrade the professional education and research skills. This is done through periodic in-service training programs and through fellowships granted abroad.

As of May 1961, women constituted 50 percent of the total working age population (10 years old and over) of 17,250,000. About 40 percent of the female population (8,625,000) are in the labor force, with about 3,000,000 actually employed. Despite fluctuations in the woman labor force from 1957 to 1961, its growth of 19 percent has outstripped the increase in population which was 10.7 percent over the five-year period.

Increasing participation of women in the economy of the country can be attributed to significant changes in the economic life and in the social customs and modes of living of the people. Other factors are increased family responsibilities, changes in women's education and vocational training, and the shift from rural to urban living.

A general decline in the prejudice against unlikely occupation caused women workers to invade various sectors of the economy. They are most numerous in the agricultural sectors, but they are turning more and more to the industrial and commercial fields for better paying jobs. Agriculture employment accounts for 39 percent of women workers, while a smaller number is engaged in commerce and manufacturing. The women predominate over the men in these two major industry groups.

The distribution of women labor force still reflects the agricultural base of the country's economy. However, recent shifts towards the industrial and professional fields of employment have been observed, with 4.6 percent engaged in professional and technical work, totalling about 139,000 in 1961.

From 13,183 women in government service in 1948 employment of women rose considerably. Women occupy both appointive and elective posts in the government as well as the regular civil service positions. The highest occupied by women are those of Social Welfare Administrator (with cabinet rank), Director of Bureau of Workmen's Compensation and Commissioner of the Workmen's Compensation Commission (quasi-judicial body) and Director of the Bureau of Women and Minors. Others are in the Foreign Service, judiciary, armed forces, and in other departments such as health, labor, science, and education. Latest available figures showed one cabinet member, two senators, two congresswomen, two judges of the Court of First Instance, one judge of the Juvenile Court, seven in the Foreign Service, and three heads of corporations and agencies.

Women employed work an average of about 40 hours a week as compared to 44.4 hours for the male. About 49 percent are married women, 44 percent single, others widowed or divorced. Their ages range from 20 to 39 years old. About 19 percent have no schooling, 62 percent have studied in the elementary grades, 13.5 percent in high school and 5.4 percent in college. Survey results showed that the unemployed generally had a higher educational attainment. One-fifth of employed females had no formal schooling. One-third of unemployed women were high school graduates and those who had completed one or more years of college.

Over all, Filipino women are participating fully in all phases of activities, social, economic, and industrial. The future is bright for the Filipino woman's complete emancipation. At this stage she is entering into the fourth dimension for a woman, technical activities.

SYRIAN WOMEN AS ENGINEERS AND SCIENTISTS

by Raja Jalaleddin
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The achievement of Arab Syrian women in engineering and the physical sciences is a remarkable one. This will become obvious when Syria is compared with some other highly developed countries. The new engineering and scientific evolution took place in Syria soon after the Second World War, when the country became independent. It is highly significant to know that the first Faculty of Engineering of the Syrian University was established in 1946, and the premises of that Faculty were formerly the military barracks of foreign troops.

The pioneering engineering class which met in 1946 included two women students. The School of Engineering at that time had a civil engineering course only and so in 1950, after four years of study, the first two Syrian women civil engineers were graduated. These first two women engineers were enthusiastically received and now occupy leading positions as heads of civil engineering government departments.

Engineering is a highly respected profession in Syria. I am not going too far when I say that in my country engineering is now the most priviledged of all professions. In government service, engineers are the most highly paid. Their social status is very high. Thus engineering in Syria does not suffer from the status complex which is prevalent in some other countries. For this reason the proportion of girls in the Faculty of Engineering has increased year after year, although this Faculty did not offer other than Civil Engineering until 1958-59.

In 1958-59 the Department of Architectural Engineering was established, and soon the proportion of enrollment of girls increased appreciably. The ratio of women students in architectural engineering at Aleppo University is 20%, and in the Department of Civil Engineering the ratio is about 8%.

In other fields of science the proportion is reasonably good. The ratio of women who were awarded degrees in physics was 34% in the academic year 1961-62, and the ratio of women who were awarded degrees in mathematics in the same year was 28%. I may add that outside engineering and the physical sciences, pharmacy rates high, where the ratio of women students is 37% and in medicine the ratio is 10%.

As a Syrian woman engineer, I am proud of my profession, and my country is giving much importance to the role of women in this great profession. In the Universities of Aleppo and Damascus there are now three faculties of engineering and architecture, with a relatively high proportion of women students. In government service, women engineers in Syria are occupying important positions.

As a representative of Syrian women engineers, I extend my thanks to the American Society of Women Engineers who invited and sponsored this First International Conference of Women Engineers and Scientists. I hope that Syrian women engineers will be able to deliver at the Second International Conference a detailed account of their experience in the practice of the engineering profession in Syria.

DEVELOPING SCIENTIFIC AND TECHNICAL TALENT IN U.S.S.R.

by Mrs. Galina N. Kadykova
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I am happy to have the opportunity to address you, women engineers and scientists of the United States of America as well as of other countries. If we look back as far as some decades, we may see that a woman engineer or scientist was very rare indeed. But at the present time and especially in my country, they represent a large portion of our engineers and scientists and have already made a contribution to the development of industry and science.

I would now like to tell you how women engineers and scientists live and work in our country. Here in this hall are gathered together representatives of what we in our country call the "precise sciences", and they love facts, so let us begin with the figures. In the Soviet Union there are more than 409,000 women engineers; this means 31 percent of the total number of engineers of our country. It must be borne in mind that they work not only in so-called "women's professions", such as textiles and the food industry, but they play an important part as metallurgical engineers, machining engineers, constructors, geologists, and so on.

Do not think that we try to push the men out of industry. As Valentina Tereshkova said, it makes it merrier to work together. The industry of the Soviet Union is developing so fast that there is a lot of work for everyone in our country. We have no unemployment at all. Women as well as men have done their best to transfer a backward agrarian country into a leading industrial state well-known now in the whole world by its achievements in science and technique. Many of them proved to be qualified skilled specialists capable of doing much to improve the national economy. They have the same rights in getting job, they are paid equally, and can be appointed to any leading post according to their education and capability. We have numerous women acting as directors, chief engineers of the plants, and heads of laboratories. In the large amount of innovations women take a great part.

I myself work in the field of ferrous metallurgy which is the leading industry of the national economy of any country, where women were not admitted before. For the last 45 years the annual output of steel in our country has increased from 6.2 million tons in 1920 to 80.2 million tons in 1963. Women work here too, but much care is taken to make womens' work easier. The majority of them work in laboratories, management departments, research institutes, and so on.

For example, in the Central Scientific-Research Institute for Ferrous Metallurgy where I work, there are more than 300 women engineers. There are 41 among them who have a doctor or a candidate degree. They are solving many problems of great importance in the science of metals.

For example, doctor of the technical sciences M.I. Vinograd is a great success in the research of non-metallic inclusions in steel in connection with mechanical properties. Candidate of technical sciences L.N. Davydova works at improving the quality of steel by means of synthetic slags. Candidate of technical sciences O.P. Maximova works with Academician G.V. Kurdyumov. She carried out interesting research on the influence of high pressures on properties of structures and phase transformation in steel as well. Candidate of technical sciences N.A. Solovieva heads the laboratory for developing and investigating alloys with definite thermal expansion coefficient.

Scores of printed works have been published in our country, where authors were women of our Institute. Our women give reports at All-Union scientific conferences. There is no branch of science in our country where women are not working. They successfully work in such new fields of science as cosmic-space research, automation, and cybernetics. In 1963 there were more than 182,000 women scientists in the Soviet Union, about 40 percent of the total number of scientists. About 31,000 women won the scientific degree of doctor or candidate of science. More than 15,000 have the scientific degree of assistant professor or senior scientific researcher. The names and works of many of them are widely known in the Soviet Union and abroad as well, for example, Academician mathematician Kochina, Corresponding member of the U.S.S.R. Academy of Sciences; Geophysist Blinova, Corresponding Member of the Academy of Medical Science Yermolyeva; Doctor of Physico-mathematical Sciences Olga Oleinik, who conducts a lecture course in differential equations at Moscow University; and Doctor of Physico-mathematical Sciences Alla Masevich, who is taking a most active part in the study of outer space. She is in charge of the optical observations of artificial satellites of the earth, and is a Vice-President of the Astronomic Council of the U.S.S.R.

Candidate of technical sciences Kazanskaya won the highest award, Lenin's Prize in 1964. She is one of the creators of a set of rolling mills for rolling out parts of very large machines. A large group of geologists was decorated for discovery of oil and gas in West Siberia, among whom were T.I. Osyko and S.G. Belkina. Three women, T.K. Berends, T.K. Yefremova, and A.A. Tagayevskaya, won the Lenin Prize for their work in creating and implementing a universal automatic system of operation of industrial processes.

All this means that if woman is completely emancipated, her work as an engineer or scientist equals that of a man. I have to note here that in our country, in general, we women have very favorable conditions for creative work. All scientific research is carried out at the expense of the state. All laboratory equipment is paid for by the state. If it is necessary to get acquainted with the work of the Institute in the other town or to take part in the work of a scientific conference, symposium and so on, all the expenses are paid by the state. We have many scientific libraries where books and magazines of almost all countries have been gathered and books can be borrowed there without charge. There are technical and scientific societies in every industrial city, and these carry on scientific exchange and develop advanced methods of work.

As you probably know, in the Soviet Union wherever she works the woman is paid equally with the man. But I must stress that it is not for salary only that our women work. Many families can do without the woman's salary. But they work for the benefit and prosperity of society which makes woman really equal to the man in the family as well as in the society as a whole, makes her life interesting, reveals her abilities and adds to her moral perfection. It is possible for woman to play such an important part in industry and science because woman in our country can and may join any institute, university, and higher school, and acquire any speciality on the same footing as man, the only exception being dangerous and hazardous professions (for example, underground in the coal mines).

One-third of the students of all higher technical schools are women. Women make up 59 percent of the graduates from specialized secondary schools and colleges. Education at all levels is free, and what is more, students who make satisfactory progress in studies receive a stipend. Nowadays external education and work in evening colleges and technical schools has spread more and more. Students who work and learn simultaneously are given many privileges, such as annual paid leave for a month to pass their examinations, fare-free passage to the school if it is located in another city, and paid leave for three to six months for defending their diploma. Many large factories and mills have their own technical colleges and departments of evening education. All this gives women a good possibility to get a higher or secondary specialized education while working, as 11 women of our Institute did in 1963.

At the same time women have duties connected with family and children, but here again the state helps them. In the first place the state itself defends the rights of mother and child. If the woman is expecting a baby, she is given paid maternity leave 56 days before and 56 days after the birth of the child. Moreover if she chooses it, she may receive a three-month leave without payment but her post is reserved.

For a mother not to be anxious about her children a large net of children establishments exists, such as kindergartens and so on, where children of pre-school age play, rest, and are looked after and fed, while the mother is at work. Now more than 6.4 million children go to nurseries and kindergartens in our country. This is very convenient for mothers as well as for children. My son, while small, went to kindergarten. Our Institute has a kindergarten of its own for 190 children. Every summer the kindergartens transfer to the countryside. We also have a pioneer camp for school children, where children rest during summer and winter vacations. More than 600 children rest in the pioneer camp of our institute every summer. The greater part of the expenses connected with this is taken up by the state and institute, and the parents pay only 12.5 rubles a month in kindergarten.

During the school year there is a so-called "prolonged day" in primary school. This is so children will be looked after while the parents are at work. There they have dinner, take walks, and do their lessons under the supervision of teachers. In the next decade it is planned to enlarge the net of children's establishments so that every family can, if the parents desire, send their children to kindergartens, nurseries, and so on.

To make housework easier and free the woman of everyday chores in the kitchen and so on, much attention is paid to canteens, cafes, and restaurants. Very many rest-houses and sanatoriums are built in our country for our citizens' summer leisure. This is also so with dwelling houses, cinemas, and catering establishments.

In our age of progress in science and technology, many fields of activity are open where the woman can demonstrate her abilities and talents. We women can and must do as much as we are able so that people lead happy and prosperous lives. No matter where we work, we can successfully realize our cherished hopes and plans if there is peace on Earth. That is why it is of such a great significance for us not to be confined to our profession alone but to do our best to get to know each other and thus establish mutual understanding of peoples and nations.