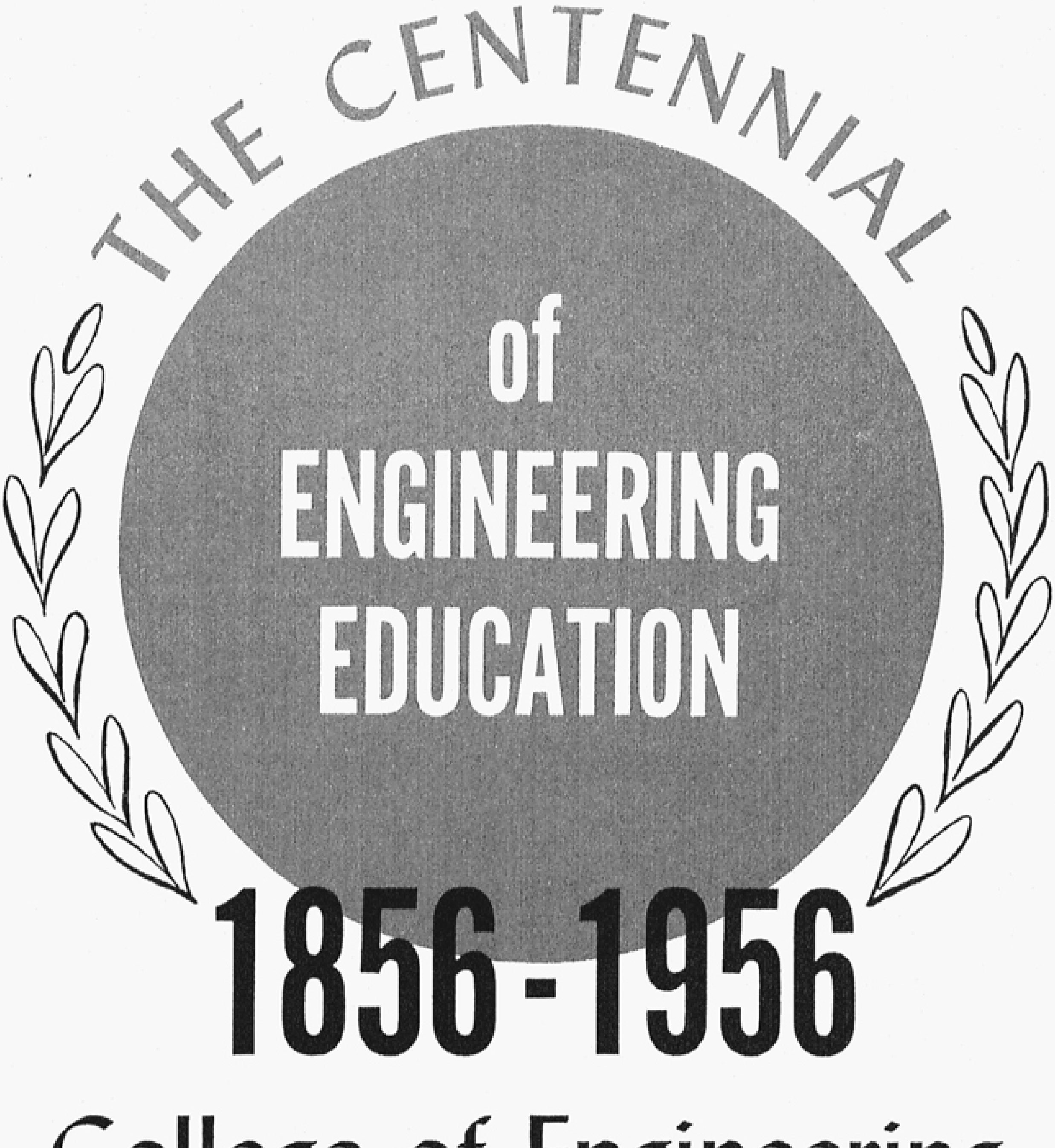

THE CENTENNIAL of ENGINEERING EDUCATION

1856-1956

College of Engineering

Columbia

THE UNIVERSITY OF MISSOURI BULLETIN

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January 22, 1957

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INTRODUCTION

One hundred years ago, William Barr and Thomas M. Field, both of Boone County, Missouri, were listed as "Civil Engineering Graduates" in the University catalog for 1856 and thus these two men were the first engineers to be graduated from the University.

On March 16 and 17, 1956, one hundred years later, the appropriate "Centennial of Engineering Education" was held at the University. The entire proceedings of the celebration are here presented to the alumni, former students, and friends of the College of Engineering, thus enabling those who could not be in Columbia in person, to take part at least through the medium of the printed word.

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Program for the

Centennial of Engineering Education

COLLEGE OF ENGINEERING
UNIVERSITY OF MISSOURI
COLUMBIA, MISSOURI

March 16 and 17, 1956

100 YEARS

1856-1956

Sunday, March 11

10:30 a.m. Assemble in front of Engineering Building
11:00 a.m. Burrall Class in Stephens College Auditorium

Monday, March 12

10:00 p.m. Serenade (meet at Engineering Building).
11:30 p.m. Midnite Show

Tuesday, March 13

8:00 p.m. Engineering Wives Tea for the Queen Finalists

Wednesday, March 14

Barbecue at Rollins Springs

Thursday, March 15

All Night Column Guard

REGISTRATION is in the Engineering Building.

Friday, March 16

9:00 a.m. to 10:00 p.m. INDUSTRIAL EXHIBITS AT BREWER FIELD HOUSE

8:00 a.m. Registration in Engineering Building

9:15 a.m. Dedication of Campus Stunt in front of Engineering Building

10:30 a.m. Annual meeting of Alumni and Members of the Engineering Foundation, Room 214, Memorial Union Building

12:00 Noon Alumni luncheon ($1.75) Room 201, Memorial Union Building
Chairman: Professor Mack Jones
"AMERICAN INDUSTRY OF THE FUTURE", a lecture by A. A. Kucher, *Director,* Scientific Laboratory, Ford Motor Company

2:00 p.m. Centennial Convocation, Jesse Auditorium
Chairman: Professor Gerhard Beyer
Welcome by President Elmer Ellis
"RESEARCH OF THE FUTURE", a lecture by C. Y. Thomas, *Vice-President* Spencer Chemical Company

5:00 p.m. to 6:00 p.m. Reception by Engineering Alumni of Columbia, Daniel Boone Hotel

6:45 p.m. Centennial Banquet ($2.00)
Room 201, Memorial Union Building
Chairman: Professor Ralph Scorah
"POWER GENERATION OF THE FUTURE", a lecture by O. B. Falls, *Manager* of Marketing of Atomic Power Equipment, General Electric Company

Saturday, March 17

8:00 a.m. to 5:00 p.m. INDUSTRIAL EXHIBITS BY 150 COMPANIES AT BREWER FIELD HOUSE

8:00 a.m. ALUMNI BREAKFASTS
Agricultural Engineering
Chemical Engineering
Civil Engineering
Electrical Engineering
} 201 Memorial Union Building
Mechanical Engineering — 223 Memorial Union Building

9:30 a.m. CENTENNIAL HONORS CONVOCATION —Jesse Auditorium

Chairman: Dail Stone, President Engineers' Club

(a) Student Honor Awards
(b) Honor Awards for Achievement in Engineering by Dean Huber O. Croft
(c) "COMMUNICATIONS OF THE FUTURE", a lecture by Eugene J. McNeely, *Vice-President,* American Telephone and Telegraph Company (to be introduced by:
Professor Clifford Wallis)

10:45 a.m. Arrival of Saint Patrick at Engineering Building and Knighting Ceremony

12:00 Noon Centennial Luncheon ($1.75)
Room 201, Memorial Union Building
Chairman: Professor Harry Rubey

"TRANSPORTATION OF THE FUTURE",
A Symposium

(a) BY AIR
Frederick H. Roever
McDonnell Aircraft Corporation
(b) BY HIGHWAY
Rex Whitton, *Chief Engineer*
Missouri Highway Commission
(c) BY RAILROAD
William M. Keller
American Association of Railroads
(d) BY WATERWAY
General W. E. Potter
Corps of Engineers, United States Army

3:00 p.m. to 5:00 p.m. Centennial Green Tea, Engineering Library, (Second floor of the Engineering Building)

6:30 p.m. Student-Alumni-Faculty Banquet, ($1.75)
Daniel Boone Hotel
Chairman: Dail Stone, President Engineers' Club

"NATURAL RESOURCES IN THE FUTURE", a lecture by Wilbert G. Fritz, *Consultant* to Office of Defense Mobilization, Washington, D. C.

9:00 p.m. Saint Patrick's Ball
Rothwell Gymnasium
Coronation of Queen of Love and Beauty
10:00 P.M.

LADIES PROGRAM

Friday, March 16

10:00 a.m. CHOOSE A TOUR:

1. Around the Columns, M.U. Campus
2. Something Old, Something New—Interior Decorating Shop, Antique Shops
3. What's Doing at Stephens
4. Birdseye View of Columbia
5. M.U.'s KOMU-TV

12:30 Noon LADIES LUNCHEON ($1.65)
Hathman House, Highway 40 East
Speaker: Mrs. Toimi Kyllonen

"AN AMERICAN HOUSEWIFE IN FINLAND"

Mrs. Kyllonen just recently returned from Finland with her two children and Professor Kyllonen, where he was a Fullbright Research Scholar in Sociology

AMERICAN INDUSTRY OF THE FUTURE

by

Andrew A. Kucher

ANDREW A. KUCHER, a native of Jersey City, N. J., graduated from Dickinson Industrial High School and following his graduation served as a draftsman and designer for various eastern aircraft manufacturers. In 1918, he was instructor in aerodynamics theory and practice at City College of New York.

Since 1951, Mr. Kucher has been director of the scientific laboratory, engineering staff, of the Ford Motor Company. Previously he had served as consulting engineer at Westinghouse Electric and Manufacturing Company, and manager of research engineering for the Frigidaire Division of General Motors. In 1942 he became director of research for the Bendix Aviation Corporation, and was promoted to vice president in charge of research in 1944.

Mr. Kucher is a nationally known engineer and inventor. He holds patents on nearly 100 inventions and industrial processes. He has developed a sealed unit refrigerating machine, pioneered a new method of aircraft construction, and invented one of the first all-fresh-air-conditioning systems for homes.

AMERICAN INDUSTRY OF THE FUTURE

A. A. KUCHER

Dean Croft, Mr. Chairman, members of the faculty, students, alumni and guests.

When I first received the invitation from Dean Croft to address you on the subject of "Engineering in Industry" 100 years hence, the thought was frightening. How could I, a factualist, presume to be a sage, and I hope that I will not be labeled a witch like Mother Shipton who is reputed to have lived 500 years ago and prophesied among other things that:

Carriages without horses shall go
and accidents fill the world with woe.
Around the world thoughts will fly,
in the twinkling of an eye.
Water shall yet more wonders do,
now strange, yet shall be true.
Under water men shall walk,
shall ride, shall sleep, shall talk.
In the air men shall be seen,
in white, in black, in green.
Iron in the water shall float,
as easily as a wooden boat.
Taxes for blood and for war
will come to every door.

My work has been predicated upon relatively short-range imagineering, generally having a firm root in economic necessity. Experience has proven this process to be highly speculative, but in the main, results have been fairly productive.

Upon further reflection, it became apparent that by taking engineering license, numerous guide posts exist which point the way for reasonable assumptions for extrapolating engineering progress in industry between 1956 and 2056.

Indeed, it became apparent that I stood on much firmer ground in predicting for the next 100 years than in attempting to predict for either the next 10 years or the next 1000 years —10 years are too short to smooth out statistical fluctuations and 1000 years are too many life spans to be meaningful.

We here, are all involved in one way or another with many of the creative phases of future science and engineering. We employ the modern techniques, new methods and devices that were scoffed at a few short years ago and which are now contributing to making more things better with less effort. This cumulative process is accelerating at an exponential rate. It is certainly exciting to speculate on the state of engineering in industry 100 years from now.

The complexities of our expanding knowledge, the evaluation and integration of that knowledge into new and useful applications, present a formidable problem to all of us.

The effect of all of this effort combines to provide each of us with an abundance of food, shelter, clothing, health, comfort and luxury in stark contrast with a relatively simple subsistence of 100 years ago.

Would we have it otherwise? Would we rather recede into a more primitive state? What is this compelling, driving force that urges us beyond the simple life? Why are we not content to live primitively? The answers to these questions seem to me to be very simple. We are where we are because *we* have chosen to emerge above the hunger, strife and discomforts of the past. As we all know, this does not imply that the individual work load has as yet been reduced, rather it means merely that the average man today lives, technologically speaking, the equivalent of several life spans of his grandparents.

We are continuously foreshortening time and what it can do for us. It requires only a brief reflection on the relative primitiveness of our ancestors of 100 years ago to realize that we have reduced tasks which required years to perform, into days, into hours, into minutes, into seconds.

This compaction of time is paralleled with the immense expansion of our physical knowledge. Each of us can possess but a minute fraction of accumulated knowledge, and, therefore, we are increasingly dependent upon the intimate association with others who possess related knowledge and ability; and that brings me to my first proposition, that the future demands of each of us an increasing respect and regard and recognition of the abilities of others and, thereby, the full utilization of convergent knowledge through collaboration and cooperation. We are making progress, but much remains to be done in order to remove artificial barriers mainly generated by intolerance toward new concepts and a lingering resistance to change. Many people resist change and innovation, not so much because they fear a new approach, but because to accept the new they must first give up the old. One of the calamities of nature is that when we get old enough to know how to live, we start falling apart. Our momentary span of life moves us to presume that we are the chosen few and that we have acquired an ultimate superiority over the past. Nothing could be further from the truth. Generations to come will look back upon us as having been relatively primitive.

To prove the point we need merely to reflect upon the marvels of science that are now upon us and await expansion into our future environment.

Modern technology is already contributing significantly to the new field of automation. We can certainly expect giant strides to be made by American industry in adapting automation on a truly broad basis. This will give industry the enormous capability to produce more things better with less manual effort and less cost than is now possible. A comparable and parallel increase in the standard of living is, of course, inevitable. And with this rise in our standard of living will come the leisure so necessary to nurture the arts, literature, music and general humanistic pursuits. As an extra dividend of extensive automation, it is easy to predict that new opportunities and new things will be provided for our expanding population.

Peacetime atomic energy offers to man an incalculable broad vista for future exploration and exploitation. The application of nuclear energy and its by-products reaches into every phase of our future technology—physics, biology, agronomy, chemistry, metallurgy and manufacturing techniques. All of these possibilities are before us, provided that we can apply the same degree of sober deliberation to human relations that we have learned to use in the physical sciences.

Beyond the realm of atomic energy, the harnessing of solar energy through photosynthesis already points the way to limitless supply of food and energy. Man has already developed a perception ranging from incomprehensible minuteness to the more incomprehensible expanse of space. Within an ordinary drop of water, there are 6 sextillion atoms. That is 6 with 21 zeros behind it. That many drops of water would supply Niagara Falls for more than 2,000 years. Beyond our tiny planet lies boundless space. Man's vision reaches 2 billion light years into that undefinable void at the rate of 186,000 miles per second. And now man is ambitious to begin to explore a tiny segment of that vast void.

Will this hunger for increased knowledge of the mysteries of nature be satiated by the discoveries and revelations of the past? Most certainly not: the future is replete with unsolved mysteries. There is no evidence that man's curiosity is on the wane. The inverse is true, just so long as man has the urge to probe into the unknown, just so long will there be compensating rewards to thwart sterility and decay.

Our reserve of fundamental and applied ideas is by no means exhausted, nor is it approaching an end point. Quite the contrary, we have just begun to pry at nature's most cherished secrets. Our problem is not one of searching for things to do, but rather one of appropriate selection.

In the vast complex in which we live and work, we have yet to find the underlying forces of nature.

Basic research provides the necessary spark of creativity in the sequence of events without which our physical world would become sterile.

The increasing emphasis on the necessity for expanding the involvement of industry in basic research, is now recognized as the prerequisite for things to come. Industrial engineering is directed toward the development and improvements of materials, processes and products in support of our expanding civilization. We are busy finding better ways of converting heat into mechanical energy. We are developing new high strength, high temperature, corrosion resistant, low cost materials for application to our present and future demands.

Such things as colored television, vertical ascension aircraft, supersonic flight and earth satellites are almost mundane.

In developing the material for this paper, I have drawn heavily upon facts developed by others. They have extrapolated the demands of the future based upon the steeply ascending curves of population growth, power demands and expanding world economy. Abundant material exists to substantiate these projections and I will accept them as factual. This acceptance is justified since progress has been more rapid than the extrapolated estimates in the past.

Therefore, let us assume from these estimates that by the year 2056 man will require 28 times the present power input for a world population increased from the present 2.5 billion to 6 billion.

I would not care to carry the population growth curve out much further since such a progression would shortly result in "standing room only" on this tiny planet, in which case we would have long since run out of Bridey Murphys.

Next let us assume that by employing all forms of available energy including coal, fossil fuels, nuclear and solar energy, that the needed supply of primary energy exists.

Of vastly greater economic significance than the means for producing the energy, is the means for consuming the energy. The elevation of the standards of living of the peoples of the world depends largely upon the means of distribution and consumption of energy produced. The primary problem of providing adequate food, shelter and clothing for the billions of people inhabiting the globe, remains the primary economic problem of our time. Each person must consume the equivalent of 10 horsepower a day to approach our standard of living and that is a lot of light bulbs, heaters, tractors, automobiles, etc.

Now we begin to see the enormity of the problem confronting industrial engineering —first to produce machines that produce the energy and then to produce the machines and devices to consume the energy.

I will not dwell upon historical accumulation of scientific discovery and engineering development nor the implications of economic, political, and sociological change. The continued compaction of time and space and the development of world concepts are prerequisites to the accomplishment of the task before us. I will attempt rather to define some of the mechanisms that industrial engineering must employ in order to provide the abundance demanded by these assumptions. The solution of the myriad complex problems depends largely upon the contributions that American science and industrial engineering will make. We have the urge, the brains, and the facilities necessary to accomplish the task.

How do we go about it?

We must immediately concede that technological advance is dependent upon knowledge, energy, and materials. Substantial improvements must be made in these three categories.

The scientific method is bound to prevail and accordingly the preponderant shift in thought will require increasing millions of people both male and female to be trained in science and engineering.

The enormous expansion of industrial laboratories, now extant and projected for the future, places a burden on our entire educational system. We at Ford are erecting a 25 million dollar scientific laboratory and engineering research facility within a $200,000,000 engineering center, dedicated to the advancement of knowledge of principals, materials, processes, and devices. Ten thousand engineers, scientists and supporting personnel are contributing to an expanding economy. What we are doing at Dearborn is indicative of the national trend and will be multiplied many fold within the coming century.

Based upon the ratio of population growth alone, a quadrupling of technically trained people will be required. At present, there exists a shortage of technically trained people in all of the physical sciences. Industry today could absorb one-third to one-half again more trained people than are now available. It is common to find hundreds of company representatives vying for graduate students where only dozens are available. No immediate alleviation of this situation is in sight. We at Ford, at the present moment, have over 1,000 unfilled requisitions for engineers and technical people. The demand far exceeds the ability of the academic fraternity to provide. We have all been working on the fringe of the problem. The solution requires the combined and concerted efforts of the university, industry and government.

One aspect of the problem which deserves immediate attention is that science and engineering have not been properly sold to the teenager. The high school sophomore is over-awed by the assumed complexities of science and engineering. The tendency to take the easy way has, therefore, deprived science and engineering of their share of potential talent. The young student must be imbued with the spirit of adventure into the unknown, the excitement and the thrill of discovery and invention which the extra effort affords. The adventurers of old sought new land. His modern counterpart makes his discoveries in the laboratory. An appetite for such things can be developed in the young by presenting the subject matter in a simple, understandable and usable form through personal association with those who have experienced the joy of discovery. The transition from the university to industrial will thereby be made more compatible.

Modern industrial laboratories provide not only an environment conducive to high level creative thinking and cross fertilization, but, also, ideal facilities and an atmosphere of necessity and security. The time has long since passed when we were looked down upon as a necessary evil. Basic research and long-range development is recognized by top management as a prerequisite to self-preservation. Today a liberal and affirmative attitude is expressed by all components of industrial management in the establishment of modern laboratories staffed with highly competent technical personnel. The rate at which industrial laboratories are growing has created an acute shortage of competent technical brains to fill the splendid opportunities that exist. A much higher degree of association and collaboration between the technical elements in education and industry must be developed if we are to prevail in the expanding requirements confronting us.

Permit me to glance backward 250 years for just a moment. At the Greenfield Village Industrial Museum in Dearborn, a ponderous steam contraption occupying about 30′ x 30′ capable of producing about 7 horsepower, is reminiscent of one of the men and devices that radically changed the world. Today we compact 10,000 controllable horsepower into a device hardly larger than a rain barrel. The era of the atom and electron will dwarf the era of steam. Within 100 years we may know enough about the photogalvanic phenomena to begin the generation of electrical power by solar radiation without the intermediary of the steam cycle or other conversion processes. The period of consuming concentrated and stored energy and mineral wealth is almost over. The bounty of the sands of the shores, the waters of the seas, and the heat from the sun, will become the primary sources of energy and basic materials.

I would like now to do a little imagineering on a few of the things which appear feasible within the next 100 years.

Industrial laboratories will gravitate deeper into the fundamental nature of things and will continue to contribute significantly to scientific knowledge, primarily in fields which are related to their technological interests. New discoveries in diversified fields will combine to establish a closer liaison between the contributors. The future of materials will be limited largely to four metallic elements—iron, aluminum, magnesium and titanium; and one semi-metal—silicon; for major construction. The other elements are becoming scarcer and, therefore, too costly for use even as alloying agents. Copper, for example, is already more expensive than aluminum and may be restricted to electrical uses only. The present position of titanium cost-wise is very likely to change in the future and may easily compete with stainless steel.

Materials for use in the 2,000° to 3,000° F. range will undoubtedly be developed. Ceramics or ceramic metal compounds capable of standing rapid temperature changes will be commonplace. Metals in general will be produced to realize a bigger fraction of their theoretical strength. For example, the theoretical strength of present-day steels may be raised from 100,000 PSI to about 1 million PSI resulting in lighter and stronger structures.

The extremely high mechanical properties of single crystal metal whiskers calculated from bending tests of these whiskers have now been confirmed by direct tensile tests. In the next 100 years, metal scientists will have developed ways of imparting these very high properties to bulk metals.

Scientists will have learned much about the structure of matter and will be able to engineer materials to suit one's tastes. Engineers will build in or remove dislocation and impurities so that the resulting material will have precisely the properties required. It will no longer be necessary to adapt systems to materials. On the contrary, the engineer will write a prescription for a material, hand it to the metallurgist and he will compound the material in a fashion reminiscent of modern pharmacy.

By 2056, scientists will have long learned how to control the thermonuclear reaction. New furnaces will be available to the metallurgist—furnaces with temperatures in excess of 10 million degrees. By means of these new furnaces, scientists will be able to take a common material, for example, sand, and break it down into elementary entities and then re-synthesize it into material of structural and electrical value.

Scientists will have learned about the ultimate particles in nature and with this knowledge will have learned how to utilize them.

Silicon, one of the most plentiful of materials, will be used as an electronic device to harness the free electrons. The efficiency of such devices will be increased to an extent that they will be widely used to convert solar energy into electrical energy, tapping an almost inexhaustible supply of energy.

One can conceive of cars run by electrical power generated by atomic reactors and propagated by microwave beams directed toward the car. The engine will consist of semi-conducting devices and motors of unusual design made of materials whose magnetic properties exceed those now unknown.

Man will no longer depend upon human response time and, therefore, all control functions will be electronic.

Industrial engineers will incorporate these response functions into sealed devices having complete dependability.

The degree of precision of mechanical devices will be expressed in angstroms rather than parts of an inch.

The quality of all products will have improved to a degree that those of us who are familiar with aircraft gadgetry can relax in complete tranquility.

Such things as miniature turbo machines to power vehicles, which we now look upon as a thing of the future, will be as commonplace in the not too distant future as the covered wagon was of not many years ago.

Without doubt, individual transportation in the 3rd dimension will compete with wheeled and wheelless ground vehicles.

We know today how to harden soft materials, how to make plastics which stand great stresses by a variety of treatments such as precipitation, radiation, etc. As yet unrealized is the ideal polymer, resistant to heat, corrosion resistant, able to withstand usable loads far in excess of yield loads of present-day metallic materials. The ingredients of this polymer are yet to be found; however, there is good theoretical reason for believing that they will be found.

The age of the electronic brain is nearly, but not quite, upon us. Computing machines are still too cumbersome and expensive to be used for all but the most exacting, complicated and indispensable tasks; yet one can already visualize electrical memory devices and information storage mechanisms requiring but a small volume, easily portable and inexpensive.

The prodigious rate of growth in our technology has been accompanied by a vast accumulation of technical knowledge; yet our method of recording, transmitting and reviewing results of research are totally inadequate for their purpose.

Already the impetus for effecting a transformation in graphic records has been generated and research is underway for providing automatic electronic equipment for recording and storing information and, more importantly, for selectively searching and coordinating such information for broad ranges of complex subject matter. A further aspect of this research is the development of an apparatus for language translation. The engineer and scientist of the future will be able not only to dial into a machine for a bibliography of references on a subject of interest to him, but also to push a button and have a transcription presented to him.

Industrial chemistry will be developed to a point where a new chemical can be developed by feeding a set of specifications to a calculator and the required structure and synthesis will be promptly indicated by the machine. The products, whether it is a plastic, glass or other material, will have unheard-of strength and durability because the invisible flaws which now cause all materials to exhibit only a fraction of their theoretical strength will have long since been eliminated.

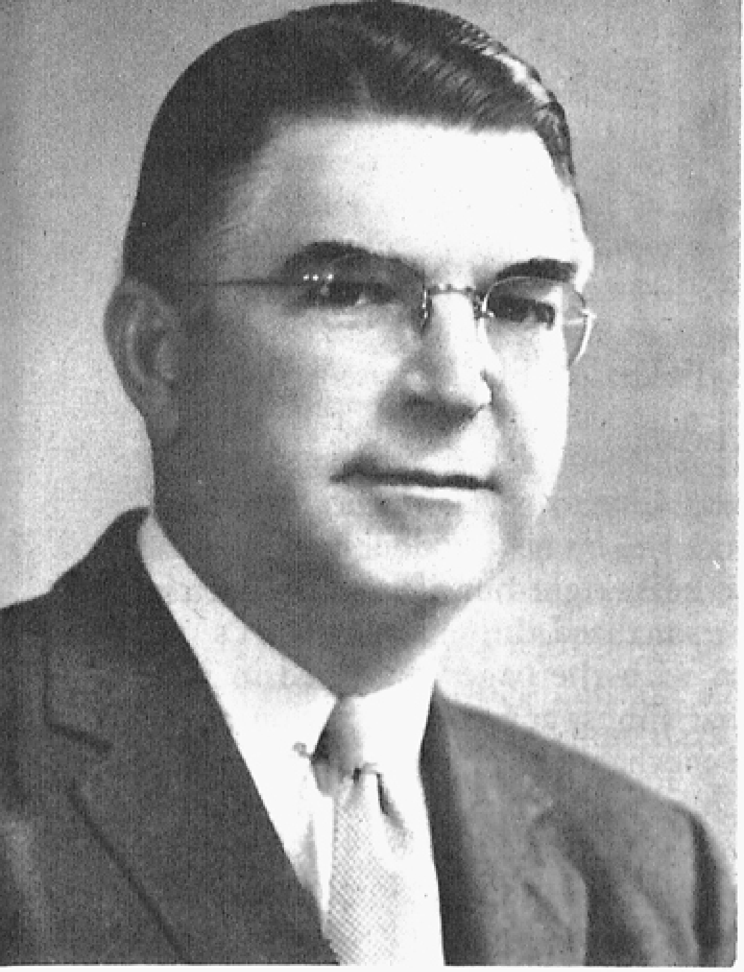
Voice writers and voice files will have been engineered into office use.

Steel, stone, wood and other materials will be removed or cut by ultrasonic or electronic means at a rate and with a precision unheard of by present methods.

Already electromechanical devices have been created which program mechanical operation from tape, rather than employing the human cross link between the blueprint and the machine.

All these things conspire to develop a concept of the future in which all repetitive function now performed by man will be performed electromechanically.

In closing I should like to leave this thought with you: Engineering progress in industry during the past twenty years has been a phenomenon difficult to comprehend and evaluate in terms of its impact on modern society, for progress has been so rapid we are unable to reach a steady state for proper evaluation. I believe that the historian of the future in evaluating the basic factors that have influenced human progress most, will point to engineering during 1956 to 2056 and proclaim this century the golden years of engineering progress.



RESEARCH OF THE FUTURE

by

C. Y. Thomas

C. Y. THOMAS, a native of Roanoke, Virginia, received a B. S. degree in mechanical engineering from Purdue University.

His first job was an apprentice instructor with the Atchison, Topeka, and Santa Fe Railway. Subsequently, he became supervisor of apprentices for the Kansas City Southern, and later served as chief locomotive inspector of the Kansas City Southern system. In 1929, he joined the staff of the Pittsburg and Midway Coal Company as mechanical engineer, later becoming chief engineer.

When Spencer Chemical Company was organized in 1941, Mr. Thomas became chief engineer and acting manager. In 1942, he was made general manager and in 1946 was promoted to his present position as vice president in charge of operations.

Mr. Thomas is active in professional, engineering, and civic organizations and is currently a member of the Kansas Engineering Society, American Society of Mechanical Engineers, and American Institute of Mining and Metallurgical Engineers.

RESEARCH OF THE FUTURE

C. Y. THOMAS

When Dean Croft was in Kansas City to speak to the Engineers' Club on March 5, he distributed a brochure, by now undoubtedly familiar to all of you, which virtually tore the heart right out of my introductory remarks. Since my own ideas were personalized through my father's college catalog, and as I compare them with the pages reprinted in your Centennial brochure, it is apparent that almost any college catalog of the day would suffice. My father studied mechanical engineering at the Virginia Agricultural and Mechanical College, now known as V.P.I., and I have here the college catalog of the college year 1887-88, which was father's sophomore year. These old catalogs are not only interesting, but, to say the least, are unique because they publish the grades, the ranking, and the demerits of every student. The rules were even more strict in those days. For example, with respect to holidays, students at V.P.I. were released from classes on Thanksgiving Day and for one week at Christmas. No one could be absent from the college for more than 24 hours without permission from the President.

Having rather recently put our son through medical school, with its virtually non-remunerative internship and a 3 year residency, and then bearing the burden of two daughters through their baccalaureate degrees, I'm sure that those of you who are struggling along one jump ahead of the sheriff would like to think of an entire year at college for $142.30. Let me read some details of the annual expenses from my dear old Dad's catalog.

As to courses of study, I won't go into the details of them, but it appears to me that they were somewhat more general than is true today, and they were just on the verge of beginning specialization. There were no courses in chemical engineering, in metallurgical engineering, in electrical engineering and in other prominent fields.

By and large students a hundred years ago were not as well prepared to enter college and once there they progressed more slowly. Not until his senior year did the engineering student of a century ago study analytics or calculus. Commonly for many years, in all branches of engineering it has been necessary to complete differential and integral calculus before taking up many of the junior year engineering subjects.

While it is interesting to consider college life, rules and facilities when father or grandfather or great-grandfather were in attendance, I have a real purpose in such references. Excepting a few notable inventors of the type of Edison or Bell or Whitney or Hall, to name only a few, who worked virtually alone in relatively small shops or laboratories, research was carried on almost solely at our colleges and universities. Only the institutions of higher learning had technical staffs capable of any considerable research work. Without the vast amount of technical information which is ours today, research of previous generations was largely on the basis of trial and error, without good instruments, metals and materials. The wonder is that they did so well.

Like a surveyor who must set a back stake before going ahead, it seems to me that we might take a look backward before we consider research of the future. In these days of television, high fidelity radio and record systems, I find it difficult to convince my own children that even in my college days there was no such thing as even the old fashioned crystal radio set. It is even harder for my children to believe that one of the earliest clear memories which I possess is that of being permitted, at the age of 5 years, to light the taper and then the gas lamps which illuminated our residence at Topeka, Kansas, after we moved there from my birthplace of Roanoke, Virginia. I was 9 years old before my father finally bought a house which was equipped with electric lights. Today and tomorrow, from other speakers on the program, will come recitations of the marvelous developments everywhere in our country. I would be out of place if I attempted to trace any of these seemingly impossible developments which have resulted in so much pleasure and comfort for those of us here in America.

There are all sorts of definitions of research, but my favorite one is that of Dr. E. Duer Reaves, Executive Vice President of Esso, who says that industrial research can be best defined as an organized effort on the part of a company to provide itself with the technology for its present and future operations.

While the term "research and development" has been used very commonly in recent years, there are a few who define the words properly. The General Electric Company, after some years of struggling with definitions, has come up with three classifications and definitions which I think are simple and very good.

1. Basic research is a search for new knowledge in advance of specific need.
2. Applied research is a search for new knowledge for a specific need.
3. Development is the application of existing knowledge for a specific need.

The National Science Foundation reports that 554,000 scientists and engineers employed by industry in research, may be classified as follows:

409,000 engineers
60,000 chemists
11,000 metallurgists
10,000 life scientists
10,000 earth scientists
8,000 physicists
6,000 mathematicians
and 34,000 in administrative work.

There is no gainsaying the fact that industrial research today is one of our largest industries. It will account for more than 1% of the gross natural product. Already more than one-half million people are engaged in industrial research and the number is growing as rapidly as competent staffs can be secured.

Despite its size, its importance and the emphasis placed on industrial research today, it has not always been thus. Industrial research is a comparatively young industry, having grown up from essentially nothing since World War I.

Since the first days of organized research in the United States up to the present time, about $39 billion have been spent. Of this figure nearly 45%, or $17 billion, has been spent in the five year period 1950-54.

Of the $5 billion spent in research in 1955, about 75% was spent by industry, and 25% by government.

Research today is the glamorous part of American industry. Compared to the longer established divisions and departments of the average company, the research department is the fair-haired lad. Our magazines of both the popular and the scientific type have published hundreds of articles on every single phase of research, any one angle of which would take more time to pursue than I have available here this afternoon.

Yes, research is a magic word these days. Perfectly stupendous developments like the A-Bomb and the H-Bomb have necessitated careful security programs. We are now accustomed to nearly all research being conducted on a hush-hush basis.

The most sophisticated visitors at the average industrial plant today are the security analysts or other representatives of investment trusts or investment bankers. Though secret research projects are seldom disclosed to these visitors, they have ways and means of appraising the volume, the general nature and the caliber of the research work being done by the company being inspected. Let me assure you that these experts may take for granted the operating efficiency of a big sprawling industry, but they are always asking pertinent and pointed questions about the research program.

If I were a young scientist or engineer starting out today, I would not be concerned particularly about the sick leave plan, or the retirement program, for example, but I would be tremendously concerned with the research and development program of a prospective employer.

Admittedly, it is exceedingly difficult to measure with any degree of accuracy the return on the investment on research. Drs. McNamee and Erlandson of Carbide and Carbon have estimated that from their inspection of the available data that 30% of the 1953 sales for a group of companies under investigation came from products which originated in research activities within 10 years. They found that for each dollar expended for research they will have generated $3.50 of annual sales beginning 4 years after the end of the research expenditure period, and after a lapse of 10 years, $6.80 in sales. Another interesting figure from Drs. McNamee and Erlandson is that it is possible to show a relationship of research expenditures to growth which is expressed in capital investment. It is found that this ratio is surprisingly consistent in approximately $4 of capital investment in new plants for every dollar expended on previous research expenditures.

In general, it can be said that research is paying off handsomely. Thus, it would take no other reason to predict that research and development benefits of the future are going to run into perfectly astronomical figures.

Some of you may be wondering what industry and all agencies will be spending on research 25, 50 or 100 years from now. I can't begin to look that far into the future, but I do know that as of the moment there is a great deal of argument as to the amount an individual company should spend on research. It has been understood in recent years that the proper yardstick was that of a certain percentage of total sales to be spent on research. Depending upon the company, this varied from a fraction of 1% to as high as 10%. More and more there seems to be substance to the feeling that expressing research and development dollars as a percentage of sales often leads to meaningless comparisons. One authority believes that research is the best insurance a company can buy and, accordingly, he believes that the research and development should be at least as large as all of a company's insurance premiums on plant and people. He has found that insurance premiums usually amounted to from 1 to 1.5% of net worth and he certainly believes that net worth is a better guide to the research budget than sales. Accordingly, I can only say that we are going to spend fabulous sums of money in the future on research and that anyone who has an interest in or a flair for this type of work need not worry about opportunity.

For a great many years, research to the average person in industry could be pictured as a brilliant, long-haired genius virtually locked up in a laboratory filled with instruments, gadgets, glassware, and from which emanated all sorts of odors and noises. I presume this general idea had its roots in the fact that traditionally research was carried on by our universities. In Europe today, while many big companies have their own research departments, it seems that they continue to depend on research, especially basic research, through arrangements with their universities. I think it can be truthfully said that while a considerable amount of fine work is being done in our colleges, that a greater emphasis in recent years has been made by the research staffs of private industry.

In a recent speech to the Chamber of Commerce of Kansas City, Mr. Defore of the DuPont Company very properly observed that progress has to be created and that it follows that only the productive can be strong and only the strong can be free. Despite 19 failures out of every 20 projects in the average research laboratory, one success can be tremendously useful as well as profitable. The DuPont Company spent 80 million dollars on its new polyester fiber dacron before the first pound was produced in commercial quantities. This in itself indicates that only through bigness, which many people today criticize, can there be some of the spectacular developments such as nylon and dacron.

With so much being done everywhere in our country to have more high school boys and girls take the necessary subjects for science and engineering in high school, and with so much being done at the college level to turn out more scientists and engineers, I hardly think it worth the effort to stress again the importance of getting more men and women into engineering and science. Through the years we must see to it that our boys and girls generally take much more science than they do at present in high school and then we must see to it that they are attracted to the engineering and science schools and colleges of the country. Our usual method of the teamwork approach in industrial research is going to require many, many more graduating scientists and engineers each year.

I have the feeling that many of the tedious boresome details of research in the future will be eliminated through the use of modern statistical methods as well as electrical computers, mass spectrometers, etc. A point of considerable importance is that man's knowledge of his universe has been growing since recorded time. Then, since new learning is built on acquired knowledge, the rate of new knowledge advances in a geometric progression. Technology is moving ahead so fast that today no one person possesses the intellect capable of acquiring a proficiency in many fields, and this will unquestionably lead to a demand for more and more specialization which means that there will be an increased emphasis on the team approach to research. A team of specialists will be required to pool their know-how and to assemble enough knowledge to adequately attack a problem.

In this generation we have seen research activities increase from just a very few one-man laboratories to huge institutions employing as many as 4 or 5 thousand people in one big laboratory. I have the feeling that as we come to understand human nature to a better degree that the future will find more smaller or medium sized establishments which will permit a great amount of freedom on the part of the investigators, yet which will be small enough to permit the staff to be rather intimately acquainted. I feel quite sure that the team approach is a good and sound one and, further, that ever increasing complexity of problems makes it all the more necessary for us to further specialize research activities.

With our entire civilization becoming more complex and the problems more terrifying and baffling, it is believed that only the very large industrial organizations will be able to maintain complete research facilities able to handle almost any type of a problem. This would be an extremely serious situation down through the years for the little fellow were it not for the fact that I am confident that we will have a vastly expanded growth of the privately owned and operated research organization such as our own Midwest at Kansas City, Battelle, Mellon, Southwest at San Antonio, and others. These organizations, relatively new in their approach to industrial problems, are doing an outstanding job.

Without attempting to be partial, let me give you a few facts concerning a typical modern day research institute—our Midwest Research Institute at Kansas City. It was conceived by some leading Kansas City businessmen, opened up for business in 1945 when they were housed in some very modest quarters. They have now grown to the extent that they are occupying their new million dollar building facing the Nelson Art Gallery. Since 1945 they have undertaken approximately 1,750 projects, 110 of which are currently active. They have had a total of 721 different sponsors, . . . industry, government, Chambers of Commerce, and the like. At the present time, their staff is made up of men and women from 71 different colleges and institutions of higher learning and perhaps one of the reasons for their success is the fact that about one-third of them are from Missouri.

In this modern day and age it costs from 30 to 40 thousand dollars to equip a laboratory for each individual employed in the laboratory. This very formidable capital expenditure in itself is enough to discourage all except the very large industries. Our colleges and universities are all struggling with greatly increased expenses and they are finding it almost impossible to keep all laboratories right up to date. Building and equipping new and modern facilities, especially in face of an overwhelming influx of new students, presents a problem which must be solved by our colleges and universities in the immediate years ahead.

Many scientists are today studying the subject of creativity. Just the other day in our own shop I picked up a bibliography on the subject and the bibliography itself was 150 pages long. Many individuals and organizations are digging into the human side of creativity and they are learning that creativity can be sharpened and improved by teaching techniques. This emphasis certainly confirms the fact that research is the business of creative technology and like every other phase of business, it depends on the people in it to do the job. I predict through the years that we will all hear and learn much more about the development of creative people.

We are not unmindful of the great progress which has been made in human research but I'm sure we have barely scratched the surface. Despite the best of testing and placement technique, we still put square pegs into round holes. As long as there are human beings I doubt if there can ever be a 100% perfect selection of people so that we could classify without fail the really creative ones, the best salesmen, the top administrators and the like. We can promote a lot of happiness when we can quite accurately determine whether a young engineer should stay in operations or go to ordinary engineering or go into creative research.

As we contemplate the future, perhaps no one subject defies accurate prediction more than peacetime uses of atomic energy. As recently as 1933, Lord Rutherford, renowned British nuclear physicist, said "anyone who expects a source of power from the transformation of the atoms is talking moonshine."

In less than 6 years the Danes and Germans had made the first big discovery of the basic facts which led directly to the spectacular development and use of the first A-Bomb toward the end of the Japanese War.

Already fourteen power stations are being planned, some are in construction, which will depend upon atomic fuel. Other countries, England and Russia among them, are building atomic power plants.

The success of our submarine, the Nautilus, has exceeded all expectations.

Just how rapidly atomic subjects will become commonplace in our schools and colleges, I do not know. Unquestionably, however, within 25 to 50 years, atomic energy will be commonly used the world over. I doubt if the wildest of one's imagination these days will begin to match the use of atomic energy of the future. There will be tremendous economic adjustments when vast areas of this old globe, needing only a reasonable source of power for spectacular development, build their atomic power plants. Areas of development, airplanes, automobiles, materials, medicines, and what not, await the researchers' searching and painstaking studies.

For a number of years I have been disturbed over a situation of status which prevails in our country. Many brilliant men and women have veered away from a field of interest in which they excelled because of status which also means economic reasons.

Our movies, our TV shows, and our modern literature have all helped to create a peculiar condition wherein a top administrator carries a higher status in a community than a top ranking scientist or professor. Ambition knows no single upward path. We must find ways and means to attract and keep topflight personnel on the research side as well as in the administrative field. In Europe today and for generations in this country, the top professors in the institutions of higher learning were considered to be and are respected as being the real community leaders. Our economic system has changed a great deal and this is problably the reason for the acclaim given to administrators.

Status in business is a serious and important and necessary thing. Status may be identified by stars, eagles, or oak leaves on a shoulder, or chevrons on one's arm, a Cadillac, thick carpet on the office floor, or a bigger desk. The quest for status, whether at the office, or at the Country Club, all too frequently results in inefficiency, misunderstanding, road blocks and plenty of heartaches.

It is difficult for most people to believe that it is right and proper for a man to earn $20,000 per year working in a laboratory with perhaps one or two helpers, when down the street there may be a factory employing several hundred people where the man in charge of the whole establishment gets the same $20,000 salary.

Let us hope that in the years ahead, that there will be a better understanding of status. From the days of Adam and Eve there never has been a society in which a person's standing as compared to others wasn't important. There have always been present some sort of a classifying symbol.

I confidently expect that the future will bring a better understanding of one's worth and one's contributions to society, restoring to their proper places in the sun our educators and our scientists.

As we think about research in the future and try to figure out just what course our educators should pursue in doing the best possible job of preparing our young men and women careers in science and research, I suppose there are as many ideas as there are people here today.

Dean Croft has long been an advocate of a 5 year engineering curriculum. With that I disagree, if it were only to provide time for certain of the broadening liberal arts subjects. I do firmly believe that in most engineering fields one can't get enough technical preparation in four very short years.

I predict we will find all sorts of experimenting in the future. The University of Michigan, for example, has a new course leading to a degree of BS in Science Engineering in an effort to meet a demand of the present day not satisfied by conventional degrees in ME, CE, EE, ChE, etc.

Technical advances of the past 15 years have produced a revolution in the industrial life of the entire world, and I need not name specific items—just two fields, the atomic and the electronic are enough, to illustrate the point that the classical boundaries of engineering courses as you and I know them are no longer sufficient in several new fields.

These trends are accelerating so fast that none of us can predict the future boundaries of engineering. Yes, we will continue with our present fields of specialization, but we must be alert to new areas if we are to properly and adequately prepare our young people for careers in research and science.

Long before now, you have come to the conclusion that your speaker, a poor old broken-down mechanical engineer from who's watch chain dangles neither a Tau Beta or Sigma XI key, has hardly lifted the curtain for a peek at research activities of the coming century. In order to keep out of the way of the really distinguished speakers today and tomorrow, I have purposely refrained from specific prophecies. My purpose has been a rather broad view ahead, rather than a focus on one particular spot.

As best I could, realizing full well my limitations as a scientist and as a public speaker, I have tried to think ahead and to raise some questions for your future consideration. I hope you will agree with me, as we contemplate "Research of the Future," that:

1. Engineering and scientific training of today will seem to future generations as crude as that of a century ago appears to us today.
2. Our institutions of higher learning will be doing a greater part of the fundamental basic research, leaving applied research to industry and to the research institutes.
3. Research as an industry itself will be making perfectly incredible demands for funds and manpower, on the order of a geometric rather than an arithmetic progression.
4. There will be a tremendous growth of the research institutes with every city of any metropolitan standing having one or more such institutions.
5. Industry large and small will depend more and more on the research institutes.
6. There will be a further growth in the teamwork approach to research rather than the individually performing scientist.
7. We will need vastly expanded institutions of higher learning to provide the men and women needed for research activities, with many departures from engineering and scientific curricula as we know them today.
8. There will be better means of selecting and training those des-

tined for research and there will be limitless opportunities ahead for those who are attracted to and will specialize in the field of research.

9. With America's future very largely dependent upon the caliber of the people who will be conducting the research activities of the future, we must provide ample status and reward for them.

POWER GENERATION

by

O. B. Falls, Jr.

O. B. FALLS, JR., a native of Texas, earned a B.S. degree in Physics and Mathematics at the University of Richmond and received B.S. and M.S. degrees in Electrical Engineering at Massachusetts Institute of Technology.

After graduation from M.I.T., Mr. Falls was employed on the Engineering Test Program at Pittsfield, Mass., and at Schenectady, N. Y. He later worked for two years in the Transformer Division at Pittsfield. He was then assigned to the Electric Utility Engineering Department at Schenectady and in 1948 was sent to Seattle as a central station application engineer in the Pacific Northwest District. He was appointed manager of product sales for the district in 1950.

Mr. Falls is now manager of the marketing section of the Atomic Power Equipment Department of the General Electric Company. Until his appointment to that position in 1955, he had been manager of electric utility sales for the company's Apparatus Sales Division.

POWER GENERATION

O. B. FALLS, Jr.

Suppose for a moment that we could remove ourselves from the present. We will go to a place from which we can look down on all the great things that man has built, and said, and fought for. Then too, from this place we can even see man's future accomplishments. We focus our thoughts on a certain time in history. Then we see it—the wonder of a new gift to mankind. Into this gift has gone the inventive effort of many men. Into this gift has gone the genius of some of the keenest minds of the twentieth century! This wonderful thing is a great, new, machine—not one that was designed merely out of scientific curiosity—but that was *labored* over by men who knew the riches of its reward, who knew that its reward was needed and sought by mankind throughout the world.

We are not at all surprised that a mere mechanical device can be such a significant function of our very society. After all, this is a *machine* age—the age when our hopes are *pinned* to the *success* of new machines that bring tomorrow *closer.*

Picture, if you will, this strange and wonderful new thing. It is a tall, cold, steel monster, almost a story high. It has no graceful lines, or any other esthetic features. It is actually rather ugly, drab, and crude looking. For some droll reason, it has been painted black. And somehow you can actually *sense* its newness, its unique, untried awkwardness. For this machine is the first of its kind in the world. True, men have made attempts to build it before, but here they think they have succeeded. It embodies new scientific *principles,* new *methods,* new *materials.* Picture it as a revolutionary contribution to society.

But let us not stop there. Picture also the men who stand beside it. Imagine in this small group the inventors, the builders, the buyers who called for its construction—long before they had the right to even expect that it would work! And will it work? This is the thought in the minds of all these men. They don't know if its reward will actually be rich —or explosive! And you must realize that these men are familiar with the machine. They understand its operation. Think, though, of the thoughts of the skeptics . . . the press, the public, and the financial and industrial leaders of the nation. What will this beast do to the economy, to the society; what industries will be affected?

And if it doesn't work . . . ? Well, for one thing, the value of the stock of the General Electric Company, as well as the Company's future, are in the balance.

Yes, this device is designed to turn out electric power. Electric power . . . the force that has reshaped our whole world! Is it any wonder that so many are so concerned with the success of this device which, if it works, promises to answer the power needs of the future for all mankind . . . ?

This thing it truly a *giant step* in our industrial evolution!

Have you guessed what this machine is? I have described a milestone in power generation . . . a milestone that occurred 53 *years* ago! I have just described a steam turbine—a machine that was built by my company for the Commonwealth Electric Company in Chicago. It was installed in 1903 in the Fiske Street Station. This machine today sits on display at the Schenectady General Electric plant. We have labeled it, perhaps immodestly, a monument to the courage that built it. This was the machine upon which hung the future of power generation. When tests on this turbine ran well, the stock of the General Electric Company went up. When tests ran poorly, the stock fell. Industry watched the pulsebeat of this machine. And the story of this machine sounds just like the story of another milestone that is being established even today . . . the entry of atomic energy into the realm of power generation.

My story about the turbine describes our present position in respect to atomic energy. It is a position of not really knowing what the outcome of all our efforts will be. We are entering a new phase of power generation—the atomic phase.

Here then is just another scene in the drama of power generation. These so-called milestones are the natural results of growth in such an important function.

You have asked me to tell you about this component of our economy, power. You have ranked it rightly with such other basic elements of this economy as industry, transportation, research, natural resources. I congratulate you on having chosen such a scope of study for so significant an occasion and am honored to have been invited to participate in such an historic occasion.

For this is a centennial celebration, a milestone in *another* basic institution of our society: education.

I was not invited here to speak this evening on education. However, you will note that I have referred here to education as *another* basic institution. And, being *basic,* it must be an integral part of the social and economic system of which it is a part.

So I will pause here a moment to reflect upon the importance of the institution of education from the standpoint of the company which I represent, and from the extremely complicated corner of that business which I represent —atomic energy.

We currently have about 13,000 people working in our atomic operations in all capacities. Of these, over 2500 are engineers or scientists, a ratio of nearly one to five. Of these, approximately 250 have doctors' degrees.

These engineers and scientists are people that we *must* have. We cannot run a highly technical industry, an industry that is still developing its basic technology, on decisions *alone.* We *depend* upon the nation's colleges and universities to provide us with the men who can develop the nuclear technology from its present state, and *carry it forward* to the position it must assume.

A couple of weeks ago —out of curiosity—I counted in the business section of a New York Sunday newspaper the advertisements for engineers of one kind or another. The count: 86.

To me, this illustrates two things:

First, industry *needs* engineers *desperately*—engineers of all types.

Second, since our colleges and universities are the operating arms of that basic institution, education, they must take stock of our move in the direction of a technological existence, and *act* to *prepare* greater numbers of men to meet this demand.

The very theme of this week on the Missouri campus, "The Next 100 years of Engineering," is indicative of *progress* in this direction.

You are, I hope, aware of the "Progress" slogan of my company. Progress is also the byword of our society. It is therefore more than coincidental that I should be telling you of power generation. For power generation actually paces the progress of industrial development. Although my prime interest at the present time is in the implementation of atomic energy *into* electric power generation, atomic energy is just another *part* of the greater function: power generation.

Let's turn back the calendar once more, but to a much earlier period.

When did power become an integral part of a social economy? Perhaps when the first oxen were harnessed to a plow. Or when the first flour mill used either slave or animal power to grind the grain. Certainly when the first water wheel was built to run a mill, or merely to haul water, there were applications of power. So you might say that wherever there was an effort to produce, or to establish the signs of an economy, or to improve the lot of man, there was power "generated" in some way.

We normally think of power generation as beginning about the time of the industrial revolution, in the late 18th and early 19th century. But, from the very beginning, power of one kind or another has been associated with economic progress. Wherever there was flowing water, men built factories and mills. The water wheel was the generator of history. As better water power was developed, greater production followed. Then the steam engine became the key to industrial power. In manufacturing and transportation . . . *steam* took over.

As the machine age evolved, and as nations expanded and their populations grew, new and better ways were devised to get things done. With the harnessing of electricity, the reciprocating engine and the steam engine were put to use in *electrifying* the world.

Industry by this time lived by *power!*

Electricity promised to light and run the entire world. It was quite obvious to some men, however, that if vast quantities of electricity were to be needed, there must be some efficient way of generating it. Reciprocating engines were doing the job, but far-sighted men saw the need for generating machines of far greater capacity.

This brings us up to the dramatic event of the operation of the first big commercial steam turbine.

With power generation as the *spine* of the industrial evolution, you can easily understand why this significant event was so seriously watched by industry. At General Electric, where the Curtis steam turbine was developed, the whole project was filled with excitement—and *apprehension.* Even though several test models of steam turbines had been constructed and run, doubt and anxiety were constant companions of those men to whom it meant so much.

The success of that turbine was *assurance* of the vital role electricity could play in the future of American growth.

This was the beginning of the first chapter in modern power generation.

The remainder of that chapter is a story of brilliant engineering, and of foresighted planning by the power generation industry.

Essentially, coal, oil and gas have been used as the basic energy source for the generation of power. The amount of coal needed to generate one kilowatt-hour of electric power has been improved from an average of about six pounds per kilowatt-hour, to about three-quarters of a pound for many modern plants. The value of this progress is evident. How has this been done? Turbines operate at certain temperatures, pressures, quantities of steam-per-hour of load, certain speeds, and other given factors. Through improvement of these factors, the efficiency of the steam turbine, and the entire generating plant, has climbed immensely. For example, the average pressures used in these plants have climbed from 850 pounds to about 1800 pounds. Turbine temperatures have risen from an average of about 500° F to about 1000° F.

Similarly, the practice of reheating the steam after it travels through the primary cycle of the turbine has grown from zero in 1947 to about 80 percent of new units today. Actually, *this* practice was used earlier in the century, but was replaced by other economies.

In respect to capacity, the "huge" Fiske Street turbine was rated at 5000 kilowatts, while modern turbines are rated at electrical outputs as high as *260,000* kilowatts.

These are just some of the highlights of the phenomenal growth of the prime mover of industry, the steam turbine.

As the turbine grew to such efficiencies and capacities, the generator followed suit.

Progress will not allow anything to remain sacred. It became evident that steam was not to monopolize the turbine field. As you well know, the gas turbine, first cousin of the aircraft "jet" engine, has been designed, developed, and is now used for electric power generation, as well as pipeline pumping, and rail transportation. The principle is the same. The application has changed, though. Gas turbines, burning natural gas or cheap, Bunker-C fuel (which has to be *melted* before it can be used) have *natural* advantages in certain parts of the country.

Knowing what development has been made in power generation, let's take a look at the future demand for this basic component of our society.

Last week, over eleven billion kilowatt-hours of electricity were consumed by the American people. During the same week in 1955, somewhere over nine billion kilowatt-hours were used. This is about a 15% increase. This is not a freak variation. Electric power doesn't vary back and forth that much. This is *growth.*

Another indication of growth is that this year, over 4 million babies will be born. But 4 million people will not die. This population growth will result in a United States population of over *200 million* by 1975.

And besides this population increase, the number of electrical appliances per capita is increasing. Today we require more automatic washers and dryers, fans, air conditioners, lights, both for utility and decoration, as well as hosts of other electrical appliances. Also, our ever increasing income levels now bring us more and more of the refinements of *better* living. After all, the electric kitchen is here now. Increasing numbers of people sleep beneath automatic electric blankets, wake up to music provided by electric clock-radios, and make the morning toast, coffee, and scrambled eggs by means of electricity. And in the office, the typewriter has gone electric.

Now new devices are being made available to us for *additional* convenience. The heat pump, for one, is a device that actually uses electricity to utilize the heat, or lack of heat, stored far below us in the ground. Imagine heating or cooling your house without fuel! Well, you can actually *do* it *now*.

We must face up to it. Everywhere we turn, requirements for increased power generation are glaringly evident. The United States will more than double its use of electricity within the next ten years. This is of course not just an optimistic feeling. It is based on the fact that for fifty years the electrical industry has been growing at this rate, and we can see nothing that will change this rate except to perhaps increase it.

So much for the short range forecasts. By 1980, when we will have established space satellites, when we may be seriously thinking about a trip to the moon, when automobiles will have bubble tops, and when women's fashions change just as erratically as they do now, we should be using about 5 times as much electricity as we will use this year. That *might* mean that there will be 5 times as many steam turbines (of the same size) as there are now. And 5 times as much fuel will be required, in terms of present efficiencies.

Let's take a look at the distant future. In the year 2056, 100 years from now, our predictions tell us that our energy requirements per year will be between 25 and 300 times what they are now. Another way to look at these astounding figures, is that in the year 2056, the world will require, for *just that year,* at least as much energy as has been used throughout all history up to 1956!

When you begin to see the vast energy requirements of the future, you realize why future power generation must be calculated in terms of nuclear fuel.

Therefore, the *next* chapter in modern power generation, the chapter written in terms of nuclear energy, is yet to be written. As a matter of fact, we are in the very process of writing it now. The first page has not been turned, but the outline is fairly complete, and the writing has begun.

Let us look, for a moment, at the power generation cycle, to see where atomic energy fits into the picture.

Unless we have vast quantities of falling water available, we must rely on a *heat source to produce steam.* This steam, in turn, passes through the turbine, which turns the generator, producing electricity. Atomic energy is another *source of heat,* by which steam can be produced. Essentially, the rest of the cycle remains the same. You might call atomic energy a new fuel, which requires special heat conversion facilities.

As far as power generation is concerned, this new energy source does not allow us to do *anything* that we are not already capable of doing. The advent of atomic energy *does,* however, assure us that we can continue to count on plenty of electric power, and that we can generate and use this power in more remote places on the earth. It is another *source* of energy to add to our store of fuels.

There are other uses of atomic energy, to be sure. Some of these used have already been proved. In transportation, for example, there is one nuclear powered Navy submarine on duty right now, and another, the Seawolf, is scheduled to be under way this year. Besides *heat* energy, atomic fission also produces valuable *radiation* energy. The AEC has announced that industry is already saving millions of dollars each year by using radioisotopes for tracing and instrumentation.

There are some areas where it appears that we will be able to accomplish things that would be unattainable without this newly harnessed force. In the realm of research we now have available to us very high neutron flux densities over relatively large areas. This promises to promote materials, agricultural, chemical, and medical studies. There are reports that there may be an application of radiation energy to the reactions of petrochemical processes, increasing the effectiveness of this already booming industry. We actually do not know where all of the uses of nuclear fission will be found.

All of the projected uses of atomic energy have recently been the subject of a nine man civilian panel, sponsored by the government. This McKinny Panel has submitted to Congress its report, which is an outstandingly thorough insight into the future of atomic energy.

It is well founded, though, that for the predictable future, electric power generation will be the dominant application.

Perhaps I should stop here for just long enough to assert one fact. Atomic energy is not going to put oil, or coal, out of business, even though it *will* ultimately take over many of the fossil fuel jobs. There is plenty of coal, oil, and gas to go around now. We expect that there will be sufficient amounts for many years to come. The petroleum industry still locates more recoverable crude oil every year than it uses. But the gap between the amount *found* and the amount *used* is slowly closing. As the cost of recovering conventional fuel goes up, the need for atomic power success increases. After all, only about 3% of the oil business and 15% of the natural gas business is in power generation. Both of these figures, according to the petroleum people, are decreasing.

The coal situation is slightly different. The major use of coal today is for power generation. This will continue. In the year 1980, we estimate that four times as much coal will be used for power as is used now, and we estimate that of the total power being generated at that time, 68% will be by coal, oil and gas; only 23% will be by atomic energy. This certainly shows anything but pessimism about the relationships of these energy sources. Also, the fossil fuels are finding, and will contine to find, many more uses other than as a fuel.

We have just examined some startling facts about the future of power generation. Use of coal will increase, but not at the rate of demand.

Here is where the *atom* steps in.

Rest assured that it will not be a *fuel starved utility* that orders an atomic power plant. It will be a *cost conscious* utility that does it. The cost of using conventional fuels is higher in some areas of the world, and of this country, than in other areas. It is these areas that will first change over to nuclear fuel.

Exactly how fast do we expect atomic power plants to take a part in the role of power generation? To arrive at realistic figures, we assumed that when the cost of electricity generated by nuclear fuel is equal to conventionally generated power, half of all new installations will be nuclear. When the nuclear generated power is 10% cheaper in that area, *all* new plants there will be nuclear. This is rather basic economics; it is also rather conservative.

Now let's look at the number of new power plants that will be *nuclear.* In 1965, only a small fraction, maybe 2% will be able to compete economically, due to the newness of the art. In 1970, about one-eighth of all new plants being installed will be nuclear powered. In 1975 it will still be less than half, but in 1980 it will have jumped to two-thirds.

That is twenty-five years away, but I would call two-thirds of all new power plants in 25 years, especially the *next* 25 years, a rather big order.

Now let's look at the *total* capacity of *all* power plants that are in operation in this same 25 year period. As we said earlier, there must be at least 5 times as much total capacity by 1980 to answer the demand. But one quarter of it will be nuclear powered. This also means that there will be four times as many conventional powered plants then as now. Still another way to observe this, is that the nuclear power plant business will be *four times* as big in *1980* as the *conventional* power plant business *is now.* (And as we just said, that will be only ⅔ of the business.)

Enough for figures. It is apparent that .atomic energy will become an integral part of power generation. It won't be because atomic energy is novel; it will be because it is needed.

How do we stand right now? I described for you the suspense behind the building of the first big steam turbine. I did this to illustrate that power generation, in the atomic age, is now in the *same position* as it was 53 years ago.

Despite all the anxiety, all the suspense, we can justify a great deal of confidence in the future of power generation for just one fundamental reason: the *men* who are *doing the job.*

It is deeply satisfying to observe a young engineer, perhaps out of college only two or three years—maybe 25 years old—working on a problem, the outcome of which will answer questions affecting whole nations, affecting the future of the utilization of this powerful force.

* * *

I have deliberately painted the picture of a new and unsettled industry. The General Electric Company has been in this business for about twenty years and believe it or not, that makes us old timers.

During the thirties, Drs. Kingdon and Pollock, of our Research Laboratory, began work which culminated, in 1940, with the isolation of Uranium 235, as the fissionable isotope of uranium.

During the second World War, General Electric scientists were on loan to the Manhattan District Project for the development of the nuclear weapons that precipitated the end of the war.

Then in 1946, the new Atomic Energy Commission asked General Electric to take over the operation of its Hanford plutonium producing facility in Richland, Washington. There, we have constructed and operated large reactors for the government for over nine years.

Also in 1946, General Electric was asked to set up the Knolls Atomic Power Laboratory in Schenectady, New York. There, we developed and fabricated the prototype reactor for the submarine Seawolf, and operated it at nearby West Milton. The actual Seawolf power plant was also built there for the Navy and AEC.

At West Milton, incidentally, the free world's first commercially distributed atomic power was generated. General Electric installed, at its own expense, a turbine-generator set, and operated it with steam from the Seawolf prototype reactor. On last July 18, the lines of the Niagara Mohawk Company carried this power to homes, farms, and industry.

The Submarine Advanced Reactor, a newer type of submarine propulsion reactor, is now being developed at the Knolls Atomic Power Laboratory.

Another General Electric atomic activity is centered in the Aircraft Nuclear Propulsion Department, in Evendale, Ohio. This facility is operated for the AEC and the USAF to develop and build an aircraft atomic propulsion plant.

Naturally, all of these facilities I have mentioned are closely restricted. However, I can say that General Electric has supplied many, many technically trained men to these operations to help equip this nation for atomic preparedness.

Now that we are in the commercial —or peacetime—atomic field, we have set up a special department to handle this fast growing business. Shortly, we shall relocate in San Jose, California, where the project is already under way for the design and development of the nuclear power plant for the Commonwealth-Edison Company of Chicago.

You will pardon me if I have digressed a bit to tell you of the background of my company. I feel that it is a rather impressive one, and it influences the statements that I have made regarding the future of the nuclear power generation business. It is also representative of the great activity in which hundreds of businesses are engaged right now.

We have seen what the history of power generation has been, what its milestones represent, and what its future demand promises. How then are we preparing to meet this bright future? What is some of the actual work being done in power generation today?

First, conventional equipment is not sitting around waiting to be kicked off the fence. The steam turbine, for example, is more efficient today than ever before.

An *example* of this progress is shown by a new steam turbine that we have completed and are now testing. This turbine operates at an initial pressure of 4500 pounds, over 200 pounds higher than any previous design, and an initial temperature of 1150 degrees, 50 degrees higher than ever before. There are of course certain inherent problems in this great advance in engineering. But, in the near future, when machines with ratings of 400,000 kilowatts or higher are *required,* such steam conditions will be able to afford an improvement in heat rate of about 6% over currently planned machines.

Also, we are now actively studying the feasibility of combining the steam turbine and gas turbine cycles. Though this is the very early stage, it has some very promising advantages.

Second, the government and private industry are working hard to hasten the day of atomic power generation as a reality. The Atomic Energy Commission has inaugurated programs designed to prove the feasibility of atomic power. One is the government sponsored experimental reactor program. Under this program, all the important types of power reactors are being built, on a small scale, at several of the AEC facilities. These reactors will provide information on projected systems.

Examples are the liquid fueled reactors at Los Alamos, Oak Ridge, and at Brookhaven. Some of these have been built and operated, and others are being built. The sodium reactor experiment, being built by

North American for the government, will study the use of sodium as a coolant for power reactors. The Argonne National Laboratory, operated as part of the University of Chicago, has developed a boiling water principle which has proven out as a power reactor possibility.

Another of these programs is the power demonstration program, whereby utilities will submit proposed plans for an atomic power plant to the AEC, and if it seems to be feasible, the government will grant funds to help defray the developmental costs. Under this program comes the Consumer's Public Power District of Nebraska, which is proposing a sodium type reactor; the Duquesne Power and Light Company plant at Shippingport, Pa.; and the Yankee Atomic Electric Co., which proposes a plant, similar to the Duquesne plant, for the New England area.

Still another group of planned power plants is being undertaken by private industry. One proposed plant under this category is for the Consolidated Edison Company of New York. This promises to be a very new type of installation, using both nuclear and conventional fuel. It is planned to incorporate the use of thorium with the uranium fuel, which would be bred into a fissionable form of uranium for prime use in the reactor after breeding.

Another plant is the one which the General Electric Company will build for the Commonwealth-Edison Company of Chicago. Associated with the Commonwealth-Edison Company in this undertaking is the Nuclear Power Group, Inc. Included in this group are the Union Electric Company of Missouri, and the Kansas City Power & Light Company. Pacific Gas & Electric, American Gas & Electric, Commonwealth-Edison, Illinois Power & Light, Central Illinois Light Company, and the Bechtel Corporation are also members.

The plant, known as the Dresden Station, will be the largest all-nuclear power plant in the world. With a capacity of 180,000 kilowatts, it will be completely privately financed. The heat source for this station, the General Electric Dual-Cycle Boiling Water reactor, will, we believe, be able to compete economically with conventional types of plants sooner than any other reactor type being considered now. The plant is scheduled to be in operation in 1960.

* * *

From articles in the papers regarding atomic power—from what I have said about all the different approaches that are being taken to *proving* atomic power—and from the very fact that you asked me here tonight to *tell* you something of these activities, you can easily see the signal interest in making atomic energy a working reality.

Of course, it *will* be done. We don't know *which* reactor system will prove best. We don't know what the solution to all of our major problems will bring. They may well bring *more problems.* These problems are such things as the *safety* of these plants, the *insurance* that we must obtain before we can operate the plants, the *cost* and *availability* of nuclear materials with which to operate the plants, the intricate *materials* problems that *have* to be solved before atomic plants can be competitive.

Truly a breath-taking future. And truly a breath-taking array of problems to be faced and solved. Private industry, the government, the institutions ... *all* will factor into the solutions of these problems.

We are not in any more untenable a position than that of the promoters of the first steam turbine. The atomic energy industry will drive just as hard, sweat just as hard, and succeed *just as brilliantly* as did the electrical industry, I am *confident.*

* * *

Once more, though, the centennial celebration of the University of Missouri. "The Next 100 Years of Engineering." Atomic power generation will *NOT* succeed unless we begin the next 100 years of engineering ... *now.*

Unless we breath life into it, *NOTHING* will grow, except the grass under our feet.

If the world is to appreciate and accept atomic power, it should first appreciate the *role* of power, of electrical energy. This is a very colorful story to be told about power generation. Here is power—power that cooks our steel ... and our food! Power that lights our homes and the operating rooms of our hospitals. Power that brings us comfort ... and strength.

All history is divided into hundred-year increments. An institution that can share these increments with history is indeed in a position to anticipate the needs of the future.

Today we are all aware of the dearth of college trained people, especially engineers and scientists. Not only the progress of power generation, but of all the basic functions that are to be discussed at this celebration, are sorely in need of these creative minds.

So with the same breath that I congratulate you, I charge you to furnish even more trained minds. And if the progress that is to be predicted this week is to be realized, you have no alternative but to accept this charge.

COMMUNICATIONS OF THE FUTURE

by

Eugene J. McNeely

EUGENE J. MCNEELY, a native of Jackson, Missouri, received his B.S. in Electrical Engineering degree from the University of Missouri. After his graduation, he successively held a variety of positions with Southwestern Bell Telephone Company. Among these, he has been general plant personnel supervisor, area plant superintendent, and general plant manager.

In 1948, Mr. McNeely served as assistant vice president in the American Telephone and Telegraph Company Personnel Relations Department. He later was elected vice president (operations) of the Northwestern Bell Telephone Company, and finally became president of the company.

In 1952 he was elected vice president of the American Telephone and Telegraph Company in charge of Personnel Relations. Later he took charge of the Department of Operation and Engineering, and in 1955 he was elected a director and appointed executive vice president and a member of the executive committee of the company.

COMMUNICATIONS OF THE FUTURE

EUGENE J. MCNEELY

Dean Croft, members of the faculty, alumni, students, and friends of the School of Engineering.

I am delighted at the opportunity to share in this celebration.

The past 100 years in engineering education here at Missouri have contributed in full share to the story of human progress, and there is no doubt but that these 100 years have left a solid challenge to the future.

It has been just a little over a century since the ability of one human being to communicate instantly with another was limited to the line of sight or range of human hearing. In 1832 Samuel Morse invented the telegraph. In 1876 Alexander Graham Bell invented the telephone (that is just 80 years ago). The wireless was invented in 1896 by Marconi, and the first transcontinental telephone circuit was put into service in 1915—just a little over 40 years ago. The first TV picture was sent over the wires in 1927.

It's interesting to imagine how different history would be if there had always been a telephone. Paul Revere wouldn't have made his famous ride. General Custer might not have been trapped at Little Big Horn—nor Davy Crockett at the Alamo.

Each January, the people down in Louisiana celebrate the anniversary of the Battle of New Orleans—fought January 8, 1815.

The invading British army—twelve thousand veterans of the wars against Napoleon—marched toward New Orleans. They were met by Andrew Jackson and his patchwork army of backwoodsmen. The battle lasted fifteen minutes. In that time, the coonskin-capped frontiersmen shot down two thousand men. The invader went to his ships and sailed away.

It was an exciting victory—but a tragedy. Because—two weeks before—a peace treaty had been signed on neutral soil—in far off Belgium. It took a month for the news to reach New Orleans by boat from Europe.

The communications service we have today would have brought the news of the peace treaty the moment it was signed.

In less than 80 years the "toy" of Alexander Graham Bell has become the nerve system of a nation. Today the Bell System is one of the world's largest private enterprises—with nearly $15 billion in assets. It joins with 4700 independent telephone companies in this country to give the best telephone service in the world. Together they interconnect more than 56 million telephones here at home and can connect with some 40 million in the world outside. This country, with 6% of the world's population, has 57% of the world's telephones.

There is in the plant of the communications service of this country sufficient wire to circle the globe 10,000 times or to make 500 round trips to the moon. In the next five years, in the Bell System alone, we plan to engineer and build wire plant sufficient to circle the world another 5,000 times. This will be in addition to the circuits we will obtain from the use of microwave and coaxial systems.

While our communications industry as a whole is big, it is essentially a community operation, and it can only survive as now constituted if it works for the good of the community *from the community's point of view.*

Such is the scope of communications today—in aggregate large to serve a nation, yet dedicated to the best interest of each local community.

My own connection with the industry has been 34 years— a little over one-third of a century. Thirty-four years ago we looked forward to great progress because we had two major developments on which to build —the electromagnetic relay and the vacuum tube. Today's communications systems have been built around these two instrumentalities. Lest I be accused of oversimplification, let me hasten to add that countless other devices have played essential roles. But in the main there were just two fundamentals—the relay for the complicated job of interconnecting telephone lines and the vacuum tube for extending transmission to great distances. These were the foundation stones. Each has given birth to a vast art. Yet both have grave limitations. So today we are going on to build a new communications art, about which I will say something later.

So much for the past. The subject you have assigned me is "The *Next* 100 Years in Communications." That is a difficult subject, because what happens in the next 100 years will depend on you and your fellow students all over the country, and I don't know you all well enough to forecast what you will do. I don't know how hard you are going to work or how ingenious you will be, how much determination you will have, how tolerant and understanding you will be of your fellowmen, or how well you will work on a team.

I do, however, know a great deal about some of the members of your generation, and that gives me confidence. It leads me to believe that you are mature, self-reliant and capable. All of us have every reason to expect great things of you.

In addition to your own capabilities you will start out with a lot more basic knowledge, and you will have better building blocks with which to work.

Just as 34 years ago we didn't even dream of television, radar, microwave systems, switching systems with built in logic and memory, controlled atomic energy and other such developments, it is safe to say that you and your associates will develop things in the next half century that haven't been dreamed of today.

I do want to tell you of some of the new things that most certainly will open new vistas in the communication field.

In modern science, even more clearly than in other affairs, the seeds of the future lie in the present. Here, if anywhere, coming events cast shadows before.

A few years ago, a new device known as the transistor was invented at Bell Laboratories. As Dr. Kelly, president of the Laboratories said, "This device is one of those big break-throughs in science that occur only at rare intervals. Just as the vacuum tube and the relay symbolized the past era, the transistor will symbolize the era beginning to unfold."

"Fortune" magazine characterized it in these words, "The transistor and its minute relatives will almost certainly stimulate greater changes in commerce and industry than reaction motors, synthetic fibers, or even perhaps atomic energy. In the transistor and the new solid-state electronics, man may hope to find a brain to match atomic energy's muscle."

In the telephone business, the transistor is already a vital part of an electrical brain. It will ultimately enable any telephone user to dial his calls across the continent as easily as he now dials his calls across the street. In fact, people in many communities are already doing so.

All equipment will be miniaturized (of particular importance on the military side), and the power required will be small indeed compared with the present. The equipment elements will function in millionths of a second instead of tenths of a second as at present. In a millionth of a second we now not only know how to switch something, but even to perform more complex operations involving choices based on conditions at the instant.

Transistors are in various products now on the market, in secret war devices, and Dick Tracy's wristwatch radio is closer to a commercial reality because of it. (In fact, I have one here—you can see it is much smaller than a pack of cigarettes. It is not in commercial production—merely a laboratory stunt model.)

The Bell Solar Battery which converts sunlight directly into electrical energy is new, and is being used on one experimental project to provide telephone service. Also, so-called over the horizon radio service is being tried on an experimental basis to provide telephone service between Florida and Cuba.

Our intercity network resembles a huge spider web. Great progress has been made in its development. This web is composed of microwave radio systems, coaxial cable systems, aerial and underground cables equipped with carrier, and traditional open wire.

Each microwave channel can be equipped to carry up to 1,800 circuits as can also each pair of tubes in a coaxial cable. The microwave systems send their energy in a direct beam and so do not "broadcast" their waves. Thus, they do not use up frequencies badly needed for radio, television and the military. As I am sure all of you know, there is a great demand for radio frequencies, so much so that their scarcity is the limiting factor in the development of mobile-radio telephone service and commercial plane-to-ground service.

The network of intercity circuits continues to grow. Last year, for example, we established another "backbone" route across the country. This uses both radio relay and coaxial cables, which can carry hundreds of conversations as well as television. To make even surer that essential services will be maintained in time of disaster, and also to provide for continuing growth, we are working on construction of 5,500 miles of new "express" routes. These will by-pass congested areas that might be primary targets in event of war, and will connect with existing routes outside such areas.

Our network serving the television industry continued to grow in 1955. The network now reaches 390 stations in some 260 cities, and can carry color programs to about 270 stations in more than 150 cities. In addition to television broadcasting, there is considerable use of "closed-circuit" networks for sports events and sales meetings. Last year, for example, there were more than 25 closed-circuit programs, each going to theaters, hotels or other locations in cities across the country. For sales meetings, color shows merchandise to best advantage. In 1955, we used closed-circuit color television ourselves to promote a nationwide telephone sales program, and to good effect.

Communications in the new era will be favorably affected by a completely new philosophic concept known as the "information theory." Stated simply, this theory tells us that all information can be measured in "bits" (a "bit" is a yes or no answer—a relay on or off, a capacitor with or without a charge.) These bits of information can, of course, be expressed in pulses.The field for development has great promise. Instead of carrying the pulses in different frequencies they can be interspaced in millionths of a second. Thus, you and I can both be talking on the same circuit on the same frequency at the same time —the pulses carrying your voice will be sent at intervals between the pulses carrying my voice.

It is found that information can be readily stored as well as transmitted in "bits." A memory tube of the size I have here is capable of storing 16,000 bits of information and this little one inch square piece of glass, covered with photographic emulsion, stores 256,000 bits.

Within the next two years we expect to put into service the first electronic switching office. The memory tube will be an important part of this office. Whereas today when you dial a number a thousand or more relays must operate to put your call through, the new electronic system will have no moving parts. It will be self-testing, will of itself indicate trouble spots, will have a good logic system, lots of memory at low cost, and will occupy less than a quarter as much space as present systems.

Next year is the centennial of the first transatlantic telegraph cable. That cable lasted only a few hours before it broke and, because of the Civil War and other reasons, it was 10 years before permanent telegraph communications were established with our neighbors across the Atlantic.

Now 100 years later, we are about to complete laying the first transatlantic telephone cable. It is fitting that this cable should be completed on the 100th anniversary of the University of Missouri School of Engineering, since Mervin Kelly, president of the Bell Laboratories who headed the development work on the cable, and Cleo Craig, who heads the Bell System, are both graduates of this school.

Before looking further to the future, let us stop and take a closer look at today—where we stand in history and how communications are a factor. Our Western civilization is threatened by an ideology that seems bent on destroying our way of life. If open warfare should come for which we were not prepared, our civilization could collapse or be set back hundreds of years. To help prevent such a cataclysm, we are building a defense system.

The telephone system is an essential part of this defense setup. Recently the Director of Communications of the Air Force said, "As an assistance to national defense, particularly in the air defense aspects, the telephone system is becoming a greater national asset each year."

All branches of the Bell System are continuously at the service of the Army, the Navy, the Air Force and other government departments. We do not make it our practice to seek military contracts, but when we are asked to perform work in the fields where we are specially qualified, we make special effort to meet the requests. There are three reasons why we are called on. First, communications are literally the first line of defense. Second, modern weapon systems use in large measure the same art that we use in telephone systems. Third, the skills of communication experts cover the whole range of inventing, building and operating systems that use this art.

In 1955, Bell Laboratories continued to work on electronic methods for the control of new defense weapons, and Western Electric, our manufacturing arm, maintained high-level production of "NIKE" guided missile systems to protect American cities. Also last year a 1,500-mile submarine cable system was completed for a guided-missile test range over tropical waters north of the Caribbean; this was largely engineered by the Laboratories and built by Western Electric. In the far north, construction proceeded on the Distant Early Warning Line of radar stations, and also on related military communication facilities in Alaska. The Sandia Corporation, Western Electric's subsidiary, continued to manage the Atomic Energy Commission's Sandia Laboratory in New Mexico, which develops and designs atomic weapons.

The Air Force has asked us to provide certain services for its proposed semi-automatic air warning and control system known as SAGE. This is a system for tying together radars and defense weapons through a chain of electronic computing centers. It was developed by the Lincoln Laboratories of M.I.T., and is being built to provide the nation a more nearly automatic defense against air attack. It is not a new air defense system, but an improvement over the existing system for which the telephone companies now provide communications. Western Electric has been called on to design and supervise construction of key government-owned buildings, and to coordinate engineering and administrative work. The Bell telephone companies, and the non-Bell companies likewise, are to provide the interconnecting communication facilities and services.

Among the chores that the SAGE system will perform are the following: First, transmit the knowledge of any possible aircraft target to centralized locations; second, compare each flight with innumerable known flights of friendly aircraft; third, sort out and spot any enemy flight; fourth, compute and advise which form of defense is best for the problem as it presents itself, (this may involve interceptor planes, NIKE, or other weapons still under the cloak of secrecy); and finally, if interceptors are involved, guide the pilot to his target and guide him home after the battle.

I mention all of this defense activity because I feel very strongly that the advancement of the communication art in the next 100 years will depend upon our ability to defend ourselves against any style or form of aggression. Approximately half of Bell Laboratorie's effort is now being spent on military projects assigned by the government and approximately ⅓ of Western Electric's output is for the government. I wish I could tell you a great deal more about these activities, but I can't, for security reasons. Suffice it to say that every time I visit with the communications people working on military projects, I am thrilled. Please don't misunderstand me—we are only a part of a great research team. Our efforts must be integrated with the efforts of many other great organizations.

To return now to civilian communications in the future—the kind of work we would much prefer to spend all our efforts on if world conditions would permit. There are some predictions that can be made without hesitation. The communications industry will grow. The current types of service will be improved in their usefulness, and new forms of communications service will become available.

This year the telephone cables to England will be completed and telephone conversations to London and the Continent will be as good and as dependable as any other intercity conversations. By the end of this year a submarine cable to Alaska will be in service, and by the end of next year one will be completed to Hawaii. We should have the second pair of telephone cables to Europe by 1961.

By the year 2000—if the population forecast of 300,000,000 is reached —there should be more than 100,000,000 telephones in service in this country. Most of them will likely be in color. An extension in each room should be as commonplace as an electric outlet by each chair. Party lines should disappear. Hands free telephones will be in general use and a second line to residence will be commonplace.

Cigarette-size paging devices will be regularly used in the next few years. They can be carried in the pocket or purse, so that anyone can call you to the nearest telephone regardless of where you are.

Six-hundred-word-per-minute-magnetic tape teletype transmission will be placed in commercial service to supplement the present 60-word.

Data transmission over regular telephone circuits will be used generally, permitting efficient centralized bookkeeping by national concerns.

The use of facsimile over regular telephone circuits will be extended.

Television and other forms of visual communications will be used in industry.

Extensive research is being carried out on an entirely new system of mass production of intercity circuits, and it seems reasonably safe to predict that a hollow tube waveguide transmission system in which two hollow pipes associated with appropriate electronic circuitry will handle tens of thousands of voice circuits and hundreds of TV pictures.

These are only a few of the things that one can readily foresee in the civilian picture.

The military picture cannot be freely discussed.

I am glad that you can see a NIKE missile for yourself. I know you can visualize the potentialities of the principles used in it. I know that you can see the necessity for the rapid completion of the DEW line around our northern outposts, the intermediate warning lines and the SAGE system and why so little can be said about them.

Those of us in communications now and those of you who may join us will carry a heavy responsibility, now, and in the years ahead both for the defense of our country and for the maintenance of good communications which are so necessary to our way of life.

There are two things that might seriously hamper the growth in communications.

First, political or legislative regulations so restrictive as to hamper managerial functions and choke off expansion and growth. We have seen many proposals of this kind made from time to time.

The second thing that would seriously handicap or stop development in the communications field would be lack of adequate earnings. The communications industry is a regulated industry—its rates and earnings are set by state and federal regulatory authorities. To progress, a utility must at all times pay its owners adequately for the use of their money.

President Ed Clark of the Southwestern Bell Telephone Company put it very aptly this year in his annual report:

"Regulatory authorities are recognizing that low earnings by a utility do not indicate that the company is operating at maximum efficiency.

"A company with inadequate earnings cannot operate and plan its future effectively. It is our belief that regulatory bodies will look more into the long-range planning in the future and this will result in even better service than we have today, and ultimately at a lower cost than the customer would otherwise have to pay."

So far I have emphasized things, more things and a few ideas. Yet I have left until now the most important element in any organization—people. The success of any organization—business, city, or nation depends upon three things: (1) the kind of people in it—their character, their ability, their objectives; (2) the money, material, information, equipment available; and (3) how well the people work together as a team.

To those of you here who have not yet launched on your careers, I will add one more prediction. I know that wherever *you* go, you are going to be the right kind of people. I presume that you will choose an employer who can give you the proper financial backing, equip you with the right tools, materials, know-how, etc. But the matter of how well you can work on the team will be largely up to you.

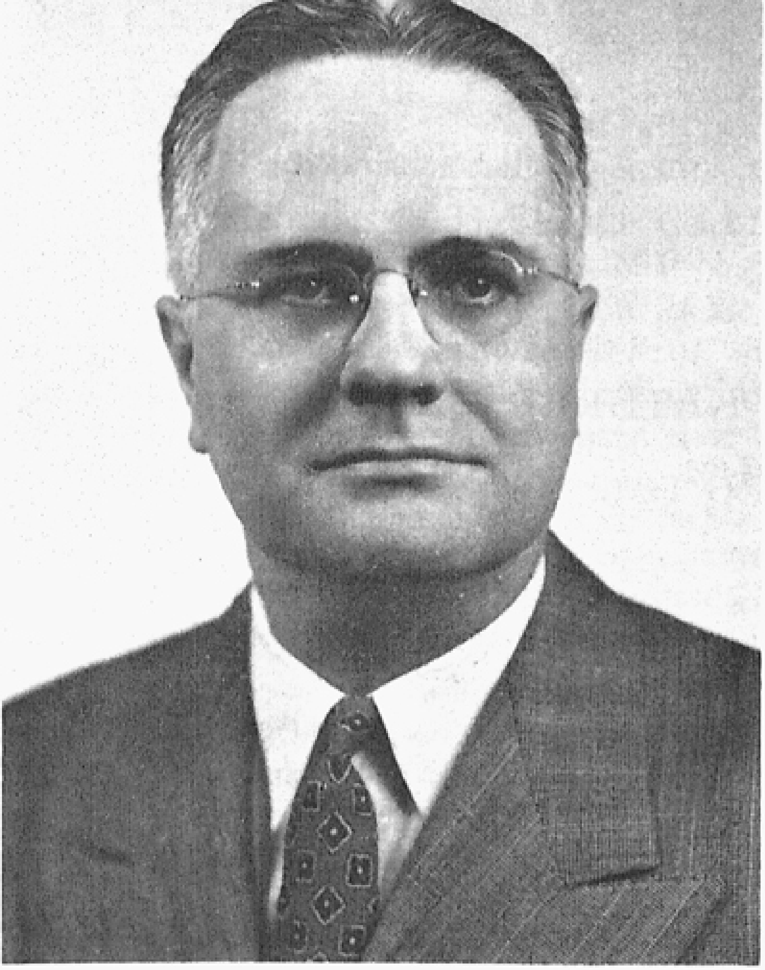
With all of the brilliant research that has been done and all of the amazing scientific discoveries, we still know very little about people and why they act like they do. Jealousy, greed, a desire to be a big shot or to dominate others is just as common now as it was 100 years ago. Will it still be as bad 100 years from now?

Understanding your fellow human beings will be a difficult problem and knowing what to do about it will be even more difficult.

I am sure of two things—first, you will go just as far in any organization as those with whom you work want you to go. Second, you will get back from your teammates just what you give.

I hope that you will work at the human side of the job just as hard as you work at the technical side because only through that effort will you find real success and happiness.

It is a pleasure to be here on this centennial anniversary of Missouri's Engineering School. Thank you and best wishes to all of you for your future success.



THE FUTURE OF OUR NATURAL RESOURCES

by

Wilbert G. Fritz

WILBERT G. FRITZ, a native of Clay Center, Kansas, received a bachelor of science degree from Kansas State College and a master of business administration degree from Northwestern University.

At present Mr. Fritz holds the position of consultant and chief of program coordination, Office of Defense Mobilization, a position which he has held since 1952. Prior to his current employment, Mr. Fritz served in a number of capacities on resources boards of the United States government, including chief of the industrial section, National Resources Planning Board; head economist, program bureau, War Production Board; chief, natural resources—public works branch, Bureau of the Budget; and director, domestic resources, President's Materials Policy Commission.

He is the author of a number of books and articles on natural resources and industrial policy for both government and private publications. He is a Life Fellow of the Royal Economic Society (London), and maintains a number of professional memberships.

THE FUTURE OF OUR NATURAL RESOURCES

WILBERT G. FRITZ

Mr. Chairman, ladies and gentlemen, it is a pleasure and an honor to speak on natural resources at this Centennial Celebration. Having been reared in the neighboring State of Kansas, I regard Missouri as more or less home territory.

I have another reason also for a special interest. To me, Missouri is in many respects a cross-section of the United States. It is not wholly northern, southern, eastern or western, but rather a conjunction of all sections. It is partly urban, partly agricultural, partly level, partly hilly, partly mountainous. Industrially it is one of the most typical states, if not the most typical state, in the Union. That is the conclusion of an extensive study of the location of industry in the United States on which I worked some time ago. The study showed Mississippi at one extreme as the most agricultural state and Rhode Island at the other as the most industrial state. Missouri, I recall, had the distinction of being squarely in the middle as the most representative, or typical, state.

This Centennial Celebration comes at a most opportune time. What could be more appropriate than to take inventory of where we stand and where we may be going in the emerging atomic era which is introducing a new dimension into our thinking about basic resources? The past hundred years might well be labeled the preatomic century and the next hundred, the atomic century.

I claim no exceptional powers of prognostication of the next hundred years in the natural resources field or in other respects. Nevertheless, I can approach the subject with complete abandon, because not even the youngest undergraduate is likely to be around at the end of the period to hold me accountable.

In recent years, I have participated in a number of projections of our natural resource availability and needs. The period of time has grown progressively longer in these studies. One study, for the Twentieth Century Fund, used a projection of 6 years; another, for the President's Materials Policy Commission (commonly known as the Paley Commission), used 25 years; and still another, for the Mid-Century Conference on Resources, used 50 years. As the period has lengthened, it has become necessary to paint with broader and longer strokes.

Since the thinking at this Celebration is in terms of a hundred years, we might begin with the global observation that the earth is in reality a ball of resources. These resources are distributed in a complex fashion. It might be said in slang terms that, "they are all balled up." Such a picturization, however, would be grossly inaccurate. I am reminded of the views of a young man from the great state of Texas who came to me some time ago to inquire about a position. When I asked about his field of work, he replied in characteristic Texas fashion without blinking an eyelash, "the earth is my field." I am sure that I blinked several times before I suggested that his field certainly provided ample scope. He then explained that as a geologist he related almost everything to the geology of the earth, including even sociological, economic and political matters. Although I can see some merit in such an approach, I am sure that it can easily be overextended, and I do not intend to do that this evening. At least I want to confine attention principally to the United States.

The American economy now uses approximately 20 tons of industrial raw materials and foods per capita annually, or roughly 70 tons per average household.

A little more than a third of this total is fuels, and a little less than one-third is bulky nonmetallic building materials, such as lumber, stone, sand and gravel. Food consumption is a little more than three-quarters of a ton per capita per year, or about 4½ pounds per day, including loss and wastage.

These figures show the overall bulk of our raw materials consumption. Certain materials the United States consumes in larger quantity than all the rest of the world combined, even though it has only 6 percent of the world's population and 7 percent of the world's land area. The United States has approximately half the world's steel consumption, more than half the world's petroleum consumption and nine-tenths of the natural gas consumption. It is the leading consumer of almost every industrial material.

Such a high rate of consumption results in a heavy drain on natural resources. According to estimates prepared by the staff of the President's Materials Policy Commission several years ago, the United States until 1939 produced in the aggregate as much raw materials as it consumed. A balance, of course, was not achieved for all raw materials, but deficits of certain raw materials were counterbalanced by surpluses of other raw materials. In each year since 1939, the nation has had a net deficit of these materials. Dependence on foreign sources has increased both in relation to domestic consumption and in absolute amounts.

Immediately after World War II, consumption of raw materials showed a faster gain in the United States than in foreign countries generally. During the past several years, however, consumption appears to have surged ahead more rapidly in foreign countries than in the United States. World demand for raw materials has reached new heights, with the result that worldwide shortages of certain materials, such as copper, aluminum, nickel and even steel have been experienced. Never before, even in wartime, has there been such a heavy demand on natural resources. If standards of living continue to rise, as we hope, the demand will increase still further.

History would teach us that depletion can have a serious effect on the the rate of industrial progress. The denuding of the timber resources in Great Britain before coal came into use undoubtedly led to a period of retarded growth, if not of retrogression. The handicap was overcome, however, as soon as coal became accepted fuel. On the other hand, depletion of timber and land resources of Greece dealt a blow to that economy from which there has never been full recovery.

We may understandably be concerned, therefore, about the future of our resources. Will impoverishment of these resources become an obstruction to continued industrial growth in the future? This is a question to which I would not venture a categorical answer.

In making use of resources, of course, we do not physically destroy matter. It is frequently noted that resource utilization is a question of taking concentrations of materials from the earth and spreading them more thinly over the surface. This concept is now out-dated to some degree. In the case of magnesium recovery from seawater, for example, we are now winning a metal from a source that is actually less concentrated than the average of the earth's crust. During recent decades, there has been a persistent trend toward the use of more and more dilute resources. This trend is likely to continue. A hundred years ago, copper ores were seldom worked if they did not show concentration of copper metal of at least 4 or 5 percent. At the present time, the great bulk of copper production is from deposits having a copper content of less than one percent, and some parts of deposits having less than one-half of one percent of copper content are being used. This trend toward the working of lower-grade resources means that increasing amounts of crude materials must be handled to obtain the desired end results. Demands on technology to achieve more economical production are intensified.

During the past quarter century, the gross national income, or product, of the United States has about doubled in terms of dollars of constant purchasing power. Coincidentally, population in the United States has increased about one-third and agricultural production about one-half. Output of minerals has expanded almost in proportion to the gross national income, having approximately doubled in 25 years. Expansion of production has been relatively uniform among the major groups, such as the metals and the mineral fuels, although there has been a diversity of trends for individual minerals as well as for other individual raw materials.

It is noteworthy that only a minor percentage of our total national effort (probably less than 2 percent) is devoted to obtaining mineral raw materials. Even if twice as much effort were required, the percentage would still be relatively small, although an increase in domestic costs out of proportion to that in foreign countries would place us at a disadvantage in international competition. Recent experience in Great Britain and continental western Europe, however, would suggest that substantial industrial development can occur so long as foreign raw materials supplies are accessible. The handicap of dependence on foreign supplies may thus be largely a matter of national security.

In order to provide for the national security, the Federal Government is accumulating stockpiles of key materials and stimulating the development, where necessary, of capacity that would be usable in an emergency period. These special measures are necessary because of the lack of self-sufficiency in some raw materials, wartime needs that exceed the peacetime productive capacity or the possibility of forcible interruption of supply lines or production. The Federal Government is stockpiling 74 materials. The materials once in the national stockpile can be released only on order of the President when in his judgment they are required for the national defense.

Of course, we are not much more dependent on certain raw materials than on others. Estimates presented by the President's Materials Policy Commission show that in 1950 more than a third of the value of all industrial raw materials consumption in the United States consisted of mineral fuels—coal, petroleum and natural gas—reflecting the extent to which we are becoming a power-driven nation. Agricultural non-foods were somewhat less than a fourth of the total consumption. Metals as a group were one-ninth of the total and were somewhat less than the value of forest products. The large use of forest products is not so surprising when we consider the quantity of newspapers, magazines, fiber packaging and other paper articles too numerous to mention that consumers and industry use in a year's time.

Of the resources needed for our industrial development, the energy-providing materials are the most crucial, because they are needed continually in massive quantities to make possible the economies of power-driven machinery to lessen human toil and to multiply its effectiveness. We utilize about 8 times as much inanimate energy per capita as we used 80 years ago. Despite this heavy consumption, however, our resources of mineral fuels are moderately satisfactory. Our bituminous coal resources are adequate to meet an annual consumption equal even to the highest rate in the past 20 years for more than a thousand years and our anthracite resources are adequate at such a use rate for more than 175 years. Proved reserves of coal in the United States have declined moderately since 1908, when the first comprehensive survey was made, and there have been no sizeable discoveries in the 48-year period. To the extent that coal consumption rises, of course, the life of the reserves will be shortened.

In sharp contrast with this situation for coal, proved reserves of petroleum and natural gas are relatively small compared to current and prospective consumption, but large discoveries are made each year. No very useful estimate of the probable life of the reserves can be given, although it appears that the life should be measured in decades instead of centuries, in view of the rising consumption and the increasing difficulty of discovering new reserves. Industry in the United States appears to be close at least to a partial solution of the problem of obtaining liquid fuels as a result of improvements being effected in the technology of producing these fuels from oil shale and coal, both of which are far more abundant than petroleum.

The depletion of our forest resources is generally familiar. Virgin forests have steadily disappeared. At the present time, the Mountain and Pacific Coast states have about two-thirds of the nation's saw-timber stand. Because of the receding supply and rising costs, lumber production in the United States reached an all-time peak almost a half century ago, in 1907, contrary to the trend of the construction industry which is the principal user. Perhaps our standard of living has not been markedly affected by this decline in saw-timber, but surely greater availability would have aided, especially in recent years when construction in nearly all its forms has been unprecedented.

Forest resources are of the renewable type. The chief problem of supply is that the time span for replenishment is too long to meet the rapid pace of industry. Trees of pulpwood size and quality, of course, are being replaced much more rapidly than saw-timber. Fortunately, the growth period of trees is being cut by the development of fast-growing hybrids and by concentrating production in areas where the growing season, moisture and soil conditions are favorable to fast growth. It is encouraging that the rate of growth and the rate of use of hardwoods are approximately in balance and that the deficiency of saw-timber replacement has been reduced to the softwoods whose lagging consumption in recent years has helped to reduce the gap.

Water resources also are generally to be considered as renewable. In most cases, the replacement takes place rapidly. Nevertheless, in the majority of states, including Missouri, ground-water levels have been falling steadily. Water has been used for many years in Arizona at a more rapid rate than it has been replaced. The state has had a growing deficit of water that cannot continue indefinitely without serious consequences. In most of the country the principal problem is not yet an actual scarcity of water but pollution of the supplies that are available. Growing population and industry aggravate this problem, and call for increased expenditures for anti-pollution measures.

From the standpoint of advancing technology, metallic materials hold a key position. Among the metals, steel is by far the most widely used because of its versatility and generally low cost. The United States meets 85 to 90 percent of its requirements for the raw material, iron ore, from domestic resources, but the percentage is declining. Domestic supplies of high-grade iron ore are dwindling rapidly. Taconites and other low-grade iron ore resources are abundant and are being used on an increasing scale, although their high cost as a source of iron places them at a disadvantage compared with the richer ores in Canada, Venezuela, Brazil, Sweden and other foreign sources.

Copper is a similar case of declining high-grade domestic resources. Favorable lead and zinc resources are even more limited domestically and unfortunately the quality of low-grade reserves of these two metals also is relatively limited. If our economy were dependent inevitably on these metals, the outlook for the future would be most somber.

Luckily, considerable interchangeability of metals does exist. The chief hope of the distant future lies with the metals whose resources are available in almost unlimited quantities. The metallic millenium has been reached in the case of magnesium where an economic source, seawater, occurs practically in unlimited abundance. It is interesting to note that less than a cubic mile of seawater could supply all the metallic magnesium that has ever been produced. So we need not establish any society for the conservation of magnesium in seawater at the moment.

The resources of aluminum which can be used feasibly now or in the near future also are virtually unlimited. The extra cost of using abundant low-grade resources of aluminum is relatively small. As long as high-grade resources are available at even a minor cost saving, of course, they will be used. It has been estimated, however, that almost boundless resources of clays and anorthosite could be used at an increase of only 10 percent in the cost of aluminum metal.

Examples could be cited at great length of the shifts in the use of resources that can take place to help avoid a famine of raw materials. Largely because of intermaterial relationships, depletion of resources, although persistent and unremitting, and actually fatal for certain local areas, is not necessarily incurable for the United States as a whole.

Numerous changes are occurring that are protecting our resource position. One type of change is the reduction of waste in production. In years past, a large share of the timber cut was left unused at the site. This loss is being reduced and in addition more of the wood is being put to use in one form or another after it leaves the forest.

Wastage and losses of agricultural products also are being reduced. The large part of the orange crop that formerly was discarded as culls, for example, is now being processed into frozen or canned orange juice. Mining and mineral processing losses are declining and more of the low-grade materials around the fringes of mine workings is being recovered. Scrap materials are being retrieved increasingly, thus easing the load on the production of primary materials.

On the consumption side also, notable changes are helping to reduce the burden on our natural resources. We are achieving more results with less materials by reducing the size, weight or complexity of many products. In the electronics field such developments as simplification of design, miniaturization and the use of semi-conductors and printed circuits have helped to conserve materials. Building construction is becoming less massive. Efficiency of fuel use is improving steadily. These changes mean that more work is being accomplished with less use of resources.

It is worthy of note also that some materials are really only borrowed when they go into consumption and are returned in large part as a secondary supply after they have served their purpose. The use of better anti-corrosion measures and preservatives has helped both to extend the useful life of products and to permit a higher salvage.

The energy resources hold a position of especial concern among the class of materials whose further usefulness is destroyed in the process of consumption. These resources are used in such large volume and come from sources that can be depleted severely if demands continue to rise.

The fuels that we use today are largely fossil fuels. It is frequently suggested that the problem of fuels can be solved by turning to live sources. Why not grow agricultural products and convert them to fuels? Two disadvantages stand in the way of using this approach as a major remedy. Costs of producing such agricultural fuels have been far above the economic range. In addition, the potential supply of such energy is much smaller than is commonly assumed. If all agricultural and forest products were converted to fuel, they would not provide as much energy as is now derived from either coal or oil. In addition an attempt to meet much of our energy needs by agricultural production would tend to deplete our soil resources.

Agricultural production, of course, is a means of converting the energy of the sun into a more compact and useable form. Some types of plant life can convert the energy quickly and efficiently. Experiments with the unicellular chlorella suggest that this or similar plant life may offer possibilities of economic concentration of the energy of the sun. Also direct concentration through photoelectric cells or collectors may present possibilities for the distant future. Currently, most of the energy that these means can provide is too diffuse or low-grade to be widely applied at a reasonable cost.

Atomic energy is almost certain to become a major source within a few years, since large expenditures are already being made on various types of atomic power plants both in the United States and abroad. This development will broaden our energy-resource base. More than 95 minerals containing significant quantities of uranium and thorium have been identified. The supply of these resources is much larger than was thought to be the case only a few years ago. Nevertheless, the extent to which atomic energy can meet growing energy requirements over a period of many decades is still problematical. Progress may depend considerably on the possibility of "breeding" fissionable materials. Harnessing of the thermonuclear type of reaction might open almost unlimited potentialities for mass energy production. Some hope is now being expressed that this reaction can be put to constructive use.

Under present conditions, we have many avenues open to us for expanding the use of our natural resources to support a rising standard of living. Although shortages doubtless will threaten repeatedly, they seem likely in the shorter run to be more in the nature of growing pains than chronic deficiencies that cannot be overcome by accelerated technology.

In terms of centuries, however, the changes in our needs and resources are astonishing. A hundred years ago when this engineering school was in its infancy, the United States had a population of about 27 million inhabitants. It now has about 165 million, a 6-fold increase. The rate of population growth is now about 1½ percent per year. If this rate continues, the population will rise to about 700 million in the next century.

The nation's gross national income, or product, as stated in the recent *Economic Report of the President,* is now on the threshold of $400 billion annually. The trend of the gross income is rising at an annual rate of about 3 percent. At this rate, the total income in a century would be about $7½ trillion.

Assuming further a continuation of the present growth rates for 200 years, the population of the United States would become about 3 billion and the national income about $140 trillion. The computed levels thus appear to reach the fantastic.

Imagine the crowding that would occur in the United States if these levels were reached to any considerable degree. Imagine the effort and resources required just to keep the population disentangled, but imagine also the lush materialism that would be possible in spite of it all.

Whether such a sustained compounding can occur is problematical and doubtful. In the past, the rise of civilization has been shaken periodically by plagues, famines and wars. Medical science has all but overcome mass illness as a deterrent to growth. Famines, at least in the United States, appear to be remote in this day of agricultural surpluses and rapidly rising agricultural productivity. The chief threat to our well-being is war. Mankind now has, or soon will have, the potentiality to destroy almost instantly more people than have been destroyed by wars in all history. I say this not to engender alarm, but rather to challenge our thinking to find peaceful solutions of the problems we face. Never before have our educational institutions faced a greater challenge. We look to them more than to any other institutions or groups to provide guidance and perspective.

We can be assured that earth-shattering changes will evolve in the next century. When we think in terms of such long periods, time becomes almost geological. In a real sense, we are justified in proclaiming with my friend from Texas that, "the earth is my field." I am not sure that this ball of ours can provide raw materials on the magnanimous scale that I have indicated and I am not sure that it should be expected to do so.

I am content to live in this year 1956, for all of its tensions, and to look back with you at a century of at least semi-solid progress. I am delighted that the next century is making such an auspicious beginning in so many respects. I will even predict that in the several decades ahead our natural resources will permit a much higher standard of living than we now enjoy.

The standards achieved in the more distant future will depend heavily on the foresight shown in developing and applying technology to a changing resource base. As this great Centennial Celebration draws to a conclusion, I would leave the thought that if it will help to place technology in such a broader perspective, it should be counted a resounding success.

AIR TRANSPORTATION IN THE FORESEEABLE FUTURE

by

Frederick H. Roever

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AIR TRANSPORTATION IN THE FORESEEABLE FUTURE

FREDERICK H. ROEVER

Statistical summaries for the calendar year 1955, which are just now becoming available, indicate that in every way this was a record year in air transportation. Briefly, the U. S. scheduled airline industry, in 1955, established the following records. It operated 1500 transport airplanes in completing 730 million miles of scheduled flights. It carried 42 million revenue passengers for a total of 25 billion passenger-miles. The passenger-mile is the accepted unit for recording passenger carrying activity. The transporting of one passenger over a distance of one mile establishes this unit. Similarly, the volume of mail, express and freight carried by air are recorded in ton-miles. The complete record of these 1500 airplanes for 1955 must also include the carrying of 150 million ton-miles of mail, 53 million ton-miles of express and 283 million ton-miles of freight.

Had this presentation been made just nine years ago, the 1946 record by comparison would have shown that the U. S. scheduled airline industry operated 800 transport airplanes in completing 371 million miles of scheduled flights. It carried 13 million revenue passengers for a total of 7 billion passenger-miles. The complete record also includes the carrying of 39 million ton-miles of mail, 39 million ton-miles of express and 15 million ton-miles of freight.

With the exception of air express, there has been an uninterrupted growth during these ten years since World War II. The number of transport airplanes has almost doubled. The number of passengers has more than tripled. The mail carried has almost quadrupled and the freight is 19 times as much.

The segments of American industry that produce and operate the aircraft that have contributed to such an impressive transportation record are deserving of recognition and appreciation for these many accomplishments. However, certain economic considerations must be included at this time to fully understand what has happened in the last decade and what is forecast for the next decade. Since 1946, the American economy has been in a state of vigorous expansion. There have been significant increases in the gross national product and in the national income. The annual rate of increase of the U. S. population has been nearly 3 million. The Bureau of the Census estimates a 1960 population of 177 million and a 1965 population of 190 million with the labor force growing from a present size of 69 million to 78 million persons. It is assumed that international conditions of the next decade will be similar to the last decade, that of relatively high military expenditures, a continuing of international tensions but with no full mobilization.

On this basis, the Office of Planning, Research and Development of the Civil Aeronautics Administration has estimated that in 1960 there will be 60 million revenue passengers to be carried a total of 36 billion passenger-miles. Furthermore, in 1965 there will be 76 million revenue passengers to be carried a total of 45 billion passenger-miles. On an average then, this means that each year of the next decade will see the U. S. scheduled airlines carrying 3.4 million more passengers with an annual passenger-mile gain of 2 billion. It is presumed that the mail, express and freight shipments will also grow in volume but in the absence of well defined assumptions, no forecast has been attempted.

Adherence to the implications contained in the title of this presentation has had the tendency to lead the author into the realms of economics and statistics. However, it is believed that the technical aspects of air transportation are really more interesting and more fundamental to an understanding of the activities within the industry.

Air Transportation a By-Product of Military Development

Historically, commercial air transportation came into being and has always progressed as a by-product of military aviation. The costs of basic research, applied research, experimental engineering, flight testing and even tooling and manufacturing have normally been charged to military development. From this fund of knowledge and from the many fine military aeronautical products which have been produced, there has been a certain percentage which has been used directly or adapted to commercial air transportation. The American people, through their government, have paid the bill in the interest of national defense and have received a transportation network within their economic reach as an extra dividend. This would never have been possible if commercial aviation had had to bear the development costs involved.

In the future, military aviation will probably have an increasing impact on commercial flying since air transportation will play an ever growing part in military operations. This has prompted military planners to investigate the capabilities and operating costs of all the possible types of transport airplanes that could be developed in the future, based on present day engineering knowledge. The necessary airframe and engine development programs for future operational military transport aircraft will give full consideration to operational costs, both direct and indirect.

The milestones of aviation are marked by the advances in the design of power plants. The principles of flight were known long before the availability of a sufficiently light internal combustion engine made powered flight possible in 1903. As the horsepower output of the piston engine increased, the size, speed and range of the airplane grew. The piston engine is best suited to speeds under 400 miles per hour and altitudes under 25,000 feet. It was the earliest type developed as an aircraft power plant and until a year ago was the only type used in commercial airline operation in the United States. The most powerful piston engine in commercial use produces about 3500 horsepower. A second milestone was passed when the turbojet engine came into being, thereby making possible a whole new concept of military airplane design. The turbojet engine is best suited to speeds above 500 miles per hour and altitudes of 40 to 55 thousand feet. Development began a little over 15 years ago but the levels of economy and dependability required for commercial operation are just being reached today, with no actual service contemplated for another three years by U. S. airline operators. A third significant milestone, though somewhat less spectacular, was reached in the last decade with the advent of the turboprop engine. The turboprop engine, consisting of a jet engine turning a propeller, is best suited to speeds between 400 and 500 miles per hour and altitudes of 20 to 40 thousand feet. The Allison T-56 turboprop engine, selected for early use by U. S. scheduled airlines, has an equivalent shaft horsepower of 3750. The fuel economy is comparable to piston engines now in use. It is lighter and offers less drag than a piston engine of the same power. The economics of the turboprop have endeared it to airline operators very early in its service life.

In discussing air transportation in the foreseeable future the three types of engines just enumerated are significant. The piston engine in one of its most powerful and advanced versions, the R 3350, is just now making its final appearance on the Douglas DC-7C and the Lockheed 1049G Constellation. These two transports are the end products of years of evolution. They are the perfections of fundamentally sound designs, initially produced years ago and steadily improved through the incorporation of technical advances and operational knowledge. They will render a very high quality, long haul service for the next five years and remain a very important segment of the transport fleet for at least five years after that. Nevertheless, they signify the end of an era. No new piston engine developments are active at this time and no new piston powered transport projects are contemplated by the leading airframe manufacturers. At this same time, two great new high speed, long range turbojet powered transport projects, the Boeing 707 and the Douglas DC-8, are just coming into full scale activity. They represent the beginning of a new era for domestic and international trunk airline operators. The availability of this equipment in quantity is several years away and its assimilation into scheduled service will be one of the significant innovations of the era which is the subject of this discussion.

The turboprop powered transport, best suited to short routes and those of medium length, has just gone into scheduled service in the United States. Oddly enough, this first fleet operated by Capital Airlines is of British manufacture, the Vickers Viscount. The most active turboprop powered airplane project in the United States at this time is the Lockheed Electra which has already been ordered in quantity by four leading U. S. airlines. In addition, the well established Convair CV-340 transport has been considered for redesign, using four Rolls-Royce Dart turboprop engines as replacements for the two Pratt and Whitney R-2800 piston engines now in service.

Since nuclear power has received a certain prominence in present day scientific and popular journals, its implications cannot be left unnoticed when cataloging the effect of prime movers on air transport design. A nine man civilian panel appointed in March 1955 to investigate the impact of the peaceful uses of atomic energy for the Joint Congressional Atomic Energy Committee has found that atomic powered aircraft will have no real impact on civil aviation in the United States for at least 15 or 20 years. The report stated that the results of the U. S. military program in this field during the next decade should give a fair basis for evaluating possibilities of commercial application. The advantages of a nuclear-powered atomic plane would be a virtually unlimited range, freedom from a system of overseas refueling airfields, and a reduction of the supply problem associated with demand for fuel stocks. It cited as the major stumbling blocks the cost, weight, radiation hazards, and technical problems of developing a light but powerful and economic reactor. Towards the end of January the Atomic Energy Commission announced that it had just begun test work on an aircraft nuclear power plant at its National Reactor Testing Station in Idaho.

Air Transportation Costs and Comparisons

Scheduled air transportation, which is of necessity a regulated industry, is nevertheless a highly competitive business. As an industry, it competes with surface transportation. Within its own medium, the various airlines compete with each other on the basis of schedules, routes and equipment. Speed has always been and will continue to be the number one commodity and the attainment of the fastest schedules is the target of all planning effort. All airlines have an equal interest in safety and all airlines would like to make money. Therefore, they are very selective in choosing equipment and show great restraint in the adoption of new innovations, in the interest of economic survival. Passenger fares have remained remarkably stable for a number of years and will continue to do so in the future both because of regulation and competition. The price of the average domestic airline ticket is only 3.7 greater than it was in 1939. The fare on domestic routes averages about 5.4 cents per mile and on international routes it averages about 6.8 cents per mile. Both domestic and international operators offer a higher density coach service which can be had for about 4.2 cents per mile on domestic routes and for 5.7 cents per mile on international routes.

This seems to be an appropriate time to point out some economics of the future. An airline operator, once he has selected his equipment, has just so many pounds of payload carrying capacity to sell on any flight and to place within the cabin confines of his airplane. By selecting seating arrangements approaching the minimum acceptable limits for an average sized person, the revenue load can be distributed over a greater number of passengers, thereby reducing each individual fare. Where an element of greater comfort or a degree of luxury is sought, a higher unit fare is required for equal revenue. This is the result of a greater space allotment for each passenger and the increased weight of the furnishings—seats, galleys, soundproofing, or any other comfort item.

Since airline fares are about 60 percent more than railroad fares for a comparable class of service and since airline fares are more than double inter-city bus fares, the airlines can be expected, in the future, to put great emphasis on the coach service. Many of the scheduled flights today are coach flights. All proposals for new equipment include high density seating versions, some throughout the entire airplane and some on a two class arrangement—part coach and part first class, with separate entrances.

Out of the total domestic common carrier passenger market, the airlines account for about 30 percent of the passenger-miles covered. A great segment of the future increase in volume will result from attracting persons now using surface transportation. This, in turn, means exploiting every means to keep fares low and to offer justifying reasons for the price differential that will probably always exist.

An examination into all segments of air transportation shows that the newest, biggest and fastest airliner in current operation is not symbolic of this nation's transport fleet. As an example, the DC-7 and the Constellation 1049 have been cited as the "queens" of the present transport fleet. Forty percent of the 1500 transport airplanes referred to at the beginning of this presentation saw service during World War II. An additional 30 percent went into service between 1946 and 1952.

The average airline trip length for each domestic passenger has been

500 miles, and for international passengers 1300 miles. There are only 10 percent as many international passengers as domestic passengers.

These last two statements have been made to focus attention on an intensive era of equipment buying which began late in 1955 and which is in full swing now and to indicate the need for the various classes of equipment suited to the travel patterns of the American people.

At the end of February, 156 pure jet transports had been ordered at a cost approaching 900 million dollars and 182 turboprop airplanes had been ordered at an approximate cost of 350 million dollars. These are the types that will be in service during the era for which traffic forecasts have already been presented. Obviously, this is only the beginning of a large equipment replacement program. A few comments might be of interest here.

In the long haul category, the Douglas DC-8 four jet transport weighs about twice as much as its immediate predecessor the Douglas DC-7C. Its cruising speed of 586 miles per hour is over one and one-half times as fast as the DC-7C. The take-off distance run for the two planes is the same. The DC-8 has a payload of 34,000 pounds compared to 21,000 pounds for the DC-7. It can carry 118 to 144 passengers against 62 for the DC-7C. This sounds like a comparison of the "new" with the "old." In this case, the "old," of which over 80 have been ordered, will have an initial delivery next June, while the "new," still a paper airplane, won't have any deliveries until mid-1959.

As a general comment regarding Douglas designed airplanes, which have been used by airlines more than those of any other plane manufacturer, the DC-3 first introduced in 1936, cruised at 180 miles per hour, the DC-4 at 230, the DC-6 at 310 and the DC-7 at 360. In 20 years of airliner evolution, the cruising speed doubled. A new type power plant will now triple the 180 mph speed in just three more years.

A competitor to the DC-8, the Boeing 707, of which the Boeing Airplane Company has airline orders for 70, is comparable in performance and appearance, but is no paper airplane. It has been developed over a period of years as a military tanker and transport. It has accumulated many hours of test time since July 1954, and is in production now for the Air Force with airline deliveries beginning late in 1958. The existence and simultaneous use of the 707 and DC-8 will probably hasten the accumulation of operational data for determining the suitability of the jet plane as an airliner.

A statement showing the inter-play between speed and economic restraint was recently made by Mr. W. A. Patterson, President of United Airlines. "Airlines planning future jet transport operation can look forward to something new in equipment stability," Patterson predicted. He forecast that a jet "may be a 15 or 20 year airplane—but conservatively, a 15 year airplane. Heretofore, we have been fighting obsolescence. The engineering, technical and scientific developments have been such that our airplanes have become obsolete as a result of improvement. I think and believe that anyone who will analyze this carefully will realize that the jet will not become as obsolete as quickly as airplanes in the past." Explaining the change, Patterson pointed out that the reason for past obsolescence has been speed, but that now both Boeing and Douglas transports have come up to the barrier of sound. ". . . I do not believe there is anyone in the industry today who is going to worry about penetrating the barrier of sound commercially . . . it certainly is necessary in the military, but the economics of going through the barrier . . . to give you that added speed is something that no industry could stand financially, economically, and survive."

A third significant new airplane is the turboprop powered Lockheed Electra. One hundred and three have been ordered with deliveries beginning in August 1958. It will carry from 66 to 91 passengers, cruise at 410 miles per hour at 25,000 feet and require a 5000 foot runway for landing and take-off. While still an airplane of the future, it is supposed to have great flexibility in performance making it a possible successor to a number of different types of airline planes now in operation. Lockheed gained experience in turboprop airplanes in the military cargo field with the four engined C-130 which is undergoing flight evaluation and is in production at this time.

There will be no effort made to predict what design features will be incorporated in the yet-to-be produced airline transports that will follow the ones just described. Through extensive research, some important economic factors have been established. They are certain to be used as guides in the foreseeable future and are mentioned here as being more dependable indications of future design trends than any attempted descriptions of particular airplanes. These predictions, as published in the March 1955 issue of the SAE Journal, page 17, are restated as follows:

1. Large airplanes have lower direct operating cost per ton-mile than small airplanes. And, their range can be varied with less adverse affect on cost per ton-mile and lifting capacity.
2. Turboprop engines give lower direct operating cost per ton-mile than reciprocating or turbojet engines for any combination of design, payload and range.
3. The cruising speed which gives the lowest direct operating cost per ton-mile depends on the type of engine, but is independent of payload and range.
4. Selection of a preferred airplane must consider the cost of a fleet

of airplanes to do the total logistical job, rather than the cost of one airplane to do one payload-range job well.

This article gives the following additional information used by designers to achieve a maximum airlift capacity at the lowest direct operating cost per ton-mile.

The direct operating cost per ton-mile can be expressed as a Cost Index.

$$\text{Cost Index} = \frac{\text{Direct operating cost}}{\text{Block Speed x Payload}}$$

Direct operating costs include fuel, oil, flight and maintenance crew time, initial cost of aircraft and spare parts actually used by the plane.

Block speed is an average speed in knots obtained from dividing the distance traveled by the time elapsed between starting and stopping the engines.

Payload is the maximum tons that can be carried for the particular range.

Non-Scheduled Flying

This discussion has covered the existing elements of scheduled air transportation and projected them ten years ahead. It is not to be presumed that this service, either now or in the future, is completely adequate to meet all the transportation requirements for which air travel, because of its speed, has been selected. Two other segments are mentioned here because the magnitude and vitality exhibited by each is sufficient to indicate a continued existence and reasonable rate of growth in the next ten years.

The first segment in the non-scheduled air transportation group is the fleet of airplanes owned by business corporations. They are operated to suit the needs of executives and to serve the patterns of travel most advantageous to company interest. Surprisingly enough, the fleet of business owned aircraft has grown to 22,000 of which 2,500 are multi-engined. In numbers, this fleet is 17 times as big as the scheduled airline fleet and flies more airplane miles per year than the scheduled airlines do. In 1955, flying businessmen bought 4434 airplanes worth 91 million dollars, a 60 percent increase over 1954. The Civil Aeronautics Administration has predicted a very bright future for the business corporation fleet.

The second segment in the non-scheduled air transportation group is the "Non-Scheds" themselves. They are the cut-rate operators of the industry. They are prevented by law from advertising regular daily schedules. Their service is limited to the high density, coach types. There are at least

30 different companies in this group, organized into the Aircoach Transport Association (ACTA). Their aggressive business methods, including the securing of numerous military contracts, have brought them a fair share of the air transportation market. While regarded as undesirable and irresponsible competition by the scheduled airlines, they were able, nevertheless, to gain business stature and the elements of permanency when in 1955 the Civil Aeronautics Board handed down its ruling which labeled them as "supplemental air carriers" and found that they filled an important need for periodic travel demands beyond the capacity of the scheduled airlines.

Current Transportation Problems

As the evolution of air transportation moves from one era to the next, many of the circumstances surrounding airplane operation change. Sometimes these changes eliminate existing problems and sometimes they create new ones. A few items are mentioned here as a sampling of some of the conditions that are developing and to which serious attention is and must continue to be given in the years ahead.

The first is the increasing air traffic congestion with the development of potentially hazardous conditions on the airways and in the vicinity of airports.

The second relates to airport size for those terminals for which turbojet operation is contemplated in the next few years.

The third is noise, a nuisance that is increasing rapidly as engine power becomes greater and as the frequency of operation grows.

A fourth item is the relative absurdity of faster airline schedules wherein the gains are partially nullified by the surface transportation times at both ends, caused by traffic congestion and the increasing distances of newer airports from city centers.

These problems and many others are not being allowed to develop in intensity without vigorous efforts towards solutions. Some sampling on constructive effort is offered here to illustrate the awareness and aggressiveness that exists and is being applied towards fully exploiting the benefits of air transportation.

President Eisenhower has recently appointed and sworn in a special assistant for aviation facilities. His responsibilities are threefold: (1) the direction and coordination of a long range study of aviation facility requirements, (2) the development of a comprehensive plan for meeting these needs in the most effective and economical manner and (3) the formation of legislative, organization, administrative and budgetary recommendations to meet this plan.

In the matter of research, both private industry and the federal government are seeking new scientific knowledge at a rate never before attempted. In private industry, as an example, in the year 1953, 3.7 billion dollars were spent on research. This included 758 million spent by the aircraft industry and 778 million spent by the electrical equipment industry. These two industries led all others in research. Electrical equipment is, in part, closely allied to aircraft, examples of interest being development of navigation and control systems, airborne radar storm warning systems and radio communication systems. Aircraft research, of interest to transport development, includes investigating boundary layer control, a method of reducing the skin friction drag on a wing, thereby gaining a reduction in take-off, climb and landing speeds with consequent reductions in landing and take-off distances. Another item, reverse thrust, now obtainable on propeller driven airplanes, is being evaluated for future use on jet powered airliners to reduce the landing roll and to spare the wheel brake system. A still more interesting comment within the field of research concerns the use of statistical methods in predicting risks for removing the guessing out of engineering in the continual fight for greater safety.

These are only a few samples of research programs, mentioned because they are illustrative and timely.

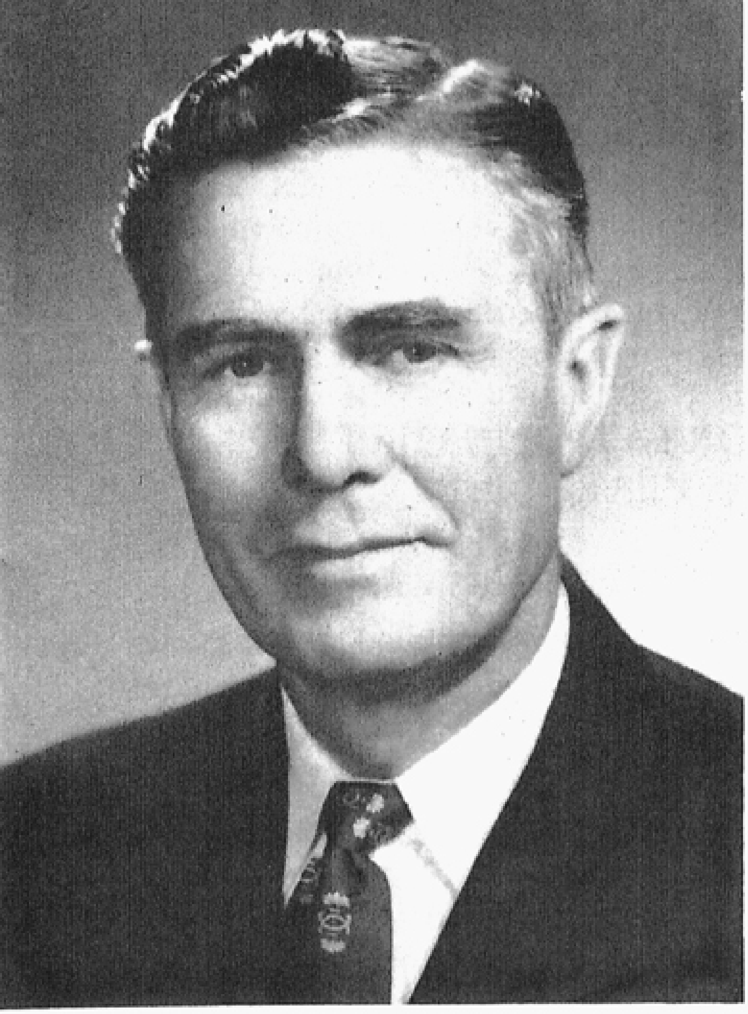
A discussion of this sort should not go much farther without acknowledging the potentials of the helicopter in the field of short haul transportation. Expansion in this field represents the possibility of a much greater market than in the long haul field. Even though helicopter speeds are not likely to exceed 150 miles per hour for some years to come, it is generally accepted that for distances of 40 to 175 miles helicopter service between city centers can better the sum of airplane flight time plus airport transit time. Furthermore, smaller communities without airports would not be penalized, although it is recognized that specifically designed air stop facilities are required and the helicopter operators must be allotted their own air channels, with their own unique landing and take-off procedures. Experience to date with airport shuttle service and mail pick-up operation in the New York, Chicago and Los Angeles areas has indicated a sound future for scheduled helicopter operators assuming that a federal policy is established to extend to them liberal financial aid similar to the assistance given trunk airlines in their early years.

In order for air transportation to be a successfully operated service there are many conditions to be met besides the mechanical perfection of the equipment. Mountains, oceans and political boundaries are crossed with equal facility. However, in doing business around the world, with the implied reciprocal obligations, there are many areas of agreement to be established to safeguard the advantages of air travel from nullification by customs officials, quarantines, monetary exchange and other frontier rulings. The International Civil Aviation Organization serves as guardian of the interests of the 65 member nations which control the activities of almost 95 percent of all international airlines. ICAO was born at an international conference at Chicago in 1944. It was established to make sure that airline operations in practically all parts of the globe would be uniform and, because of this, safe. Through the past decade ICAO has concentrated on what is known as "facilitation." As the parliament of the air age, it has fought to simplify the passage of people and goods across the myriad frontiers of the world. The responsibilities and achievements of ICAO could well be the biggest single factor in shaping the future of international air transportation.

Generally, there are three theories about the future of scheduled transportation. The first assumes the market to be a pie which is sliced up and divided among busses, railroads, steamship lines and airlines. A bigger slice for any particular form is won at the expense of the other segments. The second theory superimposes the compressing effect that the private automobile is having on the bus, railroad and airline common carrier market. Excluding trips of less than 50 miles, the private automobile prior to World War II was used for 73 percent of the entire inter-city passenger travel market. By 1954, the automobile accounted for 88 percent of the inter-city travel passenger-miles. The last theory assumes that new forms of transportation generate their own markets and will come into being and prosper in direct proportion to the service rendered.

The rapid changes to which the aviation industry has become accustomed have had a restraining effect on long range predictions. With the present research intensity, no desire exists for projecting air transportation as far into the future as may seem reasonable for other mediums of travel. Before too many years of the next century have passed, the design impact of nuclear power plants is certain to be felt. The engineering and operational manifestations are not defined and cannot be discussed seriously at this time.

In making a single prediction on the future of air transportation, I would limit it to an endorsement of faith in the activities which have already been described, those of research, development, private enterprise and the spirit of cooperation. In combination they have demonstrated a capacity for supplying the equipment and service to take care of our ever changing needs.



HIGHWAY TRANSPORTATION FOR THE NEXT 100 YEARS

by

Rex M. Whitton

REX M. WHITTON, a native of Jackson County, Missouri, received a degree in civil engineering from the University of Missouri.

Mr. Whitton began his long tenure of service with the Missouri State Highway Department in 1920, and has been with the department since that time. He has advanced through all phases of highway engineering to his present position as chief engineer for the Missouri State Highway Commission. In this position, he is responsible for the planning, construction, and maintenance of the highway transportation system of Missouri.

He has been an active member of the American Association of State Highway Officials and has served as chairman of several important committees. At present, he is president of the organization for Region 5. He has long been active in the American Road Builders Association and this year he is a member of the Committee on Express Highways.

HIGHWAY TRANSPORTATION FOR THE NEXT 100 YEARS

REX M. WHITTON

Highway transportation for the next 100 years? Frankly, I do not know the answer for the next 100 years. In fact, I am having difficulty determining the needs for today. One thing is certain though, the type of highways during the next 100 years will be directly controlled by the new developments in the vehicle.

Certainly no one can deny that the vehicle is and has been the controlling factor in the development of the highway. A study of history reveals this back from the earliest times.

A man carrying his food on his back to his shelter was probably the first mode of transportation. As he continued this operation it is probable that the first normal trail was established. Man then discovered the travois and sled, which was followed by the discovery of the wheel and the axle. He then found that to use these new inventions successfully he had to have a road or highway. Thru the years, as the vehicle has improved, improvements in the highways have come about. It has been true continuously that the vehicle has been improved faster than the highway over which it speeds.

In order to have some semblance of accuracy in the prediction of highway transportation for the next 100 years, it seems that a look into the past to study the development of highway transportation would be of benefit.

It is fairly well established that the first constructed roads were built in southwest Asia. The Romans are recognized as the first scientific road builders. A classic example of their work is the world-renowned Appian Way, construction of which began in 312 B.C.

The oldest long distance highway on record is the Royal Road, which reached 1755 miles across southwest Asia and Asia Minor, between the Persian Gulf and the Mediterranean Sea. Over its beaten path were transmitted discoveries which have made civilization possible—invention of the wheel and axle, domestication of the horse, the true arch later used in bridges, possibly the first pavements, discovery of silver.

Incidentally, this road may also have had the first limited access feature, which is becoming so popular and necessary in today's elimination of traffic congestion. It passed through Nineveh, the residence of the King of Assyria, and his last instructions were that any person whose property encroached upon the road's right of way as it passed thru the main street of his city, be put to death by impalement upon a pole erected in front of his home.

The longest road on earth, in its zenith in the second century, crossed Europe and Asia and joined the Atlantic and Pacific Oceans. It began in Spain and terminated in China. It was more than 8,000 miles in length and reached an altitude of 14,000 feet.

The queen of them all, though, was the Appian Way, which must be labeled the most famous road ever built. It was one of 29 great military roads radiating from Rome which totaled approximately 50,000 miles in length and is still in use today.

The fall of Rome in the 11th century brought a setback to roads. Thereafter for many years travel was restricted to pedestrian movement and riding. Also, the secret of natural cement was lost with Rome's fall and was not rediscovered again until the 18th century.

The 12th century, with its population increases, brought some renewed interest in roads and an order from King Henry I of England that all highways be broad enough for two wagons to pass or for 16 soldiers to ride abreast. The first stone bridge also was built across the Thames.

The 17th and 18th century brought the toll road idea, with tolls collected to build turnpikes. The father of the modern roadbuilders entered the picture in the 18th century—Jerome Tresaguet, in France. He advanced the idea of lighter pavements and crowned subgrades, along with emphasizing the need for continuous organized maintenance, instead of intermittent repair, to keep roads in condition at all seasons of the year.

John Metcalf, an early English roadbuilder, expanded the use of gravel surfaces, while Thomas Telford, another Englishman, was noted for his promotion of the need for proper drainage. John London McAdam was another early authority on roads, with his strength being in promotion of drained and compacted subgrades to support the load upon the road, and with stone to act as the wearing surface.

Moving to our own country, the first permanent white settlement in the present territorial limits of the United States was St. Augustine, Florida, and it served as the parent hub for our first roads. The first road built by white men in Florida joined the original crude wood fort with Fort Caroline, about 40 miles to the north, in 1560.

The first bridge was at James Towne Island, Virginia, in 1611. However, it wasn't an actual bridge but was about 200 feet of wharf extending from the river bank to water deep enough to provide docking facilities.

A town in Maine had the first paving (cobblestone) before 1625. The Boston Post Road, 1873, was the first road over which colonial mail was carried; the Philadelphia to Lancaster Turnpike was the first long distance stretch of broken stone and gravel surface in this country —completed in 1795.

The first macadam surfaced highway in this country was laid in 1823, between Hagerstown and Boonsboro, Maryland.

The next advancement that should be noted probably was the erection of the first iron bridge in this country in 1839 at Brownsville, Pennsylvania. A steam roller was introduced in 1869, the bicycle in 1889, the first state aid road was built in New Jersey in 1892, and the first U. S. automobile was introduced in 1893.

That year, 1893, brought two other developments in highway history worthy of note —the establishment of the U. S. Office of Road Inquiry, which has evoluted into the Bureau of Public Roads, which has had much to do with developing our present national highway system, and laying of the first brick surface road in this country on Wooster Pike, near Cleveland, Ohio.

The year 1898 brought us the first dust palliatives, when California experimented in the use of crude oil for that purpose. The Bureau of Public Roads conducted tests in 1905 of coal tar and crude oil as road surfaces, and the first such road was built in 1906 in Rhode Island.

The first portland cement concrete used on a public rural road was laid in Wayne County in 1909.

The federal government did not get into federal aid for highways until 1916, with the passage of the Federal Aid Act of that year. The first road built with federal aid then was laid in California in 1918. Two years later, 1920, when the number of vehicles had increased from the first one in 1893 to slightly under ten million in 1920, the demands upon the highways were becoming so heavy and the highways themselves were so inadequate that a nation-wide program of highway research in large scale proportions was inaugurated by the American Association of State Highway Officials. It might well be said that our modern highway system dates from the beginning of those experiments.

Some of you know as eye witnesses, much of the history of our highway system since that date. You no doubt remember the old dirt roads—in fact, some of them still remain; the first gravel laid in your community; the oil surfacing of streets and rural roads to control dust. You probably remember paving of the streets in your home community, and possibly the first pavement on a rural road in your area—likely 9 feet wide, and the growing use of bituminous surfaces.

The years since 1920 have seen highway transportation demands soar, soar and soar. With the increase in speed and the size of the motor vehicle our highways have expanded from the early day 12 feet wide roads to 18 feet, to 20 feet, to 22 feet, to 24 feet and to divided, multi-lane highways.

That interim sees us doing much research and experiment to better fit highways to traffic demands. More concrete is used in bridge structures, precast bridges have come into being, we're experimenting with pre-stressed concrete, thinner slabs, even experimenting in some states with rubber surfaces. We have turned to intricate traffic interchanges and grade separations, sometimes multi-level. Limited access on the major highways is becoming the rule rather than the exception.

The result has been that today we realize more than ever before the great need for an expanded and improved highway system across the United States; yes, even world wide. Here the great desire of the people to move from place to place and obtain the goods grown or manufactured in all parts of the world as soon as possible has created a demand for highway transportation that was unbelievable twenty short years ago. The total number of vehicles in the United States today numbers approximately 61 millions. It is predicted the number will be 81 millions by 1965 and 100 millions in a decade after that. So, the prediction for the future in highway transportation must be based on the aforementioned historical facts.

Still other factors stand out as we consider the future. Our highway transportation must, and I repeat the *must*, be made more safe. Also, our people desire it to be even more convenient and, if the past is any criterion, more swift.

Thus, it does not take too much foresight to predict that, within the next 15 or 20 years, the major highways or interstate highways of our nation will become divided lanes in order to separate the opposing lanes of traffic, and will have the access completely controlled so there will be no cross traffic and no stop signs or stop lights from coast to coast.

These freeways will pass through our cities from large to small, as well as around, thus affording the highway user the option of either going into or through the city, or passing around it.

Looking closer, those freeways no doubt will be lighted for their entire length. They will be always free of ice or snow, being so designed and so constructed that snow and ice will melt either as it falls toward them or at least upon contact. More than likely pedestrians not only will not be permitted to walk upon the pavement they also will be prohibited on the right of ways.

But those things are only a few short years ahead. We must look still further into the future—a hundred years hence. When we do that we can be sure that the vehicle which has directed the way in the past will have much to do with charting our course in the future. Automation appears to be the watchword. We must let ourselves go, we must be visionary.

It seems not unlikely that within a hundred year period we will come to vehicles completely controlled by mechanical, electronic or other yet to be invented automatic methods. Most likely they will travel either on the highway or through the air. Such being the case, most certainly we will have highways fitted to the needs of such vehicles.

The result? You will get into your vehicle at your home, punch your destination on its keyboard. If it is a land cruiser it will carry you automatically to the nearest electronic, or other power, controlled freeway, then on to your designated turnout. Electronic, or some other type power, installations will control the speed of your vehicle, as well as prevent collisions of any type. The controlled lanes of travel will, no doubt, be paralleled by normal highways to serve local traffic, with entrance from them to the controlled routes being only at established points.

If your vehicle is an airmobile, perhaps it will take off straight up, as you punch your destination on its keyboard, as does today's helicopter, and then zip you, at an assigned, safe flight level, to your directed point, with a vertical landing. Again, it may be the combination type. First you may be carried automatically to the controlled freeway, or even to a normal highway, then turn out to the airstrip, which will be a part of highway design. You'll then push the button on the keyboard to move wings into place, and take off through the crowded airways.

It is also within the realm of reason, even, that your vehicle and your highway's controls will be so highly automatic that you may even sleep or nap safely when driving. Perhaps you would be enroute to Kansas City and be asleep on reaching there. The controls on your vehicle's keyboard, tuned to the highway's automatic devices, would carry you to a parking lot where you could finish your nap. Again, if you were awake, you would simply switch the controls to manual operation and drive where you choose.

Again, perhaps you are on a cross-country tour. You will have no work or worry about driving your car. All you will do will be punch the destination on the keyboard for your morning or day's drive, then sit back and enjoy the scenery, a card game, the conversation or a nap. The highway and your vehicle will do the rest, with the vehicle signalling you anytime it may need fuel or other attention. Speeds of 150 miles per hour will be common.

Let's not overlook, too, a round-the-world trip. I'm just as confident as I can be that within the next 100 years we will have at least one highway, probably more, encircling the globe. I won't hazard a guess here as to just how automatic they will be, let's just keep guessing at that a while longer.

Skeptical? Don't be. More than likely I haven't even gone far enough in picturing highways a hundred years from now. We already have power steering and power brakes on our vehicles. These are part of an overall development on the automatic pilot or automatic driving that most certainly will be a part of our future vehicles just as soon as enough modern freeways have been built. Even now the radar automatic brake is about ready for use, and will reduce rear end type collisions.

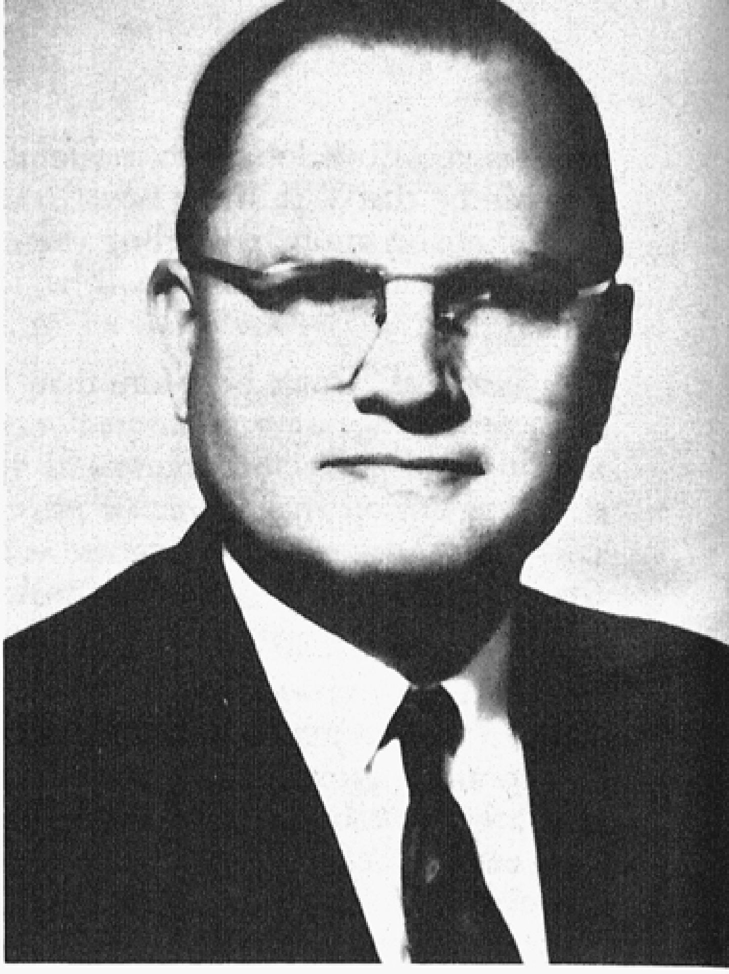
Let's not overlook the fact, too, that in recent years automobile manufacturers have put nuclear physicists in high places in their companies and continuing experiments are being made on atomic propulsion. Work also is being done on turbine engines, using lower grade fuels, with some such engines being driven on roads and streets even now. Atomic powered vehicles will follow the turbojet car; and certainly in the next century we will have a hot debate on whether the highway bridge between New York and London shall be a free bridge or a toll bridge

There you have my prediction for future highway transportation! I see no end to its use in our civilization. I do predict a leveling off of the present increase in the number of vehicles —approaching more nearly the number of our adult population. After that the vehicle increase should follow very closely to the population increase. Highway transportation in the future must be made safer. This will be accomplished by better engineering and better education of the driver.

RAILROADING IN 2056

by

W. M. Keller



W. M. Keller, a native of Pittsburgh, Pa., studied engineering at the University of Pittsburgh and completed the course in Mechanical Engineering at Pennsylvania State University Extension School. He later took additional courses at the University of Pennsylvania and Temple University.

From 1919 through 1951, Mr. Keller was employed by the Pennsylvania Railroad. Beginning as a machinist apprentice, he later served in a number of different capacities including that of assistant mechanical engineer in charge of research.

In 1952, he was appointed director of mechanical research for the American Association of Railroads in charge of, and responsible for, all research activities of the association's mechanical division. In 1955, Mr. Keller was promoted to executive vice chairman and director of research where he has been in charge of the design of railroad equipment.

Mr. Keller holds a number of patents on railroad trucks, journal bearings, car stabilizers, and car designs.

RAILROADING IN 2056

W. M. KELLER

It is easier to view the past than to anticipate the future. To look at the past, one need only refer to historical writings to determine what occurred. What, in the case of political history, the historian thought occurred, did not always take place. The contemporary historian builds a full structural story upon a meager framework of fact. If the contemporary can look back and reconstruct, by what logic is he denied the right to look ahead and construct.

Nostradamus not only looked into the future, he wrote his prophesies in rhyme. Born in 1503 he predicted many things. Being a wise man he confined himself to generalities. Being too specific invites contradiction. Perhaps the poetry of his writing compensated for lack of specific detail. But generalities are not interesting in prose, and those who are willing to risk being proven wrong by events can complacently predict what may happen in the future.

The suggestion of ideas contained in predictions may spur men to accomplish in fact the dream of the prophet. Perhaps Dick Tracy's wrist radio is the mental stimulus that perfected the transistor. It would be appropriate at an institution of higher learning such as this, if some imaginative predictions stirred the minds of men to revolutionize transportation by rail. The pragmatic requirements of the use of truth, to which the University is dedicated, dictate that pronouncements made in its atmosphere serve some practical purpose. It is therefore suggested that what is imagined as a possible improvement in transportation may provide the germ of substantial accomplishment for the future. At the same time it would be idle to suppose that the imagination of today is adequate to foresee all of the developments of tomorrow. The changes of the next 100 years may surpass the most vivid imagination we bring to bear today. Few minds could have imagined 100 years ago the technological progress attained today. To have given a recitation of today's accomplishments a century ago would have branded the prophet as an unrealistic dreamer, who, for his own well being, should be watched with suspicion. In this attitude lies the contemporary pitfall of looking too far ahead.

The two principal divisions in transportation service are the relocation of man's goods and his own movement. These two categories of transportation are designated as freight and passenger traffic, and appear to offer such clear definition as to be understood without explanation. Man has less interest in the shipment of his goods than the movement of his person. In passenger traffic the experience of the patron is very personal. In freight traffic the ultimate transportation user frequently does not know his products were moved by rail. In all the current discussions of interplanetary travel one hears only of passenger traffic. If the idea of bringing needed minerals or products from other planets to the earth has been expressed before it has not been widely circulated. A trip to the moon is currently described as a sightseeing adventure, and a personal experience with more the aura of the carnival than any practical necessity of interplanetary traffic. Thus it may be said that passenger traffic is more exciting than the movement of goods.

The field of railroading represents a transportation medium about 100 years of age, and we have already experienced phenomenal improvement. It can be said that the railroads have progressed from wood burners to Diesels, from wood to metal cars, and from austerity to luxury for travelers. Perhaps the latter is summed up in an expression used by the Association of American Railroads which is "Take It Easy—Take the Train." This paper cannot therefore be considered an apology for the theme that railroad progress has been slow, but rather a thesis on the unabated march of rail transportation improvement. Why, one may inquire , should railroads exist at all in another century? Will we not have enough highways and air transportation to suffice the needs of the 400 million Americans who will then inhabit the United States? Shall we not have learned how to broadcast electrical energy over the air to light, heat or cool homes and hence will not need to ship coal? Similar changes could be cited to show that rail transportation would be obsolete in another century, but this is negative thinking and we must apply a positive approach to our predictions.

We must face the unpleasant fact that fuel is being depleted. We have no way of creating fuel to replace what has been used. Per capita fuel consumption continues to increase steadily and as the world population increases economics will become increasingly necessary. On level tangent track a gross ton can be moved on a railroad at a total resistance of about 5 lb. at a speed of 10 mph. Now let us see what this means in equated terms for a highway truck. Assuming a 10-ton truck, this would equate to 50 lb. total resistance. Now, at 10 mph, or 14.67 ft. per sec., this power rate becomes about 1½ horsepower. Can you visualize a 10-ton truck with a motor of this size? The need for greater power is present as the motor truck does not have steel wheels on steel rails. Freight trains generally require one horsepower per ton but with favorable grades sometimes only about one-half horsepower per ton is used. Therefore, fuel efficiency alone will be sufficient cause to keep the railroads here for our great-grandchildren. Having thus the provided assurance in this simple illustration that railroads will continue to be necessary to our National welfare let us now look ahead.

Some of the items presented here as a possibility will occur to you as a reality now possible. It should be remembered that necessity and economics dictate or control many changes. Economics control the extent to which Cadillacs, color television and yachts are used. These luxuries are a definite reality but in limited use, not because they are not popular but because they are not economically available to all. So it is with railroads. Railroads can only provide what services can be afforded by the shipper and traveler.

Discussing first what awaits those on the scene in 2056 let us consider first the passenger. He will probably make his travel reservation by dialing RR on the telephone. Since this will be a special coded phone number it will connect his line to a special electronic brain. He will then dial the letters of the railroad, towns between which he desires to travel and the date of departure, thus, SF—CHI—LA—5-17, which tells the electronic brain he desires to use the Santa Fe between Chicago and Los Angeles on May 17th. He then dials the train number, and reservation desired, thus, 17—Ro, which indicates he will travel on train 17 the Super Chief, in a roomette. Then he dials his own telephone number. When the electronic brain sorts all this information and studies the space available it will arrange his reservation, print a bill for the cost, and automatically telephone back a coded message telling him his reservation may be picked up at a central office. If he telephones four days or more before departure date he will receive his reservation by mail. Instructions for making train reservations will be listed in the telephone directory.

Just as passenger trains are infinitely quieter now than they were 100 years ago, in the future car interiors will be noiseless. Insulation and sound isolation methods will reduce sound to about the level of your living room if you live in the suburbs and don't have the radio or TV in operation. The ride will be unaccompanied by shocks and jolts. Stabilizers and a centrifugal neutralizer will provide the same ride comfort on curves as on tangent track. Travel time will be reduced because of increased speed. Television lounges as well as the present practice of having a radio in ments of the nation make it imperative that adequate and effective coordi- luxe trains will be continued. These features will entertain those who are not interested in watching the scenery.

Passenger Terminals—Suburban living is increasing and commuter service offers the fastest transportation from home to work. On the other hand, intercity passenger business has been on the decline since 1920. With increasing congestion of vehicular traffic in cities, there is an increasing necessity for comprehensive rearrangement of passenger terminals to provide expedited commuter and intercity transportation. The tremendous construction costs involved in large scale track rearrangements and provision of suitable station buildings is more than passenger traffic can bear. Such costs can and should be participated in by the cities as a part of providing the necessary passenger transportation for its residents. In crowded centers it must be remembered that 700 people can be transported in a train 800 ft. long. With two people per automobile this number of passengers would require 350 cars. With automobiles 16 ft. long and 30 ft. between each car this is a line of cars over 3 miles long. The importance of train transportation is therefore evident even when the parking problem is not considered.

Locomotives will be powered by atomic fuel. They will be equipped with every safety device necessary for safe travel. We now have train telephones where locomotive crews can talk with wayside interlocking towers, as well as other train crews. The locomotive crew can now talk to the train crew at the rear of the train but in another century communication will be further improved. Probably the proper electronic brain will supersede the human crew in the locomotive cab. Controlled by the proper signals and safeguards this change is foreseeable. The New Haven Railroad has in 1955 operated a train by remote control with no one at the controls. The Pennsylvania Railroad has installed an automatic control on some of its trains which will apply the brakes if the crew disregards adverse signals. The familiar wayside signal seems destined to disappear. Cab signals show in miniature the same aspect as the wayside signal. There is really no essential need for both. The cab signal was developed to enable enginemen to "see" through fog. Before he could see the wayside signal he was able to glance at the cab signal and know what aspect the next wayside signal would display, so that fog, smoke or other visibility barriers were overcome.

Considering the changes in freight traffic perhaps car equipment is of primary interest. Smoother riding cars with greatly improved draft gears will be in use. Speeds will be increasd. Overnight freight trains are now being operated between the large cities where they are about 500 miles apart. Pittsburgh to Chicago and Buffalo to New York are examples of present day overnight freight service.

Freight cars will be lighter and require infrequent repairs. Journal bearings will be of such design that the expression "hot box" will disappear from railroad vocabulary. Freight car brakes will be improved. Car interiors will be improved to prevent lading damage.

Freight Terminals—The advantages and economics of expedited shipping time for freight and the economies that can be effected in the amount of freight equipment required place great emphasis on the desirability of eliminating freight train terminal delays which now constitute such a large part of freight travel time. It seems quite likely within 100 years that principal terminal areas will have receiving and departure yards located to give substantially less delay in getting to and from the roads that now exist. In addition, belt or loop terminal lines will no doubt be established so that the interchange of freight cars between roads and to shippers within terminal areas will be very greatly expedited.

Rail Highway Coordination—The increasing transportation requirements of the nation make it imperative that adequate and effective coordination of the advantages of the highway for pickup and delivery and of the railroad for intercity movement be adequately coordinated and utilized. The present interest and emphasis on the so-called piggyback movement is an important step in this direction. It seems quite likely that within another century the major portion of intercity hauling, especially between cities located 100 or more miles apart, will be effected largely by rail, utilizing highways for the pickup and delivery at each end. Perhaps the medium used will be the piggyback system. A road rail type freight car unit of about 10 tons capacity likely will be developed that can be handled in trains on the rail and picked up and delivered by tractor units at terminals. Units of this type will become economical and feasible with electronically controlled train operation, eliminating the necessity and expense of train crews for each train movement. Perhaps even a monorail system may be employed utilizing the right-of-way along side existing track for the monorail support and developing a type of truck body unit that can be hauled behind tractors on the highways and transported on the monorail with overhead wheels located on top of the truck body at each end. With such an arrangement, ramps could be utilized to lower or raise the truck body on or off the monorail. In any event, it seems quite certain that within the next century a well coordinated rail-highway system will be in use.

Roadway and Structures—The difficulties involved in maintaining transportation of the nation's requirements while effecting a radical change in the general character of the roadway throughout the nation, from a practical standpoint, are almost insurmountable. It does not appear that there will be any radical changes in the rail section that is used in tracks other than improvements in the design of the cross section and in its metallurgy. No doubt, continuous welded rail will be in quite general use. Perhaps the treated wood cross tie, which has given such good service performance and has a life on the average of some 25 to 30 years, may be supplanted by a synthetic or plastic tie that will have even longer life and good insulating and impact absorbing properties, yet without the disadvantages of checking, splitting and mechanical abrasion that are associated with the treated wood tie. It may even be possible that a radically different type of rail support will come into use consisting perhaps of longitudinal T-beams supporting the rail and resting on asphalt ballasted roadways with track surfacing to be effected by pumping material under the T-beams, rather than the conventional ballast tampering proceduce now used. In any event it is quite certain that hand work in railway and track maintenance will be almost entirely supplanted by mechanized processes toward which end such amazing steps and accomplishments have already been effected. Roadway vegetation growth will be entirely controlled by chemicals, and roadbed will be stabilized so that difficulties with adverse ground conditions in localized areas will be a thing of the past, including slides in cuts and along mountainous country.

Inasmuch as the life of bridge structures is on the order of 100 years it does not appear likely that there will be radical changes in the overall outlook in the next century. Changes to be anticipated are the welding of joints to eliminate riveting and bolting and the use of steel having corrosion resistance that will eliminate the expense of painting. Development of specialized automatic welding machines will be required to make welded structures economical and the development of some type of protective cladding rolled on as the steel is rolled will no doubt be required to economically eliminate the requirements for painting. Neither of these appear to be so remote from solution that they could not be attainable within a 100-year period.

It seems almost certain that within the next 100 years there will be virtually complete elimination of highway grade crossings, especially on main trunk lines. Requirements for handling the greater volume of traffic, elimination of grade crossing accidents, and advantages to the cities and towns dictate this.

To increase the efficiency and improve railroad service as best fits the needs and desires of the public, certain barriers will have to be faced with a realistic outlook. Government regulation of railroads should be reduced. Railroads do not have a monopoly on transportation, but they face the same regulation that was in effect when there was very little competitive transportation. Subsidy of transportation competing with railroads should be stopped or the railroads should receive the same type of subsidy. Perhaps an enlightened public will begin to form opinions which will require that corrective steps be taken to equalize the effect of subsidies and regulation. Those who are anxious to see progress on railroads are hopeful that this will happen before we proceed very far into the next century. It is essential that each type of transportation performs the services to which it is best suited. I do not believe any inquiring minds will take exception to this theory. However, when it is not followed, the cost of transportation increases. The shipper and traveler may not be aware of the increased cost because some of it is in his tax bill.

Perhaps the greatest need in 2056 will be for clear thinkers who demand that every service be made to pay its own way. Subsidies may be needed to nurture a feeble industry which is essential to the nation's welfare, but when the industry is well established and becomes fully developed the premise upon which subsidy was established must be reconsidered in a new light.

THE NATION'S INLAND WATERWAY SYSTEM

by

Brig. Gen. W. E. Potter

BRIGADIER GENERAL W. E. POTTER, a native of Wisconsin, is a graduate of West Point and received a B.S. degree in Civil Engineering from the Massachusetts Institute of Technology.

He was assigned as division engineer, Missouri River Division, U. S. Army Corps of Engineers, in July, 1952. He has responsibility for a large-scale river development and military construction program in the Missouri Basin. This is his second tour of duty in the basin, the first being when he served as Kansas City district engineer. It was during this period that construction on the flood control and water resources development program was initiated. The Corps' part of the program is now approximately 42 per cent completed.

General Potter is now serving his second term as chairman of the Missouri Basin Inter-Agency Committee which coordinates the work of the Federal and State agencies in the basin water resources program, one of the largest ever undertaken in history.

THE NATION'S INLAND WATERWAY SYSTEM

Brig. Gen. W. E. Potter

It requires something less than a profound knowledge of modern civilization to recognize that transportation is the life blood of a nation. And even the casual reader of history is aware that the great empires of the world were built upon trade routes, both land and water. Ancient Athens, Rome and Carthage are exemplifications of this fact.

Thus, our discussions here today concern a fundamentally challenging subject, one which profoundly affects our human relations, our national security, our economic growth and stability, and our continued striving toward a better way of life. The advancements of science and industry have contributed much toward making America great. It must be obvious, also, that our transportation system must advance in development just as we develop new techniques of production in our factories and industrial plants. Transportation cannot be a static thing; it must be dynamic in an America rapidly heading toward a population of 200 million people. Diversification of transportation is as inevitable as decentralization of industry.

As a general premise, these basic principles probably are acceptable to all of us involved in this panel program. But the highly competitive nature of the free enterprise system which has made the nation great, gives rise to inevitable conflicts of interest which must be taken into account in our approach to this problem. A calm appraisal of the many facets of the transportation complex is, therefore, a healthy thing and can be productive of a better understanding of the requirements for the future.

It is unimportant to our considerations today whether the boat preceded the wheel, or vice versa, in man's early history. The vast populations of the earth could not live today without the modern adaptations of both. The goods and commodities of our modern existence move today by rail, water, truck, airplane and pipeline. What economist would say that the world of the middle Twentieth Century could meet the demands of this and future generations without any one of these trade devices?

The early colonization of this country was effected without benefit of rail, air or pipeline transportation. The river systems were the arteries of travel and commerce in the formative era of the young Republic of the United States. Three Old World nations—England, France, and Spain—struggled for dominance in this New World, a struggle in which the great inland waterways played a dramatic role. For whoever controlled the rivers controlled the destiny of the West.

It is a natural corollary that from the earliest days of our national life the growth of the nation's population and industries has centered around navigable waters—seacoasts, harbors, lakes and inland rivers. It has been estimated that about two-thirds of the nation's 1950 population of 151,000,000 resided in counties at least half of whose area is situated within 50 miles from navigable waterways. For water has always been and continues to be a prime essential of life. When Thomas Jefferson consummated the Louisiana Purchase 150 years ago one of the major considerations was to acquire the greatest inland waterway system on earth—the Mississippi.

The importance of the inland waterways to the nation's future was keenly recognized by the framers of the constitution. They wrote into the body of our laws those safeguards which have kept these waterways free to all. In 1787, when the Northwest Territory was established by the Confederate Congress, the Ordinance for the Territory provided that:

> "The navigable waters leading into the Mississippi and St. Lawrence, and the carrying places between the same, shall be common highways, and forever free, as well to the inhabitants of the said Territory as to the citizens of the United States, and those of any other States that may be admitted into the Confederacy, without tax, impost, or duty therefore."

But the nation's transportation picture began to change with the invention of the steam locomotive in the middle 1850s. The woodburning railways of this early transition period first served as feeders to the waterways. In this early era they operated without Federal rate regulation, free to establish rates among shippers and localities in competition with boat lines. It was some 35 years later that the first practical steps were taken to protect national commerce in the United States against unrestricted exploitation by the carriers, through establishment of the Interstate Commerce Commission.

Just as the river boats and covered wagons had opened up the West in a dynamic surge of settlement, the steel rails now fanned out across the continent to meet the demand for speedier transportation. This was progress and development. It paced an epic of growth never before witnessed in this or any other nation. But as the railroads grew and flourished, traffic on the waterways declined until by the turn of the century it was almost non-existent. River development likewise had reached a low ebb, when, in 1902, Congress created the Board of Engineers for Rivers and

Harbors with independent power to review all examination and survey reports on navigation projects.

As the nation's phenomenal industrial growth continued in the early years of the Twentieth Century, some far-sighted leaders began in question the wisdom of total reliance upon one form of transportation. In 1908, Theodore Roosevelt said: "The rivers of no other country are so poorly developed, so little used or play so small a part in the industrial life of the Nation as those of the United States. The failure to use our own (rivers) is astonishing, and no thoughtful man can believe that it will last. The greatest return (from the development of inland waterways) will come from increased commerce, growth and prosperity of our people." Every President since has advocated development and use of our river systems.

The turning point in resumption of navigation development did not come, however, until World War I. The tremendous transportation problem in gearing the nation to all-out war production jolted the public into an awareness of the shortcomings of a single system of transportation. The railroads did a magnificent job, but with no highway system worthy of the name, the nation had to turn to inland waterways for the movement of a substantial wartime tonnage. This situation was repeated in World War II. Fortunately between the wars substantial progress had been made on waterways development.

Chart I

This schematic chart shows the connected waterways of the Mississippi River system, the Atlantic Intracoastal system, and the Gulf Intracoastal system. Of the 28,000 miles of improved channels, only about 9,000 miles comprise the interconnected inland and Intracoastal systems with fully improved modern standards, upon which barge service has become firmly enough established to be an important factor in domestic transportation. It is the system shown on the chart, on which most Federal money has been spent, and it carries the most tonnage.

As of 1954, the total development of inland waterways, including the Columbia, Sacramento and other west coastal area developments, represented 1,944 individual navigation projects constructed or under construction by the Corps of Engineers. This spans a work period of more than a century. Through 1954 Congress had appropriated $1,878,700,000 on development of these projects, which are estimated to cost a total of $2,343,600,000 when completed.

This represents a tremendous investment of public funds. I say investment rather than expenditure because, as an Engineer Officer of 28 years' experience in civil and military construction works, I am firmly convinced that these developments on our rivers will pay for themselves over and over again in the years to come. You have only to look at the record of tremendous tonnages of the nation's bulk freight now transported by water to find substantiation of this outlook.

Chart II

The bar graphs shown on this chart tell the story of what has been happening on our inland waterways in the last three decades. In 1927 the total commerce on our inland waterways amounted to slightly over 200 million tons. By 1954 it had grown to 320,000,000, exclusive of the Great Lakes and deep-sea traffic. In terms of ton-miles, the growth was from 9 billion in 1927 to over 60 billion in 1954.

The chief commodities handled by the barge lines represent the bulk freight of industry: steel, coal, aluminum, paper, fertilizer, petroleum products, molasses and grain. In 1954, sixty-four rivers, canals and ship channels each had over one million tons of waterborne commerce. This compares with forty-six the year before. For a single example of the importance of cheap bulk water transport take the paper and pulp industry. Inland waterways now serve 342 paper and pulp mills in 36 states. Low cost barge service is essential to this industry because paper and pulp are largely bulk transportation commodities. One mill on the Gulf Intracoastal Waterway alone consumes 700,000 cords of wood annually.

The resurgence of navigation development is outstandingly illustrated on the Ohio River. Back 125 years ago the Corps of Engineers was assigned by Congress to tasks of snagging and channel clearance on the Ohio. In the early part of this century a system of locks and dams was constructed on that river, the bulk of the work being accomplished in the '20s and '30s. The total Federal investment to date on the Ohio is $150,000,000. The public benefits of this improvement include not only navigation, but flood control and increased water supply. It is currently estimated that the annual savings in reduced freight rates now amount to over 80 million dollars.

What has this meant in terms of business and industrial growth? In the last six years it is estimated that industrial expansion in the Ohio Valley has amounted to between 8 and 10 billion dollars. Since World War II, 2,500 new industries have located in this valley which is often referred to as the Ruhr of America. Nearness to sources of iron ore, coal and other raw materials was a factor, of course, in this growth. But other major factors were a controlled river for cheap bulk commerce, adequate water supply and flood control. As mentioned earlier, the Ohio River now carries 60 million tons of commerce each year.

While the chief role of the inland waterways from a transportation standpoint is that of carrier of the bulk raw materials of industry and commerce, it has its generally competitive aspects with other means of transportation. Critics of river navigation development have charged that costs of such projects are prohibitively high, and that the benefit-cost ratio on which they were justified, have not been realistic. The figures shown in the following tabulation speak for themselves. They show the dates the projects were initiated, the Corps of Engineers' estimates of expected tonnage on which they were justified, and the actual tonnage now experienced:

River	*Tonnage Estimate*	*Current Tonnage*
Ohio, 1910	13,000,000	60,000,000
Upper Mississippi, 1930	9,000,000	15,000,000
Illinois, 1937	8,330,000	16,000,000
Gulf Intracoastal Waterways, 1945	7,000,000	40,000,000

Chart III—Tabulation

There are other controversial aspects of the Federal Government's development of inland waterways. It has been charged that if all factors of construction cost, operation, maintenance and interest charges were considered, that inland waterway development is economically unsound. In 1953, the Chief of Engineers prepared an evaluation of these factors for submission to a Congressional committee. His report follows:

Annual Charges:	
1. Interest at 2½ percent and amortization in 50 years on the total of $1.1 billion	$ 39 million
2. Maintenance and operation	$ 40 million
Total	$ 79 million
3. Annual transportation savings: (Using a unit of saving of 5 mills per ton mile rather than the 9.18 mills average for the major waterways) 50 billion ton miles x 5 mills	$250 million
4. Benefit cost ratio for 1953	3.17 to 1

A more specific application of this evaluation by major waterways projects also was prepared in 1953. It shows benefit to cost ratios ranging all the way from 1.4 to 1, to 14.8 to 1. While these figures naturally fluctuate somewhat from year to year, the presentation in tabular form of the 1953 results is of interest:

Waterway	*Ratio of Benefits to Cost 1953*
Gulf Intracoastal	14.8
Lower Mississippi	9.5
Monongahela	9.4
Illinois	8.1

Ohio	7.3
Sacramento	5.3
Middle Mississippi	4.4
Cumberland	3.6
Warrior	3.1
Kanawha	2.9
Upper Mississippi	2.1
Allegheny	1.4

Chart IV

Navigation today is big business—private business. Privately owned and operated vessels used on all inland waterways totaled 17,250 in 1951. Towboats operated on inland waters numbered over 4,000; non-propelled vessels, 13,218. This represents a tremendous investment of private capital and employment of many thousands of persons. The rate of increase in inland waterway transportation equipment is illustrated by the following figures for the Mississippi River system and Gulf Intracoastal Waterway:

	1940	*1953*
Number of towboats	902	1,692
Total horsepower	282,306	936,713
Number of barges	4,915	7,939
Total capacity	3,564,716	6,996,113
Average capacity per barge	725	938
Total Tonnage	70,176,661	224,957,448

Chart V—Tabulation

While the inland waterways carried a larger proportion of the nation's freight load in 1954 than in any previous year prior to the advent of the railroads, percentage-wise it is still relatively small. The tabulation shown here gives the relative positions of the five major freight carriers for 1943 and 1954. These computations are on a ton-mile basis.

Carriers	*1943* *% of Total*	*1954* *% of Total*
Railroads	71.9	49.5
Motor Trucks	4.7	19.1
Great Lakes	11.4	8.1
Pipelines	9.4	16.0
Inland Waterways	2.6	7.3

The latest available figures comparing the operations of the five major carriers both on a tonnage and ton-mile basis are for 1953; as follows:

Carriers *1953*	*Ton Miles* *(billions)*	*Tons* *(millions)*
Railroads	639	2,750

Motor Trucks	206	233
Great Lakes	127	188
Pipelines	165	561
Waterways	75	327

The developments now under construction on the St. Lawrence Seaway and the Calumet-Sag connecting Lake Michigan with the Illinois river waterway, are another measure of the importance Congress and the nation attach to waterborne commerce.

Chart VI

This map shows the strategic importance of these developments to our own Mid-West region. The St. Lawrence project will permit seagoing commerce of the world to move on the St. Lawrence and through the Great Lakes to Chicago, Duluth, Detroit and other industrial ports on the Lakes. This will bring ocean shipping some 800 miles closer to our midland area than ever before. The Cal-Sag canal, a connecting link between the Chicago port and the Illinois waterway, is being widened to 220 feet. This will permit world commerce to be trans-shipped by river barge to the entire Mississippi waterway system via the Illinois.

I think the economic implications of this transportation development with respect to our industrial growth in the Mid-West are readily apparent. It will make our inland cities, especially those located on the waterways, much more competitive with the industrial East. It will enhance our opportunities to profit by the industrial decentralization which is definitely underway.

Now, I should like to move closer home for the concluding part of my discussion. By home I mean the Missouri Basin where for the last four years, I have supervised the Corps' part of one of the nation's largest water resources development programs. Navigation is but one facet of the authorized program under construction in our basin. It is a multiple-purpose project designed to bring about control of disastrous floods, expand irrigation in semi-arid sections by some 4 million new acres, produce about 13 billion kilowatt hours of hydro electrical energy, assure adequate water supply for cities and industries, as well as float barges on the Missouri from Sioux City, Iowa, to the mouth.

This program has been under construction for ten years, and it has reached the point where its beneficial returns are being realized in growing measure year by year. Some thirty reservoirs, including four major impoundments on the Missouri River have been built or are nearly completed. Such projects are fast giving the people of the Missouri Basin the means of controlling and conserving water resources which in the past ran out of the rivers uncontrolled and wasted.

Major destructive floods on the upper and middle reaches of the Missouri River are a thing of the past. The four main stem reservoirs now in operation in the Dakotas and Montana have sufficient capacity to reduce a flood such as the record flood of 1952 to well within banks at Omaha and St. Joseph. During the drought summer and fall months of 1954 and 1955, stored water from these reservoirs provided three-fourths of the flow at Omaha and Kansas City, assuring adequate water supply and pollution abatement and navigation depths on the main river. Total capacity of the four reservoirs is the equivalent of twice the average annual flow of the Missouri at Sioux City. Eventually the authorized main stem system will include six reservoirs with a combined capacity of almost three times the average annual flow of the Missouri.

Further details of the Missouri Basin program would not be pertinent to our discussions here. The point I wish to emphasize is that basin-wide water resources development to be fully effective should be planned and executed on a multiple-use basis. Navigation improvement in most major stream basins is an integral part of such development. The costs of river controls should properly be allocated to all the public benefits which it will produce, not to navigation alone or to any other single benefit.

For example, a 9-foot channel stabilization and navigation project from Sioux City to the mouth of the Missouri River is an integral part of the over-all Missouri Basin project. Without a stabilized channel it would have been engineeringly infeasible to build levees and floodwalls for the protection of cities, industries and agricultural lands. The channel stabilization prevents the river from meandering back and forth across the flood plain as it was free to do in the past. Thus, the benefits of this part of the project should not be charged wholly to navigation.

Charting VII (Showing Controlled River Channel)

This is an example of what I mean by channel stabilization and its effects upon stabilization of agriculture, municipal development and industry. Shown here is a stretch of the Missouri River below Omaha. Note the conditions that existed before channel stabilization works were installed—a braided channel, a meandering river, unstable agricultural areas and arrested development. Contrast this with the present controlled channel which permits farmers to till the soil right up to the river banks. The combination of channel stabilization and upstream reservoirs will ultimately provide protection for over 1½ million acres in the Missouri bottoms, some of the most productive land in the basin.

Chart VIII (Fairfax District)

A typical example of what river controls can mean to industrial development is graphically illustrated on this chart. It shows an area of 2,000 acres in a bend of the Missouri River at Kansas City, Kansas, which was wasteland prior to 1923, a part of it consisting of a big sandbar called Goose Island. Contrast this with the situation today. Here is an example of one of the finest industrial developments in the Mid-West, known as the Fairfax Industrial District, which is familiar to many of you.

Today the Fairfax Industrial District, developed by the Union Pacific Railroad, contains 144 industrial plants, with an annual payroll of $125,000,000, employing 30,000 people. Without a stabilized river channel and Federal levees this District would still be at the mercy of the river, flooding almost every year.

Chart IX (Navigation)

Finally, I come to the navigation story on the Missouri River. It is not a spectacular picture today, but the potentials for the future are of great importance to the growth and development of the Missouri Valley area. You can see that before we had upstream reservoir control the tonnage was negligible —50,000 tons in 1952. But notice how the trend has surged upward since then. In 1953, the tonnage was 150,000; in 1954, 287,000 and last year 414,000. Peanuts compared with the Ohio River's 60 million tons. Yes. But there was a time when the Ohio carried little tonnage. Locks and dams and other improvements built the Ohio up to the status of one of the world's largest carriers of waterborne commerce. It can happen proportionately on the Missouri when the authorized 9-foot channel project is completed permitting free inter-change of 9-foot draft barges from the Mississippi River up the Missouri. Navigable depths on the Missouri now range from 6½ to 7½ feet up to Omaha.

In summary, may I point out that our nation at last is aroused as never before to the urgency of water resources conservation and use. Already water supply is inadequate in many industrial and municipal communities and threatening to limit their future growth. We must conserve what we have and put it to fullest use. Navigation is one of the important elements of sound planning and development. As this nation grows all economic means of transportation will be necessary to keep pace. To ignore or stifle any of them would be short-sighted and not in the American tradition. In the next century of engineering, river development in all its facets will be a major field of technical endeavor. The rivers of America must fulfill the destiny envisioned by our forefathers.

CONVOCATION PROGRAM

JESSE AUDITORIUM

9:30 A.M., March 17, 1956

CALL TO ORDER by Dail Stone, President of Engineers' Club.

INVOCATION by Dean Seth W. Slaughter, Bible College of Missouri.

INSTRUCTIONS for attendance cards and remainder of the day by Dail Stone.

ANNOUNCEMENT OF WINNING EXHIBIT by William Marshall.

INTRODUCTION AND PRESENTATION OF STUDENT AWARDS.

Presentation of outstanding freshman engineer,
Roger Pape —by Dail Stone

Presentation of outstanding sophomore chemical engineer,
Duane Luallin —by Richard Hazel

Presentation of Chi Epsilon sophomore award to
Gordon Scott—by Robert Moe

Presentation of ASAE sophomore award to
Rodger Garrett—by James Frisby

Presentation of Pi Tau Sigma sophomore award to
George Huber —by Shelton Ehrlich

Presentation of Eta Kappa Nu sophomore award to
Roger Pape and Paul Klock — by Bruce Jordan

INTRODUCTION of Dean Croft by Dail Stone.

PRESENTATION OF ENGINEERING AWARDS by Dean Croft to:

J. Brownlee Davidson
Procter Thomson
William Grant Purdy
George Albert Delaney
Louis Harry Winkler

INTRODUCTION OF SPEAKER by Professor C. M. Wallis.

ADDRESS "Communications of the Future" by Eugene J. McNeely, Vice President, American Telephone and Telegraph Company

FINAL INSTRUCTION for attendance cards.

BENEDICTION by Dean Seth W. Slaughter.

ADJOURNMENT by Dail Stone.

MISSOURI HONOR AWARDS FOR 1956

INTRODUCTION TO THE AWARDS

By Dean Huber O. Croft

In particular is this Centennial Year of Engineering at the University a most propitious occasion to honor five outstanding engineers by presentation to them of the Missouri Honor Award for Distinguished Service in Engineering. This Award in the form of a bronze medal is made possible by the support of the Missouri Engineering Foundation.

We honor here today, a famous and revered professor of agriculture engineering; a chemical engineering administrator of a world famous American corporation; a civil engineer who has literally made a place for himself in the stars in the field of rockets and guided missiles; an electrical engineer who is the chief engineer of a well-known automobile company; and a mechanical engineer who is one of the distinguished metallurgists of our time now connected with a large steel company.

Four of these engineers graduated here, of whom the youngest graduated in 1941 and the oldest in 1907.

The contributions which these men have made are intimately invoved in the present and future of this great civilization, which is America. They were once, not many years ago, students such as the young men in the audience and we hope that in this centennial senior class that here may be at least five men who may become as distinguished as these medal recipients we honor here today.

We will now proceed to the Awards.

J. BROWNLEE DAVIDSON

The Citation

J. Brownlee Davidson, in recognition of his outstanding achievements in the field of agricultural engineering and engineering education;

His vision, leadership, and pioneer work in the application of engineering to agriculture, which have contributed substantially not only to the solutions of problems in this field, but also to the development of the whole American economy and way of life;

His service to engineering education as a pioneer in the development of college instruction in agricultural engineering, his authorship of textbooks, bulletins, and technical papers, his long and respected service as a college teacher and administrator;

His promotion of high professional standards through his work in engineering societies, which has brought national acclaim;

The College of Engineering and the Engineering Foundation of the University of Missouri confer upon him the Missouri Honor Award for Distinguished Service in Engineering.

Mr. Davidson's Response

It is with a feeling of humble gratitude that I accept this award. I do so with a very sincere appreciation of the contributions to this achievement that have been made by my family, my friends, my teachers and my co-workers, and all those who have guided and encouraged me through the years that are past.

I am proud to be their representative as I take my place among the eminent engineers who have received this award before me.

Biographical Information

J. BROWNLEE DAVIDSON, a native of Nebraska, received a B.S. degree in Mechanical Engineering in 1904, and Doctor of Engineering degree in 1931 from the University of Nebraska.

After obtaining his first degree, he served as an instructor in farm mechanics at the University of Nebraska, and later became professor of agricultural engineering at Iowa State College and the University of California. In 1919, he returned to Iowa State College where he again headed the department of agricultural engineering.

He is the author of many important publications in the field of agricultural engineering and was cited by a special committee of the American Society of Agricultural Engineers as author of two papers of "exceptional merit." He has served on many important governmental committees and organizations and as adviser to several foreign countries.

Mr. Davidson is an honorary member of the American Society of Agricultural Engineers and is a life member of the American Society of Engineering Education, Iowa Engineering Society.

PROCTER THOMSON

The Citation

PROCTER THOMSON, in recognition of his notable achievements in the fields of standardization and quality control;

His leadership in the application of statistical methods to chemical and engineering problems;

His work in connection with the Process Standards Department of a large corporation with respect to translating the results of research and development into plant operating procedures and quality control;

The College of Engineering and the Engineering Foundation of the University of Missouri confer upon this alumnus the Missouri Honor Award for Distinguished Service in Engineering.

Mr. Thomson's Response

It is with great pride that I accept this honor. One's achievements are the result of his opportunities. I have been fortunate in being with good people, people of character, integrity and intelligence. In such surroundings one naturally does good work.

Biographical Information

PROCTER THOMSON, a native of Astoria, Oregon, received his B.S. degree in Chemical Engineering in 1912 from the University of Missouri. After his graduation, he worked for the Solvay Process Company, the Brunswick Collender Company. and Sears-Roebuck and Company, before joining his present firm, the Procter & Gamble Manufacturing Company.

Here for many years, he served as associate director of the Process Standards Department of the Chemical Division, where he gained a reputation for translating results of research and development into operating procedures and quality control for factories. He was a pioneer in the application of statistical methods to chemical and engineering problems.

Two years ago, Mr. Thomson joined the Patent Department but continues his work in standardization activities. He is a member of the Chemists' Committee of the National Cottonseed Products Association, the Technical Committee of the National Soybean Processors Association, and he is a member of the Governing Board of the American Oil Chemists' Society.

WILLIAM GRANT PURDY

The Citation

William Grant Purdy, in recognition of his contribution to national defense and to space navigation;

His rapid progress, while still under 40, in the forefront of a new technology distinct from that of his specific educational background;

His responsibility for development of the Viking rocket, a foundation for our country's defense;

His up-grading to head engineering advanced design on rockets and satellites;

His recent assignment as director of all engineering activity on the major weapons development program of an outstanding aircraft corporation;

The College of Engineering and the Engineering Foundation of the University of Missouri confer upon this alumnus the Missouri Honor Award for Distinguished Service in Engineering.

Mr. Purdy's Response

It is with a particular degree of humility that I accept this Honor Award.

Biographical Information

William Grant Purdy, a native of Sullivan County, Missouri, studied three years at Northeast Missouri State Teachers College at Kirksville, before enrolling in the College of Engineering at the University. He received his B. S. degree in Civil Engineering here in 1941, and went to work immediately for the Martin Aircraft Corporation where he soon became known for his close association with the development and testing of the Viking research rockets.

Mr. Purdy is director of all engineering activity on a major weapons development program of the corporation. Previously he had served as supervisor of the Flight Instrumentation Laboratory. He was responsible for the engineering efforts in the development of the Viking rocket until mid-1954. At that time, he was assigned responsibility for engineering advanced design activity on rockets and satellites.

He is a member of Tau Beta Pi, the American Association for the Advancement of Science, the American Rocket Society, and the American Ordnance Association.

GEORGE ALBERT DELANEY

The Citation

George A. Delaney, in formal acknowledgement of his distinguished career in the science of automotive engineering;

His technical leadership as chief engineer of the Pontiac Motor Division of General Motors Corporation;

His productive service in the field of standardization as director of the American Standards Association;

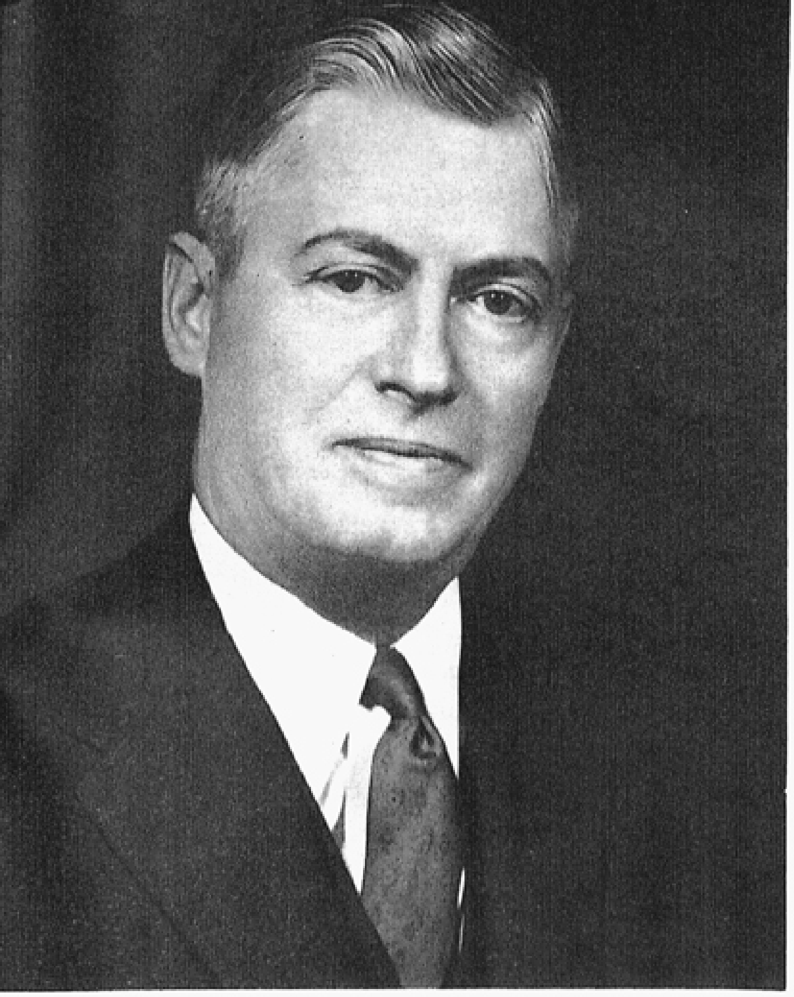
His professional leadership as former chairman of the Technical Board of the Society of Automotive Engineers, and now, as the current president of this society;

The College of Engineering and Engineering Foundation of the University of Missouri proudly confer upon this alumnus the Missouri Honor Award for Distinguished Service in Engineering.

Mr. Delaney's Response

It is a deeply appreciated honor to receive this Award for Distinguished Service in Engineering.

My gratitude and sincere thanks to my Alma Mater and the automotive industry, both of which have furnished so many opportunities and such ample rewards.



Biographical Information

George A. Delaney, a native of Centerview, Missouri, graduated from the College of Engineering at the University of Missouri in 1917. Immediately after graduation, he entered officers training camp and served as a 1st lieutenant during World War I.

Mr. Delaney's first automotive engineering experience was as a draftsman with the automotive division of the Savage Arms Corporation. After a year with that firm, he joined the staff of the Paige Detroit Motor Car Co. as a project engineer, and remained with the company and its successor, the Graham Paige Company, until 1934, when he joined Pontiac Motor Division of General Motors Corporation as an electrical engineer. He became assistant chief engineer in 1939, and chief engineer in 1947. During World War II he supervised the aircraft engineering in General Motors' Fisher Body Division.

He is a past director of the American Standards Association and is the current president of the Society of Automotive Engineers.

LOUIS HARRY WINKLER

The Citation

LOUIS HARRY WINKLER, in recognition of his outstanding achievements in the fields of metallurgical engineering and steel manufacture;

His leadership in the development of technical codes for the design, manufacture, and testing of steel rails, locomotive forgings, wire rope, wire and wire rods, and tubular products;

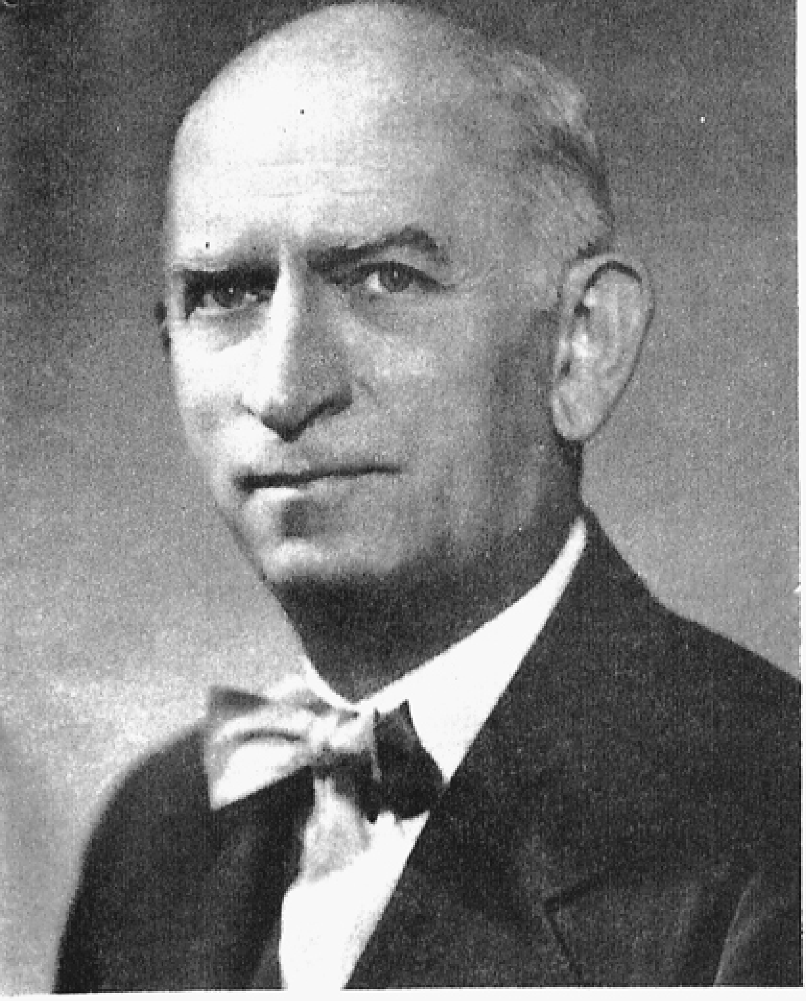
His high ability to understand his fellow man, to provide effective and responsible technical leadership in the steel manufacturing industry;

The College of Engineering and the Engineering Foundation of the University of Missouri confer upon this alumnus the Missouri Honor Award for Distinguished Service in Engineering.

Mr. Winkler's Response

It is indeed a great honor to be chosen for this Award for Distinguished Service in Engineering.

I accept this honor with a deep feeling of humility and appreciation.



Biographical Information

LOUIS HARRY WINKLER, a native of Carthage, Missouri, graduated from the University of Missouri in 1907 with a degree in Mechanical Engineering, and in 1909 received the degree of Mechanical Engineer for work *in absentia.* He joined the engineering department of the Cambria Steel Company and was assistant metallurgical engineer from 1909 until 1917 when he was promoted to chief metallurgist. In 1923 the company was acquired by Bethlehem Steel Company and Mr. Winkler was made metallurgical engineer.

Mr. Winkler is an authority on railroad steel products, wire rope, wire and wire rods, and steel tubular products. He has been chairman of the General Technical Committee of the American Iron and Steel Institute since 1946.

He is a member of many technical and professional societies, including the AISI Technical Committee on Rails and Joint Bars; the American Railway Engineering Association —American Iron and Steel Institute Joint Contact Committee on Railroad Rails; and the American Petroleum Institute Standardization Committee on Wire Rope and Tubular Products.

Recipients of the Awards

1951

Carl Wright Brown
William Valentine Kahler

1952

Lief John Sverdrup
Wilfred Sykes
Charles Allen Thomas
National Bureau of Standards
(by Allen V. Austin, Acting Director)

1953

Francis Gano Chance
Roy Putnam Hart
Fred K. Powell, Jr.
Stanley Stokes

1954

Leonard J. Fletcher
Webster Newton Jones
Carthrae Merrette Laffoon
Sterling Price Reynolds
Rex Marion Whitton
The E. I. duPont de Nemours and Company
(by Granville M. Read, Chief Engineer)

1955

Vecdi Diker
Glenn L. Dimmick
C. W. LaPierre
Lee Schneitter
John Merrill Olin

1956

J. Brownlee Davidson
Procter Thomson
William Grant Purdy
George Albert Delaney
Louis Harry Winkler