Texas and Technology[1]

By Martin Goland[2]

It is a pleasure to have this opportunity to talk with you about the Texas scene and its stake in science and technology. The force of science in modern society is a compelling one, reaching into virtually every aspect of our lives, and the future health of our state and our nation hinges in large measure on the extent to which we plan wisely to have technology serve our ends, rather than control our destiny.

In approaching so broad and significant a topic, it is perhaps well to start with a brief historical perspective of the emergence of science and technology as agents of social power. During the earlier years, science, along with mathematics, persisted largely as a part of our cultural heritage. Originally called "natural philosophy," it was basically the quest of curious minds to better understand man and his environment. Insulated in the large from the daily problems of the community, operating on a scale of abstraction all too rare in our scientific environment today, the giant minds of the past laid the intellectual foundations for the structure of technology as we know it today.

In parallel with the theoretical and experimental growth of the natural philosophers, and operating quite independently of their findings, the artisans of old labored to establish their traditions of the master craftsman. Pride in the construction of devices useful in society was their shining goal, and toward this end they concentrated the ingenuity of their minds and the skill of their hands.

It is a memorable experience to savor some of the flavor of the infant years of engineering, for example, by reading through such source material as the early volumes of the *London Mechanic's Magazine*. The August 14, 1824 issue of this journal contains a review of a book by Robert Stuart on the history of the steam engine. Both author and reviewer are in agreement in the opinion that "all that has been done by merely learned men, in the applica-

[1] Presented before the Annual Meeting of the Philosophical Society of Texas, Stagecoach Inn, Salado, Texas, December 8-9, 1961.

[2] President, Southwest Research Institute.

tion of steam as a moving power, is of no practical mark or likelihood. Twenty years ago (1804), Hornblower observed that 'the most vulgar stoker may turn up his nose at the acutest mathematician in the world, for (in the action and construction of steam-engines) there are cases in which the higher powers of the human mind must bend to mere mechanical instinct'; and the observation applies now with greater force than it did then."

The technological revolution which brought together the scientist and the craftsman is largely a product of the twentieth century. Beginning with the turn of the century, theory and practice—science and technology—came together to cause the chain reaction we are so aware of today. Accelerating year by year, and with such breathtaking speed during the past two decades, modern technology has brought us close to the secrets of life itself, has unlocked the almost limitless energies of nature, and has enabled man to challenge the planets.

The impact of scientific application and of technology was at first felt mainly in the sphere of industry and trade. Alert companies drew strength and profit by recognizing that knowledge is power, even on the production line, and nations become great by virtue of their industrial might.

Suddenly, as a consequence of the new world which emerged from the Second World War, the full and broad impact of technology as a controlling factor in our society and civilization reached to every corner of the globe. World War II was a struggle between mighty nations, and its outcome was decided by industrial brawn. For the cold war which followed, and in which we now find ourselves so fully engaged, even production might is insufficient—the quality of our science, in schools as well as in factories, is shaping world events and influencing the minds of men away from, or toward the sinister message of Communism.

New weapons of horrendous power vie with technological crusades to elevate the living standards of underdeveloped countries on the modern scene. In truth, science has reached far beyond the laboratory and has become the battleground of politics.

The race for space is, of course, the most dramatic evidence of the new role of scientific achievement and industrial might in testing the virility and prowess of nations. The Russians issued the challenge

with Sputnik I, and only this year our own President accepted it with full force. We shall exert our every energy to be the first on the moon, with an American astronaut demonstrating to all peoples the vigor of the free enterprise system.

This, then, is the background against which we must discuss science and technology in Texas. For the welfare and the financial security of its people, Texas must share in the growing authority of technically oriented communities. The choice of Houston as the site for the new NASA Manned Spacecraft Center highlights our obligations to national technological goals.

And, amidst all of this talk of the physical powers of science and technology, let us not forget that the scientist and the craftsman both enjoy rich cultural experiences. The enlightened citizenry of today, striving toward his higher destiny, is deeply ingrained with the philosophies of the scientific method and inspired craftsmanship. In looking to Texas, we must also evaluate the opportunities afforded our citizens to contribute toward these noble pursuits.

WHERE DO WE STAND?

During my earlier years in Texas beginning some six years ago, I was impressed time and time again as I came in contact with the distinguished record of scholarship built by the staffs of Texas institutions in various areas of endeavor. The record is all the more admirable when it is reflected against the relative youth of many of our programs. Texas has by nature been somewhat precocious, and nowhere is this more evident than in the speed with which science and technology have been injected into those pursuits which reflect the interests of Texans.

In terms of a balanced program of technological development, however, our state has barely had the time for planning, let alone execution. The year 1901 is perhaps the truest point in time when Texas first began to turn from the land toward science, engineering and industry. This particular year marks the founding of the first two major meat packing plants in Fort Worth, and the discovery of oil at Spindletop. Since then, progress has been rapid in the directions of exploring the rich cattle and petroleum resources so characteristic of our lands.

Texas universities have become famous for their forward-looking research in petroleum engineering and in geophysics. Graduates of

schools in Texas and the Southwest are today the living pioneers of the great natural gas industry, with its almost unbelievable ribbons of steel stretching thousands of miles from their underground sources. When we speak of the wonders of modern technology, where can we look for a better illustration than to the Gulf Coast, with its offshore drilling platforms and its massive petrochemical complex where materials unknown to nature's natural state are produced for our benefit?

In agriculture, too, the Texas record is illustrious. The educational and research programs of the A and M College of Texas are justly famous, drawing students from all parts of the world, and sending forth its staff as advisors to all corners of the globe. The great ranches of Texas have no equal anywhere in their animal husbandry accomplishments, combining a rich pioneering heritage with technical progress in breeding and care.

We need not look only to the Texas story in land and oil, however. In broader areas of science and technology our universities have also been active. It may not be known to some of you that one of the finest departments of mathematics forms a part of our own University of Texas. Professor Ettlinger recently circulated with pride certain statistics which show that this department stands first in the nation in the training of top quality research mathematicians, according to an index which relates the number of research publications to the number of doctoral graduates. In a state noted for its concentration on the more practical aspects of science, it is interesting to observe the record of the University of Texas in the purest branches of mathematics.

Much credit should also be given to the engineering schools and colleges of Texas. Notable among the great technical universities of our times is Rice University, where so much pioneering work has been done on the process of education itself. Among the first universities in the country to install the five-year curriculum for undergraduate education, Rice has been an unquestioned leader in pointing the way toward a more mature and fuller training of our young engineers and scientists.

In areas of university research, it is worthy to note that the oceanographic and meteorological program at Texas A&M is acknowledged to be among the nation's finest. The great Defense Re-

search Laboratory of the University of Texas is an important element in our national military research and development strength. In physics research, the record at Rice University stands among the finest.

This recounting of some of the strengths of the Texas scene is obviously a haphazard one, for I have neither the depth of knowledge nor the time available in this talk to cover the countless areas where Texas has contributed to the growth of science and technology. I bring up these few illustrations only to show that many of our weaknesses are matched by other strengths, and to dispel any lingering illusion that our state is a novice in the affairs of science, engineering and industry.

In applied research, too, we have a proud story to tell. The Aerospace Medical Center of the U. S. Air Force, located in San Antonio, is helping to pave man's way to outer space, and the forthcoming NASA Manned Spacecraft Center in Houston will be the focus for some of the most advanced technology of our age.

Finally, in this sketchy outline of our Texas institutions, permit me to mention my own organization, Southwest Research Institute. Recognized throughout the country as a leading center of applied technology, large and small companies, trade groups and the military seek us out for help in solving their scientific and engineering problems.

The goal of our physicists, chemists and engineers is to translate fundamental scientific knowledge into the products and processes which enhance the welfare of our people and which make our economy strong. With philosophic roots in both the university and the industrial laboratory—but with primary objectives different from each—we serve as a bridge which connects the pure scientist with the industrial entrepreneur. With pride, and yet with modesty, I point to our Institute as another source of technological strength in the Southwest.

THE OTHER SIDE OF THE COIN

Promising as the Texas scene is in many respects, it is even more constructive to spend our time in examining our shortcomings. In many instances, these are as striking as our proven accomplishments.

To begin with, it must be admitted that our overall program in science and technology is unbalanced. Only within the past decade

have we begun to emerge from our dependence on an economy born of cattle, petroleum and natural gas. The appearance of an aerospace industry in the Dallas-Fort Worth area, and the beginning of an electronic complex in our industrial cities are illustrations of the new trend.

In recent years, so much written and spoken attention has been centered on the spectacular community benefits which accrue from the growth of science-based industry as to make any repetition here superfluous. Yet, I cannot refrain from once again bringing to your mind the classic example provided by Texas Instruments in Dallas. Basic research conducted approximately thirty years ago led to the invention of the transistor some ten years ago. First placed in production seven years ago, this revolutionary solid-state device is the major product line of the company. The greatest benefits which can flow to a community should be measured in terms of its human resources, and it is impressive to note that Texas Instruments employees now number approximately 10,000 persons. Three thousand of these are college graduates, and 80 are persons with Ph.D. degrees. It is an interesting sidelight to note that 10 of these 80 doctoral scientists and engineers are graduates of MIT, and an equal number were trained at the University of Texas.

Per-capita personal income during 1960 in the Southwest was $1912, compared with more than $2500 for the Middle Atlantic and New England states. It is science-based industry and commerce in the Southwest which will help to rectify this imbalance.

The incentive for Texas and the Southwest to become more deeply immersed in the broadest of technological horizons is not confined merely to the attraction of the new. It is equally vital that we have the knowledge and skill to protect and enhance our native strengths amidst an international environment characterized by rapid change and shifting values.

A good example is to be found in our petroleum and natural gas industry. At present, the major portion of the energy demands of our nation are met through this invaluable natural resource. Research laboratories in every part of the world, however, are now engaged in a massive effort to exploit new sources of energy, or to use the more conventional sources in new and better ways. The spectacular strides being made in the peaceful uses of nuclear energy

are but one illustration of this program which is challenging the very finest of our scientific and engineering minds. Other examples chosen at random are the liquid transport of methane from lowcost production areas, the burning of coal in fuel cells, and the imaginative concept of using biological mechanisms for energy production.

The impact on Texas of these new developments can well be disastrous unless we also are benefitting to the maximum from the strengths drawn from technological progress. We must be alert to the competition, sensitive to its implications, even as we strive to perfect the efficiency of our own industries. We can do this only if our citizens combine the finest of training with their native attributes of ingenuity, boldness, and pioneering courage to test the new; only if our classrooms and laboratories reflect the intricate paraphenalia of the future, as well as the experiences of the past.

At the very core of our capability to establish technological leadership is the quality and the quantity of our graduate education. Dr. Lloyd Berkner, President of the Graduate Research Center of the Southwest, has some sobering statistics to offer along these lines.

In 1959, the Southwest, with 10.7% of the nation's population, granted 10.7% of the country's Bachelor degrees; 10.3% of the degrees at the Master level; but only 5.7% of the nation's Doctorates.

Using the figures for 1960, the United States granted 52 Ph.D. degrees per million of population. In a ranking by state, Massachusetts led the list with 140 Ph.D. degrees granted per million population; nine of the Northeastern states averaged 73 doctoral degrees per million of population.

By comparison, the Southwest granted only 28 Ph.D. degrees per million of population, and the figure for our own state of Texas stands at 30.

In relation to the Northeast, therefore, the Southwest and Texas reflect a level of activity in graduate education which is three times too small. If the picture is presented in terms of the actual numbers of graduates, the record of our region is even less impressive. Of the approximately 9,000 Ph.D. degrees awarded in this country during the 1958-59 academic year, the Northeast produced 3,300; the North graduated 3,000; the West was responsible for 1,500; 850 came from the Southeast; and only 417 claimed their degrees from Southwestern institutions.

To put these statistics into further perspective, Dr. Berkner points out that there is almost a one-to-one correspondence between the number of doctoral graduates and the level of industrial development on a technological base in the mid twentieth century. He concludes that a leading industrial state should produce between 75-85 doctoral graduates per million of population per year.

Looking beyond the level of our university activity, let us examine the second greatest asset of a technically oriented region—the size and excellence of its technical libraries. It is perhaps not an exaggeration to say that any community which is serious in its intellectual pursuits and sound in its planning would do well to judge its progress by the quality of its library services.

In this area, too, our present status leaves much to be desired. Texas does not boast of a single major technical library collection, although it is true that acceptable collections are to be found at the University of Texas and in the joint holdings of the A & M College and the Texas Engineer's Library.

Underlying our technical library weakness is perhaps a more basic characteristic of the citizens of our state, namely, a failure to adequately reach for the cultural and intellectual environment which is so much a part of modern advancement. The character of our public library system offers a clue in this direction.

I have the pleasure of serving on the Library Board of the City of San Antonio, and some of the facts brought to our attention are cause for deep concern. In the fiscal year 1960-61, the public library expenditures per capita in the city of Boston totalled $4.72; in Kansas City—$2.67; in Detroit—$2.73; and in Cleveland—$5.24. The per capita figures for leading Texas cities are as follows: Dallas—$1.63; Fort Forth—$1.26; Houston—$0.65; and my own city of San Antonio—$0.66.

It is perhaps fair to say, then, that Texas has not yet fully awakened to the quickening intellectual pace so necessary for the future. Surveys which reflect the major factors which determine the locations of new, science-based industry are unanimous in placing at the head of the list (1) the character of the people as expressed by their cultural and intellectual environment, (2) the size and excellence of the nearby universities, and (3) the extent to which library services are available in the area. In truth, these are not three distinct

factors. To a large extent one is a reflection of the next, and we in Texas would do well to carefully examine our image.

OUR NEIGHBORS TO THE SOUTH

In appraising the role which Texas should play in international science and technology, the ties of geography and of a shared heritage force us to look to the South—toward our neighbors in Latin and South America. Here we see great lands whose people are in turmoil, a surging complex of political and economic unrest, harried by poverty and hounded by hunger. Shining through their adversity, however, is a magnificent culture deeply rooted in the finest traditions of our civilization, and holding forth the promise of new legions who can join with us in the search for freedom and justice.

There is little question that the Latin and South American problems are complex, but it is equally clear that an enlightened technology can provide many of the answers. The cynical Communist onslaught in these countries is based on the promise of better material standards of living, and if we do not exert leadership in this important direction we shall not deserve the allegiance of hopeful peoples.

Using my experiences in Mexico as a basis, I believe I can speak for some of the technological needs so apparent in the Latin and South American countries. It was some ten years ago that my own Institute helped to establish the Instituto de Investigaciones Industriales in Monterrey, Mexico, in collaboration with the great technical university located in that city, the Instituto Technologico y de Estudios Superiores de Monterrey. Working through private sources and completely free of either government subsidy or control, the Instituto is committed to elevating the levels of Mexican technology at the small industry level. Against great psychological as well as financial obstacles, this small laboratory is paving the way for a more self-sufficient technological climate in Mexico which, through the system of free enterprise, will better serve its population. It is reasonable, I believe, to extrapolate some of the hard-won lessons in Mexico to Latin and South America as a whole.

One is surprised to find that pure science fares better in these countries than do the more practical aspects of technology. The universities, some of them among the oldest in the hemisphere, draw their academic traditions from the Europe of a century or more ago.

Scholarship is respected as an end unto itself, and its practical applications are viewed with the classical mistrust of the rigid academician. More importantly, in the modern frame of reference, this long standing concentration on theory rather than practice has made it difficult for the South American universities to train the large numbers of applied technologists so necessary to catalyze an upswing in the technological climate of their countries.

Here is a unique area where we in Texas have an opportunity to fulfill an important international obligation. The training of research scientists for Latin and South America can be accomplished in almost any of our country's universities. But it is here in Texas that we possess the unique understanding which can focus our efforts on the education of the working engineers and the craftsmen so desperately needed south of the border.

There is a movement among American universities toward education in science and away from the more classical patterns of engineering. While this may well serve the more sophisticated needs of our environment, it is diametrically opposed to the educational requirements of the underdeveloped nations of the world. In world perspectives, the highly practical hydraulics engineer is equally as important as the research aerodynamicist; the structural engineer who uses the routine handbook to obtain a serviceable design is as potent as the most advanced research scientist in structural theory. The technological scene in Texas could do no better than to reflect both areas of world need.

I am continually impressed by the fact that the problems of underdeveloped peoples are dealt with daily by politicians, economists, sociologists, and agriculturalists, but seldom does the name of an engineer stand out. Here is a great new area of opportunity for Texas. While helping to advance the frontiers of science, we can also serve as the focal point for the technology of nations which have not yet reached our own level of technological sophistication. The problems are different, but with our unique understanding and appreciation of these differences, we might well be the leaders in this great new humanitarian quest.

THE NEW SPINDLETOPS

This, then, is the broad sweep of Texas science and technology, patterned to the best of my ability. Along with our accomplish-

ments are the serious shortcomings we have not yet had time to remedy. Chief among the challenges for the future are the strengthening of our educational institutions. Their high standards of excellence must be extended into new areas, and their graduates must be sufficient in number to fashion a bright future. Our communities must aggressively pursue a balanced base of technology, guided by citizens alert to the changing philosophies of a world in which science can well become absolute power.

The theme of this talk does not afford me the opportunity to discuss with you some of the deeper philosophic relationships between science and our society, a subject in which I am prone to dabble. It is not out of place here, however, to mention the great need for inspiration and leadership in discovering how science can be made to most effectively serve the highest ideals of man. The ethical, social and political problems posed by scientific advance are the central issues of our age. As the youth and vigor of our state are turned toward great plans and imaginative enterprises in the affairs of science and technology, here is another direction in which our leadership can be tested.

Texas, with its Manned Spacecraft Center, is poised at the Spindletop of the space age. The opportunities of the future crowd in on us with new Spindletops whose outlines we cannot yet discern. Let us hope that the years ahead will find us equal to the test with both ambition and wisdom.