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ABSTRACT

In 1967 Southern Methodist University (SMU) changed the name of their School of Engineering to the Institute of Technology so that the scope of the division might be broadened. At that time, a 5-year plan was devised that allowed for certain goals to be reached by 1972. This 1972 report seeks to identify the various forces at work that will affect technological higher education in the 1970's. In addition, the impact of these forces is assessed. This report outlines some of the responses to these forces that have been designed and implemented at the SMU Institute of Technology and that reflect a part of planning for the next 5 years. (Author/HS)

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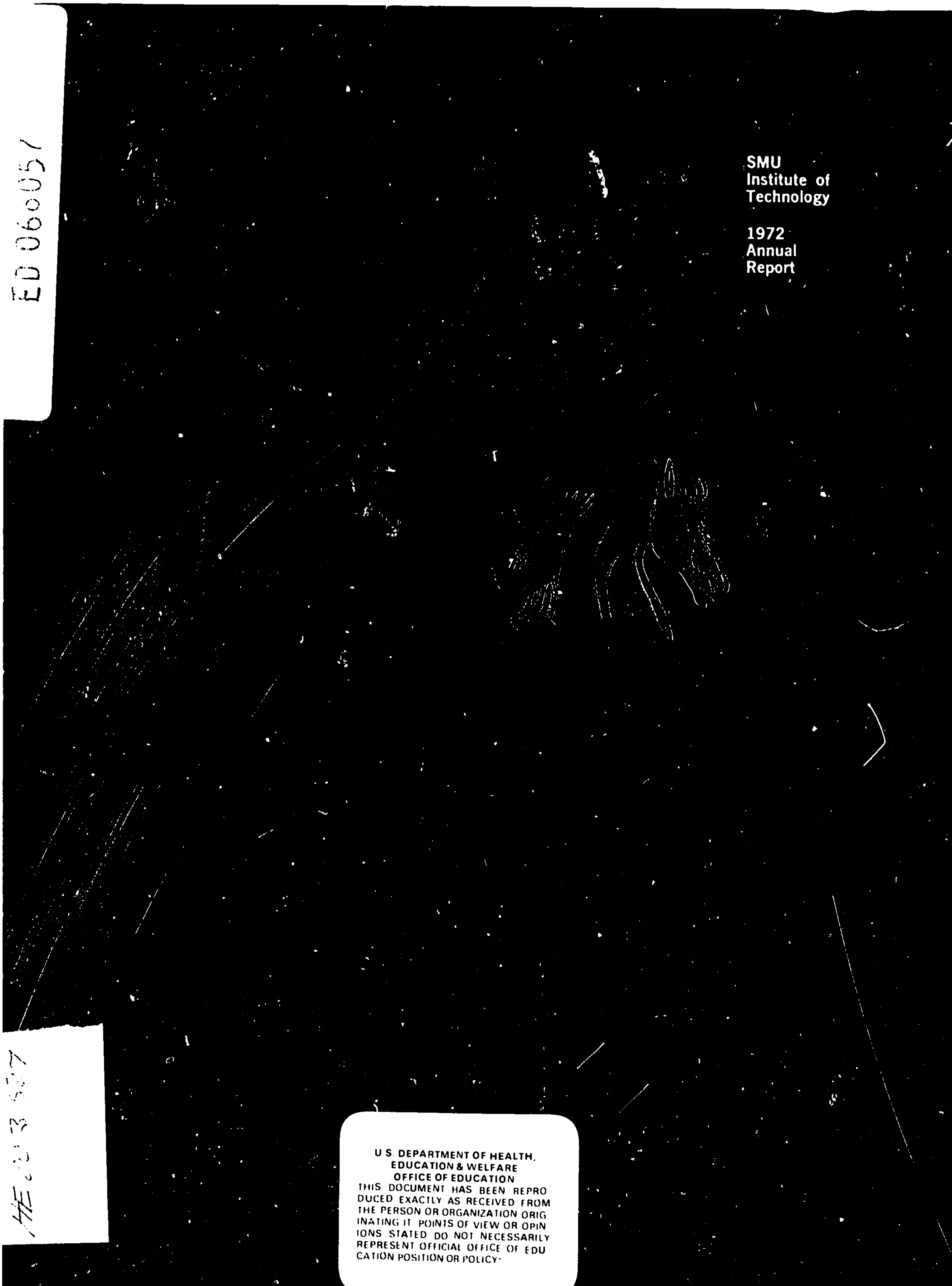


SMU
Institute of Technology

1972
Annual
Report

HE 003 597

Foreword

Five years ago, in early 1967, SMU changed the name of the School of Engineering to the Institute of Technology to signify a major change in its role, scope and objective. The new Institute of Technology was committed to the achievement of a specific objective — educational excellence of the first rank in engineering and applied science. Quality, not size, was to be its hallmark and measures of quality and performance were to be established so that progress toward goals could be measured.

Although a number of goals were set, those relating to the production of Ph.D. degrees were central to the achievement of measurable excellence. A five-year plan was developed to achieve the goal of producing an average of 25 Ph.D. degrees per year by 1972 — in early 1967 the school had not yet produced a Ph.D. in engineering. The plan revolved about the assembling of a bright productive faculty, the equal of those found anywhere in the best schools, and then establishing procedures whereby their productivity and effectiveness could be measured.

These goals have largely been secured. Ph.D. degree production reached 26 per year in 1971, 40 per year in 1972, and should remain in the range of 25-30 indefinitely. A first-rate faculty has been assembled and continues to grow in effectiveness, but not in size. Many new techniques have been developed to measure progress and productivity, building upon Terman's work, but also introducing some wholly new approaches unique to the SMU Institute of Technology.

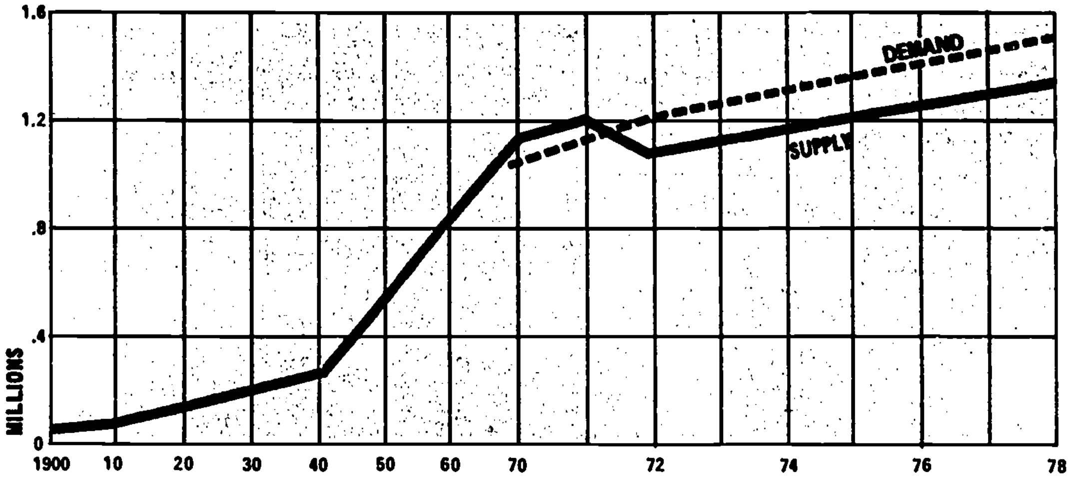
In five short years a quiet, but positive, revolution has been wrought. The SMU Institute of Technology has achieved national visibility in many ways and on many fronts. It is known as an innovative school which has a number of pioneering efforts to its credit. Most of the faculty are nationally known and very highly regarded.

With the earlier goals set in 1967 largely achieved, and with an entirely changed set of circumstances in 1972, the time has come to devise another five-year plan appropriate to current circumstances, but remaining true to the single goal of excellence of the first rank.

This Report seeks to identify the various forces at work which will affect technological higher education in the 1970's. In addition, the impact of these forces is assessed. This Report outlines some of the responses to these forces which have been designed and implemented at the SMU Institute of Technology and which reflect a part of planning for the next five years.

In the 1970 Annual Report of the Institute, the need for quantitative measures of institutional quality was featured; in the 1971 Report, an approach to evaluating faculty productivity and effectiveness was presented. In this, the fifth Annual Report of the Institute, it is shown that the external forces which affect future operations continue to point up the need for emphasis on educational productivity. A specific response by the Institute to this continuing need, described in this Report, is a major revision in faculty promotion and tenure policy. It is hoped that this can be initiated in the Institute in the academic year 1972-73. The objective of this plan is to assure continuing institutional self-renewal and consequent steady improvement in faculty quality.

As in previous editions, the second half of the Annual Report provides a summary and an interpretation of the various numerical factors used to reflect the current status and future prospects of the Institute of Technology.



CAREERS IN ENGINEERING

Let's set the record straight...

QUESTION:	What are the job prospects for a person going into engineering today?	ANSWER:	There will be a shortage of engineers before 1980 according to the Engineers' Joint Council and the U.S. Bureau of Labor Statistics. The graph above, modified from Fortune, June 1971 issue (sources: Bureau of Census, Bureau of Labor Statistics and Engineering Manpower Commission), tells the story. However, in 1975 the supply will drop below that shown in the graph, probably more than 25% simply because freshman enrollments in engineering have dropped significantly since the Fall of 1971.
QUESTION:	How did 1972 engineering graduates do in getting jobs?	ANSWER:	Engineering graduates did better than virtually any other discipline in getting jobs, according to a sampling of colleges across the country.
QUESTION:	What about job prospects for 1973 engineering graduates?	ANSWER:	There was an increase of 12% in job opportunities for engineers at the Bachelor's level in 1972 over that of 1971, according to a College Placement Council Survey. The increase should be greater for 1973 as the gap between supply and demand widens.
QUESTION:	Is engineering drying up?	ANSWER:	The challenges in engineering have just begun. Technology will progress more between now and the year 2000 than it has since the beginning of man.
QUESTION:	Are engineering salaries competitive with other fields?	ANSWER:	The chart below taken from the College Placement Council survey of July 1972 should answer this.

MORE QUESTIONS?

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Average starting salaries offered to 1972 graduates, according to College Placement Council Salary Survey - July 1972:

	Per Month	Per Year
Engineering - Chemical	$928	$11,136
Engineering - Mechanical	894	10,728
Engineering - Electrical	888	10,656
Engineering - Industrial	871	10,452
Engineering - Civil	869	10,428
Accounting	854	10,248
Sciences (Chemistry, Math, Physics)	795	9,540
Business - General	726	8,712
Marketing & Distribution	706	8,472
Humanities & Social Sciences	702	8,424

Adapted with permission of the Newark College of Engineering.

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Section I

PART I Statement of the Problem

The Critical Point

Growth and development, whether human, organizational, or national, tend to move rather discontinuously from one critical point to another. All too often one of these critical points is reached before its existence is discovered. With the critical point passed, the chance for decision vanishes and events move toward another decision point without a conscious choice of the path of approach.

In human growth and development the singular events of conception and birth are fairly well recognized. But early in development, within the first two or three years, there are a number of very important points that greatly influence later development. For example, according to Wyden:[1]

> "After age three the various aspects of a child's development will be more coordinated. By then a child is set on his biological track for life. Barring serious disease or accident, he is proceeding inexorably along the growth channels that are now set, and how well he does, how far he goes toward reaching his inborn potential, depends to a large extent on how he has been fed during the first 45 months of his life."

Business enterprises consciously seek to recognize these types of critical points in their development *beforehand* and make intelligent decisions which control their future development. Surely the decision by Texas Instruments Incorporated to move strongly into the transistor business was one of these singular points in corporate development. Other companies can undoubtedly cite similar examples. At the same time, many business enterprises have disappeared from the scene because they failed to recognize critical points which greatly altered their modes of operation and markets.

Today higher education, and particularly science and engineering education, seem to be fast approaching such a singular point. Such points are so rare in education that only a few people seem fully aware of the forces and factors that are leading to what may well be a decisive turning point in the history of American technical education. These forces must be brought into focus if, within the Institute of Technology, we are to make intelligent plans and decisions that would enable us to retain control of our future development.

A reading of the changes which have produced critical points for technological higher education in the past indicates the Institute of Technology of the future will operate in an environment which is principally determined by three partially coupled factors. These are:

1) Productivity (of various sectors of the economy)
2) Posture (changing values and goals of society)
3) Population (the numbers which relate to higher education)

The Productivity Factor

One of the broad and encompassing forces at work at this critical point for technological higher education is the relative productivity of the various sectors of our American society. This has been a subject of great concern to Patrick Haggerty[2,3] and a few excerpts drawn from his papers and speeches will highlight the situation in very general terms.

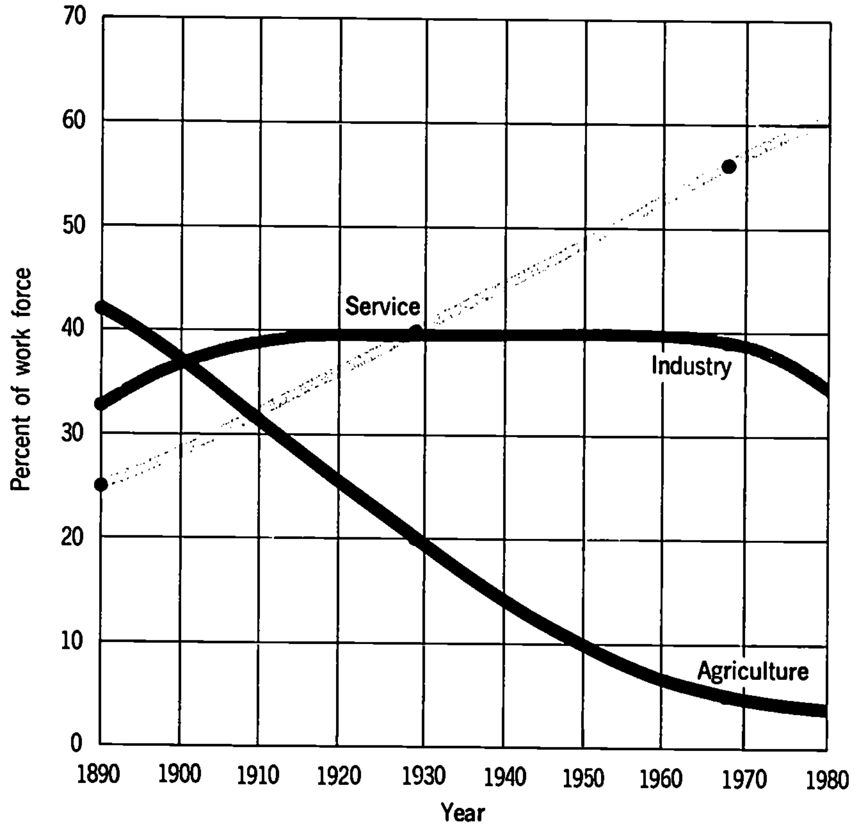
Figures 1 and 2 show trends in relative employment in three principal areas of the economy for several decades in the United States.

Consider agriculture first. In 1890 it required 42 percent of the work force to feed the nation. By 1967, through intensive use of capital investment and technology, only 5 percent of the national work force was required to feed a nation in greater abundance and to export huge domestic surpluses. There has obviously been a tremendous increase in agricultural productivity — an increase of more than eight-fold.

While industrial employment, as a fraction of the total, increased initially, it is now declining and will undoubtedly continue to do so. This decline, despite a huge increase in the industrial contribution to the gross national product, is once again clear evidence of the application of capital investment and technology to increase worker productivity. In fact, in 1967, agriculture and industry combined represented less than half (44%) of the nation's work force. It is even less today.

Relative Employment in the Three Principal Areas of the Economy 1890 – 1980

Figure 1



In contrast, the service industries — including education, government, health care, real estate, finance, trade and personal service — continue to absorb a larger and larger fraction of the working population. It is estimated that by 1980, 65 percent of the American work force will be in these service industries. It appears that there is nearly a one-to-one correspondence between the increasing demand for services and the employment required to produce them. In short, there is little, if any, evidence to indicate that productivity is increasing in the service sector of the economy. Indeed, quite the reverse appears to be true.

Characteristics of the Service Sector

There are significant differences in many ways between the service sectors and industrial sectors of the economy. According to Fuchs,[4] the service sector is characterized by many small firms rather than a few large ones, a much smaller ratio of capital investment per worker, more self-employed people (13% vs. 5%), more females (50% vs. 20%), more part-time workers, more oldsters, fewer union members and higher average educational attainment.

He goes on to observe that the principal method of increasing productivity in agriculture and manufacturing has been to increase the intangible investment; that is, to increase research, development, engineering, and the educational level of employees. The service sector is presently characterized by an under investment in these intangibles. If service sector productivity is to be increased, then intangible investment must be increased. When this occurs, as it must, then there will be increasing opportunities for technologically-educated people to play important roles.

Haggerty put the matter into somewhat sharper focus by consolidating the low productivity construction industry with the low productivity service industries enumerated earlier. He then combined agriculture with the high productivity industries of mining, manufacturing, transportation, communications and utilities. Figure 3 results. This shows that of the 24 million new jobs to be added between 1965 and 1980, 21 million will be in low productivity areas. Little wonder that there is galloping inflation in the U. S. with these rapid payroll expansions of people who are "overhead" in the national economy.

This led Haggerty to pose a question whose answer is critical to the future of the SMU Institute of Technology:

What are the really long-term implications[5] "of the apparent shift which has been taking place from agriculture, manufacturing, transportation, utilities and communications — where we have proved we know how to use technology and capital investment to get high annual rates of increase of productivity per worker — to the lower productivity services-producing areas, particularly government, where the record thus far suggests that we do not yet

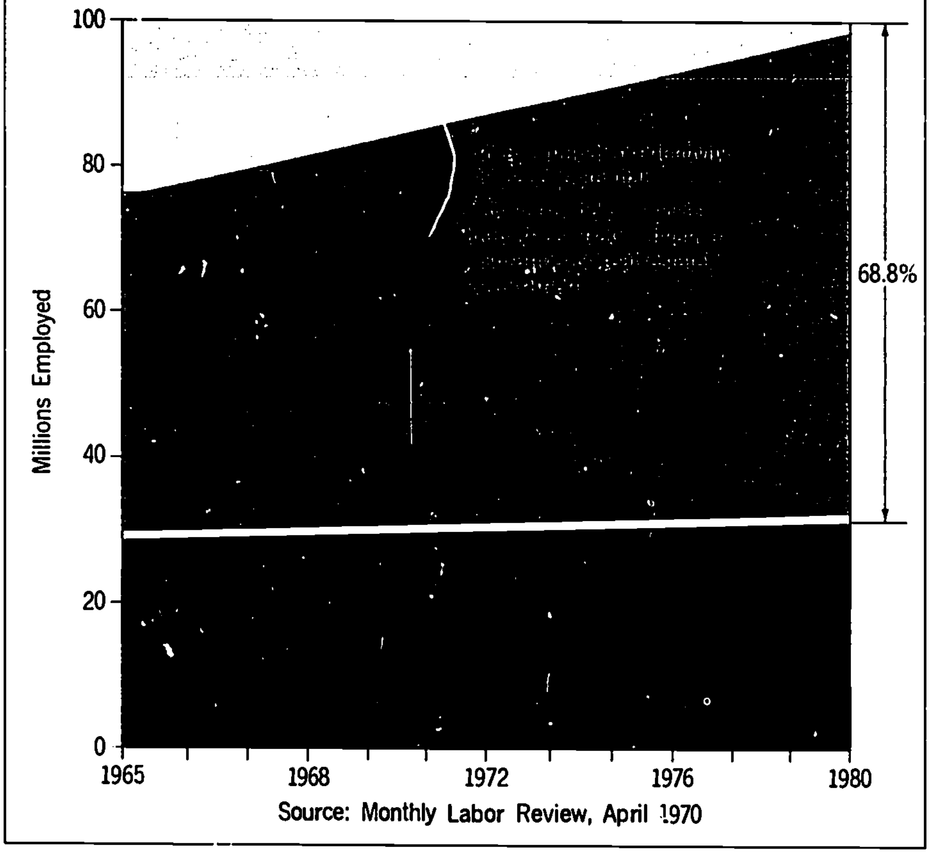
Relative Employment in the Three Principal Areas of the Economy for Selected Years

Figure 2

Employment Category	[illegible]	[illegible]	[illegible]
Agriculture	[illegible]	[illegible]	[illegible]
Industry	[illegible]	[illegible]	[illegible]
Service	[illegible]	[illegible]	[illegible]

Productivity Increase Potential of U.S. Employment Sectors

Figure 3



Source: Monthly Labor Review, April 1970

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[1] *Barbara Wyden, "Growth: 45 Crucial Months," Life Magazine, December 17, 1971, p. 95.*

[2] *Patrick E. Haggerty, "Inflation and the American Standard of Living," May 9, 1970, before the Business Council, p. 11, Fig. 6.*

[3] *Patrick E. Haggerty, "Remarks," November 20, 1970, before the National Commission on Productivity.*

[4] *Victor Fuchs, "The Service Economy," 1971 Annual Meeting of the National Academy of Engineering, November 1-3, Washington, D. C.*

[5] *ibid: p. 19.*

know how to increase annual productivity per worker at a rate sufficient to maintain the relative gains in productivity attained since World War II "?

Haggerty then goes on to state[6] a conclusion that is a significant guide to the future of the Institute of Technology:

"The need for sustaining high annual rates of productivity increase in the sectors of our economy which now have them and improving productivity sharply in those sectors of the economy where it is lagging certainly *calls for the application of increasing quantities and sophistication of technology.*"

Similar conclusions were drawn in a recent report by the Electronic Industries Association. It was concluded that there are several forces at work, forces being created by changes in labor, changes in social values, and changing technologies.[7]

"The labor-related forces include unavailability of people to perform menial labor, welfare availability that competes with low-level jobs, minimum-wage requirements, and an apparent long-term trend of labor costs increasing more rapidly than other components of cost. All of these forces suggest the need for a more rapid rate of technical innovation and a more rapid rate of increase in capital expenditures in the future.

"Social forces include environmental control, on which companies are beginning to spend substantial sums of money; the large body of law building up that will require a more vigorous response by industry; and the increasing application of technology needed to achieve the desired results. Improvements required in medical care, education, transportation, and law enforcement are examples of other social areas demanding increasing use of technology.

"In technology, the rapid change in materials and device technology is leading toward components and systems for which costs per function are continuing a downward trend relative to other costs.

"An analysis of these forces suggests that there will be a strong movement to automate the operational aspects of businesses in the decade ahead. In addition, instrumentation and process control will see heavy growth."

It seems apparent then, that in the future there will be a penetration of the service industries by engineers and others with educations firmly grounded in mathematics and the physical sciences. The need to improve productivity in this sector of the economy is very intense and it seems certain that educational programs aimed at this need should be successful.

The Situation in Education

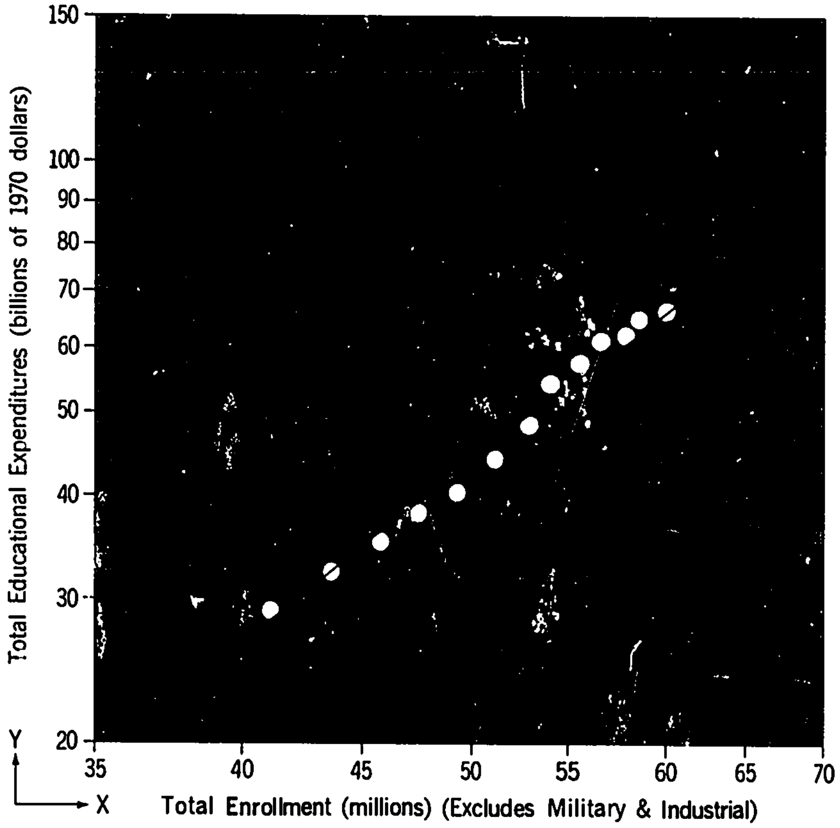
As a part of the service sector of the economy, the lack of increases in productivity in education is not to be overlooked. In fact, the situation in higher education can, at best, be described as appalling. The problem of productivity in education is graphically illustrated in information developed by Macdonald.[8] Figure 4 shows, on a semi-log scale, a plot of education expenditures as a function of enrollment. The linear curve that results is an exponential function of the form $y = bx^m$, where the exponent m is 2.4. A value of 1.05 might be reasonable, but 2.4 is shocking to say the least. This suggests a nearly catastrophic drop in productivity.

Admittedly, the origins of the problem of low productivity are complex. However, it should be recognized that most institutions of higher learning, in their quest for quality of a high order which is responsive to the needs of society, have employed a strategy which has compounded the productivity problem.

Since the early 1930's, with only a few exceptions, all attempts by educational institutions to achieve academic excellence and prestige have depended upon institutional expansion. With an awareness that the quality of the faculty is the key measure of any form of academic recognition, university administrators have brought in large numbers of young, aggressive, imaginative faculty attuned to contemporary needs. With this type of faculty on the leading edge, the effects of older more conservative, less innovative faculty would be swamped out. This strategy has been possible only because the increased cost of these additional fac-

Education Productivity Problem

Figure 4



ulty members could be covered by the inexorable increase in enrollment that always occurred and in the ever-increasing federal support of faculty research.

In other words, expansion has been the means by which quality has been achieved. But expansion requires all kinds of additional institutional resources so that operating costs have escalated steadily and productivity has correspondingly decreased. Historically then, it has been traditional for the past 35 years or so at most schools to seek quality through faculty expansion. After a while people begin to make the mistake of equating faculty size with faculty quality. Carried to its logical extreme, this idea suggests that educational institutions will always require more and more money to sustain themselves. This is *not* true — expansion is not essential to quality *if* the school has carefully laid plans and strict policies regarding faculty acquisition and retention.

All too often, indeed almost uniformly, educational pleas for additional funds — whether for general operating support or for endowment — can generally be tracked back to a cry for more money to allow more expansion to swamp out a problem rather than solving it. Thus, the results compiled by Macdonald are not surprising.

As our society places a higher priority on achieving greater productivity in the service sector and as the economic incentives to accomplish such a shift materialize, the implications for technological education will become apparent. There will be an increasing demand for technologically-trained people to apply their talents to provide an increase in productivity. We should not, however, conclude that the highly productive sectors of the economy will require fewer people because, to remain internationally competitive, the nation must sustain its investment in the intangibles of research and engineering which up to this time have been the source of our national competitive edge.

With respect to the situation in higher education, the mandate from those who now support education with appropriations and philanthropy will be in the form of a writ requiring more effective use of these funds. This will force changes in the strategies used to achieve and maintain quality in education. Alternatives to reliance on expansion to achieve and sustain quality will have to be found. Specific strategies planned for the Institute will be covered later.

Posture — Changing National Goals and Values

The second major force at work at this critical point which affects higher education in engineering and applied science is the matter of changing national values and goals. For example, what effects result from the drastic cutbacks in government spending on defense and the space program? Will they be offset by higher government spending for socially-directed programs? A quotation from the recent report of the Electronic Industries Association[9] is apt:

"It is expected that defense expenditures will decrease for the foreseeable future, and that the space program will continue to remain at the present level for a few years and then edge upward to approximately $5 billion as the shuttle program develops and the Mars and Venus programs are determined. There will be substantial increases in expenditures for transportation, housing, education, health services, environmental control and law enforcement. However, we do not expect that in the near future the decrease in defense expenditures for electronics will be offset by increases in socially-oriented programs. This is not due to any fundamental lack of need for technology in domestic programs, but rather to the difficulty in defining clear-cut goals that will generate broad support. It also results, in part, from the fact that defense expenditures have a higher percentage of workers in the engineering and science category than in other industrial segments."

Actually, there are extremely wide variations in the number of engineers required, per dollar of expenditure, in various types of industries. This was illustrated in the 1972 Manpower Report of the President which was transmitted to Congress in March 1972. Figure 5 is from page 111 of that Report.

It is obvious from this tabulation, gross though it may be, that changes in the types of goods and services produced can have a tremendous effect upon engineering employment.

Some of the socially-oriented areas that will definitely receive increasing attention in the coming years include the following:

> environmental pollution and protection, consumer protection, population control, housing and construction, urban transportation of people and goods, law enforcement and judicial procedures, health care and its delivery, education and so on — overall attention will focus with increasing sharpness upon the concept and policy view of "Space Ship Earth".

Engineering Employment in Different Industries

Figure 5

Type of goods and/or services
Aircraft
Ordnance
Capital goods
Construction
Personal Consumption

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[6] *ibid: p. 12.*

[7] *"Economic Conditions in the U.S. Electrical, Electronic, and Related Industries — An Assessment,"* Electronic Industries Association, *December 27, 1971, p. 13.*

[8] *Dr. J. Ross Macdonald, Vice President, Corporate Research Laboratories, Texas Instruments Incorporated.*

[9] *ibid: p. 9.*

In the main these are areas identified by Haggerty as those characterized by low productivity. They are also areas which have not been penetrated by engineers or others educated in the physical sciences. Nor have they been characterized by high capital investment in the same sense as in manufacturing and the other high productivity areas.

It is becoming abundantly clear that the problems in the socially-oriented areas will begin to be solved only when the role, functions and potentials of technology are understood far more broadly than is true today. There are actually at least three identifiable dimensions to this problem. They were summarized in the recent report, *Social Directions for Technology*, published by the Commission on Education of the National Academy of Engineering. The needed efforts were identified as follows:

1. Education of engineers in the social sciences to the same degree as in the physical sciences.
2. Education of a broad spectrum of society in technological alternatives.
3. Improved public understanding of technology.

Given all the criticisms of traditional engineering education and given all the forces of change now at work, it could be concluded that the entire fabric of engineering education should be changed to accommodate the new demands of society. Nothing could be more wrong.

Despite the clamor of the zealots over issues of environment and ecology, national needs for increased energy sources will be placed in proper perspective. There will be constantly expanding demands for more communications, more transportation, more food production, more minerals, more and better housing, and more manufacturing. The technological competition with foreign countries will intensify. National defense requirements will continue to necessitate strategic and tactical weapons development. The solutions of our environment problems will require more technology and more engineering.

Of course, all of these areas — military hardware, agriculture, manufacturing, utilities, communications, mining — are all the high productivity areas identified by Haggerty. And, historically, of course, engineering schools have produced graduates who entered these fields. In fact, they are high productivity areas primarily because capital investment and the employment of scientists and engineers intersected in these areas. Every indication shows that the traditional types of engineers — electrical, civil, mechanical and so on — will continue to be needed in the future in *at least* the same numbers as in the past. In fact, there is every reason to believe that more will be needed than ever before.

But, there are *additional* needs demanded by society and not met by the existing breed of engineers. For example, a common view was given by the Electronic Industries Association:[10]

"The early training of engineers and much of their professional experience are focused on what might be termed 'physical' technology. In many parts of our society technologists are looked to largely as a means of applying new physical technology to solve specific problems of improving productivity. This view of the role of engineers has often led to the restriction of the application of technology to limited classes of problems.

"To accomplish the transition that is being sought to solve socially-oriented problems, it will be necessary for engineers to expand their understanding of society's needs to the point where they can participate in the optimum allocation of resources to meet those needs and contribute to meeting them through operational as well as physical technology.

"We see this changing role of the technologist as essential, but one which will come somewhat slowly and require his substantial education in the needs and operational mechanisms of our society."

It is important here to understand that this does *not* infer discontinuance of present engineering concern and attention to productivity in "physical" technology. The demand for such engineers remains and will continue with significant intensity. What is clear is that there is a rising demand for technologically educated people to interface with the social and life sciences in solving problems of social concern.

There are those who insist that social problems can only be solved by engineers. This view of the *unique* role of the engineer is all too common in engineering circles. Conversely, social scientists tend to insist that technology caused the present spate of problems and that the social sciences will solve them. Neither view is correct, of course. Sage[11] put it quite precisely:

"An attractive, but unfortunately simplistic, view of public and societal systems problems is that their solution consists of devising better *engineering solutions*. Unfortunately, technology transfer to the public sector cannot be achieved by engineering alone because technology does not provide total and complete problem solution. Many examples of technologically sound plans can be cited which never reached the stage of practice because of inadequate understanding and appreciation for the social sciences.

"The development of the technology to effectively control increasingly complex and interdependent public and societal systems will take place only when agreement is obtained regarding long-term societal goals. Technical and social considerations cannot be divorced in this determination. Conclusions derived from either technological or sociological considerations only are doomed to failure. The two approaches must merge and be combined."

The foregoing certainly identifies several dimensions of the problem, but there are others. For example, the *rigidity* of contemporary engineering curricula has a number of unfortunate consequences. For one, it does not allow any substantial student exposure to societal values, problems and operations. For another, it is unresponsive to changing educational needs arising either from industry, society or from the students themselves.

Programs underway at the Institute of Technology aimed at these problem areas are summarized in the discussions to follow labeled, "Solutions for the Seventies." But before turning to the specific proposals for a re-direction of engineering education, it is necessary to delineate another force at work which is causing the emergence of this unique critical point in engineering education.

The Population of 22-Year Olds

The size of the college age population is obviously an important index in estimating the potential number of students to be served by the system of higher education. Actually, however, the population group that is critical is the number of 22-year olds, because this is typically, though not exclusively, the age for completion of the bachelor's degree.

Figure 6 shows the annual population of 22-year olds in the United States.[12] "Note the nearly level period from 1925 to 1955 of about 2.2 million per year (F–F); the growth period from 1955 to 1983, from 2.1 million to 4.3 million (G–G); and the drop in size from 1983 to 1992 from 4.3 million to 3.5 million (a 20% drop in 10 years) (H–H). Note also that the number of 22-year olds in 1969 (3.5 million) is essentially the same as the number of 22-year olds projected for 1991 (X–X)."

The data up to 1992 are as forecast by the Bureau of the Census and based upon people already born. After 1992 the data are purely conjectural. There are many people who feel that the increase shown in this figure after 1992 will not materialize. In fact, there are some who feel that the recent very sharp drop in the birth rate suggests that zero population growth may well occur soon after the year 2000.

If the number of 22-year olds in 1991 is less than in 1971, it seems likely that the college population will be essentially constant during this 20-year period. Put somewhat differently, this examination of trends in population statistics shows that the total size of the faculty in colleges and universities in the United States will remain essentially constant until about the year 2000, because the college population served is likely to remain virtually constant. This prediction seems particularly valid in the case of the faculty in the areas of the physical sciences and engineering. This is a remarkably different situation from that of the past 35 years or so—being rather similar to circumstances during the depression years of the 1930's.

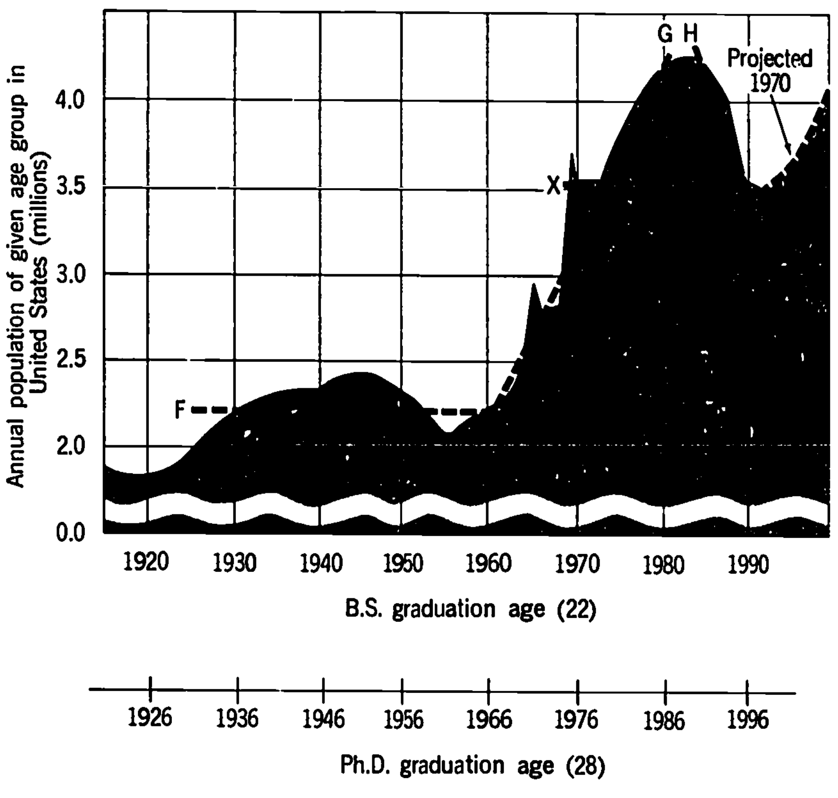
With the size of the faculty becoming essentially fixed, and with the tenure situation being as it is, the tendency will be for the faculty to grow progressively older unless decisive actions are taken. Typically then, the necessary factors of youthful exuberance, vitality and imagination will disappear from the campus; faculty quality will decline and with it, institutional quality and prestige will drop.

Population Factors in Science and Engineering

Of course, more and more students have been going to college in recent years so that a higher and higher fraction of the 22-year olds have college degrees. This is shown in Figure 7.

Annual Population of 22 Year Olds in the United States

Figure 6



Percent of 22-Year Olds with College Degrees

Figure 7

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[10] *ibid: p. 12.*

[11] *Andrew P. Sage, "Bachelor of Applied Science in Societal and Public Systems,"* SMU Institute of Technology, *November 15, 1971.*

[12] *Wallace R. Brode, "Manpower in Science and Engineering Based on a Saturation Model,"* Science, *V. 173, pp. 205-213, 16 July 1971; Fig. 5, p. 211.*

This could suggest that even though the number of 22-year olds remains almost constant, the number going to college could increase. During this same period, however, the fraction of students graduating in engineering and science has been declining as shown in Figure 8 taken from Terman's work.[13] This shows that the ratio of engineering and science baccalaureate degrees has been declining. In the case of engineering it has declined from a peak of about 16.5 percent to about 10 percent now. Enrollment reports for 1971 reveal a very substantial additional decline apparently approximating at least 18 percent nationwide at the freshman level.

Wallace R. Brode, past president of the American Academy for the Advancement of Science, concludes that:[14]

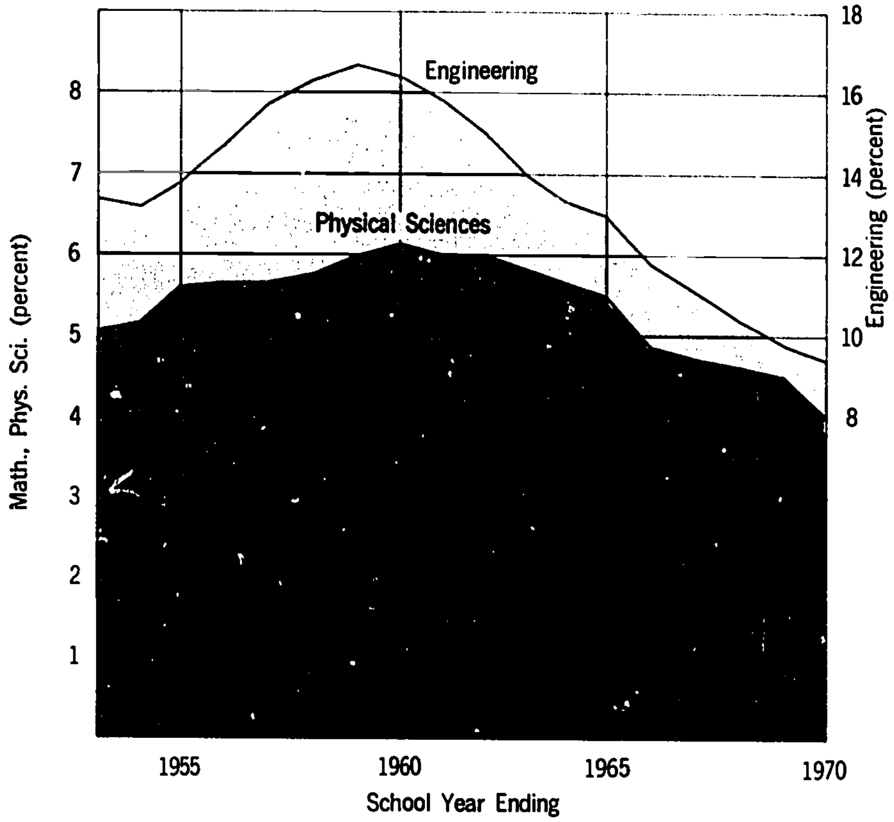
> "It has become increasingly evident from . . . many studies . . . that only a limited portion of the college age population (18–22) has the motivation and ability to complete a scientific or engineering course. Since 1960, the percentage of 22-year olds graduating in science and engineering has been essentially constant at 3.8 percent of the college-age population . . . In addition, there is ample evidence that the growing number of college students and graduates is concentrated largely in the social studies and, in general, involves those who have neither the motivation nor the ability required for science and technology."

We will return to this last and rather sweeping statement by Brode shortly.

Figure 9, taken from Brode,[15] projects the distribution of graduates with B.S. degrees in science and engineering as a percent of the 22-year olds. Note that all of these areas are approaching saturation limits. For example, he forecasts that engineering will saturate at a level of about 1.3 percent of the 22-year old population — it now stands at about 1.2 percent. All natural science and engineering combined is projected to saturate at about 4.0 percent of the 22-year olds.

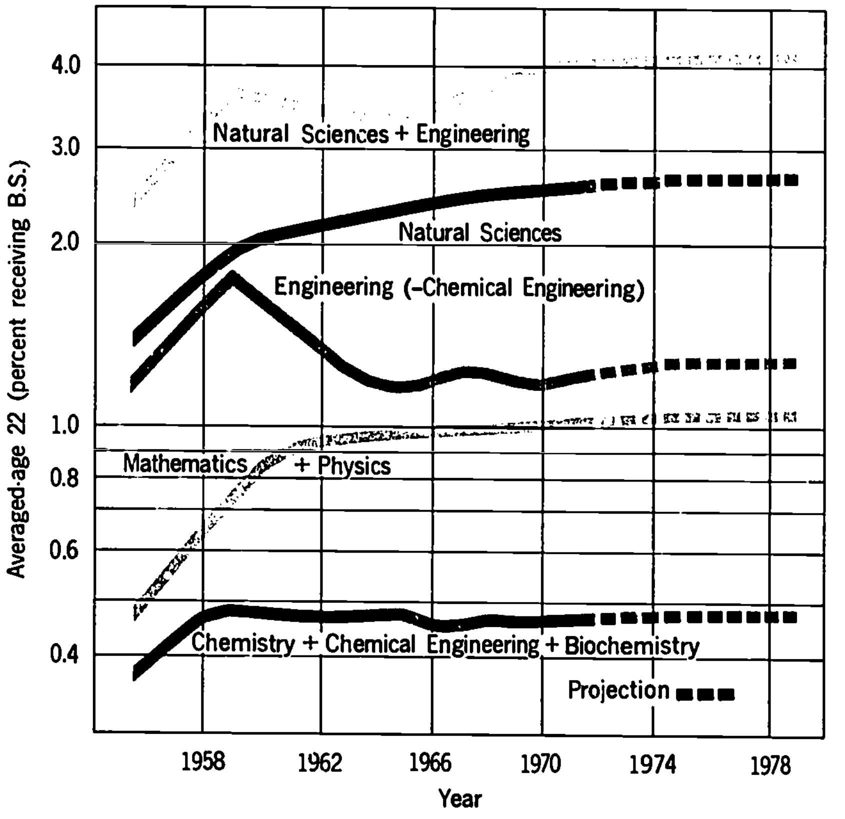
Ratio of Engineering and Science Baccalaureate Degrees (men) to all Baccalaureate Degrees (men)

Figure 8



Distribution of Graduates with a B.S. in Natural Science and Engineering, as a percent of all 22 year olds

Figure 9



In considering data of this character, with particular reference to the number of 22-year olds, Terman[16] stated:

> "It is a simple matter to project the baccalaureate output of scientists and engineers into the next decade. During the next few years, there will be a rather sudden and substantial across-the-board rise in numbers, mounting to perhaps 20-25 percent as a result of the sudden increase in 22-year olds beginning 1969."

Graduates in Engineering and Science

Unfortunately, the declining economic situation since 1969, coupled with the incredibly bad publicity given to science and engineering in 1969, 1970 and 1971 has caused a precipitous drop in engineering enrollments nationwide. Many large engineering schools experienced drops in freshman enrollment in 1971 of 35 percent. Reductions of 15 to 20 percent were common throughout the nation.

The drop in freshman enrollment has been coupled with a larger than normal upper-class flight from engineering. As a result, it appears very unlikely that the engineering and science degree output will rise as initially thought and as described by Terman. Indeed, it appears that it will drop to very serious low levels by 1975 and thereafter.

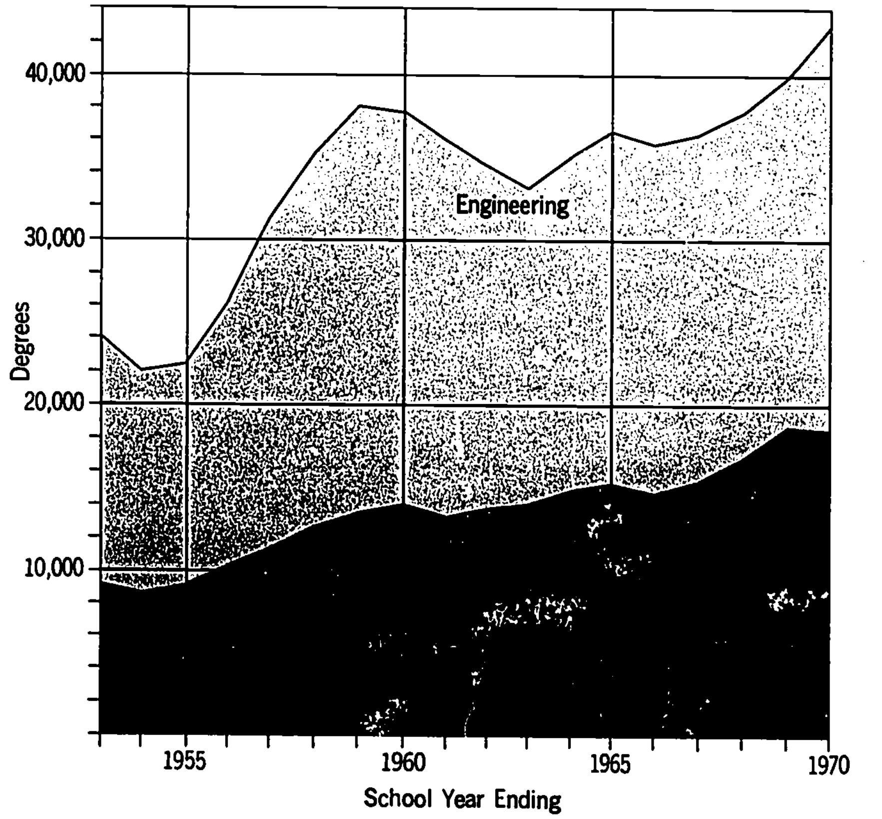
Thus, the problem faced by American engineering schools today can be stated quite specifically:

> With an essentially fixed size, how can the faculty quality continue to be increased; how can its responsiveness to changing needs be maintained; how can the age balance be maintained so that it is self renewing with frequent and periodic infusions of youthful zest, enthusiasm and imagination? Terman[17] then goes on to say that:
>
> "One can then expect the number of baccalaureate degrees in the EMP (Engineering-Math-Physical Sciences) area to decrease gradually year by year as a result of a steadily decreasing percentage of men interested in these fields. There is presently nothing to indicate that this flight from engineering and the mathematics and physical sciences will cease in the foreseeable future, and there are some reasons to fear that it may even accelerate."

Thus, the pattern of baccalaureate degrees awarded to men, as shown in Figure 10,[18] is not expected to show any particular growth through 1990, and probably into the year 2000, except for a possible small pulse in 1972-1982. Bear in mind that these forecasts implicitly assume continuation of existing academic programs and do not allow for the implementation of new academic strategies.

Baccalaureate Degrees Awarded to Men in Engineering and in Major Areas of Science

Figure 10



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[13] F. E. Terman, "The Supply of Scientific and Engineering Manpower — Surplus or Shortage," draft copy, Fig. 4.

[14] *Brode, op.cit., p. 206.*

[15] *Brode, op.cit., Fig. 3, p. 209.*

[16] *Terman, op.cit., pp. 5-6.*

[17] *ibid: p. 19.*

[18] *Terman, op.cit., Fig. 5.*

Intellectual Attainment of the Population

Figure 11[19] shows the changing educational pattern in the U.S. during the 15-year period from 1954-1969. This shows the scores earned by various categories of students who took the Army General Classification Test (AGCT) at two different points in time. The AGCT test is essentially an IQ test and the scores generally measure intellectual attainment. Thus, for example, a score of 110 is the minimum acceptable for admission to Officer Candidate School. The table shows that in all cases except one the mean scores on the Army General Classification Test have dropped as the percentage in any particular student category has increased, including those graduating from college. The one lone exception is in science and engineering which has maintained a constant mean AGCT score of about 135 for its graduates, indicating that academic standards have been maintained for these students during the past 15 years, whereas they have declined in all other areas — assuming that the AGCT test is a valid measure.

There is pressure, of course, to reduce collegiate standards and admit all students who apply. This led Brode[20] to observe:

> "It would . . . appear that in 1969 there are few uncommitted students available, unless science and engineering were to reduce qualifications or standards to include those who appear, on the basis of test scores, to lack ability."

He then goes on to say:

> "If all applicants are to be admitted to and graduated from college, it may be well to separate by institutions, type of degrees and curricula such subjects as science, engineering, medicine and law, as compared with social studies, education and business areas."

The problem is further compounded by the unnecessary expansion of engineering schools that has occurred in the past decade, despite a nearly constant supply of students. For example, in 1959 there were 154 engineering schools with curricula accredited by the Engineers Council for Professional Development. These schools produced 33,200 B.S. degrees. In 1970 there were 208 accredited engineering schools that produced 38,343 degrees. Thus, a 35 percent increase in the number of schools produced less than 11 percent more graduates. Moreover, in 1970 there were also 67 non-accredited schools in addition.

It is obvious that too many schools are competing for too few students; as a result, most engineering schools are underpopulated and uneconomic. Some excellent engineering schools are closing their doors as a result. These include St. Louis University, Florida State University, and New York University. More are certain to follow suit.

Thus, there is good reason to believe that engineering enrollment nationwide, and engineering faculty size as a result, will be nearly constant up to about 1990 and even beyond. This could be a serious problem as noted earlier.

But, in reality, a problem such as this is nothing more than an opportunity in disguise. The trick is to penetrate the disguise and reveal the opportunity. This led to Terman's Law:[21]

"The restrictions imposed by a stable faculty can, with skillful administration, be used to force the very highest quality in the faculty." The specific details of the process are described later.

Of course, this view of the future is derived, fundamentally, by seeing what happened in the past and assuming that it will continue in the future. For example,[22] "half of those who choose science and engineering (initially) move to the humanities and social sciences." These are qualified students, as good as those who graduate — they simply become disenchanted with engineering. It has always been so and nearly everyone feels it will always be so. But, is this conventional wisdom really true? Must this really continue? If it does not, then in this one area there is potential for doubling enrollment and making significant contributions to the technological sophistication of substantially larger fractions of our future national opinion leaders and decision makers.

Changing Educational Pattern

Figure 11

Total age groups	100	100	100	100
High school entrants	79	93		
High school graduates	58	80	110	100
College entrants	20	50	115	110
College graduates	12	21	118	115
General Studies	3	8	110	107
Science/Engineering	2.5	39	132	134
Junior college graduates + college entrants not graduating	8	29	110	108
High school graduates who do not enter college	38	20	106	97
Students who do not graduate from high school	42	20	90	75

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[19] *Brode, op.cit., Fig. 2, p. 208.*

[20] *Brode, op.cit., p. 208.*

[21] *F. E. Terman, "A Program for Faculty Planning," October 1967, p. 19.*

[22] *Brode, op.cit., p. 206.*

PART II Solutions for the Seventies

The foregoing analysis of the current critical point in engineering education makes the following specific points:

(1) Productivity in the service sector in the national economy is low and not increasing and is a significant factor in producing continuing inflation.

(2) Institutional expansion has been used as a means to achieve quality in higher education and the result has been a substantial reduction in educational productivity.

(3) National values are undergoing significant changes which will lead to intensified activity in socially-directed problems, generally associated with the low productivity service sector areas.

(4) The number of students studying engineering as currently defined is unlikely to change in the foreseeable future, not before 1991 in any event.

The sections that follow describe Institute plans and programs for the 1970's which seek to be responsive to each of these critical issues.

New Baccalaureate Degree Programs

It is essential to increase enrollment in the Institute if it is to remain economically viable. This is an unlikely prospect as long as engineering curricula remain so rigidly prescribed and so limited in scope. In other words, it is necessary to change the way engineering and engineering curricula are currently described. This should attract more students into these programs, reduce student attrition somewhat, and lead to programs responsive to new national values relating to socially-directed applied science.

Two "new" degree programs have been created to allow greater flexibility for the student in the attainment of legitimate academic objectives which are not comprehended by the largely fixed curricular requirements of the designated engineering degree programs. One of these new degrees is the Bachelor of Applied Science, B.A.S. The other is the Bachelor of Science in Engineering without designation of area, B.S.E.

Under the new programs, for example, a student with a strong interest in both computers and quantitative modeling in the social sciences would be able, with the guidance of his advisor, to structure a degree plan which would enable him to pursue a meaningful course of study applicable to societal problem solving. This is not generally possible in traditional engineering curricula. This plan also permits students with orientation toward socially important problems to direct their curriculum to include emphasis upon the problems and operations of society. This should lead to the entry of scientifically-educated students into the service sector of the economy.

Certain areas of concentration which have sufficient numbers of students have been formally identified as areas of concentration and have more formally organized and defined curriculum plans. At present these include:

Electronic Sciences
Biomedical Engineering
Management Systems
Computer Sciences
Environmental Systems
Operations Research
Societal and Public Systems
History of Technology

Other formally defined areas of concentration may be defined from time to time. Both the B.S.E. and B.A.S. degrees include a "General Interdisciplinary" option. This area exists to allow the development of plans of study for individual students whose academic objectives are not well comprehended by any of the existing formally organized curriculum plans, such as the example mentioned above of a joint interest in computers and social science.

General degree requirements were established within very broad guidelines as follows:

Requirements for the Bachelor of Science in Engineering:

At least

15	semester credit hours in the basic sciences of chemistry, physics, biology, geology
15	semester credit hours in mathematics and statistics beyond trigonometry
24	semester credit hours in liberal studies
30	semester credit hours in the engineering sciences
44	semester credit hours chosen to develop the ability to apply pertinent knowledge to the identification and solution of practical engineering problems
2	semester credit hours in PE or ROTC
130	semester credit hours total

Requirements for the Bachelor of Applied Science:

At least

15	semester credit hours in the basic sciences of biology, physics, chemistry, geology, and the social, behavioral and management sciences in compliance with University College requirements
15	semester credit hours in mathematics beyond trigonometry
24	semester credit hours in liberal studies
70	semester credit hours in electives chosen from advanced courses. The pattern elected must be designed to develop the ability to apply pertinent knowledge to the identification and solution of practical societal problems
2	semester credit hours in PE or ROTC
126	semester credit hours total

The Environmental Systems Program

The Environmental Systems Program is an excellent example of how this new educational plan operates to be responsive to the necessary national values and changed social directions for technology. This is organized as a program within the Bachelor of Applied Science degree. It attracted a good-sized cadre of excellent students in its first year and promises a continuing vitality in the years ahead.

The Environmental Systems Program is designed to educate an individual so that he will have an understanding of the complex technical and social factors which must be invoked to produce practical solutions to environmental problems. He will be able to identify the causes of environmental behavior and also have an awareness and a competence in the techniques which may be used to *change* and *improve* the physical surroundings.

Technology and social behavior interact to create the environment in which we live. The elements which will provide major contributions to the alleviation of environmental problems are:

(1) Social and political considerations
(2) Biological considerations
(3) Scientific principles which govern the generation, dispersion, and elimination of pollutants and environmental hazards
(4) 'Modeling and systems analysis techniques for the study of complex environmental systems
(5) Practical engineering and economic considerations

All of the above elements are represented by courses in the environmental systems curriculum. Additionally, elective courses may be chosen by the student to provide further specialization and concentration in those areas of greatest interest to him.

Because the Environmental Systems Program affords the student a broad education, it is expected that, upon graduation, he will be able to function equally well in a government agency or in an industrial organization concerned with its environmental control responsibilities. The coupling of course work in the social sciences and technology will enable the graduate to occupy a unique societal interpretive position, and a satisfying role in organizing and implementing positive actions to improve the environment.

Thus, the Environmental Systems Program should be equally attractive to students with scientific interests as well as those who wish to channel their feelings of social concern into positive and constructive action.

A Different Approach

The program in Environmental Systems is responsive to the need to educate engineers in the social sciences as intensively as in the physical sciences. However, this type of approach *alone* will not solve current national problems to any significant degree.

The process of simply providing engineers with broadened education in the social sciences, economics, law and political science is not going to inject them into the decision-making apparatus of society. The *structure*, reward systems, values and operational formats of American society are rather firmly and extensively established. These all effectively rule the engineer out of most of the social decision-making apparatus of the country. This is unquestionably unfortunate—but it is fact and a few thousand engineers with contrary ideas are unlikely to cause the United States to completely revamp its entire structure overnight.

Rather, it seems abundantly clear that engineers must learn to work through the existing systems to achieve technology transfer to these areas of social concern. This means that engineering schools must look toward the technological education of students in the liberal arts who move on into law, politics, government and the other areas and who are active participants in the processes of social decision making, in remaking societal software. Quick success should not be anticipated — actually a 25-year view should be taken so that at least two generations of students can be graduated with good knowledge of technology and technological alternatives. When law, economics, politics, and government are populated by people with this background then it is likely that technology transfer to the low productivity areas of social concern will occur. It is also likely that the decision-making process will gradually change so that engineers can more generally be included.

Education in Technological Alternatives and Public Understanding

Partly as a result of the redirection of curricula in the Institute of Technology and partly because of their intrinsic worth, a number of new courses have been developed for use by engineers and non-engineers alike — aimed primarily at assessing technological impact and exploring alternatives.

A representative example of such a course aimed at education in technological alternatives is one offered by the Information and Control Sciences Center entitled *Dynamics of Public and Societal Systems*. As might be guessed, this deals with the representation of urban and societal systems as multiple loop feedback control systems and brings in goal conflicts, inequality constraints, framework structures for policies, simulation and the need for adaptive models. It quite evidently builds on the work done by Jay Forrester at M.I.T.

Other courses aimed at increased public understanding of technology have taken two different tracks. One of these is in the *History of Technology* and another covers *Engineers in History*. These are both two-semester sequences taught by an eminent historian and enrolling engineers and non-engineers alike.

Along a second track several new freshman courses have been introduced that are available to engineers and non-engineers alike. One entitled *Systems, Man and Society* is a slightly upgraded version of the *Man-Made World*. It was well received last semester. Another treats *Energy, Technology, and the Environment*. The course includes, in four-semester hours, the following topics:

Technology and man's attempt to cope with his material environment vs. ideology and attempts to cope with spiritual environment.
The energy crisis.
Energy resources.
The environment — energy balance and social concerns.
Principles of energy conversion.
Present and future energy utilization methods.
Energy utilization as an overall problem in urban design.
Priorities for the future.

Such measures, when implemented on a national basis, should begin to provide a solid foundation for the reconstruction and development of new societal software more nearly compatible with the hardware of technology. Engineers and engineering schools will play significant roles in this process, but results will not be achieved overnight — let's hope they will be in time.

Blueprint for Self-Renewing Excellence

It was shown earlier in this report that faculty size in engineering education is likely to be essentially constant over the next 20 years or so. So, a new problem exists: with an essentially fixed size, how can faculty quality be increased continually? This section sets forth the bare details of a plan for eventual implementation in the Institute of Technology.

It is planned that the *total* faculty size of the SMU Institute of Technology will be large enough to do a few things extremely well — with a *critical* mass of faculty in each major area. According to the National Science Board[23] the *minimum* faculty size for true excellence of the first rank is between 45 and 50. This size will be maintained at SMU until the endowment in the Institute of Technology reaches $12 million. Thereafter, one additional tenure position will be added for each additional $600,000 in new money added to the endowment.

This baseline faculty will not exceed 50 full-time positions in total. *Not more* than 30 of these positions will be tenured at any one time — the remaining positions will not carry tenure.

The non-tenured positions will be identified as *Junior Faculty*. The Junior Faculty will consist of Assistant Professors, who may serve terms not to exceed a total of five years, and Associate Professors who may serve terms not to exceed three years. The *Senior Faculty* will all be full professors and all will carry tenure. The number of Junior Faculty can vary somewhat with needs, but should range between 0.4 and 0.6 of the Senior Faculty.

Junior faculty will nearly always be brought in at the beginning assistant professor level. Assuming excellent performance such appointees can continue for five years in this rank, be promoted and continue for three additional years as an Associate Professor. Thus, a total of eight years may be available for professional establishment and the achievement of national visibility.

Tenure vacancies on the Senior Faculty will be filled by finding the *best man*, wherever he may be — whether one of the Junior Faculty on campus, or elsewhere. Such appointees will generally be under 40 years of age except in very special or unusual cases.

Tenure positions that become vacant because of death, retirement or resignation will not necessarily remain in the same professional or research area, but will be assigned where the Dean feels the maximum strategic effect can be secured. Manpower needs in various administrative units will vary from time to time with student demand and related factors. These can be met by adjusting the number of Junior Faculty, Visiting Industrial Professors or even Graduate Assistants. Such fluctuations are not construed to represent a justification for the assignment of additional tenure positions.

Occasionally additional new money might be available, but less than the $600,000 required for a new tenure position. The available funds plus interest could be programmed to be expended in toto over some specified term — the term desirably approximately the retirement date of the incumbent. The position would then drop from the tenure roster when the term expires.

These policies, when fully matured, should assure the SMU Institute of Technology of self-renewing excellence in perpetuity.

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[23] *"Graduate Education — Parameters for a Public Policy," National Science Board, 1969, Supt. of Doc., U.S. Gov't. Printing Office.*

Section II

Freshman Enrollment

Last year's Annual Report pointed out three factors which are making recruiting of qualified engineering freshmen difficult:

1. Bad publicity concerning unemployed engineers.
2. Three consecutive tuition increases at SMU.
3. A current anti-technology attitude among many young people who are concerned with ecological and social problems of the world.

The Report predicted a decline in engineering enrollment in the fall of 1971, and this prediction proved to be correct. Fall enrollment figures showed 157 freshmen students in curricula offered by the Institute of Technology. The drop in engineering enrollment was quite large since approximately 40 percent of this total are applied science students in computer science and environmental systems.

Similar declines in engineering freshmen enrollment were reported at most of the nation's universities. Unfortunately, recruiting is more difficult this year than last!

Although the freshman class is smaller it is the best ever by qualitative measures. Enrollment and class profile information are shown in Figures 12 and 13.

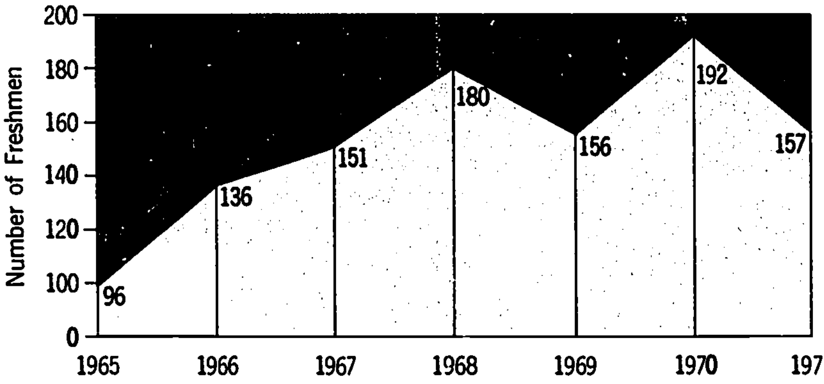
Geographic Origins
Freshman Class 1971-1972

Dallas County	31%
Other Texas cities	29%
Other states	37%
Foreign countries	3%

The Undergraduate Cooperative Program

Cooperative education, combining alternate periods of study and engineering work experience in industry, has been an important program for

Freshman Engineering Enrollment — Fall Semester Figure 12



Freshman Engineering Student Characteristics — Fall Semester Figure 13

1965	61	28	10	1	541	624	1165
1966	62	22	15	1	532	612	1144
1967	79	21	0	0	551	642	1193
1968	81	19	0	0	561	654	1215
1969	82	18	0	0	556	652	1208
1970	85	15	0	0	568	647	1215
1971	89	11	0	0	565	667	1232

engineering students at SMU since the origination of the SMU Engineering School in 1925. All students were on the Co-op Plan from 1925 until 1965, when it was made a voluntary program. As shown by the data in Figure 15, the percentage of students involved in the Co-op Plan has declined steadily to the current level of about 24.2 percent. The decline apparently originates in the increasing affluence of our society, and the increasing numbers of scholarship holders.

The 1971-72 academic year was a particularly challenging year for placing co-op students. The recent cutbacks in employment levels in the North Texas area created a serious shortage of co-op positions.

The companies participating in the Co-op Program in 1971-72:

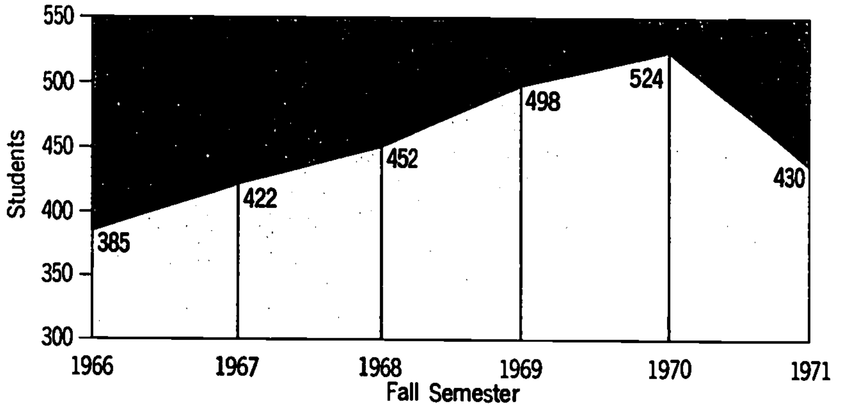
- Baylor University Medical Center
- Henry C. Beck Company
- Herman Blum Associates
- Bell Helicopter Company
- City of Dallas
- Dallas Power & Light Company
- F & M Systems
- Forrest and Cotton, Inc.
- General Electric Corporation Tyler, Texas
- General Motors Corporation (Arlington Assembly Plant)
- General Portland Cement Company
- LTV Corporation
- Lone Star Steel Company
- Mobil Oil Group
- Otis Engineering Corporation
- Peerless Manufacturing Company
- Southwestern Bell Telephone Company
- Texas Highway Department
- Texas Instruments Incorporated
- U. S. Air Force (Security Service, San Antonio)
- U. S. Naval Air Engineering Center
- Union Special Machine Company
- Varo, Inc.
- City of Vineland (N.J.)
- Weben Industries
- Western Union

The TAGER Television System

Nearly all of the graduate courses offered by the Institute are presented over the TAGER Television System to the various industrial affiliates. The

Undergraduate Enrollment

Figure 14



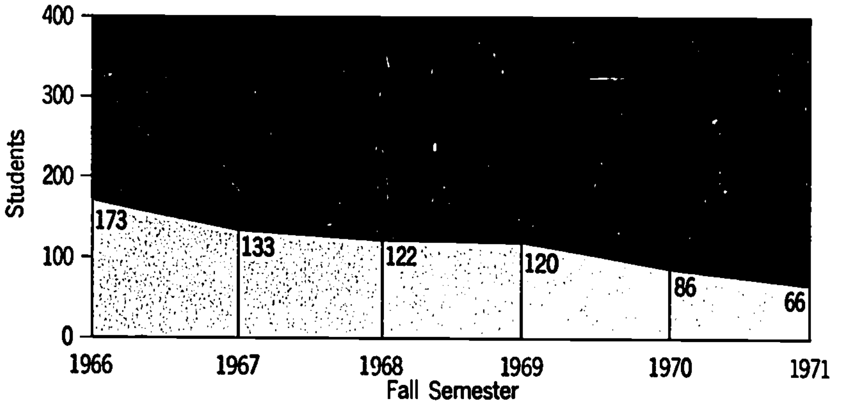
Engineering Cooperative Program

Figure 15

1971	430	157	273	66	24.2	26
1970	524	192	332	86	26.0	29
1969	498	156	342	120	35.0	33
1968	452	180	272	122	44.9	33
1967	422	151	271	133	49.2	53
1966	385	136	249	173	69.5	65

Number of Engineering Co-op Students

Figure 16



general TV enrollment pattern in the various Centers of the Institute is shown in Figure 17.

The effect of the declining economic situation in the technologically-based industries is apparent from this figure and Figure 18. The following gross comparisons taken from Figure 19 are revealing.

Thus, there was a cumulative loss for the year of 1159 enrollments, or 3477 student credit hours. This translates into a net tuition revenue loss of $243,390.

The North Texas metroplex has been hard hit by the combination of economic recession and reduced government procurement. The impact has been especially severe on the technology-dependent industries, the very companies who have traditionally supplied most of our graduate students. A number of companies—including Collins Radio Company, Bell Helicopter, Continental Electronics and LTV-Greenville—have been forced to mothball their television facilities until economic conditions improve.

Doctoral Enrollment

Although press coverage of Ph.D. unemployment has been extensive both locally and nationally, and extremely inaccurate, students receiving Ph.D. degrees from the SMU Institute of Technology have been doing extremely well. All 26 who graduated last year are well placed with salaries averaging in the range from $18,000 to $20,000 per year. SMU Ph.D.'s are employed by Lincoln Labs, Texas Instruments Incorporated, Rice University, Collins Radio and LTV Corporation, to name only a few.

Enrollment for Ph.D. work on campus remains at a high level. Although a goal to produce 30 Ph.D. degrees was set for 1972, the actual number receiving degrees this year is 40; 11 others will complete their degree requirements before the end of 1972. (Figure 20.) We have every reason to believe that our goal of a stable output averaging 25 to 30 Ph.D.'s per year should be realized with little difficulty over the coming years.

Doctoral enrollment averages about 130 to 140 during regular academic

Graduate TV Enrollments By Centers (1970-1971 & 1971-1972) Figure 17

Center	Summer 1970 off campus	Summer 1970 on campus	Summer 1970 total	Fall 1970 off campus	Fall 1970 on campus	Fall 1970 total	Spring 1971 off campus	Spring 1971 on campus	Spring 1971 total
Computer Science/ Operations Research	[illegible]	[illegible]	[illegible]	149	262	411	[illegible]	[illegible]	[illegible]
Electronic Sciences	[illegible]	[illegible]	[illegible]	58	47	105	[illegible]	[illegible]	[illegible]
Information/Control	[illegible]	[illegible]	[illegible]	37	31	68	[illegible]	[illegible]	[illegible]
Solid Mechanics	[illegible]	[illegible]	[illegible]	37	124	161	[illegible]	[illegible]	[illegible]
Thermal/Fluid Sciences	[illegible]	[illegible]	[illegible]	196	267	463	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	477	731	1208	[illegible]	[illegible]	[illegible]
	[illegible]			58 courses			[illegible]		

Center	Summer 1971 off campus	Summer 1971 on campus	Summer 1971 total	Fall 1971 off campus	Fall 1971 on campus	Fall 1971 total	Spring 1972 off campus	Spring 1972 on campus	Spring 1972 total
Computer Science/ Operations Research	[illegible]	[illegible]	[illegible]	98	208	306	[illegible]	[illegible]	[illegible]
Electronic Sciences	[illegible]	[illegible]	[illegible]	35	39	74	[illegible]	[illegible]	[illegible]
Information/Control	[illegible]	[illegible]	[illegible]	99	121	220	[illegible]	[illegible]	[illegible]
Solid Mechanics	[illegible]	[illegible]	[illegible]	20	24	44	[illegible]	[illegible]	[illegible]
Thermal/Fluid Sciences	[illegible]	[illegible]	[illegible]	16	14	30	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	268	406	674	[illegible]	[illegible]	[illegible]
	[illegible]			35 Courses			[illegible] Courses		

semesters. All but 10 of these are working toward the Ph.D. The 10 working toward the newly introduced Doctor of Engineering are expected to be joined by others as this program grows rather slowly at the expense of the Ph.D. program.

Enrollment in the Engineer Degree program, falling midway between the M.S. and the doctorate, continues to grow slowly, but steadily. Approximately 15 were enrolled in the current year and 13 received the degree in 1971-72.

Graduate Enrollment

Figure 21 shows the graduate enrollment, by head count, in the Institute of Technology from 1965 to 1971. It very accurately reflects the overall industrial activity in the North Texas metroplex. The combination of the economic recession beginning in the spring of 1970 and continuing all through 1971 and into 1972, coupled with dramatic cutbacks and changes in government spending produced serious local economic disturbances. As might be expected, this produced a large drop in part-time graduate student enrollment. This always happens as the economy and the government go through their various cycles.

Industrial response to recession and reduced government spending has taken a number of forms. There have been significant employment cutbacks. Although engineers fared better than other groups in such companies, the fact remains that many were laid off. A high proportion of those laid off were younger men, relatively new at the company, and this is primarily the group from which we attract our part-time graduate students. In addition, hiring of new engineers came to a standstill throughout the area. The so-called "new hires" have traditionally been the richest source of part-time graduate students so their absence over the past two years has caused a very large enrollment drop. Enrollment has almost certainly bottomed out and we look forward to a slowly improving situation in 1972-73.

During this two-year period a relatively large number of enrolled students completed work for the M.S. degree. Thus, the pipeline is rapidly emptying.

Geographical Distribution of TV Enrollments

Figure 18

	Fall 1968	Spring 1969	Summer 1969	Fall 1969	Spring 1970	Summer 1970	Fall 1970	Spring 1971	Summer 1971	Fall 1971	Spring 1972
Atlantic Richfield	5	7	1	8	11		7	2		7	
Bell Helicopter	7	5		3	4	1					
Collins Radio	122	104	30	115	74	21	44	41	8		
General Dynamics	192	162	58	171	151	52	139	98	23	50	35
LTV — Continental			1	4	4						
LTV — Garland	34	31	19	26	35	8	16	13	3		
LTV — Grand Prairie	68	50	11	49	58	21	44	29	3	21	19
LTV — Greenville	26	24	7	25	14	5	15	8			
Mobil	1	4		4	1	1	4	6	3	12	11
Sun	1	1						4			
Texas Instruments Dallas	286	234	91	274	224	82	182	152	38	169	163
Texas Instruments Sherman	5		3	5	5		7	5			2
SMU-On-Campus	391	448	127	541	652	281	731	688	122	406	378
Southwestern Medical School								1		2	2
Austin College				4							
Texas Christian University				10	3	2	6	1		1	
Univ. of Dallas				7	2		2	2		1	3
Univ. of Texas at Dallas	10	6	6	23	9	1	11	3		5	
Total	1148	1082	354	1271	1246	475	1208	1053	206	674	613

TV Enrollment

Figure 19

Term	[illegible]	1971-72 Year	[illegible]
Summer	[illegible]	200	[illegible]
Fall	[illegible]	674	[illegible]
Spring	[illegible]	577	[illegible]
Total	[illegible]	1451	[illegible]

Ph.D. Degrees in Engineering

Figure 20

Year	[illegible]
1966-67	[illegible]
1967-68	[illegible]
1968-69	[illegible]
1969-70	[illegible]
1970-71	[illegible]
1971-72	[illegible]

It will take a number of years for the situation to recover fully, despite a general improvement in the regional employment picture. But this is the way things tend to go in engineering education, moving through cycles of sudden increases and decreases in enrollment.

Another closely related factor has also contributed to the drop in enrollment. In the past, many of the companies encouraged their employees to take as many as two courses per semester, and about 50 percent of our part-time enrollees did so. Currently, the companies are generally permitting enrollment in only one course and then only if it is job related. This factor alone is responsible for a significant drop in student credit hours.

Nationally, freshman engineering enrollment declined by over 15 percent in 1971-72. This will cause engineering degree out-put to drop from 42,000 per year to less than 35,000. A serious shortage of engineers will then result in 1976. This shortage is likely to propagate itself for years into the future, particularly as the demand intensifies. Under these conditions it is imperative that each company find a way to keep their engineering staff at the cutting edge of engineering thinking. The advanced degree program offered to employed engineers by the SMU Institute of Technology through TAGER is the best way to accomplish this.

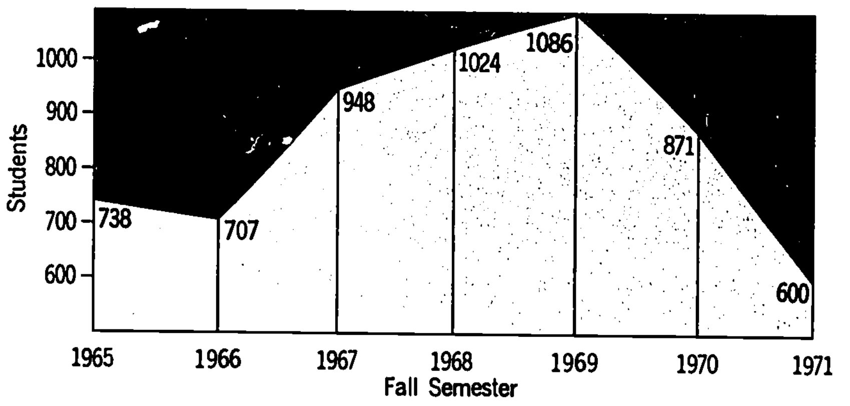
Graduate Degree Production

As predicted in last year's Annual Report, production of Master's degrees declined in 1972. The peak of 201 occurred in 1970 as shown in Figure 22. This declined only slightly in 1971 to 196. This year it dropped to 162, which is really quite good considering the local situation described earlier as well as compared to what is happening elsewhere in the country. It is expected that this will decline even more next year as the pipeline of students empties as described before. It will be several years before the output recovers to the levels of 1970-71.

The Engineer's degree, midway between the M.S. and the doctorate, appears to continue to meet a definite need. 13 students received this degree compared to 12 in 1971. It is difficult to predict the future for this, but output will probably remain fairly constant over the next year or two.

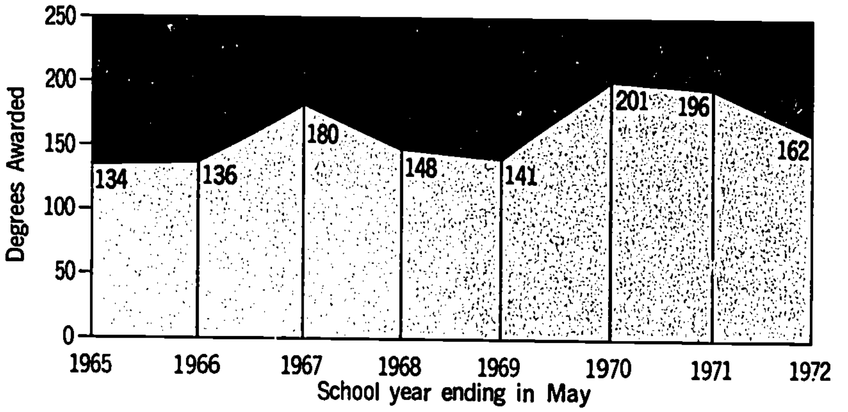
Graduate Engineering Enrollment

Figure 21



Master's Degrees in Engineering

Figure 22



This was a banner year in doctoral production with 40 students receiving the Ph.D. degree. This is well beyond the 30 degrees set as our 1972 goal in the 1966 long-range plan. The pipeline of doctoral students remains well filled so that output should hold reasonably steady at around 30 per year over the next few years.

An important historical footnote should be added here. Carolyn Jones Crouch became the first woman to receive a Ph.D. degree in engineering from SMU. Indeed, she and her husband, Donald Beauford Crouch, are the first husband and wife team to receive Ph.D. degrees in engineering from SMU. Both members of the Crouch family completed their work in Systems Engineering.

Semester Credit Hour Production

The student credit hour, SCH, is a common measure of educational productivity. It is defined as the product of the enrollment in each class multiplied by the semester credit hours assigned to that course. The data for the past six years are summarized here as a matter of historical interest.

The period from 1966 through 1969 reflected the booming North Texas economy and clearly revealed that the SMU engineering programs were closely in tune with the times. The Institute was growing in all of its aspects. As an engineer would put it, all of the derivatives were positive.

Then, beginning in 1969, the various factors of recession and the like which have been discussed previously combined to cause SCH production to decline. Another factor is the large tuition increases of the past few years which have priced many students off the SMU campus. Finally, some very forward looking curriculum changes have acted to produce a temporary decrease in SCH production. (Figure 23.)

But, as noted in Part I of this Report, the long-range future is very bright and the Institute is geared to move with it. Demand for engineers will increase. New societal needs will create demands for new types of engineers and applied scientists that the Institute is producing. So SCH production will start to climb, slowly and steadily as our carefully laid plans mature.

Semester Credit Hour Production — Figure 23

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Summer 1970	1,680	325	791	564	1,355
Fall 1970	7,283	3,580	2,101	1,602	3,703
Spring 1971	5,906	3,051	1,771	1,083	2,854
Total	14,869	6,956	4,663	3,249	7,912
Summer 1971	1,257	345	675	237	912
Fall 1971	5,356	2,383	2,169	804	2,973
Spring 1972	4,914	2,046	2,163	705	2,868
Total	11,527	4,774	5,007	1,746	6,753

Expense Budget* — Figure 24

Item	[redacted]	1971-72	[redacted]
Office of the Dean	[redacted]		[redacted]
Gen. Adm.	[redacted]	$ 254,295	[redacted]
Comm. Media	[redacted]	49,762	[redacted]
Prof. Depts.	[redacted]	19,960	[redacted]
Foundation	[redacted]	130,850	[redacted]
Machine Shop	[redacted]	9,400	[redacted]
Computer Sci./Opr. Res.	[redacted]	245,357	[redacted]
Electronic Sciences	[redacted]	185,087	[redacted]
Info. & Control Sciences	[redacted]	278,713	[redacted]
Solid Mechanics	[redacted]	167,353	[redacted]
Thermal & Fluid Sciences	[redacted]	175,515	[redacted]
Contingencies	[redacted]	0	[redacted]
Total	[redacted]	$1,516,292	[redacted]

* *Non-Federal funds*

Revenue/Expense Summary* — Figure 25

Item	[redacted]	1971-72	[redacted]
Revenue	[redacted]		[redacted]
Tuition Income	[redacted]	$ 706,058	[redacted]
Fringe Benefits	[redacted]	36,900	[redacted]
Univ. Col. Counsel	[redacted]	11,000	[redacted]
TV Surcharge	[redacted]	69,224	[redacted]
Research Overhead	[redacted]	35,000	[redacted]
SMU Found. Sci./Engr.	[redacted]	658,110	[redacted]
Special Accounts	[redacted]	0	[redacted]
Total Revenue	[redacted]	$1,516,292	[redacted]
Expenses	[redacted]	$1,516,292	[redacted]

* *Non-Federal funds*

Appendix I

SMU Institute of Technology

Faculty — As of May 30, 1972

Computer Science/Operations Research Center

Resident Faculty

U. Narayan Bhat
  Ph.D. (Stat) University of Western Australia
Leon Cooper
  Ph.D. (Ch.E.) Washington University
Dennis J. Frailey
  Ph.D. (CS) Purdue University
Harvey J. Greenberg
  Ph.D. (OR) Johns Hopkins University
Robert R. Korfhage
  Ph.D. (Math) University of Michigan
Richard E. Nance
  Ph.D. (IE) Purdue University
William C. Nylin
  Ph.D. (CS) Purdue University
Stephen A. Szygenda
  Ph.D. (CS) Northwestern University
Alan C. Wheeler
  Ph.D. (Stat) Stanford University

Visiting Industrial Professors

Paul M. Berry
  Ph.D. (Math) University of Oklahoma
Charles Ralph Blackburn
  MBA (OR) Tulane University
Howell N. Forman, Jr.
  M.S. (IE) Southern Methodist University
Dean Vanderbilt
  Ph.D. (CS) MIT

Electronic Sciences Center

Resident Faculty

Kenneth L. Ashley
  Ph.D. (EE) Carnegie-Mellon University
Jerome K. Butler
  Ph.D. (EE) University of Kansas
William N. Carr
  Ph.D. (EE) Carnegie-Mellon University
Shirley S. C. Chu
  Ph.D. (Chem.) University of Pittsburgh
Ting L. Chu
  Ph.D. (Chem.) Washington University
Jon W. Eberle
  Ph.D. (EE) Ohio State University
Lorn L. Howard
  Ph.D. (EE) Michigan State University
William F. Leonard
  Ph.D. (EE) University of Virginia
Thomas L. Martin, Jr.
  Ph.D. (EE) Stanford University
Charles R. Vail
  Ph.D. (EE) University of Michigan

Visiting Industrial Professors

Martin S. Buehler
  Ph.D. (EE) Stanford University
Tom F. Cheek
  Ph.D. (EE) University of Tennessee
Gordon Cumming
  Ph.D. (EE) University of So. California
Jack S. Kilby
  M.S. (EE) University of Illinois
Jack P. Mize
  Ph.D. (Phys.) Iowa State University
M. Bruce O'Neal
  Ph.D. (EE) University of Texas
Jack Reynolds
  Ph.D. (Phys.) University of Lund

Information and Control Sciences Center

Resident Faculty

David L. Cohn
  Ph.D. (EE) MIT
Yumin Fu
  Ph.D. (EE) University of Illinois
Someshwar C. Gupta
  Ph.D. (EE) University of California at Berkeley
Kenneth W. Heizer
  Ph.D. (EE) University of Illinois
James L. Melsa
  Ph.D. (EE) University of Arizona
Louis R. Nardizzi
  Ph.D. (EE) University of Southern California
Behrouz Peikari
  Ph.D. (EE) University of California at Berkeley
Andrew P. Sage
  Ph.D. (EE) Purdue University
John A. Savage
  M.S. (EE) University of Texas
Edmund W. Schedler
  M.S. (EE) Oklahoma State University
Mandyam D. Srinath
  Ph.D. (EE) University of Illinois
Finley W. Tatum
  Ph.D. (EE) Texas A&M University

Visiting Industrial Professors

Thomas W. Ellis
  Ph.D. (EE) University of Florida
William S. Ewing
  Ph.D. (EE) Southern Methodist University
Manus R. Foster
  Ph.D. (Math-Physics) University of Kansas
George E. Goode
  M.A. (Math) Duke University
Robert E. Griffin
  Ph.D. (EE) Southern Methodist University
Lucien Masse
  Ph.D. (Geophysics) Colorado School of Mines
J. Robert McLendon
  Ph.D. (EE) Southern Methodist University
Herschell F. Murry
  Ph.D. (EE) University of Kansas
M. Bruce O'Neal
  Ph.D. (EE) University of Texas
Theo J. Powell
  Ph.D. (EE) University of Illinois
George P. Shuraym
  Ph.D. (EE) Northwestern University
Stanley L. Smith
  Ph.D. (EE) University of Florida

Solid Mechanics Center

Resident Faculty

Charles E. Balleisen
  M.S. (ME) MIT
Herbert H. Bartel, Jr.
  Ph.D. (CE) Texas A&M University
LeVan Griffis
  Ph.D. (CE) California Institute of Technology
David B. Johnson
  Ph.D. (EM) Stanford University
Robert Millard Jones
  Ph.D. (Appl. Mechanics) University of Illinois
W. Scott McDonald, Jr.
  Ph.D. (EM) University of Kansas
Hal Watson, Jr.
  Ph.D. (EM) University of Texas
  (On leave May 1972-January 1973)

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Marion W. Wilcox
Sc.D. (Engr. Sci.) University of Notre Dame

Visiting Industrial Professors

Bill L. Gunnin
Ph.D. (CE) University of Texas
Vernon A. Lee
Ph.D. (AE) University of Texas
John W. Lincoln
Ph.D. (EM) University of Texas
Robert C. McWherter
M.S. (AE) University of Texas
Raymond P. Peloubet, Jr.
M.S. (AE) Ohio State University
Edward M. Schall
Ph.D. (Appl. Mechanics) Michigan State University
Orville E. Wheeler
Ph.D. (CE) Texas A&M University

Thermal and Fluid Sciences Center

Resident Faculty

Harold A. Blum
Ph.D. (Ch.E.) Northwestern University
Michael A. Collins
Ph.D. (CE) MIT
Carlos W. Coon
Ph.D. (ME) University of Arizona
Jack P. Holman
Ph.D. (ME) Oklahoma State University
Roger L. Simpson
Ph.D. (ME) Stanford University
Cecil H. Smith
Ph.D. (CE) University of Texas
Edmund E. Weynand
Sc.D. (ME) MIT
W. Gerald Wyatt
Ph.D. (ME) University of Minnesota

Special Studies Center

Resident Faculty

Javad Fiuzat
M.D., University of Tehran
Thomas P. Hughes
Ph.D. (History) University of Virginia
Adjunct Faculty from The University of Texas Southwestern Medical School —Biomedical Engineering Program
James W. Aston, Jr.
M.D. The University of Texas Southwestern Medical School
C. Gunnar Blomqvist
Ph.D. (Med.) Karslinski Institute
Ivan E. Danhof
M.D. The University of Texas Southwestern Medical School
Roger R. Ecker
M.D. Cornell University
Charles F. Gregory
M.D. Indiana Medical School
Robert L. Johnson
M.D. Northwestern Medical School
Robert M. Lebovitz
Ph.D. (Neurophysics) University of California
Jere H. Mitchell
M.D. The University of Texas Southwestern Medical School
Louis H. Paradies
M.D. Northwestern Medical School
John C. Porter
Ph.D. Iowa State University
William J. Rea
M.D. Ohio State College of Medicine
Floyd C. Rector, Jr.
M.D. The University of Texas Southwestern Medical School
William E. Romans
M.S. (EE) Southern Methodist University
Winfred L. Sugg
M.D. University of North Carolina School of Medicine
Gordon H. Templeton
Ph.D. (Biophys.) The University of Texas Southwestern Medical School
John C. Vanatta
M.D. Indiana University School of Medicine
Hal P. Weathersby
Ph.D. Tulane University

Resident Administrators

Thomas L. Martin, Jr.
Dean
Leon Cooper
Associate Dean and Director of the Graduate Division
Jack W. Harkey
Assistant Dean
George P. Schmaling
Assistant Dean — Industrial Relations
Peter E. Van't Slot
Assistant Dean — Development
James D. King
Finance Officer
Mrs. Mildred Moore
Administrative Assistant to the Dean
Miss Marilyn Vaughan
Director of Academic Records

Appendix II

Events Affecting the Faculty

Faculty Awards

It has not been reported in a previous Annual Report, but Dr. Andrew P. Sage received the Frederick Emmons Terman Award of the Institute of Electrical and Electronic Engineers in 1970 for Excellence in Engineering Education. This is a national award of great importance and recognizes Dr. Sage as one of the nation's outstanding young electrical engineers.

Dr. Jack P. Holman won the 1972 George Westinghouse Award from the American Society of Engineering Education. This is one of the four most prestigious honors given by the ASEE and was established to recognize excellence in teaching by young engineering leaders.

Dr. W. Gerald Wyatt, Associate Professor of the Thermal and Fluid Sciences Center, received the 1972 American Society of Engineering Education Dow Outstanding Young Faculty Award for the Gulf-Southwestern Region.

Also in 1972, Dr. Thomas P. Hughes was named the Outstanding Author by the Texas Writers Roundup. This recognized the outstanding work by Dr. Hughes in his book *Elmer Sperry — Inventor and Engineer.*

Dr. Thomas L. Martin, Jr., was elected to the National Academy of Engineering in 1971.

New Appointments

Dr. William C. Nylin, Jr., from Purdue, was scheduled to join the faculty as an Assistant Professor of Computer Sciences in September 1971. His arrival was delayed, but it is now certain that he will join the Institute by September 1972.

Dr. Myron Ginsberg received his Ph.D. from the University of Iowa. He joins the faculty of the Computer Science/Operations Research Center as an Assistant Professor in September 1972.

Dr. Robert J. Smith, II, joins the faculty as an Assistant Professor in the Computer Science/Operations Research Center on June 1, 1972. He received his Ph.D. from the University of Missouri at Rolla.

Promotions

Promotions have not been reported completely in past Annual Reports. Thus, the promotion actions for the past four years are summarized in this Report to make the Annual Report file a comprehensive historical summary of Institute activities.

Effective Fall Semester 1969

- Kenneth L. Ashley, to Professor
- Jerome K. Butler, to Associate Professor
- Harvey J. Greenberg, to Associate Professor
- William F. Leonard, to Associate Professor
- W. Scott McDonald, Jr., to Associate Professor
- James L. Melsa, to Professor

Effective Fall Semester 1970

- Carlos W. Coon, to Associate Professor
- Richard E. Nance, to Associate Professor
- Louis R. Nardizzi, to Associate Professor
- Roger L. Simpson, to Associate Professor
- Hal Watson, Jr., to Associate Professor

Effective Fall Semester 1971

- U. Narayan Bhat, to Professor
- Behrouz Peikari, to Associate Professor
- Stephen A. Szygenda, to Professor
- W. Gerald Wyatt, to Associate Professor

Effective Fall Semester 1972

- Mandyam D. Srinath, to Professor
- Alan C. Wheeler, to Associate Professor

Changes and Leaves

Dr. W. S. McDonald, Jr., Director of the Solid Mechanics Center, returned to service in January 1972 from a leave while he served as Special Adviser and Consultant to the Federal University of Rio Grande do Sul, School of Engineering, Porto Allegre, Brazil.

Dr. Hal Watson, Jr., Associate Professor of Solid Mechanics, left in May, 1972 for a six-months leave to serve the Federal University of Rio Grande do Sul in the same role as Dr. McDonald. He will return in January 1973.

Dr. Louis R. Nardizzi, Associate Professor of Information and Control Sciences, went on part-time service in the Fall of 1971 and plans to continue at approximately half time for the foreseeable future while he works toward the M.D. degree at The University of Texas Southwestern Medical School.

Dr. William N. Carr, Professor of Electronic Sciences, began a sabbatical leave for the 1972-1973 academic year.

Dr. Kenneth W. Heizer transferred from the Information and Control Sciences Center to the Electronic Sciences Center where he will assume responsibility for the integrated circuits program and laboratory.

Resignations

Dr. James E. Kalan, Assistant Professor of Computer Science/Operations Research for the two-year period from 1970 through 1972, resigned effective May 31, 1972, to accept a position as Assistant Professor of Mathematics at the University of Dallas.

Dr. Michael O'Hagan, who was serving as Director of the SMU Computing Laboratory as well as on the faculty of the Computer Science/Operations Research Center, resigned in October 1971 to accept the post of Dean of Academic Affairs at the University of Dallas.

Dr. B. L. Turlington, Assistant Professor of Computer Science/Operations Research, resigned effective May 31, 1972, to accept a post as chief engineer of a large land development program in the lake areas near Austin, Texas.

Professor Edward E. Walters, who was on leave of absence from the Solid Mechanics Center during the 1971-72 academic year, resigned effective May 31, 1972, to devote his full time and attention to consulting engineering activities with Haag Engineering of Dallas.

Appendix III

Active Grants/Contracts in Force During Fiscal Year 1971-72

Number	Description	Principal Investigator	Amount
85-04	*Title*: "Recombination in Semiconductors Through Negatively-Charged Recombination Chambers" Sponsor: NSF GK-24145 Duration: June 1, 1970 to November 30, 1972	K. L. Ashley	$ 54,573
85-05	*Title*: "Analysis of Some Queueing Systems" Sponsor: NSF GK-19537 Duration: September 1, 1970 to August 31, 1972	U. N. Bhat	$ 63,935
80-43	*Title*: "Study of Semiconductor Laser Modal Fields and Their Radiation Patterns" Sponsor: USAMERDC-DAAK02-71-C-0263 Duration: May 4, 1971 to July 3, 1972	J. K. Butler	$ 30,558
83-44	*Title*: "Optical Field Distributions and Model Selection Properties of GaAs (ALGA) as Lasers" Sponsor: NASA (Multidisciplinary Grant) Duration: June 1, 1971 to August 31, 1972	J. K. Butler	$ 19,151
84-67	*Title*: "Injection Luminescence in Metal-Insulator-Semiconductor Structors" Sponsor: NSF GK-3772 Duration: May 1, 1968 to July 31, 1971	W. N. Carr	$ 59,580
83-32	*Title*: "Boron Arsenide and Phosphide for High Temperature" Sponsor: NASA-NGR-44-007-042 Duration: July 1, 1970 to June 30, 1974	T. L. Chu	$ 62,802
83-47	*Title*: "Gallium Nitride Opteolectronic Devices" Sponsor: NASA-Langley-NGR 44-007-052 Duration: September 1, 1971 to August 31, 1972	T. L. & S. S. Chu	$ 15,790
84-77	*Title*: "Silicon Phosphides and Arsenides-Crystal Growth" Sponsor: NSF GK-3944 Duration: July 1, 1969 to December 31, 1971	T. L. Chu	$ 41,772
87-66	*Title*: "Boron Arsenide Crystals and Epitaxial Films" Sponsor: Welch Foundation Duration: May 1, 1969 to April 30, 1972	T. L. Chu	$ 45,000
87-84	*Title*: "Crystal Structure Studies of Heterocyclic Sulfur Compounds" Sponsor: Welch Foundation N-495 Duration: May 1, 1972 to April 30, 1974	S. Chu	$ 24,443
88-49	*Title*: "Crystal Structure Studies of Schistosomicides" Sponsor: SMU "Seed Grant" Duration: July 1, 1970 to March 31, 1972	S. Chu	$ 7,250
88-66	*Title*: "Modeling Social Epidemics" Sponsor: SMU "Seed Grant" Duration: February 1, 1972 to August 31, 1972	D. Cohn	$ 6,585
86-07	*Title*: "Optimal Operating Policy for Metropolitan Multiple Water Supply Reservoir System" Sponsor: OWRR 14-31-0001-3739 Duration: June 1, 1972 to July 31, 1974	M. Collins	$ 113,507

Active Grants/Contracts in Force During Fiscal Year 1971-72

Number	Description	Principal Investigator	Amount
88-61	*Title:* "Transient Dynamics of Two-Liquid Porous Media Flows" Sponsor: SMU "Seed Grant" Duration: January 1, 1972 to August 31, 1972	M. Collins	$ 5,118
83-33	*Title:* "Hemispherical Thermal Emittance" Sponsor: NASA (Multidisciplinary Grant) Duration: June 1, 1969 to November 30, 1971	C. W. Coon	$ 21,328
88-57	*Title:* "A Study of Storage Allocation Methods for Simple Data Structures" Sponsor: SMU "Seed Grant" Duration: June 1, 1971 to August 31, 1972	D. J. Frailey	$ 5,925
83-38	*Title:* "Study of Communication Networks" Sponsor: NASA (Multidisciplinary Grant) Duration: September 1, 1969 to August 31, 1971	Yumin Fu	$ 18,317
80-51	*Title:* "Minimum Rate Digital Voice Transmission" Sponsor: Defense Communication Agency #100-72-C-0023 Duration: May 1, 1972 to April 30, 1973	S. C. Gupta	$ 50,527
83-30	*Title:* "Digital Phase Locked Techniques for Aerospace Communications" Sponsor: NASA NGR 44-007-037 Duration: September 1, 1969 to March 1, 1972	S. C. Gupta	$ 43,271
83-39	*Title:* "Digital Communications for Aircraft" Sponsor: NASA-NGR 44-007-049 Duration: January 1, 1971 to August 31, 1972	S. C. Gupta	$ 62,432
82-70	*Title:* "Air Pollution Control/Fluidized Vortex Incineration" Sponsor: HEW-PHS 1 Rol APO1151-01 Duration: May 1, 1970 to April 30, 1973	J. P. Holman	$ 99,629
82-84	*Title:* "Air Pollution Control Fluidized Vortex Incineration" Sponsor: Environmental Protection Agency R-801078 Duration: May 1, 1972 to April 30, 1973	J. P. Holman	$ 33,041
85-20	*Title:* "Experimental and Analytical Studies of Jet Boiling Cooling Techniques" Sponsor: NSF GK-24637 Duration: September 1, 1971 to February 28, 1974	J. P. Holman	$ 35,568
82-79	*Title:* "Fellowship Supply Allowance for Charles L. Meyers, Jr." Sponsor: HEW-1-F03-GM52121-01-BEN Duration: August 1, 1971 to July 31, 1972	L. L. Howard	$ 1,000
83-45	*Title:* "Dynamics of Flexible Spacecraft" Sponsor: NASA (Multidisciplinary Grant) Duration: January 1, 1971 to August 31, 1972	D. B. Johnson	$ 22,573

Active Grants/Contracts in Force During Fiscal Year 1971-72

Number	Description	Principal Investigator	Amount
83-46	*Title:* "Vacuum Deposition and Characterization of III-V Antimonide Alloys" Sponsor: NASA (Multidisciplinary Grant) Duration: June 1, 1971 to May 31, 1972	W. F. Leonard	$ 14,288
85-29	*Title:* "Thermoelectric Power of Noble Metals" Sponsor: NSF GH-33178 Duration: March 15, 1972 to February 28, 1974	W. F. Leonard	$ 68,475
83-29	*Title:* "Photoelastic Model for the Evaluation of Axisymmetric Composite Structures" Sponsor: NASA (Multidisciplinary Grant) Duration: September 1, 1968 to August 31, 1972	W. S. McDonald	$ 16,666
87-78	*Title:* "Development of a Remote Time-Sharing Hybrid Computer Terminal System for Off-Campus Students Via TAGER TV" Sponsor: Alfred P. Sloan Foundation Duration: August 1, 1971 to August 31, 1972	J. L. Melsa	$ 9,800
80-47	*Title:* "Development of Silicon Monolithic Surface-Wave Arrays" Sponsor: WPAFB-F33615-71-Q-2567 (Temp.) Duration: July 12, 1971 to April 12, 1972	J. P. Mize	$ 20,898
86-66	*Title:* "Scientific and Technical Investigations" Sponsor: J. S. Kilby Duration: July 1, 1971 to December 31, 1971	J. P. Mize	$ 3,000
84-97	*Title:* "Res. Initiation — Engineering Systems — Optimal Computer Control" Sponsor: NSF GK-5608 Duration: April 1, 1970 to March 31, 1972	L. Nardizzi	$ 19,304
85-02	*Title:* "Instructional Scientific Equipment" Sponsor: NSF GY-8251 Duration: July 1, 1970 to July 31, 1972	L. Nardizzi	$ 25,000
85-10	*Title:* "Cooperative College-School Science Program" Sponsor: NSF GW-6557 Duration: January 1, 1971 to May 12, 1972	L. Nardizzi	$ 27,030
85-25	*Title:* "Cooperative College-School Science Program" Sponsor: NSF GW-7078 Duration: January 4, 1972 to June 30, 1973	L. Nardizzi	$ 32,664
83-41	*Title:* "Design of Linear Time-Varying Networks" Sponsor: NASA (Multidisciplinary Grant) Duration: January 1, 1971 to March 31, 1972	B. Peikari	$ 17,297
80-35	*Title:* "Automatic Navigation" Sponsor: AFOSR Duration: September 1, 1967 to August 31, 1972	A. P. Sage (Third Year — Extended) (3 yr. Program $600K)	$ 72,309

Active Grants/Contracts in Force During Fiscal Year 1971-72

Number	Description	Principal Investigator	Amount
80-48	*Title:* "Making Laser Anemometer Measurements in a Separating Boundary Laser Produced by an Adverse Pressure Gradient" Sponsor: AROD-DA-ARO-D-31-124-72-G31 Duration: October 1, 1971 to September 30, 1972	R. L. Simpson	$ 14,171
83-43	*Title:* "Development of a New Airfield Anemometer to Improve Operations Efficiency" Sponsor: NASA (Multidisciplinary Grant) Duration: January 1, 1971 to March 31, 1972	R. L. Simpson	$ 22,261
85-07	*Title:* "Hot-Film Anemometer Measurements of Concentration in Turbulent Flow" Sponsor: NSF GK-20016 Duration: November 15, 1970 to May 15, 1972	R. L. Simpson & W. G. Wyatt	$ 21,730
80-42	*Title:* "Analysis and Synthesis of Diagnosis and Design Techniques for Digital Systems Requiring High Maintainability/Reliability" Sponsor: DNR-N00178-71-C-0148 Duration: January 1, 1971 to August 31, 1972	S. A. Szygenda	$ 145,512
86-47	*Title:* "A Study of Prison Inmate Rehabilitation and Training in the Computer Sciences" Sponsor: Dept. of Justice, Federal Prison Industries Duration: January 18, 1971 to April 30, 1972	S. A. Szygenda	$ 23,414
86-68	*Title:* "Methodology for Systems Engineering in the Computer and Telecommunications Field" Sponsor: Collins Radio 313479-T Duration: June 1, 1971 to May 31, 1972	S. A. Szygenda	$ 34,940
84-58	*Title:* "E. E. Departmental Science Development" Sponsor: NSF GU-2604 Duration: July 1, 1968 to December 31, 1971	F. W. Tatum (Third Year — Extended) (3 yr. Program $600K)	$ 67,896
85-16	*Title:* "Fellowship for S. K. Jones" Sponsor: NSF-7131-12 Duration: June 1, 1971 to May 31, 1972	F. W. Tatum	$ 6,100
84-94	*Title:* "Undergraduate Research Participation" Sponsor: NSF GY-7383 Duration: January 1, 1970 to June 30, 1973	B. L. Turlington	$ 22,150
83-40	*Title:* "A Sapphire Crystal Accelerometer for Use in Extreme Environments" Sponsor: NASA (Multidisciplinary Grant) Duration: January 1, 1971 to May 31, 1972	H. Watson, Jr.	$ 15,263
88-54	*Title:* "Dissertation Support for Joseph E. Tepera" Sponsor: SMU "Seed Grant" Duration: January 1, 1971 to September 30, 1971	H. Watson, Jr.	$ 3,800
83-34	*Title:* "Film Conductance Coefficients" Sponsor: NASA (Multidisciplinary Grant) Duration: June 1, 1969 to November 30, 1972	W. G. Wyatt	$ 21,344
		TOTAL	$1,668,987

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