THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

SIGMA XI CLUB

"For the encouragement of scientific research"

NOTICE OF BUSINESS MEETING AND LECTURE

DATE: Wednesday, December *4,* 1968 TIME: 8:00 p.m.

PLACE: Lecture Room (M-5Q), Research Institute, UAH

AGENDA: Short business meeting - Report from John Porter on the National Meeting.
Open Lecture - "Technology and the Needs of Society"

THE SPEAKER: <u>David L. Christensen</u>

Consultant and Research Associate
Research Institute, University of Alabama in Huntsville

For the past fifteen years, Mr. Christensen has been active in various aerospace programs including direct participation on the Corporal, Redstone, Jupiter, and Saturn rocket projects. His experience has ranged from electronic checkout and propulsion system design to documentation, management and consulting activities on many different phases of this nation's missile arid space programs.

At the present time, Mr. Christensen is performing consulting services to the University of Alabama Research Institute in Huntsville. These services include coordination of technical documentation and contact of key participants as required to prepare a detailed and comprehensive history of the Saturn space vehicle program. The history v/ill cover the full research and development of the Saturn family of launch vehicles from concept to man-rated flight.

ABSTRACT: <u>"Technology and the Needs of Society"</u>

This discussion will outline past, present, and future trends of technological change and the impact on society. A review of the history of technology will identify the social benefits and problems that result from technology. Also, the cycle from concept to hardware will be traced for several key technologies.

Major emphasis will be given to the current status of technology and possible directions in the future. Selected areas of interest - such as space, defense, oceanography, housing, transportation, and medicine - will be reviewed and specific problems and research needs related to each area will be discussed. In addition, possible priorities and goals for furure R &. D and related educational efforts will be proposed.

TECHNOLOGY AND THE NEEDS OF SOCIETY

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> "Every man is a valuable member of society who by his observations, researches, and experiments procures knowledge for mankind ..."
>
> James Smithson (1765-1829)
> Founder of Smithsonian institution

Mankind is living today in an era of sudden chance; for the first time in our records all history is ancient, and technical advancements accumulate at a faster rate than we can comprehend. True, we have had cultural changes and technical milestones from century to century; wandering and war did much *to* cross-fertilize new ideas and concepts, and the effects of these breakthroughs were easily recognizable from one age to the next. However, this generation of the past fifty years has seen more change than all the preceding generations. The 25-year-old has had the electronics age, the atomic age, the computer age, the jet age, and the space age a!! thrust upon him simultaneously; and with the tremendous human capacity for adaptability, he now takes these technical miracles of science for granted.

Our scientific and technological achievements have created a huge potential for this changing world, but unfortunately we have not learned to tap this potential to solve our social problems. The immediate future of our knowledge as applied to communications, production, transportation, energy, biology, and information and environmental control is staggering. This knowledge must also be applied to social problems for optimum benefit to man if we are to meet the ultimate challenge and evolve from the age of science to the "golden age" of man so long sought and predicted by philosophers and scientists alike.

THE IMPACT OF TECHNOLOGY . .

Modifying nature's self-repeating cycle, man introduced a new process, a concept of change by communication through thought, speech, and records to form the basis of technical as well as cultural development. Each new bit of. knowledge served to begat others whilecombining and recombining with still others, thus advanced our knowledge on an ever-widening front and in ever-deepening matrices. One reason for the rapid tempo of change in America was the application of the American frontier spirit of self-reliance and inventive genius as well as its tremendous resources during the Industrial Revolution of the 18th and 19th Centuries. However, social and political change failed to pace industrial and technological progress. Additional strains were placed on our social and political relationships by a shrinking world and rapid changes on the international scene.

Today, we stand bewildered by the multitude of technical and cultural changes exploding on the scene and wonder if in our desire to implement change we are not creating a monster instead of a benevolent genie. Fiction is also merging with fact at a faster and faster rate as the development span for technology is compressed by more efficient techniques. The tempo and nonlinear rate of change from idea to finished product in recent years is illustrated by the table below.

THE TEMPO OF TECHNOLOGY

Invention	Development Span. (Years)
Photography	112
Radio	35
Radar	15
Television	12
Atomic Bomb	6
Transistor	5

Man must continually bring about conditions more in accordance with hi: needs or he will deteriorate ana[1] slip backwards. Of course, some think this might be desirable. If has always been the adventurous few of man, by their physical and psychological penetration into the unknown, who have produced most of the changes that have quickened the tempo of history. Bur the greater numbers of mankind enter this unknown arena of rapid change looking backwards at their accomplishments and the comfortable run of habitude.

Man's sense of habit always caused him to yearn for the simpler life of his ancestors. Resistance to change is ingrained in his being regardless of the rapid changes now in progress. Conservatism and stability conflict with this urge to try the new and unknown. This conflict also widens into the eternal struggle between security and freedom and between the conformity of the mass and the daring of the individual. Man's aggressive tendencies must likewise find an outlet, and this outlet is currently reflected in our drive toward the new frontiers of inner self and outer space in addition to the ancient, ever present tendency toward armed conflict.

Recently, there has been a torrent of publicity concerning the deterioration and contamination of our environment. Festering slums, mountains of garbage, rivers of sewage, concentrations of murky smog, and land scraped bare for mining and sprawling suburbs have been stressed as the result of a bursting population and industrial growth. Our social problems along with moral, political, and even technical problems seem to grow as rapidly as our population explosion. In fact, they are so closely interrelated that we now stand at a crossroads - one fork leading to stereotyped man, chaotic cities, and international disorder; the other to a society that puts technology in the service of man's needs - for his benefit and pleasure and to support the basic human desire for new experiences,-security, personal recognition, and response.

In a world where science and technology make almost anything possible, the logical question is: What do we really want? In earlier times, protection from the elements and food for the hunter and farmer met our basic needs for survival. Today, these simple needs are still the prime goals for a large portion of mankind, a fact affluent nations often forget.

Technology has already extended our sphere of influence and natural functions and allowed us a flexibility and mobility beyond the fondest dreams of our forefathers; but, in truth, do we determine or do we fulfill our needs and desires? Do we control technology or become controlled by it? Are we unbalancing the scales of our delicate environmental and social systems with blind carelessness and radical change? These questions are now being asked with greater frequency, indicating a new maturity in our thinking and subsequent actions for future change.

One goal for technology should be to provide the means for changing the local environment to meet human needs without adversely affecting the larger environments. We must understand the full significance of our technological actions and plan and work on a broad and long-term basis considering both the technological and the social consequences of our actions. We must also harmonize and establish priorities for our technical goals by objective examination and democratic decisions. Only by improved communications and more direct participation by a!l individuals can this be realized.

TECHNOLOGY TODAY

Federal authority has been tremendously affected by technological change. National and international communication and transportation systems by their nature require some sort of federal and international controls and regulation. These interactions of government and technology affect us all to an extent little realized, except through the impact of bureaucratic entanglements.

In our industries and business establishments, automation and the computer provide the flexibility and the means of meeting sudden changes. But they also affect the employment skills of the human element in an economic system as machines begin to operate other machines.

While reviewing some of the advanced technology required for our continued advancement, we can also examine possible areas of related social applications. In the near future, it may become mandatory to perform such analyses to justify research and development funding for new federal programs. Even today, a new Department of Science and Technology is being proposed by top-level federal science advisors to consolidate and coordinate our mushrooming scientific activities an'd to provide assessments of the impact of new and future technology on society.

The present national trend appears to stress technological applications and practical benefits using our large reservoir of fundamental scientific research. Following are examples of advanced technological needs in the near future that should be analyzed for their social applications and implications. Many of these items have already been influenced by urgent social needs. Also, many of these diverse technological goals are closely interrelated by common disciplinary bonds.

Aeronautics

Aeronautics is starting to receive much more attention since the civilian space program and military missile programs have decreased their economic impact on the aircraft industry. The era of the jumbo jet and the SST, with their attendant social implications, is just around the corner. Also, the continuation of the Vietnam War has made it necessary to replace a large number of aircraft in our declining inventory of air power. Technical advancements are needed in the following areas if we are to continue our position of leadership:

1. New metallic and non-metallic materials including composites with higher strength-to-weight ratio techniques. Also, a better understanding of the mechanism of material fatigue and stress corrosion.

2. New air cargo vehicles using nuclear powerplants for increased range and efficiency.

3. Automatic collision avoidance, clear air turbulence detection, and blind takeoff and landing equipment.

4. Noise and sonic boom suppression research and development.

5. Improved powerplants, inlet ducts, ejectors and improved fuels.

6. Development of a manned "strategic" bomber to replace the B-52.

7. Airborne detection systems to sense low-flying aircraft.

8. New fighter and surveillance aircraft to match advanced Russian equipment.

Atomic Energy • •

The next great market for the technology of nuclear energy appears to lie in the commercial rather than the military fields. As the nation's power requirements nearly double in each decade, the atom is becoming more economically competitive with fossil fuels to meet this demand. Breeder reactors using lower grade uranium ores suggest themselves immediately as a source for electrical power. Other potential uses include:

1. Atomic explosions for constructive purposes such as deepening harbors and passageways, forming earth-filled darns for water storage, digging canals and deep lakes for water catchment, and loosening petroleum and ore-bearing rock (Project Plowshare).

2. Development of atomic power sources needed for oceanography, meteorology, space exploration, and pollution control systems. .

3. Development of new equipment and instrumentation for power reactors and research facilities.

4. Development of reliable and economical nuclear power-plants for rockets, cargo aircraft, and merchant ships.

5. Radiation sterilization and preservation of food and medical supplies.

6. Protecting agricultural products from insects.

7. Radiation processing of materials to alter their properties.

Military/Defense

War too often has been the spur to the development of technological breakthroughs and innovations. History is full of examples of civilian applications accruing from military research and subsequent technology. Radar, large rockets, and communication satellites are examples that come to mind through recent military activity.

From all indications, military research and development will not be de-emphasized when the Vietnam conflict is settled,, On the, contrary, the war has brought out glaring weaknesses in our limited warfare techniques and sadly depleted our technological levels of leadership in strategic weapons. Stockpiles of conventional weapons will likely be rebuilt following the conflict, and new weapons and defense systems will undoubtedly make their appearance. Some of the highly specialized candidates for advanced military applications are:

1. Detection devices against ambushes, intruders, and land mines and for locating tunnels.

2. Better personnel and helicopter armor.

3. Improved air-to-ground weapon delivery systems that reduce aircraft missions and losses.

4. More effective warning and defense means against mortar and rocket attack.

5. Improved systems for night vision and battlefield lighting.

6. Continued improvement of land, air, and sea strategic weapon systems: and space-oriented surveillance, nuclear delivery and missile defense systems.

Traditionally our national security has emphasized protection from external threats by the use of military force. The basic elements of this protection are weapons and related systems, leadership and training of the armed forces, and a strong and united desire for freedom by the American people.

The military organizations and defense industries, formerly concerned with simple machines and munitions, have now evolved into a unique team with tremendous resources, influence, and capabilities for management, engineering, and problem solving. With the Department of Defense accounting for one.half of our federal tax dollar, primarily for highly technical equipment and systems, it is inevitable that the taxpayer make demands and attempt to influence the results of this expenditure. Accordingly, the Department of Defense is now seeking to contribute more to the social and economic needs of our country and to help alleviate some of the more pressing domestic problems. These problems are as equally important to our national security as protection from external military threats.

Some of the key areas now being studied by the defense department for social utilization include employment, housing, and educational improvement. For example, new materials and production techniques for low-income housing are being developed from the $650 million annual expenditures on construction and operation of military housing. This represents the nation's largest single user of housing and is an excellent opportunity for incorporating modular design techniques, volume procurement, production line assembly methods and prototype projects. These innovations could have a beneficial impact on one of our most pressing social problems: the need for low-income housing.

In the field of education, military training techniques have long been a valuable too! for opening the door to unskilled segments of society. Many of the techniques developed to instruct these people have been both practical and effective and with wide applications. Direct applications of some of these techniques could well be used in improving primary and secondary school systems throughout the country. The individual who can operate such highly sophisticated technical equipment as- found in modern aircraft or missile systems can also contribute to the technical base of our society and usually has the motivation to do so after a tour of military duty. He is also more likely to seek higher education after experiencing the role of a technician and learning some of the basics of engineering.

In the area of employment, most of us are aware of the equal opportunity clause in government contracts. This social tool has helped many individuals with economic and cultural draw/backs to enter highly technical fields previously unavailable to them. Improvements in education will materially assist in removing their handicaps and motivating such persons into entering careers formerly denied them.

Another tool now considered by the Department of Defense and industry requires the location of new facilities and placing subcontracts in labor surplus areas. If now appears that our traditional competitive bidding lav/s and procedures might possibly be changed to consider more strongly unemployment as a major factor in evaluation.

It thus appears the defense department, one of our largest suppliers of new technology, has the potential to assist our cities, states, schools, and businesses in solving some of our complex problems.

Oceanography

There has been much discussion recently concerning deep ocean technology as a new field to rival the space program in research and development funding. The 70's have been proclaimed the decade of oceanology - learning the secrets of the seas and exploiting their treasures for the benefit of all mankind. However, the recovery of resources is primarily an economic business and only secondarily a technological business. The role of technology is to enable the economic recovery of resources, and only economics will determine which engineering possibilities are put into practice. For example, the petroleum industry is currently spending over $2 billion a year for locating and recovering offshore oil and gas deposits. This offshore production now accounts for 16% of the world's total. By comparison, the current annual budget of the federal government for oceanographic programs is one half billion dollars or one-fourth that of industry.

We cannot question the need to apply various benefits from the oceans to serve the needs of society — food, minerals, energy and recreation and to develop commerce and economic growth. Marine sciences and technology are now penetrating "inner space" and many of the inherent problems in this field are similar to those in the aerospace environment and lend themselves to the same techniques for solution. Technical problem areas and objectives include:

'1. Data handling and information .transfer systems including buoy systems for telemetering data to satellites.

2. Undersea resources development studies (reclamation, conversion, and applications).

3. Continental shelf development studies.

4. Advanced propulsion and power systems.

5. Bio-medical and Human engineering studies (Man-in-the-Sea),

6. Underwater communication studies.

7. Materials and structures for undersea environments.

8. Underwater instrumentation and sound studies.

9. Farming the sea with underwater and shipboard harvesting, processing, and preservation equipment.

Space/Astronautics

The marriage of rocketry and astronautics has finally allowed man to attain his age-old dream of exploring outer space. This celestial goal has motivated countless numbers of individuals to wonder about our solar system, and now nations are engaged in competitive efforts to extend their influence into this new realm. Also, the earth continues to shrink in man's view as he now reaches the moon and fixes a more confident gaze on the stars beyond.

The period from the first concept of space travel to its reality has spanned many centuries, with the first known recordings made almost 2,000 years ago. However, the impact of the space program on mankind and the social applications from space science and technology are already evident in a variety of ways. Possibly these benefits have recently been overemphasized to justify the billions spent on "outer space" when our social problems are crying cut for solutions here on earth. It is unlikely, however, that the irreversible drive of the space program will be halted because it is one of the most obvious sources of pride and power to our nation and primarily because of the obvious challenge from the Russians.

Now that the manned lunar landing goal is almost accomplished, the next phase of space science and technology will involve earth satellite applications, manned space stations, lunar exploration, and unmanned probes of the planets. Besides the new scientific knowledge that can be expected from these activities, much more emphasis is now being given to the direct benefits to mankind. Applications of prime interest include those involving earth resource surveys from space which can help alleviate the population growth problem. Typical of these are:

1. Agricultural and forestry resources

   a. Land usage and range surveys for increased productivity
   b. Detection of crop diseases and forest fires
   c. Crop and timber identification and inventories
   d. Watershed, flood control and irrigation studies
   e. Wildlife and recreation surveys

2. Geographical studies

   a. Topographical and ocean bottom mapping
   b. Urban surveys and population analysis
   c. Transportation and linkage surveys

3. Geological and hydrological studies

   a. Geologic mapping
   b. Mineral and heavy metal surveys
   c. Thermal and volcanic surveys
   d. Magnetic and gravity field analysis
   e. Groundwater, sedimentation, and pollution surveys
   f. Snow surveys and glacier studies
   g. Erosion surveys

4. Oceanographic studies

   a. Sea state and temperature surveys
   b. Ocean mapping
   c. Fish location
   d. Marine biological and pollutant surveys
   e. Sea ice and hazard surveillance
   f. Sea tracking and rescue

These resource programs will require extensive technological development of sensors, instrumentation, and data handling systems during the next few years; but the economic payoff will be worth the expense, being estimated in the multi-billions.

Other existing or planned space projects of social and economic interest include-:

1. Communications

   a. Direct-to-home broadcast satellites
   b. Point-to-point systems via satellite
   c. Deep space relay stations
   d. World-wide data collection from remote and multiple sources (meteorological, oceanographic, ground stations).

2. Meteorology

   a. Weather observation and prediction
   b. Weather control/modification (rain, hail, hurricane, tornado)
   c. Air pollution studies
   d. Accurate atmospheric models

3. Navigation

   a. Position determination (distances, directions, rates)

   b. Traffic monitor and control

4. Reusable commercial spacecraft (Post SST)

   a. Reduce sonic boom and weather problems
   b. Approaches ultimate in high speed movement of goods and people
   c. Improved economies
   d. Earth to earth orbital logistic vehicles

5. Uses for space environment

   a. Develop low-gravity and zero-gravity engineering techniques
   b. Biological, medical, and human behavioral research
   c. . Materials research and manufacturing (vacuum, zero gravity, non-contamination, etc.)

It should be noted here that the National Aeronautics and Space Administration is a research and development organization directed to promote peaceful uses of space for all mankind. It is heavily involved in attempting to channel its new technology into the civilian economy. Typical areas that have been cited as examples of "spinoff" and improvements resulting from current space technology include telemetry systems, cryogenics, metal joining, closed environmental control systems, quality control and reliability improvement, compact electronics and computers, data processing, design procedures, lightweight structures and composite and synthetic materials. Unfortunately, the bulk of aerospace technology appears to be too advanced for immediate use in the civilian fields. When private funds are at stake, a more conservative and proven technical approach is generally called for to reduce the risk of economic failure.

Perhaps the most important result of the space program has been to make us realize that practically any technical task is feasible. Together with the nuclear, aeronautical, and military methods of systems management of huge, complex programs, The Apollo project has focused attention on one of the nation's most important resources - the highly skilled capabilities of the government/industrial aerospace team.

By using the systems approach and effective management of technology for the public good, we can meet a variety of our social needs.

Whereas the military, aerospace, and oceanology programs have many obvious impacts on our social goals, their benefits have not been primarily channeled into the complex problems that we now face in such areas as housing, transportation, heal.th, and education. Technology is now being planned and applied in more and more of these areas with direct benefits to society. The following areas illustrate the point:

Health/Medicine

Perhaps no field of science is of more vital concern to the human being than the one that is concerned with his health. Biology and engineering are now combining forces to solve such complex problems of medicine as automatic instrumentation for diagnosis and assessment of medical tests and information handling techniques. Artificial human organs, surgical lasers, and servo controlled limbs are other examples of the marriage of medicine and engineering. However, there is an urgent need for the development of materials compatible with blood and development of compact energy sources. Human limit and tolerance values for such parameters as radiation, vibration, temperature, pressure, and fluid and oxygen levels are also needed for analysis of related physiological and psychological changes and combined effects in man.

Biological science and the systematic application of advanced technologies can help us tap the most valuable resource on this planet - the human intellect - by lowering mortality rates. However, the moral, ethical, and social problems inherent in transplanting organs, birth control techniques, selective breeding, and hormone control are certainly not fully understood at this time and require much additional study.

Education

The challenge and competitions of the space age have done much to improve the availability and quality of technical education. But much more is needed to relate this education to the social values, relationships and experiences that are a part of our complex world today. Improved and more pertinent courses, more emphasis on how to make use of knowledge, and incentives to fully appreciate the value and wisdom of age old customs are also strongly needed. We must also learn to appreciate the tremendous impact of television and commercial advertising as educational tools. The need for continuing education and retraining throughout life is also a consequence of the growth of technology and rapid social change, and it is a need that must be considered by our educational institutions .-

Our educational system has been described as not really a system but a collection of subsystems with bad interfaces. The technology explosion has certainly contributed to this situation but it may also become a useful tool for the improvement of education generally. Finding the relationships between law, sociology, economics and the humanities in relationship to mathematics, physics, and engineering should be one of our prime educational objectives.

Science and technology are as limitless and as complex as the human spirit and nature. Therefore, we need to develop a technology of decisions and priorities to provide the information and consequences of our actions based on predictive models for future strategy. Only then can our moral judgments and educational policies provide the answers to the complex problems of society.

Housing/Community Relations

Technology advances most rapidly during periods that bring needs and desires clearly to the attention of society. Our current concern with urban renewal points out this need for applying every facet of technology to one of the most difficult management and logistic problems conceivable. It involves, improvement of water, power and food distribution; liquid, solid, and gaseous waste disposal as well as transportation, housing, education, recreation and communication systems for many millions of people at the earliest possible date. It also involves the coordination of many overlapping federal and local agencies concerned with welfare, labor, pollution, crime, and' fire prevention. Typical of these approaches is the current Mode! Cities program. This combined social, economic, and technical approach attempts to function under numerous federal programs with city, county and state participation.

In the field of housing, there are numerous innovations needed to improve the quality, financing, flexibility and maintenance aspects of this $100 billion yearly market. The large volumes of units now needed should provide quality and cost breakthroughs with new materials, pre-fab methods and systems techniques based on large unit purchasing/and sound engineering principles. Brand new cities and rural development for recreation and industrial uses will help alleviate many of our current urban problems.

Transportation

National officials are finally beginning to realize that we are facing a transportation nightmare and have accordingly established the new cabinet level agency, the Department of Transportation. Increasing numbers of ground and air vehicles are saturating our control facilities and seriously jeopardizing our safety and travel convenience. New high-speed mass transportation systems are being proposed along with improved traffic systems and safety devices for inter-city and infra-continental travel. Typical programs requiring intensive technological effort include:

1. Air traffic systems including improved radar and displays with three dimensional data and collision avoidance and terrain sighting studies.

2. Aircraft communications/navigation improvement and position data using satellites.

3. Ground traffic congestion control systems including flow sensing and area surveillance TV cameras at intersections.

4. Radio linked routing aids, overtaking and passing control systems.

5. Continuing emphasis on automobile safety devices to protect the occupants.

6. Development of high-speed trains, air cushion and tube track vehicles and monorails for high speed ground transportation.

7. Development of VTOL vehicles for intra and inter-city travel.

TRANSFERRING TECHNOLOGY

Today, we actually have a stockpile of technology just looking for applications; many that could be used in the common interest and with Inherent social benefits. This technical knowledge and information must also be considered as a resource in the same sense as money, people and facilities are considered resources. The cost of not knowing the necessary information to accomplish our goals can be extreme and new techniques must be found to extract available information rather than repeating the research and development and in some cases actual production activities. Computerized information research centers appear to be the answer to this problem of defining technological needs and sources.

The transfer of scientific and technological knowledge to new applications has some social problems of its own as it involves extremely complex "people problems" as shown on the accompanying illustrations. First, Figure 1 shows the relationship between research, development and production for a typical idea. Here the critical link is the coupler or innovator who can overcome the resistance to change and the status quo which are dependent upon social and political conditions as well as technical, legal and economic conditions. Of course, the final test of value is the economic success of the enterprise as reflected in profitable sales, as profit is the reward for recognizing and meeting the demands of society.

Figure 2 shows a design method for developing new items. The similarity to scientific methodology and the step by step procedures involving interfaces of

FIGURE I

BASIC CYCLE FOR TECHNICAL TRANSFER

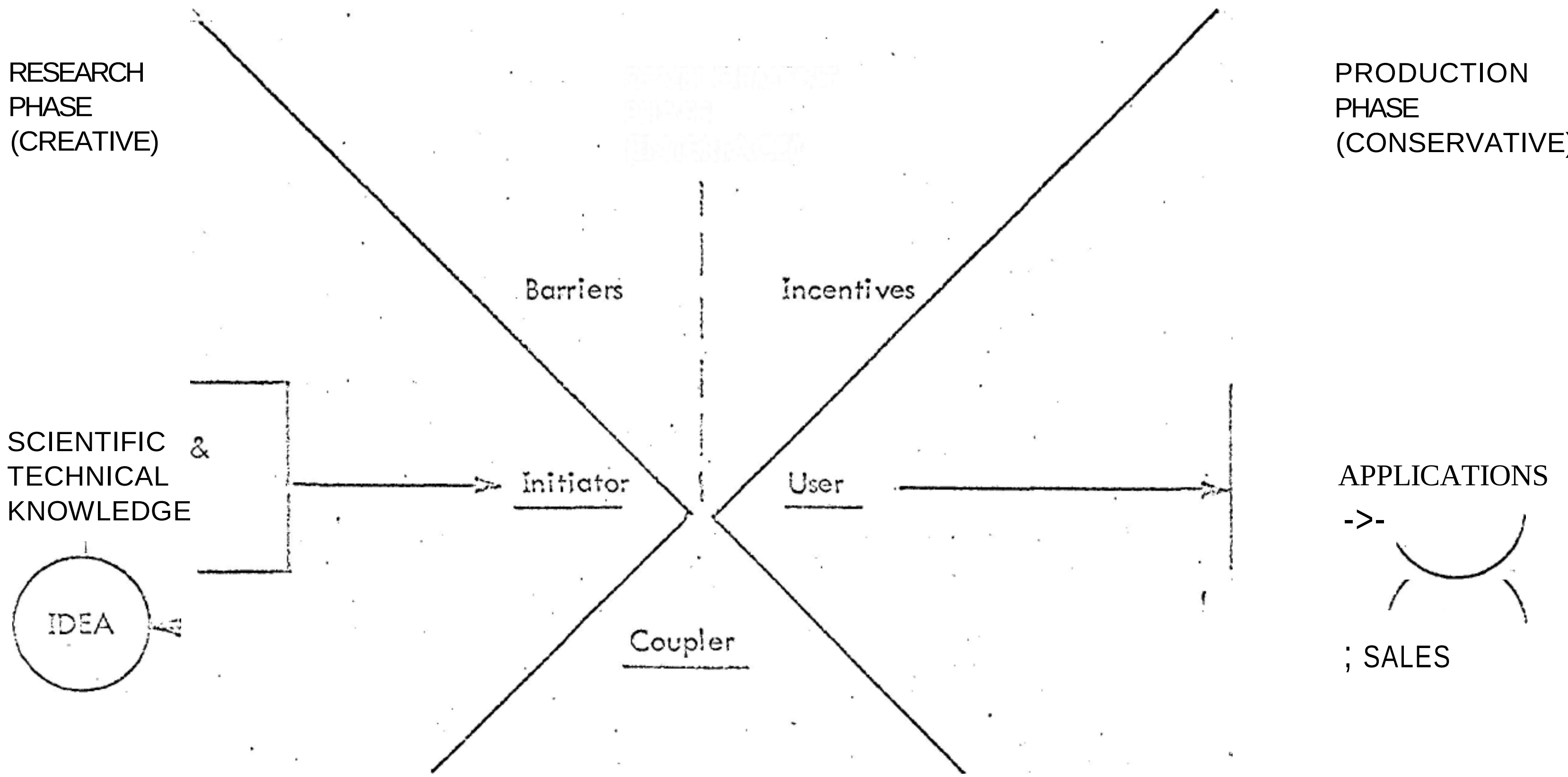
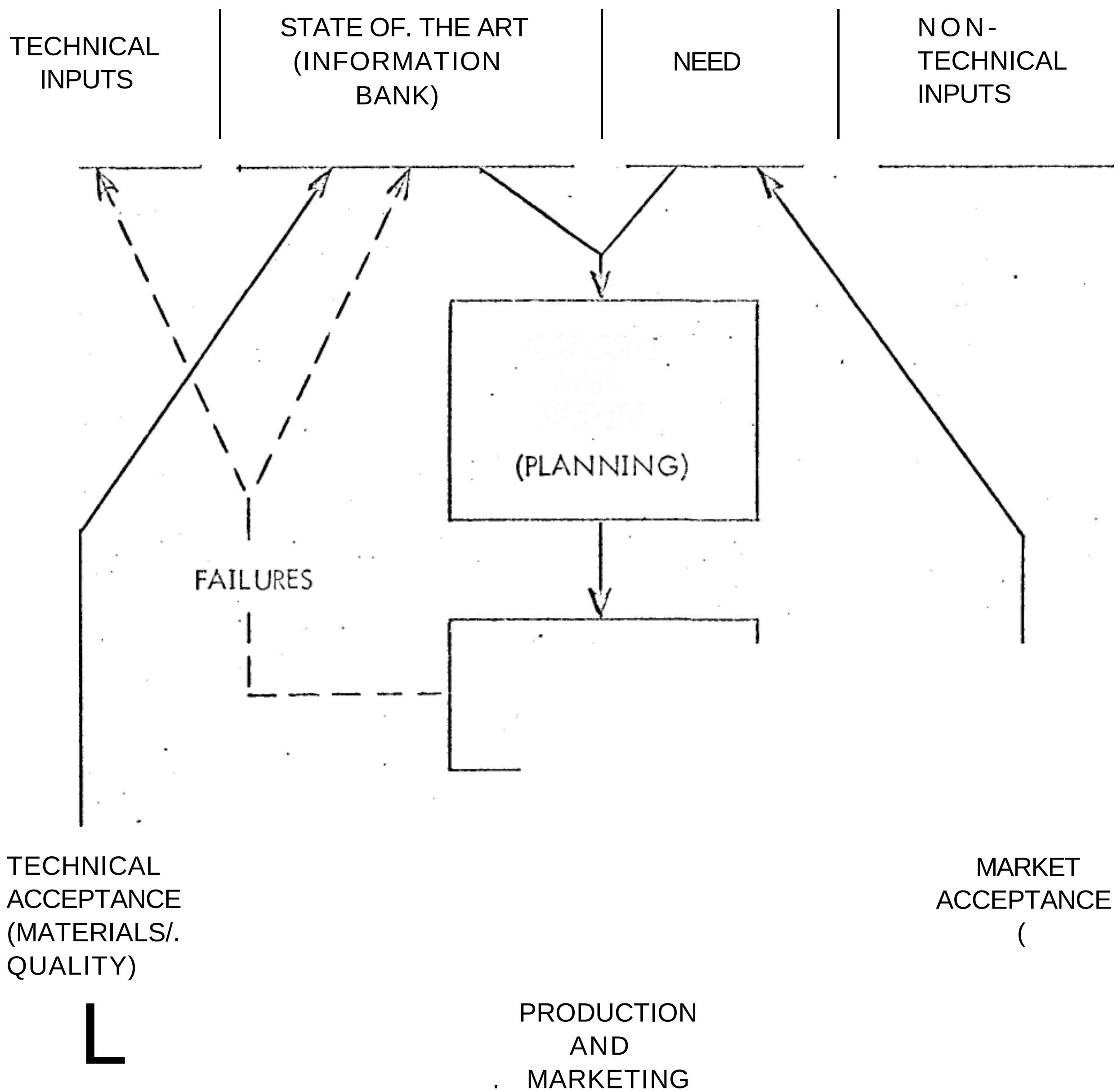


FIGURE 2

DESIGN METHOD FOR DEVELOPING NEW ITEMS



complex and divergent interests are apparent. This system for obtaining practical results can certainly be applied more efficiently to use our backlog of scientific and technological knowledge. Likewise, the system should be applied to complex social problems by more emphasis on the non-technical needs of society if we are to realize the full potential of our rapidly expanding wealth of knowledge and information.

To transfer and use information at a faster rate is a desirable goal; but, to realize it, new management techniques and more efficient methods of transfer must be studied and applied. The role of management in selecting and applying new technology is most critical. Even though we have made astounding progress in exploiting our knowledge, it is but a faint image of what could be done.

The role of education in the technology transfer process must also be closely evaluated and steps taken to recognize the human problems which are the crux of transfer mechanics. New courses are needed to deal with problem recognition and description, to perform economic and business analysis, and to help utilize resources and sharpen interpersonal relationships. Only after studying the complex factors that relate money-making products in the commercial market to social implications should the originators begin to consider valid applications for their ideas.

More effective communication links are required to shorten the time elements between scientific discovery and ultimate use of the resulting technology. Much more study is needed to consider matrix systems and computerized matching techniques for relating disciplines, technologies, and potential applications for each new technical developments.

The packaging of information is another critical factor in the communication cycle. Catalogs, indices, and abstracts of pertinent data are needed in specific categories for review by potential users. Likewise, audio-visual techniques such as film strips and motion pictures could be extremely helpful in dramatizing new technology and in showing potential applications and implications.

Additional study areas should include:

1. Development of professional coupling agents and the possible use of engineering, economic, and sociological teams as coupling agents.

2. Investigation of better techniques to close the gap between originators and users. The dynamics of the transfer process should be studied, models developed, and systematic monitoring techniques realized.

3. Stimulation of motivational factors and incentives to improve dissemination and receipt of applicable technology to both technologists and sociologists.

4. Further investigation of barriers and incentives to effective transfer. These are primarily social and economic rather than . scientific or technical factors.

5. Investigation of establishing experimental or prototype shops to adapt and develop new applications.

6. Investigation of interdisciplinary, accidental, and overlapping factors in the transfer process.

7. Additional use of trade shows, "browse" areas, exhibitions, and information centers to improve dissemination of new technology.

8. Investigation of developing completely new designs incorporating combined technologies for social applications. As an example, a number of aerospace materials, such as honeycomb structures, .flat cables, foam insulation, and adhesives could be incorporated into new housing concepts.

TECHNOLOGY TOMORROW

The population explosion is the fundamental problem of the future. Lack of productive soil and water to support future masses becomes the ultimate concern. Living space and resources to meet their needs comes next, followed by the massive problem of waste disposal and pollution.

The issueof maintaining a free choice in the selection of the fruits of technology and, at the same time, controlling the effects to reduce the adverse and encourage the beneficial is a tremendous problem. The objective must not be to choke off technological change but rather to guide it along more socially desirable paths. Current policies must be more closely analyzed to identify potential problems and to crystallize public opinion and political action. By widening the spectrum of choices available to society, technology allows us the ability to make more intelligent decisions based on more accurate information.

Current interest in predicting the future with emphasis on scientific and social trends reflects a new awareness of the close relationship between th-3 two. With our rapid transportation and instant communication, the linked effects of changes can be readily observed throughout society. We must learn to understand these changes and trends and face potential problems with the objective of controlling them. Foresight becomes more essential even as it becomes more difficult to apply it to our complex systems and rapid changes.

Some of the principal trends and predictions for our life in the future are listed to provide an insight into current directions of economic, social, and technological change.

1. Rapid and continuing growth of scientific research, knowledge and education.

2. Growth of social and centralized control and greater nationalization of social policies.

3. Rise in automation and specialization, and in professional personnel.

4. Growth of industrial monopolies, mass production, and standardization of goods.

5. Decline in income differences and reduction of economic risks.

6. Cultural integration and physical migration to rural and more pleasant climatic areas.

7. Growth of leisure, recreational, and entertainment pursuits.

8. Growth of specialized regions for agriculture and ocean farming.

9. Increased spending on landscaping, gardens, parks and forests for public use.

10. Increased research on the search for immortality, knowledge transfer, physical improvement, and memory systems.

11. Development of forecasting techniques to help control technology on a conscious and deliberate basis.

12. Evolution of computer technology as man's most useful tool.

13. Wider application of new materials as the ."Materials Age" of man sets the pace for technological development.

14. Further consolidation of industrial and educational activities to supercede the Industrial Revolution.

CONCLUSION

The intellectual and the creature needs of society present a double challenge to science and technology. Society, as represented by government, is primarily concerned with political goals while the industrial sector seeks the economic. Therefore, it is left up to our educational systems to acquaint the individual with his responsibilities to understand the implications and relationships of technological and sociological change. Understanding nature and extending the limits of our knowledge must be accompanied by incentives to improve our. environment and our sense of social responsibilities.

Technology can free man from toil, if can help him achieve a fuller and richer life if he applies his new found leisure to understand himself and his fellow man better as well as nature and the universe. It can provide mobility and rapid exchange of information. But technology cannot inject ambition or moral strength or provide a stiff backbone. It cannot provide incentives to .control our population growth or goals to stretch our technical abilities to the very limits of our imagination. Nor can it change a policy that spends more on welfare than on education. Only an enlightened people sparked by brilliant political and cultural leadership can successfully direct our energies to answer these needs of society. We must first understand our problems and then direct all of our skills to solving them. We must also' involve people and provide them with more incentives to achieve a fuller and more varied life; a life of freedom and enjoyment, of adventure and wonder, and an earthly environment of natural beauty that encourages health, happiness, knowledge, and persona! improvement.