PROJECT REPORT

SPACE TECHNOLOGY APPLIED TO MAN'S EARTHLY NEEDS

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AMERICAN MACHINE & FOUNDRY COMPANY
Advanced Products Group
Field Operations & Engineering Division
Santa Barbara, California

SPACE TECHNOLOGY APPLIED TO MAN'S EARTHLY NEEDS

A Feasibility Study on the Transfer of
Aerospace Technology to Industry Use

For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Office of Technology Utilization and Policy Planning
Washington, D. C.

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ABSTRACT OF THE REPORT

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This report on Space Technology as it Applies to Man's Earthly Needs covers Phase I of a feasibility study on the acceleration of transfer of aerospace technology to commercial industry. During the four-month period of the experiment, a determination was made of the extent of the present use of NASA technology within an industrial family — AMF. Typical needs were determined. A survey of aerospace literature, its quality, quantity and availability from the aspect of the non-aerospace user was accomplished.

Forty-seven specific candidates for transfer of knowledge to satisfy needs were formulated. Aerospace literature was reviewed from the aspect of applicability. Six good candidates for transfer were established.

Recommendations were made for the continuance of Phase II of the study.

author

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I. INTRODUCTION

This report on Space Technology as it Applies to Man's Earthly Needs was prepared by American Machine & Foundry Company, Field Operations & Engineering Division, at Santa Barbara, California, as a result of a technology utilization feasibility study, accomplished for NASA Headquarters, Office of Technology Utilization, under contract No. NASW-1139.

This study was initiated to observe the actions and interactions of the meshing of aerospace technology with American industry needs and to explore methods of accelerating the transfer of knowledge for the benefit of man and his earthly environment. AMF, with its diverse product lines, services, and technology interests was considered as a typical family of medium sized American industries and ideally suited as a test bed for this experiment.

The report covers Phase I of the study, a period of four months. Determination of the extent of the present use of NASA technology within an industrial family — AMF, was made. Typical industrial needs were determined. A survey of aerospace literature, its quality, quantity and availability from the aspect of the non-aerospace user was accomplished. Forty seven specific candidates for transfer of knowledge to satisfy needs were prepared as cases. Aerospace literature was reviewed from the aspect of applicability. Six good candidates for transfer were established.

Phase II of the experiment should include continued aerospace literature research on specific industrial problems, technology transfers to industry, and observation of the actions and interactions of industry needs with aerospace technology, to evolve an optimum organization and methodology which can best accelerate transfer. Aerospace research support and observation of the technological developments of the candidates for transfer initiated in Phase I should be continued.

This report was prepared based on the observations of an industrial family — the American Machine & Foundry Company. The study would not have been possible without the willing cooperation of AMF group executives, vice presidents, business unit managers, and engineering, research, marketing and production personnel. The authors are grateful to them for their participation in the STAMEN experiment.

We are also particularly grateful to Breen M. Kerr, Assistant Administrator, Technical Utilization; C. F. Yost, Director, Technical Utilization Division; L. E. Richtmyer, Manager, Technology Survey and Industrial Contracts; Paul Feinstein, Chief, Technology and Engineering Branch; and Victor Coles, Technology Services Branch, of the Scientific and Technical Information Division, for their help and guidance.

We would also like to thank the many who shared their ideas on technology transfer with us. Among these, we particularly thank Dr. H. L. Timms, Director of Operations, and D.W. Cravens, Assistant Director of Operations, of Aerospace Research Applications Center of the University of Indiana; John G. Welles, Head, Industrial Economics, Denver Research Institute, Denver University; Dr. Randall M. Whaley, Vice President, Graduate Studies and Research; and Bruce W. Pinc, Director, Center for Application of Sciences and Technology, Wayne State University; Dr. F. F. Muraca, Director, Chemical Division, Stanford Research Institute; and H. H. Green, General Electric Company, Patent Office.

We are also grateful to Robert W. Hall, of Aerospace Research Applications Center, for his contribution to the technology search for Case #9.

II. CONCLUSIONS AND RECOMMENDATIONS

The primary objectives of Phase I of the STAMEN study were to determine the extent of present usage of aerospace research technology in a sampling of an industrial community, initiate the meshing of commercial industry needs with matching aerospace data, and provide candidates for technology transfer so that commercial industry technology developments utilizing aerospace research data can be observed. Although the four month period of the study did not allow sufficient time to prove out and definitize all conclusions reached, the following conclusions and recommendations were made as a result of Phase I.

A. Technology transfers from aerospace to industry will occur in time, due to the natural evolution of technology and will be facilitated by transfers of people from aerospace to commercial industry. The best catalyst to accelerate technology transfer was considered to be the competitive spirit of American industry; i.e., if the competiton offers better products as a result of aerospace technology, then the rest of industry will follow along, spurred on by the need for survival.

B. It appears possible to achieve forced transfer of technology by the two approaches taken in this study; i.e., 1) match an existent industrial need with aerospace data, and 2) provide a completed product or idea for industry to accept. An example of the first type of transfer is the use of the rocket case, non-destructive test techniques, to provide a commercial tire carcass inspection device. An example of the latter type of transfer is the use of a NASA special report (SP-5005) on a retrometer, to provide a toy product line.

C. In the second approach of transfer, adaptive research must be applied before the new product or end use of the information can be fully realized. The minimum time span required to achieve a complete transfer of technology into a new product was found to be two years.

D. Forty-five (45) commercial industry cases of an existent need were formulated as candidates for technology transfer. Twenty-four (24) were matched with aerospace data. Of these, five cases were determined to be good candidates for transfer. Eight (8) cases were found to be good candidates, if industry defined its need better. An additional eight (8) cases were found to be fair candidates for transfer. The applicable retrospective literature was provided to the business units for their evaluation and decision on further development. The five good candidates selected were: Case #1, Oven Belt Material; Case #4, Heat Treating of Steel Shafts; Case #9, Tire Carcass Inspection; Case #19, Inflated Sports Ball; and Case #28, Pipe Coatings.

E. Two (2) cases for providing a completed product for industry to accept were formulated. One case, the Retrometer (Case #8), was adopted by a business unit for further development into a commercial product line. The second case (Case #7) was dropped subsequent to a new products committee decision that its market potential was not sufficiently high.

F. It appears that the Regional Dissemination Centers provided a needed service to commercial industry. This conclusion is based on the excellent service the STAMEN team received from the Aerospace Research Applications Center on the retrospective literature research for Case #9.

G. In many areas exclusive patent rights for a specific period of time will be a prerequisite for using an aerospace innovation in a commercial product.

H. Aerospace technology research was found to be just one source of data among many, and the probability of the success in using this source alone was low. Aerospace data must be used in combination with other technology source data (such as patent and professional society information) in order to obtain an accurate definition of the technology to be utilized, and commercial industry state-of-the-art. Aerospace research data was found to be of greater value in some industrial fields of endeavor such as coatings, non-destructive testing, etc., than in others such as adhesives for wood, ABS plastics, etc.

I. It was found that American Machine & Foundry Company, as was typical of the organizations of this size, was not organized to facilitate the channeling of new technology (such as aerospace and others) to the levels of need or potential users of the information. A framework, or start towards a central research information service, was found to exist in the R&D division. The services of this division should be expanded to include not only research on specific projects but also to provide an information and retrieval service on the common problems, or fields of technology interest of the AMF family. This service should include non-aerospace source information as well as aerospace information. To avoid the quick death of just another library service, it should maintain personal contact with information users, perhaps through tours of business units such as accomplished in the STAMEN experiment.

J. Professional people engaged in commercial industry technology were found to lack the knowledge or training on methods and results of literature searches, best sources for information, etc. Training is recommended in this area to teach information retrieval to undergraduates in college and to professionals by seminars, professional society-sponsored study lectures, or journal education. It was also found that industry management was not fully aware of the possibilities of benefits derivable from aerospace technology.

K. The study suggests that small-sized industry (small business), because of economic consideration, should utilize information services such as that of the NASA sponsored Regional Dissemination Centers, and attract employees with specific, advanced technology experience applicable to their industry.

L. The aerospace literature of STAR and IAA was not indexed to facilitate information ready retrieval and use by non-aerospace users. A more efficient response and dissemination system to requests for reports cited in STAR was also found necessary. The exigencies of American industrial business often requires immediate solutions to problems.

M. The TUP special reports were found to be excellent documents and were warmly received by industrial users. More of these reports are recommended, specifically in the interest areas of importance to commercial industry. Additional research, or information, should be provided in the special reports to give examples of the usefulness of the information to non-aerospace users.

N. It was found that the tech briefs suffered in the hands of industry by the NIH factor — not invented here. It was also found that tech briefs circulated through working levels of industry were put to excellent use when employed as a stimulation to creativity.

O. It was found that industry must do a thorough job of defining its needs, so they can be successfully matched with possible aerospace solutions.

P. Based on the sampling made, it appears that a majority of commercial industry was not familiar with the scope of the NASA Technology Utilization Program, its special reports, tech briefs, and its potential as a source for research data.

Q. Continuation of the STAMEN study is recommended, in order to provide more conclusive knowledge on actions and interactions of space technology and industry needs; and in order to develop a recommended plan to facilitate and accelerate transference.

III. DISCUSSION OF EXPERIMENT AND RESULTS

A. DESIGN OF THE EXPERIMENT AND PROGRAM PLAN

The initial step in the STAMEN study experiment was to first establish a definition of the industrial population so that its actions and reactions to the introduction of aerospace data can be observed and measured as in a test bed. In order to accomplish this, it was necessary to define industry's present utilization of aerospace technology, what other technology is presently used, what are the technology needs, and what are the communication paths that technology must use in order to achieve the desired goal of man's use. This was accomplished by a questionnaire and interview visits.

The second step in the experiment was to establish the current AMF technology needs that may be satisfied by aerospace research technology. Needs were selected so that experiments of a forced transfer could be made by use of various approaches. Approaches used singularly or in combination were:

1. Satisfy known industry need for a product, product improvement, new manufacturing process, or material application.
2. Provide a completed product or idea for industry to accept, to satisfy an unrealized need.
3. Utilize Technical Briefs
4. Utilize TUP Special Reports
5. Utilize STAR and IAA Reports
6. Utilize a NASA sponsored Regional Information Dissemination Service

Experiments were also conducted so that various sized industrial units and industrial units of varying degrees of technology sophistication and need could participate.

Services of the NASA/Scientific and Technical Information Facility were utilized to obtain applicable technology data. Literature search included:

1. NASA TUP Technical Briefs
2. Technology Utilization Special Publications (NASA-SP-5000 Series)
3. Scientific and Technical Aerospace Reports (STAR) and International Aerospace Abstracts (IAA).

Each retrospective search was conducted in the context of satisfying a specified industrial need as developed in an AMF business unit. The NASA literature was also reviewed to provide a completed product or idea that could be presented to a business unit and readily adapted and complement its existing product lines. The Technical information retrieved through data searches was analyzed for applicability to particular needs and to related industrial requirements, and also assessed as to probable general applicability. The literature search was confined to literature and data published since January, 1962.

A rule was established not to seek nor receive priviledged information or service from NASA, to preserve the context of the experiment and to use only that which is available to industry in general.

A STAMEN project team was established, having a combined capability in engineering, economic analysis and management sciences. The project was staffed from AMF's Field Operations & Engineering Division. The project manager reported organizationally to the general manager of FOED. Interdivisional liaison was handled at this level, and as required at the next higher company echelon, the Advanced Products Group.

The team was responsible for performing all research, evaluation of innovations and their introduction into the test bed. They made a record of all progress and observations. Records were maintained on all technology literature research, together with resulting conclusions. Technology transfers that have occured prior to the STAMEN project were reported.

Matching of industrial needs with aerospace technology were made and initial preliminary transfers of technology attempted.

B. TEST BED - AMF

1. Background on AMF

For more than half a century, American Machine & Foundry Company has concentrated on bringing new concepts of equipment simplicity and performance reliability into the more complex processes of automation for a variety of industries. The history of AMF is the history of continual technology change and development.

American Machine & Foundry Company was formed in 1900 in Hanover, Pennsylvania to manufacutre machinery for the cigarette industry.

AMF continued to expand through research, development, and manufacturing of special purpose automatic machinery for the tobacco industry. This machinery included the first high-speed cigarette maker and a cigarette packer which helped to develop the five-billion dollar domestic cigarette industry. Today, nine out of ten major domestic cigarette manufacutrers and almost ninety firms all over the world use AMF automatic tobacco machinery and processing equipment.

In 1925, AMF made its first move to diversify its product line by marketing a bread wrapping machine. This was the beginning of the second major area of company activity.

1936 saw the further diversification of AMF into the apparel industry, and 1938 marked the beginning of research that was to produce the AMF Pinspotter which brought about an extensive boom in bowling and changed the nature and economy of the bowling industry. Other developments that have helped to make AMF the world's largest manufacturer in the bowling field are "Magic Triangle" and Underline Ball returns and Radaray Foul detectors.

World War II resulted in redirected company efforts toward the design and manufacture of defense products, including gun mounts and radar systems. After the war, the company continued its growth program by seeking out and acquiring sound and well managed companies whose products added breadth and diversity to the company's established line.

One of the first industrial firms to enter the field of atomic research and development, AMF Atomics now leads in supplying complete nuclear research reactor installations, and is also active in packaged power reactors and remote-handling equipment for radioactive materials.

During the early days of the missile gap crises, AMF-APG contributed to missile launcher technology by design, fabrication and installation of launchers for Talos, Atlas and Titan I. APG today, among other projects, has developed a SMOG Burner for exhaust systems on automobile engines, and operates a Monorail at the New York World's Fair.

The corporation was organized into product groups for centralized control and flexibility along the diversified product lines. These product groups include recreational products, industrial products, advanced products, electrical products, and process equipment. A complete listing of the groups and the business units comprising the groups is contained in Table I. Today, 30% of AMF's business is in government products, with the remainder an equal mix of industrial and recreational products.

Recent technology advances summarized from the AMF annual report for 1964 are:

The Friction Welding Division delivered its first fully automated friction welder for welding bi-metals components. This system, developed by AMF, has numerous high speed production applications; machines are now being built for use in the automotive, recreation and home appliance industries.

In 1964, Tuboscope's new product, Linalog was introduced. This is an electronic device which surveys, detects and records both the internal and external condition of pipe. It is propelled forward by the pressure flow in the pipe. Capable of covering over 100 miles of pipeline a day, it constantly records its measurements and then makes its exit at selected junction points.

AMF Thermatool developed high-frequency contact resistance welding, adopting its process for several new applications, including uses in the automobile industry and manufacture of heavy structural pieces.

In 1964, AMF Cuno was able to provide the growing yachting trade with what is now a complete line of evaporators and filters for the conversion of salt water to fresh water, removal of taste and ordor from tank water, and fuel filtering.

Four Maxim Evaporators, each of 115,000 gallon daily capacity, were delivered for use in the nation's largest municipally-owned seawater distillation system. Using waste heat generated by the incineration of refuse, they will produce the fresh water required to control the air pollution of the refuse burning operation at Hempstead, Long Island.

The Voit Company was originally a producer of retread rubber. This led to a new kind of rubber covering for athletic balls, and then to automatic production of other sporting goods as well. The 45 millionth AMF Voit basketball came off the line in 1964. It was the combination of these skills plus market insight and long development efforts that enabled Voit to bring out the Orbitread system, an automated and revolutionary concept for tire retreading.

Ben Hogan Company continued its leadership in the manufacture of high quality golf equipment. Its Sure-On and Power Thrust III irons represent another advance toward greater accuracy and distance.

At AMF Western Tool, the new Homko line of power mowers for 1965 marks the first such use of stainless steel blades, and its Flexor design protects the mower crankshaft from damage normally encountered by the blades striking a solid object.

In 1965, the company expects to spend approximately $14,500,000 for research and development in its Morehead Patterson Research and Development Laboratory and the engineering organizations that serve AMF 's products groups.

It is believed that AMF business unit family represents an ideal test bed to observe the introduction of aerospace technology, the nurturing of the new ideas, and development into a new product, process or service.

The STAMEN study included all business units except Sales offices, the International Group and Overseas Operations.

2. AMF Profile

a. Questionnaire - In order to establish a frame of reference for the test bed, it was vital to the experiment to define the extent of present American Machine & Foundry Company utilization of aerospace research in the development of consumer products and services. The questionnaire device was employed to obtain this record. The questionnaire sought to document AMF's present awareness of the NASA technology utilization program, the degree of use and format of aerospace data employed, and past transfers of aerospace knowledge, if any. In addition, information was required on present technology needs of the Company, and the communication path technology data must take in order to achieve fruition. The STAMEN team was also interested in any opinions that may have been formulated on aerospace technology — its format, use, or availability.

The questionnaire is included in this report as FIGURE I. The questionnaire was submitted to the AMF business units, addressed to the general manager of each AMF division or subsidiary. A total of 37 questionnaires was sent to the business units, as indicated in TABLE I. The International Group, World Tobacco Group, Overseas Operations, and Sales and Service Offices were not included in the survey.

b. Questionnaire Results - Replies were received on all questionnaires. Answers received are summarized in TABLE II. All questionnaires received high-level consideration, and were signed by the general manager or engineering manager of each business unit. The replies reflected the opinions of the business units prior to the STAMEN team visits to discuss NASA, the Technology Utilization Program, or the benefits to technology in general from aerospace research.

It was found that the business units were not fully aware of the Technology Utilization Program and of its possible benefits to them. Business units of the Advanced Products Group and others that have accomplished work for either DOD, AEC or NASA were familiar with the program, to some degree, but the business units specializing in the commercial areas of industry such as tobacco, pinspotters, or recreational products were not.

After orientation of TUP, most business units concluded that NASA technology could be of possible benefit to them. All expressed an eagerness to participate in the STAMEN experiment.

Of particular interest were the replies from the eleven business units that use NASA technology. Six data users expressed favorable comments on technology data they have used, and were optimistic about future technology applications (answers to question #5). It is significant that these six business units have larger engineering staffs than other AMF business units, and therefore would have available more manpower to perform literature searches.

Unfavorable comments expressed by users were:

- Need for better indexing of subject matter so that it is oriented to industry use, rather than aerospace use.

- Confusion by some divisions on methods for obtaining documents.

- Need for improved availability of documents.

The most frequent NASA data used were the TUP special reports and the tech briefs. One business unit, Potter & Brumfield, used the services of the

Aerospace Research Applications Center (ARAC) of the Indiana University. STAR has been utilized with mixed results. No significant tangible technology transfers have resulted to date, but neither had there been a conscientious effort to obtain transfers. Three divisions have used NASA quality soldering techniques for quality fabrication requirements. Three divisions have used PERT, a management control technique developed on DOD projects. The Cuno Engineering Company has used the NASA tech briefs as idea generators. The briefs were circulated through the engineering and design groups, and kept on file for easy referral. Although no direct transfers have been made, the exchange of knowledge has been priceless.

The question was asked as to whether aerospace engineering or research personnel were now in the employ of the business unit, in order to determine if transfers on this basis, directly through people, were accomplished. It was found that some business units do employ missile or aerospace people on commercial products, but to date, the acceleration of technology transfer has not measureably occurred. The STAMEN team still believes this is the most direct and efficient way of achieving transfer.

Answers to questions nos. 9, 10, 11, 13 and 14 were used to determine the technology communication pattern in AMF. It was found that data can best be disseminated throughout the corporation by utilizing the communication links of the established company engineering libraries, and the R&D and Alexandria divisions. In general, the business units without libraries have a limited engineering staff, and it is customary for these business units to obtain assistance from the R&D and Alexandria divisions on product development and other complex technology problems.

The best methods for advertising or communicating new technology ideas were found to be the professional societies, the trade journals and the periodicals. Ninety-two per cent of the business units reviewed the trade journals and professional society publications. Seventy per cent sought technology information from the professional societies.

3. AMF Orientation Visits

Select AMF business units were visited to clarify questionnaire data, define technology needs in specific terms, to motivate the utilization of NASA technology and obtain personal observations and contacts with the business unit organizations, people, fabrication processes, products and marketing techniques. Visits were made to AMF corporate headquarters, including the Marketing and Long Range Planning offices. Visits were made to all group executives, except to the International Group, whose work was not considered applicable to the STAMEN project, and to the Industrial Group because of trip schedule difficulties. The business units visited are indicated in TABLE I. In general, the visits were accomplished initially with the business unit general manager, followed by conferences with the engineering and sales managers, and an introduction to shop and research personnel. Visits included a tour of the fabrication and product development areas and inspection of business unit products.

Information was obtained to supplement that of the questionnaire, and aided in establishment of the reference point for the test bed. The visits served to advertise the Technology Utilization Program, by making the working levels of industry, the people with the needs and problems, aware of this source of technology information. This will facilitate transfer by natural process, since potential users of the information are now familiar with the service and motivated to seek technology assistance in that direction.

APPENDIX I contains a summary of the highlights of the visits and the personnel contacted.

4. Conclusions on Test Bed

As a result of the questionnaire and orientation visits, it was found that the American Machine & Foundry Company, as was assumed typical of other industrial firms, was not organized to facilitate the utilization of aerospace technology. The reasons for this appear to be twofold — first, the method of obtaining aerospace data is different from existing methods for obtaining ideas and information relative to industrial business technology advances. Secondly, aerospace innovations usually require adaptive research and development before they can be utilized as end items in the industrial community. In general, the obtaining of aerospace technology from NASA sources requires the user to have at least a library function to file indexes and provide clerical support in ordering documents. Many small businesses do not have this kind of facility. The technical personnel in these organizations usually rely on trade journals to spark their imagination for new ideas. In other cases, the business units rely on a steady stream of independent inventors, seeking to sell their ideas, for maintaining an advancing product line. In every case, we find that the innovation must have a champion — either the inventor, the man who visualizes the application, or a group of persons charged, by management, with the responsibility of establishing direction on the use of an innovation.

Many commercial businesses do not have the resources nor the facilities to carry on a significant R&D effort in support of utilizing aerospace technology. The AMF business units depart from the typical small commercial business in this respect because the corporation maintains a central R&D facility, the cost of which is shared by all business units.

Some business units such as the Alexandria division, R&D division, York division, and Tuboscope, actively pursued new information on a project basis and made it available to the users in their business units. Other business units relied on an informal method of new technology awareness, such as individual review of information in trade journals. Thus, the flow of new information depended to a great extent on the conscientiousness and interest of the individual. These individuals are often burdened with more than a full time job on the daily business of the concern. The education in new technology seemed to be slow. There is no central repository for information in the broad areas of interest that are most important to the corporation; for example, new fabrication techniques.

It was not completely confirmed as to whether an industrial complex such as AMF should have a central technology utilization or dissemination service, or decentralize among various business units. The natural flow of advanced technology currently in the test bed indicated that some economic combination of both methods was needed. If AMF were to establish a central technology communications research and dissemination center, it was felt that it could best be established at the R&D division.

This service should include non-aerospace source information as well as aerospace information. To avoid the stagnancy of just another library facility, it should maintain personal contact with users, perhaps through tours of business units such as accomplished by STAMEN. The needs should continually be revised and updated to reflect the changing needs of the corporation with time.

The benefits of an information bank such as this is obvious. The technology for Case #9 illustrates that much development time and funds could perhaps be wasted on a device already patented by others. The experimentation such as NASA sponsored on missile rocket cases is a typical, good example of the potential treasure of technology that can decrease industry's commercial development costs by reading about other people's failures, rather than the investment to learn all over again at great expense, through trial and error and thus eliminate a repetition of failures already recorded. In the new technology era of today, and of the immediate future of space exploration, no industry can survive without repeated looks at how its product can be made better, or more economical and what new and better products can be developed.

TABLE III was prepared as a summary of the findings on current AMF business units' general needs the business units believed may be satisfied by the use of NASA technology. It showed that many business units have the same general needs and tends to support the idea of a need for a central information dissemination service. An attempt was made in the table to match these general needs with the thirty-four (34) STAR abstract categories. We have concluded that the match of the general needs and categories was not possible. An attempt to use NASA data by subscribing to all of the documents in the broad STAR categories could discourage and handicap a division with a limited engineering staff. Their only recourse would be to subscribe to the abstract report (STAR), review the abstracts under the general headings, and order only the documents of interest.

The table also indicates industry must do a better job in defining its technology needs, so a better, specific match with available technology can be accomplished. Improvement in definition of needs is directly related to at least an awareness in broad terminology of the major advances being accomplished in basic research. This directly relates to one of today's great problems faced by professional people in the technology fields, i.e., obsolescence. It was determined by others that if a professional person does not keep current in his field of endeavor, he will become obsolete in his knowledge within ten years.

Therefore, this is one of the great barriers new technology utilization must surmount. It was found that the American Machine & Foundry Company does sponsor professional society membership, advanced study and acquisition of new textbooks, and other information to solve this problem. But the degree of this type of technology upgrading varies amongst business units.

Based on a survey of AMF business units, it was found that the minimum cycle for the development of a product of average complexity, such as a new welding machine or a food service cart, was one-and-one-half to two years. Products that greatly advance the present state-of-the-art or market may take even longer. There were instances of five-year cycles for a new product introduction. The cycle of matching data with a product development is shown in FIGURE II.

Product modification took less time, dependent on the extent of the change. Manufacturing processes or material changes also were found to take less time to introduce than a new product development. These changes were found to be greatly dependent on quality, cost and market position.

The best accelerator on adoption of a new technology change was competition of other companies.

C. CANDIDATES FOR TECHNOLOGY TRANSFER AND LITERATURE SEARCH

1. Formulation of Cases

As a result of the questionnaire and business unit visits, a representative sampling of the technology needs of AMF were obtained. The more significant or likely candidates for transference were selected and prepared as cases: i. e., candidates for matching with aerospace data, with resultant technology transfer. Thus, using the principle of "Necessity is the mother of invention," we attempted, in the test bed, to look to aerospace data for possible solutions to the problems. This was true in all cases, except Nos. 7 and 8, which were adaptive research transfer attempts.

Forty-seven (47) cases were prepared, and are listed in TABLE IV. A summary of each case is published in APPENDIX III. The cases represent the current and real technology problems of the AMF business units. It is also believed they are a representative sample of problems confronting industry as a whole.

The cases were rated by the STAMEN team in terms of the probability of aerospace technology providing a solution to the problem., i. e., availability of applicable literature, and of the probability that new technology would be adopted by the business unit; i. e., the degree or urgency of need, additional investment of money required, management interest, etc.

A priority for literature search was established, based on the above probabilities. Attempts were made to experiment with providing representative cases of various types of needs, such as a new product, or a product modification and a fabrication process, or a material application.

The state-of-the-art category was used to cover those areas where a business unit requested a broad range of information to be utilized in a future formulation of proposed products, manufacturing or material application changes.

Because of the four-month duration of the study, efforts were concentrated on a search for matching aerospace data for those cases that had both a high probability of adoption as well as a probability of information available. All combinations of one and two ratings were selected for immediate consideration. As time permitted, further literature search was performed on the remaining cases.

2. Literature Search

Three methods of literature search were employed — computer, manual, and information center service. The type and depth of search was as is indicated in TABLE IV. Time did not permit an extensive search on twenty-one (21) of the cases. Of these, the literature was briefly surveyed to determine if aerospace data would be applicable. Results of the search have been briefly summarized in APPENDIX III.

a. Computer Search - The computer search was performed by STID, using the computer services of the Scientific and Technical Information Facility, at Bethesda, Maryland.

The search covered all of the data and abstracts provided by NASA and IAA since January 1962, except for classified and restricted distribution information. The computer search was performed on twelve (12) cases, and bibliographies were prepared.

The STAMEN team reviewed the abstracts and documents to further determine their applicability. Five of the searches revealed information applicable to the commercial problem — Case Nos. 1, 4, 19, 28 and 39. The search revealed little applicable information for the remaining seven cases.

b. Manual Search - The manual search was performed by the STAMEN team members. The search was confined to the Scientific and Technical Aerospace Reports (STAR), Tech Briefs Index, Tech. Utilization Special Reports (SP 5000 series), and International Aerospace Abstracts (published by the AIAA). The abstracts and documents were analyzed for applicability.

Twelve (12) manual searches were performed — Case Nos. 6, 9, 24, 25, 30, 31, 32, 35, 40, 41, 44 and 47. In addition, eight (8) manual searches were performed in conjunction with the computer search — Case Nos. 1, 4, 16, 17, 26, 28, 29 and 39.

In general, since the manual search was of a more intellectual nature, better results were achieved than from the computer search.

c. Information Center Service - As a result of the manual search on Case #9, four documents were found that directly related to the tire carcass inspection problem. These documents were evaluated. It was recommended that a further search in greater depth be conducted, since it appeared that non-destructive testing techniques used in rocket case inspections could be directly applicable.

A retrospective literature search was requested from the Aerospace Research Applications Center, Indiana University Foundation, with regard to tire carcass inspection and, in particular, the use of rocket case test techniques for this application.

ARAC provided additional documentation: 72 citations from STAR and IAA, together with other pertinent literature from non-aerospace sources (Society for Nondestructive Testing, Picker X-Ray Corp. : Wright-Patterson Air Force Base, Materials Laboratory: Plastics Technical Evaluation Center, Picatinny Arsenal: U. S. Army Materials Research Agency: Langley Research Center, NASA: and Ohio State University).

The literature search revealed the aerospace experience gained in rocket case testing is valuable, and could be utilized in a technology transfer for a consumer product. It was also found helpful to realize the technology developments occurring from other sources as well as NASA. In particular, the patent information uncovered could have an important bearing on the decision for continued product development. APPENDIX IV is a report on an analysis by the STAMEN team on the retrospective literature search for Case #9.

d. Technical Utilization Special Reports and Technical Briefs - The technical utilization special reports and tech briefs were reviewed from the aspect of candidates for technology transfer.

Case #7, Life Raft, was an attempt at transference of tech brief #64-10001 into a consumer product.

Case #8, Retrometer, was an attempt at transference of a special report. SP-5005, to a product.

3. Search Results and Transfer Attempts

Based on the literature search, five cases were selected as good candidates for transfer to satisfy a known industrial need. The documents obtained as a result of the search have been submitted to the business units for their review and reactions. The cases were Nos. 1, 4, 9, 19 and 28. In addition, two cases, Nos. 7 and 8, were considered good candidates for transfer, to provide a completed product to satisfy an unrealized need.

None of the searches was considered complete. It was found that a successful retrospective literature search required at least three searches. The first search was exploratory — that is, to provide a general impression of what literature was available on a subject. The second search was to provide additional or more complete information on a subject: and the third search would provide specifics on sub-categories of information, and include research on alternate solutions.

The literature search accomplished in Phase I of the study was termed as exploratory, with the exception of Case #9, in which a second search was also accomplished.

Search results to date for the good candidates for transfer indicated the following:

In Case #1, it appeared that some of the aerospace developments in material could be applicable.

In Case #4, one document revealed a heat treating process that may lead to the solution of heat treatment of steel shafts.

In Case #9, it appeared that the nondestructive inspection techniques developed for rocket motor cases may be developed into a consumer use of a tire carcass inspection device.

In Case #18, it appeared that aerospace solutions to self-sealing structures for meteoroid hazards and superpressure altitude balloons may apply to a consumer product such as a sports ball.

In Case #28, aerospace developments of coatings may provide a solution to an industrial pipe coating problem.

Eight (8) cases were found to have good availability of aerospace data, but industry either must define a more specific need, or else survey the literature on its own. These were Case Nos. 21, 22, 27, 30, 32, 37, 38 and 39. The data was submitted to the business units for their reactions, and to formulate a specific need.

Eight (8) additional cases were found to be fair candidates for continued transfer efforts, but not with the same degree of confidence as the above. Dependent upon the business units' reactions to the preliminary data presented, additional literature searches should be made to further define their possibility as candidates for transfer. These were Case Nos. 24, 25, 34, 35, 40, 41, 44 and 47.

The remaining twenty-four (24) cases were not recommended as candidates for technology transfer. All efforts on these cases were discontinued.

Aerospace research data has been transmitted to AMF business units for evaluation and opinion on the cases rated good candidates for technology transfer (Case Nos. 1, 4, 9, 19 and 28): cases labeled NASA state-of-the-art (Case Nos. 21, 22, 27, 30, 37, 38 and 39), and cases rated as fair candidates (Case Nos. 24, 25, 34. 35, 40, 41, 44 and 47). In addition, Case Nos. 7 and 8 of adaptive research transfer were also submitted for evaluation.

These searches with the exception of Case #9 were only exploratory in nature. The second step will be to obtain the business units' reactions to the literature and to formulate additional literature searches so that transfer attempts can be made.

Case #7, tech brief #64-10001, "New Inflatable Life Raft is Non-Tippable," was introduced to the W. J. Voit Rubber Corp. for consideration as a direct product application of aerospace technology. The innovation was accepted for review by the Voit product evaluation committee. The innovation was evaluated by the committee with regard to established criteria for new product acceptance and was found to be deficient in critical areas. The criteria for evaluation consisted of such items as gross sales dollars for the first three years: previous market experience: required sales outlets: and present condition of the market. A significant factor in the decision on this particular innovation was that NASA does not offer an exclusive license to protect the marketing investment necessary to promote such a new product.

Case #8 is an attempt to transfer technology directly from a NASA technology utilization report, #SP-5005 — "The Retrometer - A Light-Beam Communications System." This report was introduced to the WEN-MAC Corp. for consideration as a potential toy product. The WEN-MAC Corp. management has expressed enthusiasm over the Retrometer as a toy. The new products committee reviewed the potential toy idea and made a decision to adopt the idea and to further explore and develop it as a toy product line.

Case #9, Tire Carcass Inspection. An engineering study was made as a result of the retrospective literature search. A report on the study is published in APPENDIX IV. A presentation will be made to the business unit for the continued development of the tire inspection device. It appeared feasible to develop a tire inspection device based on NASA-sponsored research technology of nondestructive test techniques employed on rocket cases. One serious impediment exists. It appears the best approach to the problem's solution has been patented. This obstacle will be explored, dependent on the business unit's interest.

4. <u>Problems and Experiences of the Literature Search</u>

a. <u>Literature Evaluation</u> - The Technical Utilization Special Reports were found to be of a high quality of information presentation and can readily be put to use, dependent upon industrial needs. More of these reports were recommended, with a particular regard to industrial needs such as indicated in TABLE II. and NASA's state-of-the-art category, shown in TABLE IV.

b. <u>Technical Briefs</u> - These were good, if industry happened to have specific problems that matched. Industry should be encouraged to use the briefs, not only from this aspect, but as Cuno does, as an idea generator for the company's own specific problems. There was one barrier uncovered and that was the NIH factor — not invented here prejudice that may be a formidable barrier for the technical brief transfer to surmount.

c. Space Technology Aerospace Reports (STAR) - From the commercial industry's standpoint, the indexing system of STAR was difficult to use. The index and subject categories were excellent for the aerospace user, but an industry user such as that of the manufacturer of plastic toys would have a difficult experience in obtaining information applicable to his problems. More often than not, he would be discouraged and look elsewhere for technology data.

Interim progress reports such as monthly and quarterly reports were of little value to the commercial industry. Results were often indicated as inconclusive.

Reports such as bibliographies on subjects were excellent and can be readily put to use. The STAR abstracts were often found to be misleading, since the review of the document did not fulfill the abstract's information promise.

d. International Aerospace Abstracts (published by AIAA) - In general, these reports were better than the STAR reports, since they included published literature. The literature was written for a broader audience (a larger engineering or technology discipline experience), and the results published were more conclusive.

Abstracts were found to be in better agreement with the documents.

The same indexing problem, as with STAR, also existed here for the industrial user.

e. Security Problems - The writers believe, although we cannot prove it, that much basic research development information is contained in the literature that was classified, or whose distribution was restricted. And, therefore, unavailable to the STAMEN team and business units.

f. Document Availability- The time cycle of acquiring a document, once interest was created through reading an abstract, was found to be another deterrent to the utilization of space technology.

Loans and/or copies from the scientific and information service often took four weeks to obtain. It was found that when copies were on file at the document repositories, they were sent out immediately. The Western Operations Office should be complimented on their good service. If the documents were in their files, they were mailed out the same day as the request. But, here too, if the document was unavailable, it took as long as four weeks to obtain the document. The AIAA also gave good service, and responded to TWX requests in a timely manner.

Industrial concerns that had aerospace documents were very cooperative in loaning them out, but an industry not engaged in government contract work may not be aware of the source of document availability.

g. Industry Problem - Industry itself must do a better job of defining its technology needs, so that the needs can be successfully matched with aerospace knowledge.

It was found that it was difficult to research for a specific solution that a business unit already had in mind. It was better for the researcher to completely understand the basic problem and come up with data on alternate solutions.

The state-of-the-art type of research was found to be of little value for a forced transfer, but of benefit to the users on general background information, which could eventually lead to a transfer of technology by natural process.

h. Research of Other Sources - It was found that successful research of the problem required research of other sources in conjunction with aerospace, in order to put the technology in its proper context, and for a complete understanding of alternates and best solutions to the problems.

Thus NASA was one other source in conjunction with AEC, DOD, professional societies, the patent office, the Library of Congress, universities and research centers. This seemed to confirm the philosophy of the information service provided by CAST and ARAC, who utilize other sources besides aerospace technology in the research of a problem.

i. Training of Personnel - Professional engineers, scientists and business managers were found to lack training or understanding of literature research problems and their results.

j. Patent Status - The patent status of technology transfer to commercial industry can be a barrier to transference. The large investment required to introduce long-term product lines requires that industry be protected through exclusive patent rights.

IV. PLAN FOR PHASE II

Phase I of the STAMEN program concentrated on the definition of industrial needs and a review of aerospace literature, to determine if a match with aerospace data was possible. Phase II should provide an observation of the test bed to reactions of the preliminary data provided on the cases. Although some conclusions were reached during Phase I, Phase II will provide a definition of specific problems encountered in the actual transfer, and the observations will provide suggested solutions to the problem of accelerating transfer in terms of stimuli and barriers.

Primary objectives of Phase II should be to define the optimum organization, both in industry and NASA, and the methodology which will act as a catalyst to the transference of aerospace technology to the industrial community. The economic considerations in organizing a commercial business to utilize aerospace technology should also be explored.

Additional research should be accomplished on the technology-need candidates for transfer (5 cases). Research support on aerospace technology should be provided to the point of design concept of a new product, introduction of a new manufacturing process, or the successful substitution of a better material. The other cases (8 cases) now termed as fair candidates should be explored further, dependent on business unit interest and demand.

The "middle step" in technology transference - adaptive research - should be explored from the viewpoint of where should NASA and commercial industry meet in this controversial area; e.g., how much should NASA support research toward commercial ends.

In addition, more effort should be expended on technical briefs, special reports, and other NASA reports, to provide specialized industry uses. The transfer of Case #8 should be continued, to provide support and a record of occurrences. Similarly, the NASA state-of-the-art candidates for transfer can be experimented with, to provide new technology useful to industry in specific applications. The cases labeled good NASA state-of-the-art availability of information should be used in this experiment (8 cases).

The solution to the problem of industrial identification of its needs in terms of specific technology must be further explored. Alternate approaches should be developed for improving this difficult area.

After the matching of industrial needs with aerospace technology, the program established for the test bed should be as follows:

The project personnel should directly participate in the technology transfer. The team should observe the test beds and record all barriers or stimuli to the innovation's development. Case histories should be prepared, recording progress made. Research on specific technology cases should be continued as backup to the business units technology development. Development programs should be set up with the business units' engineering personnel. A market survey and plan should be established with business unit marketing and sales people. R&D and marketing costs should be estimated. Help from corporate, subsidiary and division management should be solicited to encourage and promote growth of the transferred technology ideas. Conclusions should be drawn from the test bed in order to formulate the methodology of successful technology transfer in an industrial complex.

The team should continue in the determination and definition of the communication links that NASA technology data must travel, in order to achieve fruition as an innovation of commercial importance, without the enforced transfer environment stimulated by the team. Analysis included would be what agents or agencies in the company would have to (1) be aware of the specific technology, (2) be interested in the technology, (3) evaluate the technology, (4) try the technology by introducing an innovation of a new product, material or process, and (5) adopt the product, process or material application.

The industrial problem of organization to facilitate communication of new technology should also be explored. Information obtained in Phase I of the study indicated that this can best be achieved by a central utilization and dissemination for the corporation. The technical utilization team would continue the observations, research, and provide a focal point for industrial questions and answers.

The other area of exploration is the NASA data bank itself. A feasible method of indexing the information is urgently needed, so that it would be more useable by commercial industry. The use of NASA tapes in industrial libraries should be explored. An identification of the scope of changes required should be prepared, together with recommendations as to how this can best be achieved.

The criteria of success for the experiment should be the acceptance of aerospace innovation by industrial units and their successful development by industry into a utility for man's every day life. A record of how this occurred or why it did not occur, should be maintained so that methods can be analyzed to provide recommendations on the facility and acceleration of such transfers. The system formulated must work not only in isolated cases but must be appropriate for use throughout American industry.

So that the experiment can be of benefit to all of industry, the methodology utilized should be developed and documented. A study should be made of industry to prove or indicate the application of knowledge gained in the experiment.

A manual, or "cook book," on how to best establish and organize a commercial industry to facilitate technology utilization should be prepared. This manual would be aimed at small and medium-sized businesses. It would be based on the observations and methods evolved in Phases I and II, and would provide (1) type of industry — i.e., products, processes, areas of business and type of technology utilization it would require, (2) optimum organizations to facilitate technology transfer, (3) economics involved — when should regional dissemination service be used; at what point in time is an in-house technical library required, (4) library and staff required, (5) total technology required; other sources of technology to be used in conjunction with aerospace, and (6) what industries and types can best use aerospace research; what fields of technology interest can best be satisfied by aerospace technology — and which ones cannot.

FIGURES

FIGURE I

Questionnaire For Project

Space Technology Applied To Man's Earthly Needs

Please use attachments if additional space is required.

1. Is your division or subsidiary (in particular, its engineering, product development and/or manufacturing process personnel) aware of the NASA technology utilization program and the data that is available for application by industry to commercial products?

☐ Yes ☐ No

2. Does your division have ready access to NASA technology data?

☐ Yes ☐ No

If so, in what form?

☐ Scientific and Technical Aerospace Reports (STAR)
☐ NASA Technical Reports
☐ NASA Technical Notes
☐ NASA Technical Briefs
☐ NASA Flash Sheets
☐ Patent Listings
☐ Professional Societies
☐ Trade or Professional Journals
☐ Trade Magazines
☐ Other - Describe

How or where is data obtained?

☐ In House Library
☐ Direct from NASA Agency - Specify
☐ University Library or Research Service
☐ Other - Describe

3. How can NASA technology data be improved to make it more useable or readily available to your division?

4. Does your division or subsidiary have in its employ research, engineering or process personnel with a prior background in missile/aerospace technology?

☐ No ☐ Yes - How many and of what type?

5. Has your division utilized NASA technology in:

☐ developing a commercial product
☐ developing or applying a special manufacturing process
☐ developing or applying a material
☐ solving other problems such as improved quality control, management reporting techniques, engineering problem solutions, etc.
☐ no utilization

Describe the technology utilized, its transfer process and results.

6. In your opinion, can aerospace technology be utilized by your division?

☐ Yes - How?

☐ No - Why?

7. Briefly describe the nature of the product line or service your division or subsidiary provides to the industrial market.

8. List your present products and their important features, or performance aspects, on which competition in the market place is based.

Product	Features (Performance, Life Expectancy, Unique Quality)

9. How does your division accomplish research, development, engineering or design of new products, or upgrading of existing products or processes?

☐ In House staff. Type of personnel and how many.

☐ Corporate R&D. What business unit?

☐ Outside consultants. Type and frequency used.

☐ Other

10. Is there a research or engineering library at your division's premises?

☐ No ☐ Yes - Specify quantity and types of books and journals

11. How does your division keep up-to-date in advanced technology in its fields of interest?

☐ Industry seminars

☐ Study of competitor products

☐ Professional society memberships

☐ Trade journals and magazines

☐ In House R&D

☐ Other

12. How many dollars are annually budgeted for research and product development or improvement at your division or subsidiary?

13. How do you determine what products should be developed or improved?

14. Briefly describe the marketing techniques employed by your division or subsidiary in marketing a new product.

15. What new products or product modifications are you developing or considering for development? (Briefly describe.)

16. The AMF STAMEN team will be searching various NASA centers and Technical Utilization Offices for aerospace data applicable to the varied needs of AMF. Please indicate any field of interest to which you would like us to pay particular attention?

17. What is your opinion of NASA's Technical Utilization Program?

Information supplied by: ______________________________
(Signature) (Date)

____
(Title)

____
(Division or Subsidiary Name)

____
(Address)

____
(Telephone Number)

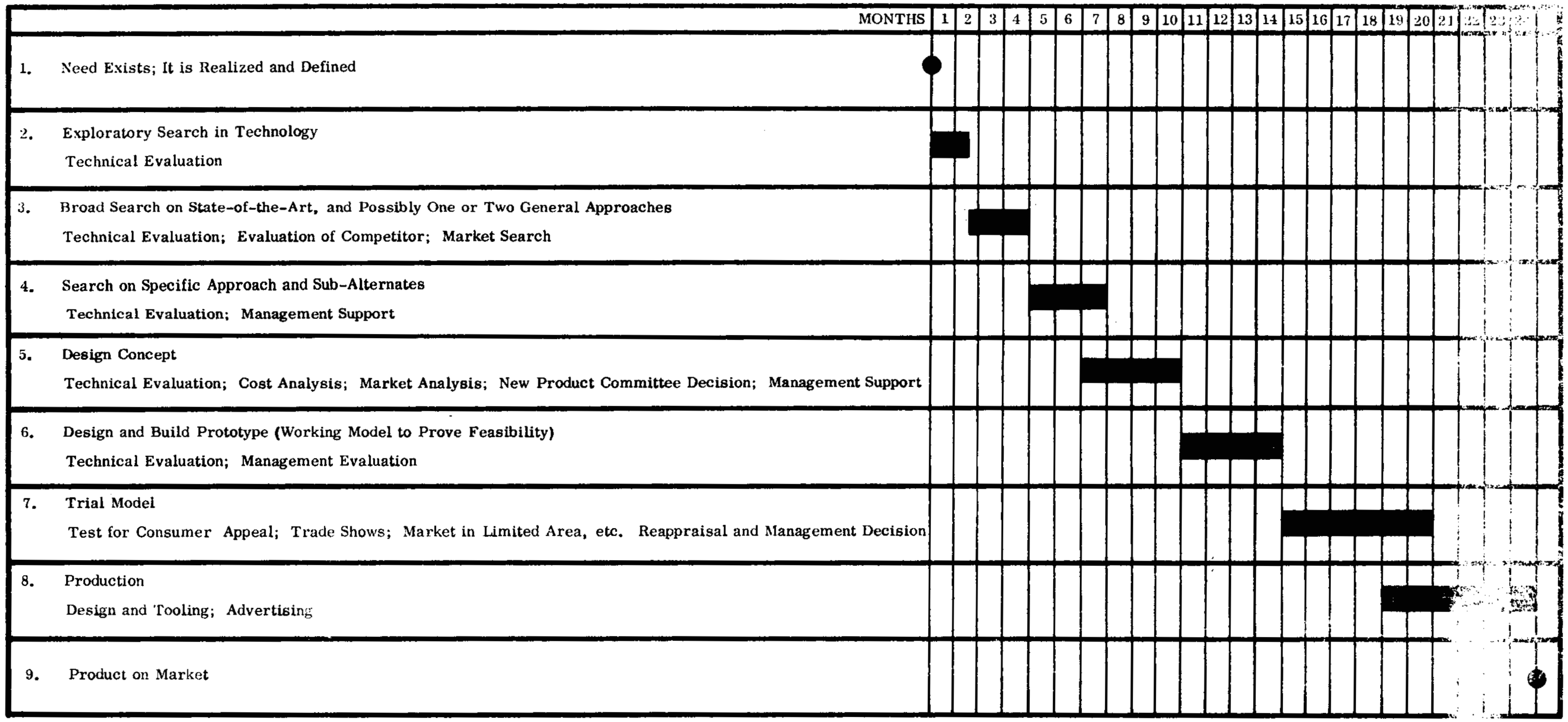
Refer all questions to: Messrs. A. Nagy, W. Dembiczak, D. Mansell

Mail to: American Machine & Foundry Company
Field Operations & Engineering Division
P.O. Box 1206
Santa Barbara, California 93102

Telephone No. 805/963-1551

FIGURE II - NEW PRODUCT DEVELOPMENT CYCLE

Typical Time Spans For A Product Of Average Complexity



TABLES

TABLE I

American Machine & Foundry Company

Executive Offices: AMF Building, 261 Madison Avenue, New York, N.Y. 10016

AMF manufactures a diversified line of products for industry, government and the consumer. This directory assembles in one convenient form a brief description of all of AMF's sales and manufacturing groups and divisions and presents a detailed listing of the wide variety of products and services offered.

The first section lists alphabetically all of the operating groups giving a resume of their divisions and product lines and the location of sales offices and plants. To obtain more product information or to place an order, write or call the particular general office or sales headquarters listed below.

The second section lists alphabetically all of the individual products and services offered by AMF. After the product name is a key letter referring back to the operating group that supplies the product.

*	VISITS
●	QUESTIONAIRE

* A. ADVANCED PRODUCTS GROUP

Group Headquarters: 1701 K Street, N.W., Washington, D.C. 20006, 202 / ME 8-6505

●	*	**1. ALEXANDRIA DIVISION** 1025 North Royal Street, Alexandria, Virginia 22314, 703/KIng 8-7221	*Proprietary research and development of new products. Government contract research and development in materials, electronics, oceanography and advanced military and space systems studies. Satellite and oceanographic instrumentation and special electro-mechanical equipment research.*
		2. AMF ATOMICS DIVISION Whiteford & Eden Roads, York, Pennsylvania 17402, 717/848-1177 (NOW PART OF YORK DIV.)	*Nuclear reactors, fuel elements control systems, nuclear waste concentration systems, master slave manipulators and remote handling and processing equipment.*
●		**3. BROOKLYN OPERATIONS DIVISION** 5502 Second Avenue, Brooklyn, New York 11220, 212/HYacinth 2-3500 *AMF Tool Division:* 5401 First Avenue, Brooklyn, New York 11220, 212/HYacinth 2-8225	*Proprietary product manufacture for overall AMF operations, contract manufacture, government contract and subcontract manufacturing.* *"Wahlstrom" Fully Automatic Chucks and Tapping Attachments, "Float-Lock" Safety Vises for drill presses and band saws.*
●	*	**4. FIELD OPERATIONS & ENGINEERING DIVISION** 924 Anacapa Street, P.O. Box 1206, Santa Barbara, California 93102, 805/963-1551	*Engineering management support services, instrumentation and control publication services, graphic arts, training and training aids, automatic pipeline welding equipment, energy absorption devices, weapons system basing concepts.*
●		**5. HYDROSPACE DIVISION** Broadway & Kennedy Road, P.O. Box 187, Station F, Buffalo, New York 14212, 716/TX 3-7800	*MK 44 torpedo, hydrospace products including sonar and underwater automatic checkout equipment.*
●		**6. MONORAIL DIVISION** 1701 K Street, N.W., Washington, D.C. 20006, 202/ME 8-6505 N. Y. World's Fair Office, Flushing, N. Y. 11380, 212/AR 1-4646, AR 1-4647	*Safege Monorail Systems, mass transportation systems.*
●	*	**7. WESTERN DIVISION** 5929 Rodeo Road, Los Angeles, California 90016, 213/837-5301	*Automotive exhaust gas burners, air and water pollution control devices.*
●		**8. YORK DIVISION** Whiteford & Eden Roads, York, Pennsylvania 17402, 717/848-1177	*Research, design, development and manufacture of missile launching and aerospace ground equipment, weapons systems and components, anti-submarine warfare equipment, ASROC launchers, radar antennas, pedestals, drives, precision optical trackers, missile range instrumentation and simulation systems, automatic handling and processing systems, "BEAR-LOC" locking actuator, hydraulic actuating and locking devices, hydraulic power packs and systems, air terminal systems and air cargo handling systems and equipment, 20mm guns, small arms, special purpose vehicles and ordnance equipment, architectural services, sonar equipment and commercial contract manufacturing.*

* B. BOWLING PRODUCTS GROUP

Group Headquarters: Jericho Turnpike, Westbury, L.I., N.Y. 11591 516/EDgewood 3-6900

●	**1. AMF PINSPOTTERS INC., NATIONAL DIVISION** 2201 Lunt Avenue, Elk Grove, Illinois 60007, 312/439-1600	*"AMF" Bowling Lanes with "Underlane" Ball Return, Bowling Pins, Balls, Bags and Shoes, Billiard Equipment, "Radaray" foul detectors, Ball Drilling Machines.*

2. PINSPOTTER DIVISION Martin Drive, Shelby, Ohio 44875, 419/744-2010	*"AMF" Automatic Pinspotters, "AMF" Automatic Candlepinspotters, "AMF" "Magic Triangle" "Pindicator" signaling units, parts and associated equipment for Pinspotter machines.*
3. AMF-UNITED BLOCK DIVISION Main Street, Arcade, New York 14009, Tel. 548 (no direct dialing) Trinity Avenue, Lowville, New York 13367 Tel. 600 (no direct dialing)	*Production of bowling pins.*
4. BOWLING PRODUCTS LABORATORY (NOW PART OF R&D DIV) 58 Commerce Road, Stamford, Connecticut 06904, 203/325-2677	*Research and development of bowling products.*

* C. ELECTRICAL PRODUCTS GROUP

Group Headquarters: 1701 K Street, N.W., Washington, D.C. 20006, 202 / ME 8-6505

1. AMF INSTRUMENT DIVISION 4304 Wheeler Avenue, P.O. Box 929, Alexandria, Virginia, 22304, 703/549-4911	*Expanded scale voltmeters, frequency meters, tachometers, wattmeters, control meters, electrical test sets, and "Amflite" illuminated indicators and switches.*
2. LELAND AIRBORNE PRODUCTS DIVISION *General Office & Plant:* P.O. Box 128, Vandalia, Ohio 45377, 513/898-5881 *District Sales Offices:* 15840 Ventura Boulevard, Encino, California, 213/783-2850 P.O. Box 265, Toms River, New Jersey, 201/349-6755 The James Findlay Company, 10237 Main Street, Bellevue, Washington, 206/GL 4-5200	*Alternators, inverters, (static and rotating) and regulators for aircraft and missiles; emergency power equipment, silicon power transistors and ground power equipment. Specialized military and commercial electrical test equipment.*
3. PARAGON ELECTRIC COMPANY *Subsidiary* *General Office & Plant:* 1600 12th Street, Two Rivers, Wisconsin 54241, 414/793-1161 *in Canada:* Phillips Electrical Company, Limited, 26 Hollinger Road, Toronto 16, Ontario	*Electric Timing Devices; time controls, time switches, defrost controls, cycle repeaters; interval, reset and sequence timers, time delay relays and synchronous clock-type motors.*
4. POTTER & BRUMFIELD DIVISION *General Office & Plant:* 1200 East Broadway, Princeton, Indiana 47570, 812/FUlton 5-5251 *Other Plants:* Franklin, Kentucky, 502/586-4451 Marion, Kentucky, 502/965-3194 Guelph, Ontario, Canada, 519/822-0390	*"P&B" relays, including general purpose, power, special purpose, sensitive, high performance, mercury-wetted contact and telephone types.*

D. INDUSTRIAL PRODUCTS GROUP

Group Headquarters: 610 Benton-Kelly Street, P.O. Box 1115, Shreveport, Louisiana 71102, 318 / 868-4441

1. AMF BEAIRD, INC. *Subsidiary* *General Office & Plant:* P.O. Box 1115, Shreveport, Louisiana 71102, 318/868-4441	*Capital equipment for the oil, gas, chemical, transportation and defense industries. Rail car tanks, "Maxim" Silencers, LP-gas systems and contract items.*
* **2. AMF TUBOSCOPE, INC.** *Subsidiary* P.O. Box 808, Houston, Texas 77001, 713/RIverside 8-1300	*Field inspection services for oil field tubular goods, automated equipment for production line inspection of welded and seamless tubular goods, in-place inspection of pipe lines, plastic coatings for tubular goods, tanks, and other metal products, renewal service for oil field valves, wellheads and Christmas trees, rubber casing protectors.*
3. AMF AMERICAN IRON, INC. *Subsidiary* *General Office & Plant:* North Indiana Avenue, P.O. Box 1177, Oklahoma City, Oklahoma 73101, 405/CEntral 2-5251	*Oil field drilling equipment, tool joints, drill collars, slush pump expendables.*
4. AMF FRICTION WELDING DIVISION *General Office & Plant:* P.O. Box 1115, Shreveport, Louisiana 71102, 318/868-4441 *Sales Department:* 1801 Nicholas Boulevard, Elk Grove, Illinois, 312 / 437-2700	*Equipment to join similar and dissimilar metals by friction welding. Contract friction welding.*
* **5. AMF THERMATOOL, INC.** *Subsidiary* *General Office & Plant:* 85 Beechwood Avenue, New Rochelle, New York 10801, 914/NE 2-5555	*Electrical high-frequency process generators and auxiliary equipment for high-frequency contact resistant welding of metals.*

E. INTERNATIONAL GROUP

AMF International Limited, 25-28 Old Burlington Street, London W.1., England. Cable: AMMAFOCO, London

1. AMF INTERNATIONAL *Export Division of American Machine & Foundry Company* 261 Madison Avenue, New York, New York 10016, Cable: AMMAFOCO, New York	*Export sales of all AMF products. Except tobacco machinery, see World Tobacco Group (H).*
†* **2. AMF INTERNATIONAL LIMITED** 25-28 Old Burlington Street, London W.1., England, Cable: AMMAFOCO, London	*Bowling equipment: electronic tire tread-making equipment; relays.*
†*AMF Svenska A. B., Gränna, Sweden, Cable: AMMAFOCO Gränna Branch Office: Kungsholmsgatan 64, Stockholm K. Sweden, Cable: AMMAFOCO, Stockholm	*Bowling equipment and supplies.*
*AMF Italia S.p.A., Corso Matteotti 10, Milan, Italy, Cable: AMMAFOCO, Milan Via Toscana 1, Rome, Italy, Cable: AMMAFOCO, Rome	*Bowling equipment and supplies.*
*AMF-C. Itoh Bowling Company, Ltd., Ozu Bldg., chome, Honcho, Nihonbashi, Chuo-ku, Tokyo, Japan, Cable: AMFITOHBOWL, Tokyo	*Bowling equipment and supplies.*
*AMF Overseas Corporation S.A., 65, Avenue de l'Etang, Geneva, Switzerland, Cable: AMMAFOCO, Geneva	*Bowling equipment and supplies.*

*AMF DEUTSCHLAND G.m.b.H., Kaiserstrasse 6, Frankfurt, Germany. Cable: AMMAFOCO, Frankfurt

Bowling equipment and supplies.

*AMF Deutschland G.m.b.H., Mainzerweg, Wiesbaden-Erbenheim, Germany
Cable: TECHSERV, Wiesbaden.

Bakery machinery; beverage dispensers; self-leveling dispensers.

*AMF Technical Services Company
AMF Building, Mainzerweg,
Wiesbaden-Erbenheim, Germany.
Cable: TECHSERV, Wiesbaden.

Installation and service of AMF bowling equipment. Bowling supply sales to U. S. Armed Forces.

†*3. AMF DEN BOER N.V.,
P.O. Box 72, Dordrecht, Holland, Cable: AMMAFOCO, Dordrecht

Bread and biscuit ovens, bakery machinery, bun packers, bread slicing and wrapping machines; self-leveling dispensers.

†*4. AMF ELECTRICA S.p.A.
Via Privata della Torre 24, Milan, Italy, Cable: AMMFLECTRICA, Mexico

Motor starting relays; thermal overload protectors; microswitches; relays.

†*5. INDUSTRIAS AMF S.A.
Abraham Gonzalez # 3, Mexico 6, D.F., Mexico, Cable: AMMAFOCO, Mexico.

Bowling equipment and supplies; bakery equipment, electric motors; recreational products.

†*6. AMF FRANCE S.A.
21 Rue d'Antin, Paris 1, France, Cable: AMMAFOCO, Paris.

Bowling equipment; recreational products; snowmaking machinery.

†*AMF France, S.A. Chemin du Contre Halage,
Les Attaques, Pas de Calais, France.
Cable: AMCUNO, Calais.

Industrial and household filters.

*7. AMF JAPAN LIMITED
Azabu, P.O. Box 31, Tokyo, Japan. Cable: AMMAFOCO, Tokyo.

All AMF Products except bowling equipment

†*8. AMERICAN MACHINE & FOUNDRY CO., (Aust.) Pty. Lt...
P.O. Box 222, Parramatta: N.S.W., Australia, Cable: AMMAFOCO, Sydney.

Bowling equipment; bakery equipment; breadovens, bread slicing and wrapping machines; soft ice cream making machinery; industrial and household filters.

*Sales †Manufacturing

F. PROCESS EQUIPMENT GROUP

Group Headquarters: One Fawcett Place, Greenwich, Connecticut 06831, 203/NOrmandy 1-7400

1. BAKERY MACHINERY DIVISION
General Office & Plant: 2115 West Laburnum Avenue, Richmond Virginia 23227, 703/ELgin 5-7961
Other Plants:
3440 Main Street, Glen Rock, Pennsylvania 17327, 717/235 3841
3232 North Kilpatrick Avenue, Chicago, Illinois 60641, 312/AVenue 3-5710

"AMFLOW" Continuous Fermentation and Mixing Systems. Pretzel Tying Machines. "Glen" Vertical Mixers, Continuous Cake Mixers, "Union" Dividers, Rounders and Intermediate Bread Proofers; "Union" "Pan-O-Mat"; "Union" Model K Roll machines; "Union" English Muffin Machinery; "Union" Pan Feeders; "Uni-Pac" Bun packers, "Selecta-Standard" Wrapping machines; "Micro" Slicers; "Benj. Franklin" Horizontal mixers.

2. CUNO ENGINEERING CORP. *Subsidiary*
General Office & Plant: 80 South Vine Street, Meriden, Connecticut 06453, 203/BEverly 7-5541
Tech-Space Division: One Main Street, Kensington, Connecticut 06037, 203/Valley 8-6321
Subsidiaries:
Cuno Lighter Company, Ltd., Walker Road, Windsor, Ontario, Canada
Connecticut Filter Corporation, Stafford Springs, Connecticut 06076, 203/684 2707
Maxim Division, Six Mill Lane, Waterford, Connecticut 06385, 203/443-1891

"CUNO" industrial, commercial and domestic filters and strainers for liquids and gases; automotive cigarette lighters. Distillation equipment to convert sea and brackish water to fresh for shipboard, industrial, commercial and home use.

3. FOOD SERVICE DIVISION
General Office: One Fawcett Place, Greenwich, Connecticut 06831, 203/NOrmandy 1 7400
Lowerator Dispensers:
Plant: Essex, Connecticut 06426, 203/767 0111
Sales Office: One Fawcett Place, Greenwich, Connecticut 06831, 203/NOrmandy 1-7400

Complete line of "Lowerator" Self-Leveling Dispensers for the food service industry. "Lowerator" Industrial Work Positioners. "AMF-ADCO," AMF-Refrigerated Beverage Dispensers, and carts for food service.

4. STITCHING MACHINERY DIVISION
General Office: One Fawcett Place, Greenwich, Connecticut 06831, 203/NO 1 7400
Plant: 5502 Second Avenue, Brooklyn, New York 11220, 212/HYacinth 2-3500

Decorative stitching, button stitching and slip-stitching machinery for men's and women's clothing accessories.

G. RECREATIONAL PRODUCTS GROUP

Group Headquarters: 261 Madison Avenue, New York, N.Y. 10016, 212 / MUrray Hill 7-3100

1. AMF WESTERN TOOL, INC. *Subsidiary*
General Office & Plant: 3811 McDonald Avenue, P.O. Box 357, Des Moines, Iowa 50302, 515/265-3461
Subsidiary: TEV Inc., 961 Chestnut S.E., Gainesville, Georgia, 404/534-5470

Reel, rotary and riding-type power mowers, edger-trimmers and rotary tillers. Complete line of home snow-removal equipment and a line of gas-powered golf carts.

2. AMF WHEEL GOODS DIVISION
General Office: P.O. Box 344, Olney, Illinois 62450, 618/EXpress 3-2991
Plants: Junior Toy Wheel Goods Plant, Olney, Illinois
AMF Cycle Division, West 65th and Patterson, Little Rock, Arkansas 501/565 1541

Complete line of bicycles and juvenile wheel goods; "Roadmaster," "Shelby" and "Hercules" Bicycles; "Junior" Velocipedes and Sidewalk Bikes; "AMF" Cars and Tractors, AMFun Outdoor Play Equipment.

3. BEN HOGAN COMPANY *Subsidiary*
General Office: 2912 West Pafford St., Ft. Worth, Texas 76110, 817/924 3226

Complete line of "Ben Hogan" golf equipment. Golf clubs: "SpeedSlot" woods, "Power Thrust" irons and a variety of putters. Golf balls, gloves, umbrellas, wood club head covers, bags and grips.

4. TIRE EQUIPMENT DIVISION
General Office: P.O. Box 958, Santa Ana, California, 714/545 9392

"ORBITREAD" Electronic Treadmaker, "Voit" tread rubber and tire repair materials.

5. W. J. VOIT RUBBER CORPORATION *Subsidiary*

General Office & Plant: 3801 South Harbor Blvd., Santa Ana, California 92702, 714/Kimberly 5-9392
Other Plants: 2344 North Columbia Blvd., Portland 17, Oregon, 503/285-3613
Subsidiary: Whitely, Inc., 29 Essex Street, Maywood, New Jersey 07607, 201/343-4762

"Voit" athletic balls, underwater and surface swimming equipment, playground supplies, miscellaneous golf accessories, water skis and related equipment, inflatable mattresses, surf riders, exercising equipment, athletic and sport shoes.

6. WEN-MAC CORPORATION *Subsidiary*

General Office & Plant: 11500 Tennessee Avenue, Los Angeles 64, California 90064, 213/GRanite 8-8213
Other Plants: 11511 Tennessee Avenue, Los Angeles 64, California

Engine-powered model airplanes, race cars; radio control equipment for model airplanes; giant construction toys plus other hobby and toy items. Low voltage outdoor lighting systems.

H. WORLD TOBACCO GROUP

Group Headquarters: 261 Madison Ave., New York, N.Y. 10016, 212/MU 7-3100 Telex: 224025, Cable: AMMAFOCO, New York

1. U.S. OPERATIONS

AMF Tobacco Machinery Division, 10 South Third Street, Richmond 19, Virginia, 703/648-4721
"AMF" automatic cigarette making, filter tipping, packaging machinery and tobacco leaf handling equipment.

International Cigar Machinery Division, 5502 Second Avenue, Brooklyn 20, New York 212/HY 2-3500, TWX-212 833 7004
"AMF-ICM" cigar making, packing, cellophaning machinery and associated equipment.

AMF Microflake Division, P.O. Box 31, East Windsor Hill, Conn., 203/BU 9-4363
"Microflake" tobacco products.

AMF Tobacco Engineering, 10 South Third Street, Richmond 19, Virginia, 703/648-4721
Proprietary research and development, engineering of tobacco machinery and equipment for World Tobacco Group.

2. OVERSEAS OPERATIONS

AMF SASIB S.p.A.
General Office and Plant:
87/89 Via Di Corticella, P.O. Box 311, Bologna, Italy
Tel. 360.401, Telex-51-020, Cable: SASIB, Bologna
"AMF" automatic cigarette making, filter tipping, packaging machinery and tobacco leaf handling equipment; cigar-making machinery; railway signaling, switching, and ticketing equipment; contract manufacturing of mechanical-electronic equipment.

Robert Legg Company
General Office & Plant:
49 Eagle Wharf Road, London N.1, England
Tel.: Clerkenwell 7911-6, Cable: LEGG ENGINEERS, London
Tobacco leaf handling equipment; automatic machinery for tobacco leaf processing.

D. K. Hamblin & Co.
General Office & Plant:
Radcliffe-on-Trent, Nottingham, England
Tel.: RAdcliffe-on-Trent 2021, Telex 37588, Cable: HAMBLIN, Nottingham
Tobacco leaf handling equipment.

AMF Machinen G.m.b.H.
General Office & Plant:
Burgerspitalgasse 28, Vienna VI, Austria
Tel.: 57 5483, Cable: AMMAFOCO, Wien
Cellophane wrapping, cartoning, and parceling machinery for the tobacco industry; contract manufacturing of mechanical equipment.

AMF do BRASIL
General Office & Plant:
P.O. Box 2930, Sao Paulo, Brazil
Tel.: 37-6469, Telex-3510102, Cable: AMAFOCO, Sao Paulo
"AMF" automatic cigarette making, filter tipping, packaging machinery, tobacco leaf handling equipment; automatic bottle-filling equipment; contract manufacturing of mechanical equipment.

3. SALES AND SERVICE OFFICES

Geneva Office
AMF Building, Geneva 2, Switzerland
Tel: 44 00 00, TELEX: 22416,
Cable: AMMAFOCO, Geneva

Western Europe and North Africa
AMF Tobacco Machinery Company
AMF Building, Geneva 2, Switzerland
Tel: 44 00 00, Cable: AMMAFOCO, Geneva

Eastern Europe
AMF Maschinen G.m.b.H.
Burgerspitalgasse 28, Vienna VI, Austria
Tel: 57 5483, Cable: AMMAFOCO, Wien

Latin America-Northern
American Machine & Foundry Company
261 Madison Avenue, New York 16, N. Y.
Tel: 212/MU 7-3100 TWX-212 867 4825
Cable: AMMAFOCO, New York

Latin America-Southern
AMF do Brasil, S.A.
P.O. Box 2930, Sao Paulo, Brazil
Tel: 37-01-71, Cable: AMAFOCO, Sao Paulo

Germany, Scandinavia and Eastern Africa
AMF Building, 25-28 Old Burlington Street
London W.1., England,
Tel: Regent 3931, 8813
Cable: AMMAFOCO, London, Telex: 24396

British Isles
Robert Legg Company
49 Eagle Wharf Road, London N.1., England
Tel: CLerkenwell 7811-6
Cable: LEGG ENGINEERS, London

D. K. Hamblin & Co.
Radcliffe-on-Trent, Nottingham, England
Tel: Radcliffe-on-Trent 2021
Cable: HAMBLIN, Nottingham, Telex: 37588

Australia and Far East
AMF Tobacco Machinery Company
32-34 Bridge Street, Sydney,
N.S.W., Australia
Tel: 27 72 66, Cable: AMMAFOCO, Sydney

Spain, Portugal and Western Africa
AMF Tobacco Machinery Company
Rua Lourenco Marques 36,
Carcavelos, Portugal

Near East, North Africa and Eastern Europe
AMF SASIB, 87/89 Via di Corticella
P.O. Box 311, Bologna, Italy, Tel: 360 401
Cable: SASIB, Bologna Telex: 51 020

Middle East
AMF Tobacco Machinery Company
Spor Caddesi No. 92/3, Besiktas,
Istanbul, Turkey
Cable: AMMAFOCO, Istanbul

Microflake and Cigar Machinery
(Outside U. S. and Canada)
AMF Tobacco Machinery Company
Muhlebachstrasse 11,
Zurich 8008, Switzerland
Tel: (051) 47 91 91 / 47 91 92
Cable: AMMAFOCO, Zurich, Telex: 54275

I. RESEARCH AND DEVELOPMENT DIVISION

General Office & Laboratories: 689 Hope Street, Springdale, Connecticut 06879, 203 / 325-2211

Manufacturing Units:
AMFare Systems Department, One Fawcett Place, Greenwich, Connecticut 06831, 203/661-7400
Automatic Equipment Department, 689 Hope Street, Springdale, Connecticut 06879, 203/325-2211

Proprietary research and development and initial manufacture and commercialization of new products. "AMFion" ion exchange membranes for water desalting and chemical separation. "AquaSpring" home water purifier. "Microflake" food dehydration system. "Versatran" and "Flexman" programmed transfer machines. "AMFare" automatic restaurant equipment system.

Product Index of AMERICAN MACHINE & FOUNDRY COMPANY

M

PRODUCT	KEY
Machine Parts	A
Machining, Contract	D
Manipulators, Master-Slave	A
Membranes, Ion Exchange	I
Meters	C, H
Frequency	C
Standard Deviation	H
Volt	C
"Microflake" Food Dehydration Process	I
"Microflake" Tobacco Products	H
Cigar Binder	H
Cigar Head Reinforcing Tape	H
Cigar Wrapper	H
Cigarette Filler	H
Missile Ground Support Equipment	A
Blast-Resistant Shelters	A
Filters	F
Fueling & Servicing Equipment	A
Handling & Transportation Equipment	A
Launchers & Controls	A
Missile Range Instrumentation Equipment	A
Mixers, Cake, Vertical	F
Dough, Horizontal	F
Model Airplanes	G
Engine Powered	G
Monorail Transportation Systems	A
Motors, Electric	C
Aircraft (AC & DC)	C
Synchronous, Clock-Type	C
Mowers, Power Lawn	G
Rotary & Reel	G
Walking & Riding Types	G
Mud Line Fittings	D
Mufflers	D
Exhaust & Intake	D

N

PRODUCT	KEY
Nondestructive Testing Services	D
Nuclear Equipment & Systems	A, F
Control Systems	A
Filters	F
Fuel Elements	A
Fuel Processing Equipment	A
Gama Irradiators	A
Manipulators	A
Reactors	A
Refueling Systems	A
Remote Handling Equipment	A
Waste Concentration Systems	A
Nuclear Research Studies	A
Nuclear Technical Services	A

O

PRODUCT	KEY
Oceanographic Instrumentation	A
Oil Field Drilling Equipment	D
Oil Field Tubular Goods Inspection Services	D
Outdoor Lighting Systems, Low Voltage	G
Outdoor Play Equipment	G
Overshots	D

P

PRODUCT	KEY
Packaged Gas Compressors	D
Packers—Oil, Gas	D
Pan Feeders, Automatic	F
"Pan-O-Mat" Machines	F
Parasols, Golf	G
Pinspotters, "AMF" Automatic	B
Pipeline Inspection, In-Place Lines	D
Pistons, Pump, Etc.	D
Plastic Coating Devices	D
Metal Products	D
Railroad Tank Cars	D
Truck Transport Tanks	D
Tubular Goods	D
Vessels	D
Playground Equipment, Outdoor	G
Plows, Snow and Rotary	G
Precision Optical Trackers	A
Premiums, Custom	G
Pretzel Tying Machines	F
Production Line Inspection of Tubular Goods	D
Proofers, Intermediate	F

R

PRODUCT	KEY
Radar Equipment	A
Antennas	A
Pedestals, Drives, Mounts & Feeds	A
Shipboard, Mobile & Fixed Base Equipment	A
Radio Control Equipment (Model Airplane)	G
Receivers	G
Transmitters	G
Radio Controlled Model Airplanes	G
Range Instrumentation Systems	A
Reactors, Nuclear	A
Power	A
Research	A
Ship Propulsion	A
Special Purpose	A
Testing	A
Training	A
Regulators	C, G
AC & DC Voltage	C
Electronic	G
Magnetic Amplifier	G
Semi-Conductor	G
Underwater Diving	G
Relays	C
Aircraft (small), Control	C
Electrically Operated	C
Emergency Lighting	C
Hermetically Sealed	C
Industrial Control and Power	C
Low Voltage	C
Magnetic Tape	C
Mechanical Latching	C
Mercury Wetted	C
Midget Type	C
Motor Starting	C
Plate Circuit	C
Plug-in Type	C
Polarized	C
Sensitive Type	C
Telephone	C
Timing, Time Delay, Etc.	C
Vibration and Shock Resistant	C
Renewal Services	D
Valves	D
Christmas Trees	D
Wellheads	D
Research & Development Studies	A
Restaurant Equipment, Automatic	I
"AMFare" System	I
Retread Rubber	G
R.F. Communication Switch Systems	A
Roll Make-Up Equipment	F
Rubber Casing Protectors	D

S

PRODUCT	KEY
Self-Leveling Automatic Dispensers	F
China and Glass Ware with Warmer	F
Dairy Products and Juices with Cooler	F
Tray	F
Work Positioners for industry	F
Semi-Trailers (pressure, chemical, etc.)	D
Servomechanism systems	A
Shoes	B, G
Bowling	B
Athletic and Sport	G
Silencers	D
Exhaust and Intake	D
Gas and Diesel Engine	D
Marine	D
Spark Arrestor, heat recovery units	D
Waste heat units	D
Simulators and trainers	A
Slicers (bread, roll, etc.)	F
Slipstitching Machines for Neckties	F
Slush Pump Pistons	D
Rod and Liners	D
Valves and Seats	D
"Smog Burner" Exhaust Control Device	A
Snow Blowers and Plows	G
Sonar Devices	A
Space Environment Equipment	A
Special Purpose Vehicles	A
Steel Fabricating & Machining	D
Stitching Machines	F
Button	F
Decorative	F
Slipstitching for Neckties	F
Storage Battery Charges for Silver-Zinc & Ni-Cad Batteries	C
Studies, Research Engineering	A
Sucker-Rod Couplings	D
Swimming Equipment, Surface & Underwater	G
Diving Lungs (Regulators)	G
Diving Tanks	G
Diving Valves	G
Ear Plugs	G
Fins	G
Inflatable Mattresses	G
Inflatable Vinyl Products	G
Inflating Pumps	G
Knives	G
Spear Guns	G
Surf Riders	G
Swimming & Diving Masks	G
Water Skis & Accessories	G
Wet Suits	G
Switches, Lighted Indicating	C
Switches, Time Delay	C
Systems Management	A

T

PRODUCT	KEY
Tachometers	C
Tanks	D, G
Air Receiver	D
Aluminum	D
Ammonia (Anhydrous)	D
Ammonia Applicator	D
Ammonia Bulk Storage	D
Cryogenics	D
Digestors (Pulp & Paper Mill)	D
Filtering	D
Gas Storage (LP-Gas)	D
Pressure Bulk Storage	D
Railroad Car	D
Skid Mounted	D
Steel	D
Storage	D
Vacuum	D
Welded Steel	D
Underwater Diving	G
Tank Coating Services	D
Tapping Attachments, Drill Press	A
Test Equipment	C
Continuity	C
Electrical Test Sets	C
Specialized Electrical	C
Tillers, Rotary	G
Garden Power	G
Timers, Electric	C
Tire Repair Materials	G
Tobacco Machinery	H
Separators	H
Stemmers	H
Threshers	H
Tipping & Blending Conveyors	H
Tobacco Products, "Microflake"	H
Cigar Binder	H
Cigar Head Reinforcing Tape	H
Cigar Wrapper	H
Cigarette Filler	H
Tobacco, Vacuum Moistening Units	D
Tool Houses and Joints	D
Torpedoes	A
Toscani Cigar Machines	H
Toys, Educational	G
Motorized Boats	G
Motorized Construction	G
Toys, Engine-Powered	G
Airplanes	G
Boats	G
Race Cars	G
Tractors, Juvenile	G
Transfer Devices, Automatic	I
Transistors, Silicon Power	C
Transportation Systems	A
Transports	D
Chemical	D
Cryogenics	D
LP-Gas	D
Over-The-Road Pressure	D
Semi-Trailers	D
Treadmaker, Tire, Electronic	G
Tubing Packers	D
Turbine, Gas, Prime mover applications	D

U

PRODUCT	KEY
Umbrellas, Golf	G
Underseas Weapons & Equipment	A

V

PRODUCT	KEY
Valves	A, D, F, G
Air	G
Beverage, Mixing & Measuring	F
Blast Closure	A
Diving Tank	G
Pump & Slush Pump	D
Valves & Seats	D
Valve repair and renewal	D
Velocipedes	G
Vending Machine Filters	F
Vessels, Pressure & Vacuum	D
Vises	A
Bench	A
Drill Press	A
Jig	A
Metal Band Saw	A
Voltage Regulators, AC & DC	C
Voltmeters, Precision	C

W

PRODUCT	KEY
Water Purification Systems, Land-Based & Marine	F, I
Home Water Filters	F
Sea Water & Brackish Water	F
Water Skis & Accessories	G
Water Treatment	F, I
Filter Media	F
Filters	F
Ion Exchange Membranes	I
"Maxim" Evaporators	F
Pollution Control Devices	A
Wattmeters	C
Weapon Systems & Components	A
Welding, Contract Friction	D
Welding Machinery	A, D
Automatic Pipeline	A
Contract Resistance	D
High Frequency	D
Friction	D
Wet Suits, Diving and Skiing	G
Work Positioners, Industrial, Self-Leveling	F
Wrapping Machinery, Bread	F

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SUMMARY OF REPLIES ON STAMEN PROJECT QUESTIONNAIRE - TABLE II

Question	Summary of AMF Business Unit Replies
1. Is your division or subsidiary (in particular, its engineering, product development and/or manufacturing process personnel) aware of the NASA technology utilization program and the data that is available for application by industry to commercial products?	Fifty one percent (nineteen Business Units) were aware of TUP prior to STAMEN study.
2. Does your division have ready access to NASA technology data?	Thirty percent (eleven Business Units) reported that they had ready access and received NASA technology data. Data used was reported as follows: Six users of Scientific and Technical Aerospace Reports (STAR) Ten users of NASA Technical Reports Seven users of NASA Technical Notes Nine users of NASA Technical Briefs Three users of NASA Flash sheets (prior to Tech Briefs) One Business Unit, Potter & Brumfield uses the Service of ARAC, Indiana University.
3. How can NASA technology data be improved to make it more useable or readily available to your division? 17. What is your opinion of NASA Technical Utilization Program?	Of the eleven NASA technology data users six expressed favorable comment. The others expressed difficulty in locating information peculiar to their needs and made recommendation such as: improved indexing and bibliographics: wider dissemination and better availability of publications; some indicated that additional data centers at local libraries or universities should be established.
4. Does your division or subsidiary have in its employ research, engineering or process personnel with a prior background in missile/aerospace technology?	Thirty eight percent (fourteen Business Units) reported that they had research, engineering or process personnel on their staff with prior background in missile/aerospace technology.
5. Has your division utilized NASA Technology in: developing a commercial product, developing or applying a special manufacturing process, developing or applying a material, or solving other problems such as improved quality control, management reporting techniques, engineering problem solutions, etc.	Sixteen percent (six Business Units) have successfully applied space technology to their needs: 1. Alexandria Division - welding of electronic circuits, quality soldering, and PERT. 2. Field Operations & Engineering Division - PERT 3. York Division - PERT, and Dynamic analysis for vibration and shock control 4. Hydrospace Division - Quality soldering 5. Leland Airborne Products Division - Quality soldering 6. Cuno Engineering - Liquid seals and relief valve approaches from Technical Briefs
6. In your opinion, can aerospace technology be utilized by your division? 16. The AMF STAMEN Team will be searching various NASA centers and Technical Utilization Offices for aerospace data applicable to the varied needs of AMF. Please indicate any field of interest to which you would like us to pay particular attention.	Prior to contact with STAMEN Team, seventy six percent (twenty eight Business Units) foresaw possible use for aerospace technology. All Business Units the STAMEN team talked to, either by meetings or telephone, concluded that aerospace technology is possibly useful to their Business Unit. AMF Business Unit's current technology needs that the business unit believes may be satisfied by NASA technology, are summarized in Table III. Some specific problems have been presented as cases as part of the study experiment. These are summarized in Table IV and included as Appendix III.
7. Briefly describe the nature of the product line or service your division or subsidiary provides to the industrial market. 8. List your present products and their important features, or performance aspects, on which competition in the market place is based.	Table I was found to be an accurate summary of business unit product lines and services.
9. How does your division accomplish research, development, engineering or design of new products, or upgrading of existing products or processes?	Ninety five percent (thirty five business units) accomplished these functions by in-house staff. Forty nine percent (eighteen business units) accomplished in part by Corporate [illegible] Four business units employ outside consultants on regular basis. Research, engineering, design or other technical people on business unit staffs [illegible] to vary from 2 to 200.
10. Is there a research or engineering library at your division's premises?	Forty nine percent utilize company research libraries. Of these thirteen business units have engineering/research libraries on their premises and five other business units are conveniently located so that use of another unit's library is no problem.

Question	Summary of AMF Business Unit Replies
11. How does your division keep up-to-date in advanced technology in its field of interest?	Fifty four percent (20) by Industry seminars Seventy eight percent (29) by Study of competitor products Seventy percent (26) by Professional society memberships Ninety two percent (34) by Trade journals and magazines Sixty two percent (23) by in-house R&D
12. How many dollars are annually budgeted for research and product development or improvement at your division or subsidiary?	Only two business units (manufacturing divisions) reported that they did not have a budget for product development or improvement. A total of fourteen million dollars was indicated. But dollar figure has no significant meaning, since some business units included in their figure, manufacturing engineering or other necessary cost to keep present lines going or included sales and marketing costs of a new product.
13. How do you determine what products should be developed or improved? 14. Briefly describe the marketing techniques employed by your division or subsidiary in marketing a new product.	Various answers were given but in general the following practice was reported: 1. market survey is made based on field representatives, sales force and customer requests; 2. technical feasibility study is accomplished; 3. cost analyses and share of market study accomplished; 4. prototypes are built and tested; 5. market analyses are reconfirmed. Most products are developed through long range planning with corporate management approval. Industrial products are introduced at trade shows. Recreational and toy products are introduced at toy shows and industry fairs, and are submitted for limited trial marketing to determine consumer opinion and interest.
15. What new products or product modifications are you developing or considering for developing?	All business units were presently considering new products or product modification. Some of these were presented as cases and are listed in Table IV.

AMF PROFILE OF INTERESTS IN SPACE TECHNOLOGY - TABLE III

AMF Business Unit	Current-Commercial Technology Need That May be Satisfied by NASA Data	STAR Subject Categories
A. Advanced Products Group		
1. Alexandria Division	1. Management Control techniques	1. General, computers
	2. Oceanographic instrumentation	2. Geophysics: Instrumentation and photography: physics, general: Electronic equipment: Nuclear engineering: communications: auxiliary systems
	3. Fabrication techniques	3. Machine elements and processes
	4. Materials research on coatings	4. Materials, non-metallic: chemistry
2. Brooklyn Operations Division	1. Welding	1. Machine elements and processes: metals, metallic
	2. Joining of metals	2. Metals, metallic: Metals, non-metallic: Machine elements and processes
	3. Improved machining techniques	3. Machine elements and processes
3. Field Operations & Engineering Division	1. Welding, automatic	1. Machine elements and processes; Materials, metallic: Electronics: Instrumentation and photography: Physics, general: Structural mechanics: Auxiliary systems
4. Hydrospace Division	1. Soldering and electrical connections	1. Electronic equipment
5. Western Division	1. High temperature, low-cost, materials and coatings	1. Materials, metallic: Materials, non-metallic: machine elements and processes
	2. Heat transfer of combustion	2. Thermodynamics and combustion
	3. Fluid flow	3. Fluid mechanics: Physics, general: Aerodynamics
6. York Division (including former Atomics Division)	1. Metal removing and joining techniques	1. Machine elements and processes: Materials, metallic; Materials, non-metallic
		2. Materials, metallic: Materials, non-metallic
B. Bowling Products Group		
1. Bowling Division-Shelby	1. Control systems	1. Electronics equipment: Electronics
	2. Materials	2. Materials, metallic: Materials, non-metallic
	3. Fabrication wood, plastics, metals	3. Machine elements and processes: Materials, metallic: Materials, non-metallic
2. Bowling Division-Chicago	1. Protection of wood surfaces	1. Materials, non-metallic: Chemistry
3. Bowling Division-Lowville	1. Coatings for wood	1. Materials, non-metallic: Chemistry
	2. Adhesives for wood and plastics	2. Materials, non-metallic: Machine elements and processes: chemistry
C. Electrical Products Group		
1. AMF Instrument Division	1. Packaging techniques of electronic components	1. Electronic equipment: Materials, metallic, Materials, non-metallic: Instrumentation and photography
	2. Integrated circuits	2. Electronic equipment: Electronics: Physics, solid state
	3. Component reliability	3. Electronic equipment: Electronics: Machine elements and processes
2. Leland Airborne Products Division	1. Ball bearings under extreme environment	1. Machine elements and processes: Materials, metallic: Materials, non-metallic: Structural mechanics
	2. Lubricants under extreme environment	2. Chemistry: Materials, metallic: Materials, non-metallic: Machine elements and processes
	3. Brushless DC motors	3. Electronics: Electronics equipment: Auxiliary systems
3. Paragon Electric Company (Subsidiary)	1. Plastics technology	1. Materials, non-metallic
	2. Lubricants	2. Materials, non-metallic: Chemistry: Machine elements and processes
	3. Insulating materials	3. Materials, non-metallic: Thermodynamics and combustion

AMF Business Unit	Current-Commercial Technology Need Thay May be Satisfied by NASA Data	STAR Subject Categories
C. Electrical Products Group (contd')		
4. Potter & Brumfield Division	1. Solid state relays	1. Physics, solid state: Electronic equipment, Electronics; Auxiliary systems
	2. Logic modules	2. Electronics; Electronic equipment; Auxiliary systems
D. Industrial Products Group		
1. AMF Beaird, Inc. (Subsidiary)	1. Cryogenics	1. Propellants; Physics, general; Thermodynamics and combustion
2. AMF Tuboscope, Inc. (Subsidiary)	1. Inspection techniques	1. Machine elements and processes: Instrumentation and photography; Structural mechanics
	2. New plastic materials	2. Materials, non-metallic; Chemistry
3. AMF American Iron, Inc. (Subsidiary)	1. Friction welding of drilling tool joints	1. Mater'als, metallic; Machine elements and processes
	2. Metallizing the bore of oil well liners	2. Materials, metallic; Machine elements and processes
4. AMF Friction Welding Division	1. Welding	1. Machine elements and processes: Materials, metallic
5. AMF Thermatool, Inc. (Subsidiary)	1. High speed welding	1. Machine elements and processes: Materials, metallic
E. Process Equipment Group		
1. Bakery Division	1. High temperature bearings	1. Machine elements and processes; Materials, metallic: Materials, non-metallic Structural mechanics
	2. High temperature lubricants	2. Materials, non-metallic; Chemistry; Materials, metallic; Machine elements and processes
	3. Dough Rheology	3. Chemistry; Materials, non-metallic Fluid mechanics
	4. Microbiology as related to breads, doughs and yeast	4. Bioscience; Biotechnology
	5. Microwave effects on yeasts and food products	5. Space radiation; Bioscience: Chemistry
2. Cuno Engineering Corp. a. Tech Space Division	1. Filtration media	1. Materials, non-metallic; Chemistry Auxiliary systems: Materials, metallic: Biotechnology
	2. Water reuse	2. Bioscience: Biotechnology: Chemistry: General
	3. Stream polution	3. Bioscience; Biotechnology: Chemistry: General
b. Maxim Division	1. Titanium plating	1. Machine elements and processes: Materials, metallic
	2. Two phase flow	2. Thermodynamics; Fluid Dynamics: Aerodynamics
	3. Refrigerant compressors	3. Machine elements and processes: Auxiliary systems
	4. Coatings for erosion and corrosion	4. Materials, non-metallic; Machine elements and processes; Chemistry
3. Food Service Division	1. Electrical heat transfer	1. Thermodynamics; Electronic equipment: Fluid mechanics; Machine elements and processes
	2. Refrigeration systems	2. Thermodynamics; Machine elements and processes; Auxiliary systems; Physics, General
4. Stitching Machinery Division	1. Machine design applications	1. Machine elements and processes
F. Recreational Products Group		
1. AMF Western Tool, Inc. (Subsidiary)	1. Fabrication of metal (steel, aluminum, and magnesium)	1. Machine elements and processes; Materials, metallic

AMF Business Unit	Current-Commercial Technology Need That May be Satisfied by NASA Data	STAR Subject Categories
2. AMF Wheel Goods Division	1. Materials application, (aluminum, magnesium and plastics)	1. Materials, metallic; Structural mechanics; Materials, non-metallic
3. Ben Hogan Company (subsidiary)	1. Adhesives	1. Materials, non-metallic, Materials, metallic; Chemistry; Machine elements and processes
	2. Heat treating of steels	2. Materials, metallic; Machine elements and processes
	3. Wood preservatives	3. Materials, non-metallic; Chemistry
4. Tire Equipment Division	1. Inspection techniques for plastics	1. Materials, non-metallic; Machine elements and processes ; Physics, general, Instrumentation
	2. Silicon control rectifier	2. Electronic equipment; Electronics; Machine elements and processes
5. W. J. Voit Rubber Corp. (Subsidiary)	1. Materials and processes	1. Machine elements and processes; Materials, non-metallic
	2. Fabrication of metals	2. Machine elements and processes; Materials, metallic
6. WEN-MAC Corp. (Subsidiary)	1. Materials and processes	1. Machine elements and processes; Materials, metallic; Materials, non-metallic
	2. Precision honing and grinding	2. Machine elements and processes
	3. Applications for battery powered devices	3. Electronic equipment
	4. New techniques for plastics fabrication	4. Machine elements and processes; Materials, non-metallic
G. World Tobacco Group		
1. U.S. Operations		
a. AMF Cigarette Division	1. Ceramics and method of application	1. Materials, non-metallic; Machine elements and processes; Physics, plasma
	2. Plating processes to alleviate friction problems	2. Materials, metallic; Materials, non-metallic metallic; Machine elements and processes
	3. Transducers and instrumentation for air flow tests	3. Electronic equipment; Instrumentation; Aerodynamics
b. Cigar Division	1. Reliability data on solid state switching circuits and mechanical components	1. Electronic equipment; Electronics; Machine elements and processes; Physics, solid state; Mathematics
c. AMF Microflake Division	1. Drying and preserving techniques	1. Chemistry; Bioscience
	2. Materials to withstand corrosive and abrasive environments	2. Materials, metallic; Materials, non-metallic
d. Leaf Processing Division	1. Air conveying systems	1. Machine elements and processes; Fluid mechanics
	2. Filtration of sand and dust from air	2. Machine elements and processes; Materials, non-metallic
H. Research and Development Division		
1. AMFare Systems Department 2. Automatic Equipment Department	1. High temperature resistant alloys	1. Materials, metallic
	2. Corrosion in water environments	2. Chemistry; Physics, general
	3. Transfer functions (torque out/variable frequency in) of induction motors	3. Electronic equipment; Electronics; Auxiliary systems
	4. Servocontrolled transfer manipulator device(e.g., very long life potentiometers)	4. Electronic equipment; Electronics; Auxiliary systems
	5. High response electric servodrives in the 1-5 HP range	5. Electronic equipment; Auxiliary systems
	6. Special position transducers	6. Electronic equipment
	7. Integrated circuits	7. Electronic equipment; Electronics; Physics, Solid State
	8. Packaging techniques for electrical circuits	8. Electronic equipment; Instrumentation and photography
	9. Check digest systems for assuring correct data entries	9. Electronic equipment; Computers; Mathematics

AMF Business Units	Current-Commercial Technology Need That May be Satisfied by NASA Data	STAR Subject Categories
	10. Magnetostriction - effects or their use as device actuators	10. Physics, general; Physics, solid state; Machine elements and processes; Instrumentation
	11. Optimal control of polar coordinate positioning systems	11. Instrumentation; Electronics; Electronic equipment; Machine elements and processes; Mathematics
	12. Stability - Liapunov functions and their calculation	12. Fluid mechanics; Aerodynamics; Mathematics; Physics, general
	13. Use of ultrasonics in measuring stress in metals	13. Machine elements and processes; Instrumentation and photography; Structural mechanics; Physics, general
	14. Techniques of non-destructively assessing residual fatigue life in metals and other materials	14. Machine elements and processes; Instrumentation and photography; Physics, general; Structural mechanics
	15. Reinforced plastics technology (filament winding)	15. Material, non-metalic; Machine elements and processes; Structural mechanics
	16. Multi-project scheduling techniques	16. General; Computers
	17. Techniques of simulation used for guiding and supplementing R & D effort	17. Computers; Mathematics; General

CASES FOR TECHNOLOGY TRANSFER - TABLE IV

Case #	Title	Type of Need: State of Art	Type of Need: Material or Process	Type of Need: Product	Probability of Adoption*	Probability of Information Available**	Universal Industry Need	Type of Search
1.	Oven Belt Material		X		2	II	No	Computer: Manual - 1964 STAR
2.	Corrosion of Aluminum		X		1	II	Yes	Computer
3.	Aluminum Extrusion		X		2	III	Yes	Computer
4.	Heat Treating of Steel Shafts		X		2	II	No	Computer: Manual - 1964 STAR
5.	S.C.R. Circuitry			X	4	II	Yes	Survey
6.	Adhesive - Nylon to Wood		X		2	III	Yes	Manual
7.	Liferaft (New product)			X	4	I		Tech. Brief
8.	Retrometer (New product)			X	3	I		Tech. Report
9.	Tire Carcass Inspection			X	2	II	Yes	Manual - 1964 STAR: Regional Dissemination Service
10.	Colorability of ABS Plastics		X		4	IV	Yes	Preliminary survey
11.	Injection Screw Molder Purge for Plastics		X		3	IV	Yes	Preliminary survey
12.	Fabrication of Molds for Plastics		X		4	IV	Yes	Preliminary survey
13.	Motion Sickness			X	4	II	No	None
14.	Weighing/Measuring Device		X		3	III	Yes	None
15.	Decorative Finish of ABS Plastic Products		X		1	IV	Yes	Preliminary survey
16.	Model Airplane Engine Noise			X	2	II	No	Computer: Manual - 1964 STAR
17.	Remote Control Unit			X	2	II	No	Computer: Manual - 1964 STAR
18.	Golf Club Fabrication		X		2	III	No	None
19.	Inflated Sports Ball Fabrication		X		1	II	No	Computer
20.	Synthetic Rubber & PVC Molding		X		2	III	No	None
21.	Filtration			X	3	I	Yes	None
22.	Water Reuse			X	3	I	Yes	None
23.	Two Phase Flow	X				I		None
24.	Titanium Plating (Piping)		X		1	I	Yes	Manual - 1963, 1964, 1965 STAR
25.	Compact Refrigeration Compressor			X	2	II	Yes	Manual - 1964 STAR
26.	Heating in Cylindrical Shells			X	1	III	No	Manual - 1964, 1965 STAR
27.	Electron Beam Welding	X				I	Yes	Preliminary survey
28.	Pipe Coatings		X		2	I	Yes	Computer: Manual - 1964, 1965 STAR
29.	Die Casting		X		1	III	Yes	Computer: Manual - 1963, 1964, 1965 STAR
30.	Dough Rheology	X				III	Yes	Manual - 1964 STAR

*Rated 1 thru 4; 1 being highest probability
**Rated I thru IV; I being highest probability

Case #	Title	Type of Need			Probability of Adoption*	Probability of Information Available**	Universal Industry Need	Type of Search
		State of Art	Material or Process	Product				
31.	Wood Sealant		X		1	II	Yes	Manual
32.	Liapunov Function	X				I		Manual - 1964, 1965 STAR
33.	Sliding Seal for Steam		X		2	IV	No	Preliminary survey
34.	Belt Material		X		1	II	No	In conjunction with Case #35
35.	Protective Coatings for Steel		X		2	II	Yes	Manual - 1964 STAR
36.	Fatigue Testing	X				I	Yes	None
37.	Bearings for Adverse Environments	X				I	Yes	Preliminary survey
38.	Lubricants for Adverse Environments	X				I	Yes	Preliminary survey
39.	Brushless DC Motors	X				I	Yes	Computer; Manual - 1964 STAR
40.	Short Circuit Welding	X				I		Manual - 1964 STAR
41.	Infrared Puddle Tracking		X		3	III	Yes	Manual - 1964 STAR
42.	Low Carbon Steel Weld Backup Material		X		3	III		None
43.	Tachometer Generator			X	3	II	No	Computer
44.	Adhesive for Aluminum		X		1	I	Yes	Manual - 1964 STAR
45.	Torsional Load Affects on Tubing	X				II		Preliminary survey
46.	Tracking of Weld Seam		X		3	III		None
47.	DC Amplifiers	X				I	Yes	Manual - 1964 STAR

*Rated 1 thru 4; 1 being highest probability
**Rated I thru IV; I being highest probability

APPENDIX I

HIGHLIGHTS OF VISITS TO AMF BUSINESS UNITS AND PERSONS CONTACTED

A. ADVANCED PRODUCTS GROUP, Washington, D. C. (12 January 1965) - H. W. Burdett, Jr., Director of Long Range Planning, expressed group, as well as corporate, support in making the STAMEN program forced transference experiment a success.

B. ALEXANDRIA DIVISION, Alexandria, Virginia (12 January 1965) - Dr. D. C. Miller, Director, R&D Lab. and General Manager; and Dr. C. L. Morrison, Technical Director and Assistant General Manager, described technology transfers accomplished at Alexandria, one of which was a radiation meter calibration unit previously designed for the Navy, and now successfully redeveloped as a low cost instrument for municipal civil defense. This is evidence of transfer accomplished by a division of technology used for a government customer and transferred to the civilian consumer.

C. AMFARE TEST SITE, Levittown, Long Island, New York (3 February 1965) - D. Dinney, Test Site Manager. Technology problems uncovered as a result of development tests on the new product AMFare, automatic restaurant system, currently in progress were discussed.

D. BAKERY MACHINERY DIVISION, Richmond, Virginia (2 February 1965) - M. R. Euverard, Assistant to General Manager; and M. E. Phillips, Jr., Engineering Manager. Mr. Euverard described the division's interest in technology as being that technology that relates to machinery. Food preservation, added taste, etc., are important only in this light.

Long range R&D for the division is accomplished by corporate R&D. Short range R&D or product improvement is accomplished by in-house functions. Opinion was also expressed here that the corporate R&D function can only go to a certain point. After this point, the particular division must take over the product and develop it into a salable product.

A prime interest to the STAMEN team is the lead time that is required for a product to become a market reality from the time of concept. For any area of development, this depends a lot on the size, complexity, the market and the type of product being marketed. A number of examples were cited. The AMFlow continuous mixer was developed in Springdale for two years prior to coming to the Bakery Division to be developed for the market. From this point, it took two additional years before the first prototypes were put into bakeries. A bread slicer development took as long as seven years. The long lead time was primarily due to the fact that the tests of the prototype unit and the first preproduction units in bakeries were not representative of the conditions that would be met in the complete market. As a result, a redevelopment phase was required. For the general run of moderately complex machinery, the following schedule can generally be considered as typical:

> From concept to prototype will generally take one year. Following the prototype, a field evaluation would be made which would take from two to six months. Preproduction would take another two to six months; giving a minimum lead time of at least two years.

In talking with the people at the Bakery Division, the STAMEN team was given a new insight on the subject of high reliability. The opinion has generally been voiced that the reliability of missiles and of the aircraft industry is of much more importance than commercial or industrial applications. However, in the bakery industry, the reliability required is every bit as high as in the missile industry. For example, if one machine breaks down in a bakery, the whole bakery is shut down, which means a loss in revenue. Therefore, the baker is interested in 100% reliability. We also saw this high reliability requirement in other commercial applications, e.g., AMFare.

Construction of bakery equipment is necessarily of materials that will not contaminate the human consumable products. Therefore, a good portion of the material used is stainless steel. During recent years, considerable advancement has been made in the coating of various materials. The bakery machinery division would be interested in long life, non-toxic, protective coatings for plain carbon steel.

E. BOWLING PRODUCTS GROUP, Westbury, Long Island, New York (3 February 1965) - T. A. Meade, Vice President, Sales. The STAMEN team had an enthusiastic reception. Some technology needs of the group were discussed.

F. CORPORATE HEADQUARTERS, New York, New York (15 January 1965) - J. W. Russell, Corporate Planning Staff. Corporate planning functions were discussed along with several technology problem areas. Corporate planning support was given to the project.

G. CUNO ENGINEERING CORPORATION, Meriden, Connecticut (4 March 1965) - Clarence Sicard, Vice President, Engineering. This was the only AMF business unit that the STAMEN team found to be currently making use of the NASA Tech Briefs in an efficient and effective manner. The publications are distributed among the engineering and design personnel, and are then filed in a permanent folder. Selected, special publications are also received and distributed among the engineering personnel. This data is used to stimulate ideas along related lines. It is also used for the solution of immediate needs, as in the case of a check valve adaptation and some sealing adaptations. These adaptations take the form of direct adoption of the whole idea submitted in the tech briefs, or by adoption of a part of the idea presented in the tech briefs.

H. ELECTRICAL PRODUCTS GROUP, Washington, D. C. (1 February 1965) - J. P. D'Arezzo, Vice President and Group Executive. Mr. D'Arezzo was a strong proponent for dissemination of information within AMF. In line with this philosophy, he has set up a number of committees within his group; such as a purchasing committee, an engineering committee, a manufacturing committee, etc. These committees are made up of the department managers of the various operating units within the group. The prime function of these committees is to share information, transfer technology, and provide for a closer working relationship and better communication between the various business units. He provided examples of benefits that have accrued from this committee organization. One of these business units was forming round wire into a square shape for use in a particular product. Another business unit, in another part of the country, was buying a square, cross-section wire directly. By sharing source notes, the business unit that was forming round wire was able to make a considerable saving by purchasing the hardware. Considerable savings have been realized in other purchasing areas in which sources, prices and availability have been compared between business units.

Mr. D'Arezzo expressed little faith in the possibility of a direct transfer of a product from space technology publications, such as the flash sheets or the NASA tech briefs. As backup to this theory, he cited that our own R&D division generally cannot give a working division a direct transfer of a product. It does provide the base from which a working division can build on, but R&D can take a project only so far; at that time, it must be put into a working division to make it a salable product.

Several technology problem areas were identified for STAMEN search.

I. FIELD OPERATIONS & ENGINEERING DIVISION, Santa Barbara, California (8 January 1965) - Marvin Rimland, General Manager. Utilization of tech briefs by the new products committee was discussed. In the past, tech briefs were obtained by the new products committee and reviewed for potential new product ideas. Mr. Rimland gave his support to the project by coordination with corporate management when it was required, and his senior management guidance to the study.

J. FOOD SERVICE DIVISION, Greenwich, Connecticut (3 March 1965) - H. F. Penfold, General Manager. New products were discussed as well as the division's needs for future products and product modifications. Mr. Penfold was interested in obtaining exclusive patent rights.

K. BEN HOGAN COMPANY, Fort Worth, Texas (5 February 1965) - Louis Moretti, Director of Manufacturing; and Jack Blades, Vice President, Sales. Proposed technology changes in manufacturing techniques were discussed. The R&D division is utilized for many research needs. Keen interest was expressed in the TUP program.

L. MAXIM DIVISION OF CUNO ENGINEERING CORPORATION, Meriden, Connecticut (4 March 1965) - William R. Williamson, General Manager. Basic research and development projects on the conversion of salt water to fresh water were discussed. Technology needs of hardware and materials to accomplish desalinization of water were discussed.

M. RECREATIONAL PRODUCTS GROUP, New York, New York (3 February 1965) - R. L. Sargent, Vice President and Group Executive. Technology needs of the group were discussed.

N. RESEARCH & DEVELOPMENT LABORATORY, Springdale, Connecticut (15 January 1965) - N. D. Crane, Vice President and Deputy Director, R&D; and Dr. Greg L. Laserson, Manager, Mechanical Development Lab. Information was obtained on current technology problems.

O. STITCHING MACHINERY DIVISION, Greenwich, Connecticut (3 March 1965) - V. M. Ivansheck, General Manager; and Charles Saunders, Chief Engineer. Technology problems on future product developments were discussed.

P. THERMATOOL, INC., New Rochelle, New York (3 March 1965) - A. W. M. Carmichael, Sales Manager. Desire for new materials, controls for process equipment machinery, and other technology areas were discussed.

Q. TIRE EQUIPMENT DIVISION, Santa Ana, California (28 January 1965) - Clayton DuBosque, Jr., Vice President and General Manager; and Jack Allen, Electrical Engineer. Genuine interest in utilizing TUP information was evidenced. A requirement for a new product and product modification were suggested.

R. TOBACCO MACHINERY DIVISION, Richmond, Virginia (2 February 1965) - W. A. Brackman, Corporate Vice President and Divisional Manager. The STAMEN team found that the general attitude prevailed at this division that we found at some of the other divisions. That is, that "our work and our technology needs are relatively unsophisticated, and thus not able to utilize NASA technology." However, during the course of the discussion, points were brought out which indicated the possible usage of aerospace technical data. The primary use would be a library source and a means of keeping up with the state-of-the-art in materials, processes, etc. Possibly, the direct application of space technology would not be possible. However, the subtle transfer and increase in knowledge in areas such as materials and processes would represent an increase in the knowledge of this particular division, as a result of space technology.

S. TUBOSCOPE, INC., Houston, Texas (4 February 1965) - E. G. Holm, Vice President; C. N. Posey, President; F. M. Wood, Manager, Inspection Research; R. A. Lahr, Manager, General Sales; B. J. Ramey, Manager, Coating Research & Engineering; E. A. Placke, Chief Mechanical Engineer, Inspection Division; and B. P. Goodman, Coating Research & Engineering. The Tuboscope division appeared to be most knowledgeable in the availability of data, the sources of data, and the means for obtaining data from the various agencies and services. However, it is important to note that they thought they would get all data from any one of the sources. For example, if they made a request from DoD or DDC, they thought they would obtain all NASA, AEC, OTS data, etc. In the past, their requests for data have been limited to DDC.

In addition to having the most knowledge about the availability of technical data, Tuboscope is also organized in such a way that they can make maximum use of technology sources, such as NASA. They have a library of a significant number of volumes, a librarian who conducts searches of a limited nature, and a R&D engineering organization which is separate from the rest of the organization. This type of organization has been shown to be very effective in obtaining and utilizing data from library type sources.

T. W. J. VOIT RUBBER CORPORATION, Santa Ana, California (28 January 1965) - Bruce Henderson, Vice President and Manager of R&D; Mark Abbott, Supervisor of Sales; Harry Gould, Plant Engineer; and David Caplan, Senior Project Engineer. Requirements for new fabrication processes, materials application, and new products were discussed. NASA Tech Brief N64-10001, "New Inflatable Life Raft is Non-Tippable," was introduced for a new product evaluation.

U. WEN-MAC CORPORATION and WESTERN DIVISION, Los Angeles, California (27 January 1965) - Harold Lipchik, General Manager of Wen-Mac Corporation, and Vice President and General Manager of Western Division. Mr. Lipchik was well aware of the existence of the Technology Utilization Program. He proposed a few ideas on data dissemination to make it more accessible to small industry. Included in those suggestions were:

1. Information should be available in printed form at all major industrial areas, perhaps in conjunction with college and university libraries.
2. Information should be available without charge, at least initially. Once small industry has been introduced to, and finds the available information usable, most will be willing to pay for it.
3. Information centers should follow-up with users to determine if a better method of distribution could be effected.
4. Colleges and Universities should be encouraged to include a short course in how to use a library to encourage the use of information, in addition to that contained in textbooks.
5. If a charge must be made for information, it should be as minimal as possible; otherwise, small business will not be able to afford it, and big business will look to their own R&D effort.

Technology problems in areas of plastic materials and their fabrication were discussed, as well as heat of combustion theory for application to SMOG Burrner Design. A technology utilization report, NASA SP-5005, was introduced as a possible toy product.

APPENDIX II

SUMMARY OF VISITS TO INFORMATION CENTERS

Visits were made to technology information centers, in order to obtain background information on methods used in past transfers, mechanics of preparation of TUP special reports and tech briefs, and to define aerospace documents and their availability. Ideas on methods of transference were also exchanged.

Highlights of the visits and the persons contacted are summarized in this appendix.

A. AEROSPACE RESEARCH APPLICATIONS CENTER (ARAC), University of Indiana, Bloomington, Indiana (19 January 1965) - Dr. H. L. Timms, Director of Operations, ARAC; and D. W. Cravens, Assistant Director of Operations, ARAC. The University of Indiana, through a contract with NASA, has established an information center called the Aerospace Research Applications Center (ARAC). This center serves the industrial community, on a paid subscription basis, with literature search services. The search services can take the form of retrospective searches or selective dissemination search services. Under some circumstances, a person-to-person contact between NASA scientists and industrial scientists can be arranged.

ARAC has been in operation for two years. It is presently supported one-half by NASA funds and one-half by industry subscription, and plans to be self-supporting on industry subscriptions by the sixth year of operation.

Two types of services are supplied by ARAC - retrospective searches, both machine and manual, and interest profile data supplied on a regularly scheduled basis, consisting of abstracts on subjects of indicated interest by the member companies.

ARAC has grown from 23 membership subscriptions in the first year to 38 in the second year.

The normal timing for information is two weeks, however, answers can be obtained on an emergency basis in 48 hours.

Data is available from NASA, AEC, DoD, MEDLAR, World Translations, and OTS. Actual documents can be obtained either in print form or microfiche.

A special service that is supplied by ARAC is to arrange personal contact with industry personnel and NASA personnel who are most knowledgeable in a particular field.

Graduate students provide the "man relationship" of the search activity. Each of these graduate students is assigned to one or more of the member companies to assist them in a personal way, both in the preparation of the companies' interest profiles and preparing retrospective search requests

AEROSPACE RESEARCH APPLICATIONS CENTER, University of Indiana, Spring Meeting (8 and 9 April 1965). The program conducted by ARAC was excellent in all respects. All of the speakers were knowledgeable in the embryonic field of planning and organizing for innovation, yet none was so naive to state that he had the panacea for solving the problems associated with the challenge. Many ideas and thought-provoking theories were introduced by the panel members and audience participants. The STAMEN team concluded that that which works well within the environment of one corporate structure may not necessarily work well for the next company. Each company is a separate entity, with a unique image or personality. Members of industry must experiment and adjust their organizations to meet the dynamic conditions which exist in the business environment.

B. AMES RESEARCH CENTER, Mountain View, California (18 February 1965) - G. Edwards, Technology Utilization Officer, NASA Ames; and Horace Emerson, Staff, Technology Utilization Officer, NASA Ames. The primary function of the Technical Utilization Office at the NASA centers is to act as liaison between the personnel of the centers and the Technical Utilization Office at NASA headquarters.

The personnel that make up the Technical Utilization Office at Ames consisted of three technical men (aeronautical engineers) and one secretary. In addition to this full time staff, there are some 65 technology utilization representatives within the organization. These representatives are appointed in each department, group and area of the center. In addition to their normal duties and functions, they encourage the group members to prepare technical discussions and write-ups on projects and innovations that they feel would be of benefit to the industrial community.

The TUO at the center is responsible for the preparation of the Flash Sheets from which the tech briefs are prepared at NASA headquarters. They are responsible for gathering data on the state-of-the-art data to be used in published state-of-the-art studies. They also prepare backup packages for the tech briefs.

Mr. Edwards emphasized the fact that each NASA center operates its TUO somewhat differently. He explained that there was very little contact between the TUO at the center and the industrial community around the center. The TUO has a full time job reviewing, preparing new write-ups and studies within the NASA center itself, and does not attempt any contact with the industrial community. The TUO also tries to avoid discussion of problems between industrial personnel and NASA center scientists. He also indicated that a flood of requirements for this kind of service would prevent the center from doing its normally assigned work.

In Mr. Edwards opinion, one of the most important and most time-consuming efforts is the preparation and filing of backup packages for the tech briefs. Each tech brief provides a location from which additional information can be obtained by interested persons. These locations are generally the centers that prepared the Flash Sheets. In order to service requests for information concerning the tech briefs, extensive additional information must be on hand. Ames receives an average of 50 to 60 inquiries on tech briefs each month. To date, Ames has received 575 total requests for additional data.

During a general discussion about the NASA services at the centers and at headquarters, Mr. Edwards volunteered the information that he does not believe the computer services supplied by STID are of much value to the scientists at the center. In fact, he did not believe that these services are used to any extent by the centers. His belief is that the scientist in each particular area of interest keeps up with the state-of-the-art in trade journals, publications, translations, and state-of-the-art which is normally obtainable in published form.

One of the first tech briefs prepared by AMES was the "Ames Piezoelectric Transducer." This transducer was developed for the purpose of recording impacts of meteorites on space vehicles. The instrument was found to be so sensitive that the heartbeat of embroys could be recorded. Sufficient interest was generated within NASA to attempt an accelerated transference to the industrial community. The time from the initial write-up to the first transfer of the instrument was one year. The technology, and specifically the device, was transferred to the Federal Drug Administration for use in recording the heartbeat in embryo chickens which were used for the study on effects of drugs.

C. CENTER FOR APPLICATION OF SCIENCES AND TECHNOLOGY (CAST), Wayne State University, Detroit, Michigan (22 January 1965) - Dr. Randall M. Whaley, Vice President for Graduate Studies and Research; Bruce W. Pine, Director, CAST; and C. Song. Wayne State University operates a regional dissemination center for NASA data called the Center for Application of Sciences and Technology (CAST). It is concerned with providing the industrial community with two types of services; i.e., providing a library search function in which they will supply retrospective searches on any subject required by their members, and supplying a consulting service which they call applications engineering. Any member company that requires assistance, either in the search, understanding of data, or application of data received from NASA technology, can request the services of an applications engineer from Wayne State University. The applications engineer is usually a member of the faculty at the University. At the present time, the services are free to the companies within the area.

The meeting attended by the STAMEN team was the annual review of CAST's progress. Following Mr. Pinc's presentation, a panel discussion was presented. The panel was composed of member industry companies and faculty members. Unfortunately, in the eyes of the STAMEN team at least, all of the companies represented were large; companies which could not make use of the applications engineers. Typical companies on the panel were Burroughs Corp., Wyandotte Paint Products, General Motors Corp., Chrysler Corp., etc. It was interesting to note that the General Motors representative was a librarian who, in addition to being a librarian, was a graduate engineer with an advanced degree. He felt the most useful purpose of a service such as that at Wayne State was to act as an extension of the already available library and information sources. He stated that this was the capacity in which GM used CAST, and suggested that the services they were performing were very useful to GM. His general attitude was echoed by the other corporations.

The Wyandotte Paint Products representative had a concrete, specific example of the transference of technology from aerospace industry to commercial industry. Wyandotte had developed a high temperature paint directly from one of the NASA briefs.

The growth of the CAST organization so far as the member companies are concerned has been very good and is an indication that the services rendered are useful, and are used by the member companies. Mr. Pinc pointed out that this was probably the best yardstick by which one could measure the effectiveness of the program, much more so than actually being able to point to specific transferences.

D. DENVER RESEARCH INSTITUTE, University of Denver, Denver, Colorado (20 January 1965) - John G. Welles, Head, Industrial Economics (DRI). A general discussion was held in which Mr. Welles expressed some of his ideas and made suggestions for our particular program.

Mr. Welles felt that, with the shortness of time of the AMF STAMEN program, the most productive area for study would probably be in processes. He also suggested that two charts be prepared - (1) a profile of the AMF needs such as cutting, welding, painting, etc., and (2) a profile of NASA information availability. A cross plot of the two graphs would show the most likely subjects and information.

Mr. Welles suggested that we contact Mr. H. H. Green for information concerning company organization for technology transfer among divisions of the General Electric Company.

E. GENERAL ELECTRIC COMPANY, Corporate Headquarters, New York, New York (2 March 1965) - H. H. Green, Patent Office. The program established by GE is concerned only with "in-house" innovation, transference and utilization. A corporate level organization has been established, called Patent Marketing. The organization is headed by Mr. John Sullivan and is currently composed of two technical persons of a projected six-man team. The team is to operate in much the same manner as the STAMEN traveling team. They will travel among the various GE groups looking for problem areas, innovations, recent patents and opportunities to pass along technology developed by other groups. The team will work with ideas that are, so to say, "hot off the press." Experience has shown that old ideas do not have the glamour and interest required to pay off. The team will be continuously circulating among the various organizations of the corporation, and will take a physical part in the transference and utilization process. Mr. Green dooms all "paper shuffle" attempts at transference to failure — this includes a centralized library service. He believes that person-to-person contact is the key to successful transference.

In order that the team may be effective, it has been endowed with the authority to sell or license innovations outside the GE family, if the particular "in-house" group does not act on the innovation in a specified time.

F. STANFORD RESEARCH INSTITUTE, Palto Alto, California (19 February 1965) - Dr. F. F. Muraca, Director of Chemical Division; E. Riggs Monfort, Client Services Coordinator; and J. A. Butler, Long Range Planning. In addition to his duties as Director of the Chemical Division of SRI, Dr. Muraca is responsible for the review of all NASA Flash Sheets that are sent to Stanford RI. His office receives the Flash Sheets from the NASA headquarters in Washington. He makes a quick summary review and decides which group in SRI would be most knowledgeable to review the Flash Sheets, and initiates the review. After the review, a summary sheet is prepared with recommendations to NASA on whether the Flash Sheet should be made into a Tech Brief, or whether it should be dropped.

Dr. Muraca seemed to feel that the NASA Technology Utilization Program of Tech Briefs can be overdone. He believes that the transfer of technology as a natural process, is going to take place regardless of the pushing by a specific group. He expressed the opinion that the main form of the transfer of technology information was by person-to-person, by the review of technical literature, integration of diverse technology fields, and NASA Tech Briefs; in short, all technical publications.

The STAMEN team was also informed that SRI can provide the same general service of data searches that are supplied by ARAC and CAST.

G. WESTERN OPERATIONS OFFICE/NASA, Santa Monica, California (19 January 1965) - Dr. R. Brenneman, Technology Utilization Officer. Dr. Brenneman indicated that it has been his observation that industry must make an effort to give more attention to that information which is available, in order to achieve transference. He cited a recent conference to which he had invited representatives of all major manufacturers and aerospace firms in the greater Los Angeles area; a meeting that was ultimately attended only by representatives of the aerospace industries. He indicated that the general impression he drew from that meeting was that the manufacturers do not feel they have the people, time, money, or internal communication necessary to review TUP publications, and that TUP should attempt to classify the technical briefs and tailor them to particular firm interests. Some manufacturers thought that TUP personnel should go so far as to suggest how, where and why their particular firm should use each NASA development; a function that the two-man Western Operations TUP staff cannot and should not accomplish.

The AMF approach to the TUP problem, i.e., concentrating on looking at ourselves for answers to the technology utilization bottleneck problem, rather than only at the NASA procedures, was apparently warmly accepted by Dr. Brenneman.

APPENDIX III

CASE DESCRIPTIONS AND LITERATURE SEARCH

Case #1 - OVEN BELT MATERIAL

I. Description of Problem

Hamburger patties are broiled in an oven and are conveyed through the oven on a continuous belt. The oven atmosphere is similar to a natural gas furnace, plus evaporating and cracking fats from meat. Belt material is Hastalloy X. Belt speed is six feet per minute. Corrosion is a major problem when flame impinges on belt. Belt life is short, with failure usually occurring at the welded joint.

II. Information Requested

A. Corrosion of high temperature alloys in oxidizing atmospheres; in a reducing atmosphere.

B. Effect of cracked fats (carbohydrates) on metals at high temperature.

C. Techniques and methods for joining continuous metal belts; welding, cold weld, etc.

D. Materials for use in the environment described.

E. Thermal effects on metals when subjected to cycling temperature.

III. Summary of Literature Search

A. The literature review of the bibliography provided by STID revealed four documents that were of general interest in providing a solution to Case #1.

B. The manual review was confined to the 1964 issues of STAR. One document was found that may be helpful in understanding the problem of Case #1.

The documents were submitted to the business unit for further evaluation.

IV. Conclusion

It was determined that this case was a good candidate for technology transfer. A continued literature search is recommended. Aerospace research technology of new, high-temperature alloys, and new techniques in joining metals, may provide a solution to this commercial problem.

Case #2 - CORROSION OF ALUMINUM

I. Description of Problem

An evaporator condenser exhibits excessive corrosion of an aluminum part when treating alkaline water. Plastics have been tried and found unsatisfactory because of taste imparted to the water. Glass is objectionable because of fragility. Cost is an important factor.

II. Information Requested

A. Characteristics of plastics at moderate to high temperatures - with emphasis on out-gassing.

B. Corrosion of aluminum in an alkaline environment.

C. Interaction between aluminum and zinc in an alkaline environment.

D. Coatings for aluminum including anodize and irridite.

E. Coatings for plastics to prevent out-gassing.

III. Summary of Literature Search

The literature search provided no applicable data on the effects of alkaline water with aluminum, or methods of preventing corrosion of aluminum in this environment.

IV. Conclusion

It has been concluded that Case #2 is not a good candidate for technology transfer. No attempts at transference will be made. Aerospace research technology does not seem to have been applied to the alkaline environment problem of aluminum.

Case #3 - ALUMINUM EXTRUSION

I. Description of Problem

It is desired to maintain the roundness tolerance of an aluminum extrusion to within 0.075-in. total indicator reading. Utilizing existing extrusion techniques, tolerances in the order of 0.250-in. are obtainable. The extrusion is 6-1/2-in. diameter cylinder with wall thickness of 1/16 of an inch.

II. Information Requested

A. Factors influencing roundness in thin wall, large cross section extrusions.

B. Techniques and methods of maintaining roundness of aluminum extrusions.

III. Summary of Literature Search

Only two documents were found that may relate to the solution of this case. One document was written in French, and an attempt to obtain a translation of the document was initiated. The other document was of possible interest for the solution of the problem. In general, the bibliography literature was not applicable to the problem of improved dimension control for complex shaped aluminum extrusions, but instead discussed other metallurgical characteristics such as strength, corrosion and high temperature.

IV. Conclusion

Case #3 was not a good candidate for technology transfer. No advances in dimensional control of aluminum extrusion appear to have been made by aerospace technology.

Case #4 - HEAT TREATING OF STEEL SHAFTS

I. Description of Problem

An attempt is being made to heat treat thin wall tubular steel shafts. In the course of heat treatment, considerable warpage and/or fracturing occurs. A process must be devised which will produce a heat treatment that will give a hardness of Rockwell C-48 without undue warping.

II. Information Requested

All available literature and data relative to heat treatment of thin wall tubular sections. The cross section need not be circular.

III. Summary of Literature Search

A. One document from the computer search was found to be of interest and was submitted to the AMF business unit for further evaluation. Another document, though not directly applicable, led to the review of a process in other literature, which may provide a solution to the problem. This document also provided the name of an expert in the field, who was contacted for additional information.

B. The manual search was confined to the 1964 issues of STAR. The search revealed no related information to Case #4.

IV. Conclusion

Case #4 was found to be a good candidate for technology transfer. Aerospace technology on heat treatment of steels may be helpful in the solution of this problem. The research and development project is presently undergoing management review. When the project is resumed, the approaches outlined in the literature search documents will be attempted.

Case #5 - SILICONE CONTROL RECTIFIER CIRCUITRY

I. Description of Problem

A silicone controlled rectifier circuit is needed for sustained full load operation of a 1/3 horsepower, 115 volt, shunt wound, direct current motor over a range of a few hundred to 1800 revolutions per minute. Primary considerations include simplicity and economy. Stability and reliability are important but of secondary consideration.

II. Information Requested

A. General consideration regarding silicone-controlled rectifier selection.

B. Design information regarding fractional horsepower speed control circuitry.

C. SCR circuit for a 1/3 hp, 115 V DC shunt motor.

III. Summary of Literature Search

A preliminary literature survey was performed and it was determined that there was limited information relating to the problem.

IV. Conclusion

This case was determined to have limited data available. Therefore, due to the short AMF contract time, and research load at NASA/STID, no further effort was expended.

Case #6 - ADHESIVE NYLON TO WOOD

I. Description of Problem

Present method of bonding nylon jacket to wood on bowling pin often yields poor quality results. Present product set-up is to use a 3M No. EC 1099 adhesive which is solvent-activated. The nylon jacket is coated with adhesive approximately one week ahead of time and allowed to dry. The adhesive is spread on the wood pin and the jacket is assembled to pin within two minutes time. The problem is that the use of an adhesive of too high viscosity, hydraulic pressure would split wood; cannot squeeze adhesive out as solid residue formed is objectionable.

II. Information Requested

Adhesives and processes for bonding nylon to wood.

III. Summary of Literature Search

A manual search for Case #6 was made in conjunction with the manual search for Case #44. No related information was found.

IV. Conclusion

Case #6 was considered a poor candidate for technology transfer. The possibility does exist, however, that air frame technology, prior to the establishment of NASA, may have solved this wood adhesive problem.

Case #7 - LIFE RAFT (New Product)

I. Description of Problem

Develop a marketable product of an inflatable life raft which is non-tippable. Use NASA tech brief N64-10001.

II. Information Requested

Attempt a technology transfer of this product idea into W. J. Voit Rubber Corporation.

III. Summary of Literature Search

A manual search was made of tech briefs, and this innovation was selected as a candidate for a direct product application of aerospace technology.

Case #7 - LIFE RAFT (cont'd.)

IV. Conclusion

The new product idea was evaluated by Voit Rubber Corp.'s product evaluation committee. The committee decided not to develop or market the product. The innovation was evaluated by the committee with regard to established criteria for new product acceptance and was found to be deficient in critical areas. The criteria for evaluation consisted of such items as gross sales dollars for the first three years; previous market experience; required sales outlets; and present condition of the market. A significant factor in the decision on this particular innovation was that NASA does not offer an exclusive license to protect the marketing investment necessary to promote such a new product.

Case #8 - RETROMETER

I. Description of Problem

Develop a marketable toy product using Technology Utilization Report, NASA SP-5005 - The Retrometer: A Light-Beam Communications System.

II. Information Requested

Attempt a technology transfer of this product idea into WEN-MAC Corp. Additional information with regard to this innovation was requested from NASA/Code AGP on 19 February 1965.

III. Summary of Literature Search

A manual review was made of the TUP special reports and this innovation was selected as a candidate for a new product transference.

IV. Conclusion

The WEN-MAC Corp.'s new product committee has decided to explore possible toy products suggested by the Technology Utilization Report.

Case #9 - TIRE CARCASS INSPECTION

I. Description of Problem.

A nondestructive means of detecting tire carcass ply separation is needed. Tires are constructed of alternate layers of elastomer and reinforcing material. Separation of those layers may cause catastrophic tire failure, but cannot generally be detected by visual inspection. Elastomers used in tires include natural rubber, styrene-butadien (SBR), polybutadiene (PBR), polyisoprene (PIR), ethylene-propylene (EPR), ethylene propylene terpolymer (EPT), and isobutylene-isoprene copolymer (butyl). Reinforcing materials include nylon, rayon, and cotton. Styrene-butadiene-vinyl-pyridine is often used to bind nylon tire cord to the elastomer portions of the carcass. It is anticipated that non-destructive inspection techniques have been developed by NASA for elastomer laminate materials, and that those advanced techniques may be applicable to tire carcass inspection.

II. Information Requested

A. Elastomer laminate inspection techniques.

B. Advantages and limitations of the following inspection techniques, especially as they may apply to the inspection of elastomer laminates:

1. Sonic
2. Radio frequency (RF)
3. Soft X-ray
4. Infrared

III. Summary of Literature Search

A. The manual review was confined to the 1964 issues of STAR. Four documents were found that directly related to the tire carcass inspection problem. These documents were evaluated. It was recommended that a further search, in greater depth, be conducted since it appears that nondestructive testing techniques used in rocket case inspections may be directly applicable.

B. Regional Information Center search. A retrospective literature search was requested from the Aerospace Research Applications Center, Indiana University Foundation in regard to tire carcass inspection, and in particular the use of rocket case test techniques for this application.

Additional documentation of STAR and IAA was received (72 citations), together with other pertinent literature from non-aerospace sources (Society for Nondestructive Testing, Picker X-Ray Corp.; Wright-Patterson Air Force Base, Materials Laboratory: Plastics Technical Evaluation Center, Picatinny Arsenal; U. S. Army Materials Research Agency; Langley Research Center, NASA; and Ohio State University). For bibliography of documents from non-aerospace sources, refer to Part C of the bibliography.

The literature search revealed that the aerospace experience gained in rocket case testing is invaluable and could be utilized in a technology transfer of a consumer product. It was also found helpful to realize the technology developments occurring from other sources as well as NASA; in particular, the patent information could have an important bearing on the product development.

IV. Conclusion

Case #9 continues to be a good candidate for transfer. A report will be presented to the AMF business unit on the feasibility of the product based on the current literature. This report is published in APPENDIX IV.

Case #10 - COLORABILITY OF ABS PLASTICS

I. Description of Problem

It is desired to provide an improved method of coloring and color matching opaque ABS (acrylonitrile, butadiene, and styrene) plastic pellets. It is desired to provide repeatability of color value between successive batches of plastics. Presently, ABS plastics can be procured in standard and custom colors. But this means a large inventory of different color plastics. Another method is to pigment powdered natural resins. This method requires the use of elaborate mixing equipment and presents problems in matching colors of successive batches.

II. Information Requested

A. Dyes that may be used to color ABS plastic pellets.

B. Methods and equipment for mixing dry-color into unpigmented resins or pellets that ensure repeatability of the mixture (controlled mixing devices).

III. Summary of Literature Search

A preliminary survey of STAR literature was made. It was determined that there was limited information relating to this problem from aerospace data.

IV. Conclusion

It was decided that this case was a poor candidate for transfer, due to apparent lack of aerospace technology in this area.

Case #11 - INJECTION SCREW MOLDER PURGE FOR PLASTICS

I. Description of Problem

It is desired to find an improved method for purging injection screw molders. ABS plastic (acrylonitrile, butadiene and styrene) in pellet form is heated to plasticity and forced under pressure by a screw passage into a mold. Upon changeover from one color plastic to another, the injector is purged by using the new plastic. Purge time required is lengthy and results in considerable waste of plastic materials.

II. Information Requested

A. Materials for purging injectors used with ABS resin.

B. Methods for purging thermoplastic molding injectors.

III. Summary of Literature Search

A preliminary survey of STAR literature was made. It was determined that there was limited available information relating to this problem from aerospace research.

IV. Conclusion

It was decided that this case was a poor candidate for transfer, due to apparent lack of aerospace technology developed in this area.

Case #12 - FABRICATION OF MOLDS FOR PLASTICS

I. Description of Problem

It is desired to provide a more efficient and economical means of fabricating injection molds for use with ABS plastics. Injection molds are presently machined from steel blanks by use of a duplicating machine that follows a model profile. Machining time is lengthy and considerable hand polishing is required.

II. Information Requested

A. Methods of fabricating injection molds for ABS plastics.

B. Materials for fabrication of injection molds for ABS plastics.

III. Summary of Literature Search

A preliminary review of STAR literature was made. It was determined that there was limited information related to this problem from aerospace data.

IV. Conclusion

It was decided that this case was a poor candidate for transfer, due to apparent lack of aerospace technology developed in this area.

Case #13 - MOTION SICKNESS

I. Description of Problem

The operator of a line(wire) controlled model airplane or car must revolve about his vertical axis, often causing the hobbyist to experience mild motion sickness.

II. Information Requested

Any data that will assist in the selection of a safe, inexpensive, motion sickness preventive medication that may be marketed in conjunction with control-line operated toys.

III. Summary of Literature Search

No search was made due to low probability of adoption and short contract time.

Case #14 - WEIGHING/MEASURING DEVICE

I. Description of Problem

Small plastic parts are stored in bulk lots. A comparator scale is utilized to determine the approximate number of parts in a lot by means of a ratio-bar mechanism and three weighing pans. The present system will determine the quantity of one gram items in a two-pound batch, with an accuracy on the order of one per cent. Often, the available quantity of parts to fill an order is found to be marginal, necessitating a short production run to assure component availability; then the original quantity is found to be sufficient. A more accurate means of determining the quantity of small parts in a bulk lot would result in considerable production savings.

II. Information Requested

Information regarding the design or selection of accurate weighing devices suitable for, or adaptable to, the counting of small components in bulk quantities.

III. Summary of Literature Search

No search was made due to short contract time and low probability of adoption and literature available.

Case #15 - DECORATIVE FINISHING OF ABS PLASTIC PRODUCTS

I. Description of Problem

Spray coatings, decals and vacuum metalizing are used for decorative finishing of ABS (acrylonitrile, butadiene and styrene) plastic products. Methods and materials were established a number of years ago. It is desired to utilize new technology to advance the state-of-the-art of commercial ABS plastic decorative finishing, with particular regard to mass-production economics.

II. Information Requested

NASA state-of-the-art information on coatings, including methods of application, for ABS plastic decorative finishing.

III. Summary of Literature Search

A preliminary review of STAR was made. It was determined that there was limited information available from aerospace data which related to this problem.

IV. Conclusion

It was decided that this case was not a good candidate for transfer due to apparent lack of aerospace technology in this area.

Case #16 - MODEL AIRPLANE ENGINE NOISE SUPPRESSION

I. Description of Problem

The noise produced by an operating model airplane engine is such that many metropolitan areas have passed ordinances prohibiting or restricting operation. The engines generally operate in a range of twelve to eighteen thousand revolutions per minute, generating a sound pulse two to three hundred times per second, and harmonics of appreciable magnitude throughout most of the audible spectrum. A small, economical, lightweight muffler device is needed.

II. Information Requested

Information is desired regarding the design of noise-control units, together with information concerning small, unique noise-control devices and sound-insulating materials that may have been developed for application to internal combustion or pneumatically-operated devices.

III. Summary of Literature Search

The manual search was confined to STAR, 1964. Both searches, computer and manual, disclosed no related information for the solution of Case #16.

IV. Conclusion

Since this case was a specific noise-suppression problem, it was difficult to find directly related aerospace technology. This case was a poor candidate for aerospace technology transfer; further efforts at transference will be discontinued.

Case #17 - REMOTE CONTROL UNIT

I. Description of Problem

It is desired to utilize the unique components, circuits, and construction techniques developed for aerospace and bio-medical telemetry to develop a low-cost wireless remote control device suitable for application to model airplanes, cars and boats. Compact lightweight receivers and low total cost are prime considerations. A line of sight control range of a few hundred feet is adequate.

II. Information Requested

A. Descriptions of unique (i. e., other than radio-frequency) telemetry techniques that may be suited for short range, low power control applications.

B. Descriptions of unique and/or advanced radio-frequency telemetry techniques and devices that may be suited for low power, short range control applications.

C. Details regarding components, circuits, and construction techniques of low power transmitters and receivers.

III. Summary of Literature Search

The manual search was confined to STAR, 1964. The computer search disclosed no documents applicable to this case. Most of the documents from the computer bibliography referred to manipulators rather than a remote control system for model airplanes. The

Case #17 - REMOTE CONTROL UNIT (cont'd.)

manual search uncovered one document that may be of interest as a new product idea, unrelated to Case #17.

IV. Conclusion

Not a good candidate for transfer; applicable aerospace technology appears too sophisticated and costly to adapt for simple, commercial application.

Case #18 - GOLF CLUB FABRICATION

I. Description of Problem

The production of golf clubs has been historically accomplished by machining a forged blank to the head configuration, and attaching that unit to a step-tapered, chromium-plated steel shaft with a steel pin. It is desired to produce a high quality golf club, utilizing more advanced technology; i. e., by the use of precision casting or powdered metal molding techniques, adhesives, and advanced metal forming methods.

II. Information Requested

A. Methods of casting or otherwise forming precision high-strength, small, metallic structures.

B. Forming methods for manufacturing small, diameter, tapered, metallic tubing.

C. Types, advantages and limitations of various adhesives that may be suitable for joining metals.

III. Summary of Literature Search

This case was determined to have little or no chance of being adopted by the business unit, and to have limited data availability. Therefore, due to the short AMF contract time, and research load at NASA/STID, no effort was expended in a literature search for this case.

Case #19 - INFLATED SPORTS BALLS

I. Description of Problem

Inflated balls are molded of polyvinyl chloride (PVC). Lightweight balls, such as volley and four-square, are molded in one operation, while basketballs are produced by wrapping an inflated-molded PVC bladder with monofilament nylon and dip coating the assembly with PVC. Three distinct problems affecting inflated ball production have been identified.

A. Inflated balls are subject to pinhole puncture. Attempts to patch or seal a puncture invariably result in an unbalanced or non-spherical ball. Resilience and balance have been found to be adversely affected by the inclusion of common puncture sealing compounds. A puncture sealing material is needed that will not cold flow, so as to affect balance, nor significantly alter the resilience of PVC balls.

B. Automated techniques have been developed for all phases of volley ball manufacture, except the painting of simulated seam lines along molded indentions. A hand held tool is presently utilized to apply the one-quarter inch wide stripes. A method is needed to accurately and automatically locate the simulated seam indentations so as to guide an automatic striping tool. The location and geometry of the indentations vary, dependent upon brand name and/or contract specifications.

C. It is desired to substitute monofilament vinyl for the nylon reinforcing used in fabricating basketballs. A source of monofilament vinyl, with a diameter of 0.015 to 0.020-inches, has not been found.

II. Information Requested

A. Materials for, and/or methods of, puncture-proofing or puncture-sealing thin section polyvinyl.

B. Methods for locating and tracking shallow depressions (polyvinyl).

C. A Source for monofilament vinyl with a diameter of 0.015 to 0.020-inches.

III. Summary of Literature Search

The literature search provided five documents that are of interest in providing a solution to Case #19. These documents will be submitted to the AMF business unit for evaluation for technology transfer. In addition, a mechanical search uncovered an additional document of interest.

IV. Conclusion

This case is a good candidate for transfer. Aerospace techniques on self-sealing structures for meteoroid hazards and super-pressure balloons may be applicable to the problem of puncture-proofing sports balls.

Case #20 - SYNTHETIC RUBBER AND PVC MOLDING

I. Synthetic rubber and PVC compound are molded in iron castings which are alternately heated and cooled with treated water circulated at 200°F and 50°F. Two distinct problem areas have been defined.

A. Despite intensive water treatment, calcium deposits occur which degrade heat transfer and impede water flow. A means of preventing or limiting calcium deposits in the mold water jacket is needed, together with information regarding methods of removing existing deposits.

B. PVC and synthetic rubber compound are prevented from adhering to the chromed surfaces of iron molds by frequent applications of Kel F. A more permanent parting agent is desired. Teflon was tried without success.

II. Information Requested

A. Chemical additives, processes, or coatings that will prevent or limit calcium deposits in a hot water circulating system.

B. Chemicals and/or processes that will remove calcium deposits.

Case #20 - SYNTHETIC RUBBER AND PVC MOLDING (cont'd.)

C. A coating or surfacing material that will prevent PVC and synthetic rubber material from adhering to metallic surfaces.

III. Summary of Literature Search

No search was made due to low probability of information available and short contract time.

Case #21 - FILTRATION

I. Description of Problem

A NASA state-of-the-art survey was requested on filtration of fluids.

II. Summary of Literature Search

No search efforts were expended due to short contract time and lack of definition of specific problems requiring a technology solution.

Case #22 - WATER RE-USE

I. Description of Problem

A NASA state-of-the-art survey was requested on water re-use technology.

II. Summary of Literature Search

No search efforts were expended due to short contract time and lack of definition of specific problems requiring a technology solution.

Case #23 - TWO-PHASE FLOW

I. Description of Problem

Methods of prediction and calculations of the effects of two-phase flow was requested.

II. Summary of Literature Search

No search efforts were expended due to short contract time and lack of definition of specific problems requiring a technology solution.

Case #24 - TITANIUM PLATING (PIPING)

I. Description of Problem

This case is concerned with the process of coating ferrous metals with titanium. The process could be one of plating, clading or plasma spraying.

II. Information Requested

Do any of the above processes exist for titanium? If so, what are they, and who is doing it? Are any or all of the processes feasible for titanium? etc.

III. Summary of Literature Search

The manual search covered a review of STAR for 1963, 1964 and 1965. The search provided two documents that related to the technology required for this case. The documents were submitted to the AMF business unit for further evaluation.

IV. Conclusion

This case is a fair candidate for technology transfer. Aerospace advancements in plating and titanium technology may provide a solution to this problem.

Case #25 - COMPACT REFRIGERATION COMPRESSOR

I. Description of Problem

A search is being made for a refrigerant compressor which has about a 3:1 compression ratio, and a continuous operating life of at least 8,000 hours. The compressor is to be used in a 7-1/2 ton (10 hp) refrigeration system. The refrigerant now used is freon; however, this should not be a limiting factor. It is desirable to utilize a centrifugal type compressor to avoid some of the lubrication evaporation problems experienced in reciprocating machines. Reliability and long life are prime requirements.

II. Information Requested

What types of compressors in this size and application range are being used in the space program today? Who are the suppliers?

III. Summary of Literature Search

The manual search was confined to STAR for 1963, 1964 and 1965, and IAA, 1965. Four documents were found to be of general interest in providing a solution to the problem.

IV. Conclusion

This case is a fair candidate for transfer. Compact refrigeration or air conditioning packages for space ships, or launch equipment accessories, may provide the solution to this case.

Case #26 - HEATING IN CYLINDRICAL SHELLS

I. Description of Problem

A method of heating is required for polymer and ceramic objects contained in a thin wall, stainless steel cylindrical chamber. The objects are to be maintained at an approximate temperature of 150°F. The chamber is open to room environment (50° to 90°F). The cylinder is in the vertical position, with a height of 28 inches, and a diameter from 6-to-12-1/2 inches. The inner shell surface must present a clear cylindrical storage space. The heater must use a 110 (or 220) volt AC power source. A low cost mass production unit is required.

One approach to the problem is to provide a uniform, grid type heating element with a plastic covering. The heater grid would be emplaced on the outside of the chamber. In this approach, the heating element must not be affected by cleaning detergents or abrasives, and should be capable of being submerged in water for cleaning. Standard, electrical strip heaters have previously been employed, but heat developed is localized, due to poor conduction of heat in the stainless steel shell. This method is also objectionable, due to the effects of detergents, and its inability to withstand water immersion. It is understood that NASA has employed grid type (graphite) heaters on oil tanks for experimental aircraft. Another approach is to provide an entirely new method of heating the objects, such as with conductive coatings, infrared or other advanced technology that may have been developed by NASA.

II. Information Requested

A. Construction and performance of grid type electrical heaters.

B. List of suppliers who may have developed grid type electrical heaters for NASA.

C. Information on heating methods and equipment applicable to objects stored in thin wall cylinders.

III. Summary of Literature Search

A. The computer search revealed no applicable information to Case #26.

B. The manual search included STAR for 1964 and 1965. One document was found to be of interest.

The literature related to more complex technology than that required for the solution to Case #26.

IV. Conclusion

This case was determined to be a poor candidate for technology transfer. Aerospace technology appears too sophisticated or costly for a solution to this simple, commercial problem.

Case #27 - ELECTRON BEAM WELDING

I. Description of Problem

A NASA state-of-the-art literature search was requested on Electron Beam Welding.

II. Information Requested

Information is desired with regard to the extent of its use in industry, techniques, application, and available equipment.

III. Summary of Literature Search

A preliminary survey was made of STAR, and it was determined that there was good availability of information pertaining to this case.

IV. Conclusion

This case, if specifically defined by the business unit, could be a good one for transference.

Case #28 - PIPE COATINGS

I. Description of Problem

It is desired to provide a coating to the inside of ferrous pipes. The coating is required to provide protection against acids, hydrocarbon solvents and salt water. The coating must be capable of withstanding temperatures of 850°F. The coating should be capable of being applied to clean metal surfaces, in an impermeable film of a thickness of 5-to-40 mills. Another coating is also required which is impermeable to hydrogen sulfite (H_2S) at temperatures of 450°F.

II. Information Requested

Coating for ferrous pipe that provides protection in the environments stated.

III. Summary of Literature Search

A. Six documents from the computer search were found to be of interest and were submitted to the AMF business unit for further evaluation.

B. Five documents from the manual search were found to be of interest and were submitted to the AMF business unit for further evaluation.

IV. Conclusion

Results to date indicate this case is a good candidate for technology transfer. Aerospace research advancements in coatings may provide a solution to this problem.

Case #29 - DIE CASTING

I. Description of Problem

It is desired to provide an aluminum or zinc die casting, suitable for die casting around solid inserts of a tubular aluminum framework. Methods should be suitable for production use.

II. Information Requested

Die casting processes and methods.

III. Summary of Literature Search

A. The computer search did not disclose any data applicable to this subject.

B. The manual search was confined to 1964 issues of STAR. No information applicable to Case #29 was found.

IV. Conclusion

This case is a poor candidate for technology transfer.

Case #30 - DOUGH RHEOLOGY

I. Description of Problem

A NASA state-of-the-art search, including studies within NASA, is requested relative to the rheology of dough, and the microwave effects on yeast and food products. Of particular interest are the chemical changes wrought by microwaves.

II. Summary of Literature Search

The manual search included only the 1964 issues of STAR. There was a good quantity of information available in the NASA reports which related to this case. Since this case is a survey of the state-of-the-art, the documents were submitted to the AMF business unit for further evaluation.

III. Conclusion

This case is a good candidate for transfer. However, the case must be more specifically defined by the business unit before a literature search in any depth can be continued.

Case #31 - WOOD SEALANT

I. Description of Problem

A hard wood product is manufactured to precise dimensions. While in storage, the wood expands and contracts due to humidity changes. The present sealant is inadequate. It is desired to provide a better sealant and wood filler which, when applied to the surface of the wood block, will prevent changes in geometry dimensions. Since this is a consumer item, the appearance of the sealant should be attractive.

II. Information Requested

Available information on wood sealants and preservatives.

III. Summary of Literature Search

A manual search was conducted using STAR 1964 and 1965, and IAA 1965 issues. No documents relating to this case were found.

IV. Conclusion

This case is a poor candidate for technology transfer. No further attempt at transfer is recommended.

Case #32 - LIAPUNOV FUNCTIONS

I. Description of Problem

Information is desired regarding the utilization and restriction of Liapunov functions, and their calculations.

II. Information Requested

NASA state-of-the-art information regarding Liapunov functions and their calculations.

III. Summary of Literature Search

The manual search was confined to the 1964 and 1965 issues of STAR. There was a good quantity of information available in the NASA reports relating to this case. Since this case pertains to mathematical equation solving, the documents were submitted to the AMF business unit for further evaluation.

IV. Conclusion

This case was a good representative for transfer that occurs in basic theory and knowledge, but no measureable, direct, tangible transfer will be possible. No further attempt at forced transference was recommended.

Case #33 - SLIDING SEAL FOR STEAM

I. Description of Problem

It is desired to find a method of sealing steam leakage around a moving belt. Belt material is stainless steel. The belt dimensions are 425 feet long, 60 inches wide, and 40 thousandths of an inch thick. Steam escapes around the sides of the moving belt from a steel pan container underneath the belt. Belt speed is 200 feet per minute and is in operation 24 hours a day. Material used must be non-toxic and withstand the effects of water and alcohol. It will be subject to temperature changes from 212°F to 80°F in 3 seconds.

II. Information Requested

Sealing devices and materials applicable to the described problem.

III. Summary of Literature Search

An evaluation of the ratings originally assigned to this case resulted in a reassignment of ratings to a lower possibility of transfer and availability of information. It was determined that, in literature searches, it was difficult to find an exact, specific solution to a problem as requested here. The solution, if found, would be purely coincidental. Accordingly, after a preliminary survey of STAR, the search and technology transference efforts were discontinued.

IV. Conclusion

This case is a poor candidate for transfer. Further efforts at transference were discontinued.

Case #34 - BELT MATERIAL

I. Description of Problem

It is desired to find a better material for a moving belt used in process machinery. The present belt is of stainless steel and has a short service life. The belt dimensions are 425 feet long, 60 inches wide, and 40 thousandths of an inch thick. The belt must lie perfectly flat. The belt operates as a pump for a molasses-like product, and must withstand the corrosive effects of water and alcohol. The belt speed is 200 feet per minute and is in operation 24 hours a day. It is subjected to a knife blade cutting action load of 50 lbs. pressure. The belt is subjected to temperature changes from 212°F to 80°F in 3 seconds. Material used must be non-toxic. One approach to the problem is to use a ceramic material on a carbon steel base. Another approach is to substitute titanium for the stainless steel belt.

II. Information Requested

A. Stainless steel applicable to environment described.

B. Ceramic materials applicable to the environment described.

C. Titanium sheet metal availability and its performance characteristics, particularly with regard to non-toxic capability.

D. Any materials or coatings that can be applied to the problem stated.

III. Summary of Literature Search

No attempt was made to search the literature for an approach which advocated a substitution of titanium for stainless steel. Rather, this problem was combined with Case #35, due to the similarities in end usage, and a search for coatings was conducted.

IV. Conclusion

This case is a fair candidate for transfer. Further efforts of literature search and attempt at transference should be continued.

Case #35 - PROTECTIVE COATINGS FOR STEEL

I. Description of Problem

Construction of bakery equipment is necessarily of materials that will not contaminate the human consumption products. Therefore, a good portion of the material used is stainless steel.

II. Information Requested

AMF is interested in long life, non-toxic protective coatings for plain carbon steel, to be used in the dough storage equipment of the bakery industry.

III. Summary of Literature Search

The manual search was confined to STAR, 1964. Four documents were of interest for a possible solution of Case #34, or Case #35, and were submitted to the AMF business units for evaluation.

IV. Conclusion

Case #35 is a fair candidate for technology transfer; further literature search should be continued.

Case #36 - FATIGUE TESTING

I. Description of Problem

It is desired to develop a technique of non-destructively assessing the residual fatigue life in metals and other material.

II. Information Requested

NASA state-of-the-art information regarding nondestructive techniques of assessing the residual fatigue life in metals and/or non-metals.

Case #36 - FATIGUE TESTING (cont'd)

III. Summary of Literature Search

No search was made because of lack of specific information on what problems this case was to solve, and short contract time.

IV. Conclusion

This case is a good representative of transfer that occurs in basic theory and knowledge, but no measureable, direct, tangible transfer is possible. Accordingly, no further attempt at transference is recommended.

Case #37 - BEARINGS FOR ADVERSE ENVIRONMENTS

I. Description of Problem

Small rotary devices are operated in an air atmosphere of varying temperature and pressure. Temperatures range from -100°F to +400°F (200°K to 475°K), while pressures vary from atmospheric to 10^{-6} mm Hg (10^{-6} Torr). Information is desired regarding the performance of various rotary bearing configuration and materials under those environmental conditions.

II. Information Requested

A. Rotary bearing configurations suitable for operation in the above-cited environments.

B. Bearing materials suitable for operation in the above-cited environments.

C. Test reports citing experience with various bearing configurations and materials in the above-cited environments.

D. Design study reports citing experience with various bearing configurations and materials in the above-cited environments.

III. Summary of Literature Search

A preliminary survey revealed good availability of aerospace literature which was applicable.

IV. Conclusion

Continue efforts when specific problems are provided.

Case #38 - LUBRICANTS FOR ADVERSE ENVIRONMENTS

I. Description of Problem

Small rotary bearings of various configurations and materials are operated in an air atmosphere of cyclic temperature and pressure. Temperatures range from -100°F to +400°F (200°K to 475°K), while pressures range from atmospheric to 10^{-6} mm Hg (10^{-6} Torr). Information is desired regarding bearing lubricants suitable for those environmental conditions.

II. Information Requested

NASA state-of-the-art, test reports and design study reports citing experience with various lubricants in the above-cited environments.

III. Summary of Literature Search

A preliminary survey revealed good availability of aerospace literature which was applicable.

IV. Conclusion

Continue efforts when specific problems are defined.

Case #39 - BRUSHLESS D C MOTORS

I. Description of Problem

It is desired to incorporate the latest NASA state-of-the-art techniques into the development of a brushless direct current motor. Such a motor consists of an alternating current induction motor and an integral direct current to alternating current inverter. No specific development problems have been identified, but it is anticipated that considerable, independent engineering and development activity can be bypassed by utilizing the most current available information regarding brushless D C motor design and construction.

II. Information Requested

A. Design of direct current brushless motors.

B. Design of induction motors for inverter operation.

C. Design of inverter for operating induction motors.

III. Summary of Literature Search

A. Five documents from the computer search were found to be applicable to this case.

B. The manual search was confined to the 1964 issues of STAR; one document was found to be applicable.

IV. Conclusion

This case is a good candidate for technology transfer. Efforts should be continued, dependent upon the AMF business unit's evaluation of the literature.

Case #40 - SHORT CIRCUITING WELDING

I. Description of Problem

It is desired to incorporate NASA's state-of-the-art information into the development of an automatic short circuiting type welding machine. Of particular interest are the factors affecting the welding of low carbon steel via the shorted arc welding technique.

II. Information Requested

A. Any available information regarding experience with shorted-arc or short-circuiting-transfer welding.

B. Any available information regarding experience with automated electric welding of low carbon steel.

III. Summary of Literature Search

The manual search was confined to the 1964 issues of STAR. Only one document was found that was applicable to this case; this document was submitted to the AMF business unit for further evaluation.

IV. Conclusion

Continue efforts when specific problems requiring solutions are defined.

Case #41 - INFRARED PUDDLE TRACKING

I. Description of Problem

It is desired to further automate a semi-automatic short-circuiting welding machine. The majority of all weld variables (i. e., welding current, filler wire feed, and shielding gas flow) are now programmed into the machine; however, precise positioning of the filler wire in the molten puddle remains a manual function. An automatic means of precisely locating the relative positions of the molten puddle and filler wire is needed. It is anticipated that a small infrared heat sensor would accomplish the desired function.

II. Information Requested

A. The application of infrared sensors to automated welding machines, if such has been accomplished by NASA.

B. Characteristics of infrared sensing devices.

C. Sources of infrared sensing devices.

III. Summary of Literature Search

The manual search was confined to STAR, 1964. One document was found to be applicable to this case, and it was submitted to the AMF business unit for further evaluation.

IV. Conclusion

This case is a fair candidate for transfer. Literature search efforts should be continued, after business unit's evaluation.

Case #42 - LOW CARBON STEEL WELD BACKUP MATERIAL

I. Description of Problem

Short-circuiting welding (short arc) is utilized to join the butted ends of cylindrical low carbon steel sections. A hydraulically expanded segmented copper backup ring is employed to position the surface to be welded, prevent unmelted filler wire from projecting into the sections, and to limit the flow of molten material at the inner face of the weld. An anti-spatter material - known in the trade as "Glop" - is brush applied to the copper segments prior to each weld operation in an effort to prevent erosion and subsequent copper inclusion in the weld. It is desired to improve weld quality by (1) employing an alternate backup ring material and/or configuration, or (2) applying a more effective and more permanent anti-splatter material to the existing backup ring, or (3) eliminating the backup ring.

II. Information Requested

A. Materials utilized for fabricating weld backup fixtures.

B. Configurations of weld backup fixtures.

C. Coatings for weld backup fixtures.

D. Techniques of eliminating the need for a weld backup fixture.

III. Summary of Literature Search

This case was determined to have little or no chance of being adopted by the business unit, or to have limited data availability. Therefore, due to the short AMF contract time no effort was expended in a literature search.

Case #43 - TACHOMETER GENERATOR

I. Definition of Problem

It is desired to monitor, within 10%, the speed of a shaft turning from one to forty RPM, with a tachometer generator that provides a D C voltage proportional to shaft speed. The tachometer generator need not monitor, but must not be destroyed by, a reverse shaft rotation of 1750 RPM. Economy, low maintenance, and an ability to withstand high humidity and dustry environments are qualifying restrictions. No commercial unit has been found that meets all requirements.

II. Information Requested

Identity of a vendor or manufacturer, or a design concept, that can supply a tachometer generator meeting the above-cited requirements.

Case #43 - TACHOMETER GENERATOR (cont'd.)

III. Summary of Literature Search

No information was found relating to the tachometer generator problem. The bibliography literature related to other control problems.

IV. Conclusion

This case is not a good candidate for technology transfer. No further efforts will be made toward transfer.

Case #44 - ADHESIVE FOR ALUMINUM

I. Description of Problem

It is desired to use an adhesive to assemble the various tubular aluminum and zinc die cast components of a structure. The desired adhesive would cure at room temperature, not be degradaded by brief exposure to 165^{o}F, have a room temperature shear strength greater than 2000 psi, and require a minimum of surface preparation.

II. Information Requested

Characteristics of the various adhesives suitable for bonding aluminum to aluminum and aluminum to zinc.

III. Summary of Literature Search

The manual search was confined to the 1964 issues of STAR. Six documents were found applicable to this case; they were submitted to the AMF business units for further evaluation.

IV. Conclusion

This case is a fair candidate for transfer. Continue search effort after business unit's evaluation of literature submitted.

Case #45 - TORSIONAL LOAD EFFECTS ON TUBING JOINTS

I. Definition of Problem

Torsionally loaded aluminum tubing is bonded with an adhesive to aluminum and zinc die castings. It is desired to increase the torsional load capability of the bonded joints.

II. Information Requested

A. Factors affecting the torsional strength of adhesive bonded aluminum tubing to aluminum, and aluminum tubing to zinc connections.

B. Optimized joint configurations for maximum torsional load capability in an adhesive-bonded aluminum tubing to aluminum, or aluminum tubing to zinc connections.

III. Summary of Literature Search

A preliminary survey of STAR was made.

IV. Conclusion

This case was found to be a poor candidate for transfer; efforts were discontined due to short contract time.

Case #46 - TRACKING OF WELD SEAM

I. Description of Problem

The automated welding of butted low carbon steel cylindrical sections presently requires considerable preliminary effort to obtain a straight, constant gap, weld seam. A means of tracking the weld seam, together with a means for detecting small variations in the seam width, would permit compensatory welder functions to be automatically performed; thus eliminating the necessity for a precise, consistent seam configuration.

II. Information Requested

A. Methods of locating and/or tracking gaps or seams between steel sections.

B. Methods of detecting the gap width between steel sections.

III. Summary of Literature Search

This case was determined to have little or no chance of being adopted by the business unit, or to have limited data availability. Therefore, due to the short AMF contract time no effort was expended in a literature search.

Case #47 - D C AMPLIFIERS

I. Description of Problem

Small direct current (D C) amplifiers are procured and utilized as a portion of an instrumentation assembly. It is desired to reduce the size of the assembly as well as increase the performance and reliability requirements of the amplifier.

II. Information Requested

General information relative to the state-of-the-art development of miniaturized and integrated circuit direct current amplifiers., i.e., size, performance, reliability, and specialized characteristics.

Case #47 - D C AMPLIFIERS

III. Summary of Literature Search

The manual search was confined to the 1964 issues of STAR. Two documents were found that may relate to this case, and they were submitted to the AMF business unit for further evaluation.

IV. Conclusion

This case was found to be only a fair candidate for transfer.

APPENDIX IV

REPORT ON THE RETROSPECTIVE LITERATURE EVALUATION

CASE #9

by Jack C. Goodman

NON-DESTRUCTIVE TIRE INSPECTION TECHNIQUES

Purpose

To ascertain, the feasibility of non-destructive testing of tire carcasses prior to recapping, using semi-skilled personnel, through a cursory review of technical literature on non-destructive testing. Proposed market to be the tire recapping establishments.

Summary

A review of technical literature on non-destructive testing has shown two methods have been used to test tires. The two methods used either X-ray or ultrasonic techniques, and were primarily quality control type tests on new tires. Past development of non-destructive test equipment has produced laboratory type devices requiring skilled, and in some cases licensed, operators. For the market under study, the recapping industry, no evidence of penetration or equipment directed at this market was found. The bibliography of literature used is published in APPENDIX V.

During the course of this review, three techniques were viewed as possible for a tire inspection system — X-ray, infrared, and ultrasonics. Of the three, ultrasonics seems the more feasible from the standpoint of economy, safety, ease of operation and reduction of data, and the high probability of detecting the type of faults found in tires. X-ray techniques were ruled out because of the high initial capital investment, safety hazards, high operating cost, and its ability to detect only certain faults commonly found in tires. Infrared techniques are unacceptable due to the difficulty in reducing data and the possibility of the need to condition the tire carcass prior to inspection.

A proposed program for development of an ultrasonic tire inspection device is outlined and directed toward the tire recapping market, with projected future markets of tire manufacturers for quality control tests, and the armed forces for receiving inspections.

* * * * *

Tire Inspection Techniques

A. X-RAY METHOD

Tire inspection using X-ray fluoroscopy methods is used primarily as a quality control tool in manufacturing. However, past experience has shown that test results reveal only voids and inclusions, but no unbonds or ply separation data. Equipment consists of an X-ray generator, image intensifier, optical system, film, shielding, and tire handling devices. If direct viewing is desired, additional optics are required, and a viewing screen. Tires must be unmounted, so that the X-ray tube can be placed between the tire and the image intensifier.

The fact that X-rays cannot detect unbonds or ply separation, unless a void exists, makes this technique totally unacceptable for the proposed application, since these faults are the more common ones found in used tire carcasses. Other disadvantages of this method, compared to either ultrasonic or infrared methods, are the high equipment cost, skilled operator requirements, safety hazards requiring elaborate shielding, and the required tire handling equipment and controls. Also, the test results at the conclusion are not complete enough to assure that the tire is suitable for recapping.

B. INFRARED METHODS

Review of non-destructive testing documentation posed the possibility of using infrared detection after localized heat soaking the test sample. This provides another method of inspecting tire carcasses. Equipment requirements would be a heat source to heat soak a local area of the sample, apparatus to continuously rotate the sample, and an infrared detector to measure the radiation of the sample. Output of the detector would be recorded for analysis of the tire's condition.

This technique has shown promise for relatively smooth surfaced samples of uniform thickness and made of various materials; but for tire carcasses, it woud seem necessary to completely remove the tread to approach the uniform surface and thickness requirements. Otherwise, a random radiation would result from tread pattern. Another disadvantage for the intended application would be the extreme complexity necessary in the design of discrimination circuits to provide automatic, GOOD/BAD, indication of the sample's condition. Without such circuits, highly trained operators would be required to analyze the test data. It should be noted, however, that the initial capital investment for equipment using infrared methods would probably be the least expensive of all non-destructive test methods. It should also be noted that no evidence was found which indicated this method had ever been investigated for use in tire inspection systems.

C. ULTRASONIC METHODS

By the process of elimination, this leaves what appears to be the most feasible technique for non-destructive testing of tires, without removal of tires from wheels or wheels from the vehicle-ultrasonics. Before a particular method of ultrasonic testing is proposed, an analysis in abstract will be presented to illustrate various ultrasonic techniques.

One of the basic attributes of ultrasonic testing, using a coupling media — i. e., water, between the transmitter and the sample under test, is the velocity of propagation of ultrasonic energy in water is very close to that in rubber, approximately 59, 000 inches/sec. Only about 3% of the transmitted energy is reflected at the water-rubber interface, or about .3 db energy loss.

Ultrasonic testing falls into two techniques — a) acoustic shadow method, and b) pulse-echo method. Either of these approaches must use a "C" scan arrangement to provide acceptable data of the sample under test, and either a visual display or recorded data can be used to present the test results. However, for the application intended, recorded data and discrimination circuits to provide ACCEPT/REJECT visual outputs is the most acceptable presentation. This is assumed to aleviate the requirement for skilled operators.

For illustrative purposes, let us assume a fixed plane for the ultrasonic transducer operating in a "C" scan configuration, and then proceed to demonstrate the two methods of testing-acoustic shadow and pulse-echo. Testing in the acoustic shadow configuration, two transducers are used — one for transmitting the ultrasonic energy through the test sample, and the other to receive the ultrasonic energy which passes through the test sample. Since the acoustic impedance of rubber and water are very nearly equal, approximately 97% of the energy transmitted is received, if the sample is 100% sound. However, if the transmitted signal experiences an abrupt change in acoustic impedance, as would be the case for an area of unbond, ply separation, inclusions, etc., a large portion of the transmitted energy about the fault area will be reflected. Therefore, the received energy in the region of the fault will be greatly reduced, thus producing an acoustic shadow of the fault at the receiver transducer. If the received energy is recorded, a record of the physical size and shape of the fault is produced. The depth of the fault in the test sample cannot be ascertained using this technique. Disadvantages of the acoustic shadow test method is the requirement of two transducers, and for tire inspection, this method requires the tire be removed from the wheel. Thus requiring the use of tire handling apparatus to hold and rotate the test sample. This method, however, from the electronics point of view, is simpler since only one signal is involved per transducer and gives greater penetration because related energy travels through the media only once, and transducer alignment has less effect on transmitted signals than on reflected signals.

The general test configuration using pulse-echo techniques of ultrasonic testing incorporates one transducer in a "C" scan operating mode, tire stays on the wheel, an external rotational fixture to rotate the tire on its axis as the transducer scans the periphery. Test data would be recorded as in the acoustic shadow method. In this mode of operation, periodic pulses of ultrasonic energy would be transmitted through the coupling media, water, through the tire carcass to the rubber air interface on the inside of the tire. At the rubber-air interface, the ultrasonic energy experiences a drastic change in acoustic impedance and the greater part of the energy will be reflected and received at the transmitting transducer. For the case of a sound tire under test, this sets up two base lines in time, i.e., T_O when the transmitted pulse is sent out, and T_n when the reflected energy from the air rubber interface is received. The time of fault reflections received, measured from T_O, corresponds to depth of the fault, when properly scaled. As in the acoustic shadow method, "C" scan operation of the pulse-echo transducer and recorder will provide a profile as well as depth of the fault. Any tire inspection system using pulse echo principles will probably require three transducers, one for the tread area, and one for each sidewall area, if the tire is to remain in place on the vehicle. The essentials of a system of this sort will be proposed as a feasible system, for operation by unskilled operators in recapping establishments, to ascertain the condition of tire carcasses prior to recapping.

Proposed System for Ultrasonic Inspection of Tires

Before embarking on a proposed system of non-destructive testing of tires using pulse-echo techniques of ultrasonics, it must first be noted that under this report, no development work has taken place and no originality is intended. The knowledge expressed has been derived from a pure literature search and documentation of work performed by others. Also, the essentials of the proposed system is based on an existing patent with appropriate modifications. No evidence could be found to show that any device, as covered by the patent, is presently in use. Considerable documentation was reviewed and pertinent reports read for educational background and possible adaptation to tire inspection.

This proposed development program is based on the inspection of a single tire at one time, while the tire and wheel remain on the vehicle. An extension can easily be projected where all four tires on an automobile can be inspected simultaneously. However, it is more logical to develop a single prototype of sufficient accuracy and high probability of fault location, and acceptable to the market prior to exploring the many operational configurations. From documented evidence, the feasibility of such a system is indeed within the present state-of-the-art, and in fact currently used to a limited degree, but purely as a laboratory type tool. Further development and/or refinements are required for marketing for use by unskilled personnel.

The three transducers would be mounted about the perimeter of the tire, and scan the tread area, inside sidewall, and the outside wall as the tire is rotated about its axis. All three transducers as well as the tire rotating actuator will be submerged in a container which holds the coupling media, water. The motor, which drives the actuator will be mounted on an outside wall of the container. Transducer and motor cables will connect in a control console, which contains motor controls, transmit/receive electronics, discriminator electronics, recording equipment and displays and indicators. Once the tire is placed in the container, the operator maintains complete control of the inspection from the control console.

Since three transducers appear to be essential, the next consideration is how to handle the transmission and receiving operations. One approach, though by no means economical, would be to pulse all three transducers simultaneously and use three receivers and a three channel recorder to record each transducer independently, proving complete test data in one revolution of the tire. This approach can easily be seen to at least complicate the electronics by a factor of three, but at the same time, it provides the most rapid means of testing, i.e., one tire revolution.

A more reasonable approach in view of economy and simplicity would be to develop a single channel throughout with automatic switching among the three transducers. This would provide a complete test in three revolutions of the tire. If GO/NO-GO logic is used, the test can be made to halt upon reception of the first fault. Still another refinement could include a programmed discriminator to select fault size and discriminate against the programmed level, stopping the test only when faults exceed the selected level. Recorded data will follow the "C" scan transducer cycle to provide a record of tire conditions.

The test procedure would be similar to the following:

- Elevate vehicle and position the tank and transducer assembly under the tire to be tested
- Lower vehicle so as to make contact with the rotary actuator
- Start actuator motor and adjust tire rotational speed
- Start electronics and allow time to temperature stabilize
- Actuate start switch
- Verify recorder paper drive started
- Observe GOOD/FAULT indicator light
- Observe transducer indicator light (this identifies which transducer is scanning)
- At conclusion of test, tire rotation will stop and an indicator light will signify end of test
- Proceed to next tire by raising vehicle and moving equipment. Repeat the above procedure.

Conclusion

Ultrasonics have been proven as a means of non-destructive testing of various materials and components, one of which is automobile tires. It appears economically and technically feasible to develop a tire inspection system for testing tires without the need to remove said tires from their respective wheels. The projected market would be the recapping industry, for testing tires to determine the advisability of recapping carcasses. An extended market would be the tire manufacturer. for production quality control.

Development cost for a proposed system will not be forecast here, but it is conceivable a production model for use in the above mentioned markets could sell for approximately $15,000. This figure is based on what similar laboratory equipment is now selling. The need for a comprehensive market survey cannot be overemphasized to determine accurate market potential as well as to determine the receptiveness of such equipment by prospective users. The patent now in existence on tire inspection should also be further investigated before development can proceed.

APPENDIX V

BIBLIOGRAPHY OF LITERATURE USED

PART A of the bibliography is a listing of aerospace data utilized in technology research for the technology transfer cases. To conserve space, full title, authorship and sources are not listed, since they are readily available from the Space Technology Abstract Reports (STAR) and the International Aerospace Abstracts (IAA).

Accession numbers indicated by an asterisk are reports which are considered to be applicable to the solution of the cases.

PART B of the bibliography is a listing of the general literature used in the study, in preparing the report, and to formulate some of the conclusions and recommendations reached.

PART C of the bibliography is a listing of non-aerospace literature used in the study of Case #9.

BIBLIOGRAPHY - PART A

Case #1 - OVEN BELT MATERIAL

A. STID Computer Search - Bibliography #893 (revised), dated 1 March 1965; 13 citations.

N62-11735 N62-12049 N62-13211 N62-14113 *N62-15943 N62-17071 *N63-12583 N63-13822 *N64-12658
N64-28002 *N64-32409 N65-11728 N65-12793

B. Manual Search - Annual Index and Abstracts of STAR, January-December 1964.

N64-16786 *N64-26059

Case #2 - CORROSION OF ALUMINUM

STID Computer Search - Bibliography #894, Part I (unclassified), dated 4 February 1965; 22 citations.

A63-11254 A63-12006 A63-12007 A63-12009 A64-26002 N62-17693 N63-14299 N63-15272 N63-18283
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N64-24275 N64-33610 N64-83029 N64-84295

Case #3 - ALUMINUM EXTRUSION

STID Computer Search - Bibliography #896, Part I (unclassified), dated 4 February 1965; 20 citations.

A63-16181 *A63-17477 N62-11984 N62-12574 N62-13095 N63-10358 N63-11230 N63-17493 N63-19330
N63-19502 N63-21703 N63-82448 *N64-10450 N64-13820 N64-19286 N64-21003 N64-28248 N64-28417
N64-30117 N64-84922

Case #4 - HEAT TREATING OF STEEL SHAFTS

A. STID Computer Search - Bibliography #872, Part I, dated 26 January 1965; 16 citations.

N62-11370 *N62-11382 N62-12623 N62-13546 N62-13603 N62-15064 N62-15065 N63-15943 N62-16065
N62-11714 N62-17874 N63-11721 N63-16537 N63-19198 N63-21010 *N64-85000

B. Manual Search - The Guide to Subject Indexes for STAR (NASA SP-7016) and the 1964 issues of STAR.

N64-23213 N64-28241 N64-28242 N64-28243

Case #5 - SILICONE CONTROL RECTIFIER CIRCUITRY

No applicable information found in preliminary survey.

Case #6 - ADHESIVE NYLON TO WOOD

Manual search was conducted in conjunction with Case #44. No applicable information found.

Case #7 - LIFE RAFT

Manual search - Technical brief #64-10001.

Case #8 - RETROMETER

Manual search - Technical Utilization Special Report SP-5005.

Case #9 - TIRE CARCASS INSPECTION

A. Manual search - Annual - January-December 1964 of STAR.

*N64-14319 *N64-20319 N64-20437 N64-24787 *N64-31184 *N64-32984

B. Information Center search (ARAC)

A63-10750 A63-11550 A63-17165 A63-17176 A63-17177 A64-12735 A64-17834 A64-19003 A64-21301
A64-22068 A64-22888 A64-22950 A64-23527 A64-23531 A64-25435 A65-10421 A65-11582 A65-14827
N62-10639 N62-10640 N62-11047 N62-13634 N62-14127 N62-14350 N62-15052 N62-15063 N62-17403
N62-17404 N62-17639 N62-17685 N62-17720 N62-17721 N62-17722 N62-17723 N62-17724 N62-17725
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N63-15420 N63-15710 N63-20146 N63-21406 N63-23592 N64-10213 N64-11923 N64-12344 N64-14314
N64-14319 N64-14422 N64-15022 N64-18048 N64-18611 N64-18612 N64-18613 N64-18614 N64-18615
N64-18745 N64-19266 N64-20319 N64-26228 N64-31184 N64-31822 N64-32984 N65-11066 N65-12567

Case #10 - COLORABILITY OF ABS PLASTICS

Limited information available per preliminary survey of STAR literature.

Case #11 - INJECTION SCREW MOLDER PURGE FOR PLASTICS

Limited information available per preliminary survey of STAR literature.

Case #12 - FABRICATION OF MOLDS FOR PLASTICS

Limited information available per preliminary survey of STAR literature.

Case #13 - MOTION SICKNESS

No search; low probability of adoption.

Case #14 - WEIGHING/MEASURING DEVICE

No search - due to low probability of adoption and literature availability.

Case #15 - DECORATIVE FINISHING OF ABS PLASTIC PRODUCTS

Limited information available, per preliminary survey of STAR literature.

Case #16 - MODEL AIRPLANE ENGINE NOISE SUPPRESSION

A. STID Computer Search - Bibliography #963, dated 5 March 1965; 10 citations.

A63-12092 A64-10957 A64-20464 A64-22811 A64-22968 N63-17942 N63-81325 N64-11315 N64-83463 N64-83467

B. Manual Search - STAR 1964 issues.

N64-13089 N64-14650 N64-25262

Case #17 - REMOTE CONTROL UNIT

A. STID Computer Search - Bibliography #961, dated 4 March 1965; 41 citations.

A63-17536 A63-24078 A64-10942 A64-14074 A64-14352 A64-15597 A64-19650 A64-21057 A64-24195
A64-26488 A64-26852 A64-28108 A64-80916 N62-10695 N62-11497 N62-13013 N62-13087 N62-13457
N62-13498 N62-14237 N62-17536 N63-10075 N63-10670 N63-11810 N63-22321 N64-11529 N64-11910
N64-11917 N64-11993 N64-13722 N64-15714 N64-18934 N64-20214 N64-20443 N64-21343 N64-21352
N64-27433 N64-29784 N65-12018 N65-12339 N65-13993

B. Manual Search - STAR 1964 Annual Index.

N64-12356 N64-12367 N64-13790 N64-19154 N64-21343 N64-22525 *N64-25807 N64-30234 N64-32331 N64-33225

Case #18 - GOLF CLUB FABRICATION

No search - limited literature.

Case #19 - INFLATED SPORTS BALL

A. STID Computer Search - Bibliography #962, dated 5 March 1965; 9 citations.

N62-10301 *N63-13244 *N63-13519 *N63-15390 *N63-17928 *N63-18867 N63-19323 N63-21363 N64-25469

B. Manual Search

*N64-31232

Case #20 - SYNTHETIC RUBBER AND PVC MOLDING

No search - low probability of information available.

Case #21 - FILTRATION

No search - limited data available.

Case #22 - WATER REUSE

No search - limited data availability.

Case #23 - TWO PHASE FLOW

No search - limited data availability

Case #24 - TITANIUM PLATING

Manual Search - STAR, 1963, 1964 and 1965 issues.

N63-22538 N64-16784 *N64-17130 N64-17148 *N64-17736 N65-14256

Case #25 - COMPACT REFRIGERATION COMPRESSOR

Manual Search - 1963, 1964 and 1965 issues of STAR, and 1965 issues of IAA.

A65-11098 A65-12518 A65-13822 A65-13828 A65-13843 A65-15605 *N63-20049 *N63-20054 *N63-20055
*N63-20056 N64-13001 N64-13327 N64-14668 N64-20739 N64-23494 N64-23495 N64-23496 N64-23497
N64-26017

Case #26 - HEATING METAL SURFACES

A. STID Computer Search - Bibliography #966, dated 4 March 1965; 9 citations.

N62-12479 N62-12538 N62-12546 N62-13540 N62-16241 N63-22421 N64-10969 N64-12894 N64-28491

B. Manual Search - NASA SP-7016, STAR 1964 Annual Index, and Semi-Monthly Abstract Journal Indexes, Volume 3, 1965 Issue Nos. 1 through 5.

*N64-17846 N64-17995 N64-19382 N64-20117 N64-25277

Case #27 - ELECTRON BEAM WELDING

Preliminary survey indicated good availability of information.

Case #28 - PIPE COATINGS

A. STID Computer Search - Bibliography #964, dated 4 March 1965; 47 citations.

A63-13357	*A63-15228	A63-20631	*A63-20633	A63-20677	A63-25255	A63-25256	A63-25257	A63-25258
A63-25260	A63-25262	A64-14411	A64-15792	A64-24486	A64-25484	A64-25649	A64-28222	A65-10497
A65-12711	N62-11213	N62-11515	N62-12231	*N62-14789	N63-10385	N63-10964	N63-10966	N63-11801
N63-18416	N63-20725	N63-22096	N63-80610	N64-19307	N64-21157	N64-24266	*N64-25299	*N64-25513
N64-27009	N64-27010	N64-27011	N64-27012	N64-27013	N64-27014	N64-27015	N64-27030	*N64-30758
N64-83832	N65-14219							

B. Manual Search - 1964 STAR Annual Index and 1965 abstracts.

A63-12009	*N63-10559	*N64-11271	*N64-14013	N64-24269	N64-24271	N64-25353	N64-25365	N64-25414
N64-26036	N64-28188	N64-29230	*N64-30758	N64-32019	*N65-14467			

Case #29 - DIE CASTING

A. STID Computer Search - Bibliography #965, dated 5 March 1965; 51 citations.

A63-10735	A63-17242	A63-25248	A64-13709	A64-17853	A64-23947	A64-25429	A64-25518	A65-10251
N62-10481	N62-11531	N62-12067	N62-16522	N62-16869	N62-17701	N63-14402	N63-19023	N63-19330
N63-21703	N63-23390	N64-10450	N64-10586	N64-11276	N64-11483	N64-11803	N64-13101	N64-17673
N64-18708	N64-18712	N64-19286	N64-21254	N64-22574	N64-24217	N64-26627	N64-27265	N64-27895
N64-27957	N64-28248	N64-28427	N64-29048	N64-30117	N64-30599	N64-31421	N64-83855	N64-85773
N65-10311	N65-11602	N65-11737	N65-11738	N65-11739	N65-13340			

B. Manual Search - 1964 Issues of STAR.

N64-22741 N64-29035

Case #30 - DOUGH RHEOLOGY

Manual Search - NASA SP-7016 (Rev. 1) and STAR 1964 Annual Index.

*N64-10118 *N64-12357 *N64-12795 *N64-16095 *N64-17707 *N64-22852 *N64-32955

Case #31 - WOOD SEALANT

Manual Search - 1964 and 1965 issues of STAR and 1965 issues of IAA.

N64-15020 N64-30758

Case #32 - LIAPUNOV FUNCTION

Manual Search - 1964 and 1965 issues of STAR.

*N64-14804 *N64-14805 *N64-15245 *N64-26383 *N64-31958 *N64-33915 *N65-13150

Case #33 - SLIDING SEAL FOR STEAM

Preliminary survey indicated limited availability of information.

Case #34 - BELT MATERIAL

Manual Search - combined with Case #35.

Case #35 - PROTECTIVE COATINGS FOR STEEL

Manual Search - 1964 issues of STAR.

N64-10808	N64-11271	*N64-14013	N64-14189	N64-17148	N64-17317	N64-21922	N64-23213	N64-24273
N64-24333	N64-25414	N64-26036	N64-27032	N64-27044	N64-27046	N64-27087	N64-28188	N64-29230
*N64-30758	*N64-30930	*N64-30936	N64-32985					

Case #36 - FATIGUE TESTING

No search - lack of specific information.

Case #37 - BEARINGS FOR ADVERSE ENVIRONMENTS

Preliminary survey revealed good availability of information.

Case #38 - LUBRICANTS FOR ADVERSE ENVIRONMENTS

Preliminary survey indicated good availability of data.

Case #39 - BRUSHLESS D C MOTOR

A. STID Computer Search - Bibliography #967, dated 4 March 1965; 34 citations.

*A63-13659	A63-23273	A64-12132	A64-18191	A64-18201	A64-20527	A64-28312	A64-28314	A65-13715
N63-12016	N63-14171	N63-16165	N63-18350	N63-84167	N64-11076	N64-11741	N64-11742	*N64-15908
*N64-17603	N64-22650	N64-23569	N64-23574	N64-29201	N64-29886	N64-31490	N64-31503	N64-31503
N64-31713	N64-31714	N64-31715	N64-32888	N64-80341	*N65-11125	*N65-12618		

B. Manual Search - 1964 issues of STAR.

*N64-15908 N64-18587 N64-23879 N64-24027 N64-31503 N64-32888 N64-33676 N64-33779

Case #40 - SHORT CIRCUITING WELDING

Manual Search - 1964 issues of STAR.

N64-10846 N64-13250 *N64-17572

Case #41 - INFRARED PUDDLE TRACKING

Manual Search - 1964 issues of STAR.

*N64-15454 N64-18250 N64-23980 N64-27510

Case #42 - LOW CARBON STEEL WELD BACKUP MATERIAL

No search - limited data availability.

Case #43 - TACHOMETER GENERATOR

STID Computer Search - Bibliography #969, dated 5 March 1965; 12 citations.

A63-10009 A64-11208 A64-14358 A64-16592 A65-13279 N63-12776 N63-14354 N63-16165 N64-19795
N64-24545 N64-27650 N64-84608

Case #44 - ADHESIVE FOR ALUMINUM

Manual Search - 1964 issues of STAR.

N64-14730 *N64-14755 *N64-16272 *N64-16639 N64-17548 N64-20407 N64-23381 N64-23451 N64-23453
*N64-26755 *N64-26823 *N64-30930

Case #45 - TORSIONAL LOAD AFFECTS ON TUBING JOINTS

Limited data revealed in preliminary survey.

Case #46 - TRACKING OF WELD SEAM

Limited data revealed in preliminary survey.

Case #47 - ELECTRONIC MINIATURIZATION OF D C AMPLIFIERS

Manual Search - 1964 issues of STAR.

N64-11735 *N64-14016 N64-18587 N64-20130 N64-20999 N64-21313 N64-21829 N64-25632 *N64-26821
N64-27455 N64-27496 N64-28776 N64-31851 N64-33642

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