IV. TECHNOLOGY UTILIZATION

A. AN OVERVIEW OF THE NASA TECHNOLOGY UTILIZATION PROGRAM

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The speed with which technology is moving is an awesome thing, and to those who are in the business of transferring technology, it is even more so. Technology sets the pace for our entire economy and way of life; and therefore, whatever, benefits and stimulates technology, benefits everyone. One of the world's largest and most effective pacesetters of this advance in technology is the NASA aerospace program. The purpose of this paper is to explain how NASA develops the technology and gets that technology into the warehouse of knowledge and then out of the warehouse and into the economy.

In the following paragraphs some examples of where the technology comes from and its uses or spinoffs of our technology, are presented. Briefly, NASA's mission is to explore the Earth and its surroundings, conduct aeronautical research, and put the results of this Research and Development to work for the benefit of mankind. The Shuttle is a reusable Earth-to-orbit work horse that delivers payloads to orbit, eliminating costly launch vehicles. One important feature is its ability to retrieve unmanned satellites for repair or return to Earth. It is launched like a rocket, and returns like an airplane.

In aeronautics, NASA is doing research to provide safer, quieter and more energy efficient aircraft which has less impact on the environment. Earth orbiting satellites provide information that offers enormous practical benefits to help manage the Earth's resources such as crop growing conditions and changing land uses. And finally, NASA has launched more than 300 spacecraft into Earth orbit and into deep space to gain knowledge about the past, the future, and perhaps man's destiny.

In less than two decades, man has learned more about the Universe than in all the prior years of history. It is from these programs that NASA develops a vast reservoir of knowledge which can in turn be used to solve earthborn problems. The second use of this technology is called "spinoff". While the list of spinoffs is impressive, the process is far from automatic. Technology may move or it may not move, and if it does move, it moves slowly if left alone. What NASA has done to accelerate this transfer process is to develop a technology utilization program. The purpose of this paper is to discuss NASA's technology utilization program.

The problem is — how does NASA get this technology into the warehouse; how does it extract it from the warehouse of knowledge and get it back into the hands of taxpayers who paid for the technology in the first place?

The first step to be considered is how to get people to know that the technology exists and is available? First of all, when NASA contractors, and also NASA people within the NASA field centers such as the Goddard Space Flight Center, develop new technology, the technology is reported and screened for some potential commercial use. If it has potential commercial use, it is then written in a one-page dissertation called a "tech brief" (Figure 1). This is a one-page description of the technology in lay language with pictures or sketches explaining some of its potential uses. Each tech brief identifies the name of the innovator. For instance, if a person from the Goddard Space Flight Center has developed an innovation, his name is included. Therefore, if you have a question when you read the tech brief you can call that person to get more information.

Figure 1. Tech Brief

About two years ago NASA developed the Tech Brief Journal. Previous to the Tech Brief Journal, each piece of NASA technology was written on one page and sent out as a one-page description. People read them and sometimes misplaced them or threw them away. It just wasn't a very effective way of retaining the information.

The new Tech Brief Journal contains about 150 tech briefs per journal, and is issued quarterly. This increases the shelf life of the technology because an individual can place these in his or her bookcase, and at the end of the year consult an index and refer back to the technology. It has been found, over the years, that people generally take about two years to actually get to use the technology they previously read.

If more information is needed to support the Tech Brief, technical support packages are available. These are notes that the innovator has written about the technology as he developed it. Figure 2 is a plot of the requests for technical support packages. Last year over 100,000 requests for technical support packages were received by NASA. This is significant. There are about 35,000 or 37,000 people who receive the Tech Brief Journal; and if over 100,000 people requested additional information, that is some indication that there is value in the Tech Brief Journal. For every Tech Brief published, there are about three to four people who request support packages.

Some examples of the uses of the Tech Brief Journal and also the information within the Tech Brief are discussed in the following paragraphs.

The first example is the technique for providing special types of plastic foams. Figure 3 shows an assortment of Scott's reticulating foam filters used in the automobiles, lawnmowers, motorcycles and other vehicles. A Scott engineer learned about NASA technology from reading one of our Tech Briefs and later requested a technical support package. This technology was instrumental in reducing the product development time.

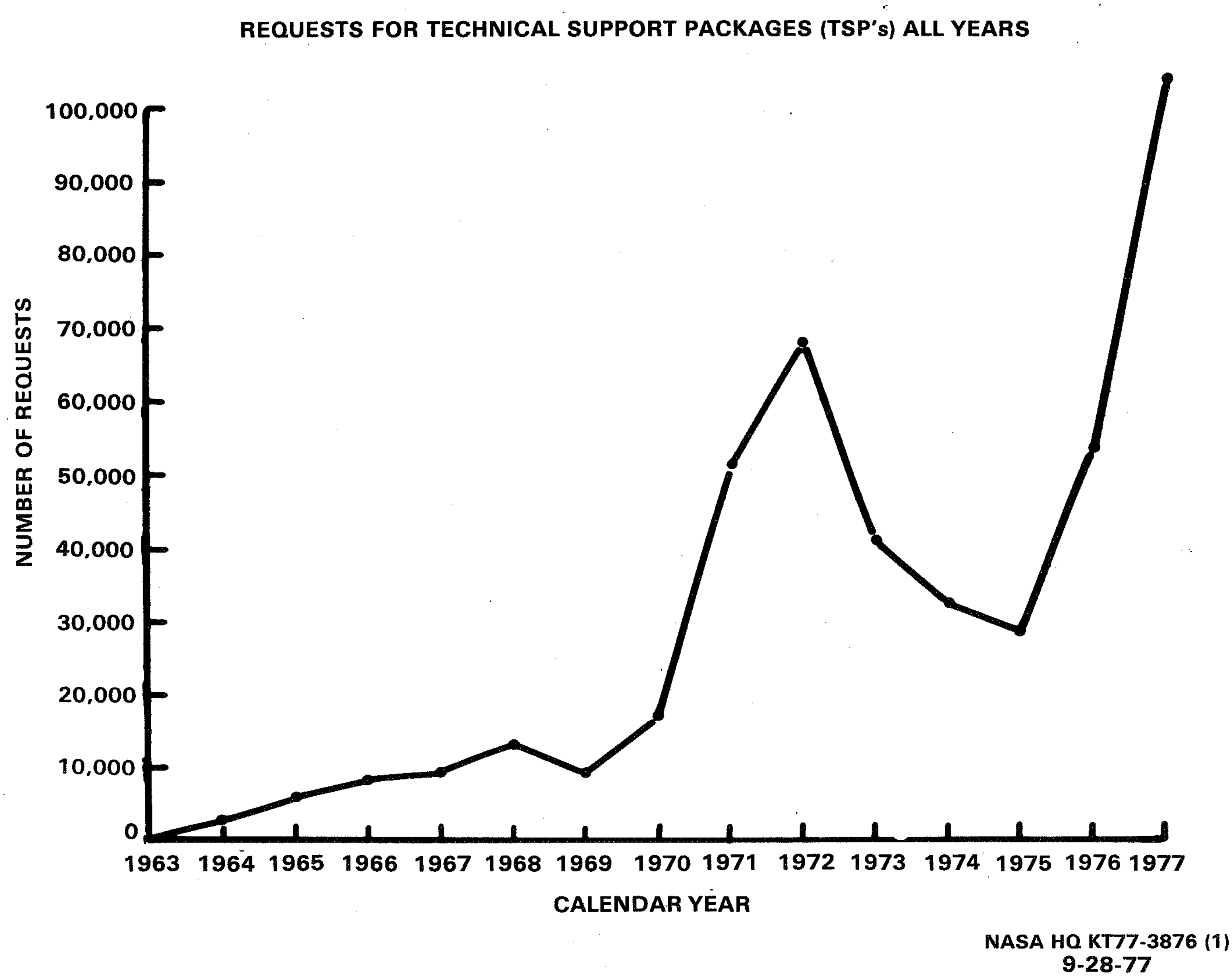

Figure 2. Plot of Requests for Technical Support Packages

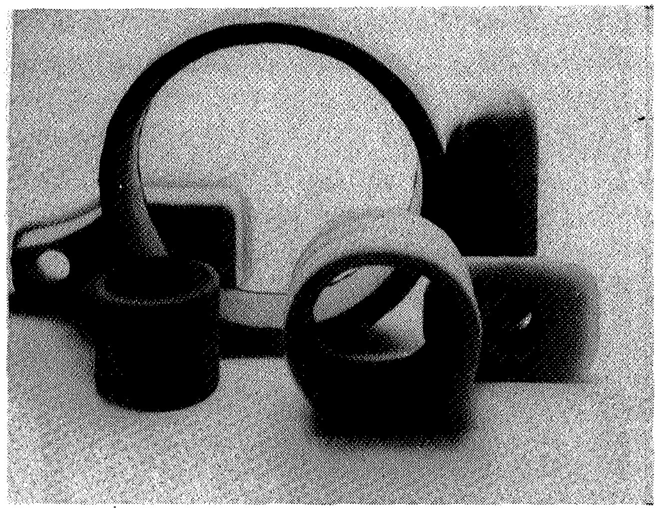

Figure 3. Reticulating Foam Filters

NASA has been asked by a number of people, particularly the Congress, to evaluate the benefits and the cost benefits of the tech briefs and the Tech Brief Journal. Denver Research Institute looked into this and randomly selected names from the list of people who requested technical support packages and questioned them about their uses, asking what the benefits were, and asking them to evaluate quantitatively the amount of dollars saved in one way or another.

As shown in Figure 4, there is a reported savings of $70 million dollars. When you consider that NASA puts $6.4 million dollars over that five-year period into the Tech Brief Journal program, you can see that there was an 11 to 1 return on the investment. That is to say, for every $1 NASA uses to publish the Tech Brief Journal, there was a reported $11 benefit to the user.

TECH BRIEF PROGRAM
Cost Benefit Analysis

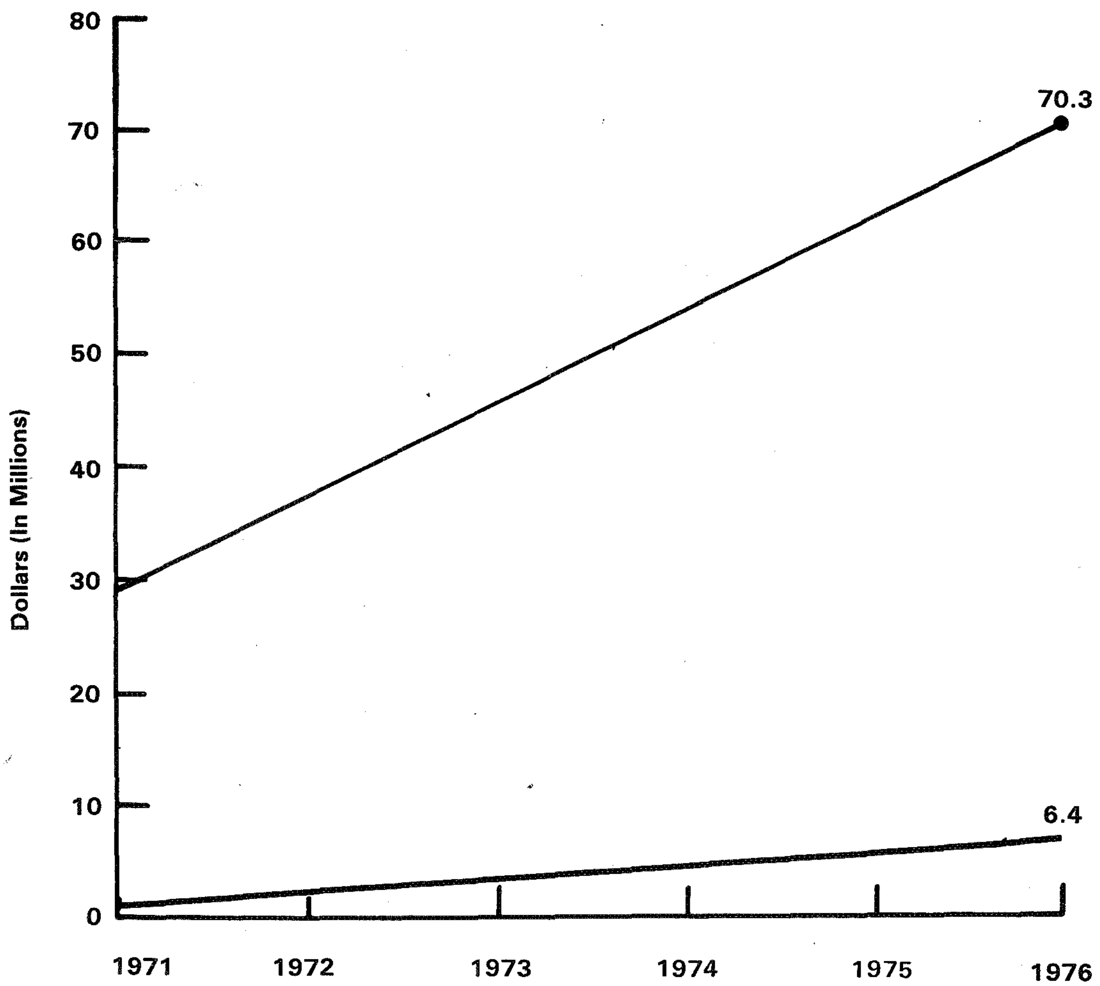

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Figure 4. Cost Benefits of the Tech Briefs and the Tech Brief Journal

Another method used to disseminate NASA technology and accelerate its use is the Industrial Application Centers (IACs). These are listed on the chart in Figure 5. The IACs provide a face-to-face relationship between the manufacturer and the technologists. The IAC's have teams (most are universities or nonprofit organizations) that go out into industry, identify the industrialist who may have a problem, discuss the problem with the industrialist or the manufacturer, go back into the NASA data bank, search for information that may be useful to him, and turn the information over to the industrialist or the manufacturer and let him apply that technology to improve his product or processes or develop new products or new processes.

There is a charge for the service. The charge is not for the research and development; but for discussing the problem with the industrialist, identifying the problem, and searching for the technology and getting the *right* technology to him.

When you sit down and talk to the technologist face-to-face, many times a technologist is helping you define the problem. In act, 50 percent of the time the value of the face-to-face interchange of information helps the person with the problem to identify his real problem. For example, an aluminum casting manufacturer recently approached one of the Industrial Application Centers and said, "I would like to have some information on the temperature at which I should pour my aluminum. I think I am pouring it too hot. What temperature should I use to pour this aluminum?" After discussing it with the technologist, he quickly came to the conclusion that heat wasn't his problem. It was the resin he was using in his molds. He was using the wrong kind of resins. So the search was conducted for different kinds of resins for the kinds of molds he was using, not for pouring temperatures. That is an example of how the face-to-face interchange with the technologist helps identify the *real* problems.

The costs for this program are underwritten in part by the TU program in the Federal government, by the fees charged to the users, and support from the universities.

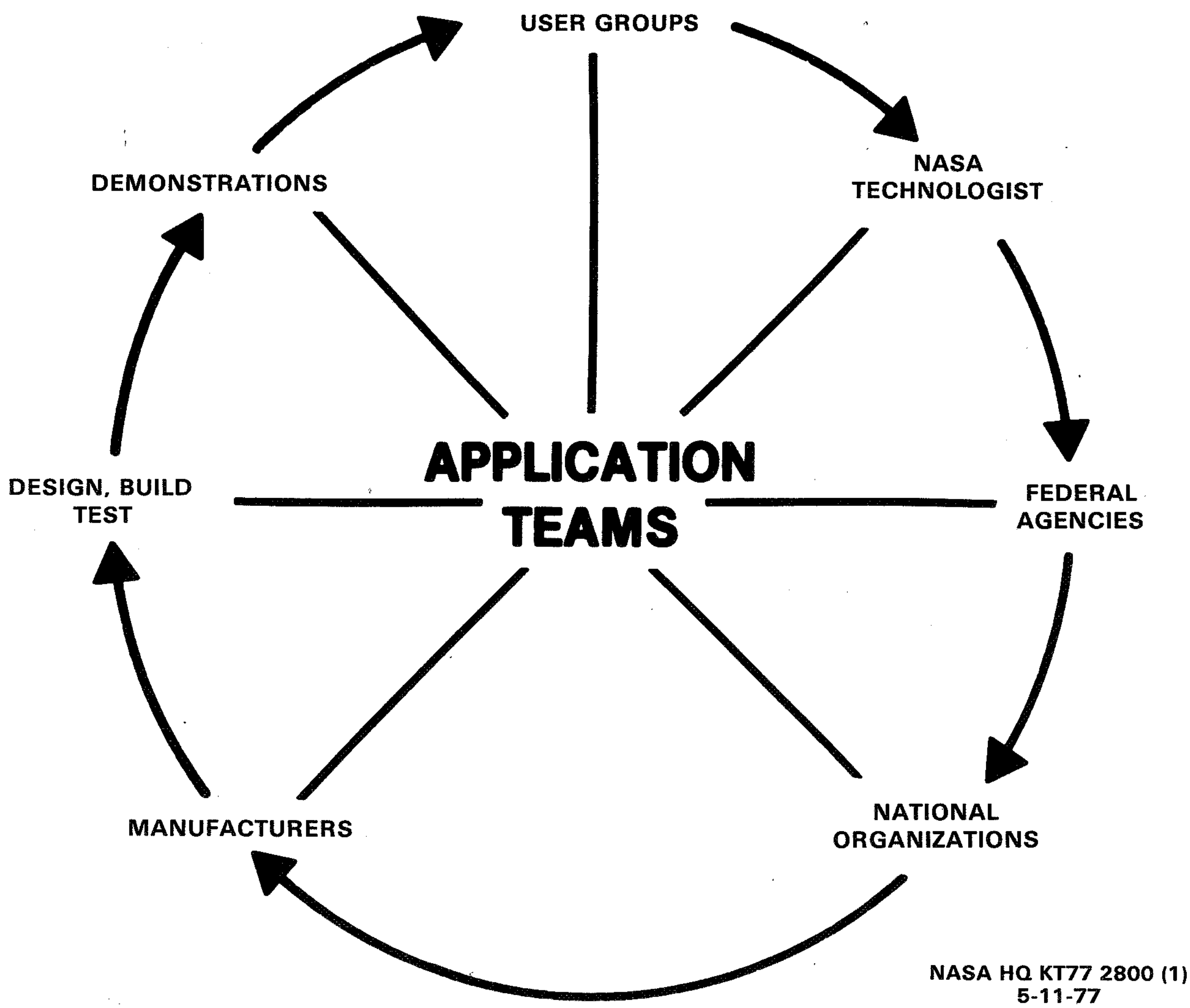

Figure 5. NASA Industrial Applications Centers

The data bank that these IACs have contains over a million technical reports that come from NASA's research and development programs plus an additional seven million reports worldwide. It is one of the largest data banks in the world, and it is growing at the rate of 50,000 documents per month.

Some examples of how this type of activity helped solve technical problems are described in the following paragraphs.

In a cooperative effort between our Industrial Applications Center in New Mexico and Goddard Space Flight Center, engineers applied heat pipe technology from NASA's Skylab program to construct the Alaska pipeline. The heat pipe anchors that are holding up the pipeline are shown in Figure 6. The heat pipes stabilized the underground temperature which prevents the supports from moving during the seasonal temperature change.

The heat pipes, called cryo-anchors, are placed in areas where there is an extreme change in temperature between summer and winter. If they were not there, the foundations would move, thereby causing ruptures in the oil pipe.

An example on a smaller scale, one of the Industrial Application Centers in California supplied information to a company on chlorate candles. A chlorate candle gives off oxygen when it burns; and this helped the company to develop a portable welding kit. These can be found in most hardware stores. It is portable, hand-held, and can deliver temperatures up to 5,000 degrees which means that one can weld and cut steel.

One of our Industrial Applications Centers provided information which led to the development of a device for recovering flue heat using heat pipe technology. This is shown in Figure 7. The right-hand corner shows the heat pipe that is placed in the flue. When the heat goes up the flue, the heat pipes transfer the heat to the other end of the heat pipe. A fan motor blows it back into the heating system and recovers it for use in the house.

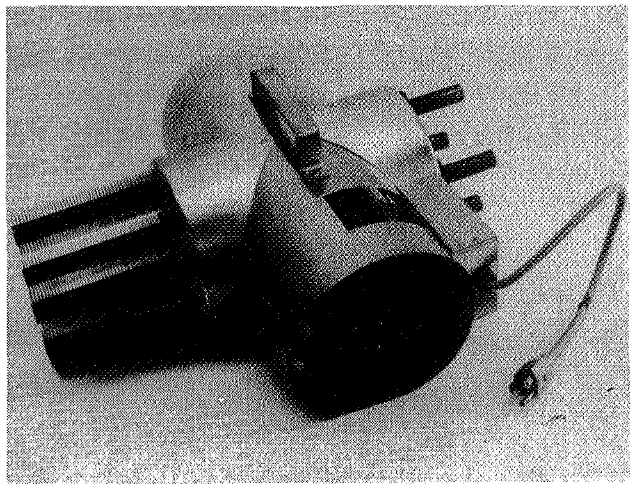

Figure 7. Device for Recovering Flue Heat

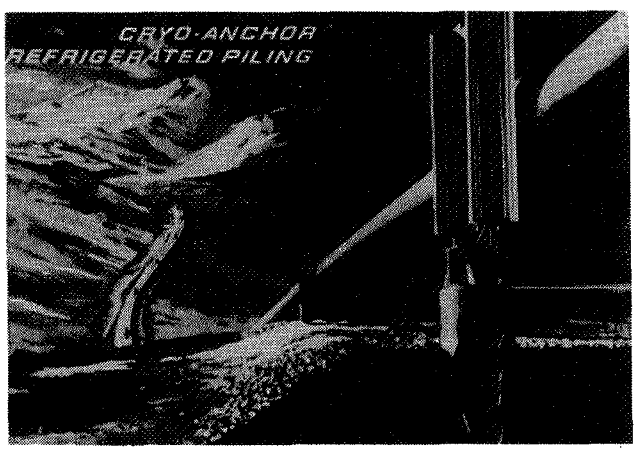

Figure 6. Heat Pipe Anchors

Another Industrial Application Center is Cosmic, at the University of Georgia (see Figure 8). This is a repository of NASA's software programs. In that repository, they have over 1,600 computer programs. One example of the use of one of the computer programs is the NASTRAN, which stands for NASA STRuctural ANalysis program. This is one of the world's most sophisticated structural analysis computer programs in the world. Cadillac used the program to develop its Seville model. NASTRAN cut the engineering time for its dynamic structural analysis to a fraction of the normal time.

NASA uses another method of transferring technology to the public sector (see Figure 9). Transferring information and technology to the public sector is a somewhat different problem. In the public sector, you can't transfer information and then step aside. They need *solutions*. Public sector people are just no geared as the private sector is, to take on the Research and Development and apply it, do the prototype work, and taking it through to commercialization.

What the public sector needs is a demonstration; that is, they would like to expalin the problem, have NASA look for the technology, build the hardware, then demonstrate that the technology can be used to solve their problem. At this point, NASA puts the hardware into the commercial marketplace, has the private sector bit on it, and lets the commercial marketplace supply the product to the public sector. Some of the solutions that NASA has worked on and is working on now are described in the following paragraphs.

The Lixiscope shown in Figure 10 is an excellent example of one of these projects.

The United States Coast Guard is attempting,

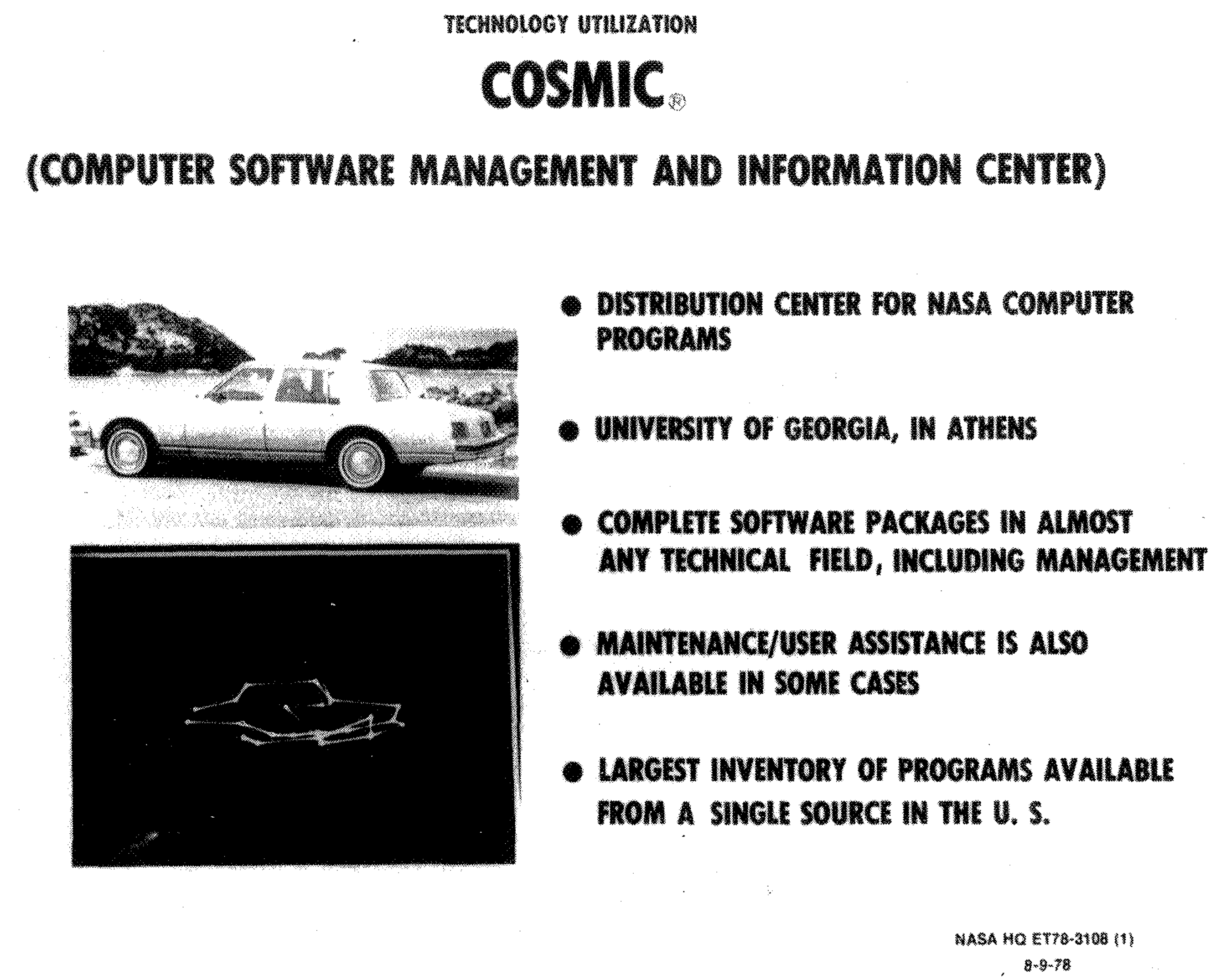

Figure 8. Cosmic Industrial Application Center

to try to respond more quickly to harbor fires. What they were looking for is a lightweight, self-contained pump which can throw water farther and faster than most of their current pumps (Figure 11).

In this case, they are looking for 2,000 gallons per minute in a stream reaching 200 feet. This is about double what they can do now (Figure 12).

They would like to have the pump portable, to be transported by helicopter (Figure 13).

The boat can go out to the fire, while in the meantime, the fire fighting module can be picked up from the shore and carried to the boat, at the scene of the fire.

The pump is now going into its final testing by the Coast Guard, hopefully it will be in service next year.

While NASA was developing this prototype hardware for the Coast Guard, a manufacturer saw a commercial application and has put a different version of this kind of fire fighting equipment on the market. It is now on the market available for land fire fighting.

Figure 14 is a picture of a bolt stress monitor which is the final example to be presented. It was developed by NASA's Langley Research Center in Virginia and uses sound waves to give off a very highly accurate measure of the stress in a bolt. Current torque testing of bolts is an inaccurate measurement because it doesn't take into consideration the friction between the threads and the nut. In this case, the system acts somewhat like measuring the sound of a violin string. The tighter you stress the violin string, the higher the pitch.

The same principle applies here. Thus, the tighter you tighten the bolt, the more it stresses the bolt, which produces a different accoustical pitch. The instrument reads the accoustical signature and then

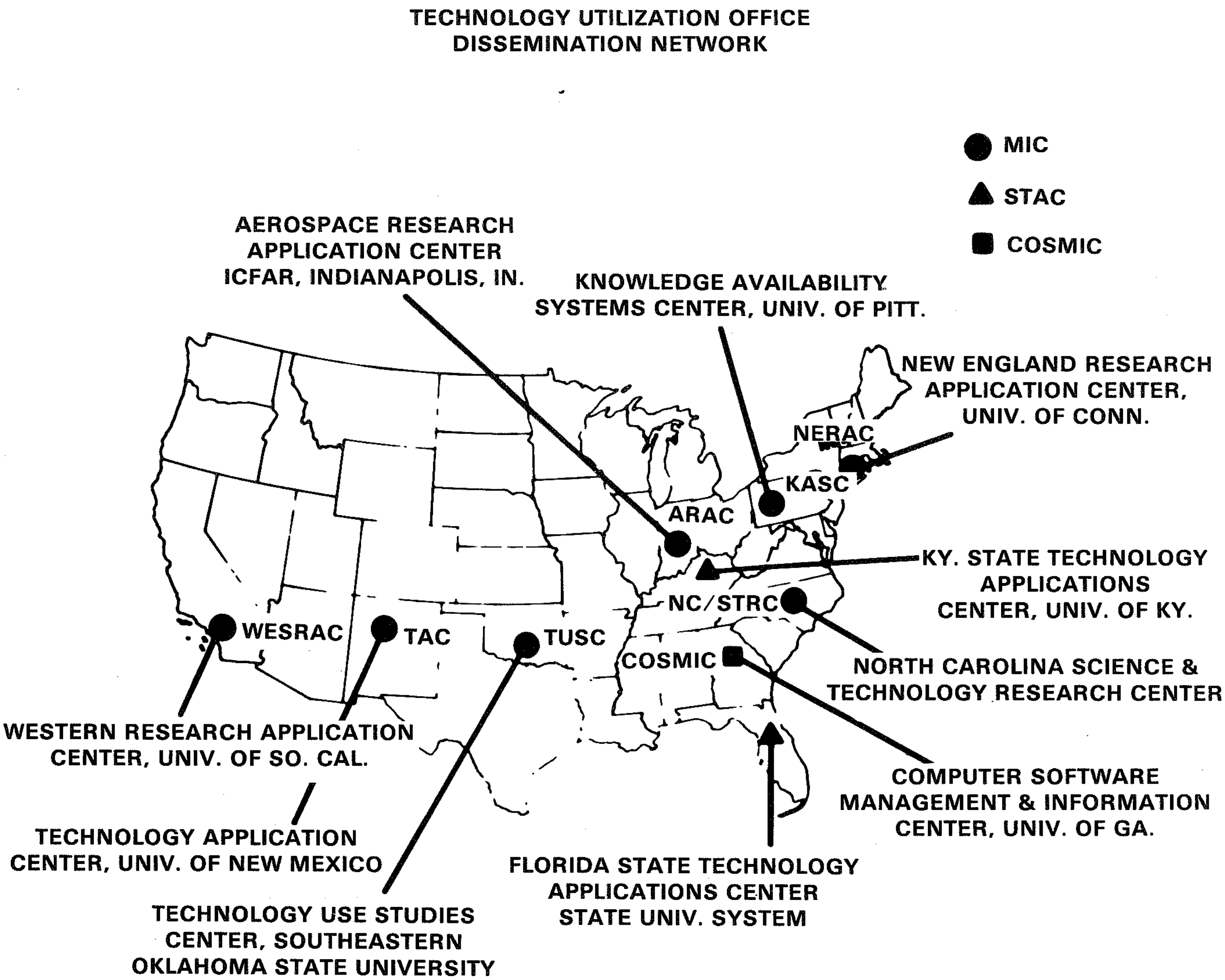

Figure 9. Technology Transfer to the Public Sector

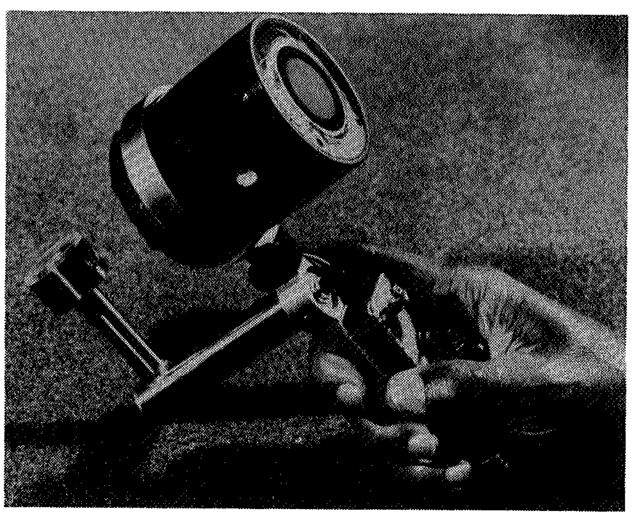

Figure 10. Photograph of the Lixiscope

reads out the stress on the bolt.

The preceding paragraphs have very briefly described the technology utilization program, the publications which are available for distribution, and the Industrial Applications Centers. Some programs were discussed which NASA developed to build prototype hardware to demonstrate that aerospace technology can be applied to public sector problems.

The primary questions often asked of NASA are: "Does technology utilization pay off? Does this system you are working with benefit anybody? And if so, can you measure the benefit?"

NASA commissioned Denver Research Institute last year to look at this method of transferring

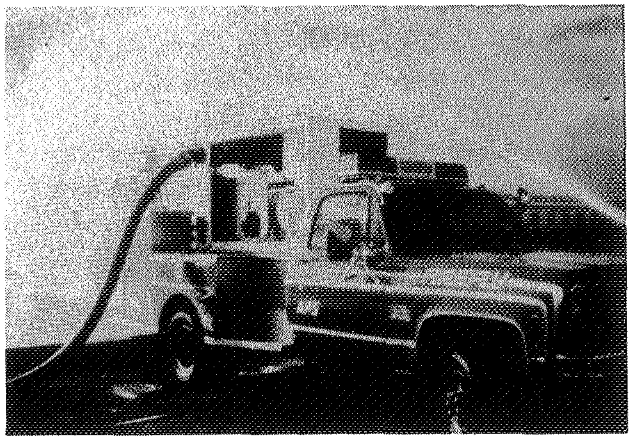

Figure 11. Photograph of a Water Pump

Figure 13. Transportation by Helicopter of Portable Pump to Boat

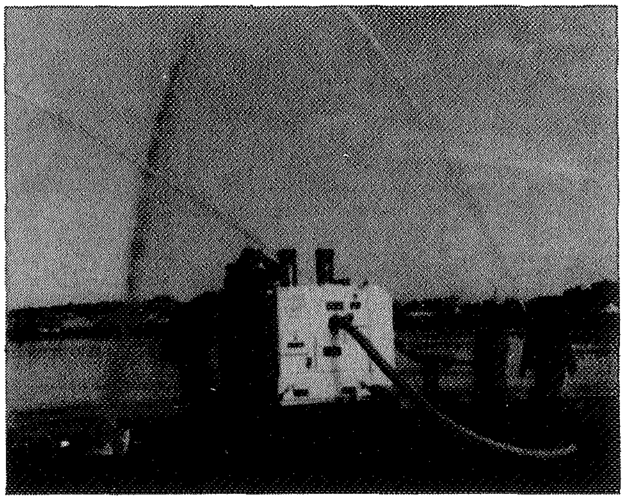

Figure 12. Water Pump

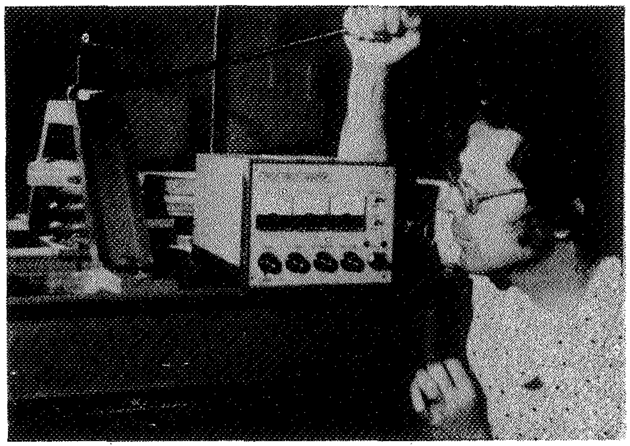

Figure 14. Photograph of a Bolt Stress Monitor

technology. They identified users of the technology and asked them to quantify the benefits. They returned with an analysis that showed there was a six to one return on the taxpayer's investment. That is to say, for the entire technology utilization program, every tax dollar NASA spent in the technology utilization program to bring aerospace technology to bear on problems in the private and public sector, there is a $6 return to the economy.

B. THE TECHNOLOGY UTILIZATION PROGRAM AT GODDARD

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The Technology Utilization (TU) Program has its genesis from the Space Act, which says that NASA will disseminate information from its space activities in the widest possible manner. To accomplish this, the major elements are through publications, Industrial Applications Centers, and application projects such as the Lixiscope. The TU Program is also involved in program evaluations.

To transfer this technology, GSFC is engaged in a series of activities, as shown in Figure 1. These include work in space sciences, applications, manned space flight programs, basic space technologies, power systems and control system development, limited work in energy with the Department of Energy, the tracking and data acquisition network at Goddard, and technology utilization.

Basically, the Technology Utilization Program is a technology transfer program; that is, performing basic space activities, and then applying some of this technology in a secondary application. One of these projects is the Lixiscope.

The NASA policy on transferring technology is to identify the technology and pass it on. As part of this effort, it is necessary to identify its significance. One

NASA ACTIVITIES

- SPACE SCIENCE
- APPLICATIONS
- MANNED SPACE FLIGHT
- AERONAUTICS AND SPACE TECHNOLOGY
- ENERGY PROGRAMS
- TRACKING AND DATA ACQUISITION
- TECHNOLOGY UTILIZATION

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Figure 1. Activities for Technology Transfer

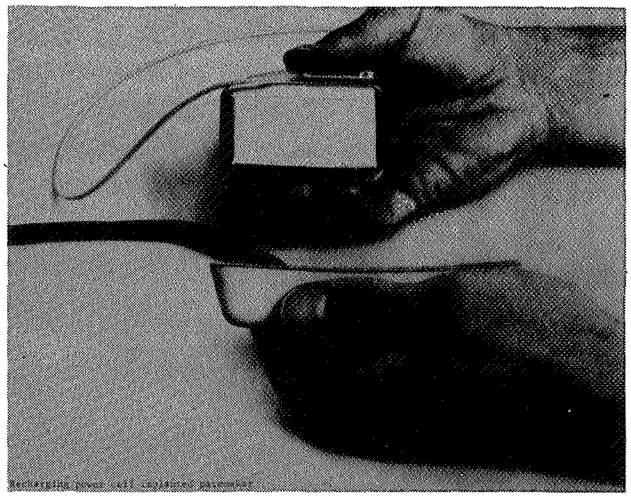

Figure 2. Rechargeable Heart Pacemaker

Figure 3. Photograph of First Heart Pacemaker Patient

of the primary objectives is to work with manufacturers to ultimately commercialize a particular product or project so it will get into the hands of the people and benefit the public.

To accomplish this, NASA assists in but does not perform market studies, and assists and helps to identify and work with manufacturers. In addition, NASA works with many Federal institutions, and either looks for co-funding or co-funds certain projects for develpment.

To illustrate NASA efforts in this regard, one project from the engineering spinoff that NASA started work on a few years ago, in collaboration with the Applied Physics Labs of Johns Hopkins Laboratory, was a rechargeable heart pacemaker shown in Figure 2. Johns Hopkins basically developed the pacemaker, but some of NASA's space technology was used, such as batteries, the electronics, and quality control techniques in the development.

Figure 3 is a picture of the first person who had the pacemaker implanted. This photograph was taken on the fifth anniversary of the implant. What makes this pacemaker unique is the fact that it is rechargeable and the batteries do not have to be replaced. The photograph also shows Bob Fischell and Dr. Lewis.

To continue this technology, GSFC is working with the Applied Physics Lab and the Johns Hopkins University on a device called the human tissue stimulator, which will be a rechargeable implantable device used to relieve pain as shown in Figure 4. This is another very good example of a spinoff. Figure 4 also shows a command telemetry system, which was developed on one of our astronomy satellites by the Applied Physics Lab. The system can be tied right to the doctor's office, through telephone lines, to control the various parameters. The stimulator is planned to be used to relieve back pains and similar ailments.

The preceding paragraphs have summarized some of the technology spinoffs of which GSFC has been a part. The Lixiscope represents another significant accomplishment in this regard. However, to find out more about the Technology Utilization Program, and what NASA is doing, NASA publishes a document entitled "Spinoff" which can be obtained from any NASA Technology Utilization Office at the nearest NASA Center.

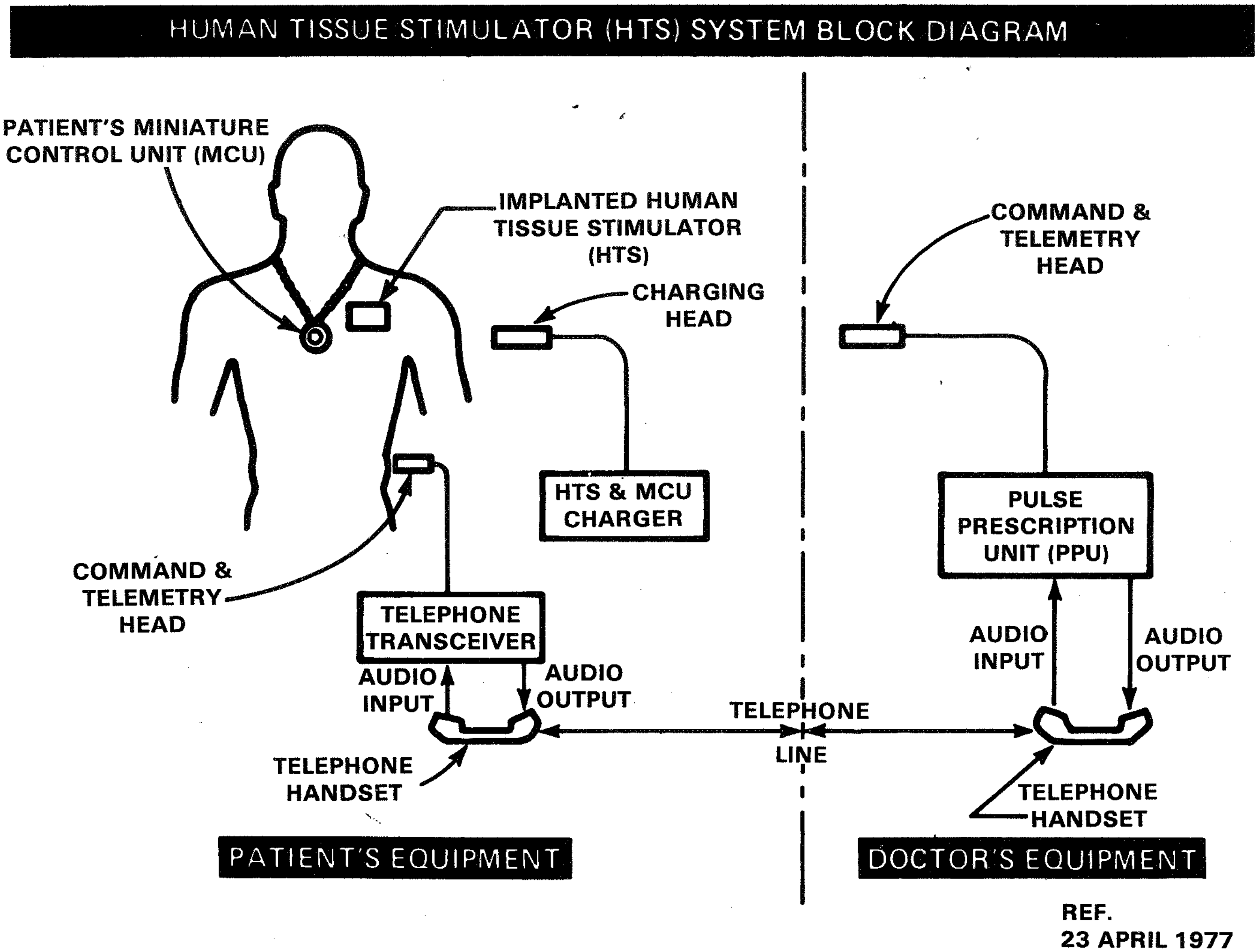

Figure 4. Human Tissue Stimulator

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