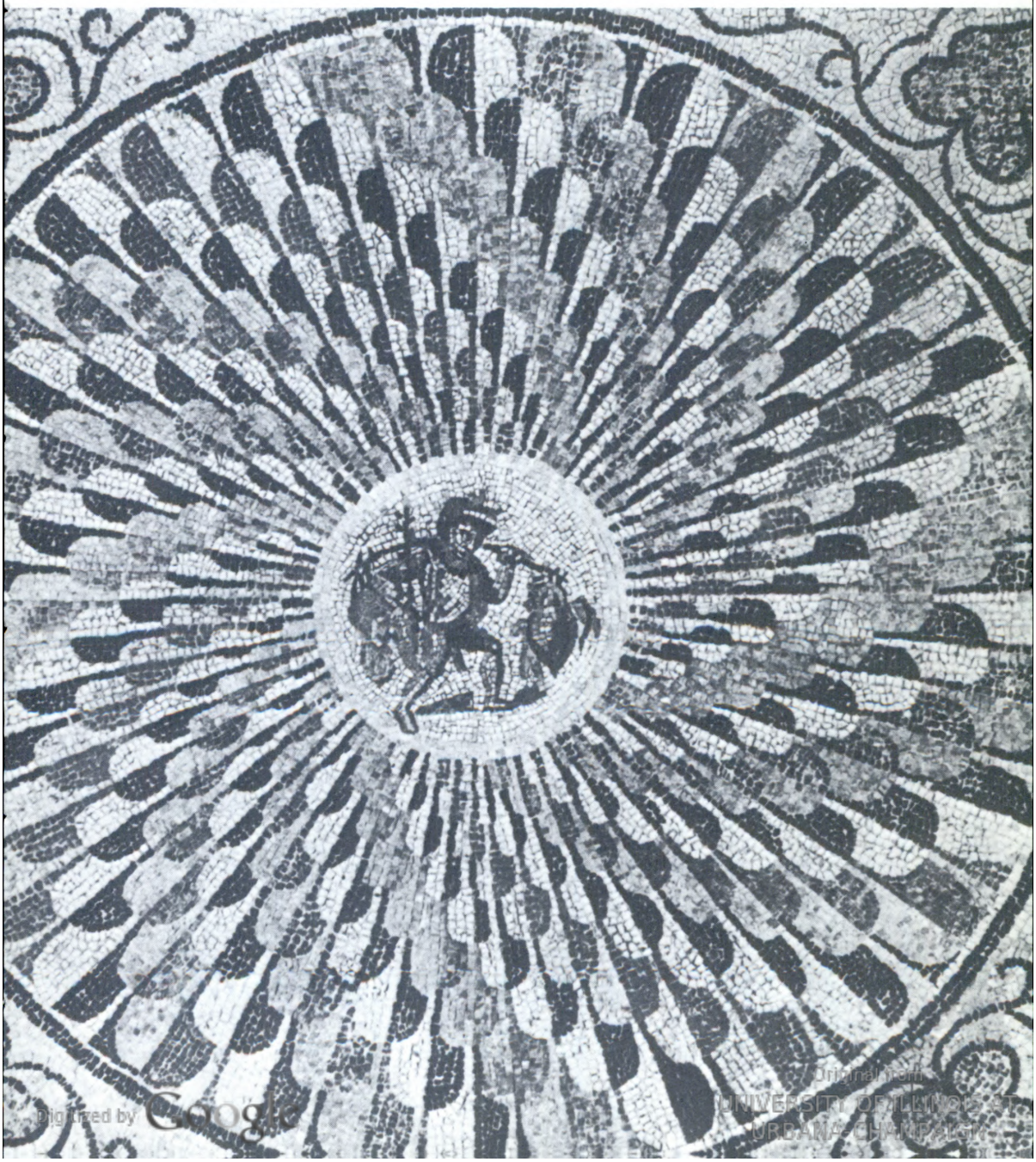
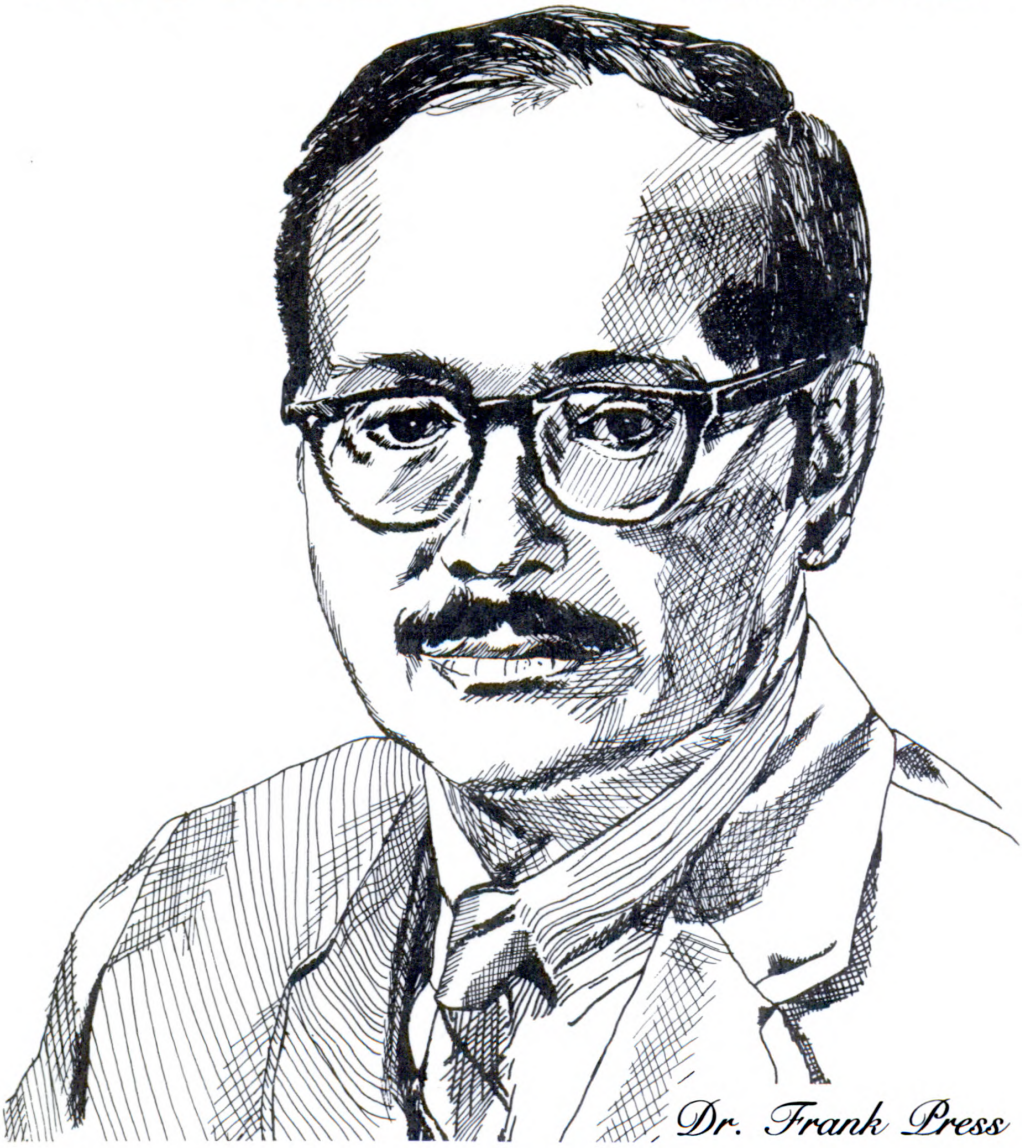
NAVAL RESEARCH

REVIEWS

AUGUST 1973



PROFILES IN SCIENCE



Dr. Frank Press

Frank Press is Chairman of the Department of Earth and Planetary Sciences at the Massachusetts Institute of Technology. His chief research interests are in the fields of internal structures of planets, regional geophysics, and seismology. In these fields Dr. Press is noted specifically for his contributions in the areas of structure of the sea floor, earthquake seismology, seismic-wave propagation, and the constitution of the Earth and moon. His first support as a beginning scientist at the Lamont Observatory came from ONR.

Dr. Press served on NASA's Lunar and Planetary Missions Board and was Chairman of the Earthquake Prediction Panel of the Office of Science and Technology in 1964-65. He was a member of President Kennedy's Science Advisory Committee from 1961-64, and served on the U.S. Delegation to the Nuclear Test Ban Conference, in Geneva in 1959-61, and in Moscow in 1963. He was appointed by the President to the National Science Board and is a member of the National Academy of Sciences.

Dr. Press was the recipient of the Gold Medal of the Royal Astronomical Society in 1971 and the Distinguished Service Award of the U.S. Department of the Interior in the same year. In 1972 he was awarded the Day Medal of the Geological Society of America. He has received Honorary Doctor of Laws degrees from the City College of New York and the University of Notre Dame.

Dr. Press is the author of several books and over 150 research publications.

The Future of Automation

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Introduction

A survey and study of some important aspects of advanced automation was started in January 1971, first internally sponsored by Stanford Research Institute and subsequently under a contract for the Office of Naval Research terminating in November 1972. Much information was obtained through discussions with key individuals both in industry and in research and development laboratories.

Two other studies also have provided valuable information and insight. The first (1,2) covers potential applications of computer-based automation to the whole manufacturing process, including design, production engineering, part forming, assembly, inspection, material flow, and transfer and storage. Although the suggested advanced automation is important to the U.S. manufacturing processes in general, the applicability to the manufacture of material required by the DOD is stressed. The second (3), was a techno-economic survey of industrial robots—a class of *programmed* manipulators. The reports included details of current and anticipated use in the U.S. and foreign plants categorized by industry, comparative performance, and cost of known U.S. and foreign machines and estimates of the growth of the market to 1980.

For the past eight to ten years, large groups of computer scientists at several universities and research institutes have been engaged in programs with the objective of developing "intelligent" machines. In essence, the aim has been to develop computer programs that could permit machines to perform tasks that normally require human perceptual, problem-solving, learning, planning, and decision-making capabilities. As part of this effort, several prototype systems that combine sensors and electromechanical actuators, both under integrated computer control, have been assembled as laboratory test-beds. The most notable of these systems are the "Hand-Eye" machines at Stanford University, Massachusetts Institute of Technology, University of Edinburgh, and Hitachi, Ltd., and a mobile robot at SRI (Figure 1). These "automatons" have certain characteristics in common. They have limited abilities to sense their environments by visual tactical means, to extract relevant information from the sensory data, to make use of

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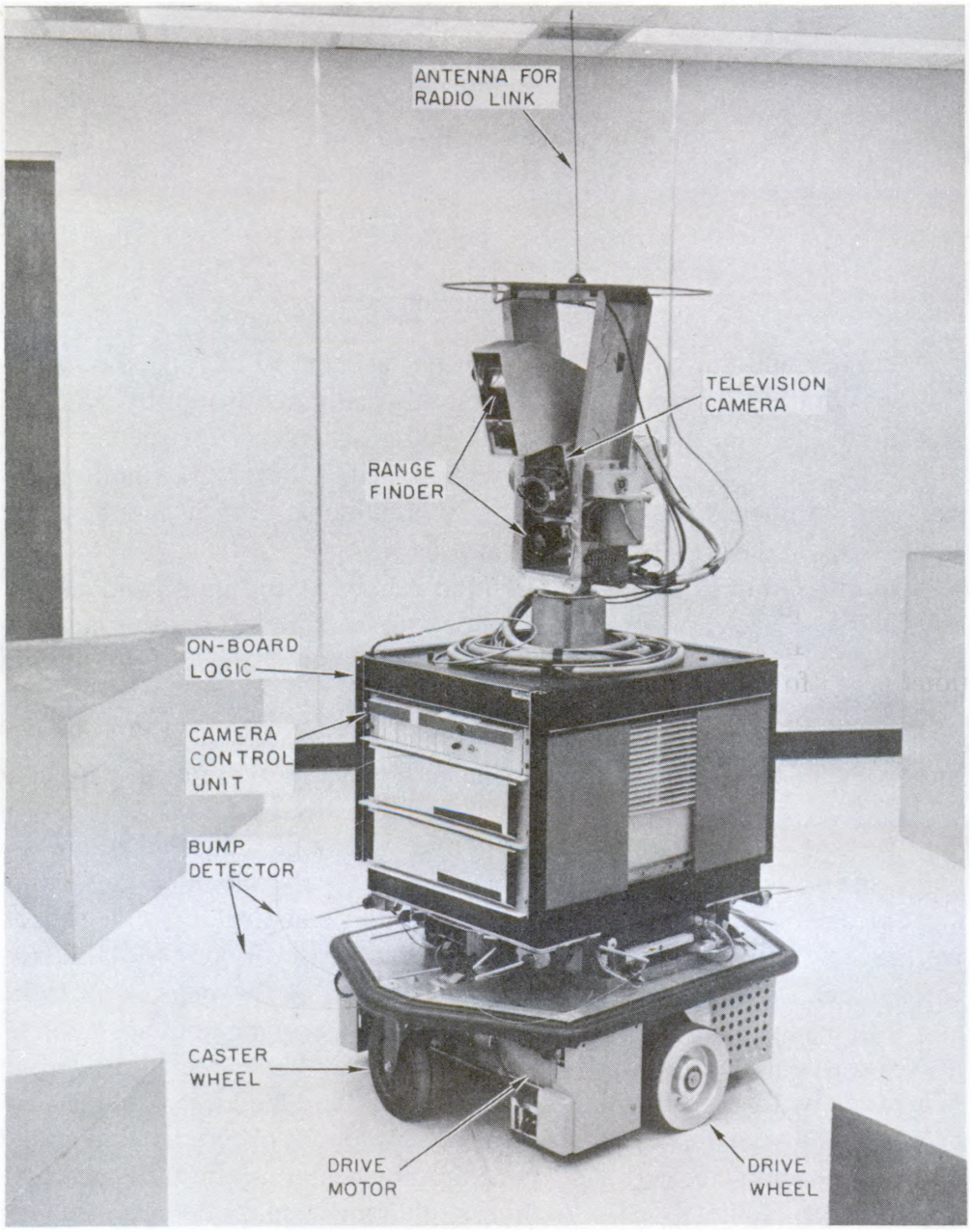


Figure 1 — "Shakey" the SRI experimental mobile automaton

stored "models" of the environment, and to plan and carry out sequences of actions that would lead to the performance of simple tasks assigned by the experimenter. It is to be noted that these systems have not been preprogrammed for a specific task but also can perform any one of a large number of similar but different tasks, constrained by the small number of performable actions and the planned simplicity of the environment. Although these tasks are comparatively simple from an adult viewpoint, they do demonstrate many of the functions needed to perform

in a far more sophisticated manner. These functions—especially perception, modeling, and problem solving—are still in a rudimentary state of development. The visual system cannot yet cope with a cluttered scene containing many objects, some partially obscured or shadowed, and all subject to a large dynamic range of light intensity. The problem-solving system cannot yet handle problems with great logical depth in an acceptable amount of computational time. Representations (or models) of the environment are currently limited to very simple scenes; in more complex scenes containing many objects and relationships, it is necessary to develop new techniques to handle large numbers of facts and relationships representing the "knowledge of the world" in the form of computer data structures, such that the vision and problem-solving programs can have efficient access.

In summary, the framework for an integrated "intelligent" system is at hand; sets of tasks can be performed if sufficient constraints are imposed. The key problems in specific research areas have been identified and are the subject of extensive research.

The relevance of the foregoing research to industrial/military applications is twofold. First, in sufficiently constrained environments such as can be imposed in industrial situations, low-level tasks entailing combined sensing, problem-solving, and mechanical activities can now be performed; it has yet to be demonstrated that this can be done in a cost-effective manner. Second, visual picture-processing techniques have been developed to such a sufficient degree that good use can be made in the near future for inspection and quality control and for upgrading the performance of the "blind" commercial manipulators that are extravagantly labeled "industrial robots."

Motivation and Justification

Among others, at least one prime motivation for the development of the aforementioned subclass of "intelligent" machines that can interact physically with the environment was (and still is to many) a desire to do useful tasks in environments that were inherently dangerous, unhealthy, or very unpleasant to man. These environments included space, the depths of the seas, arctic wastes, the bowels of the earth, and specialized areas in factories where either high temperatures, noxious fumes and particles, or excessive noise levels made work intolerably difficult. In the past two years, a more general and more important field of application has been identified; namely, replacement/augmentation of humans in assembly and quality control operations that are major constituents of the mass-production process. In the United State alone, millions of jobs are characterized as highly repetitive, boring, demanding little either of workers' actual or potential capabilities, and leading to considerable personal dissatisfaction (4,5,6). The direct consequences are

reduction in productivity; increased errors in execution (often deliberate); and more importantly, a growing degradation in quality, with ensuing costly failure and repair. These factors adversely affect the welfare of the U.S. economy, both nationally and in relation to foreign competition.

The above factors affecting costs of production and quality are equally of great importance to the Department of Defense—a very large consumer of materiel of all kinds. Although reduction of costs is of paramount importance, the technological complexity of modern weapon systems requires far greater rather than less quality if these weapons are to be used effectively and maintained in the field. Processes that depend on the mood and whim of disinterested workers, who are also subject to fatigue and error, do not lead to a high yield of acceptable components; the required quality can be obtained only at a considerable cost premium. It is widely accepted in production circles that automation generally results in significant improvements in uniformity, quality, and yield; such improvements are exemplified in process control, numerically controlled machine operations, and in the fabrication of semiconductor circuits. Similar increases in quality and cost reductions can reasonably be expected as a result of introducing advanced mechanization *directly into assembly and quality control processes*. It is clear that economical production accompanied by greatly improved quality both of goods and in the lives of workers would equally serve the balanced best interests of the DOD, U.S. industry, and the general public.

Equally clear, however, is the need to plan for the mass displacement of workers by machines and the ensuing social problems of increased unemployment, costs of welfare, and crime. Because the implementation of social plans is likely to be spread out over many years—perhaps a generation—the rate of introduction of radically new machinery will be strongly affected. Advanced mechanizations will probably be introduced in an evolutionary rather than a revolutionary manner; the changeover will occur slowly and experimentally in selected areas of the production process. The conservatism of production managers, constrained to "keep the lines moving," will be augmented by public (especially labor) pressure groups to delay drastic change in production methods.

Major Needs and Review of Available Equipment

The development of completely automated factories and repair facilities for general manufacturing can be considered a future possibility but no a viable near-term goal. In several highly automated industries such as chemical processing and gasoline engine fabrication, the required personnel have been reduced to an almost minimum number who serve mostly in a monitoring/supervising capacity. In these processes, such automation has resulted from the development of highly sophisticated process-control equipment and numerically controlled

machine tools. In many materials-handling, assembly and inspection operations, special-purpose automation is generally used where high costs can be justified only if there are large production runs and few design modifications needed during these runs. It has been estimated, however, that from one-half to three-quarters of all products are batch-produced (in quantities of roughly thousands, rather than hundreds of thousands). For these operations, no general-purpose automation exists that can be programmed quickly and inexpensively to meet rapidly changing requirements involved in batch-processing. Accordingly, cost-effective machine substitutes must be developed for the following highly developed human capabilities that are universally used in assembly and inspection processes:

- Rapid and skillful manipulation. Simple manipulation required for picking and transporting regularly shaped rugged objects requires little dexterity; it probably can be matched by such commercially available equipment as "hands." "fingers," suction cups, hooks, and magnets. Manipulation involved with human tool-using ranges from the simple to the complex, with a corresponding range of required skill and dexterity. In many assembly and fitting operations, there is usually a far greater need for dexterous control of cooperating fingers/hands. In fact, designers of products knowingly take advantage of manipulative skills as a trade-off for economizing on materials or processes. One would, however, be hard pressed to emulate by machine the skill and speed of an experienced assembler for small electromechanical devices.

- Sensing and interpretation. Although vision is generally considered to be the most important sensing modality, other sensory inputs such as aural, olfactory, temperature, and especially tactile are of prime importance. In some instances, simple forms of tactical sensing are quite adequate to control manipulation. For a majority of applications, some form of more complex noncontact visual sensing is used; although, further study is necessary to determine whether or not one can impose sufficient constraints on manipulated objects and their environment to simplify sensing requirements. For determination of position and orientation of fixed and moving objects, particularly when a number of different objects must be selectively manipulated or worked on, noncontact visual sensing together with interpretation of the sensing signals are most often used. The interpretation of sensory inputs (a process that has often been called pattern recognition) is a high-level function of human intelligence and often demands extensive logical, problem-solving, and educated guess capabilities together with a large store of accessible facts about the world. Such interpretation by machine is in an early state of development and currently requires an inordinate amount of computation time.

• Rapid learning and retraining. A relatively unskilled worker can be taught a new routine by means of human speech, written instructions, demonstrations of operations. From this basis and with some practice, he becomes adequately adept in the performance of these repetitive operations; he can also be retrained to do similar but new operations effectively.

The versatility of man in exhibiting all of these capabilities is not exhibited by any existing machine and is not likely to be in the near future. Nevertheless, this versatility represents an ideal that can define the goal of work in automation. We believe that significantly useful portions of such capabilities can be developed in the next few years and can lead to economically advantageous industrial systems. The following sections briefly review existing commercial equipment, limitations, and major requirements.

Industrial Manipulators

The current generation of commercially available industrial manipulators barely begins to have the capabilities described above. The industrial "robots" such as the Unimate* (Figure 2), Versatran,† IBM 1972 Production Terminal,‡ and a number of others§ are multi-degree of freedom manipulators that can repetitively perform simple material-handling and tool-using tasks, once they have been programmed by a human for a sequence of operations. The programming of the machine for a single specialized job has been made simple, such that a trained but highly skilled operator using manual control can guide the machine through a sequence of desired positions and can alter and refine each step until a satisfactory sequence is obtained. In this *programming mode,* accurate spatial data for each degree of freedom for each position are derived from internal feedback sensors and are recorded on drums or tape. In the *playback mode,* the manipulator accurately retraces the steps that have been recorded for each sequence and repeats such sequences thereafter with high accuracy. Special "hands" or tools can be fitted to the arm for specialized jobs entailing materials-handling, spot-welding, and spray-painting. From the evaluation of the performance of existing industrial robots in terms of the ideal characteristics noted above, it is evident that rapid learning and retrainability features have been incorporated to a useful degree; however, manipulative capability is rudimentary, and there is no provision to integrate important sensory

*Unimation Inc., Danbury, Connecticut.

†Versatran-Thermatool, New Rochelle, New York.

‡International Business Machine Corporation, Owego, New York.

§Over 50 Japanese and several British companies are either manufacturing or intend to manufacture industrial robots similar to the U.S. machines.

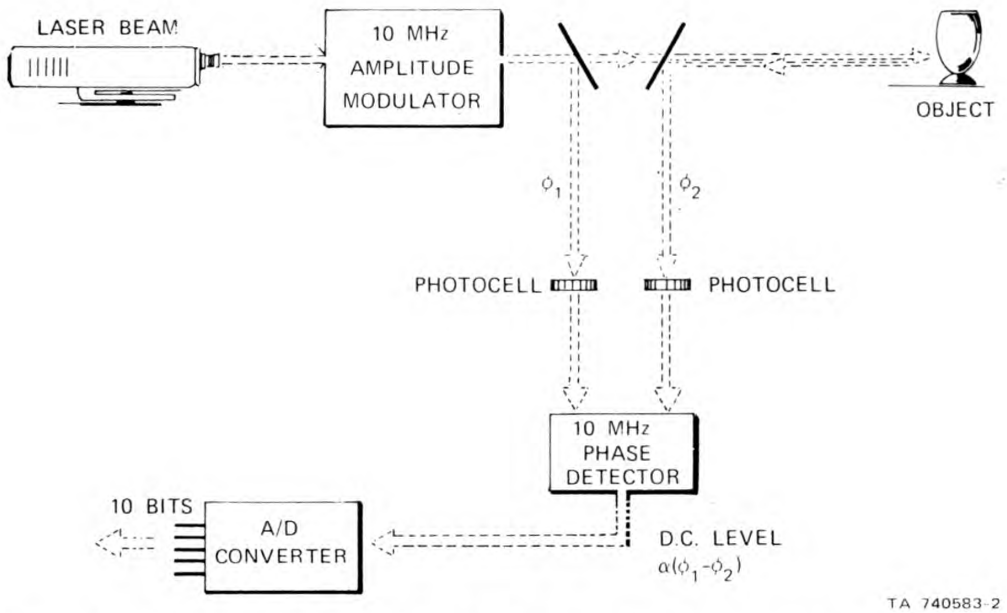


Figure 2 — Material-handling system. The upper illustration is an artist's conception of a laboratory test bed for an automated material-handling system. A label scanner can be used to identify the package. A scanning range finder interfaced with the computer can sense contours of the package to determine the package's angular and translational position, such that the manipulator can adjust its programmed actions to pick it up in general position. The lower illustration shows an SRI laboratory set-up with a Unimate manipulator and label reader operating on a package transported by a conveyor.

information to guide and control manipulative operations. Thus, moving objects (or objects not precisely prepositioned for subsequent manipulation) cannot currently be handled. Furthermore, because of the lack both of commercially available visual and tactile sensory feedback and of appropriate software, operations requiring the cooperation of several fingers/hands for manipulation of tools or objects cannot be performed.*

Sensors

Currently, the most widely used visual sensor applicable to industrial automation is the on/off light-sensitive electronic switch (photocell plus amplifier). Usually this device provides an inexpensive means for determining the presence or absence of a moving object or part of object at a specific location and thus for electrically controlling some other associated process. Arrays of such photodetectors based on modern semiconductor technology have also been developed. Together with

*The machine with the most advanced manipulator capability is the Norwegian Trallfa machine made by Trallfa, Nils Underhaug, Bryne, Norway. It is a specialized spray-painting manipulator that has been designed to be "programmed by doing" with especial ease by a trained operator. He programs the machine by going through the complex manipulative motions of actually spraying a part, thereby generating the program with very frequent sampling and recording the angular and linear displacements of each degree of freedom (80 times per second).

suitable logic circuitry, these arrays can be used to extract salient features such as the edges of cartons of objects which move past the array.

Optical scanning systems have become available for remote sensing or printed marks. In these systems, a collimated optical beam scans labels or marks affixed to packages; the printed coded marks are read and decoded and thereby provide important information useful for such functions as costing, inventory, or routing (Figure 3). These new scanners thus are beginning to provide, under constrained conditions, only a simple useful version of the wide range of information that humans obtain with their eyes and interpretive faculties. As yet no commercial system is available that is capable of identifying an object or package in random position (or in motion) without the use of auxiliary coded marks. New techniques are now being developed in the laboratory to bridge this gap. One approach is based on the development of optical range finders (Figure 4) that will yield three-dimensional data that can be

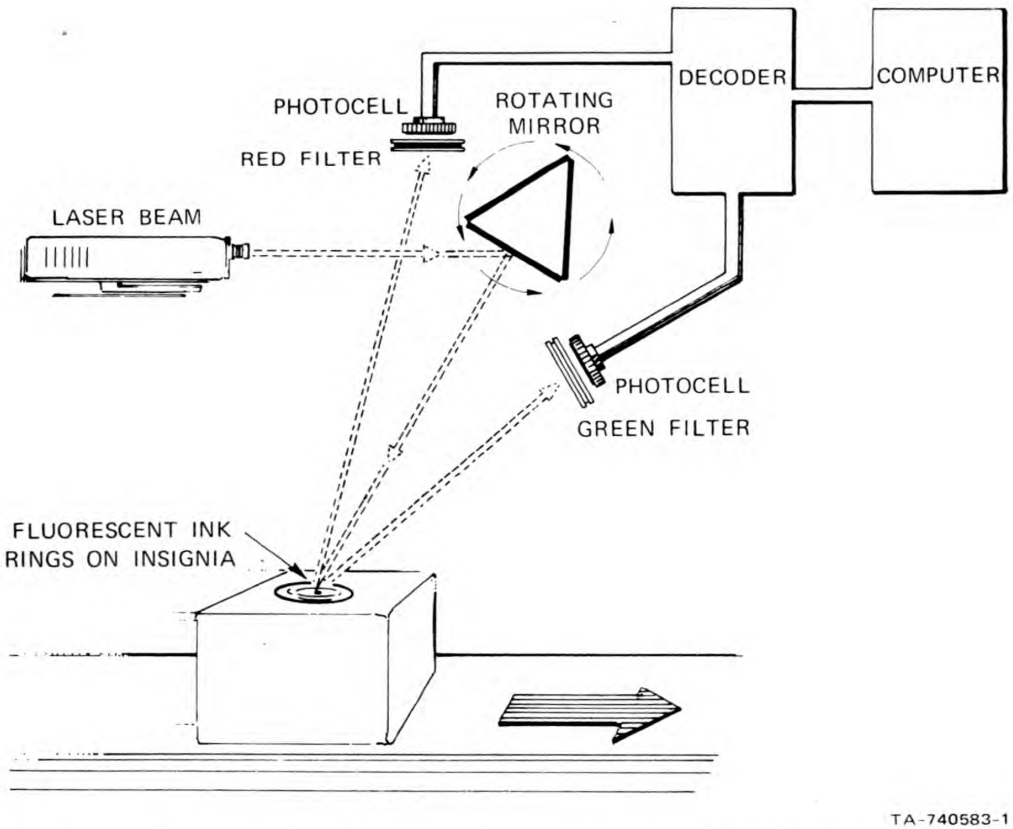
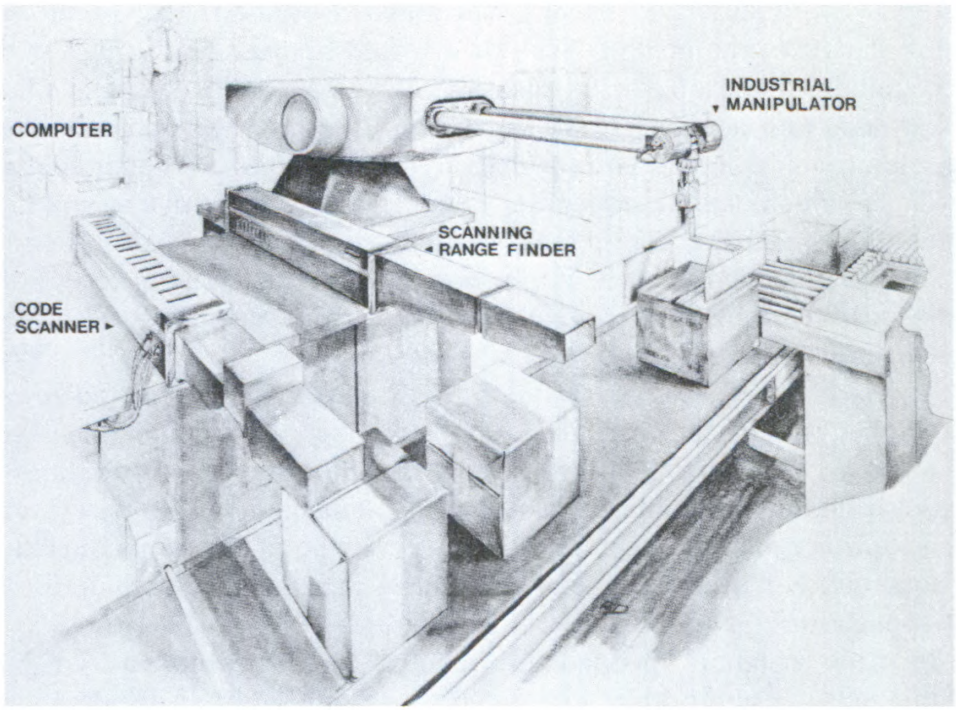


Figure 3 — Remote label reader. A set of circular concentric encoded marks printed on a label in two fluorescent colors are scanned in one plane using a 1-millimeter-diameter laser beam. Photocells with red and green filters sense the returned scattered light signals, which are then decoded for identification of the package to which the label is attached. Labels can be read at distances of from several inches to feet, in any orientation, (under development at SRI).



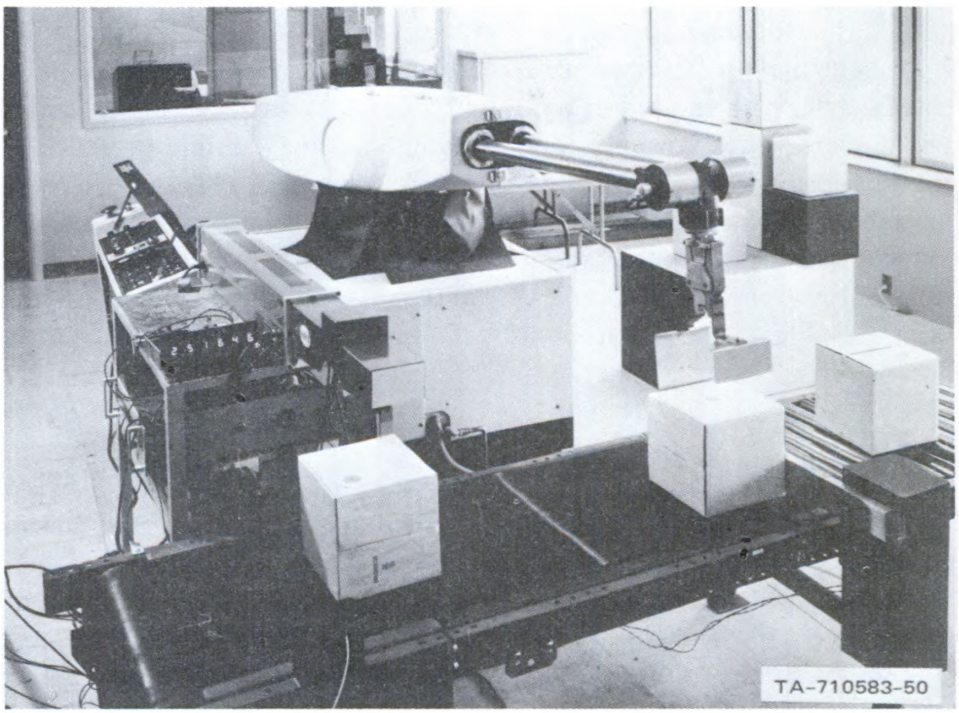


Figure 4 — Laser range finder. A laser (or Light Emitting Diode) optical beam is amplitude modulated and caused to scan mechanically a given field of view. Light scattered by the objects in the field is returned coaxially to photocell detectors. The measured phase difference between transmitted and received light is proportional to distance. A roster of range (or depth) points is thus obtained. (Under development at SRI.)

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interpreted to describe the physical outlines of the object (or a convenient part of the object). Such data would be useful not only for the recognition of the object but also for the determination of its position, its attitude in space, or its relative motion. Another approach makes use of a television camera that takes pictures of the object. When processed by a digital computer, the resulting data can yield descriptive information useful for similar purposes to those as noted above. Considerable software to implement such "picture-processing" techniques has been developed over the past ten years (7-11), but no general application to useful industrial tasks has yet been made.

The systems making use of the types of optical scanners noted above, *i.e.*, label (or printed mark) readers, the range finder, and the linear diode array, appear to be simpler and less expensive than TV systems to develop and use for integration with programmable manipulator systems and for other material-handling applications. The TV system coupled to a computer is more versatile and is capable of handling a far wider range of applications.

In many instances, manipulation control can be facilitated by use of tactile sensors appropriately mounted on a "hand." In such operations as grasping or lifting delicate irregular-shaped objects, inserting pins in close-fitting holes, and threading nuts on bolts, it may be necessary to control the forces exerted on the workpiece. In other applications, visual sensing can be dispensed with entirely by use of multiple tactile sensors that, with the aid of a computer, can discern shape and orientation of workpieces for subsequent manipulation. Multiple-pressure and force-feedback sensors are now under development (12-16) that, when integrated with manipulator and computer, can provide the digital dexterity required to manipulate tools or delicate parts in assembly and disassembly operations. An important goal will be to devise software that is capable of coordinating both the mechanical actions of controlled fingers and, ultimately, the actions of two hands working cooperatively.

Visual Inspection and Quality Control

Visual inspection/quality control is a ubiguitous and often necessary operation in all stages of the production process. It is often an *implicit* function; *i.e.*, staged assembly of a product cannot proceed unless the right parts are at the right place at the right time, and each of the parts or subassemblies has been properly fabricated in earlier stages. Thus, the main job of an assembler may be to fasten parts together or add to a subassembly. He must, however, make sure by visual inspection that he is able to proceed. In many other instances, *explicit* inspection is necessary to avoid the generation of scrap, such as in the output of a high-speed stamping operation, or to assure the quality of a finished package or product. In these cases, the main job of a worker is to inspect.

The majority of both implicit and explicit visual-inspection functions are qualitative or semiquantitative in nature, answering questions such as:

- Is anything missing from the subassembly?
- Is the part malformed or deformed?
- Is the package or part soiled, cracked, or otherwise blemished?
- Is it the right part for a given model?
- Are the parts in the right relative positions?
- Is there evidence of excessive die-wear or broken dies?
- Is the part correctly labeled?

Currently, there are no general-purpose commercial machine substitutes for these forms of human qualitative and semiquantitative inspection capabilities. By the use of available principles, however, techniques of processing images derived from television pictures can be applied to a broad class of visual-inspection and quality control problems. Complete integrated systems need to be assembled that are composed of television camera, optics, and electronics all interfaced with a digital computer to demonstrate solutions of typical problems, to permit economic assessment, and to provide the basis of design for specific applications.

Cooperation of Multiple Manipulators

There are no instances today of two manipulators operating cooperatively in a completely autonomous mode. The development of general-purpose integrated sensory-manipulator computer systems can lead directly to the cooperative coupling of two or more manipulators through the common computer. Software techniques suitable for such control as yet have not been devised and will be difficult to develop. However, when initial techniques for control of two manipulators are available, extension of control to three or more may be facilitated. In that event, completely new methods of assembly will be possible because all current assembly is based on the use of fixed jigs and two-handed workers. Similarly, the impact on product design may be extensive, since this important part of the mass-production manufacturing process is dependent to a large degree on methods of fabrication and assembly.

This problem area is in many ways very challenging, and progress will be slow. Advanced techniques in modeling, problem solving, and system integration now under active development by the large artificial intelligence groups will provide some guidance but no immediate solutions. Initial studies will have to be made to specify precise needs, preferably in well-defined practical situations, with contributions from product designer, tool designer, production and manufacturing manager, and from the marketplace.

Supervisory Control

We have assumed that semiautonomous machines must be capable of being supervised in an overriding control mode. This can be effected by using switchboard, joy-stick, teletype, or variants of these controls. A more general means of such control however would be based on the recognition of human speech. Several large "speech understanding" programs have been initiated in the past year (17) and it is hoped to develop the capability of understanding flowing human speech utterances, limited to a vocabulary of 1000 words in a specific domain of discourse. Other programs exist in which a small number of key words and phrases such as the digits can be recognized when spoken one at a time. A useful intermediate result of the more complex programs above could well be the capability of recognizing phrases spoken in English. The system could be sufficiently powerful to permit a rich choice of selected adjectives and adverbs used with verbs and nouns, all within a prescribed vocabulary, such as:

"a little higher"	"six inches, forward"
"to the right"	"cancel last command"
"stop at once"	"repeat last step."

With such a capability, one can envision being able to use eyes and voice to assume control of the operation of a machine in a natural and unimpeded manner. His control could be timely and rapid, and would require minimal training. Certainly, methods involving manipulation of switches/keyboard could augment his control capabilities, where required.

Recommended Research and Development

This survey has concentrated primarily on those parts of the manufacturing process that were both labor-intensive and considered to be centrally important; namely, materials-handling, inspection, and assembly processes. No attempt has been made to assess either the requirements for a completely automated factory or the automation needed for repair and maintenance. The following recommendations are therefore concerned with development of systems, sensors, and techniques for the former processes.

Demonstration System Development

Current R&D expenditures in this field by U.S. industrial firms are small because of lack of knowledge about what can be done and lack of confidence that cost-effective systems can be devised in the near future. Most U.S. firms are definitely interested in increased productivity and

are disturbed about the rapid increase of foreign competition and the rising disaffection of workers. They are as yet unprepared, however, to make the rather substantial commitments required—in trained people, hardware, and software—to mount adequate programs.

In aggregate, the R&D establishments of these firms have resources dwarfing those available to universities, government, and nonprofit research establishments. To catalyze these potential resources, initial R&D programs should aim at producing several integrated systems that can serve as the basis for economic assessment and engineering design. At the same time, studies should be initiated to guide future elaboration and extension of those systems as to apply them to an increasingly larger range of industrial tasks. The following two systems are suggested as candidates for simultaneous development:

- A programmed sensor-controlled manipulator system
- A programmed visual quality control and inspection system.

These two mutually compatible systems have been selected because they are needed, they constitute the logical extension of capabilities of the present industrial programmable manipulators, and they would be readily accepted by industry. Furthermore, after their feasibility has been proved by actual use in factories, the two systems can serve as a necessary base for further development of more advanced automated systems. The sensor-controlled manipulator is urgently needed now for many assembly and materials-handling jobs. Programmable inspection systems would not only be important to extend the use of the programmable manipulators but also would make possible a considerable improvement in quality of the goods produced.

After successful development of these two systems, they can be merged into a complete assembly station, in which staged assembly and inspection functions can be performed automatically for a wide range of products. By the concurrent development of programming methods designed for easy application by the *user,* initial setup and modification for each product can be minimized, and significant economies in the manufacturing process can be effected. By the performance of simple repetitive assembly operations with controlled precision, and by the introduction of considerably more quality control at critical intermediate steps *via* the automated inspection procedures, the quality of product can be substantially improved.

More details of the requirements for implementing the two systems are described in the full ONR report.

Effect on Product Design

The automation of the assembly process initially will be based on little, if any, change in product design. Ultimately, product design will

be influenced considerably by the then-available automatic assembly-machine capabilities. For example, a more expensive fastening method might be selected in a trade-off for less cost in the automated fastening process. A rigid gasket may be chosen rather than a more flexible one because automated manipulative operations are simplified. Location pins and holes may be introduced in castings to greatly simplify precise mating of parts before fastening. Special bosses, holes, or pins may be designed into parts to greatly increase the positional precision of acqusition by the manipulator. The trend in design toward reduction of the number of component parts of assemblies—made possible by more sophisticated casting and machining methods—may be accelerated as a consequence of new automated assembly techniques that would mandate a minimum of manipulative and fastening operations. In short, product design methods will be greatly changed to accommodate the new technology.

Conclusion

Ultimately, the whole process of specifying the design, the assembly and the inspection routines will be effected by an interactive man-machine system that uses a specialized computer language to write the software required for each of these modalities. By the insistence that each function be user programmable in a simple manner, modification and changeover will be inexpensive and will lead to wider and earlier acceptance by industry. These projected capabilities will constitute an important part of the control by man and computer of the whole manufacturing process including production planning, material and parts flow, assembly, inspection inventory, costing, warehousing and storage, and finally, distribution.

These projected changes in the manufacturing process presage increased quality of product and quality of life for the worker, both contributing to the enhancement of the real productivity of our industrial society.

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16. A program is underway at Draper Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts, in which force-feedback sensors controlling a manipulator can effect insertion of a rod into a closely fitting hole. This program is under the direction of J. Nevins.
17. Speech-understanding research, sponsored by Advanced Research Projects Agency as part of a planned cooperative program, being carried out simultaneously by the following organizations:

    - Bolt Beranek & Newman Inc., Cambridge, Massachusetts
    - Carnegie-Mellon University, Pittsburgh, Pennsylvania
    - System Development Corporation, Santa Monica, California
    - Lincoln Laboratories, Massachusetts Institute of Technology, Cambridge, Massachusetts
    - Stanford Research Institute, Artificial Intelligence Center, Menlo Park, California.

Morphine Addiction

Dr. Theodore M. Brody is producing morphine addicts among mice in an effort to determine what changes in the metabolic processes of brain cells may be characteristic of the state of addiction. He finds that polysomes derived from the brain of addicted mice dissociate less eadily into ribosomes than in the case with control animals. It would be anticipated that this circumstance would inhibit protein synthesis by the cells, but it does not seem to do so. Speculation at this point, therefore, is that the drug addiction may modify the kind of protein produced, rather than the amount.

Solar Magnetic Fields and Their Influence on the Earth

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Stanford University
Stanford, California

In the last few years we have discovered that the outer part of the sun—the solar corona—is continually expanding outward. This solar wind consists mostly of ionized hydrogen, and because of its high electrical conductivity it has the property that solar magnetic field lines are frozen in and transported outward from the sun. The solar wind with its extended solar magnetic field lines streams past the earth and much farther out—at least as far as the orbit of Jupiter, and perhaps ten times farther than that. The transit time for the solar wind plasma to flow from the sun to the earth is about four or five days, so that the solar magnetic field observed today will cause terrestrial effects four or five days later. Much of this research has been sponsored by the Office of Naval Research.

During the past ten years spacecraft observations obtained near the earth have thus given us a means for examining the sun's magnetic field. The results include surprises, intriguing mysteries, and a considerable advance in our knowledge of the sun. This paper attempts to give a progress report of this field, which is changing considerably from year to year.

Within the past several years three new ways for observing the sun's magnetic field have become available. This is a happy situation for the solar observer, since experience shows that completely new observations often give rise to completely new fundamental knowledge. The first way of observing the sun's magnetic field is from a ground-based solar telescope using the Zeeman effect. If a Fraunhofer (absorption) spectral line is formed in the sun's atmosphere in the presence of a magnetic field, the resulting radiation observed at the earth contains information about the field which can be recovered with a suitable optical analyzing system. Such synoptic observations of the sun's magnetic field have been obtained during the past several years at Mount Wilson Observatory near Pasadena, and we have been privileged to be associated with Dr. Robert Howard in one phase of this work.

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*Dr. John Wilcox of the Institute for Plasma Research, Stanford University is an internationally recognized expert specializing in solar physics, solar and interplanetary magnetic fields and the solar wind interaction with the geomagnetic field.

The second way of observing the sun's magnetic field is with magnetometers on spacecraft. At the sun the average magnitude of the large-scale magnetic field is about 1 gauss, but after this field has been expanded over 93,000,000 miles the average magnitude decreases to about 5×10^{-5} gauss. Sensitive spacecraft magnetometers are therefore required to detect this field, but such a measurement with a good signal-to-noise ratio is now well within the state of the art.

The third way of observing the sun's magnetic field is by using the earth itself as a detector. It was discovered by Svalgaard in Denmark and by Mansurov in the USSR that the daily variation of the polar geomagnetic field has a form that is dependent on the polarity (toward or away from the sun) of the extended solar magnetic field in which the earth is immersed on any given day. These polar geomagnetic observations exist without interruption since 1926 at the station of the Danish Meteorological Institute in Godhavn, Greenland. It is amusing to think that this station in the frozen north, using essentially a small magnet suspended on a quartz thread (Figure 1), is observing a physical quantity that was formed in a rather warmer environment, and that it is also

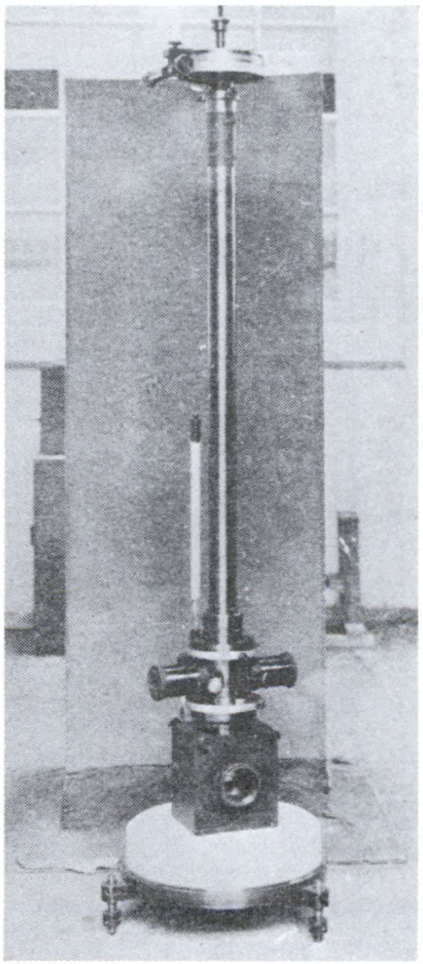

Figure 1 — Variometer for observing variations in the geomagnetic field. This instrument at the station of the Danish Meteorological Institute in Godhaven, Greenland has observed the sun's magnetic field during the last five sunspot cycles. The picture was taken in 1926.

being observed with the most modern electronic equipment by spacecraft magnetometers. A considerable advantage of this third way of observing the sun's magnetic field is that observations exist during five 11-year sunspot cycles, so that we have a much better chance to determine the magnetic features of the sunspot cycle that are important and reproducible. One of the surprises, in fact, has been to discover in this way that several interesting features observed during the present sunspot cycle with modern electronic equipment appear to have existed in the preceding sunspot cycles. The sun's magnetic field appears to be more highly organized that we would have imagined.

What specifically have we learned? Figure 2 shows a large-scale structure in the sun's magnetic field that rotates with the sun and is extended by the solar wind to the earth and beyond. As these magnetic sectors pass the earth there are important consequences such as changing conditions for and sometimes interruptions of radio communications, ground current surges that can have serious consequences for the networks of power companies, increased radiation levels that can be

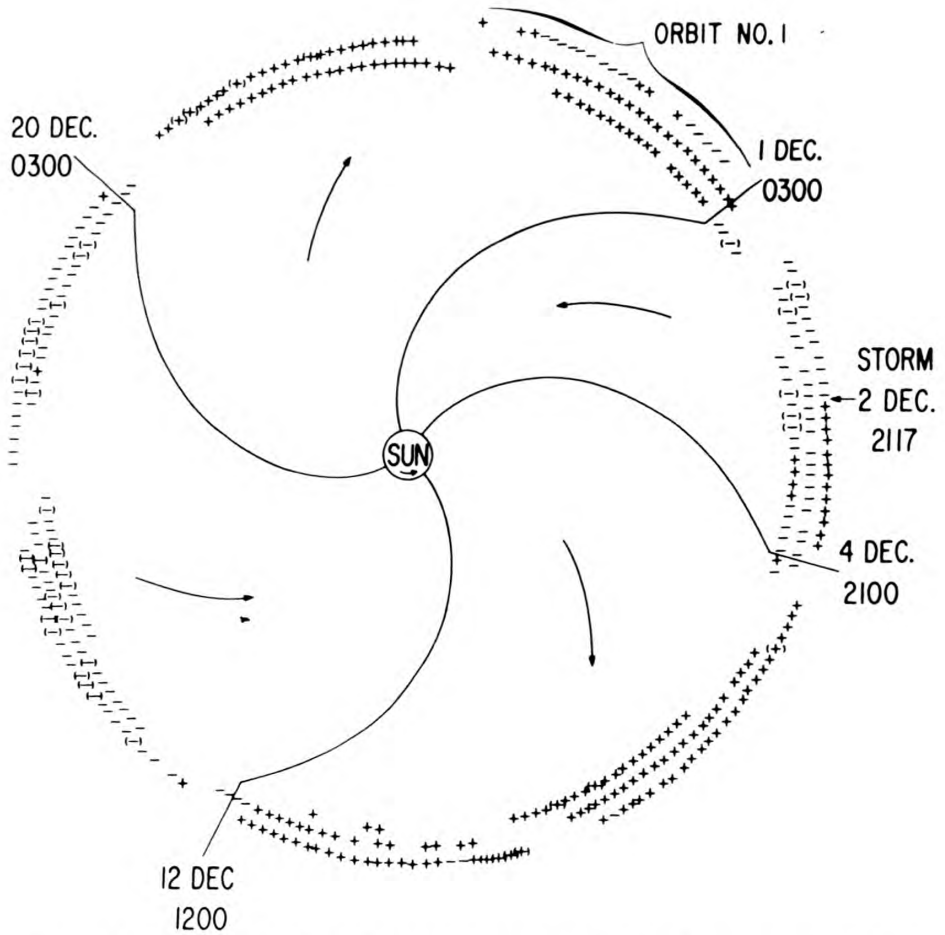

Figure 2 — Schematic of a solar magnetic pattern having four sectors per solar rotation, as observed by spacecraft near the earth.

hazardous for unprotected astronauts and passengers in high-flying planes, and important effects on the earth's weather. The plane of Figure 2 represents the plane of the ecliptic in which the earth is orbiting about the sun. The Archimedes spiral shape of the average field lines is caused by a combination of the radial expansion of the solar wind plasma plus the rotation of the sun. This spiral has been compared with the similar spiral that can be observed to emerge from a rotating garden sprinkler. The most common pattern is to have four magnetic sectors per solar rotation. Each pair of sectors is separated by a very narrow boundary within which the field direction changes from toward the sun to away or vice versa. We see intriguing hints that this four-sector structure may exist in some underlying position in the sun unchanged during many sunspot cycles.

What does a magnetic sector boundary look like on the sun? Comparison of sector boundaries observed with spacecraft near the earth with observations of the sun's magnetic field obtained at Mount Wilson Observatory suggest an average solar sector boundary as shown in Figure 3. Large areas of the sun in both the northern and southern hemispheres have the same polarity on one side of the boundary shown in Figure 3, and similar large areas on the other side of the boundary have the opposite field polarity. Suppose at the time shown in Figure 3 we have to observe the sun as though it were a star, (*i.e.*, to observe the average field of the visible solar disk). At the time of Figure 3 such an observation would yield an average field close to zero, since there would be

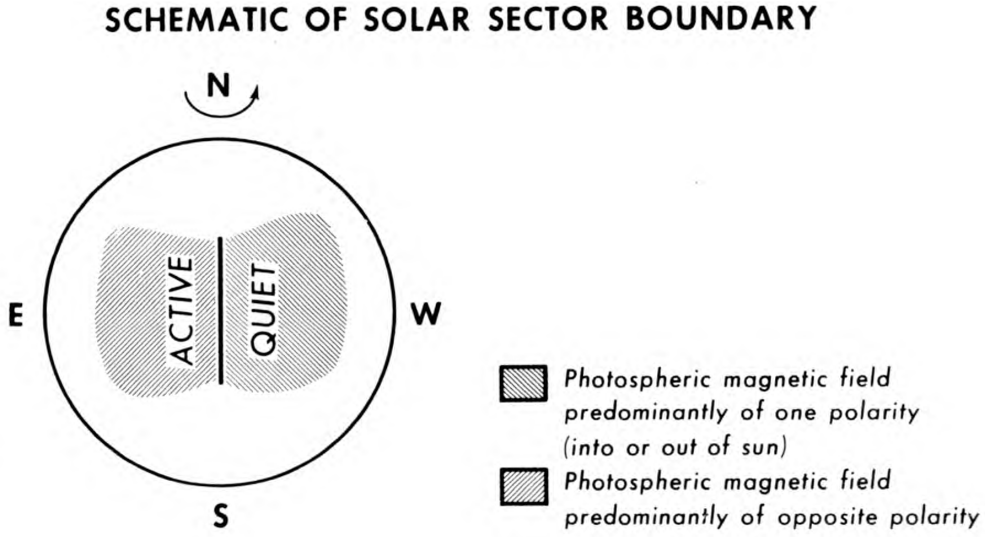

Figure 3 — Schematic of the average shape on the visible disk of the sun of a sector boundary shown on Figure 2. The boundary is approximately in the North-South direction over a wide range of latitude. The solar region to the west of the boundary is unusually quiet and the region to the east of the boundary is unusually active.

cancelling contributions from the two equal and opposite sectors on each side of the boundary. One day later the boundary will have rotated to the right with the sun, and an observation of the average field would then show a field with polarity corresponding to the polarity left of the boundary. Observations during approximately the next week (*i.e.*, the solar rotation period of about 27 days divided by four sectors per rotation) would continue to show this same polarity, until the next sector boundary arrives near central meridian.

On the basis of the above discussion we might expect that the average solar magnetic field (the sun observed as a star) might be quite similar to the interplanetary field observed by spacecraft near the earth. In making such a comparison we should have to displace the solar observations four or five days later to account for the transit time of the solar wind plasma that is bringing the field lines from sun to earth. Professor A. B. Severny, the Director of the Crimean Astrophysical Observatory in the USSR, has obtained such average solar field observations for the past few years. In collaboration with Professor Severny we have compared these average solar field observations with the interplanetary magnetic field observed with spacecraft near the earth with results as shown in Figure 4. These two fields separated by a distance of 93,000,000 miles are remarkably similar. The existence of the four or five day transit time gives rise to a forecasting possibility with the same time interval.

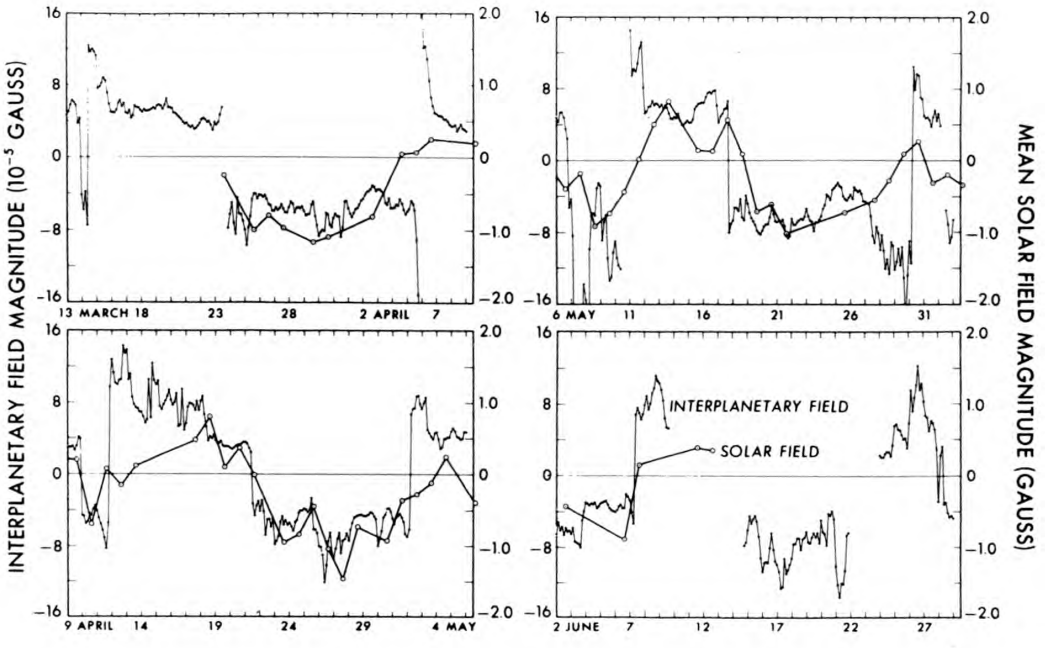

Figure 4 — A comparison of the average magnetic field of the sun observed as though it were a star with the interplanetary magnetic field observed with spacecraft near the earth. The solar observations are displaced by 4-1/2 days to allow for the average sun-earth transit time.

The straight North-South average sector boundary shown in Figure 3 can be discussed in terms of an interesting dichotomy between the solar sector magnetism that we have been discussing and the classical model of solar magnetism formulated by H. W. Babcock, the Director of Hale Observatories. Classical solar magnetism relies on the differential rotation of the sun (the equator is rotating with a period several days shorter than the period of polar regions) to twist and shear the solar magnetic field lines such that a field line originally in the North-South direction would end up after a few rotations of shear in almost the East-West direction. It appears that both rigid rotation and differential rotation effects exist simultaneously in the sun's magnetic field, even though they appear to be quite contradictory properties. In this regard we may recall the wave-particle nature of light, which is another example of the simultaneous existence of apparently contradictory properties. We do not yet understand how these two different properties of solar magnetism can coexist, but a possible important link between them is shown in Figure 5, which was obtained by the Czechoslovakian astronomer Bumba and the USSR astronomer Obridko. The figure shows the distance in solar longitude between regions on the sun in which large flares occurred and the nearest solar sector boundary. It can be seen that the sites of solar flares are not distributed at random longitudes in the solar sector boundaries. Thus solar flares and activity, which we may associate with the differential rotation of classical solar magnetism, appear to be very much organized with respect to the rigidly rotating solar magnetic sector boundaries.

We have recently discovered that there is a considerable influence on the earth's weather as the solar magnetic sector structure is carried past the earth by the solar wind. In collaboration with Drs. Walter Orr Roberts and Roger Olson we have studied the large-scale low pressure troughs at a height of about ten kilometers. Typically there are about a dozen such troughs disposed around the northern hemisphere of the

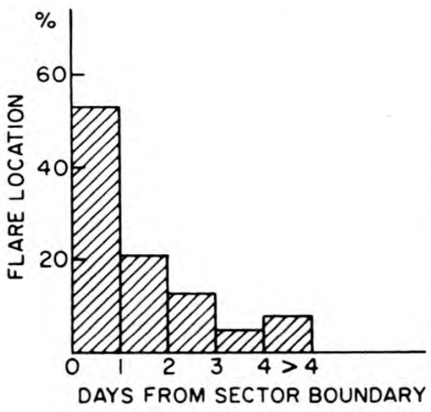

Figure 5 — Histogram of the difference in longitude between the location on the sun of large flares and the nearest solar sector boundary. Each day of rotation on the abscissa corresponds to 13° of longitude.

earth. To measure the size and intensity of these troughs we used an index of the area within the troughs in which the vorticity of the earth's atmosphere exceeded a certain value. Figure 6 shows the average response of this vorticity area index during the several days preceding and following the well-defined time at which a sector boundary sweeps past the earth. We should emphasize that the response of the earth's weather is to the large-scale sector structure, and that the time at which the boundary sweeps past the earth is used as a well-defined marker. The vorticity area index begins to decrease about two days before the boundary and reaches a minimum about one day after the boundary, thereafter returning to approximately its previous level. The amplitude

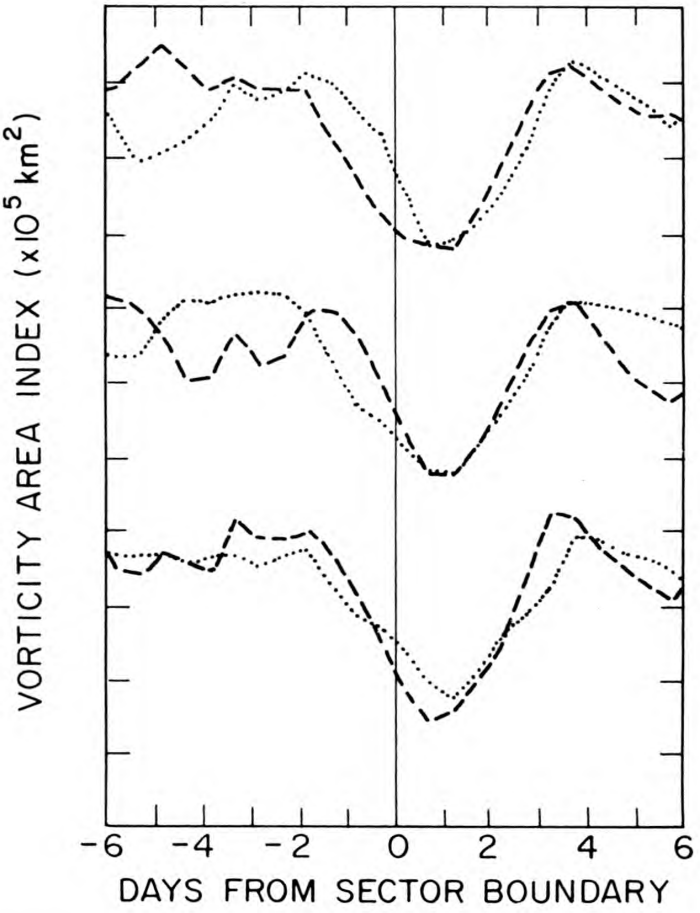

Figure 6 — The average response of the vorticity area index (representing the size and prominence of low pressure troughs in the earth's atmosphere) as the solar magnetic sector structure is swept past the earth by the solar wind. The list of boundaries was divided into two parts according to (a) the magnetic polarity change at the boundary, (b) the first or the last half of the winter season, and (c) the yearly intervals 1964-1966 and 1967-1970.

of the effect is about ten percent. Since we can observe a sector boundary on the sun four or five days before it is swept past the earth, there are obvious weather forecasting possibilities after the physics of the relationship becomes better understood.

At the present time it seems most important to establish the reality of the connection between solar magnetic fields and the earth's weather, since once we are convinced of this reality we know that we should work hard to understand it. In order to investigate the reality of the effect shown in Figure 6, the list of sector boundaries was divided into two parts, and the average response of the vorticity area index to each half of the list of boundaries was computed. The list of boundaries was divided in half in three different ways according to (a) the magnetic polarity change at the boundary, (b) the first or last half of winter, and (c) the yearly intervals 1964 to 1966 and 1967 to 1970. The reality of the effect is indicated by its persistence throughout these investigations. This discovery appears to be a happy combination of great intellectual interest and also considerable practical importance. (This effect was mentioned in *Naval Research Reviews,* February 1973, page 28.)

In order to follow up the interesting leads discussed in this paper, we are constructing at Stanford a solar telescope dedicated to observing the average solar magnetic field, and other quantities related to the large-scale solar structure and the formation of the solar wind. The Stanford Solar Observatory is being built in the foothills behind the campus with support from the Office of Naval Research, the Max C. Fleischmann Foundation, and the National Science Foundation, and is scheduled to begin observations near the end of 1973. The solar magnetic field will be observed during all sunlit hours from sunrise to sunset. We will collaborate with the Crimean Astrophysical Observatory, which is the only place in the world where a similarly dedicated telescope is located, to obtain nearly continuous observations of the sun's magnetic field. This collaboration will be enhanced by an exchange of visits of post-doctoral scientists between Stanford and the Crimean Astrophysical Observatory. In addition to the considerations outlined in this paper, we will investigate theoretical ideas such as the possibility of the sun ringing in spherical oscillations after a large flare similar to the way the earth rings after an earthquake. Another investigation will concern the heating of the solar wind by waves that pass through the visible layer of the sun where we can observe them and then propagate upward into the cornoa where they steepen into shocks and deposite energy in the solar wind. Another investigation will concern a careful look with the best-possible instrumentation for any effects of the fast-rotating solar core.

In conclusion, we may note that although being able to examine the sun's magnetic field back through five sunspot cycles using the polar geomagnetic observations seems almost prehistoric, there is really

nothing new under the sun. The cover shows a Roman mosaic in Egypt in which the four-sector pattern can readily be distinguished.

Freezing Effects on Arctic Beaches

Beaches in arctic regions differ substantially from those in temperate and tropical areas in that subzero air and water temperatures during the largest part of the year cause freezing of the beach sediments and inactivity of normal transporting agents. During ice-free conditions, wave action and near-shore circulation cells modify and change the beach topography in a manner similar to that of nonarctic beaches. Once the temperature falls persistently below 0°C, freezing of the land and water is initiated, and swash runup on the beach face freezes in place and is contiguous with deposition of sediment. During this period of time the beach face is quite smooth and firm, offering excellent trafficability conditions. Once the nearshore waters freeze and offshore pack ice exerts pressure, ice-pushed ridges offshore and on the beach are common features. Beach topography is extremely irregular, and trafficability is hazardous. Movement alongshore can often be negotiated, however, because natural smooth ice lanes are common between the offshore pressure ridges and the shoreline. Thawing of the beach during the spring season results in melting of the ice layers and frozen swash incorporated in the beach deposits. Collapse features and extremely soft zones are then common in the beaches, and topography is extremely rugged. Quite commonly, wind-blown sand will mask these features, and their presence is identified only when attempts are made to navigate across the beach face. Thus trafficability conditions vary considerably throughout the season. This information is essential for the proper planning of amphibious and mine warfare operations in the total Naval operational environment.

NRL Develops Shipboard Hydrophone Calibrator

Scientists at the Naval Research Laboratory's (NRL's) Underwater Sound Reference Division have developed a hydrophone calibrator to calibrate hydrophones as large as 12 cm in diameter.

The NRL calibrator employs the comparison method in the frequency range 25-1000 Hz at sound pressure levels from 130 to 190 re 1 μPa. Therefore, it is possible to calibrate a hydrophone immediately before deployment and immediately after recovery.

The calibration includes the complete electronic measuring system as well as the hydrophone. Vertical stabilization of the calibrator for ship roll and pitch of 10 degrees isolation from ship's noise is provided.

On the Naval Research Reserve

Miss Eleanor F. Kehoe Retires

On 30 June Miss Eleanor F. Kehoe, Research Reserve Training and Plans Officer, retired after nearly seventeen years with the staff of the Research Reserve Program in the Office of Naval Research. Miss Kehoe joined the staff in 1956 and has served as Education Specialist, Training Officer, Fifth and Sixth Naval District Research Reserve Liaison Officer and Training and Plans Officer. She has been a member of the Research Reserve Program since 1955 drilling with Naval Reserve Research Company 5-8 in Washington and retired as Captain in August 1972. On her departure CAPT C. H. Bird, Jr., Deputy and Assistant Chief of Naval Research (Acting) presented her with a letter of appreciation from Rear Admiral M. D. Van Orden, USN, Chief of Naval Research, thanking her for her years of outstanding and loyal service to ONR.

Research Notes

NRL Director Named to Naval Research Position in London

Captain Earle W. Sapp, (USN) has assumed the Posts of Commanding Officer of the Office of Naval Research Branch Office in London, England and Assistant U.S. Naval Attache for Research after having completed his 3-year tenure here as Director of the Naval Research Laboratory.

In his new position, Captain Sapp will be responsible to the Chief of Naval Research in discharging his responsibilities for surveying the worldwide findings, trends, potentialities, and achievements in research and development. He will establish and maintain liaison between the U.S. Navy and all scientific research agencies in the United Kingdom, Europe and such other areas as may be designated by the Chief of Naval Research.

Captain Sapp's new job also calls for him to represent the Assistant Secretary of the Navy (Research and Development), the Chief of Naval Operations, and the Chief of Naval Research in all matters of general scientific and technical interest to the Navy in designated geographic areas of responsibility.

Furthermore, the former NRL Director will assist Navy bureaus, offices, and systems commands in contracting for desirable research and development, and in patent matters, in the United Kingdom, Europe and adjacent areas.

As Director of the Naval Research Laboratory, Captain Sapp has been responsible for heading one of the principal in-house research and development institutions of the U.S. Government. During his term as Director, the Laboratory celebrates its 50th year of scientific research for the Navy and the Nation. The Lab officially opened July 2, 1923 and since that time has produced an enviable record of scientific "firsts" for the Defense Department, and spinoffs to society.

Captain Sapp was appointed Director of NRL in June 1970 after serving as Deputy to the Assistant Director for Ocean Control in the Office of the Director of Defense Research and Engineering.

A physics major and graduate of Duke University and the Naval War College, Captain Sapp also attended several Naval Antisubmarine Warfare and Electronics schools and has taken special courses in oceanology. His Navy technical subspeciality is oceanography.

The new ONR Branch Commander has broad operational and command experience in destroyer-type ships and on fleet staffs, and has commanded two ships, the USS MALOY (EDE 791) and USS GREENE (DD 711). His research and development experience includes assignments in DDR&E (Director of Defense Research & Engineering), in Antisubmarine Warfare Test and Evaluation commands and ships assigned to Navy laboratories as well as to the operational test and evaluation force.

Captain Sapp holds the coveted Legion of Merit and other awards. He was cited by the Secretary of the Navy for his professional competence and dedicated efforts for the successful operation of the U.S. Defense's Ocean Control Office in the Presidential Legion of Merit Award Citation.

Captain Sapp received the Navy League's 1973 Rear Admiral William S. Parsons Award for Scientific and Technical Progress in recognition of his pioneering work in the evolution of towed passive sonar systems.

A veteran of more than 25 years of Naval service, Captain Sapp has held many research assignments which gave him broad experience in research and development, particularly in undersea warfare programs of special interest to the Navy.

Captain John Geary Named Director of the Naval Research Laboratory

Captain John T. Geary, USN, became the new Director of the Naval Research Laboratory in a formal change-of-command ceremony held July 16 at the NRL complex. He relieved Captain Earle W. Sapp, USN, who has held the position for the past three years.

Captain Geary's most recent assignment before being selected Director of NRL, was with the Naval Electronics System Command where he served as Deputy Commander for Planning, Programming and Resources Management since August 1971. He also served as NAVELEX Deputy Commander for Acquisition Engineering, as well as the Command's Inspector General.

A native of Phoenix, Ariz., Captain Geary graduated from the U.S. Naval Academy in 1946. He received an MS degree in Engineering Electronics from the Naval Postgraduate School in Monterey, California in 1953, and an MS in Business Administration from George Washington University in 1970.

He graduated from the Industrial College of the Armed Forces (ICAF) in 1970 and attended numerous other service schools, including the Defense Weapons Systems Management course and the Naval Radar Training School. He also served as an instructor at the U.S. Naval Academy.

Captain Geary has served in various capacities in shipboard assignments, including destroyers, cruisers, and amphibious ships; as well as operations officer for Commander, Destroyer Squadron 15.

Selected for Engineering Duty, in 1956, he was assigned to the Pearl Harbor Naval Shipyard and in 1959 to Commander Service Force, US Atlantic Fleet in electronics billets, before coming to the Naval Research Laboratory in 1962 as Project Officer and Bureau of Ships Liaison Officer.

In 1964, he transferred to BUSHIPS, where he became Head, Electronics Warfare Branch and managed many R&D Programs in electronics countermeasures systems and equipment.

Upon graduation from ICAF, Captain Geary reported to Naval Air Systems Command as Director, Astronautics Division, providing systems command management of Navy R&D efforts in Space, including SOLRAD and Timation.

NRL to Use Outmoded Missiles for Space Research

The Naval Research Laboratory is expected to enhance its space science program, while saving hundreds of thousands of dollars, by converting phased-out Minuteman I missiles to sounding rockets.

Robert D. Arritt, NRL's program manager for the project, said a number of Minuteman I second stages are being converted into large payload capacity, high performance sounding rockets for X-ray astronomy research. The surplus second stage motors are being adapted with specially designed nose cones and scientific payloads for the forthcoming experiments.

Instruments aboard the new sounding rockets, dubbed the Aries, will be used by NRL scientists to determine the ultraviolet background levels of the stars from above the earth's atmosphere.

The atmosphere's ozone layer at about 100,000 feet absorbs the ultraviolet rays emitted by the stars, so studies of this nature cannot be conducted from the earth's surface.

The feasibility of the novel system will be determined in an experimental flight of the Aries, carrying a dummy payload. The test flight will be made from San Nicolas Island, Point Mugu, California.

The future scientific payloads of the Aries will weigh about 1,800 pounds and will consist of ultraviolet measuring devices, telemetering instruments and a guidance system. They will be hurled into a ballistic trajectory to a height of some 300 miles by the Minuteman I second stage, giving the experimenters the advantage of controlled dwell time out of the atmosphere of about 8 to 12 minutes. A drogue chute will be employed to bring the scientific payload safely back to earth.

The Naval Research Laboratory has been given 62 of the surplus rockets by the Air Force and has asked for options on any others that are available. Minuteman I, the nation's first solid-fuel propelled ICBM has been replaced with more refined and powerful Minuteman II and III missiles.

Rather than destroy the missiles, the Air Force offered its leftover Minuteman first and second stages free to the Naval Research Laboratory and other interested government agencies. One of these other agencies, the Air Force Cambridge Research Laboratory has joined with NRL in the test flight at Point Mugu this spring.

If the maiden diagnostic probe of the Minuteman I is successful in checking out the aerodynamic configuration, structure and control system, NRL expects to fire future scientific payloads with the Aries from White Sands, New Mexico.

Mr. Arritt said the use of the surplus Minuteman I will save the U.S. taxpayers hundreds of thousands of dollars. As a matter of fact, he said, the cost of new missiles for this purpose would be prohibitive under present budget restraints.

NRL has been using rockets for astronomy studies for 27 years. The Laboratory began its investigations with captured German V-2 rockets as early as 1946.

Automation of Dental Examination

Digigraphic methods have been explored for application to the oral health record in a naval dental clinic.

The Dental Health Record used by all Federal Services to document the oral health of individuals upon entry into the service, record treatment while in the service, and serve as an official record for a possible forensic application, has been evaluated for automation. A system for voice input was designed and

appropriate electronic filters were built to discern 8 different frequencies of voice sound and an attempt was made to develop a system to utilize a PDP 12 on-line computer for processing. The dentist ascertained the tooth number on the display screen by actuating a foot switch. His spoken sound describing the condition of the designated tooth was introduced, via the microphone, through the filtering network into the computer. Instantaneous recognition was achieved by comparison of the voiced sound with a stored library of sounds which corresponded to the various possible diseases and oral conditions. Success was dependent upon a limited library due to the constraining parameters of core size and processing speed. Seven sound forms were described and analysed. Once identified, a condition was displayed on the screen. The dentist could view the display and ensure accuracy. When the examination was complete, the record could be stored on magnetic tape for subsequent printing on a chart via the teletype. Thus, permanent, accurate, standardized charting might be accomplished, record storage space could be reduced to magnetic tape dimensions, and personnel time could be hypothetically saved.

NRL Scientists Find Method to Measure Oil Spill Thickness

Naval Research Laboratory (NRL) scientists have devised a method to measure the distribution and volume of sea-surface oil spills through the use of multifrequency microwave radiometry. The system works in any type of weather, day or night and on a real-time basis.

Dr. James P. Hollinger and Mr. Robert A. Mennella of NRL's Space Science Division, principal investigators in the ecology-oriented project, said multifrequency passive microwave measurements from aircraft have been successfully made of eight controlled marine oil spills.

It was learned from the experiments that over 90 percent of the oil is generally confined in a compact region, with thicknesses in excess of one millimeter, which comprises less than 10 percent of the surface area of the slick.

Although radar has been used to locate oil spills in the past (also by NRL-developed methods), radar is unable to determine the thickness and distribution of the oil slicks.

The new experiments, sponsored by the U.S. Coast Guard, were conducted under the rules of the Environmental Protection Agency and the control of the Virginia Institute of Marine Science and the NASA-Wallops Island station to assure no damage to local ecology.

The scientists reported that microwave radiometry offers a unique potential for determining the thickness of oil slicks greater than 0.05 millimeters.

The apparent microwave brightness temperature is greater in the region of an oil slick than in adjacent unpolluted sea by an amount depending on the slick thickness. In effect, the oil film acts as a matching layer between free space and the sea, enhancing the brightness temperature of the sea.

In reporting their success, the NRL scientists said there is mounting concern by the public and governmental agencies over the increasing number of marine oil spills and the more serious resulting pollution. Before appropriate corrective

action can be taken, a knowledge of the nature, thickness, areal extent, direction, and rate of drift of the oil spill must be established.

Reliable determination of oil-film thickness is of major importance, the scientists related. It is the film thickness, along with areal extent, which allows the volume of the slick to be established. A knowledge of the volume of oil is essential for assessing the impact of the spill on marine life and environment as well as litigation and damage claims resulting from major oil spills. More importantly, knowledge of the oil distribution and the location of those regions containing the heaviest concentration of oil would enable the most effective confinement, control, and clean-up of the oil.

The NRL development promises an answer to these problems and the method should be of great value for those concerned with pollutants at sea.

New Class of Lasers, Excimer Laser

Excimer laser action has been the goal of a number of groups. A Russian scientist, Basov first orally reported laser action in high pressure gaseous xenon with electron beam pumping. A group with the AEC at Livermore has just recently observed some coherence in emission from xenon, again electron beam pumped. A combine of researchers from Northrop, Los Alamos, and Maxwell has observed extreme line narrowing in xenon when using electron beam excitation. Now Professor S. E. Harris of Stanford University has observed fluorescence line narrowing in both argon and xenon when these high pressure gases are irradiated with a laser. As an example, Harris used a quadrupled Neodymium laser pulse (2660A) of 20 picosecond duration, and 10 megawatt peak power (0.2 millijoules) to irradiate a sample of argon gas held at 10 atmospheres pressure. Fifteen percent of the 2660A radiation is absorbed in the gas, and the gas fluorescence (1250A) is narrowed from 110A to about 80A under the given conditions. The fluorescence narrowing depends on a change in gas pressure or in irradiation power in a way consistent with population inversion in the argon.

The excimer lasers of the future will most likely use electron beam pumping rather than optical, but the optical pumping affords a very interesting diagnostic tool for determining excimer lifetimes and molecular kinetic parameters. The ultimate importance of this new class of laser, excimer lasers, is hard to assess. However, two aspects of the excimers bode well, namely a dissociative ground state and a broad emission. The latter could mean good energy storage and tunability, and the former could mean no lower laser state interference. It is anticipated that even more interesting than the rare gas homonuclears will be heteronuclears, say alkali and rare gas molecules.

Air Pollution—Flow and Diffusion Over an Urban Complex

In connection with the possible environmental pollution hazard associated with the location of naval shipyards, power plants, repair facilities, munitions manufacturing facilities, *etc.*, a recent ONR investigation has pointed the way towards a modeling technique which can give a reliable indication of whether a problem will exist.

At Colorado State University for research on predictability of winds in the lower atmosphere, an investigation has been completed which explores the feasibility of wind-tunnel modeling as an alternative to expensive and tedious full-scale urban diffusion experiments. Professors J. E. Cermak and F. H. Chaudhny have reported on a wind-tunnel study in which a model of the city of Fort Wayne was constructed to a horizontal scale of 1:4000 and a vertical scale of 1:2000. The dynamic similarity between wind tunnel and natural full-scale flows was achieved by designing the model so that flow over it was fully rough, which was considered to be more crucial than strict geometric similarity which was compromised by exaggerating the vertical scale. In addition, the approach flow in the model was made similar to the atmospheric boundary layer. The pattern of the heat island over Fort Wayne was reproduced almost exactly in the model. Simulation of diffusion from an aerial line source was accomplished and compared well with field data. The model was found to give the same overall picture of the effect of the city on dispersion processes as that observed in the field. The results showed that the heat island effect vitiates the environment by bringing pollutants down from elevated releases through enhanced vertical mixing. The results of the study have proved that it is indeed possible to simulate the flow over a city and obtain useful information. This investigation opens the way for systematic studies of air-pollution problems for purposes of urban planning, particularly concerning the location of industrial sites relative to major topological features, the groupings of tall buildings, and the judicious placement of open and residential areas to minimize air pollution potentials under adverse meteorological considerations.

Hypoxia

The generalized response of the body to any stress involved the controlled interaction of the hypothalamus and pituitary gland in the brain acting on the cortex of the adrenal gland in the abdomen. The adrenal is stimulated to release hormones (*e.g.* cortisol) into the blood stream which cause large amounts of glucose, fatty acids and amino acids to be dumped in the blood stream. These first serve as sources of quick energy and the latter serves as building blocks for the repair of any tissue proteins that might be damaged during the stress. In addition to this general response, each individual type of stress has its own specific set of responses that overlie the general stress response.

Hypoxia is a stressful condition in which insufficient oxygen reaches the tissues of the body. This condition can arise from various disease states; ingestion of toxic agents; altitude or faulty breathing equipment. Although the ultimate end in hypoxia can be death, the initial stages are far from stressful and may, in fact, involve feelings of euphoria. The mechanisms involved in the responses of the nervous respiratory and circulatory systems to deliver more highly oxygenated blood to the tissues are well known. The mechanisms for the involvement of the hypothalamus, pituitary and adrenals are not that well known.

The respiratory response to hypoxia involves a marked increase in respiration rate with the subsequent wash-out of carbon dioxide from the blood. Effects due to the changes in carbon dioxide content (measured in terms of pCO_2) of

blood are difficult to separate out from effects due to changes in pH. As a first approach to studying the mechanisms of involving the hormonal system, Dr. S. Marotta, one of the investigators in the Physiology Program from the Universiy of Illinois Medical Center (NR 101-580) developed a technique whereby he could vary the pH of the cerebrospinal fluid in the brain independently of the pCO_2.

Using indwelling cannulae in the ventricular system of the brain of anesthetized dogs, he was able to perfuse an artificail cerebrospinal fluid (CFS) over the hypothalamus. At the same time an indwelling cannula in the adrenal vein periodically sampled blood leaving the adrenal gland. The animal breathed either air or an hypoxic mixture while the perfusing fluid in the brain was varied as to pH. He found that the normal pH in an animal breathing air had no effect on the release of cortisol from the adrenal gland but that the more acidic pH facilitated the release of cortisol while the basic CSF inhibited the release. Hypoxia itself markedly increased the level of cortisol while an acidic pH greatly augmented this effect and a basic pH suppressed the release of cortisol. This effect could possibly explain the feeling of euphoria that first affects the victim of hypoxia.

Exhaustive Study of Shipboard Life Launched by Navy

More than 20 ships and 7000 people are involved in what is perhaps the Navy's largest organizational study of life aboard ships. Sponsored by the Office of Naval Research and the Bureau of Medicine and Surgery, the study just underway is aimed at a first-hand analysis of the effects of various shipboard conditions on the health, morale, and generally, the effectiveness of ship crews.

The findings of the three-year long study are expected to help the Navy improve methods to select and assign personnel, provide optimum medical care, and reduce health and morale problems. These conditions are necessary, the Navy feels, to continue attracting and retaining qualified personnel.

The study is being conducted by the Institute of Behavioral Research at Texas Christian University and the Navy Medical Neuropsychiatric Unit, San Diego, California. The subjects of the study are men from ships of the Atlantic and Pacific Fleets, ranging from destroyers to an aircraft carrier. Also participating are shore stations, Navy hospitals and a few isolated posts.

The information will be collected by means of personal interviews with enlisted men and officers, questionnaires, and on-site observations of existing conditions.

The objective of the investigation is to obtain accurate measurements of individual and group illness rates, work performance, absenteeism, disciplinary problems, premature separation from service, health hazards, drug abuse and other indicators of ineffectiveness. Also studied will be the traditional complaints of ship crews, such as long duty at sea, lack of adequate space, comfort and privacy, and separation from family. The researchers expect to be able to establish the relationship of these factors to individual or group performance.

The findings will be utilized by the Navy in personnel training programs, forecasting and prevention of drug abuse, health care delivery, changes in the leadership structure, selection and assignment, as well as in the design of work and recreation areas.

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The Birth of Hurricane Agnes

The formation of hurricanes is a problem which has continued to elude meteorologists. Not much can be said about an incipient hurricane until it has essentially formed and appears as a large suspicious-looking cloud mass in satellite photographs. Dr. Jerome Namais, a meteorologist at the Scripps Institution of Oceanography, has postulated that the complexity of this problem may be due to the fact that different hurricanes have different or even multiple causes. As a spin-off from his NORPAX-related work, Dr. Namais has suggested such an example in the following chain of events which led to the birth of last summer's Hurricane Agnes.

Using a series of ATS-3 satellite pictures, a small nucleating cloud cluster several hundred miles in diameter was observed forming off the coast of Peru on 9 June. It migrated northward, crossed Panama, and then reached the area between Yucatan and Cuba. In this area it met an intense southward-moving cold front, increased in strength, and on 15 June was first observed—as a tropical storm. On the 17th it was designated a hurricane, and on the 19th it hit Florida and moved inland. It went out to sea across Hatteras two days later, regained strength, and went inland again. It merged with a storm system moving down from the Great Lakes region and gradually dissipated, producing record rainfall in much of the east. Dr. Namais has suggested that, from off the coast of Peru (where an El Nino was occurring) to the Atlantic waters (subjected to a previously warm winter), Agnes passed over anomalously-warm water, thus increasing convective activity. This, together with the interaction with the cold front near Cuba and with the storm from the Great Lakes region, provided sufficient opportunity for Agnes to obtain the energy for her long life.

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Cover Caption

Detail of a Roman mosaic pavement from Egypt. The hub of the sun, from which the spiraling rays emerge, is of real gold. The dynamic character of the mosaic is apparent in the rays, which are reminiscent of the protuberance flung out by the real sun. Four vine leaves surround the circle, while in the center we see a Bacchant with wineskin and jar. The dionysian traits of the picture are unmistakable.

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