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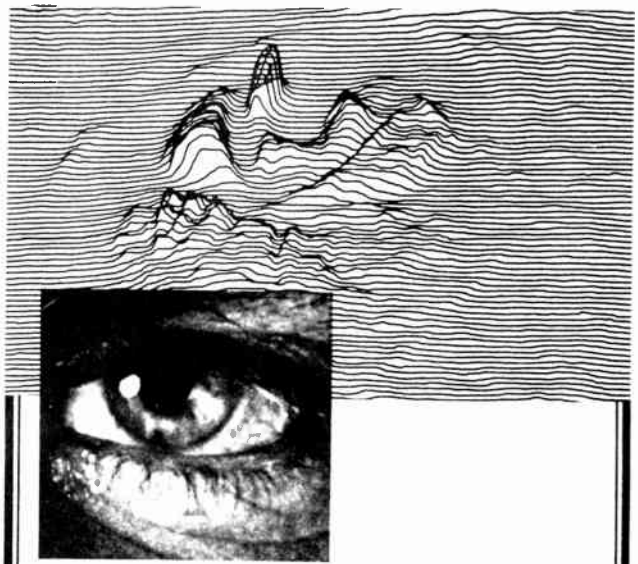
the cover

Donald Fink, Director Emeritus of IEEE and a long-time amateur astronomer, took the photograph that illustrates the article (p. 42) on listening for signals from outer space. Mr. Fink used a Nikon FTN at f/1.4, ASA 500 film, and a 15-minute exposure. The camera moved with the stars by means of a Questar tracking clock. Our "signal" emanates from the vicinity of Sador (gamma Cygnus).



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spectral lines

Fact vs. feeling

Lately one hears a great amount of criticism of the technical community because it so seldom expresses an opinion unequivocally. What the lawmakers need, we are told, is a clear cut yes or no from the experts on questions involving permitting the *Concorde* into the U.S., or proceeding at full speed in constructing nuclear power plants. Engineers (or scientists) must "speak with one voice," we are told.

A danger resides in this repetitious demand for unity of opinion: technologists may be lured into forcing a consensus where one does not exist. Yet, given the choice between expert and nonexpert "lobbying" in scientific matters, most of us would prefer to see the expert view prevail even if that view is not based 100 percent on fact. Perhaps the thought here is: as long as our sociotechnical future is to be determined in the political arena, let's see to it that the emotion-quotient necessary to the formation of public policy be provided by the scientists and engineers rather than less well-informed interests.

There may be some sense to this view. We are living in an age when policy decisions too often *must* be made before the "facts are in." The too-frequent consequence: retrofits or even abandonment of misguided policy. Nevertheless, premature judgments and ill-informed decisions are being made daily whether engineers and scientists like it or not. So why not, the argument seems to go, make mistakes out of knowledge rather than out of ignorance?

There are several reasons why not. One danger is the damage that can be done to the overall credibility, within and outside the profession, of scientific judgment. A second danger is the possibility that as the expert allows himself to be lured into not-quite-expert judgments, he may begin to find simplistic answers habit-forming and self-deluding.

Alvin Weinberg, director of the Institute for Energy Analysis, observed in a recent issue of *Science*,[1] "The debate on most matters at the intersection of science and society is largely conducted in the public, not the scientific, forum. When scientists express opinions on scientific matters in the public forum they are not subject to the sanctions that regulate opinions expressed in the usual channels of scientific communication. Because these traditional sanctions do not operate, the extra-scientific debate often tends to be irresponsible scientifically; lower standards of proof are demanded in the public than in the professional debate, and half-truths are perpetrated on the public by scientists."

In this regard, he noted recent pronuclear power and antinuclear power petitions signed by groups of scientists, and he suggested that the signers of both petitions were implying that they possessed adequate knowledge to make judgments on nuclear power. "How many of the signers of either petition had studied nuclear power sufficiently to have a responsible scientific opinion on this complex issue?" asked Weinberg.

Suggesting that most issues at the junction of science and policy cannot be answered unequivocally—either because science has not progressed sufficiently or because the issue is unresolvable in principle—Weinberg pleads for greater responsibility on the part of scientists when they engage in scientific debate in the public forum. When they engage in "informed guessing," let them at least clearly distinguish between judgments that are firmly based on scientific fact and those that are based on less than scientific fact. (Such an exercise, he suggests, might mean more "I don't know" answers from the experts—not an undesirable result.)

The implementation of such a recommendation may be the only feasible way to separate fact from feeling, thereby permitting the technical expert to retain his credibility with both the public at large and in the eyes of his colleagues, while, at the same time, adding his expertise to public debate.

Some scientists have made notable attempts to testify only with regard to the facts when the public interest was at stake, and literally to disguise their own judgments, or to withhold them in the interest of retaining their scientific credibility. For example, the Reactor Safety Study (*Spectrum*, January, p. 41), which projected probable hazards due to the operation of 100 commercial nuclear power plants in the U.S., clearly makes no attempt to judge the acceptability of nuclear risks, but rather leaves it to a broader segment of society than that involved in the study to make that judgment.

On the other hand, it is quite possible that members of the study team, viewing the identical data and projections, might reach different conclusions concerning the desirability of nuclear power. Should they not be able to speak out, to expose their own assessments of the impact of the studies, and to make their individual recommendations known to the public?

We think the answer should be yes, and that they can retain their credibility as objective technical experts, while disagreeing about the way in which society should respond in its own best interests.

Donald Christiansen, Editor

1. Weinberg, Alvin M., "Science in the public forum: keeping it honest," *Science*, vol. 191, p. 341, Jan. 30, 1976.

Components

Batteries: today and tomorrow

Developments have been steady if not spectacular—the result: microwatts (now) for LCDs, megawatts (soon) for utility load leveling

Battery systems have enjoyed several important and ongoing technical improvements during recent years, but they tend to go almost unnoticed because they lack the element of surprise often associated with changing technology—such as accompanied the calculator, the digital watch, or space exploration. New battery systems enter the market gradually, often from military and other "price-is-no-object" applications, rather than suddenly appearing "in quantity and inexpensive," pushing older products into obsolescence. And predictions dating from the 1950s—of fuel cells and other "superbatteries" replacing the internal combustion engine—still seem far off. But several new batteries are on the market that give performance far superior to carbon-zinc and "wet" lead-acid designs.

Many of the most visible battery improvements involve primary (nonrechargeable) cells for toys, flashlights, watches, and hearing aids. The common alkaline battery varieties containing manganese dioxide and mercuric oxide (separately or in combination) are one example. Others include the zinc-air battery developed by Gould and now undergoing field tests with consumers, and the extremely high energy density lithium battery just now becoming available.

Appliances requiring more current (tape players, cordless tools, calculators, TV sets) have benefited from secondary (rechargeable) systems based on nickel-cadmium and sealed lead-acid cells. A large portion of future secondary battery development involves high-temperature batteries, most notably, sodium-sulfur, sodium-antimony chloride, and lithium-iron sulfide. Evaluating these systems involves tradeoffs between energy density, cycle life, materials/manufacturing cost, and charging methods. No sure winner is forecast, and parallel development efforts are underway.

Power in the primaries

Since its introduction over 100 years ago, the "Leclanché" cell (zinc anode, manganese dioxide cathode, and electrolyte of ammonium chloride and zinc chloride dissolved in water) has dominated the primary battery market. Because a carbon rod often serves as the positive terminal, these cells are popularly known as carbon-zinc cells. The blister packs of flashlight and transistor radio batteries adorning most supermarket, drug, and hardware store counters testify to an enduring popularity—and not without good cause. Carbon-zinc cells are inexpensive, widely available in many voltage/size combinations, and well suited to most intermittent-, light-, or medium-drain applications.

Novel packaging configurations have actually expanded the use of carbon-zinc cells in recent years. For example, the Polaroid SX-70 color film pack includes a 6-volt carbon-zinc battery containing all the energy to run the camera's small motor and flash attachment for ten exposures. The flat, rectangular battery stack was designed for Polaroid by the Ray-O-Vac Division of ESB Inc., Madison, Wis.

A close relative of the Leclanché system that holds promise because it uses most of the same inexpensive ingredients is the zinc-chloride cell. Instead of an electrolyte made from a solution of ammonium chloride and zinc chloride (Leclanché), the zinc-chloride cell uses only zinc chloride as the electrolyte while retaining the familiar carbon rod, manganese dioxide, and zinc can. The ammonium chloride in the Leclanché cell prevents oxygen from the air from reacting with the zinc electrode, a necessary feature for a reasonably long shelf life, but inhibits the electrochemical action. The better sealing techniques adopted for zinc-chloride cells eliminate the need for ammonium chloride, resulting in a battery that gives much improved performance with heavy, continuous use. And zinc-chloride batteries have the added advantage of being "dry" when fully discharged, greatly reducing the opportunity for corrosive leaks. Both Union Carbide and Ray-O-Vac are actively marketing zinc-chloride batteries.

Next most common among primaries are the alkaline batteries. They all employ a potassium hydroxide or sodium hydroxide electrolyte, and include the manganese dioxide type delivering 1.5 volts per cell open circuit (sold as one-on-one replacements for Leclanché batteries), and the mercuric oxide varieties most often fabricated in a "button" package for hearing aids. Of the two types of mercuric oxide cell manufactured, one has an open-circuit voltage of 1.4 volts, and the other an open-circuit voltage of 1.35 volts. The only difference between the cell constructions is in the cathode material. The higher-voltage cells use some manganese dioxide in combination with mercuric oxide, whereas the lower-voltage cells contain only mercuric oxide.

Batteries built with these cells have a flat discharge curve, excellent capacity retention, and high energy density. The standard mercuric oxide cell (without manganese dioxide) is often used as a stable voltage reference for electronic and medical instruments. A leading producer of both mercuric oxide and manganese dioxide batteries, and a pioneer in the field, is the Mallory Battery Co., Tarrytown, N.Y. Other active manufacturers include Union Carbide, New York, N.Y., Ray-O-Vac, and Matsushita (Panasonic). Mallory is also aware of the battery-handling problems involving consumer products that use several single alkaline cells to develop the required voltage. Old and new

Don Mennie Associate Editor

are mixed or polarity is not observed. As a result, Mallory has introduced the Flat-Pak® cartridge battery, keyed so it can only be inserted properly.

Another primary battery in common use contains silver oxide and an alkaline electrolyte. Like many of the mercuric oxide batteries, silver oxide batteries are also made in button packages, specifically for low-rate, continuous-drain applications. They have been most important to the digital watch industry where they meet the demands of small size coupled with up to a one-year replacement interval. Other common uses include powering hearing aids and the automatic exposure mechanism in 35-mm cameras.

Seeking even better performance, Ray-O-Vac has pushed development of the divalent silver oxide cell. Branded Silver II® by Ray-O-Vac, these batteries offer greater capacity compared with standard (monovalent) silver oxide types. By the use of special voltage-depression techniques, the normal 1.8-volt open-circuit voltage of the divalent battery is reduced to 1.5 volts, making it compatible with watch electronics designed around the older monovalent cell.

Emerging—or merely exotic?

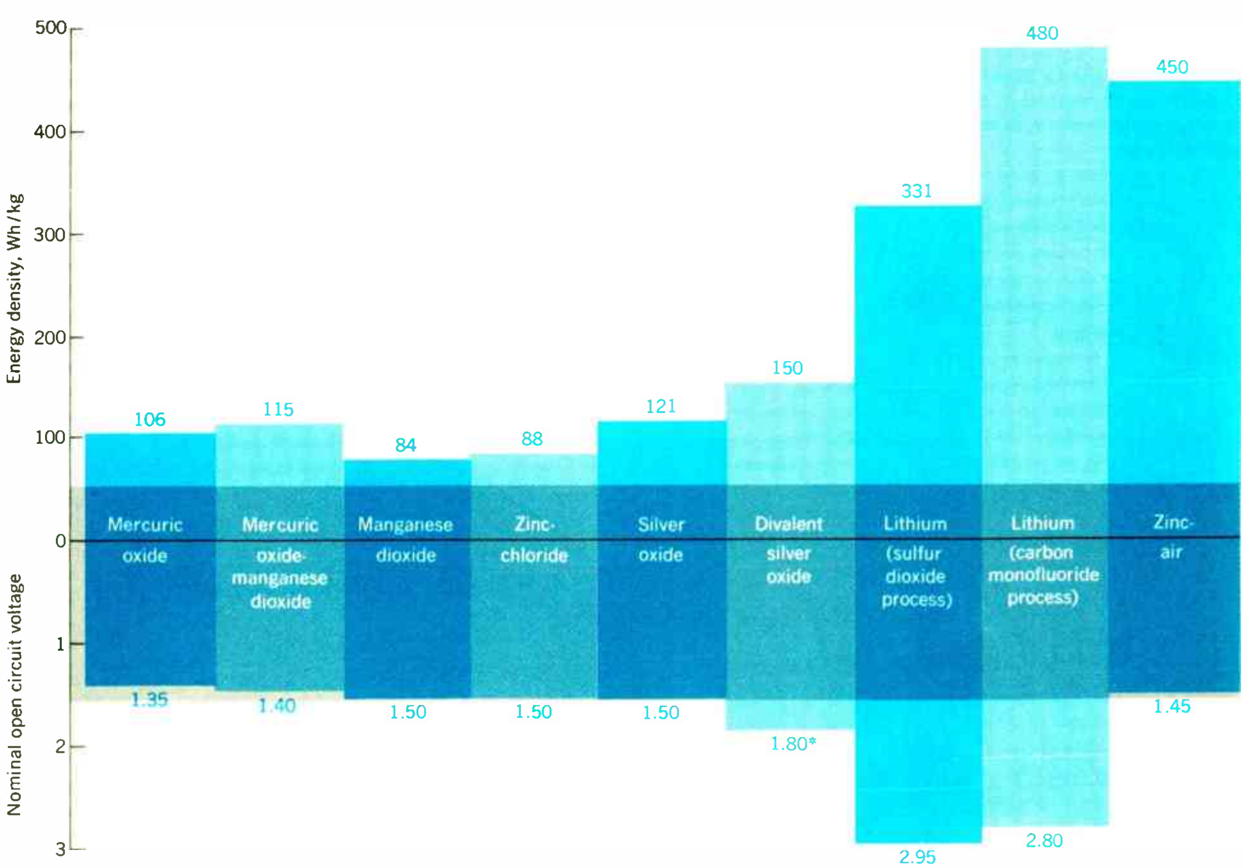
Really spectacular improvements in energy density for primary cells are being projected—and in some cases demonstrated—by developers of the lithium battery (Fig. 1) and the zinc-air battery (Fig. 2). The lithium story is a bit involved, since all that most companies will reveal about their efforts is that they, indeed, use lithium.

Spectrum found at least two completely different approaches being exploited to produce a finished battery. The method championed by Mallory and by Power Conversion Inc., Mount Vernon, N.Y., utilizes a lithium anode, organic electrolyte, and proprietary cathode material. Finished batteries produced in this manner contain some sulfur dioxide gas, of which trace amounts are vented during use. Mallory is also developing a hermetically sealed lithium cell intended for consumer use.

Consumers who didn't flinch at spending $10 for a flashlight got their first chance to try out Power Conversion's Eternacell 10® this past Christmas. Sold through Abercrombie & Fitch, Wallach's, and other department stores, the flashlight package included a mail-in offer for replacement lithium cells at $3.50 each. Power Conversion explains that development of an elastomer crimped seal, effectively containing the sulfur dioxide gas, is responsible for this early introduction at the consumer level.

By contrast, the Japanese-based Matsushita company has concentrated on producing lithium cells using carbon monofluoride as the cathode. Sample quantities of this product are available in the U.S. through Panasonic under the National brand name. C-size cells

Here's how the Leclanché or "carbon-zinc" dry cell (grey band) stacks up against several other available and emerging primary cells on an energy density and voltage basis (color bars). The data for energy density apply to *normal* discharge conditions (i.e., a silver oxide battery used in a watch, not in a flashlight), and will be significantly less for batteries that are drained rapidly or used at very high or low ambient temperatures. High open-circuit potential is an important advantage since batteries made from such cells need fewer layers to develop the desired terminal voltage, and thus are simpler to assemble. When battery *volume* is critical, energy density data should be obtained in Wh/cm³.



* Reduced to 1.50 by voltage depression techniques in commercial batteries

are tagged at $6 each in small quantities.

Spectrum questioned several battery manufacturers on the future of lithium cells, and expectations ranged from prospects of a solid, growing market soon to cautious skepticism based on the (present) high cost of producing and processing lithium. On a watthours-per-dollar basis, lithium batteries are approaching a competitive position for some alkaline battery applications, but are still far from touching the vast trade in the Leclanché product.

Development of a commercial zinc-air battery is essentially under the sponsorship of Gould Inc., St. Paul, Minn. (Fig. 2), although Ray-O-Vac also reports supporting some experimental work. The immediate object is to produce high-energy zinc-air "replacement" button cells for the many hearing aids and other tiny electronics now using mercuric oxide and silver oxide batteries. Gould's button-cell design combines a conventional slurry zinc anode with a novel cathode structure that extracts oxygen (one of the cell's reactants) directly from the ambient air. This "air cathode" eliminates any need to contain active cathodic material within the cell. Accordingly, zinc-air cells contain more anodic material, giving them greater capacity than conventional alternatives. Several air cathode implementations are plausible; Gould's approach derives from fuel cell developments and uses a thin catalyzed conducting screen backed with a hydrophobic membrane. Gould already has some zinc-air button cells under test by consumers who would normally buy mercuric oxide batteries for their hearing aids.

Finally on the subject of primary cells, the magnesium-manganese dioxide battery deserves a mention. It has been produced in large quantities for the military, most often as a power source for field radios. However, these batteries have two serious drawbacks, other than cost, that limit their future for commercial applications. First, the cells exhibit a very noticeable lag in responding to a demand for power when first connected to a circuit—they kind of "warm up" to the occasion. And second, once discharge has been initiated, the cells continue to self-discharge quite rapidly, even after the load has been removed.

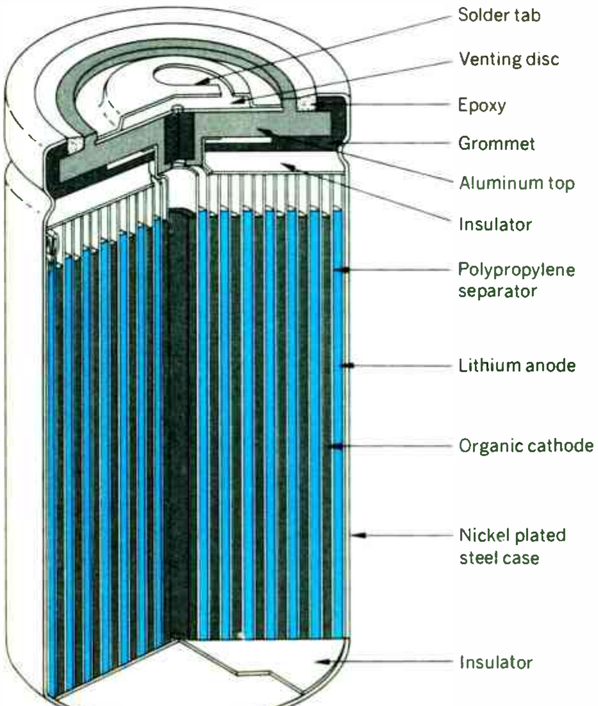
Sealing the secondaries

Because primary batteries are essentially a throw-away item, little justification exists for building them with expensive raw materials. And, high energy density or low, none have the economic characteristic (total cost per delivered kilowatthour) allowing them to handle the really big jobs slated for batteries in the future: powering electric vehicles and providing temporary energy storage for electric utility load leveling. As a result, much battery research effort is aimed at further developing secondary (rechargeable) systems.

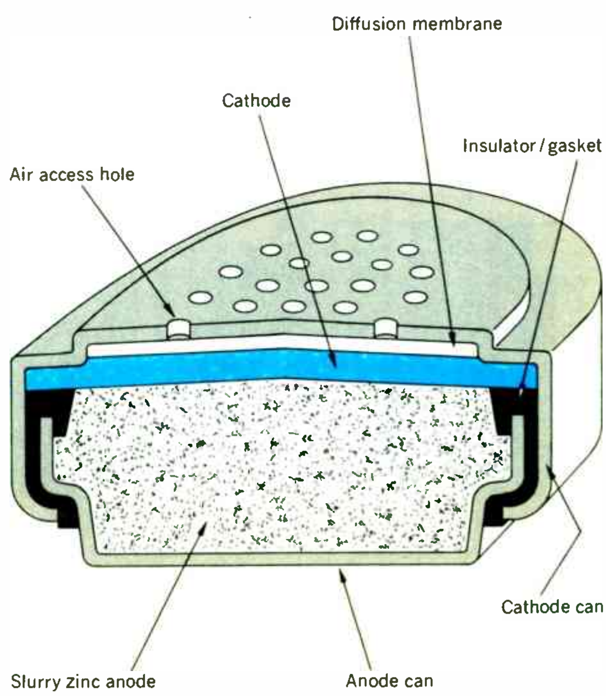
Practical, widely available secondary batteries now include only the lead-acid and nickel-cadmium types. Within these two categories, however, are several important varieties. Depending on the method used to reduce (or in some cases almost eliminate) gassing on overcharge, lead-acid secondary cells are now produced in "sealed" packages in addition to the "wet" automotive-type design that requires periodic topping off with distilled water. In fact, so-called "no maintenance" automotive batteries have become quite popular in the last couple of years. They are still lead-acid designs, but the familiar cell vent caps are gone.

New alloys used in constructing the battery's plates are mainly responsible for this development. Battery

[1] Lithium batteries, independently developed by several manufacturers, offer energy densities far greater than found in any other primary system. Construction of Mallory's organic lithium cell (shown here) involves spirally winding the foil anode (lithium), separator, and carbonaceous cathode. Since the electrolyte is nonaqueous, no hydrogen is evolved during cell discharge.



[2] This zinc-air "button" cell developed by Gould contains a novel cathode structure that extracts oxygen (one of the cell's reactants) from the air, eliminating the need for active cathodic material within the cell. Now undergoing field tests, Gould's design derives from fuel cell developments.



Battery brush-up

The performance and life of both primary and secondary systems are greatly affected by such variables as rate of discharge, depth of discharge, ambient temperature, and just plain aging. Each electrochemical system is unique in these respects, offering the user a wealth of tradeoffs to consider. Summarized here are several important terms relating to this issue. A more complete treatment is available in *The Gould Battery Handbook* edited by Gustav A. Mueller and available from Gould Inc., St. Paul, Minn.

Capacity (C)—The time integral of current to a specifies cutoff voltage (during discharge) expressed in ampere-hours (Ah). Where the discharge is conducted at a constant current, $C = It_c$. The capacity may be given at various time rates, such as the 5-hour rate or the 0.5-hour rate. If $1C$ is the rated capacity of the cell, the current drain at the 5-hour rate would be $C/5$ amperes. For numerical illustration, let $1C$ be 2.0 Ah, then the current to be drawn at the $C/5$ rate would be $2/5 = 0.4$ ampere.

Charge rate—Secondary cell (or battery) charging current expressed as a function of the cell's or battery's rated capacity. For example, the 20-hour charge rate of a 10-ampere-hour cell would be equal to $C/20 = 10/20 = 0.5$ ampere.

Cycle life—The total number of cycles (charge/discharge) before failure of a cell or battery. Failure can be either complete, as when a cell has an internal short, or it can be defined as a reduction of available capacity to a specific value under a given set of conditions for a specific secondary system.

Depth of discharge—The percentage of rated capacity to which a cell or battery is discharged. For example, if 5 ampere-hours of capacity is discharged from a 100-ampere-hour battery, the depth of discharge (DOD) is 5 percent.

Discharge rate—The current at which a cell or battery is discharged, frequently expressed as a function of its rated capacity. For example, the 0.5-hour rate discharge of a 5-ampere-hour cell would equal a discharge current of $C/0.5 = 5/0.5 = 10$ amperes. (In some battery systems, such as the lead-acid, a different method is used to determine capacity at a specified rate. In this method, the discharge current is adjusted so that the cutoff voltage is reached at a specified time.) All secondary cells are assigned a rate capacity based on a discharge rate, temperature, and cutoff voltage. (See "rated capacity.")

Energy output—The energy of a cell under specified conditions is equal to capacity times voltage, expressed in watthours (Wh). Specifically, assuming a constant current discharge, the energy output to a designated cutoff voltage, V_c, would be the integral of IV as a function of t (between t_o and t_c) where t_c would be the time to the cutoff voltage, V_c.

Energy density—Ratio of cell energy output to weight or volume: watthours per kilogram or watthours per cubic centimeter.

Rated capacity—The rated capacity of a cell is a conservative estimate of the amount of capacity that can be withdrawn from a freshly manufactured primary cell, or a fully charged secondary cell when discharged at a specified discharge rate. In all cases, the discharge temperature and cutoff voltage must be defined.

Shelf life—For a primary cell, the period of time, measured from the date of manufacture, at a storage temperature of 21°C, after which the cell retains a specified percentage of its original capacity.

makers have substituted calcium for antimony in these lead castings. The result is a lead-acid cell that produces very little hydrogen or oxygen gas unless overcharged. Self-sealing vents relieve any pressure build-up, and the automotive batteries of this type are designed with an extra measure of electrolyte over the plates so water removed by gassing will not cause an immediate loss in capacity.

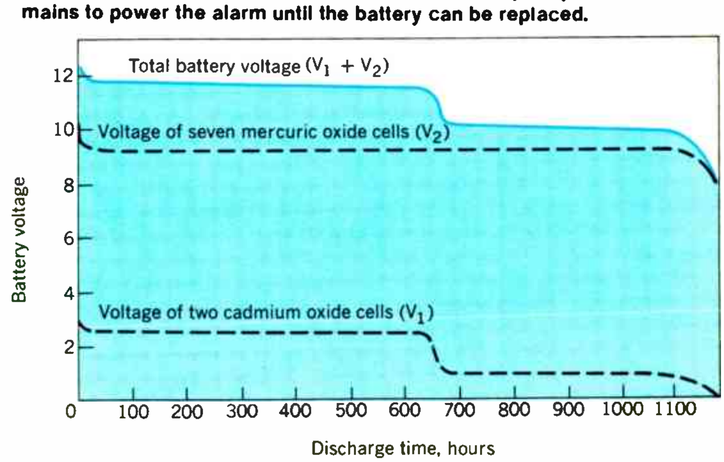
Smaller sealed lead-acid batteries, which also make use of the calcium-lead alloy and a "gelled" electrolyte, can be used in any position, and may be completely charged and discharged 200 to 500 times, depending on the charging system used. If not completely discharged, up to 1000 cycles of operation are possible. Batteries of this design—intended for small appliances, lanterns, and portable electronic test equipment—are available from Globe-Union Inc., Milwaukee, Wis.; Elpower, Santa Ana, Calif.; Gould; and Matsushita (Panasonic).

A completely different approach to sealed lead-acid design has been taken by Gates Energy Products, Denver, Colo. The Gates Energy Cell is built with pure lead plates—no calcium or antimony—and a "starved" electrolyte containing even less water than the "gelled" lead-acid batteries. Gates' design involves using very thin, closely spaced plates with a glass separator insensitive to chemical action. Electrolyte is conserved because gases produced during charge or even overcharge can recombine, much like the process in a sealed nickel-cadmium cell.

Nickel-cadmium cells, of course, comprise the other major category of secondary battery that portable electronic equipment designers can turn to as a source of power. These batteries are more expensive than lead-acid, but offer a greater cycle life as compensation, especially under deep discharge conditions. The "wet" variety is often used in aircraft electrical systems, whereas sealed cells are best suited for powering electric shavers, carving knives, calculators, hand tools, and portable audio equipment.

Sealed nickel-cadmium cell capacity is always deter-

Designed for powering smoke alarms with a voltage-sensitive "low battery" indicator, Mallory's model 304116 12.6-volt mercuric oxide/cadmium oxide battery delivers approximately 630 mAh over a nearly level discharge curve. Then the output quickly drops by 1.5 volts, activating a low battery sensor circuit in the smoke alarm. Sufficient capacity remains to power the alarm until the battery can be replaced.



mined by the quantity of active material (nickelic hydroxide) on the positive plate. This is a design feature to eliminate the opportunity for hydrogen gas to form during overcharge (chemical changes on both the positive and negative plates occur at the same rate and gassing could occur at both plates if they were of equal size). To make sure that only oxygen gas is formed during overcharge, the positive plate is purposely kept about 30 percent smaller (less active material) than the negative plate. Oxygen is desired because it has the ability to diffuse through the nylon (or polypropylene) separators and react with the cadmium metal and form cadmium hydroxide (uncharged negative plate material). This eliminates the opportunity for pressure buildup or loss of electrolyte through vented gas, providing overcharge rates are reasonable. Vented "wet" nickel-cadmium cells by contrast have a gas barrier between the plates to prevent oxygen recombination, and the distribution of active materials (between positive and negative plates) is nearly equal, giving maximum energy density.

Much of the adverse comment relating to nickel-cadmium cells involves what is termed "memory." Cells that are frequently discharged only a small amount and then immediately recharged many times over a long period are reported to not deliver rated capacity if pushed beyond the established discharge pattern. Such might be the case with a businessman's electric shaver constantly left on charge except during the morning routine before going to work. When the shaver (without charger) is packed off on a trip, it dies after one shave.

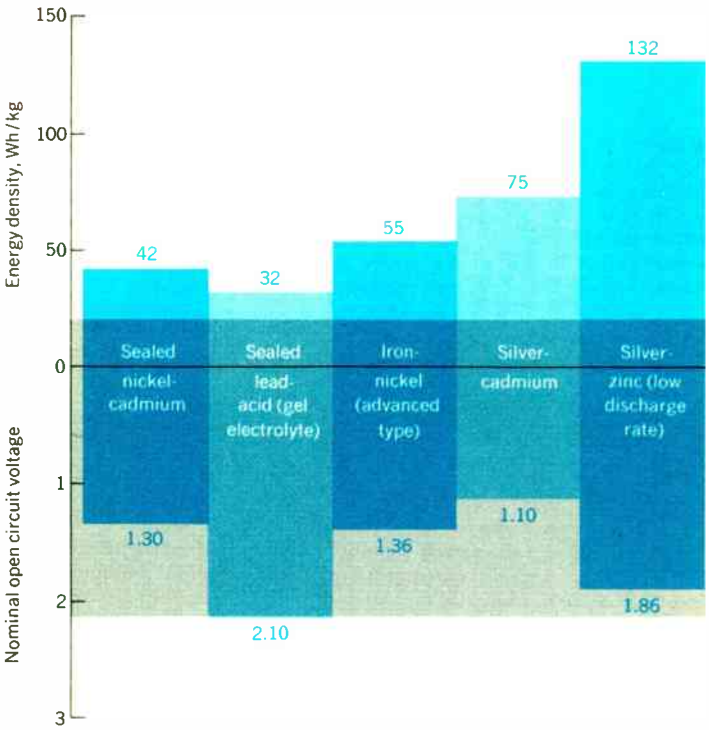
Opinion ranges widely on how serious or common this effect is. Lead-acid manufacturers mention it frequently, while nickel-cadmium manufacturers say the phenomenon is difficult to produce even under laboratory conditions. Whatever the circumstance, such "memory" can be easily erased by first discharging the affected battery completely; then recharging it to full capacity. (Open, shorted, or chemically deteriorated cells cannot be renewed by this method.)

Among the main advantages claimed for nickel-cadmium batteries is a deep-discharge life approaching 1000 cycles, excellent low-temperature performance, and long storage life. A complete treatment of the subject is to be found in the *Nickel-Cadmium Battery Application Engineering Handbook* edited by Joseph C. Grant and available from the General Electric Co., Battery Business Dept., Gainesville, Fla. GE is the major producer of nickel-cadmium batteries in the world; other companies include Gould, Matsushita, Union Carbide, and the Swedish-based NIFE Inc.

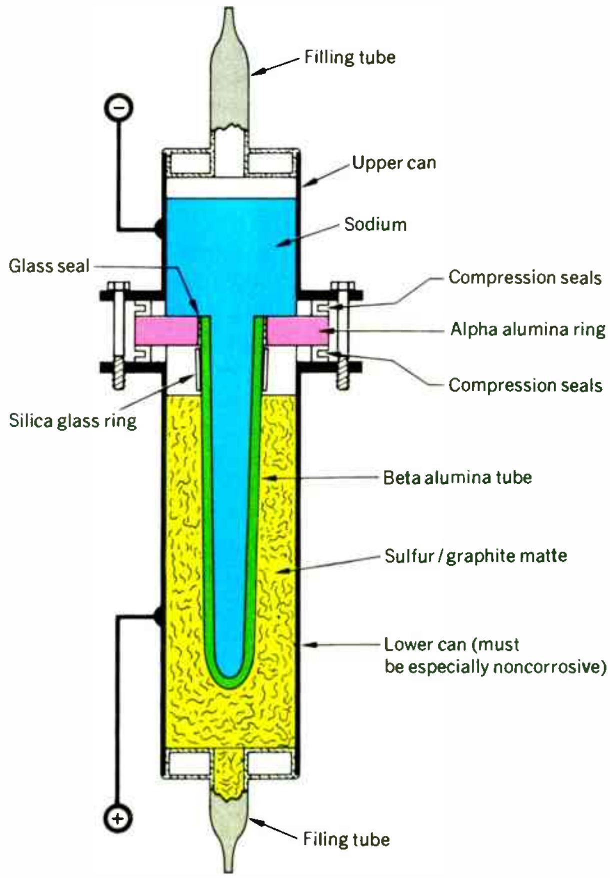
A look at the future

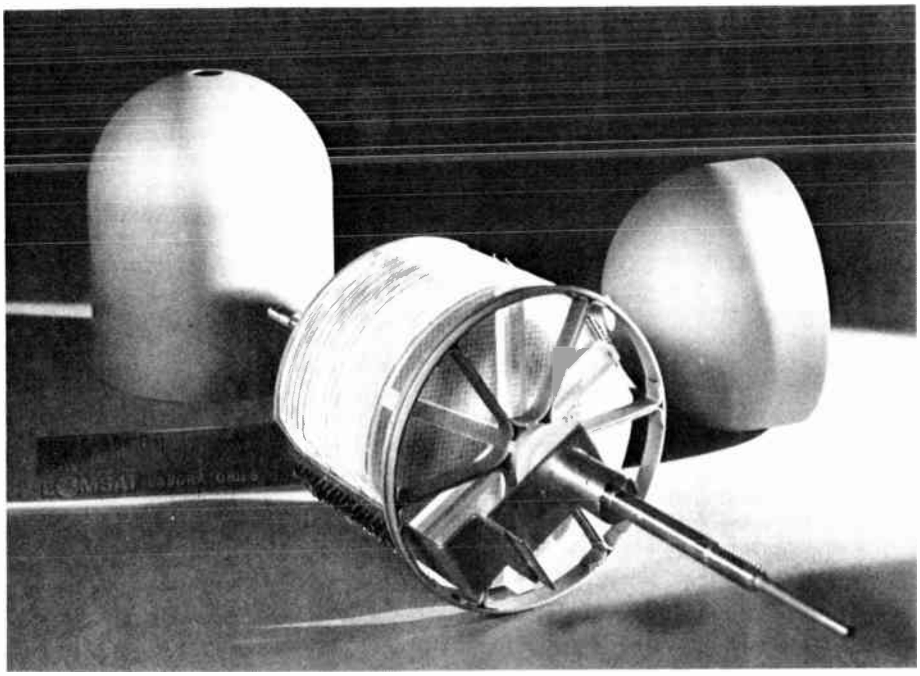
No doubt remains that better secondary battery systems must be developed if motorists are ever to be weaned away from the internal combustion engine. Electric utilities, interested in energy storage as a po-

The energy density and cell voltage for a "wet" lead-acid storage battery built with antimony alloy plates (grey band) are compared with several other important secondary systems (color bars). Of the commonly available types, sealed nickel-cadmium offers the best cycle life and low-temperature performance, while sealed lead-acid has the lowest initial cost and simplest charging requirements. Despite silver-zinc's very superior energy density, its expense and limited cycle life are serious drawbacks. Under development by Westinghouse, advanced iron-nickel batteries are a possible power source for electric vehicles.



[3] An important candidate for electric utility load-leveling applications is the high-temperature sodium-sulfur cell. To enhance conductivity, the sulfur electrode is formed as a matte of sulfur and graphite. Ion exchange takes place through the "solid" beta alumina ceramic electrolyte. Development programs are currently being funded through EPRI, ERDA, and the National Science Foundation.





Recently developed for aerospace use by COMSAT, the nickel-hydrogen secondary cell offers considerable energy density and cycle life advantages compared with nickel-cadmium, silver-zinc, and other rechargeable systems. Cells such as these will be fabricated into a battery and placed aboard the U.S. Navy's Navigational Technology Satellite (NTS-2) planned for launch this fall. The satellite needs battery power during periods of eclipse.

tentially better method of meeting peak demands, also place improved batteries high on their list of alternative solutions.

Direction for much of the research being carried out on behalf of the utilities is provided by the Electric Power Research Institute, Palo Alto, Calif. Project manager at EPRI, James R. Birk, spoke with *Spectrum* about the various programs EPRI is monitoring, and supplied status reports on much ongoing research.

One of the major secondary systems the utilities are looking at is the sodium-sulfur battery (Fig. 3). Funded development work on sodium-sulfur is currently underway at General Electric and TRW Systems; and, with U.S. Energy Research and Development Administration (ERDA) support, at Ford and Dow. One of the high-temperature-type batteries, it operates at about 300°C. Important advantages include low-cost raw material and liquid electrodes that are able to reform without sloughing. Problems still to be fully resolved involve cycleability of the solid electrolyte and positive molten sulfur electrode, seals, and development of a corrosion-proof container for the positive electrode.

Another strong candidate among the high-temperature secondaries is based on a lithium-metal sulfide composition. Liquid lithium or lithium alloyed with aluminum or silicon is being used as the negative electrode while iron sulfides (FeS or FeS_2) serve as the positive electrode. Electrolytes are a eutectic mixture of molten salts (lithium chloride and potassium chloride) at 400–450°C. Dr. Birk reports that much engineering work remains to be completed, but the basic system is promising. Laboratory lithium-metal sulfide cells are reported to have given 350 deep-discharge cycles with only a 2-percent loss in capacity. Major efforts in this area are being conducted at Argonne National Laboratory and Atomics International (division of Rockwell International). Problems still facing lithium-metal sulfide developers include building a better container for the positive electrode and improving the ceramic separator between electrodes. Lower cell voltage and the cost of lithium are economic disadvantages as compared with sodium-sulfur.

More work on high-temperature batteries is underway at ESB Inc.'s Technology Center in Yardley, Pa. This is the sodium-antimony trichloride cell operating at 200°C, which is displaying promising life-test results for small laboratory cells. A potential cost advantage is claimed for the polymeric seals that can be used in the sodium-antimony trichloride system because of the system's significantly lower temperature (compared with sodium-sulfur).

Most of EPRI's battery programs involve high-temperature, nonaqueous systems. The notable exception is the zinc-chlorine system under development by Energy Development Associates (a joint venture of Occidental Gulf and Western). In physical appearance, the zinc-chlorine cell is really more of a "chemical plant" than a battery. It uses pumps and refrigeration equipment to handle chlorine as a gas, and store it as chlorine hydrate. This "yellow ice" is a stable compound at 9.6°C, and can be held in the bare hands safely. To date, tests with a 1-kWh EDA breadboard cell indicate that near 75-percent electrochemical efficiency has been obtained for over 100 deep-discharge/charge cycles. These tests are continuing. At present, the EDA battery must be fully discharged before recharging.

Ultimately, as far as EPRI is concerned, the best battery for utility load leveling may only emerge after extensive testing of rather large (e.g., 5 MWh) battery energy storage systems. Plans are in the works to set up a National Battery Energy Storage Test (BEST) Facility to implement such evaluations. When completed, the testing site will be open to all comers. Present projections show that testing could begin with advanced lead-acid batteries in 1979, and run through the mid-1980s as more exotic systems become available. Working together with ERDA, EPRI has already secured commitment for a test site at the Public Service Electric and Gas Co., Newark, N.J., the result of competitive selection among several utilities. The BEST facility is expected to become a focal point of battery developers, utilities, EPRI, and ERDA. ◆

Communications

An ear to the universe

Sensitive antennas, pattern recognizing computers, and informed conjecture are being tuned to possible signals from the stars

Right now, electromagnetic waves from a civilization outside the solar system may be passing through this page. Although such waves may be at levels too low to be detected with present equipment, there are good reasons for believing they exist. Thirty years ago, most astronomers thought that man was alone in the galaxy. Today, it is believed by most (but not all) knowledgeable scientists that in our galaxy there are billions of stars with planets on which life could originate. It is probable, therefore, that there exist a great many civilizations capable of communicating—or at least making themselves known to us.

Today, in fact, astronomers are more likely to discuss ways of discovering extraterrestrial civilizations than to debate their existence. One reflection of the seriousness U.S. scientists accord to the search is a project at the National Aeronautics and Space Agency's Ames Research Center to determine the feasibility of looking for signals. Known as the Search for Extraterrestrial Intelligence (SETI), the project is small (funded at a rate about 0.0001 that of the Apollo Project) but work has proceeded for nearly five years, beginning in 1971 with a summer study called Project Cyclops under the direction of Bernard M. Oliver of Hewlett-Packard.

The SETI team is presently studying advanced technologies to determine whether they can provide improvements and cost reductions. In addition, the team is performing preliminary system design, elaborating search strategies, and supporting some related development efforts (especially in data processing). Finally, the team is studying schemes for detecting signals—a prerequisite to communication. The plan right now is only to listen—transmitting a response would involve a whole added set of problems—but deciding how best to listen is, in itself, a project.

At various times, a number of signal types have been mentioned as possible communication media. Current

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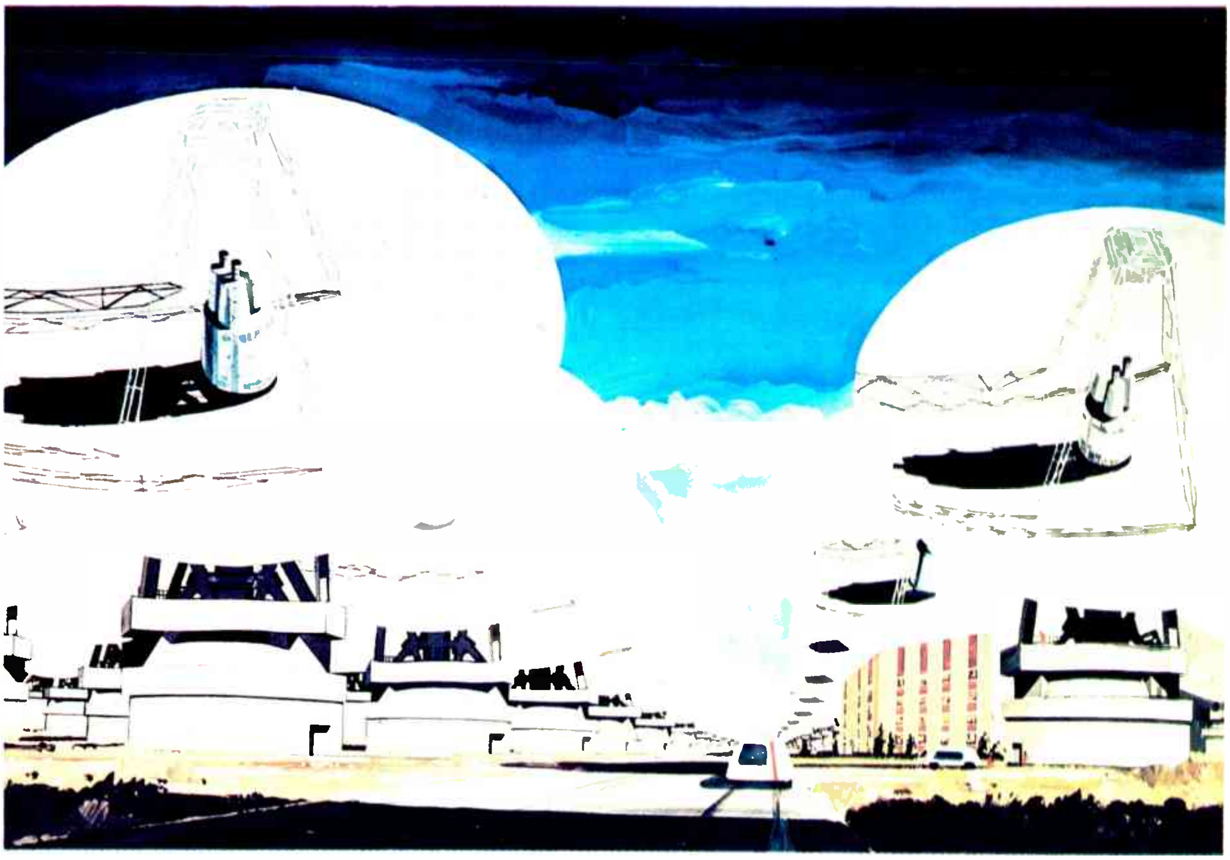
Antennas designed to receive intelligent interstellar signals might appear, from the ground, like a forest of huge round trees. Control and processing equipment could be housed in a central building.



thought is that only electromagnetic radiation offers a reasonable hope of providing a detectable signal. Within the electromagnetic spectrum, microwave frequencies are the most promising region for extraterrestrial signals. Efforts have been focused on this region because it contains the hydrogen line at 1.420 GHz—the most prominent radio line in the sky—and the strong hydroxyl line at 1.667 GHz. It is thought that these frequencies and the range between them must appear especially interesting to any life on the chemistry of water (hydrogen plus hydroxyl). Consequently, where are we most likely to "meet"? At the water hole!

X rays or higher-frequency radiation have been rejected as possibilities because of their high energy per quantum. Ultraviolet radiation at about 10^{-7} meters would be only barely possible: such a signal beamed at the earth from a nearby star for the purpose of making contact could be detected because the blackbody radiation from the star—with which the signal must compete—is very low at this frequency, and because high antenna gain is possible. A 1-kW laser operating at 100 nanometers with a 10-meter transmitting dish could produce 25 photons per second in a 10-meter receiving dish at a distance of ten light-years—perhaps the maximum range for such a system. The dishes would have to be precise and the beam would be so narrow that, if pointed at the sun, it would miss the earth by a wide margin.

Ultraviolet signals are occasionally sought using spaceborne telescopes, but the Ames group is concentrating on systems with greater range, in the belief that the probability of success is low if only the nearest stars are examined. After all, there are about a million times as many stars within 1000 light-years as there are within ten light-years.

Visible and near-infrared radiation appear impossible because of the overwhelming background radiation in this range from the nearby star. Far-infrared radiation is considered possible by some Soviet scientists, for reasons the Ames scientists do not find compelling.

The microwave region permits signal detection (or communication) at minimum energy. At frequencies below the microwave region, the background galactic noise becomes prohibitive; at higher frequencies, the quantum noise (high energy cost per photon) becomes prohibitive.

The minimum energy microwave range is broad, extending from about 1 to 60 GHz. But the earth's atmosphere attenuates the upper range, narrowing the window for ground-based systems to about 1 to 10 GHz. If antenna cost and sensitivity to Doppler frequency shifts are taken into account, the window narrows even further to 1 to 2 GHz. Fortunately, this includes the 1.420- to 1.667-GHz water hole. Although assumptions

Drake's equation

Astronomer Frank Drake of Cornell University, in his *Intelligent Life in Space* (Macmillan), wrote, "At this very minute, with almost absolute certainty, radio waves sent forth by other intelligent civilizations are falling on the earth. A telescope can be built that, pointed to the right place and tuned to the right frequency, could discover these waves." Drake's "almost absolute certainty" is based on an equation he developed for N, the number of technologically advanced extraterrestrial civilizations that are communicating:

$$N = Rf_s f_p n_e f_l f_i f_c L$$

In Drake's equation, R, the average rate of star formation in the galaxy, is equal to about 20 stars per year. While f_s, the fraction of stars that are suitable "suns" for planetary systems, is about 0.1; most stars belong to class *M* (see Table) and are probably too small, whereas a few, such as *O* and *B* stars, are almost surely too short-lived. The fraction of "good" stars with planetary systems, f_p, is now thought to be around ½—a value that has helped change scientists' minds about the possibility of extraterrestrial signals. Thirty years ago, f_p was estimated at a pessimistic 10^{-9}.

The mean number of planets suitable for life, within such planetary systems, n_e, is probably greater than 1. The value depends on what is considered necessary for life, but even if liquid water is assumed necessary, there are probably several planets per solar system that are neither too hot (like Mercury) nor too cold (like Neptune). Even secondary satellites, such as the large moons of Jupiter and Saturn, may be among the suitable habitats.

Estimates of f_l, the fraction of such planets on which life actually originates, have changed recently, and have given more reason for optimism. Thirty years ago, it was hard to conceive how the organic matter of life could originate. Since then, it has been demonstrated that a mixture of methane, ammonia, water, and hydrogen gases (which are constituents of Jupiter's atmosphere) is transformed by ultraviolet light or electric sparks into a wide variety of amino acids, and precursors of nucleotide bases, sugars, and other components of living matter. Some key remaining steps are obscure—it is still not known how replicating substances such as DNA–RNA are synthesized, or how a cell or sex develops. But in an ocean full of organic molecules and with lots of time, these steps do not appear improbable.

The fraction of such planets on which, after the origin of life, some form of intelligence arises—represented by f_i in Drake's equation—is also thought to be high. Evolution doubtless takes place wherever life arises, and intelligence has survival value.

It is intriguing to speculate on the value of f_c, the fraction of such intelligent species that develop the ability and desire to communicate with other civilizations. The intelligent beings might be like porpoises and therefore be unlikely to build radiotelescopes, or they may not have developed writing and therefore cannot accumulate knowledge, or they may have rejected technology and developed a pastoral society, or they may have developed a rigid 1984-type civilization in which such a thing as interstellar communication is discouraged. Nevertheless, few people are so pessimistic as to put the value of f_c below 0.1.

The mean lifetime, L, in years, of a communicative civilization might be zero if its members destroy each other before they can communicate, or it may be millions or billions of years if they solve their sociological problems. Because the value of L depends on the nature of a civilization that is surely very different from ours, and because even our own society isn't clearly understood, this factor is the most uncertain on the right-hand side of Drake's equation.

Since R is about 20, and since the product of the next six factors is probably not much below 0.05, N may be numerically almost equal to L—which means that there may indeed be a large number trying to establish contact.

R.E.M.

about the kind of signal a strange civilization might send us are fraught with uncertainty, and there is danger of being too anthropocentric, the microwave region seems to be a reasonable place either for a meeting or for eavesdropping.

As originally proposed in the Cyclops report, a phased array of paraboloidal dishes, each 100 meters in diameter, could be used to detect 1- to 2-GHz signals. There might ultimately be a thousand or more such dishes, but the search could start as soon as a few had been constructed. The dishes would be spaced with their centers about 300 meters apart so that they do not cast shadows on each other at low elevation angles. An antenna of 1000 dishes needs many square kilometers—it could perhaps be located in the desert in the southwestern United States.

The complete SETI system might ultimately cost many billions of dollars, depending on how many dishes were built. The cost of the antennas dominates the cost of the system; therefore, the cost will be lower if a signal is detected early during construction.

Drifting in a sea of frequencies

A complicating factor in the detection scheme is frequency drift. Drift may come from instability in the transmitter or receiver, or from revolution and rotation of the earth and of the planet on which the transmitter is located. (Uniform relative motion between a star and our sun will cause a fixed frequency shift but no continually changing frequencies.)

It is easy to compensate for Doppler drift rates produced by the earth's rotation and revolution—since it is known where the receiver is looking, the necessary shift in the local oscillator frequency is also known (although slightly different degrees of shift are required at opposite ends of a wide band such as the water hole).

It is conceivable that the extraterrestrial transmitter may be purposely shifted in frequency. If two people are searching for one another in a forest, it is better for one to stand still than for both to be moving about. But the worst possible situation is for both to stand still. With this analogy in mind, the transmitting civilization might decide to sweep slowly through the 242 MHz of the water hole. At a sweep rate of 1 Hz, the process would take almost eight years.

For eavesdropping, Doppler drift compensation cannot be expected and some drift in the received signal must be expected.

Pointing and processing

The difficulty of the problem may now be grasped. If we wish adequate S/N (signal-to-noise power ratio) in our receiver, we must have low noise power, which requires a narrow band—probably less than 1 Hz. But this means about 10^9 channels even within the water hole, and we should probably search all of them. Furthermore, we need a strong signal, hence a large anten-

Why search?

Why—when millions are starving; when man is dangerously polluting his environment and exhausting the earth's resources; when the human race may extinguish itself in atomic war—why should money be spent on seeking signals from intelligent life on another world? There is no reason, if one believes that our civilization is at the end of the road after 4½ billion years of evolution. In fact, there is then little reason to carry out any large-scale socially supported projects such as the space program or research into biochemistry, medicine, cosmology, particle physics, or the mysteries of the brain.

But there is every reason for the search if one believes that the human race has not yet attained the peak of its evolutionary development, and that it may survive long enough to inherit a future as far from modern man's comprehension as the present world would have been to Cro-Magnon man. The search is prerequisite to communication, and communication will yield a vast array of benefits.

It would be an extraordinary coincidence if some other race were exactly as advanced as we were—more probably it is millions of centuries older or younger. But if it is as much as one century behind us, it is not yet using radio. It follows that any civilization that we contact is likely to be enormously more advanced. Thus, we may be able to use "their" knowledge and take a giant leap in our own science and technology. Far more important, we may discover the social structures most apt to lead to self-preservation and genetic evolution. We may discover new art forms that lead to a richer life. At the very least, communication will end the cultural isolation of the human race, enabling us to participate in a community of intelligent species. Then, perhaps, a spirit of adult pride in man will supplant childish rivalry among men.

It is likely that interstellar communication has been going on in our galaxy ever since the first civilizations evolved some four or five billion years ago. The participants in this heavenly discourse will have accumulated an enormous body of knowledge handed down from race to race—a sort of cosmic archeological record of our galaxy. If such a heritage exists, it will illuminate the human race's future. It would certainly be worth the cost of the search many times over.

By responding to a beacon, we reveal our existence and advertise earth as a habitable planet. Will then hordes of superior beings invade earth and annihilate or enslave mankind? If, as seems probable, interstellar travel is enormously expensive even for an advanced culture, then only the most extreme crisis would justify a mass interstellar migration—and even then it seems likely that the migrating population would seek uninhabited worlds to avoid adding the problems of conflict to those of the journey itself. In any event, our not responding would not really protect us, since a race bent on invading us could find us through our present radio emissions.

The possibility that mere communication with a clearly superior race could be so damaging to our psyches as to produce retrogression instead of advancement, even with the best intentions on the part of the alien culture, has been suggested. But there will be time for mankind to prepare itself. The round trip for communication may take a century or more, so the information exchange will not be a rapid-fire dialog. We may receive a vast amount of information, but the rate of reception, the gaps in the picture, and the effort needed to construct a model of the other race from the data should prevent any violent cultural shock.

No one can assert that interstellar contact is totally devoid of risk. But the potential benefits outweigh the risk. To obtain the benefits we must take that first step: We must search.

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Hewlett-Packard

na, and therefore a narrow receiving beam; which may mean 10^9 different pointing directions and we may have to search most of them. Furthermore, we do not know the drift rate, the polarization, or the modulation, adding further to the volume of the multidimensional parameter space that must be searched. Finally, we do not know *when* to look, and may wish to reexamine the same signal "point" in this space.

As indicated below, each "point" must be examined for several minutes, so it is hopeless to search them all sequentially. Fortunately, it is possible to examine many such "points" simultaneously by using currently feasible data processing techniques.

Essentially, this examination requires a high-resolution spectral analysis, obtained by taking the Fourier transform of the raw received radiation. A spike in the frequency-domain representation (the power spectrum) indicates a sine wave in the input and therefore a possible signal from space.

Analog Fourier transform processors are most advanced at the moment—especially optical processors that use lenses and photographic film, but processors based on surface-wave acoustics are also being developed. Digital processors employing the fast Fourier transform (FFT) are not as yet so well developed as the analog, but it seems likely that they will soon be more powerful and less expensive.

The effectiveness of a processor can be measured by its time–bandwidth product (TBP), which is the ratio of the total bandwidth searched (here called the frequency band) to the width of the "channel" (here called the frequency bin). TBP is therefore equal to the number of channels that the system is capable of analyzing simultaneously. (The name, "time–bandwidth product," derives from the fact that the bandwidth, instead of being divided by the width of the frequency bin, can be multiplied by its reciprocal, the coherent integration time.)

Since the noise power is directly proportional to the width of the frequency bin, it is desirable to reduce that width as much as possible. Bin widths below 0.001 Hz are probably not of interest even if we could build them—partly because of modulation limitations, but mostly because the receiver requires at least $1/B$ seconds to settle down to a bin width of B hertz, which means that the search time would be excessive at such small bin widths. Bin widths of 0.1 Hz are technically feasible, but staying within the frequency bin during the 10-second coherent integration time requires drift rates less than 0.01 Hz.

Another lower limit on the width of the bin is the loss that occurs if it is narrower than the transmitted signal. One can only guess at the bin width needed to eavesdrop on communication signals, but there is good reason to believe that widths far below those of usual communication channels might be useful. For example, typical broadcast signals on earth, with bandwidths measured in kHz or MHz, have a large part of their power in the carrier, which often is stable to a fraction of a hertz.

A data processor with a TBP of, say, 10^6 could examine simultaneously one million 1-Hz bins over a 1-MHz band, or one million 10-Hz bins over a 10-MHz band, or 500 000 10-Hz bins in each of two orthogonal polarizations over a 5-MHz band (which would make it possible to examine all polarizations simultaneously). Optical processors available today have TBPs ranging roughly from 10^5 to 10^6; digital processors range from 10^3 to 10^4. With a 10^9 TBP system, it would be possible to search the entire water hole in quarter-hertz increments. To examine the entire microwave region, of which the water hole is only a small part, we would need more data processors and different receivers—and we must solve very serious radio-frequency interference problems.

What wave shape?

Since the phase of the signal is not known, a square-law detector must be used. (If the exact phase were known, a specially adapted coherent detector could be used and the signal-to-noise ratio would be improved by up to 3 dB.) The system will thus search for sine waves. If such a signal is detected, it should not prove difficult to determine whether it is natural or of intelligent origin. If it is modulated to carry a message, inter-

Why not travel?

Why not visit instead of sending messages? Because interstellar travel—while not theoretically impossible—is extremely difficult.

Theoretically, if a spaceship could accelerate at 1 *g* for one year, it would reach approximately the speed of light. If it accelerated at 1 *g* for 4.6 years (according to its own clock) and then decelerated at 1 *g* for 4.6 years, it would arrive at a point 100 light-years away. Within 100 light-years there are more than 1000 stars sufficiently like our sun (types *F*, *G*, and *K*) to be interesting. The ship could travel to one of these, explore it, and then return in a total ship time of only 20 years (of course more than 200 years would have passed on earth before the ship's return—the "twin paradox" of relativity).

But from the viewpoint of energetics, it is not so easy. Consider the energy required for a much more modest journey—round trip to the nearest star, 4.3 light-years away, in ten years. For the spaceship propulsion system, assume the theoretical ultimate: a 100-percent-efficient matter-annihilation engine whose exhaust velocity is equal to the speed of light. The trip would consume 34 pounds of fuel (half matter, half antimatter) for each pound of payload. For a 1000-ton spaceship (including crew, living quarters, engines, life-support systems, and whatever else is needed), 34 000 tons of fuel would be required. The total energy expended in the trip would be about 10^{18} kWh—far in excess of all the fossil and nuclear energy expended in human history.

For more moderate amounts of energy, the trip time and the size go up rapidly. A fusion rocket would take 80 years for the round trip and require a minimum theoretical mass ratio of 80; a fission rocket would require many hundreds and a conventional rocket many thousands of years. This is only to visit the nearest star, and we would expect to have to visit thousands—perhaps hundreds of thousands—of stars before detecting intelligent life.

Would even a highly advanced civilization be able to surmount these obstacles? It doesn't seem likely. Certainly, we on the earth lack by many orders of magnitude the ability to explore other solar systems.

In comparison, the energy requirements for radio communication are surprisingly modest. It would take of the order of 1 kW to power a transmitter that could be detected from as far away as 1000 light-years, using transmitting and receiving antennas no larger than the 300-meter dish at Arecibo, and a bandwidth of 1 Hz at S-band. *R.E.M.*

***Either mankind is alone in the galaxy, or he is not; either alternative is mind-boggling.*—Lee DuBridge**

esting questions will arise in decoding it, but they cannot be examined in this short article.

Where are you?

Likely directions to look are those in which there is a star of "reasonable" properties within a "reasonable" distance. At least one star (our own sun, termed a G star—see Table) is known to have planets, at least one of which is known to provide a habitat suitable for life. Similar main sequence stars (*F*, other *G*, and *K* stars) can therefore be regarded as most suitable.

Received signal power decreases with the inverse square of distance. In addition, the long round-trip delay time reduces the advantages of establishing communication over great distances. For these reasons, 1000 light-years seems a reasonable upper limit. Within this distance, there are between one and two million *F*, *G*, and *K* main sequence stars to be searched. It is only necessary to point at the star; the microwave beam is broad enough to include the system even for the highest-gain receiving antenna and the nearest star.

Selectively searching the most likely stars would take a lot less effort than searching the entire sky. On the other hand, there are several reasons why a signal might be missed by a selected-target search. Other kinds of stars might have planets suitable for life—notably, *M* stars, which are far more common. Or a signal might come from a star farther away than 1000 light-years—even from another galaxy—with sufficient strength to be received. It would be worthwhile to receive such a signal, even though it couldn't be answered in any reasonable length of time. Or a signal might conceivably originate from some object not visible as a star from earth—perhaps a Jupiter-sized isolated mass.

If it were decided to search the entire sky (or entire promising areas of the sky) in a reasonable length of time, it would be necessary to look in several directions at once, and this means adding data processing capacity. For example, the proposed Cyclops dish array can accept signals from another main beam next to its original main beam if a duplicate phasing system and data processing system are added. In fact, another beam can be added for each phasing system and data processor added, up to the number of dishes in the array.

Equivalent to adding processors is recording the received radiation of each antenna element after it has been put through its IF amplifier, and processing it later. The beam can then be "pointed" in a sequence of directions by the processor. Non-real-time data processing would offer other important advantages if the state of the art in recorders could be sufficiently advanced. The hard copy that it produced would be invaluable if the receiver eavesdropped on an intermittent or highly directional signal. Within the data processor, the receiving antenna polarization could be adjusted; the beam could be repointed to put the target exactly at its center; and a filter could be matched to the signal. The net effect would be to increase the sensitivity (or range) of the system.

If weak signals are to be received, a large, high-gain antenna is needed, which implies a narrow beam. But the narrower the beam, the longer it takes to search the sky. The 300-meter dish at Arecibo, Puerto Rico, for instance, if operated at the water hole, would have to be pointed in 100 million different directions. For an even larger antenna, such as the Cyclops array, the number of pointing directions increases in proportion to the effective antenna area.

The number of pointing directions can be reduced by broadening the beam, by selecting a limited number of promising directions, or by looking in many directions simultaneously. A broad beam might be useful for a quick search for strong signals, but it would not aid in the ultimate search.

Where or when?

A signal meant to attract our attention might be omnidirectional and continuous. Or "they" may choose to use high gain and point sometimes in one direction and sometimes in another. They may illuminate a given direction for only a few seconds, returning periodically (maybe once a year). Or they might illuminate a given direction for a long time and come back only after millenia have passed. Or they may have selected a few stars, of which we might hope to be one, for special and perhaps even continuous attention.

It has been suggested, for example, that a beacon from a binary-star system might be a fan-shaped beam whose plane is perpendicular to the orbital plane of the stars and includes the line joining them; in that case we should look at such a system only when that line is pointing toward us.

For eavesdropping, a signal from a planet rotating at the same speed as the earth would intersect the SETI receiver for 1000 seconds if its beam were at least 4 degrees wide along the chord of intersection. Such an occurrence might seem like an extraordinary coincidence. On the other hand, if there are many such beams and if they are looked for long enough, at least one of them is bound to show up.

In any event, the question of *when* to look seems al-

Star Spectrum Character by Class

Spectral Class*	Spectral Characteristics
O	Very hot stars with He II absorption
B	He I absorption; H developing later
A	Very strong H, decreasing later; Ca II increasing
F	Ca II stronger; H weaker; metals developing
G	Ca II strong; Fe and other metals shown; H weak
K	Strong metal lines; CH and CN bands developing
M	Very red, TiO bands developing

*Sequence of letters remembered by generations of beginning astronomy students by the mnemonic: "Oh, Be A Fine Girl, Kiss Me!"

most unanswerable. It may be necessary to prepare for all possibilities, including reexamining promising directions and/or frequencies repeatedly.

Trading off

In a working SETI system, many tradeoffs will have to be made to ensure an acceptable probability of success at a reasonable cost. For example, attempting to improve signal-to-noise ratio by the brute-force method of adding dishes would cost billions of dollars per decibel in an ultimate system. It would be far better to expend a more modest amount on reducing the noise temperature of the system. Fractions of a degree are significant, especially near the theoretical lower limit of 3 K (the sky temperature) for a space-based antenna, or somewhat higher for an earth-based antenna.

Data-processing equipment can be traded for time by doing things sequentially instead of simultaneously, and time can be traded for antenna area since signal-to-noise ratio goes up linearly with antenna area and with the square root of integration time. The exact compromise depends on the objectives of the system (for example, how much more is it worth to get the first positive result in, say, 10 years instead of 20 or 1000 years), on whether an area search is chosen in preference to a selected-target search, and on the maximum frequency-drift rate decided on. It might even be reasonable to suppose that the total expenditure for data-processing equipment should be of the same order of magnitude as the antenna expenditure.

Consider one of the possibilities: a Cyclops-like system consisting of 1000 100-meter dishes with a bin width of 0.4 Hz, a system noise temperature of 10 K, and coherent integration time of 2.5 seconds. Total integration time of 250 seconds in each pointing direction will be required to obtain adequate probability of detection and false-alarm rate. Such a system could detect a transmitter putting out 1 GW of equivalent isotropic radiated power at a distance of several hundred light-years. The system could, during the course of about 25 years, examine the million or so most likely stars (operating at a moderate duty cycle of 1/3), provided the frequency drift rate did not exceed 0.15 Hz. And it could do all this with only two processors, one for each polarization.

The system could search the entire sky in a slightly longer time—but would need 2000 data processors instead of two.

Or the system could look at the million selected targets and allow for frequency drift rates up to 1 Hz. But it would need 26 data processors, 13 for each polarization. For the same maximum drift rate, the system could look at the whole sky if it had 26 000 data processors.

In these examples, if each of the data processors had a TBP of 10^9, the system could cover the entire water hole. To search a wider band of microwave frequencies requires more data processors, or more powerful data processors, or more time, or some combination of these. To search promising directions more than once, the time of the search or the power of the data processors must be raised accordingly. These equipment numbers could be cut by a factor of 3 with non-real-time data processing if the data processors operated continuously while the antenna worked only one third of the time.

For further reading

The literature on life in the universe and the problems of detecting it is scattered through many journals and books. *Intelligent Life in the Universe,* by Sagan and Shkovskii (Holden, Day Inc., 1966), is a classic reference. *We Are Not Alone,* by Walter Sullivan (McGraw-Hill, 1966), is an excellent popular treatment. The technically oriented reader will find the "Project Cyclops" report (NASA document CR 114445, available from John Billigham, NASA/Ames Research Center) enlightening reading; many points that are omitted here, or treated only sketchily, are examined there in greater detail. A comprehensive bibliography prepared by Linda D. Caren, Eugene Mallove, and Robert L. Forward—all of Hughes Aircraft Co.—appears in *Interstellar Communication: Scientific Perspectives,* Cyril Ponnamperuma and A. G. W. Cameron, editors (Houghton Mifflin Co., 1974), a book that provides a good overall view of the subject.

The first search for extraterrestrial signals of intelligent origin was made in 1960. Project Ozma, directed by Frank Drake, presently at Cornell University, searched 100-Hz bins over a 400-kHz band near the hydrogen line with a 26-meter dish, looking in two directions (at two promising stars about ten light-years away) in a single linear polarization. The system had a noise temperature of 350 K.

Today, with state-of-the-art receivers and existing radiotelescope antennas, the system sensitivity could be increased by at least 60 dB compared with Ozma: 15 dB by reducing noise temperature, 25 dB by reducing bin width, and 20 dB by using the 300-meter antenna at Arecibo. Furthermore, many more directions and frequencies could be examined. But to do this, more powerful data processors are needed. Thus, the NASA–Ames SETI group has turned its attention to the development of data processors. The group is developing a digital FFT processor and correlator with a TBP of 2×10^6, which, it is believed, can ultimately be expanded to a TBP of 2×10^9. The expanded processor is expected to be available in a few years at a price between $10 million and $100 million. As soon as even a more modest processor is ready, the Ames group hopes to begin a serious search with it.

If such a search is unsuccessful, the next step would be to construct larger antennas. But perhaps a signal will be detected! ◆

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Power

The FEA on productivity

How the U.S. Federal Energy Administration recommends improving power plant efficiency and productivity

The primary thrust of the Federal Energy Administration's *Report on Improving the Productivity of Electric Powerplants*, published in March 1975, is "to reduce our dependence on foreign oil supplies by increasing our reliance on coal and uranium—our most abundant domestic energy resources." By keeping this goal in the forefront, the FEA task force that prepared the study believes that the inevitable fallout will be greater generation productivity and concomitant increases in overall system reliability and efficiency in fuel/energy use—plus the bonus incentive of substantial cost economies.

Although the power industry, for many years, has maintained an excellent track record in providing its customers with reliable service, it is hardly a secret that the utilities, since 1973, have been hard pressed by fuel shortages (and the sharply increased costs for these fuels), and difficulties in obtaining financing for major new construction projects.

According to Federal Energy Administrator Frank G. Zarb, the report essentially "represents a first step by the FEA in identifying the specific problems to be overcome in achieving [the objectives] of higher reliability"—and improved self-sufficiency.

Gordon D. Friedlander Senior Editor

Included in the report are some specific recommended actions to improve the existing situation. The FEA stresses, however, that while the Federal government will continue its close cooperation with the utilities toward focusing attention on basic problems and in helping to develop solutions, *the major responsibility for implementing these actions must be with the electric power industry itself.*

Statement of the primary problem(s)

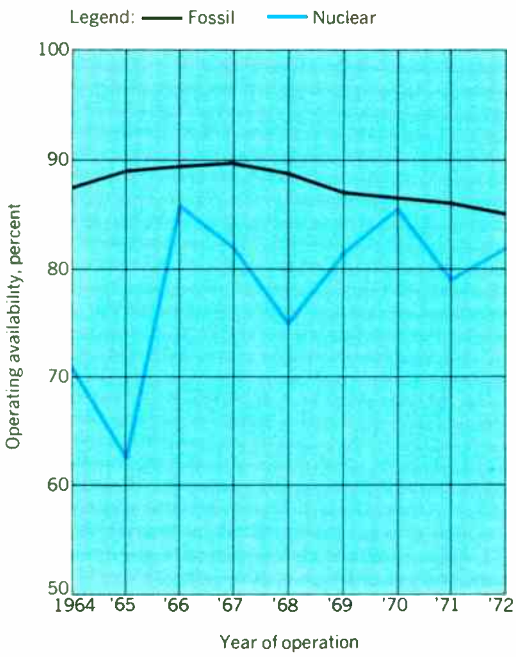
The U.S. must build and support about 5 kW of electric generating capacity to supply 4 kW of peak demand; and, on average, a productivity of about 50 percent from each kilowatt of capacity is obtained. This fact of life is, to some extent, unavoidable because of

- Differences between forecast and actual demand.
- Daily and seasonal demand fluctuations.
- Plant shutdowns for scheduled maintenance and/or nuclear refueling.

For base-loaded units, however, the situation is largely attributable to institutional, technical, and human factors "that could be altered in the interest of productivity."

The report contends that "over the past year or two, on the average, the nation's large nuclear and fossil-

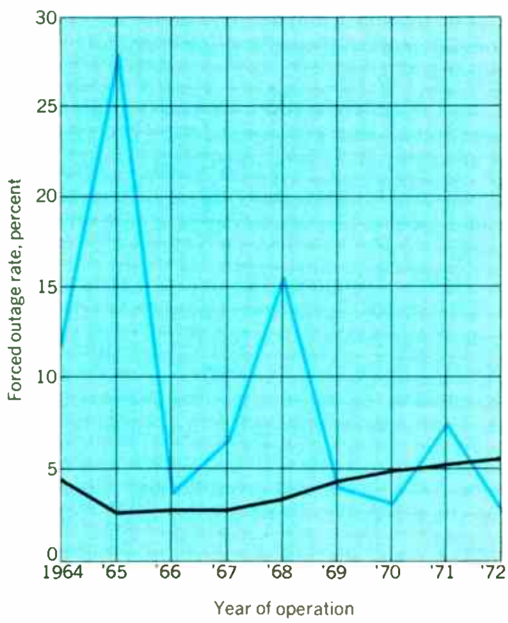
Comparison of fossil and nuclear generating units. The sample table serves to illustrate the preponderance of fossil-fired units, and also the disparity of operating availability and forced outage rates between fossil and nuclear units.



Sample table

Year of operation	Fossil no. of units	Nuclear no. of units
1964	68	3
1965	335	3
1966	322	5
1967	318	6
1968	607	7
1969	624	7
1970	645	8
1971	692	11
1972	757	10

Unit year averages 1964–1972



fired base-loaded units were forced out of service more than 15 percent of the time, were unavailable for service more than 25 percent of the time, and operated at less than 60 percent capacity factor." Hence, a large fraction of the highest-capital-cost generating capacity was not in service to the degree that was anticipated. The FEA contends this situation has "severely aggravated the financial, siting, licensing, manpower, and other problems afflicting the industry.

Improvements in capacity and availability factors, plus a reduction in forced outage rates, would be a significant benefit, in both the near term and long range, in restoring the financial viability of the power industry—and in ameliorating many of the factors that have been forcing electric energy costs to rise.

Status, trends, and underlying causes

Generally, the availability and capacity factors of large fossil-fired and nuclear base-loaded units put on line in recent years are considerably below what had been expected by utility planners when the units were ordered. Edison Electric Institute (EEI) statistics provided to the Task Group showed some slight improvements in 1973 for fossil-fired units 600 MW and larger, perhaps indicating a "bottoming out." But, for nuclear plants, recent Nuclear Regulatory Commission (NRC) figures show a continuing decline.

The FEA group feels there are a number of industry factors that will continue the momentum of present trends and impede a turnaround in reliability; these include:

- Insufficient operating experience with the new very large generating units.
- Increasing environmental and safeguard requirements.
- Poor-quality coal fuel.
- Deferrals of maintenance to conserve cash.

The report continues: "With few exceptions, information on the underlying causes of poor reliability is not available. There is a general lack of understanding of these causes by utilities even though such understanding is a vital prerequisite to improving reliability." The Task Group was informed that "knowledge of underlying causes is more extensive in a few organizations such as the EEI Prime Mover Committee and some equipment vendors' organizations."

Financial incentives, regulations, and unit size

All of the utilities and power regulatory agencies contacted by the Task Group felt that the utility rate structures provide "a strong financial incentive" for utilities to improve their reliability and overall performance.

Key environmental factors are state air-quality regulations and mining regulations. The former are having an adverse impact by precluding the burning of available high-sulfur coal. Therefore, the utilities are required to burn lower-quality, low-sulfur-content coal. Mining regulations that require the removal of coal debris (formerly left in place) from the mines are reducing the quality of the deep-mined coal, thereby causing malfunction—or failure—of power plant boiler equipment such as coal pulverizers. Thus, the FEA report concludes that "environmental and nuclear regulatory requirements, notwithstanding their merits for the purposes intended, are significant contributors to reduced plant productivity."

Table I is based on data taken from a recent EEI report and lists the cumulative average performance factor of fossil-fuel station generating units, in various size ranges, over the 13-year period from 1960 through 1972. Similarly, Table II is predicated on data taken from the latest NRC report, and sets forth cumulative average performance factors of various sized nuclear units, starting from the date of commercial operation through June 30, 1974.

The data in these tables indicate a very strong unit size effect on unit performance for both fossil-fired and nuclear installations. In view of the increased outage rate, and decreasing availability factor, of the larger generating units, a moratorium "of sorts" is in effect on the maximum size of fossil-fired units, and a ceiling

I. Fossil-fired-unit performance data

Size Range (MW)	No. of Units	Forced Outage Rate (percent)	Availability Factor (percent)	Capacity Factor (percent)
60–89	71	1.7	91.6	70.2
90–129	170	3.3	88.5	64.3
130–199	252	3.1	89.2	75.3
200–389	216	4.7	86.2	74.8
390–599	89	8.7	80.0	66.6
600 up	46	16.6	73.2	59.7

Note: These statistics represent the cumulative average for 1960–72.

II. Nuclear-unit performance data

Size Range (MW)	No. of Units	Forced Outage Rate (percent)	Availability Factor (percent)	Capacity Factor (percent)
139–199	1	1.1	79.7	69.6
200–389	2	8.2	61.6	46.8
390–599	7	11.5	70.3	63.8
600 up	18	20.5	64.3	50.0

Note: These statistics represent the cumulative average performance factors of nuclear units, of the sizes indicated, starting from the date of initial commercial operation through June 30, 1974.

has been imposed by NRC on the maximum size of nuclear units.

Design deficiencies, maintenance deferral

According to the report, "a large fraction of outages resulting from component and systems failures are [sic] attributable to deficiencies in design, materials application, and testing. A significant fraction of outages results from improper operation and maintenance of the equipment."

In the last-mentioned category, the report assures the reader that "surveillance and preventive maintenance necessary to ensure *safe* operation of nuclear plants are continuing in accordance with technical specification requirements." But then comes the caveat: "However, other surveillance and preventive maintenance in both nuclear and fossil-fired units is being deferred to an increasing degree, partly as a consequence of the utilities' cash squeeze and partly due to diminishing system reserve margins."

In the area of "designing for reliability," the study confirms that, together with initial investment, fixed and operating costs, fuel, etc., reliability is given "explicit consideration" by the power industry and its architect/engineer consultants in the evaluation of plant design and equipment procurement in order to minimize power-generation costs. Nevertheless, it is generally difficult to make a meaningful design tradeoff between a unit's initial cost and its lifetime reliability, because of the lack of dependable reliability data on plant systems and components.

The FEA document also observes, in the context of R&D and its priorities, that "little of the energy conversion funding by utilities and the Federal government is being applied to provide solutions to current reliability problems. The importance of improved reliability warrants some shifting of these priorities to be of assistance in the near term."

Recommendations

In all, 13 recommendations were made by the FEA Task Force's report. The group's assignment, it should be emphasized, did not include the preparation of a detailed and comprehensive action plan for improving power plant reliability. Therefore, as might be expected, its recommendations are broad in scope and general in nature. The Task Group felt that the implementation of certain of its recommendations is necessary to establish a plan of action; however, other recommendations also offer important elements for effective action. The recommendations, each with a brief descriptive paragraph, include:

1. Establishment of reliability goals—Within three to six months, the utilities should draft selective operating goals for improved power plant reliability of large base-loaded coal-fired and nuclear units in the near term (1976–77), in the intermediate term (1977–80), and for the long term (early 1980s).

2. Formulation of action plans—The power industry should develop and implement additional action plans for the improvement of power plant reliability and it should carefully weigh which actions stand the best chance of success in terms of short-range impact and optimum cost/benefit ratio.

3. Improvement of reliability data base—The Task Group suggests that the existing EEI report on reliability should be more timely and "include much more of the information already being provided by the utilities." This update should contain the data necessary to determine the reliability of large fossil-fired plants with respect to their number of years in service. Furthermore, the Nuclear Plant Reliability Data System (NPRDS), administered by the American National Standards Institute (ANSI), should be extended beyond "safety-related systems and components in nuclear plants" and should be applied, at least, to the large (400 MW and higher) base-loaded coal-fired units.

4. Determining underlying causes of plant outages—The power industry in cooperation with the equipment suppliers should make a coordinated effort to compile, assess, and distribute the results of all efforts underway to determine the root causes of plant outages, and should encourage the proliferation of such efforts. As part of this endeavor, specific reasons for the difference between availability and capacity factors for large base-loaded units should be discovered.

5. R&D support for near-term solutions—Both the Federal government and the power industry should appraise their ongoing and planned R&D activities to decide whether the thrust of such work could be redirected; also, where additional effort should be made to attain near-term solutions to present problems that adversely affect reliability.

6. "Moratorium" on unit size escalation—The Task Group recommends that the present NRC ceiling on nuclear unit size and the "leveling off of fossil-fired unit size should be continued." Eventually, a determination should be made as to at what point (and under what criteria) larger-size units should be built.

7. Standardization of design—The power industry and the architects/engineers should optimize the "replication of existing designs that *limit* the preparation of custom designs to meet essential requirements." Any "anticipated product improvements through design innovation should be demonstrated prior to commercial commitment."

8. Coordination of information requests—In the opinion of the FEA group, effort should be made by operating utilities to coordinate requests for reliability information in order to minimize unnecessary duplication and to "optimize the timing and content of information received."

9. Incentives for improved reliability—The FEA should collaborate with the National Association of

Background to the report

To help in achieving the goals of "Project Independence," the Federal Energy Office, in April 1974, established the Interagency Task Group on Power Plant Reliability, with the broad objective of improving the productivity of existing and planned large-capacity fossil-fuel-fired and nuclear generating stations. The Task Group was asked to identify the key problems and the possible corrective actions associated with the reliability of these plants from the viewpoint of their productivity. The group's activities concerned the extent to which installed capacity is being utilized, but did *not* extend into areas of nuclear reactor safety and continuity of service to the customer.

Sources of plant performance data

In addition to reliability statistics, EEI data provided information that identified the individual equipment or component whose malfunction produced an outage; however, the *actual or root cause* of failure or malfunction is not identified. In this context, the FEA Task Group states that a "large amount of reliability data gathered by EEI generally is not available to the public, nor [is it] routinely available to the entire electric power industry." But the Task Group was informed by EEI that during 1971–72 there were "85 special data analyses made for utilities, manufacturers, architect/engineers, power pools, EPRI, FPC, and others."

The primary sources of performance data for nuclear generating units are the NRC's publications. Back in 1974, the Director of Regulation of the then-existing Atomic Energy Commission established a monthly report that listed, for each licensed unit, the forced outage rate, its availability factor and capacity for the preceding month, and the cumulative period the unit had been in commercial operation. This report (which is being continued under the auspices of NRC) identifies for each unit the unit outages and power reductions that occurred during the prior month. These data include, in detail: the cause of the outage, abnormal events reported by the licensee—plus information regarding the type of nuclear reactor involved; and the names of the owner, nuclear steam supply vendor, architect/engineer, and builder.

Supplementing these sources are:

1. The AEC *Directorate of Regulatory Operations*, published in 1974, contains the results of a study of the operating performance for civilian nuclear power units during 1972. This report provides data on forced outage rate and availability for each unit; lists for each unit all of the forced outages, together with their duration, description, and probable cause; provides a statistical summary and analysis of the equipment failure and malfunctions that triggered forced outages; and makes a comparison in these statistics between nuclear and fossil-fired units.
2. An AEC (now ERDA) publication, issued in 1974 by the Office of Planning and Analysis, lists for each nuclear unit the forced outage rate, availability factor, and capacity factor for each year since the unit began commercial operation.
3. The AEC (the division that is now NRC) published in May 1974 a listing of all abnormal occurrences for each nuclear unit during 1973, together with analyses of cause and safety-related significance.

Regulatory Utility Commissioners (NARUC), and with the FPC and other Federal agencies (and also with state regulatory bodies) to "suggest means of stimulating utilities to achieve high levels of reliability."

10. Study of actual reliability experience—The FEA, or another appropriate agency, should initiate a "detailed analysis" of the operation and outage experience of a representative number of large coal-fired units and light-water-cooled nuclear units to achieve a "deeper insight" into the reasons (and possible remedies) for low reliability.

11. Improving coal quality—The FEA should work with the Environmental Protection Agency (EPA) and the Department of the Interior to encourage the production of "an adequate supply of coal of a quality required by existing boilers and coal-handling equipment."

12. Identifying impact of environmental requirements—The FEA "should continue to work with EPA to assure that the real impacts of existing environmental requirements on reliability are measured, understood, and made available to the industry, state regulatory agencies, and the public."

13. Establishment of cost benefits—As the final recommendation, the Task Group believes that FEA, "or another appropriate Federal agency, should undertake a detailed cost–benefit analysis," considering such factors as the reductions that could be achieved in generating unit additions and spinning reserve requirements, and the attendant savings in capital and operating costs through improvements in the reliability of large coal-fired and nuclear units. Further, the analysis "should reflect projected improvements in system load factors due to load-leveling strategies currently being pursued, and should be based on a study of at least one large power pool"—and preferably the entire region.

Prospects for future performance

In projecting the prognosis for the future, the FEA Task Group noted that, "with some exceptions, there does not appear to be a coordinated intensive effort in the industry to *pinpoint* underlying causes of poor reliability, to establish goals for improvements, or to implement an effective program of corrective actions." Until such an effort is underway, the outlook will not be optimistic for any substantial "across-the-board" improvement in availability, capacity factors, and reductions in forced outage rates of base-loaded units.

The group also feels that "the benefits of the industry's ongoing efforts toward improving reliability—together with the 'maturing' of new units, will be offset by other factors that could cause further decreases in reliability." Some of the key negative factors are:

- The introduction, over the next several years, of large numbers of nuclear power plants in the 1000–1250-MW class.
- The slow feedback of operating experience because of the long lead times for both fossil-fired and nuclear units.
- Increasing complexity of plant designs and equipment arrangements because of escalating nuclear safety and environmental requirements.
- Reduced maintenance on some units due to the financial problems of some utilities.
- The detrimental effects of poor-quality coal on equipment performance and output at some units.
- The decreasing spinning reserve margins in some units which require "pushing" operating units to their design limitations (above nameplate capacity) for longer periods of time, and also increasing the scheduled interval between shutdowns for inspection and maintenance.

Thus, the FEA's Task Group is convinced that "actions already underway and forces present in the industry will ameliorate the impact of the negative factors noted [in the report]." These "forces" include the ongoing efforts of the EEI's Prime Movers Committee and the Association of Edison Illuminating Companies' (AEIC) Committee on Power Generation, an increasing awareness by utility management that historical reserve margins cannot be sustained, positive and definitive action programs initiated by various utilities during 1974, programs underway by the turbogenerator manufacturers, plus industry-supported efforts at EPRI, and increasing replication and standardization of nuclear and fossil-fired units. ◆

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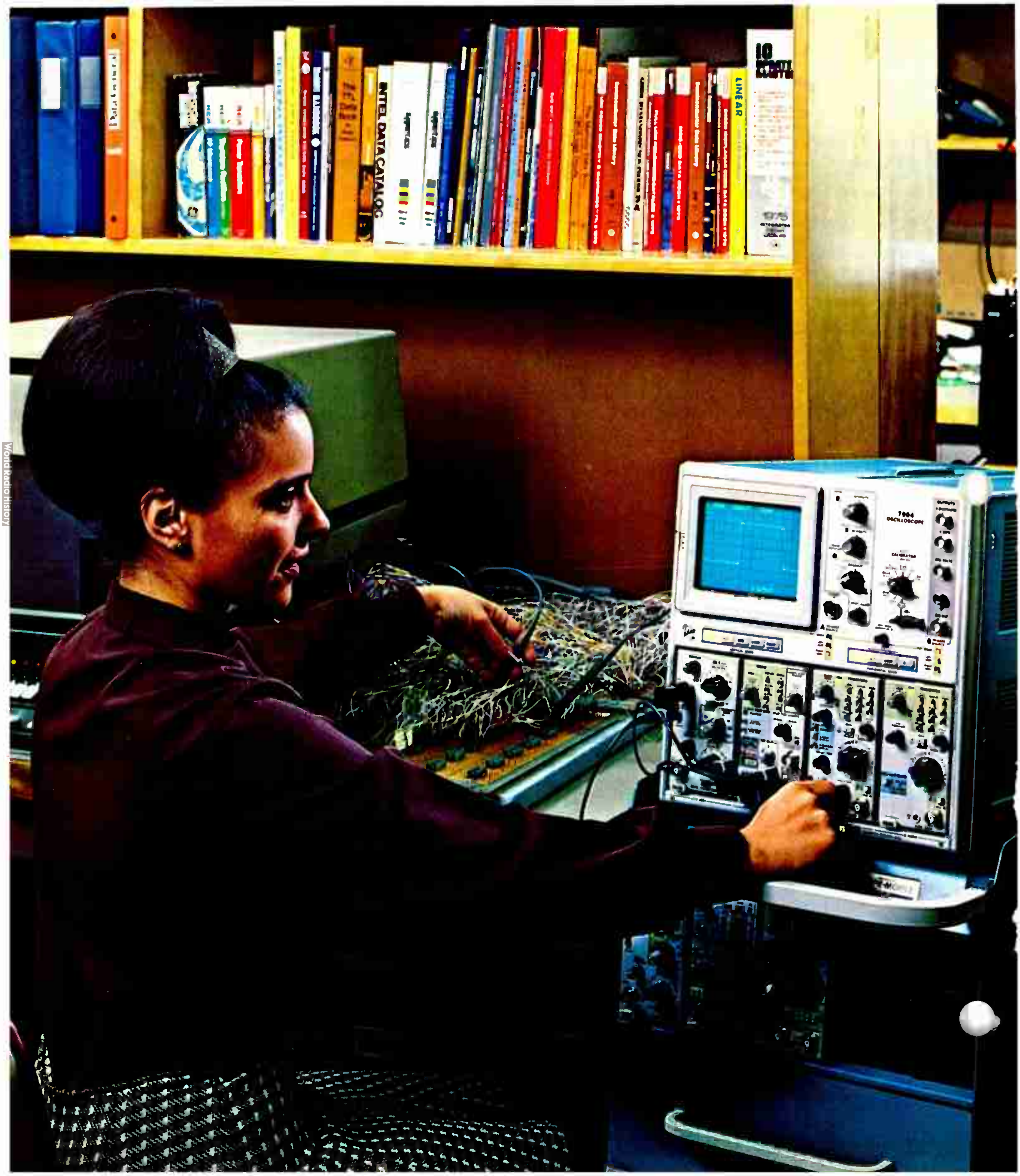

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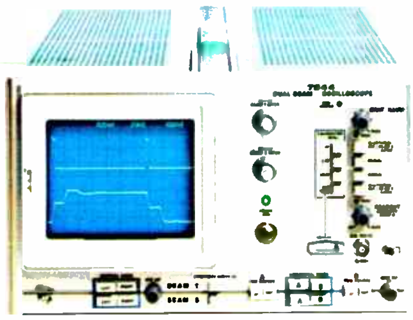

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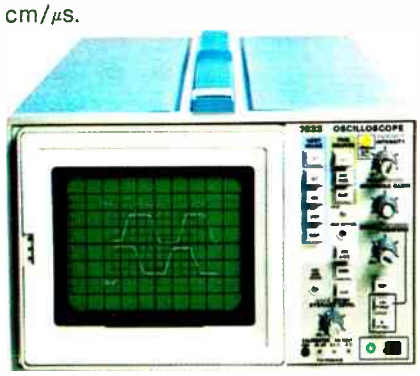

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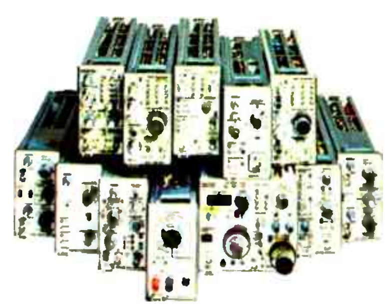

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Simulated routes of several hundred vehicles of a personal rapid transit (PRT) system for mid- and lower Manhattan (from Central Park down). The computer simulation was carried out at the IBM Laboratories at Poughkeepsie, N.Y., and this picture was obtained through time exposure of the output cathode-ray tube display during the entire simulation. Requests for transportation from several hundred passengers' origins to their destinations were simulated through use of a random number generator. Each dot in the picture represents one vehicle with one passenger aboard, and the pickup and dropoff points for passengers are marked by X signs.

Transportation

Getting around town: automatic urban transit

Prospects for personal and group rapid transit hinge on technology, safety, politics, and economics

One positive consequence of the gasoline shortage of 1974 was the resurgence of interest in public transportation. Many people were forced to abandon their private automobiles and take buses or subways or join car pools in order to get to work. Yet, when gasoline again became readily available, it seems that not everyone returned to the private car. The undeniable aggravation of air pollution, of urban congestion, and of fuel shortages caused by the automobile have focused considerable public and political attention on the need for improved urban transportation. In late 1974, President Ford signed a bill allocating $11.8 billion for the construction and operation of public transit systems. At about the same time, the highly automatic Bay Area rapid transit (BART) system became operational over its entire 71-mile route in the San Francisco Bay Area. A similar automatic system is under construction in Washington, D.C., and another one is planned for Atlanta, Ga.

In Minneapolis–St. Paul (Minn.), Denver (Colo.), and Miami (Fla.), transit systems even more sophisticated than BART are in various stages of planning. Other advanced systems are being demonstrated at test facilities in Europe and Japan. The new systems, which embody group rapid transit and personal rapid transit techniques, are based on moving people in individual, small automatic vehicles, rather than in the large, coupled vehicles of subways and commuter trains or in large buses. Personal rapid transit (PRT) is, in essence, a fixed guideway system in which automated vehicles that are no larger than small automobiles carry individuals, goods, or small groups nonstop between stations in a network of slim guideways that serve major activity centers or an entire urban area. In group rapid transit (GRT), increasingly found around airports, the automatic vehicle may be larger, the trip may not be nonstop, and up to 25 or more passengers may ride together.

Operational individual vehicle systems

The forerunners of PRT and GRT systems, automatic, individual-vehicle transit systems have been in operation for several years, but only recently have major deployments been seriously considered. Between 1963 and 1971, $7.4 million was spent to develop and demonstrate the Westinghouse Transit Expressway in Pittsburgh—the Pittsburgh Skybus—where three vehicles were operated over 5.6 km of single-lane, elevated guideway with two online stations. The 28-seat vehicles provided 80-km/h line haul service at 120-second headways. (Headway is the time interval required to travel the distance between two vehicles traveling in the same direction, on the same route, at specified speeds.)

This system has since found commercial application at the Tampa, Fla., and Seattle–Tacoma, Wash., airports, and at Busch Gardens in Virginia. Another, early system has been in reliable operation at Love Field outside Dallas, Tex., for several years. The Love Field system employs a small, cab-like vehicle suspended under an elevated monorail to provide rapid transit service between one of the parking lots and one of the terminals. It is now being converted by the PRT Systems Corporation of Chicago to use partial magnetic levitation (maglev) and linear motors. The construction of a larger, fully "maglev," GRT system, in Toronto, Ont., Canada, was recently suspended because of technical problems. Advanced transit projects, PRT and GRT, are under consideration in so many areas (Indianapolis is one example) that accurate lists are difficult to maintain in light of the rapidly changing status of individual proposals.

Advanced service concept demonstrated

In 1966, the passage of the National Urban Mass Transit Act in the U.S. led to major new thinking in the public transportation field. An attractive service concept was felt to be the key to inducing auto riders to use public transportation. The U.S. Department of Transportation then selected the University of West Virginia campus at Morgantown as a demonstration site for an advanced service-concept transportation scheme. Two service concepts are to be tested at Morgantown: During evening hours, when transit loads are light, the system will operate in personal rapid transit mode by providing private, on-demand service, whereby an individual or private party is provided with the exclusive use of a vehicle that is usually waiting for patrons and departs as soon as the person, or party, is on board. In the daytime, Morgantown's GRT operation will involve nonprivate service with stops scheduled at intermediate stations.

The Morgantown project (see illustration on p. 56) was intended to relieve the extreme traffic congestion on the routes joining three university campuses and to demonstrate new solutions to urban problems. Although the three campuses are only 2.4 km apart, the extremely hilly terrain precludes walking or bicycling between campuses to meet practical class schedules, and the driving time can be up to an hour. The project

R. Morse Wade
International Business Machines Corp.

was first proposed in 1967 and is now open to the public, although on a scale smaller than originally planned. The three-station Morgantown system includes 8.6 km of a single-lane guideway, most of it elevated, and 45 completely automatic Boeing vehicles, with a capacity of eight sitting and 12 or 13 standing passengers. The central station of the three is located off the main guideway line so that vehicles not scheduled to stop there can bypass stopped vehicles, a common practice in advanced transit systems. A second phase of the Morgantown project will add several miles of guideway, two new stations, and additional rubber-tired vehicles. When the Morgantown system becomes fully operational, it is expected to carry about 14.4 million people per year and to cover its operation costs through 25-cent tickets and $3.00 monthly passes. The three-station configuration, open to the public, now permits students to ride free.

While these advanced service concepts are being tested at Morgantown, PRT and GRT systems have been under development in France, Germany, and Japan. In Japan, several vehicles are now in operation under the control of three computers, along a 4.8-km test track near Tokyo. The fleet was expanded to more than 40 vehicles at the end of 1974 and is now being tested at one-second headways. While several different models of vehicles for this computer-controlled vehicle system (CVS) are said to be under development, the present model is a four-wheel, rubber-tired "city car" model, which looks like a small, modern van with a number of glass windows. It has a maximum capacity of four seated passengers. Although plans are not yet firm, proposals include installations in the Central District of Tokyo, and at the New Tokyo International Airport, Mebashi City and Takasaki City.

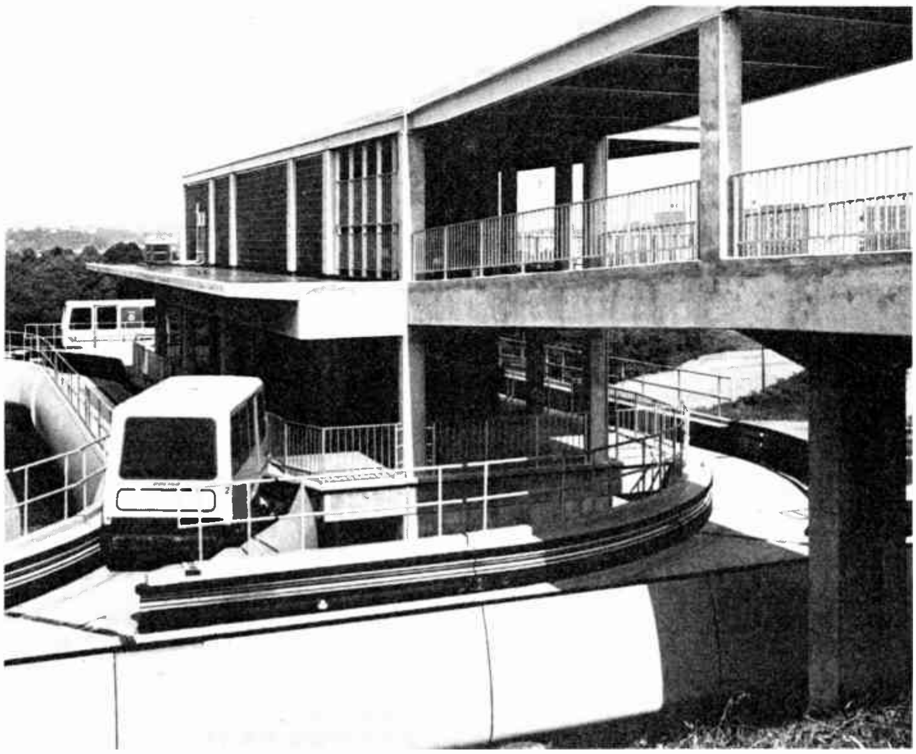
The West German Government has several advanced-concept transit systems under development. Their PRT system, called Cabinentaxi, has recently had its funding increased, and one version will be installed at a hospital complex near Kassel (see illustration on p. 58).

Safety controversy over large-scale PRTs

But testing advanced transportation concepts on a small scale is one thing, and applying them to a large city is a different ball game. With safety a paramount concern of the officials of public transportation agencies, some individuals and agencies do not want to support work in advanced-concept systems whose potential for safe operation may seem suspect by conventional standards.

For example, analyses of the application of the PRT concept to large areas such as Los Angeles, Minneapolis–St. Paul, or New York indicate that in order to handle the same number of people who now use autos, buses, taxis, or subways, a grid-like network of one-way guideways at 800-meter spacing would generally be required over an entire urban area. With an off-line station on every link of such a grid, the crushing crowds now found at subway stations would, according to these analyses, become a phenomenon of the past, while a passenger's walk to the nearest station would be 400 meters at most. With computerized controls, such a system could theoretically provide a nonstop ride at 56–63 km/h for much of the riding populace. However, the gap between many moving vehicles in the grid would be less than one second, and this has become the crux of the controversy about safety standards for these systems.

Traditionally, headways for rail mass transit systems have been established using the "brick-wall" stopping criterion. This means that the minimum space or time between vehicles must be such that the brakes of a following vehicle are capable of stopping the vehicle without collision if a leading vehicle stops instantly. Rail transit systems have had serious acci-



Advanced service transportation concept as demonstrated at the Morgantown campus of the University of West Virginia. After a short climb up the stairs of the station, the passenger uses the coded pass in a simple fare-collection unit, where it acts as a key to open a platform entry gate. On the platform, the rider indicates a destination by pressing a button for one of the three or five stations available. One of the unmanned vehicles, with a capacity of eight seated and 12 or 13 standing passengers, will be waiting or will arrive shortly thereafter. After boarding, the doors will close automatically and the vehicle will travel to the selected destination station at speeds up to 48 km/h.

Controlling fleets of small vehicles

A control system for fleets of small vehicles like those that are presently involved in operational GRT systems and those that will be involved in the larger PRT and GRT systems of the future requires a three-level hierarchy consisting of *vehicle controllers, intersection controllers,* and *central controllers.* In some control system designs, the vehicle and intersection control functions may be arbitrarily spread between on-board and wayside equipment. In small systems involving only a few vehicles or stations, the equipment may be as simple as a few relays, and the central control function may be embodied in an on–off switch. In the large systems projected for the future, the *central control computers* may control individual zones of the transit system directly and may communicate with the central control computers intender for controlling other zones, over teleprocessing links.

Vehicle controllers are generally designed according to one of two philosophies—vehicle-follower (asynchronous) or point-follower (synchronous). The vehicle-follower control system permits a vehicle to operate at a nominal civil speed, unless the vehicle ahead reduces its speed. A minimum separation is always maintained, without regard to intersection merge problems, by mechanisms that measure vehicle separation and use the information to control motors and brakes.

Avoiding vehicle collisions

West Germany's Cabinentaxi system includes a novel collision-avoidance system. In the present design, the position of one vehicle relative to another is continuously sensed if the intervehicle spacing drops below 30 meters. This sensing system is said to be accurate to within 20 cm when the leading vehicle is 10 meters away and improves up to 2-cm accuracy at 2-meter spacing.

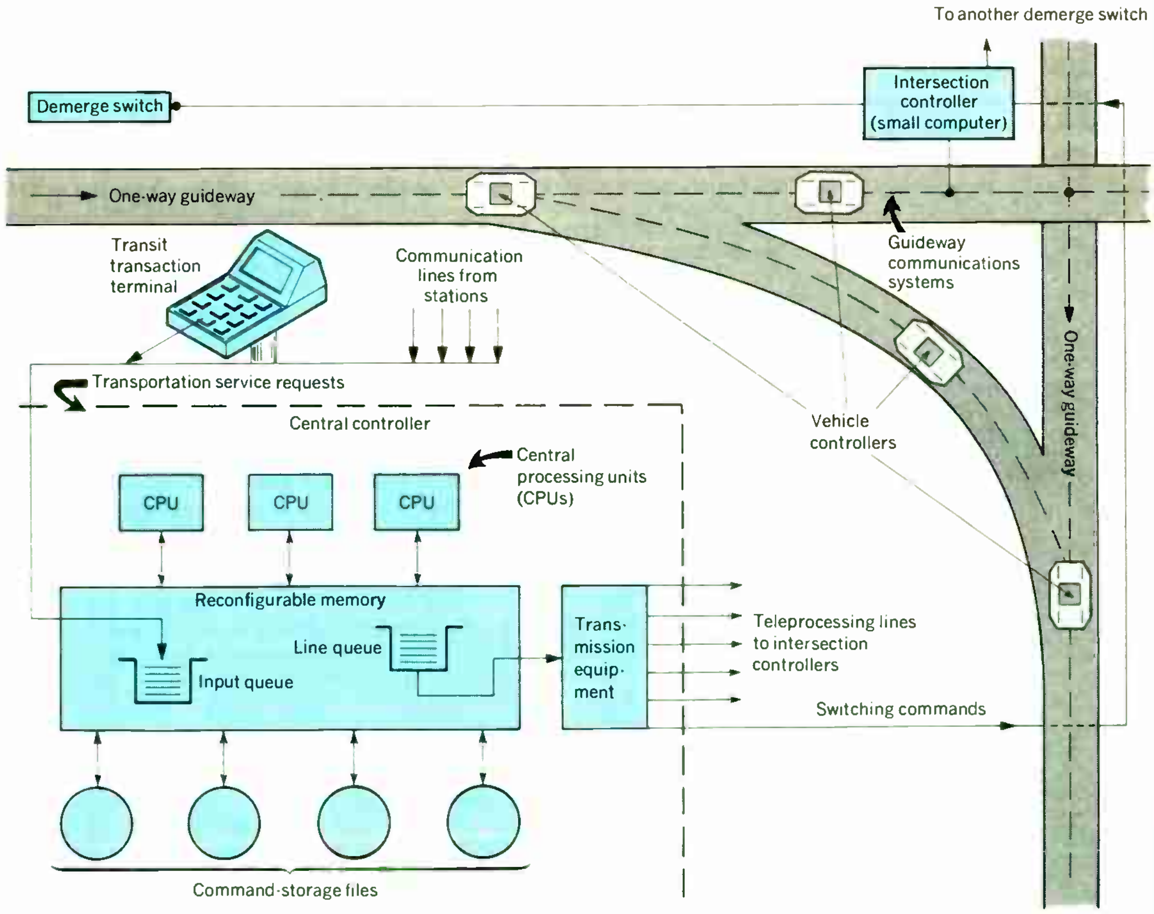
Controlling merging vehicles at intersections

The nature of synchronous (point-follower) control systems is such that each vehicle is assigned to an imaginary time slot, whose length usually corresponds to the time, or headway, between vehicles. It is the responsibility of the *intersection controller* to insure that, when two imaginary time slots merge, at least one contains no vehicle. The intersection controller also directs the demerge of vehicles by signaling on-board or wayside switching equipment to permit either a turn or a no-turn maneuver at intersections.

Merging of vehicles in an asynchronous (vehicle-follower) control system can be relatively straightforward. The intersection controller can send a false "vehicle present" signal down a guideway to cause the vehicle-follower equipment to slow down or stop converging vehicles, thus facilitating a smooth, collision-free merge.

In a fully synchronous control system, all of the time slots needed to merge vehicles are preplanned, or reserved, by the *central control computer* so that the intersection controller merely watches over the merge process, directing vehicles only when an emergency is detected.

A three-level hierarchy, consisting of vehicle, intersection, and central controllers, is required for the control of fleets of small vehicles like those in operational group rapid transit systems and those involved in the larger group rapid transit and personal rapid transit of the future. Each station includes a transit transaction terminal for passengers to indicate their destination. All transportation service requests are queued in a reconfigurable memory of the central controller, which also sends switching commands to the intersection controllers, to meet these demands.



features, each has an antenna and receiver for the collection of data from earth-based sensors.

The Landsat 1 spacecraft—launched on July 23, 1972—and the Landsat 2—launched January 22, 1975—are in nearly identical sun-synchronous orbits, enabling the spacecraft to cross the equator at the same local time on the sunlit side of the earth. From orbit to orbit, the nadirs of the two spacecraft move 2875 km as the earth rotates below. After 14 orbits, which takes about one day, the nearly identical nadir points are displaced 159 km west of their initial locations. After 252 orbits, or 18 days, they have returned to their initial locations, thereby permitting repeat observations every 18 days. Landsat 2 is phased to cover a point on the earth nine days after that point was covered by Landsat 1.

The sensors are mounted on the bottom of each spacecraft. The RBV, consisting of three television cameras operating in different spectral regions, is a frame camera in which the data are taken in a period of milliseconds, unlike the MSS, which scans the ground continuously on a line-by-line basis. These data are either transmitted to the ground or stored in an on-board tape recorder. The exposure time of the three cameras' shutters can be varied in five discrete steps.

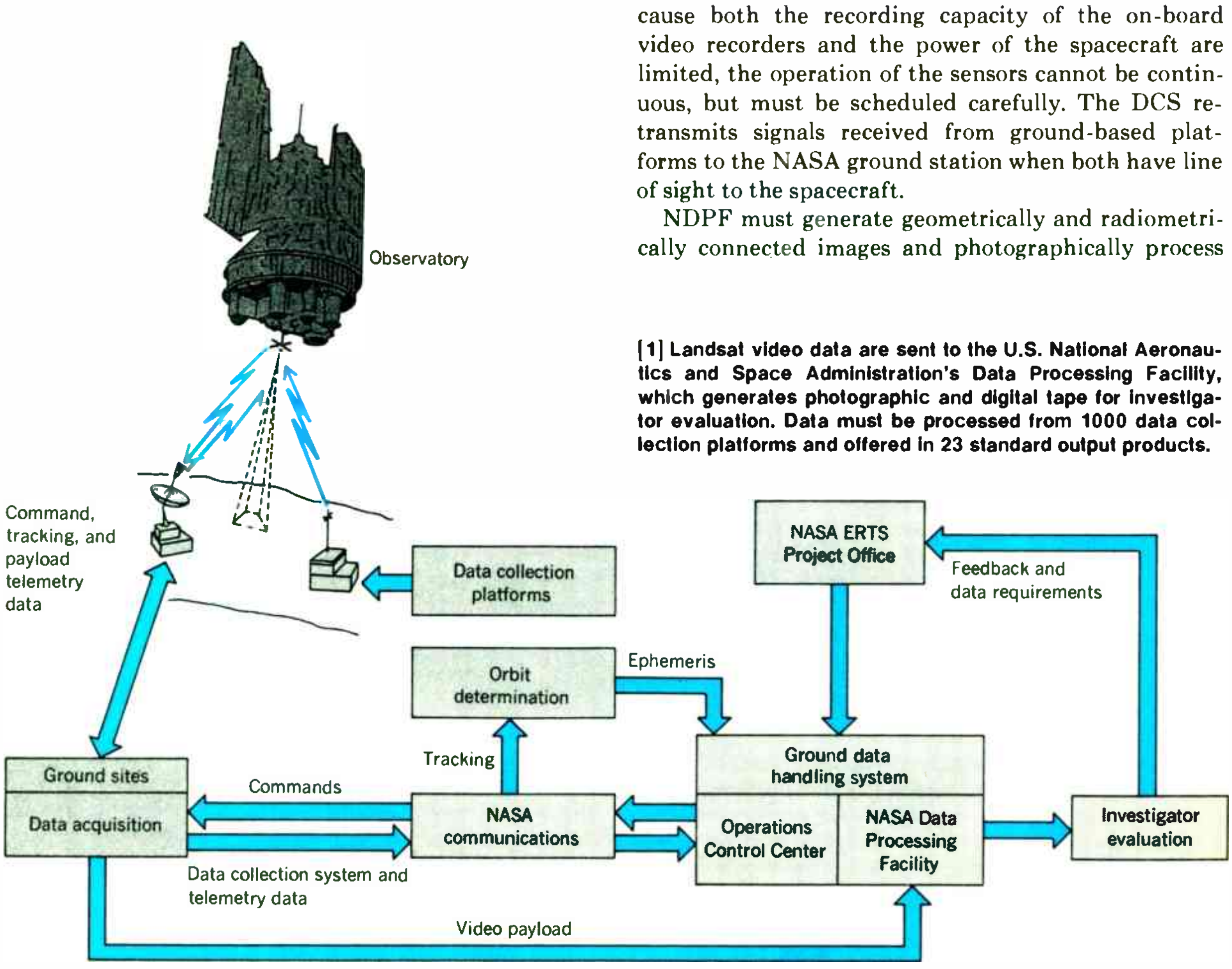
Figure 2 illustrates the concept of the MSS multidetector array and its scanning system. The scanning mirror oscillates ±2.88 degrees, causing the beam to be scanned 11 degrees, west to east. There are six detectors in each of the four bands, so that six lines are scanned simultaneously in each of the four bands. The scan period from the beginning of scan, over the 11-degree angle, and back to the beginning of the next scan occupies a period of approximately 90 ms, during which time the spacecraft will have traveled 540 meters over the ground. The RBV image shows 185 km by 185 km, while the MSS image shows a 185-km-wide strip, continuous in the direction of flight. The latter is then divided into 185-km by 185-km images by the ground processing.

Data collection and processing

The data collection system (DCS) provides a mechanism for collecting data transmitted from earth-based sensing platforms and retransmitting the data to the ground over the receiving stations. Each ground platform can have various analog or digital inputs, and the system has a high probability that data will be received from every platform within each 12-hour period. These sensing platforms are used to measure the waterflow in rivers, the water level, the seismic action, and similar phenomena. Table I summarizes the payload characteristics.

Video data from the sensors are telemetered to the earth and acquired at various data acquisition centers (Fig. 1), then sent to the NASA Data Processing Facility (NDPF), part of the Landsat Ground Data Handling System (GDHS). Both photographic and digital tapes are produced in the NDPF and distributed to investigators, who then feed back requirements for new data to the Operation Control Center (OCC), which is responsible not only for the housekeeping of the spacecraft (such as power budgeting), but also for the command sequences that turn the sensors on and off. Because both the recording capacity of the on-board video recorders and the power of the spacecraft are limited, the operation of the sensors cannot be continuous, but must be scheduled carefully. The DCS retransmits signals received from ground-based platforms to the NASA ground station when both have line of sight to the spacecraft.

NDPF must generate geometrically and radiometrically connected images and photographically process



[1] Landsat video data are sent to the U.S. National Aeronautics and Space Administration's Data Processing Facility, which generates photographic and digital tape for investigator evaluation. Data must be processed from 1000 data collection platforms and offered in 23 standard output products.

and distribute them to the various users. The NDPF must also provide digital tapes of these images, as well as a number of user services, such as prescreening of the data, preparation of catalogs, and cross-referencing. Some of the general requirements of the NDPF include the ability to process 1500 scenes a week from 9212 spectral images. Data must also be processed from 1000 DCP platforms and offered in 23 standard output data products. The images are corrected and scaled to a universal transverse Mercator (UTM) projection of one million to one. They are also appropriately annotated with coordinates, a gray scale, and other identifications. Data are combined in the NDPF computer/display device called the initial image generation subsystem to generate these images. These data include calibrations, transfer functions of radiance to voltage, and image annotation tapes containing information on the ephemeris, time of day, orbit, spacecraft attitude, and location. For example, the uncorrected video from the RBV has optical distortions as a result of the lenses, electrical distortions inside the camera, and attitude errors of the spacecraft. The image generation subsystem divides each image into 81 parts and corrects these geometric and linearity errors. The data can be reprocessed using known geographic locations to improve further the geographic fidelity of the image.

The NDPF must provide these images rapidly, maintain a system for quick retrieval of data, and answer any request quickly. The catalogs produced contain United States scenes, scenes of areas outside the U.S., and DCS data.

All data go to the Earth Resources Operational Center at Sioux Falls, S.Dak. These data are available to any user, organization, or member of the general public. In addition to the major U.S. Government agencies—Agriculture, Interior, National Oceanographic and Atmospheric Administration, and the Corps of Engineers—receiving the data, 330 other investigators use the information. To date, some 10 million images have been distributed, covering well over 90 percent of the earth under cloud-free conditions.

These products are not normal color photographs, as can be seen from the introductory illustration. Of the four spectral regions of the MSS, two are outside the visible range. In the initial image generation, the MSS produces four black and white pictures (one for each spectral region), any three of which can be combined with color filters to produce what is called a "false color" picture.

Applications

An example of the broad view provided by space exploration is shown on the opening page of this article—a single Landsat image from the multispectral scanner showing the southern end of Lake Michigan. This is a false color picture: green vegetation appears as dark red, water is either blue or black, cities are a blue-gray color, and water with sediment in it appears as a bright blue.

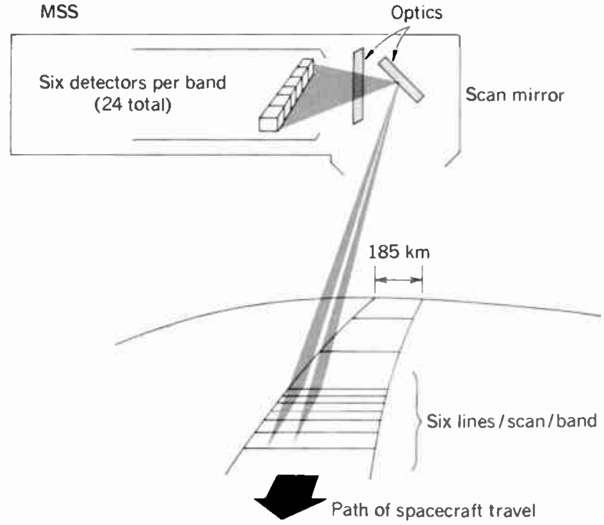
That data of social significance can be gleaned from such images is aptly demonstrated by this particular shot. It had been postulated that moisture evaporating from the surface of the lake could condense the solid particles in the smoke emissions from the steel mills in Hammond and Gary, Ind., thereby forming clouds. This Landsat picture appears to confirm the theory. In the middle of the image can be seen smoke emissions from the Hammond and Gary steel mills. The smoke is being wind-blown in a northeasterly direction across the lake. In the upper right-hand corner of the picture is a cloud perfectly aligned with the smoke plume and no other clouds appear in this 34 225-km^2 picture. On the right-hand side of the picture can be seen a snow cover on the ground, which may have precipitated from this cloud.

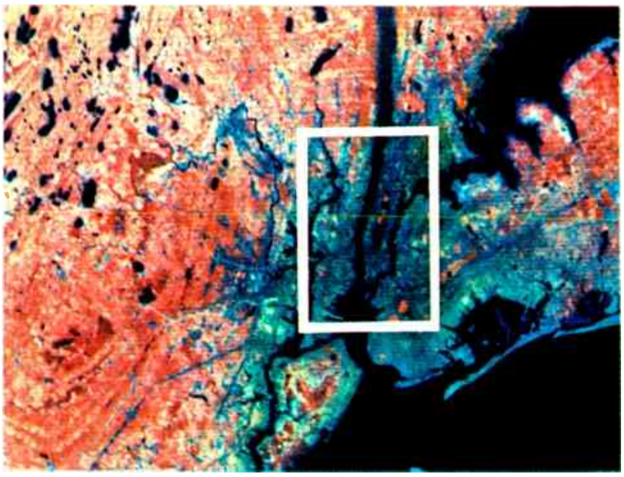
Such 185-square-km Landsat images contain an enormous amount of information. This can be demonstrated by enlarging a Landsat image as shown in Fig. 3. The original shot, shown on the left, covers an area stretching from just north of Wilmington, Del., to New York City. The enlargement on the right shows, without enhancement, New York's Central Park and its lake. The ground correction of the data makes it possible to use these images as maps at scales of 1:1 000 000 (with additional processing, up to 1:250 000). It would

I. Characteristics of the scanning system and multidetector array

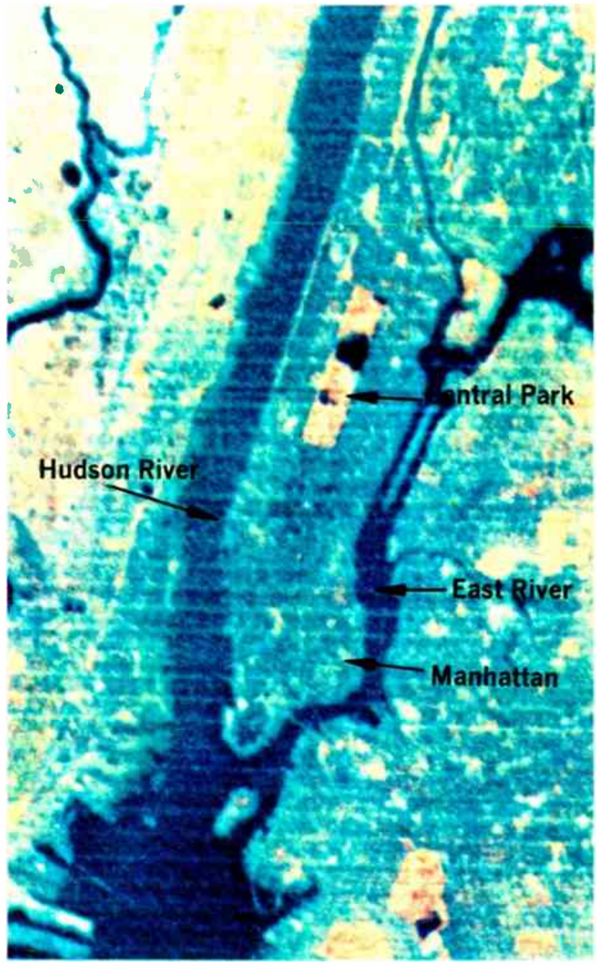
Coverage	RBV (185 by 185 km)	MSS (185-km swath)	DCS
Spectral bands	0.47–0.57 μm 0.58–0.68 μm 0.69–0.83 μm	0.5–0.6 μm 0.6–0.7 μm 0.7–0.8 μm 0.8–1.1 μm	
Time between picture sets	25 seconds		
Readout time	3.5 seconds/camera	Continuous	
Exposure	Variable, 4 to 16 ms	Electronically controlled	
Data	3.5-MHz video	15-Mb video	100-kHz digital
Ground platforms			Up to 1000
Ground-platform input			Eight analog or digital signals

|2| The Landsat multidetector array and scanning system consists of a scanning mirror and six detectors for each of the four bands. The period from the beginning to the end of a scan is approximately 90 ms, during which time the spacecraft will have traveled 540 meters over the ground.





[3] Shown above is a Landsat image of the Atlantic coast from just north of Wilmington, Del., to New York City, New York. To the right, the image has been enlarged sufficiently to pick out New York's Central Park and even the principal lake in that park. It would take nearly 2000 conventional medium-altitude photographs and approximately $100 000 in labor to achieve the same detail.



take nearly 2000 conventional medium-altitude photographs and approximately $100 000 in labor to assemble one equivalent picture by conventional aerial surveying means. When one considers that a cloud-free picture of the entire continental United States has been made by Landsat, it becomes apparent that Landsat can provide staggering economies in aerial surveying costs.

And such photographs have produced some surprises. For example, pictures of the Amazon and Purus rivers indicate that the tributaries are very different from the ones shown on conventional maps. River islands exist that are not shown, and, as has been said, the Trans-Amazon Highway was mislocated on conventional maps by more than 35 km.

Speed is another advantage of this mapping technique. The Wind River Mountain Range in Wyoming was 10- to 15-percent mapped over a period of five years. With one Landsat image, the remaining 85 to 90 percent was mapped in less than one day.

In southern California, a new fault related to earthquake activity was found. Since geological faults are often associated with mineral deposits, Landsat images have already provided sites for exploration of possible gold, nickel, copper, and oil reserves. And in a rather different vein, Landsat revealed that in the lower bay area of New York City, an acid plume and sewage sludge had come close to the New Jersey coast. Successive observations of the area have shown the extent, drift, and dispersion characteristics of the waste deposited in the coastal waters around New York. These observations indicate that the waste material remains floating in concentrated form for periods in excess of ten hours and that New York Harbor's total discharge ends as far south as Long Branch, N.J.

Landsat data can also be enhanced by computers to bring out certain features. For example, the Los Angeles basin as originally taken by the instrument has been processed in a computer and displayed on a color television screen to "emphasize" heavy industrial areas and high-density residential areas. Such enhancement techniques can also be used to identify material. A Landsat image of the Washington, D.C., area taken in September 1972 showed rivers and vegetation under normal conditions for that time of year. An image taken just 18 days later, after a period of torrential rains, showed a brilliant blue in the upper reaches of many rivers. Comparing the two computer-enhanced images revealed that the rains had produced a high sediment level. And this kind of computer enhancement is presently being used to differentiate normal sedimentation from organic pollutants caused by industrial effluents and sewage dumping.

Such repetitive multispectral coverage of land and ocean areas has brought the science of remote sensing into its own. Future savings in lives and property because of satellite remote sensing of the environment can be expected to repay the costs of these missions many times over. ◆

John J. Horan is currently payloads manager for the Nimbus and Landsat satellite programs at the General Electric Space Division, Valley Forge, Pa. He joined GE in September 1968 and has worked in its Space Systems Organization ever since. Prior to joining GE, Mr. Horan was with RCA's Astro-Electronics Division for seven years. His work there was in the areas of television, electrooptical sensor development, and infrared space systems. Mr. Horan had previously been employed by Barnes Engineering, Stamford, Conn., and CBS Laboratories. He holds the B.S.E.E. degree from the University of Rhode Island.

NEW FEDERAL BUDGET BRINGS BOOST FOR R&D

Research and development are accorded generally preferential treatment in the budget that President Ford sent to Congress last month for Fiscal 1977, which begins next October 1. While the President called for holding overall Federal spending to an average increase of 5.5 percent, R&D is budgeted for an 11-percent rise, to a total of $24.7 billion. Of this amount, $23.5 billion is for the conduct of R&D, with the remainder slated for construction and equipment. Since the inflation rate for the new fiscal year is projected at 6 percent, R&D has the distinction of being singled out as one of the few Federal activities that will experience growth--Congress willing, of course.

The proposed increase for the conduct of R&D amounts to $2.2 billion, of which three fourths is scheduled for development programs. On an agency-by-agency basis, the big gainers are Defense, 16 percent; the Energy Research and Development Administration, 13 percent; and the Department of Health, Education, and Welfare, 12 percent.

Basic research, which has been particularly hard hit by sparse budgets and inflation, is due for an 11-percent increase when all the agency figures are averaged out. However, the National Science Foundation, a mainstay of support for academic basic science, will be boosting its spending for that category by 20 percent.

The figures for energy research are actually brighter than is indicated by the 13-percent boost for ERDA, since that percentage includes ERDA's activities in nuclear weapons. For programs directly related to energy research, the increase comes out to 38 percent, for a total of $2.6 billion.

One of the few research-related agencies to be given an essentially standstill budget is NASA, whose obligation authority for space R&D will rise from $3.2 billion to only $3.3 billion. With the funding requirements of the Space Shuttle on the upswing, NASA has ordered a one-year delay in initiation of production of the third Shuttle Orbiter, postponement to 1978 of a start on development of the Space Telescope, and deferral of consideration of a Pioneer-type orbiter and probe of Jupiter.

However, NASA's civilian aeronautical research and technology program is listed for a 13-percent rise, to a total of $364 million. One major thrust of the new program is the reduction of energy requirements for aircraft. Among the new starts is a $25 million item to start construction of a National Transonic Facility for research in aerodynamic design for the transonic regime.

"SCIENCE COURT" ON TRIAL

White House science planners have given the go-ahead for an experimental try of the "science court" idea that has been long suggested by Arthur Kantrowitz, chairman of the Avco Everett Research Laboratory. As conceived by Kantrowitz, the court, consisting of "judges" with professional, scientific, and technical backgrounds, would seek to ascertain the scientific facts in regulatory controversies such as ozone depletion, nuclear safety, and food additives. The court would have no legal standing, but would rely on the thoroughness and quality of its deliberations to acquire influence.

Energy report

Terrestrial conversion efficiencies of 10 percent have been obtained with solar cells developed from impure, potentially inexpensive semicrystalline silicon. The Solarex Corporation of Rockville, Md., reports that, contrary to the generally held belief that such silicon would be unstable, the cells display a high degree of stability, with their characteristics remaining unaltered up to 400°C. Further experimental efforts are underway at Solarex to find methods for producing the semicrystalline silicon in commercial quantities. The development is significant, the company says, because the high price of single-crystal silicon is a major cost factor in the manufacture of solar cells and a cheaper cell could have an impact on the use of solar cells as a primary source of electric power.

Fifty-three electric utilities are either sponsoring or planning 220 individual solar research projects, according to an EPRI survey. Utility projects are in four categories: solar energy availability and weather data, technology demonstration, system performance and its impact on electric utility operations, and other related solar activities. Copies of the survey results are available from Dr. John Cummings, EPRI, 3412 Hillview Ave., Palo Alto, Calif. 94304.

A directory of state government energy-related agencies is available at $3.05 per copy (No. 041 000 90 9) from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Published by the Federal Energy Administration, the directory also includes such information as state government contacts for energy conservation, energy facilities' siting, comprehensive land-use planning, environmental impact assessments, and public utility regulations.

Electric load management gets increased attention as the FEA, EPRI, EEI, and other organizations put research programs into effect. The FEA has funded a $2 million program for fiscal year 1975-76 that has load-management projects underway throughout the U.S. and a $1 million paper study of the technology, costs, and feasibility of time-of-day metering, jointly sponsored by EPRI, EEI, and NARUC (National Association of Regulatory Utility Commissioners), has begun. The programs are aimed at determining, in part, whether or not energy rate patterns should be revised to encourage customers to minimize peak demands. Any resultant action could include rate revisions penalizing high peak electricity use, thereby giving incentive to run nonessential electric apparatus during low-use periods.

Four recommendations have been made by U.S. appliance manufacturers on new energy testing and labeling requirements of the Energy Conservation and Oil Policy Act of 1975. A statement filed with the Federal Energy Administration by the Association of Home Appliance Manufacturers urges: that rules for measuring the efficiencies of appliances be based on existing standards and those now being developed; that the new program incorporate existing labeling programs (such as those conducted by manufacturers under the U.S. Department of Commerce voluntary appliance labeling program); that proven and widely accepted comparison information be used rather than "cost-of-operation" averages that could mislead customers; and that no additional reports be required if needed data can be obtained from, or added to, existing reporting programs. The association also warned that excessive or improper emphasis on appliance efficiency may lead to the selection of equipment that appears to be efficient but, because it is of the wrong size or type, is less efficient in use.

Inside IEEE

Legislative forum to focus on energy

"Energy Conservation: Myth or Mandate?" is the theme of the fourth annual Joint Engineering Legislative Forum, to be held at the Washington Hilton Hotel, Washington, D.C., March 29–31. The forum's sponsor is the National Society of Professional Engineers and its technical liaison societies, including IEEE.

Decision-makers from the U.S. Congress, the Administration, and private industry will exchange views with the technological community on the Government's attempts to formulate a national energy policy. A highlight of last year's forum was a debate between consumer advocate Ralph Nader and Representative Mike McCormack on the pros and cons of nuclear energy—one of the first successful efforts to bring together arguments on both sides of the issue.

The 1976 forum will focus on three main topics, considered the key energy issues requiring legislative action during the coming year: evolving priorities—the conflict between nuclear and solar power in the debate over allocation of energy R&D funds; the energy–environment tradeoff; and energy conservation requirements. In this last area, the question to be considered is: May the Federal government require legislatively mandated energy conservation codes for commercial buildings and product design?

In addition, leading Presidential candidates will be invited to discuss their energy platforms and what the Government should—and should not—be doing to resolve the nation's energy problems.

For information, contact: Joint Engineering Legislative Forum, NSPE, 2029 K Street, N.W., Washington, D.C. 20006.

IEEE names winners of '75 annual awards

The IEEE Board of Directors, acting upon the recommendation of the Awards Board, has announced the 1975 recipients of the Institute's Major Annual Medals and Prize Paper Awards. They will be presented during ELECTRO in Boston, Mass., May 11–14.

The medal winners are as follows: Edison Medal—Murray Joslin; Founders Medal—Edward W. Herold; Lamme Medal—C. Kumar N. Patel; Education Medal—John G. Linvill.

Prize Paper Award winners are: W. R. G. Baker Prize Award—Robert W. Keyes; Browder J. Thompson Memorial Prize—Russell M. Mesereau and Dan E. Dudgeon.

The Major Annual Medals will be presented at the Banquet on May 12 and the Prize Paper Awards at the Directors' Reception on May 11.

Murray Joslin (LF) of Oak Park, Ill., will receive the Edison Medal "for his leadership in overcoming technical and financial obstacles to nuclear power generation and for managerial guidance and foresight in planning, building, and operating the early Dresden Nuclear Power Station."

Born in Independence, Iowa, in 1901, he received the B.S. degree in electrical engineering from Iowa State University in 1923. Following his graduation, he was employed by the Commonwealth Edison Company (and affiliated companies), where he remained until his retirement in 1966. At Commonwealth Edison, he assumed responsibility for nuclear activities in 1951, and was made a vice president in 1953.

A member of the Nuclear Technical Advisory Board, Mr. Joslin also served on the Illinois Commission on Atomic Energy from 1959 to 1975. He is a Fellow of the American Society of Mechanical Engineers, a Life Member of the Western Society of Engineers, and a former member of the American National Standards Institute, and from 1967 to 1972 chaired an ANSI committee drafting standards for nuclear power plants. He was awarded the Marston Medal by Iowa State University in 1959, as well as citations by the U.S. Atomic Energy Commission in 1968 and the Corps of Engineers in 1970.

M. Joslin

C. K. N. Patel

E. W. Herold

J. G. Linvill

Edward W. Herold (LF), a consultant in Princeton, N.J., has been awarded the Founders Medal "for his outstanding contributions to the electrical engineering profession at large, and in particular for his insight and leadership in the development of color television."

A native of New York City, Dr. Herold joined the Bell Telephone Laboratories in 1924 as a technical assistant in a group working on picture transmission. He later worked with an electron tube company, E. T. Cunningham, Inc. After graduating from the University of Virginia with the B.S. degree in physics in 1930, he joined RCA as an electron tube development engineer, at Harrison, N.J. Upon receiving the M.S. degree from Brooklyn Polytechnic Institute in 1942, he transferred to RCA Laboratories in Princeton, N.J., to carry on research on electron devices. During 1949–50, Dr. Herold directed a successful effort to develop a color television picture tube, one result of which was the shadow-mask tube.

He also became interested in semiconductor-device research, and in 1952 directed a group that exploited the alloy junction transistor. In 1957, he headed the RCA team that helped to build the first large nuclear-fusion research facility at Princeton University. In 1959, Dr. Herold left RCA to join Varian Associates, Palo Alto, Calif., as vice president, Research. In 1961, Brooklyn Polytech awarded him the honorary D.Sc. degree. He returned to RCA in 1965, retiring as director of technology in 1972.

An early member of the Institute of Radio Engineers, Dr. Herold was one of the founders of the IRE Princeton Section, and served as its chairman in 1949. He holds 47 U.S. patents and is the author of 49 publications.

The Lamme Medal went to **C. Kumar N. Patel** (F), director, Electronics Research Laboratory, Bell Telephone Laboratories, Holmdel, N.J., "for the invention and development of the carbon dioxide and spin-flip Raman laser and for contributions to infrared spectroscopy of gases and liquids."

Dr. Patel, who was born in Baramati, India, in 1938, was graduated from Poona University with the B.E. degree in 1958. From 1958 to 1961, he attended Stanford University, and received the M.S. and Ph.D. de-

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R. W. Keyes

R. M. Mesereau

D. E. Dudgeon

grees in electrical engineering. In 1961, he joined Bell Laboratories, where he has discovered a number of laser systems. In 1965, he invented a flowing gas laser, which utilized the transfer of vibrational energy of molecules to obtain what was then the highest continuous power output at infrared frequencies and the highest energy conversion efficiency of any laser. In 1967, he became head of the Infrared Physics and Electronics Research Department.

Dr. Patel received the Optical Society of America's Adolph Lomb Medal in 1966, the Franklin Institute's Stuart Ballantine Medal in 1967, and the 1975 Honor Award of the Association of Indians in America. He is a member of the National Academy of Sciences.

John G. Linvill (F), chairman, Department of Electrical Engineering, Stanford University, Stanford, Calif., will receive the IEEE Education Medal "for leadership as a teacher, author, and administrator, and for contributions in solid-state electronics and technology."

Dr. Linvill received the A.B. degree in mathematics from William Jewell College, Liberty, Md., in 1941, and the B.S., M.S., and Sc.D. degrees in electrical engineering from the Massachusetts Institute of Technology in 1943, 1945, and 1949, respectively. He received an honorary doctor of applied science degree from the University of Louvain, Belgium, in 1966.

From 1946 to 1951, he was assistant professor of electrical engineering at M.I.T. He then became a member of the technical staff at the Bell Telephone Laboratories, Murray Hill, N.J., where he did research on transistor circuit problems in linear and pulse circuits. Since 1955, he has been at Stanford University.

He is a member of the National Academy of Engineering and the American Academy of Arts and Sciences.

Robert W. Keyes (F), International Business Machines Corporation, Hopewell Junction, N.Y., has been awarded the W. R. G. Baker Prize Award for his paper entitled, "Physical Limits in Digital Electronics."

Dr. Keyes received the Ph.D. degree in physics from the University of Chicago in 1953. Previously, from 1946 to 1950, he was associated with the Chemistry Division of the Argonne National Laboratory. Then, from 1953 to 1960, he was a staff member of the Westinghouse Research Laboratory in Pittsburgh, Pa., where he conducted research in solid-state physics.

In 1960, Dr. Keyes joined the IBM Research Laboratory, Yorktown Heights, N.Y., and since then has engaged in research and development activity in fields related to modern electronics technology. He is a Fellow of the American Physical Society.

Russell M. Mesereau (M), assistant professor, School of Electrical Engineering, Georgia Institute of Technology, Atlanta Ga., and **Dan E. Dudgeon** (M), senior scientist, Bolt Beranek and Newman, Cambridge, Mass., are the recipients of the Browder J. Thompson Memorial Prize Award for their paper, "Two-Dimensional Filtering."

Dr. Mesereau, who was born in Cambridge, Mass., in 1946, received the S.B., S.M., and Sc.D. degrees from the Massachusetts Institute of Technology.

From 1971 to 1973, he was an instructor in the Department of Electrical Engineering at M.I.T., and from 1973 to 1975 was with the Digital Signal Processing Group of the Research Laboratory of Electronics, M.I.T., as a research associate. He transferred to the Georgia Institute of Technology last year.

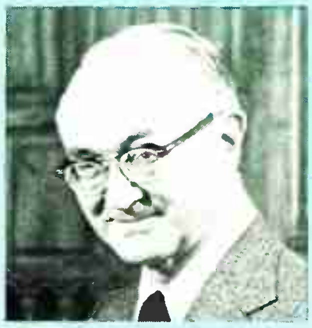
Dan Dudgeon, born in 1947 in Elmhurst, Ill., received the B.S. and M.S. degrees in electrical science and engineering in 1970, the E.E. degree in 1971, and the D.Sc. degree specializing in signal processing in 1974, all from the Massachusetts Institute of Technology. From 1967 to 1969, he was a cooperative student at Bell Laboratories, and in 1969 and 1970, worked in Bell's Acoustics Research Department. In 1972–74, he was a research assistant in the Research Laboratory of Electronics and a member of the Digital Processing Group at M.I.T. while working on his doctoral thesis. Since 1974, he has been with the Computer Sciences Division of Bolt Beranek and Newman, Inc.

Puente, Dickieson win IEEE Field Awards

The International Conference on Communications in Philadelphia, Pa., June 14–16, will be the site of two IEEE Field Award presentations. The 1975 Award in International Communication in honor of Hernand and Sosthènes Behn will go to John G. Puente (M) "for leadership in and contributions to the development of digital techniques and multiple access methods for satellite communications." Also, Alton C. Dickieson (F) will be presented with the 1975 Mervin J. Kelly Award "for contributions in the field of telecommunications encompassing voice frequency, cable, and radio systems for domestic and international services."

John Puente, president of the Digital Communications Corporation, was born in New York City in 1930. He received the B.E.E. degree from the Polytechnic Institute of Brooklyn in

J. G. Puente



A. C. Dickieson

1957 and the M.S.E.E. degree from the Stevens Institute of Technology in 1960.

From 1957 to 1960, Mr. Puente worked on the design and development of pulse instrumentation and radar equipment for Stavid Engineering, Plainfield, N.J., and ITT Laboratories, Nutley, N.J. In 1960, he joined IBM's Communications Department in Rockville, Md., where he was a manager of communication device development. He joined Comsat Corporation in 1963, and rose to director of technology responsible for research and development of earth stations, spacecraft, and communications. In 1973, he joined the American Satellite Corporation, where he served as executive vice president of operations.

Alton Conant Dickieson (F) studied electrical engineering at Brooklyn Polytechnic Institute, before joining the Engineering Department of the Western Electric Company (which later became the Bell Telephone Laboratories) in 1923. During his career at Bell, he held various positions, retiring in 1970 as vice president, Transmission Development. In this position, he was in charge of the development of systems using paired cables, coaxials, microwave relays, submarine cables, satellites, and millimeter waveguides. He also directed the experimental Telstar communication satellite project.

Mr. Dickieson's honors include the Naval Ordnance Development Award, the H. H. Arnold Award of the Air Force Association and the Hoyt S. Vanderberg Award of the Arnold Air Society (both with John R. Pierce), the 1971 Achievement Award of the IEEE Communication Technology Group, and the U.S. Navy's Distinguished Public Service Award.

Philadelphia hosts Club of Rome meeting

As part of the U.S. Bicentennial celebration, the IEEE Philadelphia Section has invited the Club of Rome to meet in Philadelphia, Pa., April 12–13. According to Fulvio Oliveto, the Section's public relations chairman, the purpose of the meeting is to present current findings in the study of the predicament of mankind and the macroproblems of the technological age.

The Club of Rome, which was founded in 1968, is an international, limited-membership, informal body of scientists, educators, and economists. Through sponsorship of research in many countries, they study the role of man and his relationship with his environment with a view toward a better life for all. The results of their studies are made known via the mass media, personal contacts with top-level planners, and conferences such as the present one.

IEEE Past President Arthur Stern has been invited to attend the meeting as one of a special group of distinguished guests from the United States, which includes—among others—U.S. Secretary of Transportation William Coleman; Emilio Daddario, director of the Office of Technology Assessment; H. Guyford Stever, head of the National Science Foundation; and James Reston of the *New York Times*. Approximately 70 members and guests will participate.

The Philadelphia Section's cohosts for the event are the Franklin Institute and the First Pennsylvania Company.

Participation in the meeting is by invitation only. However, persons wishing to observe the proceedings should request tickets from the IEEE Philadelphia Section office, at the University of Pennsylvania, Philadelphia, Pa. 19174, before March 31.

History/education groups to cooperate

The Administrative Committee of the IEEE Education Group has approved a new working relationship with the IEEE History Committee.

As a result of negotiations initiated by History Committee Chairman John D. Ryder, the Education Group will augment its Administrative Committee with two *ex-officio* members, with vote, to be appointed by the President upon consultation with the History Committee. It is also anticipated that an associate editor for history will be named for the *IEEE Transactions on Education*. The Education Group has added "electrical history" to its technical-interest profile choice.

It is expected that this joint venture will provide for regular publication of papers related to electrical history.

McNutt, Meditch citations corrected

The citations for newly elected IEEE Fellows W. J. McNutt and J. S. Meditch were incorrect as they appeared in the January issue of *Spectrum* (page 26). They should read as follows:

William J. McNutt
For contributions to the design and standardization of test procedures of power transformers

James S. Meditch
For contributions to the development and application of estimation theory

Earth-sciences papers are invited

The submission of papers is invited for a forthcoming special issue of the *IEEE Transactions on Geoscience Electronics*. The theme of the issue will be "Electrical and Electromagnetic Methods in the Earth Sciences."

Prospective authors are asked to send copies of their manuscripts to the guest editor of the issue: Dr. Robert Reeves, EROS Data Center, Sioux Falls, S.Dak. 57198, by May 1.

Forum

Readers are invited to comment in this department on material previously published in *IEEE Spectrum*: on the policies and operations of the IEEE; and on technical, economic, or social matters of interest to the electrical and electronics engineering profession. Short, concise letters are preferred. The Editor reserves the right to limit debate on controversial issues.

Air safety

This letter is in response to the particularly venomous and often rabid attack on air traffic controllers and PATCO contained in the August 1975 issue of *IEEE Spectrum* (pp. 67–71). The article, "Air safety as seen from the tower" by John K. King, is an obvious "hatchet job" employing lies, half-truths, inconsistencies, and monumental biases.

Mr. King's background is most revealing and goes far to explain the tone of the diatribe. The Air Traffic Control Association, of which Mr. King was executive director, is ostensibly a "professional society" of air traffic controllers. Before the formation of PATCO, ATCA was a sort of "sweetheart" union to the FAA, being composed in the main of management people like Mr. King who ignored and concealed both the safety dangers and personnel problems in the ATC system in return for the benefits of career advancement. Because of ATCA's intransigence and inability to bring about needed reform in the ATC system, controllers formed their own organization, PATCO, both to maintain air safety and to protect themselves from the "sweatshop" conditions prevalent in ATC. PATCO's rise as the sole voice of all controllers paralleled ATCA's eclipse and descent to its present situation, a handful of managerial personnel debating in a vacuum.

It is also noteworthy that Mr. King was chief of the FAA's Southwest Region Training Branch, the Southwest Region being notorious for its prefeudal attitude toward labor relations, and "principal advisor" on air traffic training in the Washington headquarters since controller training, or rather the lack of it, has always been one of the major shortcomings of the FAA.

Having examined Mr. King's credentials, I will now proceed to discuss his comments.

Mr. King opines that PATCO was formed because "the FAA was not as considerate of its controller workforce as it might have been." By this gross understatement, the author dismisses the six-day weeks, the ten-hour days, the inadequate staffing and equipment, management's slave-labor attitude, the inhuman pressure, and the superhuman efforts that were the everyday realities of air traffic controllers before PATCO. Mr. King would like us to return to these "good old days" when he hopes that the controller "can again be inspired to respond above and beyond the call of duty." Does Mr. King really believe that skeletal staffing, prehistoric equipment, and bare-minimum separation standards were safe conditions for aviation either then or now?

Of course it is easy for Mr. King to be nostalgic as he was probably not a controller for very long; that his 18 years were predominately spent in supervisory positions is evident from his use of the condescending and demeaning phrase "care and feeding of controllers" to describe PATCO–FAA contracts.

That PATCO "calls the shots" for FAA in any way is a blatant lie. If it were true, PATCO would not need to hound the Agency to allow controllers some input into the technical areas from which we are now foreclosed. If it were true, controllers would be receiving salaries commensurate with their responsibilities and working a lesser number of hours to minimize the strain. Moreover, if it were true, the air traffic control system would probably be safer and more efficient.

The most inaccurate slur made by the author is that the controllers, and PATCO, have recently disdained safety in favor of crasser "personal benefits." Just as the *raison d'être* for air traffic control is air safety, the separation of airplanes, one of the main reasons controllers formed PATCO was the preservation and furtherance of air safety. Mr. King obviously has not followed our history, our statements, or our actions. He neglects to mention that PATCO's safety activities include an intimately knowledgeable watchdog posture over the ATC system, a team of trained accident investigators, a PATCO Safety Program, and, most important, an overriding sense of professional pride by controllers.

And this pride is what Mr. King will never comprehend: an air traffic controller can never separate safety from job benefits because safety, in the form of job satisfaction, is the reason a man becomes an air traffic controller.

IEEE Spectrum has displayed a deplorable lack of balanced journalism by presenting Mr. King as a representative of ATC, and his article as an objective view of the system. Since you have represented the pilot's view of ATC by allowing the recognized representative of pilots, ALPA, to speak through the very able and knowledgeable Mr. Cotton (August 1975, pp. 71–74), one must wonder why a representative of PATCO, the recognized controller's organization, let alone an authentic controller, was not allowed the same privilege. Instead, *Spectrum* chose an author bearing tainted credentials, armed with obvious biases (how else to explain the special box "awarded" to PATCO), and dripping revenge.

Besides insulting the over 16 000 controllers of the U.S., *Spectrum* has done a very grave disservice to its readership by clothing Mr. King's very personal and slanted attack with the virtues of objectivity and expertise. Controllers everywhere hope that your readers are not deceived.

John F. Leyden, President
PATCO
Washington, D.C.

I have read the comments made by the president of PATCO about the article, "Air traffic safety as seen from the tower." With controllers—and others—everywhere, I share the hope that *Spectrum* readers are not deceived. Therefore, I urge those who are interested to check the pertinent reports, records, hearing summaries, and other documents already in the public domain upon which the statements in the article were based.

For those who are deeply concerned, let me say that the Freedom of Information Act now makes it possible to obtain heretofore unavailable corroborative materials relative to those reports, records, hearing summaries, and other documents. They are in the files at DOT, FAA, and NTSB, as well as at the Department of Labor, and may be obtained by following prescribed procedures.

I firmly believe that freedom of the press and freedom of expression will ultimately reveal the truth to those who seek it.

John K. King, Fort Worth, Tex.

IEEE and R&D

The IEEE resolution on R&D, "Science, Technology, and America's Future" (*Spectrum*, Sept. 1975, p. 76), was introduced in response to a growing concern that, since about 1965, the United States has been losing its position as world leader in industrial innovation. There are several recommendations in the resolution, but the main one urges President Ford to take the steps necessary to increase the total expenditures on R&D from the present level of 2.3 percent of the GNP to a level of 3 percent of the GNP. The clear intent of the resolution was that such an increase in funding for R&D would lead to increased industrial innovation and, presumably, to regaining world leadership.

It is my contention that the resolution is based on erroneous concepts and that, if it were implemented, the expected large increase in innovation would not likely materialize. Implementation would raise false hopes and lead, in the long run, to increased disenchantment on the part of the public with industry.

Basic to the resolution is the concept that the key to industrial innovation is R&D, and, therefore, increased funding for R&D will lead to the needed innovations. If R&D represented the key to innovation, surely it would follow that the major source of innovation would be the large industrial research laboratories with their enormous resources.

It is known that this is not the case.[1]

The major source of innovation is actually the lone entrepreneur or small groups of them in small companies.[1] The innovations they produce are out of all proportion to the small amounts of money they devote to R&D.

There is a widespread belief that there is a shortage of ideas and inventions on which to base new innovation ventures. A report issued by the Denver Research Institute[2] talks of the "paradox of unexploited technology," pointing out that the lack of innovation is not due to the lack of useful ideas. R&D is not the key to innovation.

The cost of the R&D involved in creating a new innovation is usually only about 5 to 10 percent of the total cost.[3] The Board's resolution has nothing to say about potential sources for the remaining large costs.

The real shortage is the lack of new innovative companies to perform the increased R&D, and this is, in turn, due to the *lack of entrepreneurs* to launch them. The incentives and rewards are no longer adequate to induce potential new entrepreneurs to take the risks involved. The possibilities for profit are far too small in relation to the high cost of money.

As pointed out recently by William E. Simon, U.S. Secretary of the Treasury, the after-tax profits of nonfinancial corporations in 1974, when corrected for underdepreciation and inventory profit, were less than one third of the reported profits, and only slightly over one half of the corresponding figure for 1965.[4] U.S. industry clearly does not have the extra funds needed to promote innovation.

The basic fallacy underlying the Board's resolution is the belief that particular aspects of industrial policy such as R&D, entrepreneurship, innovation, trade barriers, foreign ownership, etc., can be studied as isolated phenomena. Modern industry is a system, and a highly complex one at that, and it is absurd to try to separate out specific problem areas for study, completely out of context of the system of which they are an intimate part. Only a systems approach will yield the right answers.

The procedure of isolating specific problem areas for study generally leads to the danger of mistaking symptoms of problems for being the real problems. The lack of industrial R&D today is a symptom of the lack of innovative companies to do the R&D, and not the reverse.

I would be the last one to suggest there is no need for increased Federal funding for R&D, but I object to promoting the need for an increase on the basis of concepts that are likely to raise false hopes as to the results.

George Sinclair
1975 Director, Region 7

1. "Technological Innovation: Its Environment and Management," U.S. Dept. of Commerce, Jan. 1967, p. 16.
2. "Federal Incentives for Innovation," Final Report, Contract No. C790, Denver Research Institute, Univ. of Denver, Nov. 1973, p. 4.
3. Ref. 2, p. 9.
4. Jones, Reginald H., "Why business must seek tax reform," *Harvard Bus. Rev.*, p. 51 Sept.-Oct. 1975.

Maxwell or Kirchhoff?

I agree with John A. Baldwin, Jr. (Oct. 1975, p. 26) that duality is a very useful concept in circuit theory. On the contrary, it is very nebulously defined in electromagnetic theory. This perhaps can support the thesis that "circuit theory is based on Maxwell's equations" is a miconception. Rather, circuit theory is based on graph theory and Ohm's law and Kirchhoff's laws. The word "duality" in circuit theory is very unambiguous.

The parallelism between mesh and node, KVL and KCL, voltage and current, etc., is very striking. Two circuits are called dual if the corresponding graphs are dual. The purpose here is not to discuss the abstract properties of dual graphs but simply to state the result, which is: The necessary and sufficient condition for a network to have a geometrical dual is that it is a planar network.[1] Rules for finding the dual of a network, once it is determined that it has a dual, are fairly well known to circuit theorists.[2] In matrix form, the duality condition between two networks N_1 and N_2 can also be stated as $A_1 = B_2$ where A_1 is the incident matrix of N_1 and B_2 is the loop matrix of N_2. Furthermore, the number of branches of N_1 and N_2 must be equal and the rank of A_1 must equal the rank of B_2. Thus, the correspondence between the nodes of N_1 (rows of A_1) and the loops of N_2 (rows of B_2) coupled with the correspondence between the branches of N_1 and N_2 constitute the duality conditions.

The reason why Maxwell's equations cannot be formulated to reflect the principle of duality lies, in my opinion, in the fact that the "medium" of electromagnetic radiation is continuous and cannot be construed as a planar graph.

Timothy Jordanides
California State University
Long Beach, Calif.

1. Whitney, H., "Nonseparable and planar graphs," *Trans. Amer. Math. Soc.*, vol. 34, no. 2, pp. 339-362, 1932.
2. Skilling, H., *Electric Networks*. New York: Wiley, 1974, pp. 198-201.

Circuit theory is not based on Maxwell's equation. It is founded on the definition of lumped elements (resistance, capacitance, etc.) and of two rules of connection (Kirchhoff's laws). If one writes this set of equations, it is directly apparent that the interchange of voltage and current yields the same set although some equations are transformed into another equation of the set. This is the only basis of duality that is a property of Kirchhoff's model for electric circuits.

The Maxwell model is totally different. For instance, it relies on the existence of a three-dimensional space that is totally ignored by Kirchhoff's model. As a result of these different axioms, one model yields partial differential equations and the other ordinary differential equations. This stresses that the two mathematical models, although applied to the same physical phenomenon, enjoy different properties. One should not expect duality to be a property of Maxwell's model because it is a property of Kirchhoff's model.

The letter raising this interesting problem points to a basic flaw in engineers' education. Much too often, there is a total confusion between the models and the physical reality. They are so well identified that one expects the same properties to belong to the one end and to the other. Then, it is quite natural to expect different models to enjoy the same property.

Jacques Neirynck
École Polytechnique Fédérale de Lausanne
Lausanne, Switzerland

I would take exception to Prof. Neirynck's response, particularly the statements, "Circuit theory is not based on Maxwell's equations. It is founded on the definition of lumped elements (resistance, capacitance, etc.) and of two rules of connection (Kirchhoff's laws) . . . The Maxwell model is totally different."

All five of these lumped-constant equations are derivable from Maxwell's equations. Kirchhoff's voltage law (KVL) follows from

$$\text{curl}\left(\mathbf{E} + \frac{\partial \mathbf{A}}{\partial t}\right) = 0 \qquad (1)$$

$$V_{ab} = -\int_b^a \mathbf{E} \cdot d\mathbf{l} \qquad (2)$$

and the application of Stokes' theorem. Kirchhoff's current law (KCL) follows from

$$\text{div}\left(\mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}\right) = 0 \qquad (3)$$

$$I = \int_s \mathbf{J} \cdot d\mathbf{s} \qquad (4)$$

and the application of Gauss's theorem. The relations between the voltage registered by a voltmeter connected in parallel across a circuit element (L, R, or C) and the current registered by an ammeter placed in series with it are derived from Maxwell's equations in many texts (see, for example, W. H. Hayt, Jr., *Engineering Electromagnetics*). This contradicts the statements cited above.

Equations (1) and (3) suggest the following dual pairs in Maxwell's equations.

E: Electric field	**J:** current density
A: Magnetic vector potential curl	**D:** displacement div
Stokes' theorem	Gauss's theorem
closed path	closed surface
B: magnetic flux density	ρ: electric charge density
λ: magnetic flux linkage	Ω: electric charge

However, there are difficulties involved with going further. For example, the equation $D = \epsilon\mathbf{E}$ has the dual $\mathbf{A} = ?\mathbf{J}$, which appears to be nonphysical.

Although the existence of duality in lumped-constant electromagnetic theory does not guarantee its existence in the con-

tinuum version of the same science, there is, on the other hand, no reason to rule it out categorically.

Duality is also a property of the lumped-constant science of mechanics: mass, dashpot, spring, Newton's force, and velocity laws. However, local inquiries have come up with no evidence of duality in continuum mechanics. There are too many coincidences for duality to be an accidental property of lumped-constant sciences.

I thank those who responded to my original inquiry. However, the question remains unanswered. Briefly put, it is this. The five equations of linear lumped-constant circuit theory are

$$v_L = L\frac{di_L}{dt}$$

$$v_R = i_R R - i_R/G$$

$$i_C = C\frac{dv_C}{dt}$$

$$\sum_{\text{node}} i_n = 0 \quad \text{(KCL)}$$

$$\sum_{\text{mesh}} v_n = 0 \quad \text{(KVL)}$$

If one performs the transformation $i \leftrightarrow v$, $L \leftrightarrow C$, $R \leftrightarrow G$, KVL $\leftrightarrow$ KCL, mesh $\leftrightarrow$ node, one ends up with the same equations but in a different order. Is there a similar set of transform pairs that changes the equations of continuum electromagnetic theory into themselves?

John A. Baldwin, Jr.
University of California
Santa Barbara, Calif.

Pacemaker recall

In May 1975, I submitted a short article coauthored by Frank Tyers of the Hershey Medical Center to IEEE Publishing Services on the subject of problems encountered in nonhermetically sealed pacemakers. This article predicted among other things that Medtronic's new Xytron series pacemakers would likely be subject to body fluid intrusion. This prediction was recently validated by a 2377-pacemaker recall by Medtronic. The authors felt at that time, and now even more strongly, that this controversial subject deserves wide public debate.

Robert R. Brownlee
The Pennsylvania State University
University Park, Pa.

[The text of the Brownlee, Tyers manuscript follows.—*Ed.*]

The publicly reported loss of life from pacemaker speedup and the recall of General Electric, Biotronik, and Cordis pacemakers within the last few months represent just the latest in a series of problems related directly to inadequate protection of the delicate electronic functions required in implanted cardiac stimulators.[1] The intrusion of body fluids into epoxy-encapsulated pacemakers can and has resulted in lethal pacemaker "runaway" by conductive fluid bridging of electronic timing networks. Premature battery depletion and other circuit deterioration with resultant pacemaker malfunction or total failure can also occur from the gradual entrance of the caustic implant environment into the pacemaker unless means are devised to provide long-term protection from moisture. Nonhermetic metal coverings over epoxy-encased units have proved to be inadequate as moisture barriers in Medtronic pacemakers,[2] and fluid entrance into metal-encased Biotronik units has resulted in encapsulant rupture with tissue gassing and poisoning in one of our series of 25 Biotronik implants.

Thus the pacemaker industry over the past 10 to 12 years, and unfortunately with continuing practice, has absolutely proved that hermetic encapsulation of implanted electronic devices is essential to ensure patient safety and as a requirement for any significant extension of device functional life. It was therefore with some surprise that we not only learned that Caspar W. Weinberger, U.S. Secretary of Health, Education, and Welfare, recently supported his agency's earlier decision to reject a 1969 Navy standard for hermetically sealing implanted electronic components but that this stand against hermetic sealing continues.[3] In response to questions raised by Senator Abraham Ribicoff, Mr. Weinberger stated that "the FDA at this time doesn't believe simply to require hermetic sealing of all implanted pacemakers is necessary or wise. . . . Moreover it could adversely affect the present utility of pacemakers." He stated further that "the entire unit can't be sealed, however, because mercury batteries produce hydrogen gas that must be released." Why, more than five years after the development of hermetically sealed gas-producing (helium) nuclear pacemakers under Federal contracts[4] and at a time when three commercial manufacturers of pacemakers have hermetically sealed units on the market[5] and we have had hermetically sealed rechargeable mercury-zinc-cell (hydrogen gas emitter) powered pacemakers implanted for over two years, and after 23 000 pacemakers have been recalled because of problems arising from the moisture sensitivity of the electronic components and many years after the demonstration that the best epoxies are poor absolute fluid barriers,[6] is the Secretary of HEW speaking out and writing, not in favor of a standard for hermetic sealing of implantable electronic devices, but against even the need for hermetically sealed pacemakers?

The major manufacturers, Cordis and Medtronic, recently introduced devices in which some components are hermetically sealed and, somewhat belatedly, Cordis has completely sealed devices in preclinical trials. Medtronic's new Xytron pacemaker incorporates a hermetic capsule around the electronics. The RM certified cells used are still encased only in epoxy, which indicates that cell outgassing influenced the design. High-impedance fluid bridging of the epoxy-encased cells in the Xytron may result in something less than the advertised life due to the extra cell current drain. The new totally hermetically sealed Cordis pacemakers now in preclinical tests employ a palladium film getter, but rather large amounts of getter must be needed to collect the total gas emitted from the multiple cells employed. We are currently testing hermetically sealed rechargeable single-mercury-zinc-cell pacemakers with a greater than 20-year capability, nonrechargeable single-cell mercury-zinc pacemakers with a five-year capability, and lithium-powered nonrechargeable units with a greater than ten-year capability. Our single-cell mercury-zinc devices have an advantage when hermetically sealed because the volume of outgassed hydrogen is reduced simply by not requiring several emitting cells. Outgassing rates are directly proportional to the ampere-hour capacity utilized; that is, four one-ampere-hour cells emit four times the amount of gas as a single cell of the same capacity.

Problems have been encountered with the development of the new commercial hermetically sealed devices. They are encased in stainless steel or titanium and several have welded seams with the weld exposed to body environment. This exposure of the seam dictates the use of identical weld and case materials to prevent "local action" and adverse chemical reactions with body fluids. Difficulties with excess heating of internal electronic components were originally encountered during the welding process, although welded devices now on the market provide evidence that heat problems are solvable.[5] However, it is probable that components are still thermally stressed beyond desirable limits although specific internal configurations may exist for adequate component insulation during the welding process. In our own efforts to solve the hermetic encapsulation and pacemaker output connector problems, a technique was developed that is unique in that high-temperature welds are not required and minimal-length seams are utilized. Furthermore, all metallic seams are isolated from direct contact with body tissue or fluids.

The past reluctance of the pacemaker industry to seal devices hermetically was related to battery outgassing problems and probably to inadequate welding technology. However, the development and commercial application of nongassing lithium cells and hermetic sealing techniques,[7] the use of "getters," and our development of single-cell low-drain circuitry with and without rechargeability have forced the issue. A continuation of the development and sales of nonhermetically sealed pacemakers beyond a reasonable phase-out period should not be tolerated by the FDA, the medical profession, design engineers, or those responsible for consumer protection.

R. R. Brownlee, G. F. O. Tyers

1. Electronics review—faulty parts afflict pacemakers. *Electronics*, p. 41, Apr. 1975.

2. Cohn, J. D., and Thorson, R. F., "Extrusion of pacemaker pulse generator due to design defect." *J. Thorac, Cardiovasc. Surg.*, 65:323, 1973.

3. G. A. O. Assails F.D.A. over pacemakers: Study says

safety is not assured—use held risky, *New York Times*, Mar. 13, 1975.

4. Nuclear Materials and Equipment Corporation: Radioisotype-powered cardiac pacemaker system design description. Distributed by Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., 1969.

5. Markstein, H. W., "Packaging medical electronics." *Electronic Packaging and Production*, Mar.:28, 1975.

6. Lee, H. Cupples, A., Neville, K., Culp, G., and Schubert, R. J. "Development of improved encapsulation materials for implantation." *Proc. NHI Artificial Heart Prog. Conf.*, 1:777, 1969.

7. Leventhal, D. J. "Testing pacemakers," *Electronic Packaging and Production*, Mar.:42, 1975.

Certification

Your editorial on education, registration, certification, and validation (Aug. 1975, p. 33) concluded that "In the long run, the acceptance of registration/certification will hinge upon its usefulness to and impact upon all of the parties involved—engineer, manager, industry, and the public at large." Based on almost an identical premise, the Certification Commission established itself in the area of voluntary certification by engineers and by medical equipment technicians. The Certification Commission acknowledged that it could only judge usefulness and impact if it were composed of members of the various disciplines that you have enumerated, modified only by their equivalence in the health care delivery system. I welcome this opportunity to second your statements and to invite the IEEE to join with the other organizations in the certification listed herein so that in the area of clinical engineering certification, where your sentiments are well accepted, we can achieve the goals you have so well expressed.

Cesar A. Caceres, M.D.
Certification Commission
Arlington, Va.

The older engineer

How pleasant to read Teck Wilson's letter in the December Forum (p. 20). Imagine, a literate engineer! I particularly liked his mixed metaphor about "time marinating the fibers of resolve" of the older engineer. So true.

I agree with everything Mr. Wilson says about the relationship between younger and older engineers. The younger ones usually are more up to date, and are certainly cheaper. Yet too often neither salary nor knowledge is involved. Fringe benefits take precedence. Sometimes obsolescence does play a part, but the fringe benefit tail can wag the career dog. Curtails the career, you might say; and an older engineer is not hired purely because he will cost the company too much money in fringe benefits, in relation to his productive value in the future. We bring this on ourselves, in our ever-increasing yearning for womb-to-tomb protection from the world in which we live.

Mr. Wilson makes a good point about the older man of ability no longer being in the engineering ranks, and therefore not available for a side-by-side comparison with the younger engineer. The older man has probably been promoted to management.

As Mr. Wilson says, time will take its toll on most careers. Age alone will often nullify a person's market value. This is upsetting, and it will happen to me one day soon. However, there is widespread confusion over the difference between intrinsic value and market value. Despite all the boasting about personal knowledge and experience, it has no market value if nobody is willing to pay for it. This is a dreadful truth, and all unions (or guilds, as engineers prefer to belong to) know that they must at all costs deny this truth. They force employers to keep a person on the payroll because of age alone; or at least to make it a factor. To the extent that they succeed, they dilute the productivity and the economic value of the company. It's a matter of where the horizon lies. A company's plans must be long term, while the typical union man's vision extends all the way to the next payday.

I am not an employer. I work for a large company, and try to keep in mind that it is not the other way round.

P. P. Vaughan
General Telephone Company of Florida
St. Petersburg, Fla.

Discrimination

Regarding the IEEE position on age discrimination as published in the December *Spectrum* (p. 16), I submit that the position is not complete. The statement's very obvious omission is that the matter of mandatory retirement at age 65 is not approached. The *ultimate* act of age discrimination is for an employer to end an employee's career upon the attainment of an arbitrarily set age. Many competent individuals well past "normal" retirement age in government and industry are still working productively. It is quite inefficient, and cruel, to disallow a person's professional usefulness simply because of age.

Shame on us as a professional society if we fail to address this major facet of age discrimination!

William H. Parker, Gardena, Calif.

Books for Bauru

Created in 1966, the "Fundação Educacional de Bauru"—in Sao Paulo, Brazil—is now in the process of building its university campus. And paramount among the requirements of any functioning university is a well-stocked library.

As a gesture of support for the new university, and its students, it is suggested that interested readers of *Spectrum* might wish to donate collections of IEEE publications and/or technical libraries to this worthy cause. For information, contact the director of the foundation: José Renato do Vale Gadelha, c/o Fundação Educacional de Bauru, Rua Campos Salles, no. 9-43, 17100 Bauru, Sao Paulo, Brazil.

Carlos Alberto J. Lohmann
Past Director, IEEE
Sao Paulo, Brazil

New Tektronix Logic Analyzer Acquires 16 channels

Here's how the new TEKTRONIX LA 501 Logic Analyzer acquires more data than other analyzers in its price range; does it with a higher sampling rate; and provides improved ways of displaying that information.

Acquires up to 16 data channels simultaneously. In fact, you can select storage formats of 16 channels x 256 bits, 8 channels x 512 bits, or 4 channels x 1024 bits to best suit your appication.

Stores 4096 data bits on a single pass for display and study of large blocks of nonrepetitive information.

Displays data before a trigger in the pre-trigger mode. Two other modes provide for display of data centered around the trigger or after the trigger.

Provides timing analysis with 15 ns resolution in the asynchronous (internal clock) mode. For logic state analysis, the LA 501 accepts external synchronous clocks with rates up to 50 MHz.

Compares timing between channels easily using the unique capability of selecting any one of the displayed channels and positioning it vertically.

Assures detailed views of logic timing with the unmatched capability of zooming in on any segment of the 4096 bits of data for full screen display. For maximum visual resolution display units with up to 6½" screens are available.

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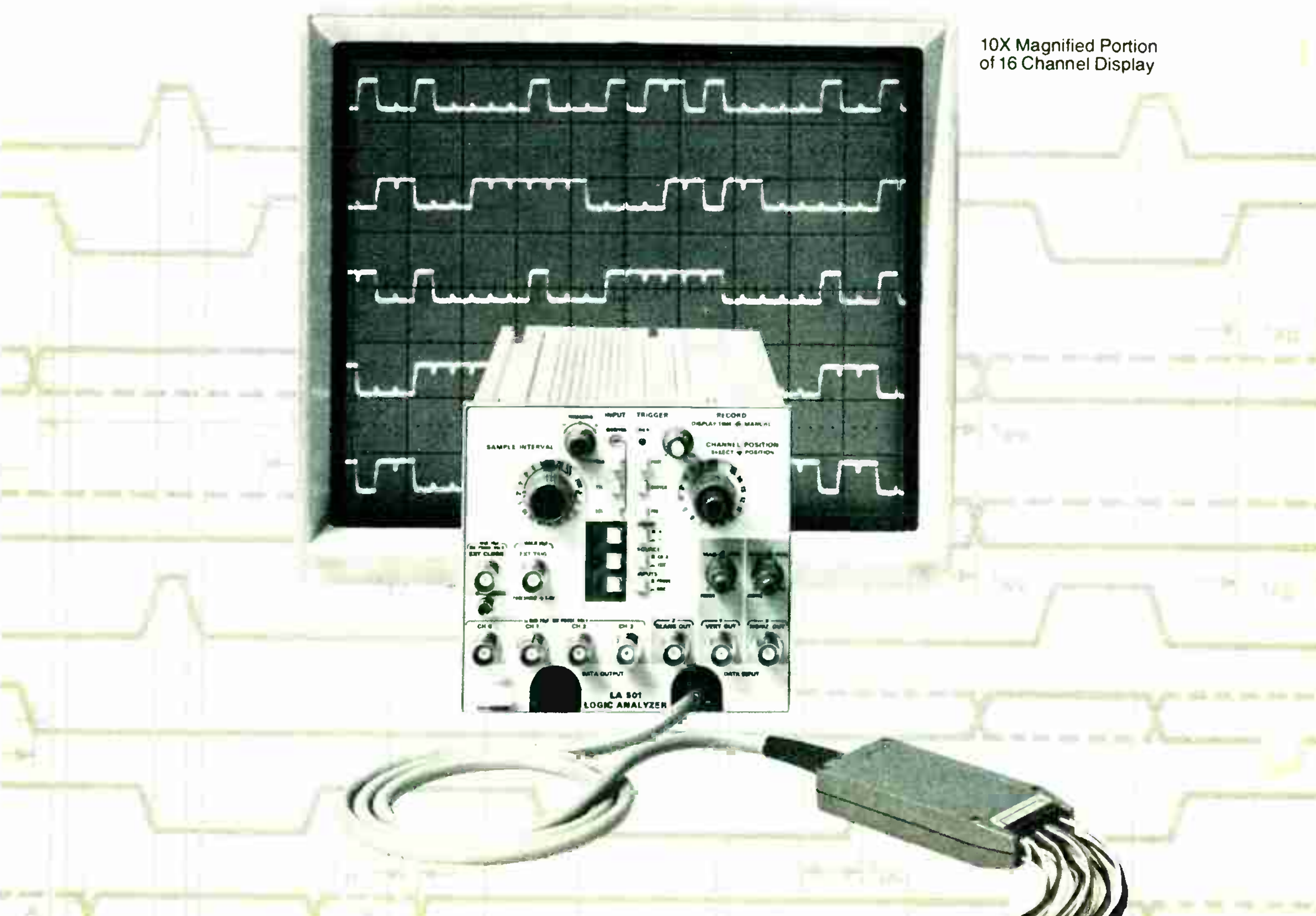

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Financial

IEEE: another AMA?

The inside story of how inflation and recession—those masters of extortion—are devouring professional society dues dollars

Do you think you've been paying more and enjoying it less? By the end of this year the dollar bill you socked away in a savings account in 1967 won't be worth more than 59 cents. By the end of next year, that dollar will have been torn in half by a decade of money-hungry inflation. Successful "Big Business" has learned to live with this inflation spiral. In some instances, so have the trade unions—a number have negotiated rigid "cost-of-living clauses" into their contracts assuring their members annual cost-of-living raises. But among professionals, few have been able to keep pace with soaring costs, and the same holds true for many of the professional associations to which they belong and to which some look for relief when times get hard.

Many EEs wonder why IEEE cannot, or will not, protect its members from inflation and recession "the way the American Medical Association protects the doctors." As perceived by a substantial portion of IEEE's membership, the AMA has created an economic paradise for U.S. physicians by somehow controlling the supply of medical practitioners in the United States, thereby protecting both "jobs" and income. The AMA, itself, denies that it controls the supply of doctors in the U.S. and many EEs would place themselves squarely against such control of the marketplace even at the cost of their own positions.

It is not *Spectrum*'s intent in this article to determine whether the AMA is or is not controlling the flow of young doctors into practice; nor is it our intent to take a position on whether the IEEE should or should not have control over the supply of engineers. Rather, *Spectrum*'s objective is to acquaint our member-readers—already experts on the effects of inflation and recession on their businesses and pocketbooks—with the havoc that this economic one-two punch can perpetrate on their professional association. Actions have been taken to soften the blows of a runaway economy—the Board of Directors, for example, recommended a dues hike to the membership, effective January 1, 1976—but have these actions been effective? Is the member getting the most for his dues dollar? Is the Institute getting support from the member? What can each expect from the other in the future? These are tough questions in the easiest of times. Brushing them under the carpet in difficult times nearly destroyed one of the wealthiest professional associations.

Panic in "Paradise"

In the United States, medical doctors pay dearly for the potent profile of their professional association. In 1967, the year that IEEE's dues were first raised (to $25) following the merger of its parent associations, the IRE and the AIEE, physicians were already paying $70 a year for the privilege of belonging to a national professional association. For four more years, the AMA dues remained $70 a year. Then, in 1971, the trustees determined that, to sustain AMA programs, an $80 dues hike would be necessary—from $70 to $150. The AMA charter empowers an approximately 250-member "House of Delegates" to rule on the recommendations of the trustees. The trustees' request was cut in half by this House of Delegates: The dues were to be increased to $110, no more.

Two options were available to the AMA management: (1) The appraisal of the House of Delegates could be accepted. If so, the trustees would have to decide whether $110 per year would pay for the programs they deemed the members wanted. If it couldn't, programs and/or staff could be cut.

But what if the programs were needed and not overfunded? Then (2) the trustees could go back to the House of Delegates for a dues hike the following year.

Neither path was taken. *Spectrum*'s questions to AMA officers elicited a variety of off-the-record rationales. One AMA official indicated that the House of Delegates was great at approving new programs but "lacked the courage" to approve increases in funding. Another maintained that, in 1971, no one foresaw the severity of the economic conditions just around the corner (besides double-digit inflation, it should be noted that the AMA was heavily subsidized by pharmaceutical advertising in its journals until the recession and stiff competition from new commercial trade journals eroded this income). Again, one official implied that many AMA members had lost faith in the ability of the association to lobby effectively in the doctor's behalf until its recent activism in malpractice matters.

Whatever the reason, or combination of reasons, for the AMA's failure to deal realistically with the action of its House of Delegates in 1971, the facts are that, as AMA Executive Vice President James H. Sammons told *Spectrum*, "We overspent for a period of five years rather than biting the bullet and going for a dues increase." Incredibly, perhaps, everyone seems to have ignored year after year of deficits. Then, in 1974, for three quarters running, skyrocketing publication costs (principally for paper) hit the AMA, along with every other professional society in the U.S. Says Dr. Sammons, "We took a bath—an aggregate 32-percent increased publications cost. Despite years of deficit reports, all of us were shocked. We couldn't meet our obligations. We had to borrow $3 million just to meet our immediate expenses."

But that wasn't all that was necessary. In late No-

Ellis Rubinstein Associate Editor

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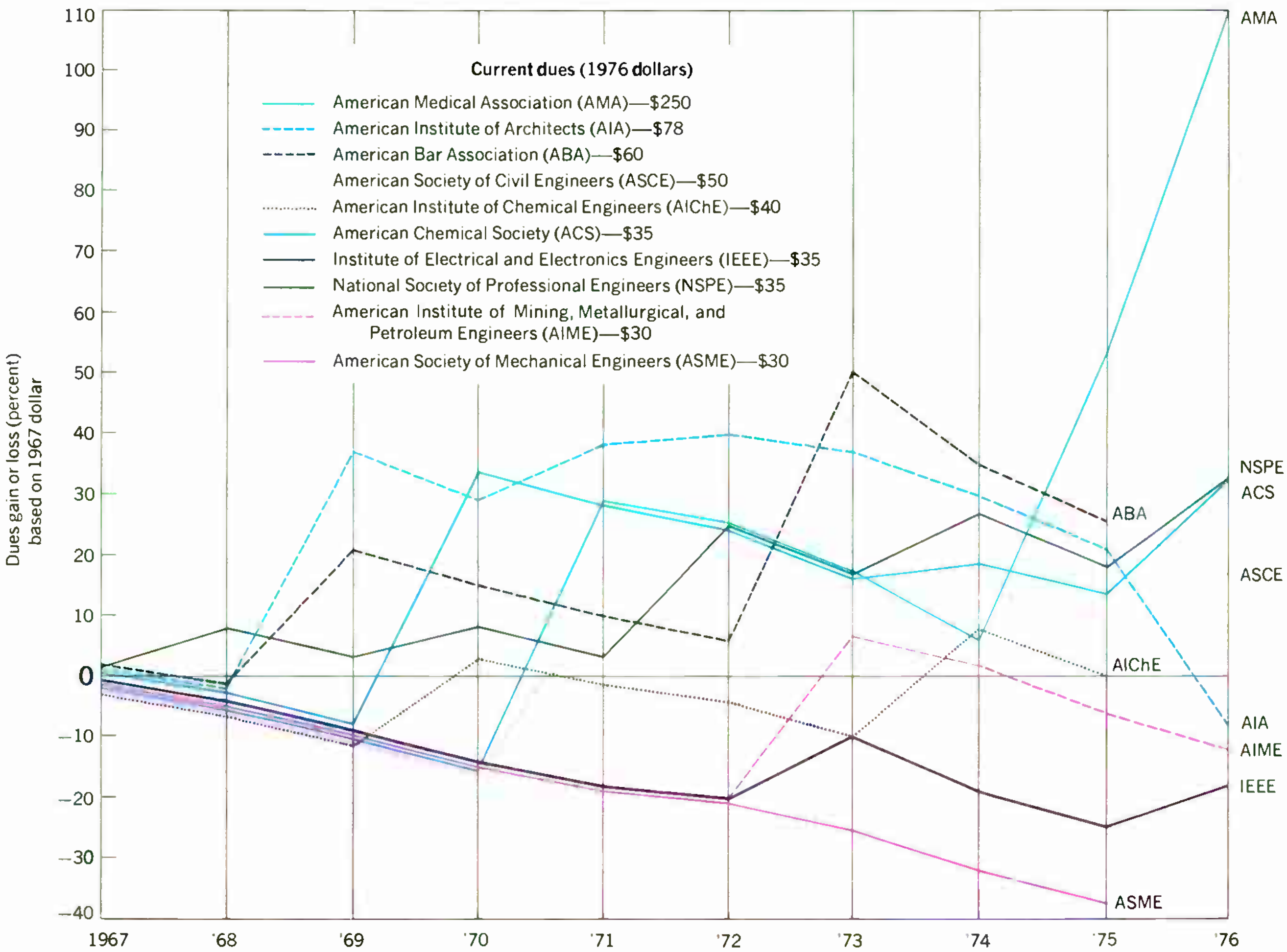
How other societies are coping with inflation

IEEE and the AMA are by no means the only professional associations that have been beset by serious economic difficulties during the last several years. To determine how some have been coping with economic conditions, *Spectrum* informally surveyed a total of ten societies having interests comparable to those of IEEE. Six of these were engineering societies—the five so-called "Founder Societies" (IEEE, the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Mining, Metallurgical, and Petroleum Engineers, and the American Institute of Chemical Engineers)—and the National Society of Professional Engineers. The remaining four associations contacted by *Spectrum* were the American Medical Association, the American Bar Association, the American Institute of Architects, and the American Chemical Society. The results of the survey shed a great deal of light on IEEE's financial status.

To begin with, although nearly all of the ten societies complained of the effects of inflation, six claimed to have managed so far to maintain—and, in some cases, actually expand—member services. In addition to the IEEE and AMA difficulties described in the main text, only the American Bar Association (ABA) and the American Institute of Architects (AIA) admitted to having had to resort to cutbacks—the former, of an unspecified percentage; the latter, a 3-percent staff layoff. But considering that 40 percent of the societies surveyed had been so adversely affected as to lay off staff, *Spectrum* inquired of each what its dues history has been. In all cases, with the exception of the National Society of Professional Engineers (NSPE) whose income is 90 percent from dues, the societies' total income is only half made up of member dues. As a result, the graph below tells only half the story—but it is a telling half. Shown are the dues histories of all ten societies in 1967 dollars. The year 1967 makes an excellent base year because it was so chosen by the Bureau of Labor Statistics for the Bureau's Consumer-Price Index. Immediately apparent is the fact that the American Society of Mechanical Engineers (ASME) and IEEE enjoy the dubious distinction of never having risen to parity—ASME has yet to raise its dues ($30 since 1967) and IEEE, despite three separate hikes, continues to receive less in "real dollars" than it did in 1967. However, while IEEE's non-dues income has remained proportionately the same throughout the decade, ASME's has risen substantially thanks to a lu-

The effects of inflation on the member dues of ten professional associations are shown in terms of percentage gains or losses with respect to the 1967 dollar. In each case, the deflator used was that of the U.S. Bureau of Labor Statistics. The dues histories of three societies—the American Bar Association (ABA), the American Institute of Chemical Engineers (AIChE), and the American Society of Mechanical Engineers (ASME)—stop at 1975 because, at time of writing, there remained some possibility of a dues change during 1976. Notable among this group of ten is IEEE, which, despite several dues hikes over the last decade, has never achieved parity in terms of the real-dollar value of the dues charged its members. (ASME has yet to try to raise its dues over the ten-year period.)



crative increase in income from the publication of standards—in the opinion of some, a liability in light of that society's vulnerability to class-action suits should a standard appear to be faulty. Furthermore, ASME differs from IEEE in that a vote of the entire membership is necessary before the dues level can be raised. Thus, it is difficult to say whether ASME is better off than the IEEE. At the moment, despite its unchanged dues history, ASME enjoys a solid financial underpinning.

Also worthy of note in the illustration is the fact that two of the ten societies, the American Chemical Society (ACS) and the American Institute of Architects (AIA), have indexed their annual dues to the cost of living. As a result, ACS has clearly maintained a strong position in reference to inflation. This held true for the AIA as well until this year when the association's board of directors, reacting to the extraordinarily harsh economic conditions in their field, determined that the only conscionable action available was to cut dues (from $96 in 1975 to $78 in 1976). It was this rollback that forced AIA to swallow a 3-percent layoff of staff.

One other anomaly of the illustration that must be explained is the meteoric rise of AMA dues income in "real dollars." The catastrophe described in the main text left the association in debt at the end of 1974 and without reserves in 1975. At the same time, the Internal Revenue Service has released regulations that, if enforced, could cost the society $20 million in back taxes. It was to produce a comparable reserve, for safety's sake, that the AMA had to raise its dues from $110 in 1975 to $250 in 1976.

From this telling illustration, we turn to an equally significant table (plus graphs), again developed from *Spectrum*'s survey. The table shows each society's approximate total budget, its membership, and its number of professional employees. From these data, we have developed three graphs: "Dollars per member," "Dollars per staff employee," and "Staff employees per 1000 members."

To understand the graphs properly, three provisos must be taken into account. First, among the ten societies listed, NSPE has a unique charter as shown by the fact that 90 percent of its income comes from member dues. For this reason, NSPE must be excluded from any meaningful comparisons. Second, the only reasonable way to compare ACS with its peer societies is to exclude its mammoth, Ohio-based publications operation, *Chemical Abstracts*. This has been done in the table where the budget and staff sizes mentioned refer only to ACS's Washing-

A comparison of "vital statistics," this table (plus graphs) provides budget, membership, and staff data from ten professional associations of interest to the IEEE member. Hasty conclusions based on the data are discouraged in that the structures, services, and member expectations of each society may vary from those of its peers. Particular anomalies in regard to the National Society of Professional Engineers, the American Chemical Society, and the American Society of Mechanical Engineers are discussed in the text. It should also be noted that the data shown have been provided by each society with the caveat that they are approximate and subject to change. IEEE, for example, had already announced, at time of writing, an 8-percent staff cutback, but as we were unable, at press time, to determine the exact number of staff personnel to be affected, this cutback has not been accounted for in the illustration.

Society	Budget (dollars)	Membership	Staff size	Dollars expended per member	Thousands of dollars expended per staff employee	Staff employees per thousand members
Institute of Electrical and Electronics Engineers	20 million	180 000	288	111.11	69.4	1.60
American Society of Mechanical Engineers	8.6 million	73 000	193	117.81	44.6	2.64
American Society of Civil Engineers	5.8 million	70 000	115	82.86	50.4	1.64
American Institute of Mining, Metallurgical, and Petroleum Engineers	3.5 million	54 000	80	64.82	43.8	1.48
American Institute of Chemical Engineers	3.2 million	37 000	70	86.49	45.7	1.89
National Society of Professional Engineers	2.0 million	71 000	70	28.17	28.6	0.99
American Medical Association	52.0 million	172 000	832	302.33	62.5	4.84
American Bar Association	22.0 million	205 000	450	107.32	48.9	2.19
American Chemical Society	17.4 million	110 000	400	158.18	43.5	3.63
American Institute of Architects	6.0 million	26 000	122.5	230.77	49.0	4.71

ton, D.C., headquarters offices. Third, a qualification must be registered in regard to ASME's figures. Over one third of its budget as shown in the table and nearly one third of its staff are devoted to its unusually large standards operation. Consequently, it could be argued that ASME's figures of merit—particularly, dollars per member and staff size per member—are inflated. On the other hand, IEEE, for one, has included its standards operation in the figures shown so that, for the sake of consistency, the table includes ASME's standards operation, large though it is.

Having expressed these provisos, it can be seen from the table that, in terms of the number of dollars spent per member, IEEE ranks second only to ASME (standards included) among the engineering societies. And in terms of dollars spent per staff employee, IEEE has no equal, including even the AMA. Two points can be made from these facts. First, considering the fact that, among the engineering societies, ASME and IEEE have relatively low dues assessments and those assessments have been the hardest hit by inflation, the liberal number of dollars spent on each member attests to the unusually high level of non-dues income achieved by the two societies. No wonder, then, that IEEE's General Manager and Board of Directors tend to see their non-dues "market" as saturated.

Secondly, Dr. Schulke feels that the relatively huge sum IEEE spends per staff member attests to the efficiency of that staff. He points out that no other society of the ten *Spectrum* contacted can boast a smaller staff for its budget. That this interpretation may be a valid one is borne out by the third of our graphs, "Staff employees per 1000 members." Excluding NSPE, only the American Institute of Mining, Metallurgical, and Petroleum Engineers employs fewer staff per 1000 members. If anything, it would seem that IEEE, which prides itself as being in the vanguard of member programs and services among the engineering societies, is understaffed. In fact, because the consequences of the Institute's 8-percent payroll cut had not become clear at time of writing, the staff total of 288 is an inflated figure representing the pre-layoff total. A post-layoff total would only increase the relative "leanness" of IEEE's figures of merit.

A broader picture

In mid-1973, the American Society of Association Executives (ASAE), boasting a membership of 5500 societies, surveyed its extensive member roster in part to determine what its members were doing about inflation. A follow-up survey was conducted in 1974 that confirmed the initial results. Of 1500 associations reporting, 55 percent had increased their dues in the previous three years. This distribution of these increases was:

1–15-percent increase:	30 percent
16–25-percent increase:	24 percent
26–50-percent increase:	24 percent
51–99-percent increase:	5 percent
100-percent increase:	7 percent

Contrary to what might have been expected, in each category a higher percentage of individual membership societies had raised their dues than had corporate-member societies, which perhaps could easier expect their members to pay inflationary dues increases. Nevertheless, it is startling to note in the *1974 ASAE Policies and Procedures of Associations* analysis of its survey results that nearly one third of the societies that had raised their dues reported receiving *less* new income than the rate increase was designed to produce. Why? In some cases, there may have been a significant membership drop following the dues increase. But in at least a few, the culprit is likely to have been the unexpectedly high rate of inflation in the year of the increase.

This fact is especially significant today. During the three years the survey covered, inflation averaged about 4.5 percent. By the end of the three subsequent years (1974–1976), inflation will have averaged as much as 8.5 percent.

Considering this, it is no wonder that many associations have been hard pressed to keep up both with inflation and member expectations. Can it be said that IEEE has?

vember 1974, the trustees finally asked the House of Delegates to approve a dues hike to go into effect in 1975—from $110 to $200. To explain what happened next, Dr. Sammons relates: "They said in effect: Let's take six months before we jump off the cliff." In other words, the House of Delegates once again turned down the recommendation of the trustees—this time, by postponing a decision.

Was it a matter of distrust? Did the delegates feel the Association was being mismanaged? Executive Vice President Sammons, who only took over the post in late 1974, says not. He feels the delegates were merely expressing the shock everyone felt. And, he says, "it gave us the time to consider a long-needed reorientation of programs."

But hidden in these words is heartbreak. Toward the end of 1974, more than 100 out of nearly 1050 AMA employees were let go as part of this "reorientation of programs." In addition, as expected when the 1975 dues increase was postponed, the House of Delegates had to levy a one-time special assessment of $60 to get the AMA through the year and to the next dues increase. And what of that needed increase? The trustees proposed and the House accepted a new dues level, effective January 1, 1976, of $250—up $140, or 127 percent, from the previous $110 level and $50 over the trustees' recommendation turned down only months before as too precipitous.

There is, unfortunately, one further "wrinkle" to this tale of economic and management woe: Despite the special $60 assessment for 1975, 70 AMA employees had to be let go in May 1975 as part of a second round of staff cuts. The total professional staff, which had reached 1041 in 1974, is at time of writing 832, a 20-percent decrease. In conversations with *Spectrum*, Dr. Sammons quickly acknowledged the traumatic nature of such a personnel cut—the kind of trauma engineers are the first to empathize with. But, says Dr. Sammons with commendable openness, there were programs that were being heavily funded that had simply become obsolete. In other words, one must assume that, at last, the AMA member is getting close to the full value of his dues dollar.

Two questions remain, however: (1) Had the climate been more benign, could not the dues have been increased in gradual steps, thus preventing massive layoffs? And (2) what are we to conclude from Dr. Sammons' projections that, "By the end of 1976 [with the new $250 per annum dues structure in place], we will supplement the staff by 70–96 people."? Have people been needlessly dislocated, and if so, with what result on staff morale?

Moral—"a mature responsibility"

The significance of this AMA case history is not in any implied criticisms of its former management policies. Rather it provides some interesting analogs to the economic quandaries faced not only by professional associations in general [see box] but by IEEE in particular. Dr. Sammons believes that the principal lesson learned by the AMA hierarchy was that "we were not hard enough; we accept this as a mature responsibility." However, between the lines, it could be read that there was far too little communication, and consequently too little faith, among the trustees, the members' delegates, the members, and the staff. Apparently, no one group trusted the others to act responsibly. Finally, at the cost of careers, programs, members, and general morale, the inevitable fiscal crisis arrived, forcing crisis-management techniques.

Is such a tragedy possible in other societies? Is it possible in the IEEE?

Financial erosion at home

In 1972, facing the prospect of an operating deficit that turned out to be $65 600, as well as continuing inflation, the IEEE Board of Directors determined that fiscal responsibility mandated the recommendation of a dues hike of $5, from $25 to $30, effective January 1, 1973. The Board foresaw an operating surplus for several years based on this increase and, as a result, the Institute, at the end of 1973, showed a record surplus of slightly over $1 million.

But if the surplus was welcome news, the inflation figures of the Federal government were worrisome. From an annual rate of 3.38 percent in 1972, U.S. inflation during 1973 turned out to have nearly doubled—to 6.23 percent. Furthermore, the Institute's convention income had decreased for the fourth consecutive year—down from $1.25 million in 1969 to $495 000 in 1973—a negative trend largely attributable to the chronic effects of the national recession, which had been eating away at the profit margins of electronics companies that had once been generous in the leasing of booths. And a third negative trend was lurking beneath the Institute's record surplus of 1973: For the second year in a row, IEEE's investment income had decreased in line with a recessionist stock market. In fact, the Institute's investment income plummeted from $438 000 in 1972 to only $35 000 in 1973.

Clearly, the snake of economic disaster was coiled. It struck in 1974 in the form of double-digit inflation: 10.97 percent. In one year, IEEE's million dollar surplus became a half million dollar deficit!

As with the AMA, the events of 1974 forced IEEE's Board of Directors to embark on a hard-nosed reevaluation of the entire financial underpinnings of the Institute. The first step consisted of a report commissioned by General Manager H. A. Schulke and written by Director Emeritus Donald Fink for the Board. This report was to contain a review of the Institute's financial history from 1963 (the time of the merger) to 1974, its present outlook (as of September 1975), and a list of needed policy decisions. The report is too long to be reproduced here but its major points can be summarized:

Positive trends	*Negative trends*
• Since 1963, the total assets and operating income of the Institute had approximately doubled while the membership had grown 12 percent.	• Since 1963, the operating expense of the Institute had approximately doubled.
• Since 1963, the basic dues paid by all IEEE members except students had doubled, from $15 to $30.	• Since 1963, the value of the dollar had decreased by nearly 40 percent, thereby all but canceling out the effects of the dues hike. Further, it could be said that the 1963 dues level of $15 had been unrealistic to begin with as it produced four consecutive years of operating deficits until the 1967 dues hike to $25 produced a surplus. If this proposition is accepted, then a realistic dues level in 1963 would have been $23, which, had the dues followed the effects of inflation, would have become $37 by 1974 (not $30) just to break even with inflation.
• Since 1963, non-dues income had kept pace with dues income.	• As with dues income, a strong case could be made that the increase in non-dues income since 1963 had been wiped out by inflation.
• Since 1963, the Institute operating fund balance had grown by about 59 percent.	• Since 1969, the general fund balance, excluding Group/Society activities, had decreased by 10 percent.
• The basic Section allowance and rebate per member in each Section had remained essentially unchanged.	• The rebate for Section, Subsection, and Chapter meetings had doubled.
• Headquarters professional staff had remained at just under 300 despite new IEEE educational, professional, and publications activities.	• Salaries and benefits expense covering staff had increased by 41 percent (inflation had been about 60 percent during the same period).

Based on this painful but realistic report, Dr. Schulke and former General Manager Fink proposed several key questions to the Board of Directors. Some of these were:

• At what levels should the operating resources be held?

• Under what circumstances should the reserve funds of the Groups and Societies be called upon to support the other operations of the Institute?

• What longer-term policy should govern Institute dues, assessments, and fees?

• When new member services or products are proposed, should a condition of their introduction be an assurance that they will return net income at once or after a stated period of initial subsidy?

Behind these straightforward questions is a series of difficult options of extreme importance to every member of the Institute. What programs does the member want? How much is he or she willing to compromise with colleagues—inevitably, one pays for programs or services one might not immediately need? To what degree will the member become involved in the decision-making processes of the Institute?

Post-report choices by the Directors

Following Mr. Fink's September 1975 report to the Board, the Directors and General Manager Schulke

I. How IEEE's dues hikes have lagged behind inflation

Year	Annual Rate of Inflation (percent)	CPI (yearly average)	Average Retail Value of 1967 Dollar	IEEE Dues	IEEE Dues in 1967 $	IEEE Dues if Indexed to CPI
1967	2.88	100.0	1.000	25.00	25.00	25.00
1968	4.20	104.2	0.960	25.00	24.00	26.05
1969	5.37	109.8	0.911	25.00	22.78	27.45
1970	5.92	116.3	0.860	25.00	21.50	29.08
1971	4.21	121.3	0.824	25.00	20.60	30.33
1972	3.38	125.3	0.798	25.00	19.95	31.33
1973	6.23	133.1	0.751	30.00	22.53	33.28
1974	10.97	147.7	0.677	30.00	20.31	36.93
1975	7.80 (est.)	159.2 (est.)	0.628 (est.)	30.00	18.84 (est.)	39.80 (est.)
1976	7.00 (est.)	170.3 (est.)	0.587 (est.)	35.00	20.55 (est.)	42.58 (est.)

began what is a continuing analysis of the options available to the Institute. The most obvious of these was to ensure the fact that IEEE's dues would, in some way, take into account the continuing rate of inflation. Table I shows that the 1975 dues level had fallen $9.80 below parity as a result of inflation since 1967. Why is the year 1967 used as a base? In that year, the U.S. Bureau of Labor Statistics (BLS) readjusted its Consumer Price Index (CPI) to account for changes in the U.S. life style and production base. Thus, the BLS, itself, considers 1967 as a base year.

Secondly, as has been mentioned previously, 1967 was, for IEEE, the year of its first dues change (from $15 to $25) since its formation. With that dues adjustment, four years of operating deficits came to a halt and the Institute's first surplus was achieved. Thus, to IEEE's Board of Directors, the $25 fee for membership was, in 1967, a realistic figure. And it is from this figure in the base year that Table I is derived.

Based on such a table, the Board of Directors was cognizant in late 1975 of the necessity of raising dues by 1976, if only to maintain a status quo in dues income. The other options available to the Board were either to increase markedly the Institute's non-dues income or to effect economies in expenditures—a choice very similar to the one facing the AMA.

The Board determined that it would be neither feasible nor reasonable to expect that immediate measures could increase non-dues income enough in 1976 to make up for no increase in dues income.

The Directors further determined that the extent of cutbacks in member services that would be necessitated by no increase in the dues level would be unacceptable to the Institute's members. This forced the Directors to conclude that a dues hike was mandatory. But by how much?

As every member now knows, $5 was decided upon. (This does not take into consideration the concomitant $5 increase in the U.S. member assessment, because that assessment was initially devised and continues to be used for U.S. programs only.) But the additional income projected from this increase could not keep pace with inflation as shown in Table I. What followed is best described by Dr. Schulke, who, as General Manager, was faced with the assigned task of producing an operating surplus in 1976 with what he considered, in itself, to be insufficient dues income:

"Although we're doing better this year, the economic conditions in the electronics industry cut into our convention income leaving us with a $70 000 deficit in 1975. Over the last three years, our labor costs have increased by 25 percent. Postage the same. Printing costs even more. And on top of all this, for a decade or more, there has been no change in the amount of our rebate to the Sections. Their needs aren't increasing linearly with membership. As long as the Bylaws prohibit Sections from imposing separate dues, to keep them viable we simply have to turn over more of the member dues dollar. Furthermore, although technical activities have always been the heart of our Institute, the ratio of income to expense of the Groups and Societies has dropped close to unity and threatens to continue to decline.

"I concluded that to maintain a viable Regional and technical operation with the dues and other income that could be expected in 1976, it would be necessary to examine every function in the Institute."

The result of General Manager Schulke's examination was announced to the Executive Committee of the Board of Directors at its December meeting. The Committee concluded that only a 10-percent reduction in staff would permit both a "steadystate" in member services and an end-of-year budget surplus. The 10-percent figure was later reduced to 8 percent—the eventual size of the payroll cut. Explained Dr. Schulke to *Spectrum:* "Like any organization, we had become top-heavy in a few areas. Some of our Regional, technical, and education activities support functions were duplicating one another. In some cases, equipment was duplicated and could be used on a pooled basis. I determined that we could tighten our belts just as everyone else has had to do and comply with the Executive Committee directive."

In answer to *Spectrum's* question regarding whether any programs would be cut, Dr. Schulke indicated that the verdict wasn't in yet. "Once we've got a lean, responsive, energetic staff," he said, "the Board can take a hard look at exactly which services the members desire. We'll also be in a better position to go to the membership with new dues proposals, one of which would be to consider indexing our dues to some appropriate cost-of-living index."

How IEEE compares to the AMA

While both IEEE and the AMA have been beset by financial difficulties, many of which are attributable to the severity of economic conditions in the U.S. in the 1970s, IEEE has not yet been, and may never be, reduced to such emergency measures as special dues assessments. (Like the AMA, IEEE borrowed money in 1975, but unlike the AMA, IEEE resorted to short-term borrowing merely to solve a cash-flow problem.) One reason would appear to be that, unlike the AMA, IEEE has generally proven itself willing to face up to its financial responsibilities. However, questions remain that link the two organizations: Could a continuity of experienced personnel have been maintained had the dues increases that were inevitable thanks to current inflation been authorized? Were such dues hikes avoided only because of an uncertainty on the part of the Directors as to their members' reactions? Or was their avoidance the best means available to force good management practices on the professional staffs?

Further, one might ask: Did the members know what options were available to their Directors? Should each individual member have been given the opportunity to choose among—or at least express an opinion on—program cuts, staff layoffs, dues hikes, etc.? Would it be fair to criticize those IEEE members who are both happy with the services the Institute provides and agreeable to dues hikes in accordance with inflation, yet will not take the time to write their Directors letters of support? In essence, how much communication and faith exists between the members and their elected representatives?

IEEE General Manager Schulke believes that the problems facing the Institute can be overcome only if the members are aware of not only the Institute's accomplishments but its difficulties as well. Says Dr. Schulke, "*We can't* bury our problems in the year-end audit reports and expect to maintain the respect and involvement of our members." ◆

Financial

Pres. Dillard on the budget

Pulling no punches, IEEE President Dillard addresses the Institute's financial problems and their implications on the member's pocketbook

IEEE is currently experiencing some of its most serious financial challenges since the merger in 1963. Despite a 1976 dues increase, the Institute's Executive Committee determined that only an 8-percent reduction in the professional staff payroll could produce a surplus budget while, at the same time, maintaining the generally high level of member services. Further, the only alternatives to another dues increase in 1977 would seem to be either a severe cut in member services or deficit spending. In light of the potentially serious consequences to the member of this financial quandary, *Spectrum* interviewed IEEE's current President, Joseph K. Dillard. His forthright responses to our questions are presented herewith in the hope that a better-informed membership can help guide our Institute through the difficult economic times that lie ahead.

To elicit an accounting of IEEE's budgetary difficulties, *Spectrum* began its interview with President Dillard by asking him to discuss the genesis of the staff reduction.

***Spectrum:* Who first proposed the staff cut?**

Dillard: I think I can make that very clear. When the various Committees and Boards that were involved in structuring the budget last December settled on programs considered to be essential, we ended up with a deficit budget in a year in which there was going to be a significant dues increase. That was the background. The Executive Committee [a nine-member subcommittee of the 28-member Board of Directors], which is responsible for the administration of the Institute, met, considered the instructions that we'd been given regarding the programs that had to be put together, and made the decision that there had to be a significant reduction in the expenses of the Institute. And since there did not appear to be any programs that we could drop or cut, the place to look was improved efficiency in the staff. So the General Manager was instructed by the Executive Committee to make a 10-percent reduction [later amended to 8 percent] in the Headquarters staff—in the payroll.

***Spectrum:* Had any alternatives been considered to avoid the staff cut?**

Dillard: All kinds of alternatives, including an examination of all the programs that had been proposed by the various Boards of the Institute. A number of those programs that were desirable but not essential were dropped. And we still ended up with a deficit budget. We thought, we *must* end this year with a budget that has a modest surplus or else we're faced with another dues increase next year.

Ellis Rubinstein Associate Editor

***Spectrum:* Did any of the alternatives involve a search for sources of new income?**

Dillard: We *did* search for additional sources of income, but we were unable to uncover any creditable forecast about how we could increase the income.

***Spectrum:* Is it true that there was some dissatisfaction on the part of some members of the Executive Committee who felt that they had not been involved in the decision-making process?**

Dillard: I think there was some dissatisfaction, but not one member of the Executive Committee was able to come up with an alternative that would produce the kind of budget we felt was essential. In the pressure to get this job done so that it could take effect early in this new year, I feel that we did not do as good a job as we could have in involving the people in the volunteer management of the Institute about what was going to be proposed. And this is one reason why I want to do something about our public relations, so that we have a better way to disseminate information about these kinds of decisions.

***Spectrum:* When the original dues hike was proposed, was there then a Budget Committee [a subcommittee of the Executive Committee] evaluation of what the outcome of that dues hike would be in terms of income?**

Dillard: There was.

***Spectrum:* And that consideration of the dues hike took place prior to the December meeting?**

Dillard: Oh, much prior to that—back in May or June of last year.

***Spectrum:* And at that time, didn't anyone realize that IEEE would be in a financial situation that would require such measures as a staff cut?**

Dillard: At the time that the dues increase was proposed, the amount and the size of the increase were based on what was considered to be an acceptable increase in the dues to the members. Not too much attention was given to what that dues increase might enable us to do as an Institute.

***Spectrum:* Now, since it was known from May or June on what the dues increase and income would be, why did it take until December before someone figured out that the Institute would have to take new measures to pull itself out of its financial situation?**

Dillard: There were a lot of new pressures for the allocation of the funds that would be realized from the increase in the dues—pressures that did not surface until the December Board meeting. One such pressure came from the Regional Activities Board, which wanted a significant part of that dues increase to be returned to the Regions and Sections in the form of increased rebates. There had been a number of years in

Joseph K. Dillard, IEEE President for 1976.

which the allocations to the local Sections had not been increased. Meanwhile, due to inflation, the costs to these Sections had gone up. So there was a great pressure to allocate something like $150 000 in additional support back to those Sections.

There was also considerable pressure to allocate a significant part of this dues increase to the technical arm of our Institute—our Groups and Societies, who also had been faced with increasing costs due to inflation.

It was realized that these organizations could, this year [1976], as a whole, be operating with a deficit budget. The Executive Committee wanted to ensure that the technical excellence of the Institute be preserved. So it was decided that support for these activities would *not* be reduced, but should be at least as great as it was in 1975.

Adding these two decisions together meant something like a $300 000 impact on the budget and a $300 000 requirement that should come out of the dues increase. The U.S. assessment [raised from $5 to $10 in 1976] is allocated for projects and programs that are specifically structured for the U.S. members of the Institute and is not comingled with the General Fund. That $5 increase was for new programs in the professional area so we did not have access to that fund. The $5 increase in the general dues would bring in something of the order of $750 000 in additional income. With $300 000 fairly well committed to the local and technical organizations, when we added up the effects of inflation—which has been the double-digit type of inflation—and the programs that our various line Vice Presidents felt were essential to provide our members, we ended up with a deficit budget.

***Spectrum:* Considering the fact that it took six months to work out the pressures of which you spoke, wouldn't it have been possible to have eased the transition that occurred in terms of laying people off, finding them other jobs, and preventing disaffection of Board members had action been taken in September or October?**

Dillard: That budget was presented to the Board of Directors twice! The first time was in September when it was referred back to the Executive Committee with additional instructions regarding priorities and the allocation of funds. The Executive Committee restructured another budget, which was presented to the Board in December. It was returned to us with the additional instructions regarding the allocations to the Regions and to the Technical Activities Board. The Board of Directors, who really have the responsibility for making these policy decisions, *twice* returned a recommended budget back to us with recommendations as to how it should be readjusted, each time increasing the appropriations for various worthwhile purposes.

***Spectrum:* This seems to be a problem . . .**

Dillard: That *is* a problem, yes.

***Spectrum:* And isn't it true that the Board of Directors, again in January, turned the budget back to the Executive Committee for revision?**

Dillard: No, the budget was approved at that meeting.

***Spectrum:* But with amendments.**

Dillard: The budget submitted to the Board was approved as submitted, but with one exception: The Executive Committee had recommended a $40 000 reduction in the Section rebates—which, as I've said, were up approximately $150 000 over the 1975 level. The Board rejected that part of the proposal and restored the full Section rebates that the Executive Committee had been instructed to include. This means that the budgeted surplus for next year will be reduced by that amount: $40 000.

***Spectrum:* In times like these, when we have inflationary conditions that are very difficult to cope with under the best of circumstances, do you feel that it is an acceptable business procedure whereby, in order to establish a financial program for the Institute, one has to go to a Board of Directors that takes up to nine months to settle on a budget?**

Dillard: I agree that it should not take so long to get these policy issues settled. As a matter of fact, it would seem to me, as a businessman, that the Board should settle these policy issues *before* the budget is presented to it, rather than concern itself with adjustment afterward. The problem with the Institute is that we have a lot of compromises that have to be made to satisfy various constituents that are represented on the Board of Directors in order to get the budget finally approved. It's somewhat akin to the Congress of the United States. Almost every member of that Board has a constituency that he feels he represents. He wants his favorite programs included, and he doesn't want the dues to his constituents increased.

***Spectrum:* What is your view of how the cuts that have been made are affecting the Institute at present?**

Dillard: If you're asking me whether programs have been cut or not, I don't know how to answer that because, in the course of developing this budget, a lot of programs were either cut or dropped. I do not expect an adverse effect on those programs that have been accepted and financed. I do recognize that this kind of drastic measure is going to have an effect on the morale of the staff. I expect that this will be a temporary effect—a loss of efficiency and all the things that can come from an environment where there is poor morale. Any organization, in my opinion, over a period of years, takes on responsibilities, jobs, and tasks, so that, from time to time, it seems to me to be necessary to examine what it's doing and make some decisions regarding those things that really aren't necessary to the conduct of its business.

***Spectrum:* Could you specify exactly which programs have been cut?**

Dillard: I don't know how to answer that. In the start of the budgeting process, we receive a great many proposals for programs along with their costs. These are sifted and evaluated. None of the programs that the Vice Presidents thought essential have been eliminated.

***Spectrum:* What about the staff cuts in educational activities?**

Dillard: Educational activities is one of the areas where the proposed cuts have been restored—$50 000 above the budget we had proposed in December. Dr. [Irene] Peden, who is responsible for [Vice President of] the educational activities program, feels that she can implement the necessary activities within the budget that has been allotted to her.

***Spectrum:* What about standards?**

Dillard: Standards is a different problem. It's very important to us as an Institute and particularly important to the Power Engineering Society and to the Industry Applications Society. When the staff reductions were being proposed, standards was an activity that was looked at very carefully. The reason it was looked at very carefully was that over a period of a number of years, the standards activity had not met its projected income or its projected expense budget. Expenses were always higher than projected and income was always less. When you have that kind of an operation in any business, when it becomes necessary to make a cut, you're going to look at that kind of an operation

Now, in 1975, the standards activity *did* meet its income and expense projections. We found, after the proposed cuts in the standards activities were made, that they were apt to result in a greater deterioration in those activities than we wanted to take place. Some of the positions in the standards area have been restored to ensure that it will not deteriorate because of these reductions.

***Spectrum:* Regarding the near-term implications of the staff cuts, will there be a surplus at the end of this year?**

Dillard: We have budgeted for a surplus in '76.

***Spectrum:* Can you provide a figure?**

Dillard: I can give an approximate figure. In the funds entrusted to the Executive Committee and the Board, we are projecting a budget surplus of $260 000—this does not include the Group/Society funds, which belong to them.

***Spectrum:* Does this take into account any liabilities the Institute might run into because of the new Internal Revenue Service rulings [new IRS rulings have created possible tax liabilities for nonprofit professional societies in two areas: so-called "unrelated business income" and employee benefits and pension funds]?**

Dillard: It does not. We decided not to establish a reserve for those liabilities. Each could cost us a very considerable amount of money—something of the order of $125 000 a year in each area. We recognize those liabilities. As a businessman, I would prefer to establish a reserve fund that we would take out of our operating expense to take care of that potential liability. The Executive Committee felt that the risk of incurring the liability was small enough so that if we did incur it, we could take it out of our Institute reserves when the time came and it would not be necessary to establish a reserve fund for that purpose.

***Spectrum:* Are you suggesting that there is no chance of a retroactive liability?**

Dillard: There *is* a chance of a retroactive liability. It could add up to as much as a half a million dollars if you accumulate the liability over a several-year period. Yes, there is that chance and that risk. And yes, to be financially responsible, we should have established a reserve to take care of that liability in case it did come about. My Executive Committee and my Board overruled me on that point and decided that we would take that risk.

***Spectrum:* Then assuming that the worst case does not occur, with the surplus that you're expecting and were inflation during 1976 to average 7 percent as is currently projected, what does that mean for 1977?**

Dillard: It means that in 1977 we will be faced with a budget that is out of balance.

***Spectrum:* A deficit budget?**

Dillard: Yes. Because clearly the budget we're projecting does not take care of inflation.

***Spectrum:* Does that mean that it's still an open possibility that the Board will consider another dues hike or has that been completely ruled out for 1977?**

Dillard: Personally, I don't think you can raise the dues every year. Maybe we can, if we can justify the programs that we're trying to support. Next year, we have some very simple choices: we either raise the dues or increase the income in some other way; we cut our programs; or we operate at a deficit.

***Spectrum:* Or another staff cut becomes necessary . . .**

Dillard: We will *not* have another staff cut. The reduction in the staff—the step that has been taken—has reduced the staff so that we cannot make additional cuts in that area without seriously affecting the services that we provide to our members. All of the functions of our staff are not related necessarily to these programs that we conduct. Some of them are; some are not. We have to collect the dues, we have to keep our membership records, we have to have an accounting function. We cannot cut that staff any more, and these reductions that have now been put in are all the shocks that the staff is going to have for some period of time.

After a two- or three-year period, certainly we will reexamine what we are doing and look at the staff again for functions that can be eliminated. But the staff does not have to expect that it's going to have another shock like this.

***Spectrum:* The next time around, then, the burden is going to have to be borne by the member either in dues or in program cuts?**

Dillard: Or in program cuts, yes.

***Spectrum:* Or in a deficit, I suppose.**

Dillard: I consider that to be financially irresponsible.

***Spectrum:* As you know, a study [see pp. 64–69, this issue] has been done indicating that IEEE's dues have not kept up with inflation for nearly a decade and, in fact, have been falling further and further behind.**

Dillard: That's right.

***Spectrum:* Does it make sense for the Institute to allow its members to think that they can continue to get the services they are accustomed to and desire while not paying the price of inflation?**

Dillard: It does *not* make sense.

***Spectrum:* What can be done about that?**

Dillard: This is the reason for my interest in the communications program with our members. I think that it is a mistake to deceive our members into thinking that they can get all of the services and all of the programs that they want without a significant increase in the dues that they pay for these services. And I think that we should condition the members that, if they want these services and these programs, they're going to have to pay for them through their dues. And it will require a very significant increase.

***Spectrum:* Does the Board need to be "educated" as well?**

Dillard: The Board needs more education than the members, in my opinion. Our problem with our financial situation really rests with our Board and until the Board decides that we have a serious problem in financing this organization, things aren't going to be corrected. The *Board* has to make that decision.

***Spectrum:* Is the problem with the Board this question of constituencies, as you put it?**

Dillard: That is *exactly* the problem. And that is the reason that the Executive Committee recommended in this budget the reduction in the Section rebates—to make the projected overall surplus what we felt would be financially responsible—and yet it was rejected by the Board, by those members of the Board who represent the Regions and the Sections that were going to have their rebates reduced if they followed the Executive Committee's recommendation.

***Spectrum:* Now, how can the Board be reeducated?**

Dillard: The Board will reach that decision when our members at the grass roots level tell them. I'm sure that the members of the Board believe that they are representing their constituencies . . . and maybe they are. But if the members are concerned about their dues and the costs of these programs, they will make this felt with the Directors and I think we won't have this problem.

***Spectrum:* How about IEEE's image with respect to this upheaval? IEEE likes to consider itself a leader among the engineering societies; it has some hopes of engendering unified action with the other societies; and yet this is the second upheaval IEEE has gone through in the last five years. How does that look and how does it affect IEEE's relationships with the other societies, as well as its image in general?**

Dillard: The last upheaval was in about 1970, so it's not something that happens every year. As I've said, I think we have to examine at some reasonable interval—like every three or four or five years—the services we are providing, the functions we are performing, and see that those that are no longer necessary are eliminated. I think you have to look at the upheaval in two ways: One is how it appears to our members. I believe that our members would support that concept that those functions and those services that are not required could be eliminated. So I believe that we have a good image to our members in that we are really taking hard, painful steps to reduce the expense of running the Institute.

I don't know how to comment on how this might appear to the other societies. I would be surprised if they don't have the same kinds of problems in ASME [the American Society of Mechanical Engineers], in ASCE [the American Society of Civil Engineers], and in the other engineering societies.

***Spectrum:* To your knowledge, have they had layoffs during the past ten years, or problems keeping their budgets balanced?**

Dillard: I do not know.

***Spectrum:* But you feel that IEEE, in particular, must do a better job of planning?**

Dillard: Yes, that *is* a problem. I have established a Long-Range Financial Planning Committee—not a permanent committee, but an *ad hoc* committee of the Board—to give me and to the Board some specific recommendations about doing our budgeting and our financial planning on a long-term basis, rather than to try to do this each year. Futhermore, our Long-Range Planning Committee has come forth with a set of recommendations regarding the basic structure of the Institute. It consists of something like 56 various, specific recommendations that would put us in a position to operate, say, over the next five to ten years. By the September meeting of the Board of Directors, we expect to have a specific set of recommendations regarding the structure of the Institute on a long-term basis that hopefully will eliminate—I hope I can be optimistic—that *will* eliminate a lot of this factionalism.

***Spectrum:* Will it be at that same September meeting that the Board will set the dues level for 1977?**

Dillard: I expect the issue regarding the dues for 1977 will have to be decided earlier than September. It will have to be decided at the May meeting.

***Spectrum:* Can that be done without the benefit of the kind of planning you are talking about for the September meeting?**

Dillard: Yes, it can be, because no restructuring of the Institute on a long-term basis can be done quickly enough to affect what it will cost to operate in 1977.

***Spectrum:* Would you like to state your personal view as to whether the Board should opt for either a 1977 dues hike, a cut in programs, or deficit spending?**

Dillard: My *personal* view is that we ought to go for the dues increase—as painful as it may be. We have not been able to uncover any additional sources of income. The programs that are proposed seem to me to be programs that our members want and that they require, and believing that we should have fiscal responsibility, I would go for the dues increase as the only way to bring the thing into balance. I don't believe in deficit spending. I do not think that the programs that we have should be cut substantially. So I would go for the dues increase even though we had one this year. ◆

Business outlook

Making it in the Third World

The new 'electronic imperialism' that began in Asia has spread to Africa and Latin America

The electronics industry in developing countries has mushroomed into a multibillion dollar export industry, as it has spread to country after country around the world. By 1974, the electronics industry in Taiwan alone was generating more than $991 million (all figures are in U.S. dollars) in gross exports. Electronics thus accounted for almost 15 percent of Taiwan's total overseas shipments and 6 percent of its gross national product. With imports of electronic products reported at $518 million, of which parts and components accounted for 70 percent, this amounted to a net contribution of more than $610 million to Taiwan's national income.

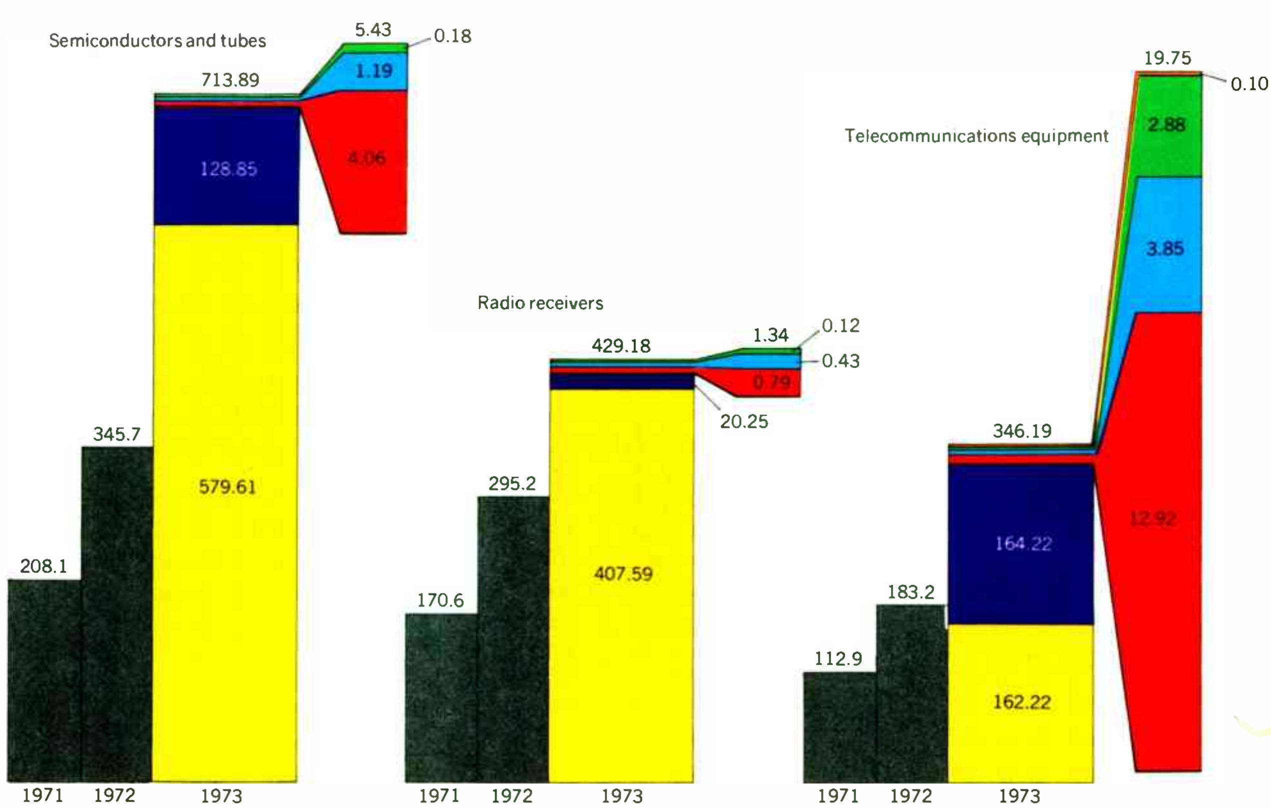
Hong Kong's 1974 exports of electronic products were valued at some $600 million, while South Korea was exporting well over $250 million in electronic products and had set a target for total electronics output in 1980 at $2 billion. Singapore, a relatively late starter in the industry, had already outstripped Korea in total exports, with overseas shipments exceeding $350 million in the boom year of 1974. In that same year, Mexico moved more than $300 million in electronic products into world markets, and both Malaysia and Brazil emerged as new forces in the shifting kaleidoscope of electronics production.

Gene Gregory Consultant

The pattern is multinational

This phenomenal spread of the electronics industry throughout developing Asia has taken on some very definite patterns. In each locality: production has emerged and grown in response to external demand and the industry is almost entirely export-oriented; Japanese and U.S. electronics manufacturers have played the role of primary energizers by establishing their own production subsidiaries, or by subcontracting with independent firms; entrepreneurs have been quick to respond with supporting manufacture of materials and components, as well as with assembly of finished products; but, although a few have tried, in no case have local manufacturers succeeded in establishing highly differentiated products on world markets through extensive sales networks of their own. The industry in each country is essentially confined to sub-

Electronics exports from world areas



contracting production, and thus has instant access to markets, with minimal capital outlay and risk, through the sales organizations of established manufacturing or commerical enterprises. Subcontracting manufacturers in Asia have thus shared the fortunes and the risks of their customers or parent companies.

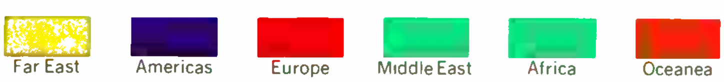
From the outset, when the Sony Corporation—then known as Tokyo Tsushin Kogyo K.K.—contracted with Champagne Engineering in 1957 for the assembly of their pioneering miniature transistor radios in Hong Kong, multinational companies have played a key role in the development of the electronics industry in Asia outside Japan. Production in developing countries of Asia has become an essential characteristic of most major international electronics manufacturers, and in some cases the entire output of some products of U.S., European, and Japanese firms has been transplanted to Korea, Taiwan, or Hong Kong. Significantly, too, multinational corporations are now providing the main impulse for the further spread of the electronics industry to Malaya, Thailand, Indonesia, and the Philippines in Southeast Asia, and to other developing regions in Latin America, the Caribbean, Africa, and Europe.

First Asia—then the world

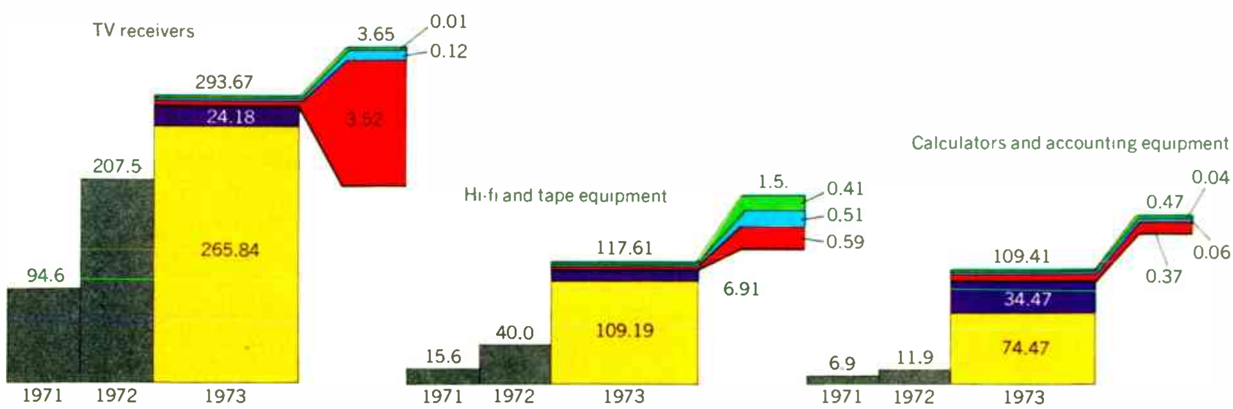
During the past five years, it has become clear that the spectacular achievements of Korea, Taiwan, Hong Kong, and Singapore have established a pattern for emergent industries in other developing countries. Reasons for the spread of electronics subcontracting beyond Asia are substantial.

In the first place, other developing countries, having witnessed the experience of Hong Kong, Korea, Taiwan, and Singapore, are now devising attractive incentive schemes for the development of their own electronics industry, employing varying inputs of local and foreign resources. Then, rising petroleum prices have had a sharp impact on the competitiveness of electronic products manufactured far from the main markets; and rising transportation expenses and other costs associated with distance have increased the attractiveness of Latin American and Caribbean production for the North American market. For the same reason, Mauritius, along with various African production sites, has taken on greater interest for Europe—especially in those countries that benefit under the Lome Convention from preferential trade with the European Economic Community. Further fueling the spread was the 1973 shortage of materials needed for electronics manufacture. This shortage was especially severe in the Far East where reliance on Japanese sources of supply was almost universal, and the disruption of that supply had serious consequences for firms heavily dependent on Asian production. There has since been a noticeable tendency to reduce the likelihood of similar future disruptions by increasing the number and spread of facilities rather than attemping to achieve maximum economies of scale at a single facility. At the same time, there has been a rapid growth of markets for finished electronic products in some developing countries.

These considerations have not only weighed heavily on the decision of multinational firms to locate production in Brazil, Mexico, the Bahamas, the Netherlands Antilles, Barbados, Haiti, the Dominican Republic, Costa Rica, and El Salvador, but they were reportedly important factors determining the location of Sony and Matsushita plants in the United Kingdom, France, Spain, and Puerto Rico. The establishment of free zones and efforts by governments to reduce cum-



Figures on this chart, given in millions of U.S. dollars, are for exports from developing countries within each of the world areas. For ease of comparison, those bar segments representing smaller dollar export volumes (less than $15 million) are shown to a common, greatly expanded scale, at the right of each set of bars. Source of the data is the Organization for Economic Cooperation and Development.



bersome administrative "red tape" to a minimum have served as inducements for new investments in electronics production for export markets in countries as diverse as Korea, the Philippines, Malaysia, India, and Panama.

Why they do it

The basic motivation for subcontracting electronics manufacture in developing countries has typically been the quest for lower-cost production, using plentifully available labor susceptible to training. In the case of assembly operations for complete products, the aim has usually been to improve and prolong the life cycle of product lines that can no longer be manufactured competitively in advanced countries. For similar reasons, manufacturers of labor-intensive, low-margin passive components such as resistors, capacitors, and wire-wound components have transferred production to developing countries. Although the prospect of lower production costs also attracts semiconductor assembly and packaging, it is more advantageous to transfer the production process at an earlier stage in the evolution of a device. The aim here is to achieve a leadership position in world markets as quickly as possible through lower prices.

But low-cost labor is by no means the sole inducement. Electronics manufacture will move, by the end of this decade, to those new centers in Asia and Latin America that offer: efficient transportation and communications; good local industrial supply capabilities; minimal limitations on employment of specialists from abroad; appropriate educational facilities; a large, disciplined, highly motivated, and easily trainable labor force; and well-developed financial institutions. Rates of interest also have a sizable influence on the development of the electronics industry, as the development of the industry in Japan, Hong Kong, Singapore, Taiwan, and Korea has clearly shown. Countries where the rate is higher than the world average are therefore at a decided disadvantage in their attempt to develop local electronics manufacture for export or to attract investment by international companies.

The first takeoff in Hong Kong

Having begun as simple assembly plants in Hong Kong, the Philippines, Vietnam, and India in the late 1950s, the electronics industry in developing Asia reached the takeoff stage first in Hong Kong with the manufacture of passive components, plastic cabinets, and other hardware used in consumer electronic products. By 1962, Fairchild had established the first semiconductor manufacturing plant in Hong Kong, adding a new dimension of higher technology to the industry. Following in the path of Hong Kong's pioneering industry, early imitators emerged in Taiwan and Korea in the first half of the 1960s. By the beginning of the 1970s, Taiwan had taken the lead with heavy injections of capital and know-how from both Japan and the United States, and Singapore had joined as a late follower with all the advantages of faster development that a late start usually entails. Within the short span of three years, Singapore became the largest center of semiconductor assembly in Asia outside Japan, with nine leading U.S. and European manufacturers establishing production facilities on the island between 1968 and 1971.

Given these favorable conditions, not only will industry in the advanced countries benefit from moves to new production sites, but there will be sizable payoffs for the developing nations as well. A recent report of the United Nations Conference on Trade and Development shows that even when as much as 50 percent of the materials used in the manufacture of electronic products is imported, the net contribution to national income is at least 35 percent of the total ex-factory price. And, as Taiwan's experience shows, when a broader industrial base is built, that percentage grows proportionately and significantly.

Since electronics production is relatively labor-intensive, at least a third of this income takes the form of direct or indirect wages for personnel employed by the ultimate assembling firm itself, while the remainder goes for locally produced goods and services used in the final product. "Insofar as the lack of jobs is one of the major sources of social and political difficulties in developing countries," the UNCTAD report stresses, "the contribution of international subcontracting operations to the development process of these countries may be far larger than would appear from a simple mathematical calculation. Beneficial side effects of such operations may include stimulus to industries totally unrelated to electronics."

However, this shift of production to developing countries is not the only change in the worldwide distribution of electronics activity. There have also been relocations from one advanced country to another. Take, for instance, Canon's decision to produce calculators in California. Previously, Canon had been buying the LSI chips from the United States and building them into calculators made in Japan. However, the savings in assembly between the U.S. and offshore production sites for calculators were virtually wiped out by the rise in labor charges abroad together with the minimal labor inputs needed for producing fourth-generation calculators. Production in the U.S. near the point of consumption, as well as near semiconductor and display suppliers, resulted in lower costs through better logistics.

By moving production close to the market, Japanese manufacturers also hedge or bypass restrictions imposed on imports from Japan and other Asian countries, a limitation that is becoming increasingly important in main markets such as the United States and Europe as well as in the developing countries. Similar considerations might curtail European manufacture or subcontracting in Asia, if import restrictions should be imposed on selective categories of products that are mainly supplied from Asian sources.

Electronic genesis in Africa

Production in Africa for European markets would be cost-competitive with Asian electronics manufacturers, if tariffs on imported components and materials were exempted and European duties on imports of the completed product were eliminated under preferential arrangements. But there are also problems of political stability and bureaucratic red tape to consider. These, along with high costs of training and relatively low productivity, are continuing deterrents to investment in African manufacture. To qualify electronic products for preferential tariff treatment, European countries now require a certain minimum of local content in manufactured products. Since no African country can yet meet these requirements, this is a very restrictive condition, the more so when a large variety of sophisticated semiconductors and advanced technical skills are involved.

Estimates provided by Philips indicate a delivered price in Europe of $13.33 for a radio receiver produced in Western Europe, assuming annual production of a million units. In comparison, a receiver produced in the Far East is estimated to run $12.85, with the lower price stemming mainly from decreased materials and production costs (about $2.66 less) since these are not offset by other costs. For receivers produced in Africa, even using lower-cost Far East materials, the estimated delivered price in Europe is $16.13. Compared with Far East costs, those in Africa are estimated to be substantially higher for duties (about $1.33 more), and for production as well (about 29¢ more.) In the Far East, with free-trade zones, there are no duties at all to be paid in the localities where manufacturing and assembly are carried out. In contrast, duties in African countries are estimated to run from $1.78 to $1.61, depending on whether the materials come from Europe or from the Far East.

As African Governments increasingly turn to serious concern for economic development, there is reason to expect further growth of their infant electronics industries. Still, countries have a long way to go before they can offer conditions that can attract highly competitive products such as consumer electronics and electronic components. Rapid changes in technology and in the market give international companies cause for extreme care in opening new African production centers, and they are likely to make such a move only where rapid changes in products and employment are possible. These same conditions inhibit the emergence of indigenous manufacture for export.

Late start in the Philippines

Many of these conditions already exist in varying degrees, along with ample domestic consumer market opportunities, in Thailand, the Philippines, and Indonesia. The Philippines, in particular, is well-equipped for entry into world markets. Manila is advantageously situated geographically and endowed with substantial transportation and communications facilities. Labor is plentiful and educated. Equally important, the Philippines has the enormous advantage of a large reservoir of highly skilled labor and, even more important, of supervisory and management personnel, who are scarce and generally expensive in many other countries. At present, there are 26 assemblers of consumer electronic products in the Philippines; almost all are engaged in the assembly of radios and radiophonographs, and 13 also make television sets. In addition, there are many manufacturers of assembled radios, and an existing capability for manufacturing passive and wired components. Many manufacturers have long experience involving relatively high standards of quality control and overall industrial performance.

Indeed, the electronics industry might have led the takeoff of Philippine export industries. But, instead of becoming a major foreign currency earner, at the beginning of 1975, the industry was draining foreign exchange at the rate of $15 million a year. This development lag has nothing to do with problems of foreign domination or dependence on foreign capital, since most of the industries are in the competent hands of Philippine ownership and management. Nor can multinational corporations be blamed for the Philippines' failure to harness global demand for electronic products. Instead, the Philippines provides a classic example of how administrative policy can act to inhibit the development of this critical sector. Cumbersome and time-consuming bureaucratic procedures; a restrictive and corrupt tariff administration; the absence of a coherent incentive policy; nationalization policies that have diverted to Singapore, Taiwan, and Korea foreign capital that might have served to develop a thriving semiconductor production and massive subcontracting of consumer electronics production—these, along with the adverse balance-of-payments situation and possible currency risks attending this unfavorable political and institutional framework, have all served persistently to hinder the development of the electronics industry. Add to these deterrents the exceptionally high interest rates that have prevailed in the Philippines over the years, and the present negative trade flow in electronics becomes wholly comprehensible.

Last March, the Philippine Government, somewhat tardily, adopted a series of measures intended to change all of this. Consignment of materials and components was allowed, to facilitate international subcontracting ventures. Common production in bonded warehouses for both export and domestic markets was also allowed. Other provisions of the new regulations now entitle export manufacturers to import raw materials, parts, and components. Sales taxes and tariffs on electronic products and their components have been restructured to encourage domestic manufacture of components, subassemblies, and accessories. And additional facilities are available for foreign investment in the Bataan free-trade zone.

Even as a late starter in the global electronics export game, there is no intrinsic reason why the Philippines should not repeat the Singapore performance. Within the next five years a $500 million export industry can be developed. The Philippines is better equipped than was Singapore when Fairchild triggered the development of the industry there with the first semiconductor plant in 1968, and it has a much larger trainable labor force, as well as a greater reservoir of managerial talent. However, much remains to be done—to remove red tape, to regain the confidence of foreign investors, to lower interest rates, and to reduce currency risks. ◆

Gene Gregory served in the U.S. Foreign Service for several years in the Far East and Washington. He has also been a Ford Foundation Scholar, publisher, entrepreneur, and consultant. While in Japan, Mr. Gregory worked closely with firms like Sony, Toshiba, Pioneer, and Sharp, helping them devise strategies for penetrating markets in Southeast Asia and techniques for transferring technology to developing countries in this area. In what he terms a "leisurely odyssey," Mr. Gregory studied chemical engineering at the University of Washington and Georgetown, foreign service at Georgetown, international studies at Johns Hopkins, and Southeast Asian subjects at Cornell University. He contributes regularly to the *Far Eastern Economic Review*, and is a member of the editorial board of the *Asian Quarterly*.

New product applications

Desktop programmable calculator has powerful minicomputer-like features at low price

The powerful desktop programmable calculator, shown here with the new thermal printer, is ideally suited for instrument system controller applications.

The HP-9825A desktop programmable calculator, priced at $5900, offers powerful features usually found in higher-priced minicomputers. It is designed for engineering, research, and statistics and as a stand-alone computing tool.

Features include interrupt; input/output speeds up to 300 000 bytes per second; a live keyboard; direct-memory access with input speeds up to 400 000 16-bit words per second, and output up to 200 000 16-bit words per second; bidrectional tape drive; mutidimensional arrays; automatic memory record and load; extended internal calculation range ($\pm 10^{511}$ to $\pm 10^{-511}$); and optional plug-in ROMs.

The formula-oriented programming lanuage is easy to learn and is suited for controller applications as well as for data processing. The language handles subroutine nesting and flags, and allows 26 simple variables and 26 multidimensional array variables that are limited only by the size of the calculator memory.

Editing of lines and characters is simple, and error locations are identified by a flashing cursor in the display. Fixed and floating-point formats can be set by the user from the keyboard, which has 12 special function keys that, with a shift function, can handle 24 different operations. The keys help in program writing and in peripheral and instrument control. They can serve as immediate execute keys, call keys for subroutines, and typing aids.

With the live keyboard, the user can perform simple calculations, can examine and change program variables, and can list programs while the calculator is performing other operations. Although the calculator appears to be performing these tasks simultaneously, the interrupt capability is actually apportioning operations on a priority basis.

Because of the unit's interrupt ability, available in extended I/O ROM, the calculator can control instruments or peripherals, and print, plot, and run programs all at the same time, with the priority schedule determined by the operator. To do this on a minicomputer, the operator would have to write a program in assembly language. In the 9825, this can be done from the keyboard.

The 32-character LED display and built-in 16-character thermal printer provide an upper- and lower-case alphanumeric readout. The display and printer provide the full ASCII character set.

The built-in cartridge drive offers an average access time of 6 seconds. The tape cartridge has two tracks and can hold 250 000 bytes, with a 2750-byte-per-second transfer rate. In the event of a power failure, this feature, coupled with an "autostart" feature, can load information into the calculator's memory and can continue whatever program had been running.

The 9825 comes with 8K bytes of internal read/write memory, which is expandable in optional 8K increments to a total of 32K bytes. Four plug-in slots in the front of the calculator provide space for optional ROMs. These ROMs are STRINGS, which provide string arrays, 32 767 characters, and functions like length, position, value, capitalization, and concatenation; ADVANCED PROGRAMMING: MATRIX, which provides standard operators like invert (40 × 40 in 70 seconds), transpose and multiplication, multidimensional array operators, and scalar multiply; PLOTTER; GENERAL I/O; and EXTENDED I/O.

The calculator is available for delivery in eight weeks. Three optional statistics software packages are also offered.

Circle No. 40 on Reader Service Card

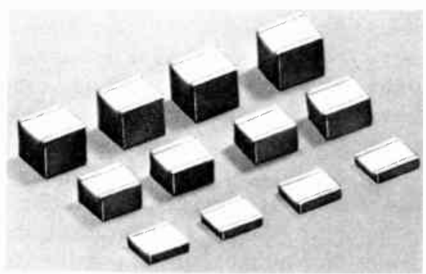
This manufacturer has also introduced a thermal line printer with upper- and lower-case and plotting capabilities. Priced at $3350, the HP-9866B printer is designed for use with all HP-9800 desktop programmable calculators.

The printer contains a 95-character ASCII set and can print up to 80 characters per line at a speed of 240 lines per minute. Under calculator control, it plots graphs and bar charts with a resolution of 0.017 in (0.04 cm) at a speed of 900 rows of dots per minute.

Information about both the printer and calculator is available from Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304.

Circle No. 41 on Reader Service Card

Low-profile, high-Q capacitors are available in three thicknesses



Low-profile and high-Q capacitors such as these 50- and 100-mil-square porcelain components are ideal for RF and microwave circuits.

These microminiature, 50- and 100-mil-square, porcelain capacitors are available in three thicknesses for low-profile applications in RF and microwave circuits: cube, mid, and thin. The low-loss capacitors are guaranteed to have a minimum Q of 10 000 at 1 MHz (typical values are in the range of 40 000). Performance is fully stable over the working temperature range of −55 to +125°C, with no measurable drift and complete retrace. Insertion loss is less than 0.1 dB.

The reduced profile dimensions of the 50-mil capacitors (in addition to the cube) are 35 mil for the mid size, and a thickness of 20 mil for the thin size. In the 100-mil size, thicknesses are 65 mil for the mid size and 25 mil for the thin size. Working voltages vary according to thickness, as well as capacitance rating per capacitor, and are available as high as 500 volts dc for the 50-mil cube.

All the low-profile capacitors are guaranteed to be unaffected by soldering techniques, including high temperatures, high-activity fluxes, and solvents. The porcelain is nonporous, with a density exceeding 95.5 percent of theoretical value. It is produced from reagent-quality raw material. Terminations adhere to the ceramic substrate for maximum hermeticity.

The units are available for immediate delivery in all ratings and sizes. Further information is available from Dielectric Laboratories, Inc., 64 Clinton Rd., Fairfield, N.J. 07006.

Circle No. 42 on Reader Service Card