The COLORADO Engineer

OCTOBER 1977

Du Pont has given me the freedom and variety of jobs I just couldn't find elsewhere.

—Michael Barbaglia BS, Mechanical Engineering

"Du Pont was just one of about 30 companies I interviewed on the U. of Missouri-Rolla campus in 1974. When I visited the Houston plant, I liked the people. And, when we talked about the project engineering work I might be doing, I also liked the feeling about my future.

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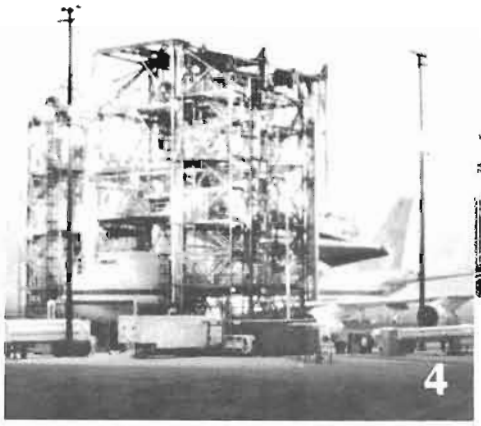
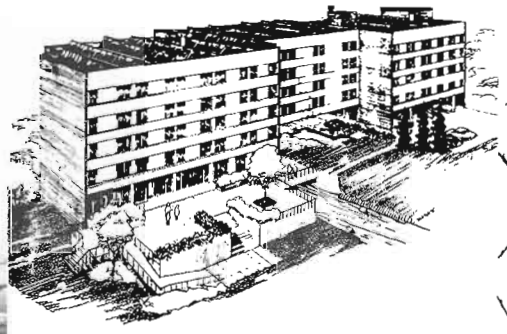
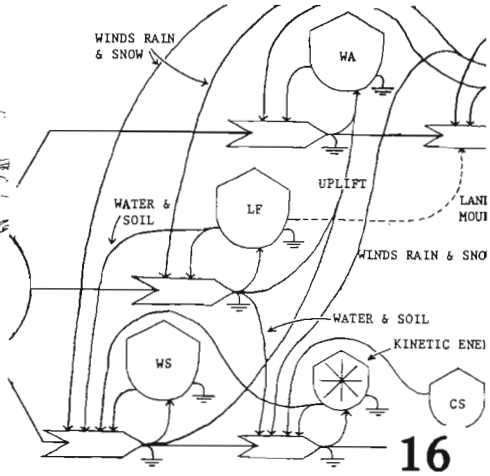






FEATURES

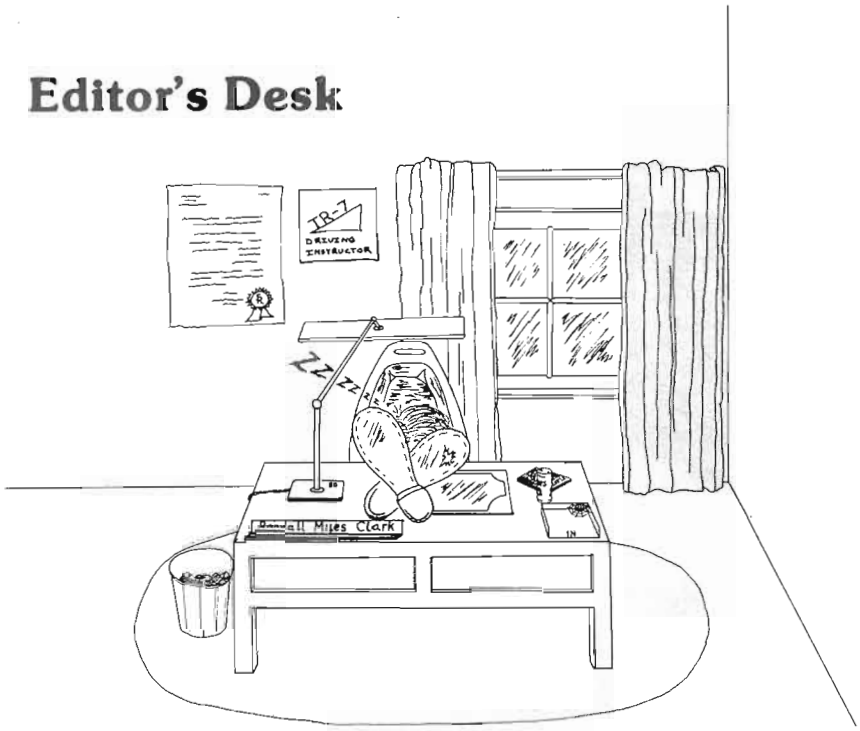
DEPARTMENTS

COVER

This issue's cover is a reversed high contrast image of the space shuttle *Enterprise* mated with the NASA modified Boeing 747 carrier aircraft. A hybrid spacecraft and glider, the reusable shuttle opens a new era of the space age by making space more accessible to man. Over 500 flights are currently planned to help in the study of the earth and the universe, and to maintain the security of the nation. Original photo courtesy of NASA, graphic design by Tom Brooks.

published since 1903

Editor's Desk



One of the biggest advantages of being editor is that I can finally play with the magazine's rubber cement without being yelled at. (Simple pleasures. . .) Another strong point is that I can try some half-baked ideas and only get a few frowns from the staff.

As my first effort I have introduced a new feature cleaverly called Yes/No. In each issue this section will address some controversial question facing the students, the college, or the state. I extend a sincere thanks to Profs. Foch and Fuller who on extremely short notice provided the responses for this issue's question. All readers are encouraged to fill in and clip out the survey card on page 9 and return it to ECOT 1-7. The results will be published in January.

Another feature that I would like to see started would be a kind of engineering students' show and tell. Once each issue, some lucky student will have his favorite project explained to the magazine's readers. Examples of presentations that might be used are personal research projects or entries in the various design competitions (the Bendix design contest, the ME rescue wench). The only restrictions are that the proposals be interesting and the length be limited to one page. If you have any questions just stop by the office or call x8635.

With this issue we welcome back *In the Final Analysis*, our light-hearted look at engineering life. Ideas for this section are always appreciated.

At this time I would like to extend a special note to my teachers who have probably forgotten what I look like over the past two weeks. Yes, I am still a student, and yes, I still plan to graduate in May.

* * * *

The January issue planning session was held on October 19 and the attendance was less than encouraging. If this magazine is to maintain the high standards that we try to set for it, much more student input is needed. I am presently trying to reorganize the staff into more efficient working units, and consequently, there are several positions that need to be filled. The most important of these is the managing editor who will be responsible for correlating and preparing all of the authors' work for typography. Also, this magazine desperately needs a graphic artist to help replace the several year old graphics we currently use. We always need authors, advertising representatives (15% commission), and layout people. Stop by and talk to us if you are interested, or just fill out one of the forms on the office door.

Randy Clark

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Air Force ROTC—Gateway to a great way of life

Space Shuttle, Supertruck

by Ross Lampert

Since mid-1975, the United States has not had a manned space mission. While unmanned missions such as Viking, Mariner, and Pioneer have been eminently successful in exploration of the inner and outer planets of the solar system, the excitement and versatility of the manned projects have been lacking. But starting in early 1979 all that will dramatically change as a new direction in America's space exploration efforts begins.

The machinery and program responsible for the change are the Space Shuttle, the Supertruck of the National Aeronautics and Space Administration (NASA). The first of these amazing new air/spacecraft has already been built and is most of the way through its low altitude Approach and Landing Tests (ALT). But what's so special about the Shuttle, and why has NASA seemingly put all of its eggs in one basket?

The Space Shuttle consists of several components. The Orbiter itself is 17 m high, 34 m long, has a 23 m wingspan, and weighs 67,500 kg, making it about the size of a DC-9. Its fuselage contains a two level crew compartment, the upper floor being the flight and mission control center and the lower holding the crew quarters. The entire crew compartment will be held at one atmosphere pressure and about 22° C, for a shirtsleeve environment. During launch, the passengers and crew will experience a stress of only three times the pull of gravity (3 g's), and during reentry, only about 1.5 g's.

The major portion of the ship, though, is devoted to the payload compartment. Eighteen meters long and 4.6 m in diameter, it can hold up to 29,500 kg of equipment, and NASA expects it to be about 75% full on each flight. The wings are in a double delta configuration, with elevator and flap control surfaces plus a split panel rudder on the tail that opens to act as a speed brake. These surfaces are controlled by a fly-by-wire system based in the control column mounted on a fixed pedestal at each pilot's station. Cockpit instrumentation includes three cathode-ray tube displays on the main instrument panel and four IBM flight control computers. Most other systems are also multiply redundant.

The advantages to this new system are numerous. Aside from the nearly $7 billion NASA has spent on research, development, testing, and evaluation of the first craft, savings over the first ten years of operation are expected to be in the range of $1 billion, coming from a reduced need to design each spacecraft individually (the Multi-Mission Spacecraft, or MMS, will provide a basic framework with a standardized attitude control, power, and communications subsystems), the recurring cost of using expendable launch vehicles for each satellite, unified flight support and control facilities, transportation of the satellite into orbit (the shuttle Oribter can carry several in its cargo bay), and in-orbit servicing of malfunctioning spacecraft. The Shuttle also offers experimenters a wider range of experimental possibilities through the Long Duration Exposure Facility (LDEF), "getaway special" payloads of small size (less than 91 kg and 0.14 m^3) and low cost (under $10,000). Already more than a half dozen places have been reserved for the latter offer.

The Space Shuttle also brings back the possibility of relatively long duration space flights. Each mission, after the first six, which will be check-out flights, will last between seven and 30 days, and ways are being explored to provide solar-generated power for the craft for up to 90 days, if the space can be found to store the other necessary provisions on-board for that period of time. The primary user of the longer Shuttle flights will be Spacelab, a variable-configuration space station being developed jointly by NASA and the European Space Agency (ESA). Spacelab will provide opportunities for scientists, both men and women, from Europe and the United States, to go into space with a minimum of special training to conduct experiments on set-ups ranging from 15 m of equipment on a pallet to nine meters of enclosed, pressurized workspace and six meters of instrument pallet. A Space Shuttle/Spacelab crew will consist of at least a base crew of two pilots, a mission specialist, and a payload specialist, plus up to six other scientists.

The Space Shuttle also gives NASA the ability to fly many more missions per year than it does now. As many as 560 flights are being contemplated between 1979 and 1991 for the five Orbiter craft the agency wants. It is also quite possible that the flights will not end in 1991, but continue for an indefinite period, depending on how great a demand there is for the Shuttle's services. For example, there are 220 Spacelab missions planned for the first ten years now, but that number could climb.

Finally, the Space Shuttle is reusable. Each flight, whether in a standard, roughly equatorial orbit launched from the Kennedy Space Flight Center at Cape Canaveral, Florida, or a polar one sent up from Vandenburg Air Force Base in California, will follow the same general routine. The Orbiter and its attendant fuel tank and solid fuel boosters will be launched from a vertical position. The three engines of the Orbiter will develop 2.1 million newtons of thrust each from the liquid hydrogen/liquid oxygen fuel stored in the huge external tank, built by Martin-Marietta, assisted by two booster rockets, developed by the Thiokol Corporation, producing 11.8 million newtons of thrust each.

Two minutes after launch, the boosters fall away, at an altitude of 43 km, to return gently to earth under parachutes. They will be recovered and returned to the U.S. where they will be refilled and reused.

The remaining Orbiter and tank continue to climb, and at 12 minutes into the flight, the now empty tank is jettisoned. It will fall back to earth, but reentry to the atmosphere and impact in either the Indian or South Pacific Oceans will destroy it. This is the only part of the system that will not be used again.

The Shuttle will spend its time in space placing satellites in orbit, recovering others for return to earth, repairing or changing the instrumentation in still others, or performing experiments carried on board. The Orbiter can maneuver in space by using the monomethyl hydrazine fuel it carries to power its Orbital Man-

euvering System (OMS).

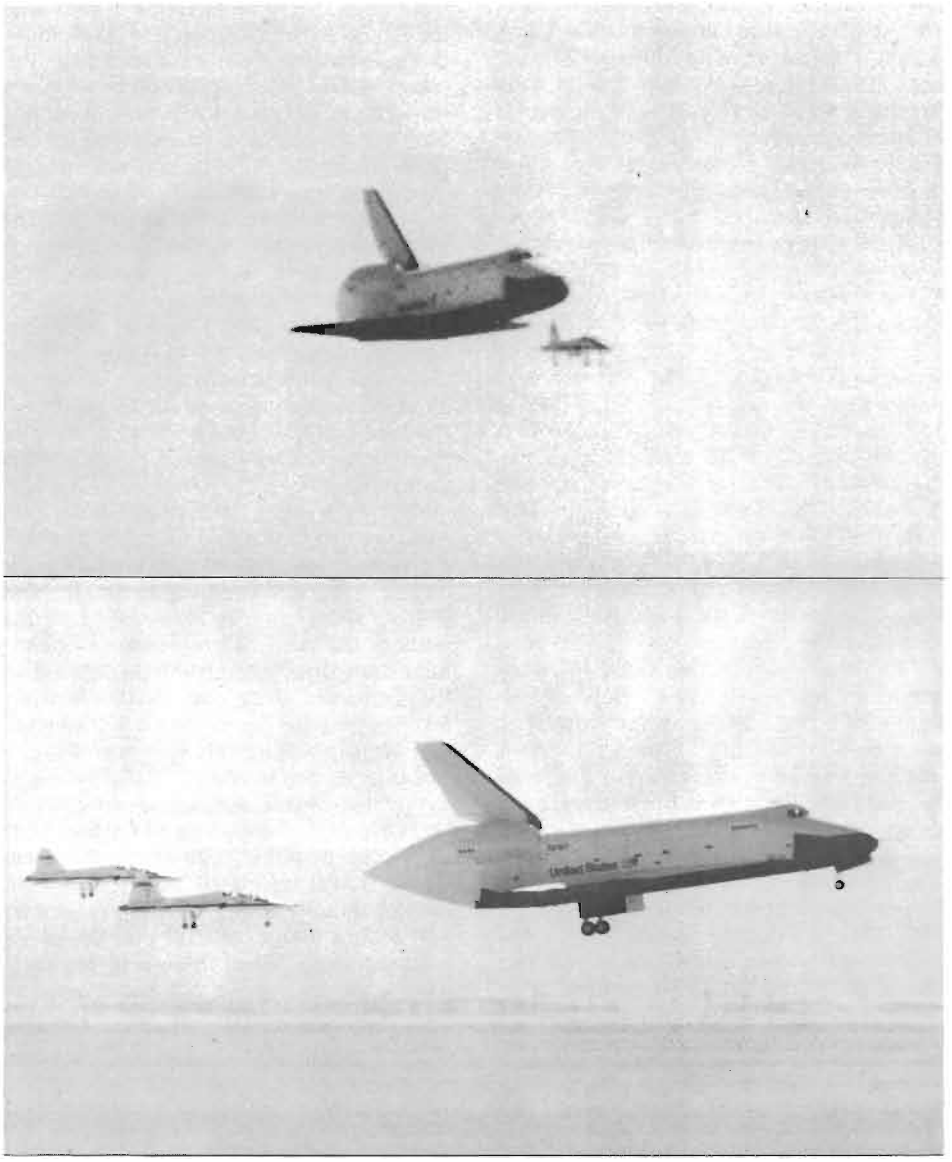
Once the crew has finished the assigned mission, they will fire the OMS thrusters to head for home. Atmospheric reentry begins at an altitude of 120 km and a velocity of about 28,000 kph. The craft will be in a nose-up attitude to present to the oncoming air the flat underside which is coated with blocks of a carbon/carbon composite thermal protection materials. The Orbiter's nose and the leading edges of the wings and vertical stabilizer are also protected this way; most of the rest of the fuselage is covered with blocks of a silicon-fiber based insulator, and the cargo bay doors and rear thruster pods are overlaid with Nomex felt. The insulating blocks dissipate heat so well that they can be, and have been, held in bare hands immediately after being taken from a 1260° C oven. They are expected to last 100 missions before needing to be replaced.

Once most of the speed of reentry has been bled off, the Orbiter will pitch over into a nose-down attitude and glide to a landing at either Edwards or Vandenburg Air Force Bases (Edwards will be used only for the first few flights, since it is the home of the Dryden Flight Research Center, where the ALT program is being conducted; Vandenburg will not be ready until the mid-1980's) or the Kennedy SFC. The Orbiter will makes its approach on a 24° glideslope, about eight times steeper than that used by commercial aircraft, to touch down at about 340 kph. Landing rollout will be about 3.2 km, after which it will be towed back to a reassembly facility to be prepared for the next flight. During peak operations, there should be a launch every two weeks or so.

But other than Spacelab, what kinds of payloads will the Orbiter carry? The Orbiter itself can place satellites into orbits up to 1000 km high and the Boeing-built Interim Upper Stage (IUS) or the Spin-Stabilized Upper Stage (SSUS), can carry craft to higher orbits or into deep space on planetary missions. As mentioned above, over 500 missions may eventually be flown, but to date only the first 14 have been scheduled. The first six flights will be primarily tests of the Orbiter and its systems, with the first operational mission being the seventh flown.

The Department of Defense is expected to use about one quarter of all Space Shuttle flights for its own purposes, as usual, mostly clouded in secrecy, and another 26% will probably be manned by scientists and technicians besides the basic crew.

The prime contractor for the Orbiter is Rockwell International, Space Division, selected in 1972. Construction of the Orbiter began in June of 1974 and on Sep-



Randy Clark

This first free flight of the orbiter took place on August 12 at Edwards AFB. The trailing vortices in the bottom picture are evidence that the Enterprise *does generate some lift. Two of the five T-38 chase planes are also shown.*

tember 17, 1976, the first craft, Orbiter 101, was rolled out at Rockwell's Palmdale, California plant and officially christened "Enterprise," the name given it by President Ford in response to thousands of letters from fans of the *Star Trek* television program. (Present at the ceremonies were Leonard Nimoy, George Takei, and DeForest Kelly; Mr. Spock, Lt. Sulu, and Dr. McCoy, respectively, in case you'd forgotten.)

The following January, the craft was trucked 58 km to the Dryden Flight Research Center where the ALT flights were to take place. The Orbiter was mounted atop a specially modified Boeing 747, and on February 18, 1977, the first captive/inactive flight took place. These flights were called this because no one was aboard the Shuttle, its systems were turned off, and it remained on the carrier 747. Eventually, the last of the six planned C/I flights was cancelled and 11 hours, 36 minutes of flight time were logged in five missions.

The first captive/active flight (with astronauts Fred Haise and C. Gordon Fullerton on board and the systems on) took place on June 18, 1977. Three of the four planned missions were flown. The purpose of these flights was to familiarize the crews (Haise and Fullerton on one and Joe Engle and Richard Truly on the other) with the Orbiter and prepare them for the free flight test phase.

This last portion of ALT began on August 12, 1977 when the mated 747/Orbiter combination, piloted by Fitzhugh L. Fulton, Jr. in the 747 and Haise in the Orbiter, took off and climbed to 8540 m altitude over the California desert at Edwards AFB. The 747 then pitched over into a seven degree dive, leaving the Orbiter in almost level flight. The paired craft accelerated to 518 kph and at 7345 m, explosive bolts were fired and the vehicles separated. The 747 turned left and the Enterprise turned right to clear each other, and then the Shuttle headed for runway 17L. During the 5 minute, 23 second flight, Haise and Fullerton tested the various characteristics of the craft, including a practice landing flare at 550 m. Touchdown occurred about 600 m down the lake bed at between 335 and 340 kph. Haise later described the flight as "super slick."

At this writing, there have been two more free descents and as many as three more (one with the special boattail cone on the Shuttle to reduce buffeting, and two without) may be flown. The flights without the tailcone are needed to determine how the Orbiter will handle when the increased drag due to the thruster nozzles and flat back end is introduced. The Shuttle will fly this way normally, so this information is vital.

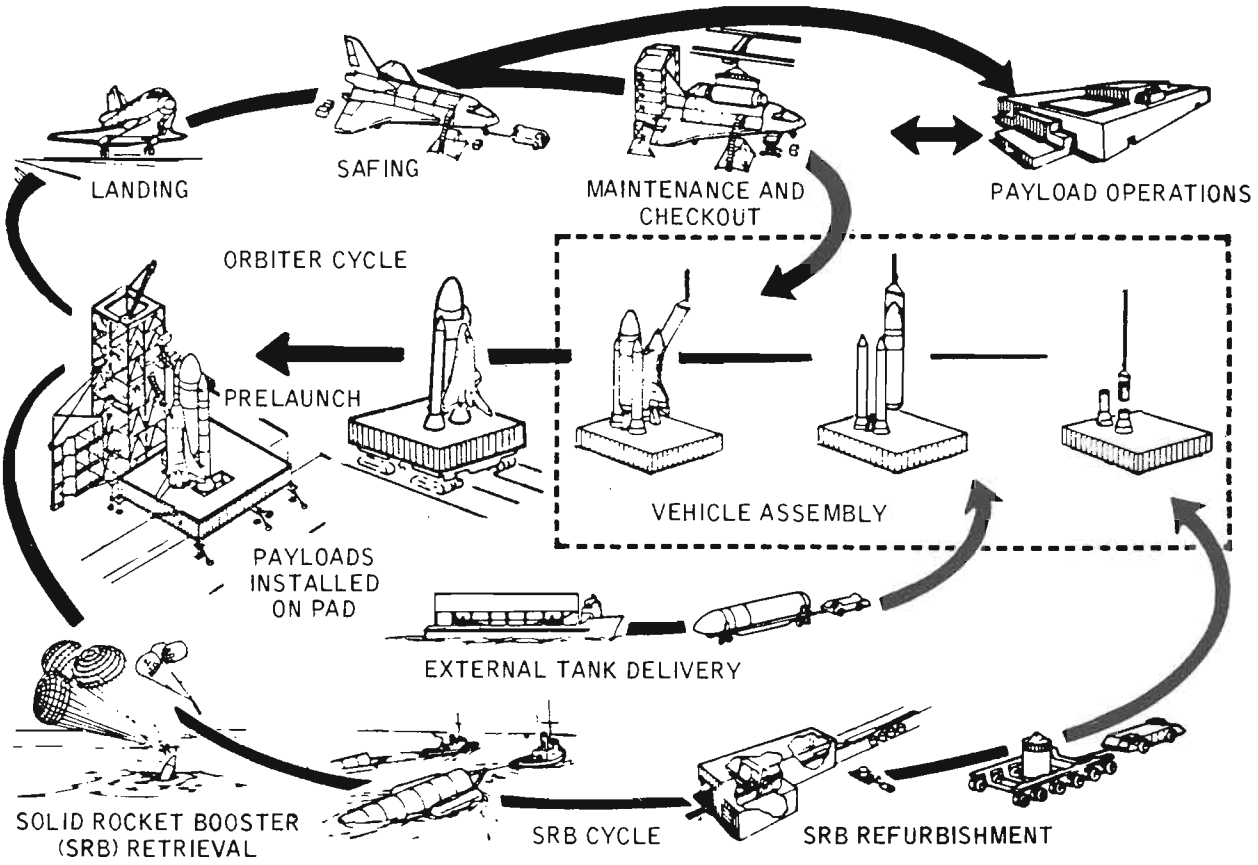
When the ALT program is completed, the Orbiter will be shipped to the Marshall Space Flight Center in Alabama where it will be mated with a fuel tank and a pair of boosters. The entire system will then undergo several months of vibration testing. When these tests are completed, the Enterprise will be returned to Rockwell's Palmdale facility for modification while Orbiter 102, scheduled to be completed next month, will be taken to the Kennedy SFC in preparation for the initial space flights.

As mentioned before, both men and women will fly on the Space Shuttle and while the environment of the crew compartment will be suitable for shortsleeve dress, some extravehicular activities (EVAs) will take place. NASA has modified the suit used by the Apollo astronauts for this task. The new suit consists basically of a soft lower half and a harder upper torso piece that is integrated with the life support backpack, which allows EVAs of up to seven hours. The new suits are expected to have a 15 year lifetime and, instead of being custom made for each astronaut, come in four basic sizes. The suit is smaller in overall size than the Apollo suit and allows increased mobility by the use of constant volume joints. The gloves, helmet, and torso halves connect by ring closures, rather than zippers, making them less susceptible to leakage. Each suit will have a microprocessor that will monitor its condition, and if something goes wrong, tell the wearer how to fix it via a light-emitting diode display mounted on the chest. NASA expects that only minor modifications will be needed for women to wear the suits.

If something should go wrong while an Orbiter is in space, NASA has developed a unique rescue system. While the regular crew climbs into space suits, other pas-

TENTATIVE SCHEDULE FOR FIRST ORBITAL FLIGHTS

Mission #	Date	Purpose and Payload
1	March 1979	A pallet of developmental flight instrumentation only.
2	July 1979	A low eight scientific instrument pallet.
3	September 1979	A flight to check out the functioning of the Canadian-built manipulator arm. A science pallet will also be carried.
4	December 1979	If the SSUS is not ready by this time, the Hughes Syncom 4 communications satellite may be flown, along with either ESA's GEOS-2 magnetospheric satellite and a barium release experiment.
5	February 1980	Either an IUS, placed on Skylab by a remote television controlled space tug operated by a mission specialist on the Orbiter, designed to send the now abandoned space station into a higher orbit, or the first LDEF. The LDEF is a 12-sided cylinder containing 72 trays that hold experiments. It will be placed in space and left there for six to nine months while the experiments do their things. It will then be recovered and returned to earth.
6	April 1980	The U.S. Air Force's Ruby Teal aircraft detection and tracking experimental system and either an MMS configuration or a science pallet.
7	May 1980	The LDEF, if it wasn't launched earlier, and the National Oceanic and Atmospheric Administration's (NOAA) Geostationary Operational Environmental Satellite #4 (GOES-D).
8	July 1980	Western Union's first Tracking and Data Relay System Satellite (TDRSS-A) and Satellite Business System's Communications Satellite A (SBS-A).
9	September 1980	Canada's Telesat E and GOES-E.
10	October 1980	TDRSS-B and SBS-B.
11	December 1980	The NASA/ESA Spacelab 1.
12	January 1981	A backup flight for Intelsat 5 if it wasn't launched by an expendable vehicle earlier, or Telesat F.
13	February 1981	Spacelab 2.
14	March 1981	TRDSS-C.



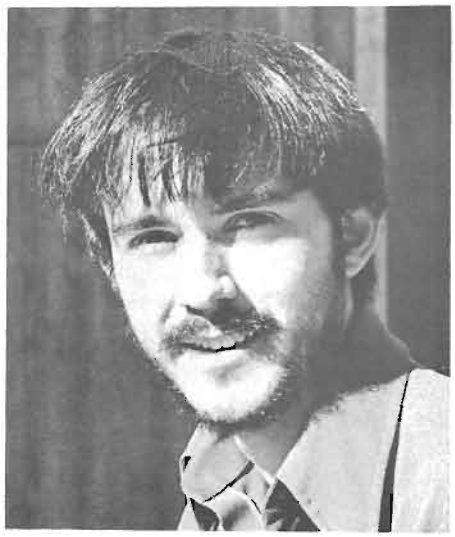
SHUTTLE CYCLE

sengers will be placed in Personal Rescue Enclosures (PREs). The PRE is an 86 cm diameter ball, made of the same material as the EVA suits, which contains its own communications and life support systems. Curled into a fetal position, the PRE occupant can survive for several hours while waiting for rescue. When it comes, the PREs will be attached to a line between spacecraft and transferred directly. Such a system may be cramped, but it certainly beats the other options by a mile (1.6 km).

Finally, the Space Shuttle will bring about new legal questions that the courts will have to deal with. In a recent speech to the American Bar Association, former astronaut Harrison Schmidt, now a Republican Senator from New Mexico, pointed out that the legal system of not only the United States, but other countries as well, will have to deal with problems involving the "weather, ocean, land, and environment" based on data gathered by people in space. How will the courts rule on evidence about the damage to the ozone layer caused by fluorocarbons or on solar power generating stations in space? How will they handle problems governing medical treatment, research and development, and other industrial activities in space? Which court system, in which country, will deal with what questions? These are unanswered questions now, according to Sen. Schmidt, but they will need to be resolved very soon. Right now, however, not too many people are concerned.

The Space Shuttle is indeed the way of the future, at least for the next 15 years or so. In the next half decade we will see the beginning of a new era that will have effects unprecedented and unparalleled in history. Just as the Mercury, Gemini, Apollo, and Skylab missions were steppingstones, so will the Space Shuttle. But it will be more than just another step. The first four programs established space technology; the Space Shuttle will utilize it.

The Space Shuttle will launch more than just hundreds of satellites, it will launch the first great era of space development. "Enterprise" is indeed a fitting name for Orbiter 101 because it and its four companion craft will be the tools of a great undertaking, a peaceful, multinational enterprise unlike any this planet has ever seen. Yes, indeed, Space Shuttle, Supertruck. □

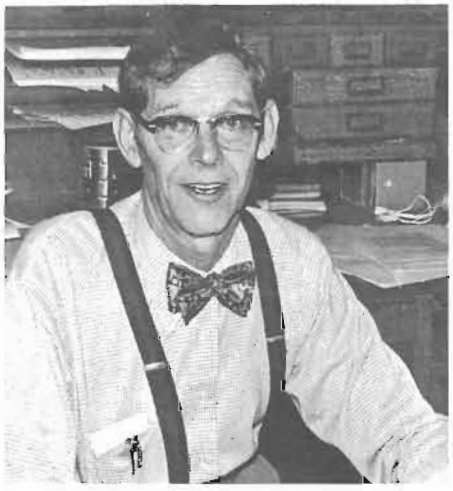


Ross Lampert is a graduate of CU with a bachelors degree in Physics. In early April, after a shave and a haircut, he will report to Air Force Undergraduate Pilot Training at Vance AFB, Oklahoma. He hopes to fly the Space Shuttle in the future. Presently working as a free-lance writer, Ross spends his spare time playing tennis, taking pictures, and flying.

YesNoYesNoYesNoYesNo

Should the Engineering Faculty Unionize?

No



Jackson F. Fuller, a Professor of Electrical Engineering, received his bachelor of science degree in electrical engineering from CU in 1945. He began teaching at CU in 1969 after spending over twenty-five years in industry as a power processes and systems engineer. He is very active in civic affairs and has received numerous awards including the CU Outstanding Teacher Award and the Distinguished Engineering Alumnus Award.

A professor, unlike people in industry, wears two hats. One hat is that of a teacher with the ability to impart knowledge and create the joy that stimulates learning in the individual. The other hat is that of the expert in his or her own field of knowledge. As students well know, not all possess equal expertise at wearing both hats, and it is difficult to evaluate us when methods of teaching and professional areas of interest vary.

In times of tightening budgets, faculty become concerned with legislative priorities for education. One proposal to strengthen this faculty voice is "collective bargaining" and the "adversary" position.

While this has a nice sound to it, there are many serious questions that need to be raised about collective bargaining. Among these are:

1. Is there a benefit to the student?
2. Is there benefit to me as a teacher or advisor?
3. Is there a benefit to me as a professional engineer?
4. Is there a benefit to me as an individual?

At present the Faculty Council represents me in concerns of tenure, academic freedom, appointments, governance and the quality of administrators. In my profession as electrical engineer I have always represented myself to those evaluating my performance in matters of work load, salary and professional competence, be they boss, department chairman, dean, or a panel of my peers. As a professor, I have the protection of tenure that does protect against almost everything except gross incompetence or no dollars from the legislature. My salary as a teacher is less with tenure because the risk is less. Concerns commonly expressed are about teaching loads, research, facilities and salary. Most are related to the money available to run the institution. My salary concern is with the share I am alloted from the total dollars, or with the dollars granted the University by the State Legislature. In the first case, I wish to do my own negotiation, depending upon my performance as a professional engineer and teacher. If the latter, I have two choices. I can assume part of the responsibility to help convince legislators of the importance of higher education or I can elect to "bargain collectively."

When all fluff is cleared away, the weapon of "collective bargaining" is the strike and a strong adversary position. Let's not kid ourselves. Unions do strike!

Now back to the collective bargaining questions.

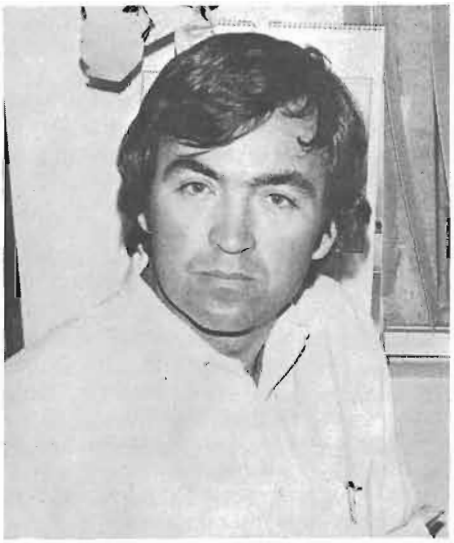
1. How is the student benefited?
   a. Does someone propose that fewer teaching hours might mean more office hours for professors to be available to the students?
   b. Pay schemes under collective bargaining always seem to end up rewarding seniority and thus mediocrity instead of competence. Is this in the best student interest?
   c. No doubt about it, evaluation for merit pay is subjective! I believe all teachers need to be evaluated each year and student evaluation is one important input. No student is fooled for very long by a professor attempting to get a "good rating."
   d. I do not believe students ever win in a strike by teachers against a legislative body. There is doubt that the faculty really wins.
2. How am I as a teacher, advisor or researcher benefited?
   Effective teaching clinics and other growth opportunities are already available. Unions offer no constructive growth for teaching.
3. What benefit does collective bargaining bring me as a professional engineer in my chosen field?
   There is no way that my competence can be "represented" by others since this is between me and my peers in my professional field. Practicing engineers are overwhelmingly non-union.
4. What benefits does "collective bargaining" offer me as an individual?
   Only in the total salary dollars available from the legislature can a collective body hope to make major gains. Under no circumstance do I wish to use the threat of a strike to make these gains, especially against a legislative body.

As both a teacher and a professional engineer, I wish to do my own bargaining, without benefit of a formalized salary structure, and to take my chances on negotiating what I believe my worth to the institution to be. As upsetting as it may be, I wish to let the law of supply and demand operate since it is already constrained by tenure, pension, health care and retirement plans. Let students and peers be the "collective" body to help keep me an effective teacher and adviser.

YesNoYesNoYesNoYesNo

YesNoYesNoYesNoYesNoYesNo

Yes



James D. Foch is an Associate Professor of Aerospace Engineering Sciences. He received his bachelor of arts degree in physics from Dartmouth and his PhD in theoretical physics from Rockefellor University. In 1968, after one year at the Bell Telephone Laboratories, Dr. Foch came to the University. His interests and specialties include fluid and statistical mechanics, as well as applied mathematics.

The key to good teaching and research is time, time to absorb and interpret new ideas, time to work on difficult problems in applied science, and time to spend with students and colleagues. But the time available to the conscientious faculty members is being eroded by two pernicious factors, with a consequent deterioration in the quality of the college.

The first of these factors is inadequate faculty pay. When I joined the faculty in 1968, my annual salary was $11,000; currently it is $18,000, which represents an annual rate of increase of 5.9%. Last spring the consumer price index for the Denver area was 1.82, with the year 1967 as a basis of comparison this represents an annual rate of increase of 6.2%. Machinists and technicians in the college, who are by no means overpaid, frequently earn more than faculty members. Some graduating seniors will probably earn more in their first year of employment than some of their teachers did after years of training and experience.

The effect of inadequate faculty pay frequently induces faculty members to seek other sources of income at the expense of time for good teaching and research. The lure of outside income is very tempting because it is usually based on what practicing engineers earn. Faculty members who are especially effective teachers or have distinguished themselves in research often succumb to this influence. This threat to the vitality of the college cannot be overestimated.

The second factor is inadeqaute communication between the faculty and the administration, and within the faculty itself. The former has resulted in demoralizingly slow promotions, salary inequities, time consuming controversies over proposed policies such as reorganization, blindness to abuses of power, and prolonged disagreements over tenure.

The effect of inadequate communication among the faculty is made conspicuous by the lack of prominent collaborative research. Five to ten ordinary mortals working in a well chosen area could thrive on one another's talents and enthusiasm and bring great credit and recognition to the college.

Unionization of the faculty offers the prospect of new attempts to cope with the problems I have mentioned. A union could speak with a stronger voice than a few individuals and leave most members with more time for their teaching and research. A union could provide a more direct link between the faculty and the citizens of the state, who would benefit from a better college.

I cannot be sure unionization of the faculty would lead to utopia. In addition, I do not regard unionization as irreversible. I do believe that a continuation of the status quo should be unacceptable to all those who have high aspirations for the college.

What Is Your Opinion? Return to ECOT 1-7.

Should the Engineering faculty unionize?

Yes ☐ No ☐ Comments _____

_____

Undergraduate ☐ Graduate ☐ Faculty ☐ Staff ☐ Alumni ☐

Do you have an idea for a question for this section? _____

_____

YesNoYesNoYesNoYesNoYesNo

Walnut Place Solar Project

by Brian Sjoberg

Whether the problem is in controlling growth, protecting the environment, or exploring new energy sources, Boulder continues to justify its reputation as a progressive community. In order to receive valuable experience for future solar engineering, a Boulder senior citizens housing facility is being retrofitted so that the sun will supply the domestic hot water and part of the heating needs of the complex. The solar energy retrofit of Walnut Place, a 95-unit building constructed in 1971, is expected to be completed by January of 1978.

The project was conceived and spearheaded by Dr. Chuan C. Feng and Dr. Robert I. Carr as the principle investigators, and Dr. John O. Dow as the technical coordinator with the cooperation of the Boulder Housing Authority (BHA). Drs. Feng, Carr, and Dow are with the Department of Civil, Environmental and Architectural Engineering. A proposal was put together with the help of Honeywell Corp., who has done a similar project at the Mount Rushmore visitors center in South Dakota, and then successfully submitted to the Department of Housing and Urban Development (HUD) for their Residential Integrated Project Demonstrations program (second cycle). An award of $245,000 was made and planning and design started in the fall of 1976.

The solar energy development team consists of the University of Colorado as the prime contractor, in cooperation with the City of Boulder Housing Authority as the owner of the building; Honeywell Corp. as collector panel and control systems subcontractor; and McFall and Konkel Company, Denver, as consulting heating and air conditioning engineers. The mechanical contractor for the project is Natkin & Company.

According to Dr. Feng, the five story senior citizens center is ideally suited for solar heating applications, and it was picked over several other buildings in the area. There is a large space in the basement of the apartment which was unusable for anything else, but which lends itself quite well as a place for the solar storage tank. It also has a large flat roof, while nearby trees and buildings do not shade the top of the structure.

The system consists of 189 roof top collectors with 316 m^2 of surface area. The hydroponic flat plate collectors (which are 2 m by 1 m each) have a black chrome selective absorber coating and are covered with anti-reflection glass. A 50-50 mixture of water and ethylene-glycol will be used as the heat transfer fluid in the collector loop. Since the antifreeze solution is toxic, (and for other reasons, such as economy) two exchange loops have been built into the system. First, the heat is transferred from the rooftop loop to the insulated 22 kiloliter water storage tank. Then another loop is used to transfer the heat to the domestic hot water (DHW) and the forced air used in heating the common areas of the building. A sensor will turn on the pumps in both the collector and the heat transfer coils when the collector temperature exceeds 32° C.

Drs. John O. Dow, Robert I. Carr, and Chuan C. Feng.

The system is designed to furnish (either directly or from storage) 100% of the hot water in the summer, and in winter approximately 50% of the heating needs for the building. When solar heat is unavailable, the present gas heating system will be used. Only the common areas of the building, such as the lobby and corridors, are to be heated by the solar system. The individual units in the complex have baseboard heaters operating at 90° C, and as such, are not considerd suitable for use with solar heating. However, since the corridors are the only means of ventilation in the building, outside air is continuously being drawn into the building, heated, and then exhausted, which places a considerable demand on the heating system for the entire apartment.

The building will also be instrumented so that data can be collected and evaluated to determine the efficiency of the system operations. The results will be published and hopefully "the knowledge derived from this project will be directly applicable to solar energy projects of a similar design and scale," Dr. Dow said.

There was an unexpected problem when the actual construction was about to begin. It was learned that the concrete roof slab was two inches thicker than was shown on the original set of plans, which turns out to be about 130 kg per m^2 of added loading. Because of that, the original configuration of panels did not have the needed support. The structural system of the collectors was redesigned, delaying the project by four months, so that now the loads are supported directly by the columns and beams below. Since the

grant could not be increased to cover the extra cost, about 10% of the collector panels were removed from the original design, with an accompanying equal decrease in hot water storage capacity. One good point of the change in design is that under the original plan, over 200 holes would have been drilled into the concrete roof to support the collectors, with the resulting problem of possible water damage. With the new design, no new structural holes will have to be cut.

Cost effective is a word that often drifts into the conversation whenever solar energy is discussed. In other words, will the initial investment of installation be paid off by benefits derived from lower energy costs. "With this project, certainly at the $245,000, there's no way it's going to be cost effective," said Dr. Carr. "In fact, handling it as a unique demonstration project, especially with some research aspects, coupled with current low natural gas prices, (and as a retrofit), makes it difficult to have it a cost effective project. There definitely will be some payback, but it won't run out the investment." However, Dr. Carr added that although solar energy is not financially attractive in many cases, the payback aspect is not necessarily the main reason for choosing it, and that is the way a lot of solar systems are being selected today.

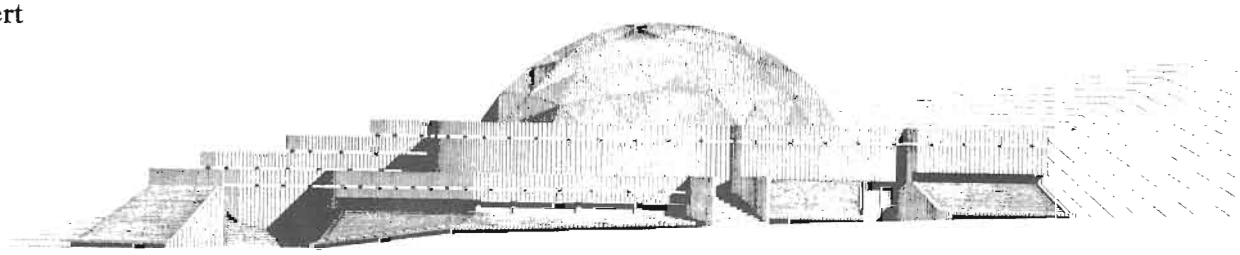
The residents of the building are "really pretty excited about the new installation," according to those involved in the project. A meeting was held in August of this year when the design team, the mechanical and electrical engineers, a representative of the Boulder Housing Authority, and many of the construction personnel, presented to the residents the design and operation of the system, and the scope of the construction work. The general attitude was one of "being real pleased that they were participating in it, and realizing that it would be a little bit of a bother, but not too much of one," according to Dr. Carr. "There's a real positive attitude, because when the system is finally in operation, they're not really going to notice any difference." □

Brian Sjoberg is a junior from Lakewood, Colorado, and is majoring in Architectural Engineering. During his freshman year at CU, he received a scholarship from the Colorado Energy Research Institute. This year he accepted an award from the Associated General Contractors of America. Brian hopes to graduate in 1979 and enter the construction industry.

PROGRAM REVIEW

Planetarium Projections

By Ross Lampert



THE EYE SEE THE LIGHT SHOW

Drifting in deep space. Far-away galaxies and planets close to home soar about you. Some places and things seem familiar; others are ones you have never seen before, or will again. Bumblebees flying in formation and huge monsters rising majestically from their secret lairs drive your senses to the limit.

But wait! That's no monster, it's only the Fiske Planetarium's Zeiss star projector rising out of the pit in the center of the star theater. That bumblebee? Nought by Tom Harman's laser flashing before you to the music of Nicolai Rimsky-Korsakov. But this is only a small part of the magical world of the *Eye See the Light Show,* now entering its (presumably) last month here in Boulder, after being held over a second time at the request of the University.

Billed as "more than a laser light show," it is a $55,000 combination of a dazzling 2.5 watt argon-krypton laser (the most powerful in use today for any show) and over 100 different incandescent light projectors, plus the star projector and music ranging from Rossini to Manfred Mann to Synergy. It takes three people to run all of the equipment, so every performance is done live; well, almost all of it is live. Jethro Tull, the Moody Blues, and the London Symphony Orchestra have not come in to help out, so they are recorded. But then, nobody I have talked to seemed to mind a bit.

Eye See the Light, based in Lansing, Michigan, has put together the ultimate in "light organ" machinery — the laser doing its myriad thing, kaleidoscopes, splash-plates, jets of streaming gas, whirling stars, and much more. It has a very strong tendency to sweep you up and carry you away to combinations of sight and sound you have never experienced before. I can only recommend that you sit back and let it happen, let your eyes roam where they will about the dome, and do not be in too much of a hurry to leave.

The entire performance is done on a high energy level, not only in terms of power output, but also the tempo of the music and intensity of the effects. The audience is taken by it from the beginning, and for the next hour or so, there is almost no let-up. But I have yet to see a performance of the show where there were not cries for encores following the encores, and I have attended nights when the star theater was not full. Just as with any live performance, the more favorably the audience reacts, the better the show is.

There is a natural tendency to try to compare the *Eye See the Light Show* with *Laserium,* but I am not going to do that for several reasons. First, they are entirely different shows, and both change their programs continually, and since I have not seen *Laserium* in over a year, I could well end up writing through my hat. Second, many of you have probably not seen *Laserium,* so it is of no value for me to talk about it anyway.

By the end of the last chords of the last piece of music you will know that in *Eye See the Light* you have more than just the stars. Shows are presented at 6:30 and 9:30 p.m. Thursday through Saturday, with an additional show at 11 p.m. on Friday and Saturday, and at 6:30 and 8:00 on Sunday. Tickets cost $2.75 for adults, $2.50 for students, and special shows can be arranged for groups.

But most of all, be prepared for a few surprises that I never even hinted at.

THE VOICE OF THE MARTIAN WIND

A summer's eve, a billion or so years ago. The air is quiet and peaceful as the people gather in the amphitheaters nestled in the low hills. But something is wrong.

The performers in the theaters, the children, and even the night watchmen are singing songs nobody knows or understands. Something is definitely wrong.

A billion years later, the planet is no longer a beautiful, lush world; it is a desert of ruddy sand and sharp-edged rocks, vast chasms and huge volcanoes. What went wrong those many years ago, and will the planet ever return to its former glory?

Is this some sequel to *Star Wars?* Hardly; this is the story told by *The Voice of the Martian Wind,* now in its last week at the Fiske Planetarium. But the awe and mystery of Ray Bradbury's story "Summer Night" somehow manage to fade as Jeffrey Bullock's story unfolds.

Part of the problem lies in trying to adapt stories with characters (Bradbury's at the beginning and Bullock's own at the end) to the planetarium's facilities. While motion pictures can be used as a part of the show, and are, believable characters need to be seen, as they are in the movies, and a planetarium show that cannot do that. The members of the planetarium staff who read the character parts detract more from the potential of the show with their wooden portrayals.

Further, in other sections, it was quite distracting to have the narrator talking about one subject while the slides projected on the dome displayed something else, or worse, were nonexistent for many seconds at a time, leaving the audience in total darkness. This cannot be attributed to cranky equipment, either, although this was another problem the night I saw the show.

But perhaps the things that bothered this Mars-follower the most were the questionable "facts" of Martian evolution foisted on a generally innocent audience by the author. Rivers on Mars? There is no substantive evidence for this; cataclysmic floods spawned when the volcanoes of the Tharsis region formed or meteorites impacted, yes, rivers, no.

But all this isn't to say that I totally despised the show. Not so! Not at all. The artists and technicians who worked on the sets of the main Martian base and several outlying stations of the future, as well as the interiors of the shuttle craft are to be commended. These scenes are quite detailed and generally well done, if a bit lacking in perceptible depth. And the wind sounds produced by Mark Petersen's synthesizers and generated by the planetarium's quad stereo speaker system seem to reduce the inside air temperature a few degrees and ruffle your hair.

The Voice of the Martian Wind finishes its run at Fiske at the end of the month, so you had better hustle if you still want to see it. Show times are Wednesday through Saturday at 8 p.m. and Sunday afternoon at 2. Admission is $2.00 for adults and $1.50 for students. □

Help Yourself.

You might not have seen our ads in the classified sections of the newspapers. So we put one here where you would see it. Because we think new graduates are vital to Boeing's future.

We're offering you a challenging career with a dynamic company. And an opportunity to live in the unspoiled beauty of the Pacific Northwest.

This is your chance to help yourself to the best of both worlds.

Engineering Student Organizations and Societies

As an entering freshman one of your main concerns was academics. But you should have quickly discovered that academics alone do not make an education. There is another aspect of college that should not be overlooked. This is the area of extra-curricular activities. Very few students realize the extensive benefits of getting involved in activities outside the classroom. As active and concerned individuals in the College of Engineering you can greatly benefit from becoming involved in student organizations.

Working for a student group will benefit you both now and in the future. Getting involved will help you improve your interpersonal skills. You will have the opportunity to meet other students, faculty members, administrators, and people in the community and learn to communicate, cooperate, and work together with these individuals. Involvement in activities outside of the classroom will broaden your educational base and help develop your personal potential. It will also serve as a vehicle for self improvement.

Although it may seem too early, or too late, to start thinking about what you plan to do after college, any time is a good time to realize the potential benefits of these activities after college. When applying to graduate or professional school, or out seeking a job, you have to be able to distinguish yourself from the next individual. Outside activities are one of the finest ways to do this. Unless you have a 4.0 grade point average there is always going to be someone with a higher GPA than yourself. When you graduate from the University of Colorado you are going to have to sell yourself to job interviewers, graduate school selection committees, and the like. You will need to stand apart from the crowd and your active involvement in student activities will facilitate this.

There are numerous student groups and activities from which to choose. Student government has a wide range of activities including organizing social functions, workshops, seminars, and projects in the college. There are a vast number of other exciting opportunities from which to choose. Other possibilities include involvement in the college magazine, the student newspaper, community and church organizations, and residence hall groups. Involvement in student activities today will be one of the finest investments in your tomorrow.

ASME

The American Society of Mechanical Engineers is composed of more than 55,000 associate members and more than 11,000 student members devoted to advancing the profession of mechanical engineering.

Membership in the student section offers many opportunities for the student to begin his professional development at an early date. He may keep up with current technical developments through the society's monthly journal, *Mechanical Engineering*. He may also learn more about the mechanical engineering career through the bi-weekly meetings. A guest speaker is usually featured at these meetings. The society periodically conducts fund raising projects so that students may enjoy benefits such as social events and out-of-state paper contests.

Membership is open to all students for a $5.00 national membership fee. The officers for this year: Dave Beckett, President; Jeff Mihalic, Vice President; Karen Pilz, Secretary; Tom Christopher, Treasurer.

AIChE

The American Institute of Chemical Engineers was founded in 1908 by a group of early chemical engineers who felt a need for a national organization. The student chapter of AIChE on the campus was organized in 1928. It provides a common meeting ground for chemical engineers outside the classrooms.

Programs include talks on technical subjects by speakers from virtually all professions. Subjects may sometimes be of more general interest, such as personal finance or personnel relations. The AIChE has participated actively in E-Days every spring. AIChE has a picnic every spring and several other informal functions throughout the year.

AIAE

No one represents Architectural Engineers as a group, anywhere, except the American Institute of Architectural Engineering.

As an organization, however, we are new and as yet, not well known. Our aim is to become well known and to benefit our members now as students and later as professionals.

You, as an aspiring Architectural Engineer, will enjoy some benefits we generate without joining A.I.A.E. But, if you want to share in the excitement come to our next meeting November 1 in CE 1-09.

President: David A. Ponder

Society of Manufacturing Engineers

SME is the Society of Manufacturing Engineers. The student chapter at the University of Colorado at Boulder is presently composed of approximately 25 students, all of whom are Engineering Design and Economic Evaluation majors. This student chapter is sponsored by the Denver Chapter 77 of the Society of Manufacturing Engineers.

Regular meetings are held on the second and fourth Fridays of each month during the academic year at 12:00 noon in CR1-14. Sandwiches are available to those who wish to buy them.

Plans for the future include night meetings with guest speakers which will be held off-campus. One of the speakers will talk on interviewing for jobs and the other speaker presently scheduled will discuss what the society means to its members.

Another project planned for implementation this year is a file of "Interviewer Evaluation" forms which will give students an opportunity to prepare themselves for job interviews at the Placement Center. The forms will be filled out by students currently interviewing and should provide an excellent source of information for future students.

Society of Physics Students

The Society of Physics Students is the only physics society explicitly designed for students. Membership is open to anyone interested in physics. Within the SPS is Sigma Pi Sigma, a nationally recognized honor society that elects members on the basis of outstanding academic achievement. There are presently about 450 active chapters at universities nationally, with the total membership, including alumni, exceeding 40,000 worldwide.

The University of Colorado chapter of SPS provides services to the individual student as well as to physics students as a group. Our office is prepared to help those students experiencing difficulties by finding assistance from upperclassmen and faculty. We also have information on graduate schools nationwide and employment opportunities both on and off campus. The Society of Physics Students regularly presents colloquia by distinguished speakers; the scheduling of specific presentations is posted in the main lobby of the Duane Physics building.

Sigma Pi Sigma is a nationally recognized honor society, a member of the Association of College Honor Societies, and an affiliated society of the American Association for the Advancement of Science. Undergraduate candidates for membership must be in the upper third of their class and have a minimum 3.5 GPA in physics. Membership is a distinction and an encouragement toward continued scholastic effort; such a membership is an important asset when applying to graduate school or for employment. The honor society provides an opportunity for association with faculty members, establishing a basis for recommendations to various positions around campus, jobs in the "real world." and graduate school assistance.

Students who are members of either SPS or Sigma Pi Sigma receive *Physics Today* free. Reduced rates are available for other national publications such as the *Journal of Applied Physics, Scientific American, Sky and Telescope,* and others. We also can usually get the *CRC Handbook of Chemistry and Physics* for about one third of retail.

Interested students are encouraged to drop by our office, Duane F-211, or call at 492-8234.

IEEE

The Institute of Electrical and Electronics Engineers is the world's largest engineering society with over 180,000 members, of which 25,000 are students. The purposes of IEEE are the advancement of the theory and practice of electrical engineering and related fields and the advancement of the professional standing of its members.

The student branch of IEEE at the University of Colorado has over 200 members which makes it one of the largest in the United States. The IEEE office and lounge are located at EE1-56 at the eastern end of the EE wing. The lounge is a great place to study and talk. The sale of donuts, coffee, tea, and cocoa has allowed us to make many improvements such as the addition of a microwave oven, a refrigerator, and a stereo. Lately, hot pretzels have been added to the snack bar.

A student member of IEEE receives the *Spectrum,* an electrical and electronics magazine, and local section publications which announce meetings and events of interest. A student member also receives discounts on memberships in the thirty-one technical groups and societies which have been formed under the IEEE. These groups and societies produce their own publications and include, as a partial list:

Acoustics, Speech, and Signal Processing
Systems, Man, and Cybernetics
Microwave Theory and Techniques
Biomedical Engineering
Computers
Communications
Nuclear and Plasma Sciences

The student branch at CU sponsors several activities throughout the year which include speakers and tours. In addition a workshop is available for students who wish to work on their own projects. IEEE also helps other groups to get started. Last year IEEE sponsored a ham radio club which hopefully will carry on into this year. There is also the possibility that two new groups will be forming soon. These are a biomedical group and a computer and microprocessors group.

If you would like to join IEEE or find out more about it, you are invited to come over and enjoy the lounge. One of the officers will be happy to answer any questions you might have.

Chi Epsilon

The University of Colorado Chapter of Chi Epsilon, a national scholastic honorary fraternity for civil and architectural engineers, climaxes its participation in the various engineering school activities twice yearly with a formal banquet for incoming members. These banquets are in conjunction with the ASCE co-sponsored Eckel and Ketchum award banquets. Requirements for membership are character, sociability, practicality, and scholarship—the professional engineering traits. The Chapter is responsible for the teacher evaluation program in the Civil, Environmental, and Architectural Engineering Department as well as recognizing prominent Civil Engineers in practice through Chapter Honor membership.

Chi Epsilon has a desk in CE 1-3 for messages and business transactions.

Society of Women Engineers

The Society of Women Engineers was established in 1949 as an educational service organization dedicated to encouraging young women to consider an engineering career. Specifically, our objectives are to inform young women, their parents, counselors, and the general public of the qualifications and achievements of women engineers and of the opportunities open to them, and to encourage women to attain high levels of educational and professional achievement. The C.U. student chapter was sanctioned by the national organization in April of 1976.

We have had two meetings this year and have gotten a good start on some activities. The Big Sisters Program was created this year to assist freshman women with the everyday hassles of attending the College of Engineering. We have more Big Sisters available if any freshman or transfer students are interested. Other activities on the drawing board are a resume service, a Hands-on-Tools workshop, and various industrial tours and panels. SWE sponsored a seminar on women in engineering last spring. We hope to make this an annual event.

The officers for this year are: Charlotte Szynskie, President; Bonnie Baird, Vice President; Leslie Allen, Secretary; and Shirin Wadia, Treasurer. If you are interested in attending our meetings, watch for the dates and times on the light board in the main lobby. Please come! Your ideas are needed.

Pi Tau Sigma

Pi Tau Sigma, the mechanical engineering honor Society, has organized several activities during the Fall semester. On September 18 an Honorary Pot-Luck Picnic was sponsored in which members of all the honoraries were invited. In mid-October a representative from the consulting firm of DMJM-Phillips-Reister spoke at a brown bag seminar. The subject of the talk was the movable stands at Mile High Stadium at Denver. Near the end of November Pi Tau Sigma will sponsor their Fall banquet honoring junior and senior pledges. A possible fruit sale is planned near finals. Spring semester will bring participation in E-Days activities, and the presenting of the Outstanding Sophomore Award in May.

Illuminating Engineering Society

The Colorado Student Chapter of the Illuminating Engineering (IES) is probably the smallest student group in the College of Engineering. This year's active membership totals fifteen, but it is felt that quality, not quantity, make for a productive and cohesive student group.

The group is made up primarily of students who are in the Illumination and Electrical Systems Design option of the Architectural Engineering Division of the Department of Civil and Environmental Engineering. The remainder of the group consists of people with a genuine appreciation for an occasional F.A.C., or perhaps some brownie points from Professor Ron Helms. Prof. Helms is the faculty sponsor and is also responsible for this University being one of two in the country to offer any extensive study in the field of lighting.

The student group keeps close ties with the national organization, and many members attend dinner meetings monthly in Denver. Through meetings such as these, and with the connections that Prof. Helms has in the industry, students can meet and talk with illumination people in the Denver-Boulder area.

Being such a small group enables the IES student chapter to undertake some activities which might not be possible by a larger group. This year a tour is planned of the Boulder based Independent Test Laboratories (ITL), and also the new Johns-Manville World Head-

quarters building southwest of Denver. Any member interested in obtaining part-time or permanent work in the lighting industry is aided by a resume program set up and run by the members themselves. Currently, a mailing list of about 80 companies receive these individual resumes. Past response has shown that this is very helpful in obtaining jobs in the field for those interested. Also, of course, is the periodic F.A.C. at Prof. Helms' house, something which sponsors of larger groups would no doubt frown upon.

All members are active in the group's activities, with leadership and attention to small detail being taken care of by three elected officers. This year's officers are: President—Marty McCloskey, Vice-President—Leisa Tice, Treasurer—Jack Hardgrave.

Please feel free to contact any of the officers listed, or Prof. Helms, if you are interested in learning more about the Student Chapter of IES.

Eta Kappa Nu

Eta Kappa Nu, the national electrical engineering honor society, was founded in 1904. Outstanding students are elected to the organization from the junior and senior classes in electrical engineering on the basis of scholarship, extracurricular activities, and character. Its primary purpose is to provide inspiration to the undergraduate to strive for the highest ideals during and after his college career.

Rho Chapter at the University of Colorado, installed in 1922 and now one of the leading chapters in the country, has several projects: the establishment of help sessions for students in basic electrical engineering courses; maintenance of a technical library; purchase of equipment for the laboratories; and the creation of interests in engineering among high school students.

Tau Beta Pi

Tau Beta Pi, the national engineering honor society, was founded in 1885 to recognize outstanding engineering students who have distinguished themselves by their scholarship and exemplary character, and to further a spirit of liberal culture in the engineering colleges of America.

The University of Colorado Beta Chapter, established in 1905, elects new members twice a year. We also try to sponsor various activities to promote scholarship such as our tutorial program, and the EIT review sessions.

Our officers for this year: Morgan Dickinson, President; Bob Evans, Vice President; Gary Kelsic, Treasurer; Dave Anderson, Recording Secretary; Jim Case, Corresponding Secretary.

Our office is in OT 1-5 and we will try to answer any questions you have.

AIAA

AIAA, the American Institute of Aeronautics and Astronautics, is the professional society for aerospace engineers. Our branch tries to provide activities which give the student a chance to learn about the aerospace field outside of the classroom and to meet people with similar interests. Members receives the biannual publication call *AIAA Student Journal.*

This year we are hoping to provide a tour of the Martin-Marietta Aerospace division, a speaker on hang gliders, a repeat visit to the training center, a presentation by a Learjet representative, new NASA films, and our annual picnic. Our branch is also planning to attend the student paper conference held this April at the Air Force Academy in Colorado Springs. Our society this year is headed by Dr. Donald Kennedy, Faculty Advisor; Donna Edens, President; Larry Price, Vice President; Leslie Allen, Secretary; and Paul Stremel, Treasurer.

ASCE

The University of Colorado Student Chapter of the American Society of Civil Engineers is open to all civil engineering students. Our activities include bi-monthly meetings (every other Wednesday) with speakers on subjects of interest to the public as well as to civil engineers. Anyone may attend our meetings.

Dues are $3.00 per year and a subscription to *Civil Engineering* is available to members. Student members are also invited to the monthly regional meetings held in Denver. These regional meetings offer the students a chance to meet practicing engineers in the Colorado area.

Our lounge is located in CE 2-2 in the CE wing. The lounge is open to all students and coffee and doughnuts are available. Current magazines and student course evaluation results are also found in the lounge.

Every year all ASCE members are invited to the students' regional meeting. This year it will be held in South Dakota. There are technical and non-technical paper contests as well as concrete canoe races, picnics and a good time. Note—CE 315 projects are ideal for technical paper contests. This event will take place in the spring, so make plans now.

The ASCE officers for 1977 are: Britt Mixer, President; John Hicks, Vice President; Marilyn Hardy, Secretary; Fred Johnson, Treasurer.

Those interested in running for office for 1978 should come to our next meeting on November 2 at 4:00 p.m. in CE 1-9.

YOUR EDUCATION REPRESENTS AN IMPORTANT INVESTMENT IN TIME AND MONEY

What will you do with it when you graduate?

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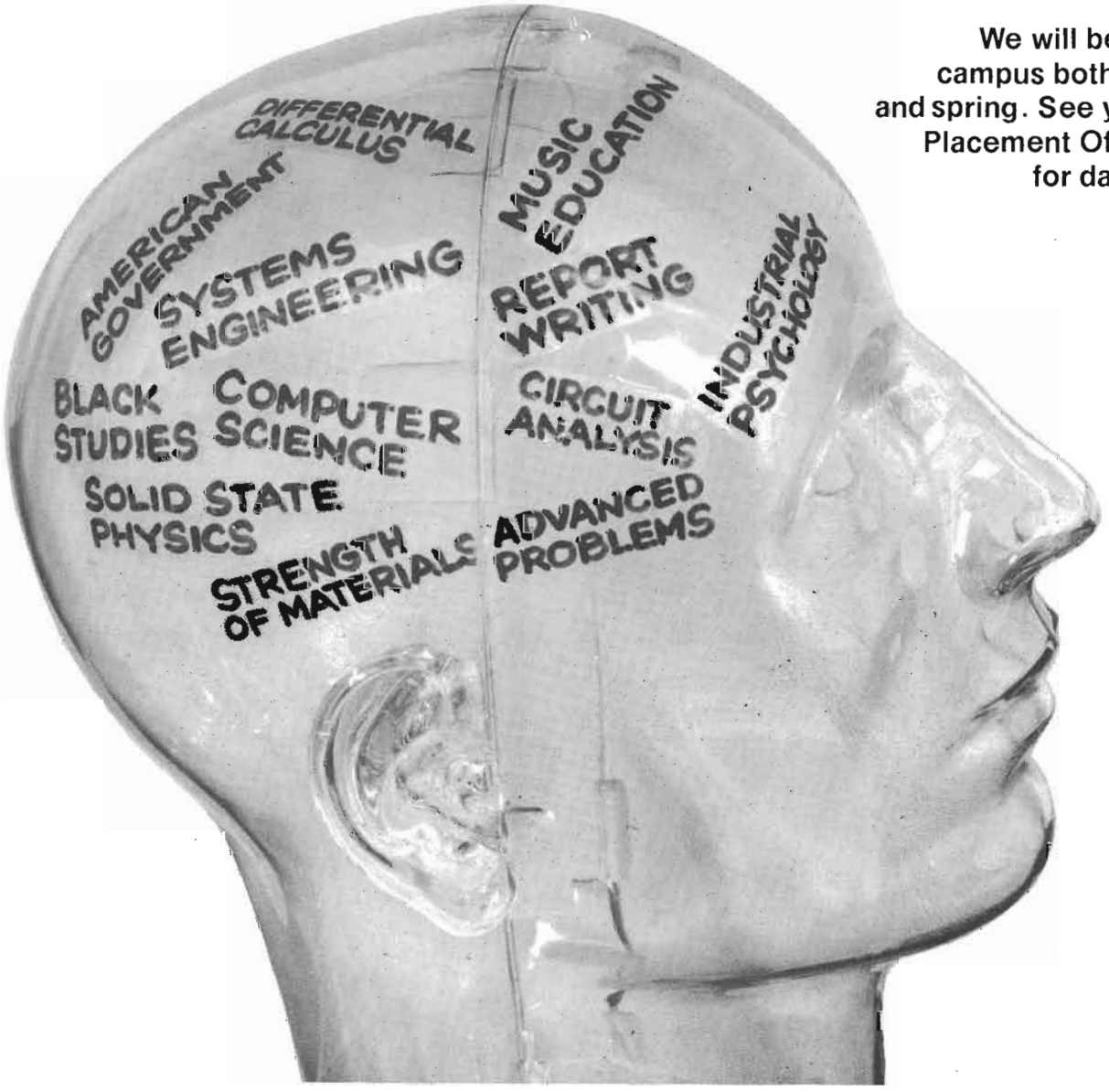

Net Energy, Creativity, and a Cosmological Question

by Scott Ready

As oil companies drill deeper, push further out to sea, and penetrate into the arctic, it takes larger amounts of energy to obtain energy. To know whether an energy tapping endeavor is actually yielding net energy, one needs to be able to see all of the energy inputs involved in the process of extracting and refining the energy source. By seeing how our energy industries are wired into the main economy and how these two are wired into natural ecosystems, we can begin to calculate net energies and write environmental impact statements.

Diagram #1 is an energy network diagram in its most simple form. All of the diagrams in this article use the symbols and style of Howard T. Odum, an environmental engineer with the University of Florida who initiated this type of synthesis.

Diagram #1 could be a schematic of the symbiotic relationship between a simple farm and nearby village. At P1, energies E of the sun and weather systems, amplified by the work E2 of the farm, and the energies of the goods and services E6 from the village result in the growth of crops and maintenance of the structures S1 of the farm. S1 represents all of the assets of the farm—the soil, the plants, the buildings, the farmer, and all of his time schedules. The farmer sells part of his crop E3 to further stimulate the processing P1 of energies E and to organize his farm. The assets S2 of the town are used via E5 to generate new structures, and sustain, regulate, and restore those already existing. The sinks or ground symbols represent energy losses due to depreciation and energy conversion processes.

The flows of energy E0, E1, . . ., E10 interconnecting the parts of the system can be expressed in units of power, kilocalories per second, or in terms of total energy flow in kilocalories over a set period of time. For each processing unit and for each storage symbol, the amount of energy flowing in must exactly equal the energy flowing out. Any dispersed and unused energy is soaked up by the sink symbols.

Very interestingly, the shape of diagram #1 serves to describe a broad range of microcosms. Diagram #1 could represent the bonds between a farm and village, oceans and land, flowers and insects, herbs and deer, green plant parts and the darker more compacted plant parts, cell cytoplasm and cell nuclei, the extended parts of your body and your head. In each case the entity to the left is expanded and concentrates the dilute energies of the source E into an upgraded form to be processed by the compacted entity on the right. Thus over and beyond the rapid surface changes of the world we have discovered here a deeper constancy in designs.

Calculating net energies involves knowing both the magnitude of energy flows and their quality. As energies are concentrated their qualities are increased. In diagram #2, as one moves from left to right the energies of the sources are being concentrated and transformed into highly specialized, organized, and influential activities of high energy quality. The energy quality of information is the total amount of energy expended in its formation. This includes a tremendous amount of dispersed heat lost through the sink symbols. As Thomas Edison once said, genius is 1% inspiration and 99% perspiration.

To calculate the true energy requirements of the city, one must convert each of the inflowing energies into a common quality level, for example into the energy density of oil. Thus, although the magnitude of the innovative energy E5 being applied to the city is small, this energy is tremendously more valuable and costly on a per kilocalorie basis than say oil in a can, E2. To convert E5 into oil energy density units, called fossil fuel equivalents (FFE), one must multiply E5 by a large number, say between 5 and 50. The energy quality of food, that is, the amount of useful work food delivers per calorie, is less than that of oil. Therefore, to convert E1 into FFE one would multiply E1 by a number less than one, say 0.1.

CREATIVITY

Presently in the United States, in terms of FFE, we are consuming 2.5 times more energy through use of fossil fuels than what we are receiving from our own natural ecosystems, the sun, wind, waves, and rains. This tremendous surge of power has billowed out into the fantastic variety of services, machines, gadgets, and ideas that are so characteristic of twentieth century America. Our fossil fuels allowed us to break out of the circle of life and let our inventive craziness run wild.

Diagram #3 is an explanation of how creative processes operate at more benign energy levels. The basic pattern is to have a participator within a system generate more new units than the system has energy to support. The restrictive amount of energy forces the new units that are best able to contribute, reinforce, and enhance the power flows of the system to be chosen among the variety of units generated. The ability of a system to design, select, and reinforce improved parts is more an intelligent property of the entire system than that of individual units. It is by the creative evolutionary process described here that large scale systems are able to repair themselves.

In diagram #3, unit S2P2 has generated eight new varieties. Units 1 and 2 are individually healthy and are looping back high quality energy to their own life support module S1P1. Energies E1, E2 help recycle materials, help P1 overcome limiting factors, and help regulate system activities. As a result of the compatibility of the designs of units 1 and 2 with the needs of the system, units 1 and 2 will be able to attract like growing antennae increasing amounts of the energies leaving S1P1. This pirating of energies leads much to the demise of units 3 through 8 and hence we say that units 1 and 2 have been constructively loop reinforced or chosen by the system.

If S2P2 has been properly chosen, then good system designing would require the ingredients of short lived units 3 through 8 to be utilized by some other participator in the system, say S3P3.

Diagram #3 could represent a pond scene where S1P1 are photosynthesizing units, S2P2 is an insect that lays many eggs, and S3P3 are reptiles that enjoy eating these eggs.

An important variation of diagram #3 is when S3P3 is actually units #1 or 2. S1P1 could then represent the waters of the oceans, which when uplifted and rained upon the highlands S2P2, generate many tributaries, units 1 through 8. Those streams E1, E2 which offer the path of least resistance carve the land and divert the waters from units 3 through 6. Thus units 1 and 2 become chosen among the choices generated. Similarly S1P1 could represent a primitive heart and S2P2 could represent tissues giving rise to the embryological development of many blood vessels.

S1P1 could represent cool down-drafts of air and S2P2 could represent warm moist air rising and developing into many competing cumulus clouds. Since units 1 and 2 are in line with the overall circular plan of the system, they are able to draw units 3 through 8 into themselves and thus evolve into thunderstorms which contribute to the overall kinetic energy of the system.

S1P1 could represent a natural ecosystem and S2P2 could represent a small society which generates a variety of cultures, units 1 through 8. The chosen cultures are those that are in partnership with nature.

Thus the requirements for creative evolutionary action are the generation of many choices and an appropriate network design to select and reinforce the chosen. The presence of these two ingredients precedes the origin of species on Earth. The ability of a system of units to generate many variations ultimately depends on the fact that all energy network diagrams are built out of a quantum bubbling substrate.

As power flows are continually being redistributed, the wiring interconnecting key system parts may vanish and rematerialize into newly discovered arrangements. Diagram #4 is a lively network involving an insect-eating bird wired into his ecosystem. The creative processes described above result in the competition between the bird and predator insect at insect #2 being resolved by the predator insect withdrawing his connections with insect #2 and interposing new wiring between himself and insect #3.

To understand why the chosen are who they are an observer must multiply expand his vision to encompass increasingly larger systems in which the chosen are imbedded. For example, by utilizing the winds, the rhythm of tides, and falling waters, seeds are widely distributed, birds soar, estuaries are productive, and mankind generates electricity. The chosen are those who enter into the stream of already existing large scale circular loops.

An even larger flow diagram is #5. If the surging energy levels of our main economy and energy industries are increased much more, we may overwhelm, poison, or displace our natural ecosystems. However, an examination of diminishing net energy returns indicates that world energy developments have reached an upper crest. The net energy that we receive from the oil industry equals E2 minus E1 minus the oil industry's contribution to environmental stress. The net energy we receive from the nuclear industry equals E4 minus E3 minus the nuclear industry's contribution to environmental stress.

E1 includes the energy cost in FFE of all of the following: steel for oil rigs, pipelines, refineries, oil tanks, and tanker construction; enormous quantities of building materials of all kinds such as steel, concrete, electrical wiring, aluminum, glass, and wood for structuring office buildings, equipment, warehouses, research facilities, processing plants, facilities for laborers, service stations, and roads; the cost of company aircraft, cars, trucks, railway cars, tug boats, barges, yachts, and helicopters; landscaping costs, advertising, lobbyists, insurance to cover accidents and mistakes, prospecting, and utility bills. As costly as everything described above is the expenditure of very high quality energies to organize, monitor, and improve the incredibly complex megastructure which the oil industry represents. Another major energy input is the defense work of our government to protect and secure the industry's oil deposits. In the 1970's the oil industry is also beset with the high energy costs of drilling deeper, pushing further out to sea, and penetrating into the arctic.

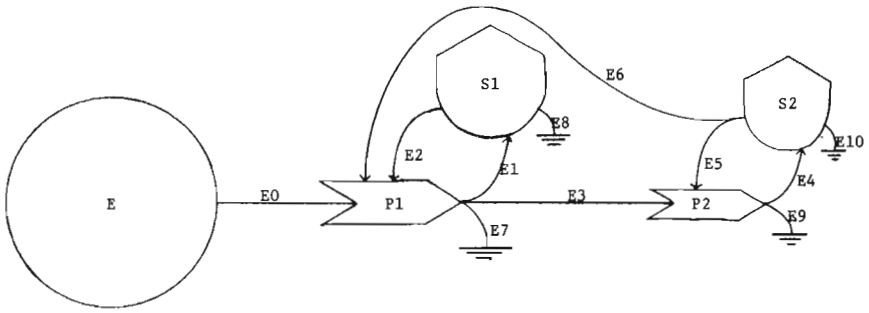

DIAGRAM #1.

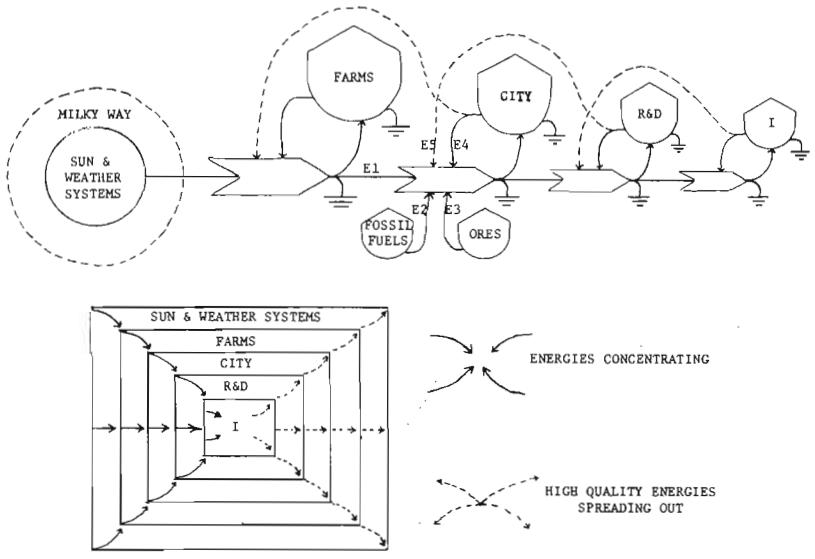

DIAGRAM #2. R&D equals research and development, I equals organized information and ideas.

Drilling deeper requires more steel and employs more pumps. Offshore drilling requires highly specialized platforms that demand special services and increased insurance rates. Arctic drilling requires special equipment, intensive heating for the laborers, and the high energy costs of transportation.

E3 includes the energy cost in FFE of all of the following: prospecting, mining, refining, and enriching the uranium ore; the total cost of constructing a plant site, the cost of handling its radioactive wastes, and after thirty to forty years the cost of disassembling and deactivating the plant site; the costs of insurance, advertising, landscaping, utility bills, and lobbyists. In general the energy inputs to the nuclear industry involving highly trained personnel, research and development, state of the art technologies, sophisticated apparatus, rare metals, monitoring work, safety, management, regulatory agency work, and defense department work require extremely high qualities of energy. Thus, when converting the bundle of energies comprising E3 into FFE, one must multiply many of the inputs by numbers much larger than the numbers used to convert oil industry inputs into FFE.

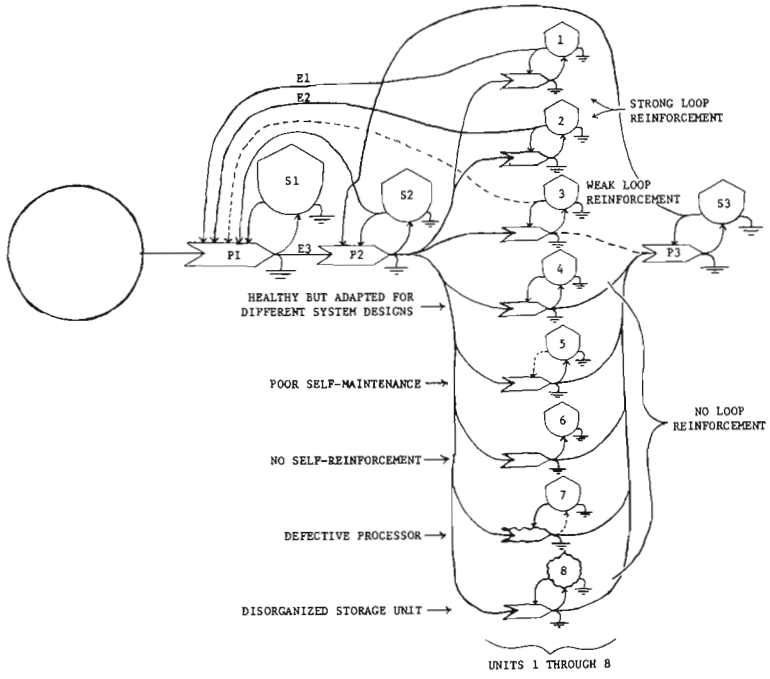

DIAGRAM #3.

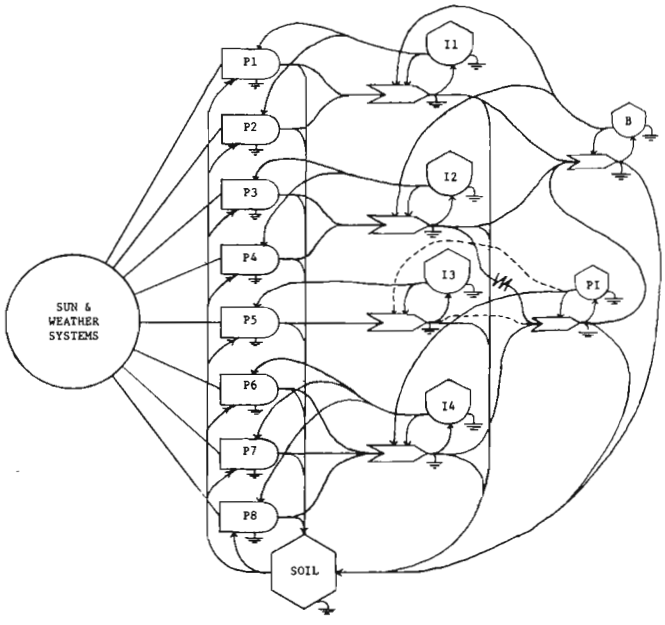

DIAGRAM #4. Pi equals plant type #i, Ii equals insect type #i, PI equals predator insect, B equals bird.

Considering the long descriptions of E1 and E3 it is clear that net energy returns from the oil industry are decreasing, and it is doubtful whether the nuclear industry can deliver any net energy at all. Table #1 gives the sobering results of several net energy calculations that have been made.

During times of diminishing net energy returns, the amount of new energy pumped into the economy per circulating dollar decreases. Overall the amount of energy flowing behind each dollar becomes less. The ability of each dollar to deliver useful work diminishes. Our present inflation, which is world wide, is a symptom of diminishing net energy returns. World energy development is climaxing.

In the twentieth century, because of our intensive channeling of fossil fuel energies, we have been able to invent and sustain far more activities than a system operating at more benign energy levels would have permitted. In effect, the burning of fossil fuels has suspended us from the creative error correcting processes described earlier. When will our use of fossil fuels be sufficiently limited to allow the ancient evolutionary processes to reengage themselves in our lives?

At this point I send many thanks to Howard T. Odum for showing me most of the ideas presented so far. In the next issue of the *Colorado Engineer* the diagrams presented here will be used to see into the future.

A COSMOLOGICAL QUESTION

All together from diagrams 1 through 5, the reader has encountered 59 heat sink symbols. To where does this dispersed heat flow? The temperature of the space through which the earth orbits is 2.7 degrees kelvin. This ambient heat is extremely isotropic to within 0.2%, indicating that it is of extragalactic origin. If the earth does not occupy a special position in the universe, or if this ambient heat is dilute energy from the initial expansion of the universe, then the temperature of outer space everywhere is about 2.7 degrees kelvin.

Now the temperature of a black hole of stellar origin is at most on the order of 5×10^{-8} degrees kelvin. Therefore, if heat pours from hot regions into cold regions,

then black holes are powerful vortexes inhaling the last of our world's dispersed heat. That black holes are cosmic ingredients of the universe is reinforced by the fact that there are enough stars in the Milky Way to develop one million black holes and there are more galaxies than there are stars in the Milky Way.

Diagram #6 shows the gravitational collapse process of a black hole reconcentrating the radiant energy of a star. The event horizon represents a cosmic drape surrounding the black hole behind which we can see no events. As energies slip behind the horizon they appear to ride off into our infinite future, that is, it takes an infinite amount of time to see them slip through. However, from the perspective of an infalling participator it takes only a short amount of time to slip through the event horizon which is hardly noticed. But once inside, the participator cannot get back out. Instead he must spiral inward colliding with intense energies as he experiences the gravitational collapse of space, time, and energy. With the collapse of space and time, the framework of every dynamic principle of physics collapses and hence physics collapses. The descriptions of physics stop, but the hidden action of gravitational collapse goes on. The cosmological question is: What happens next?

The *Colorado Engineer* invites its readers to send in their own inspired and imaginative guesses as to what happens next. To help initiate some responses I will give my own guess. The matter-energy collapsing within the event horizon is transfigured and used to generate the expansion of new spacetimes within our universe. The contribution that a single black hole has given to initiate the expansion of new spacetimes is measured by us as its mass. □

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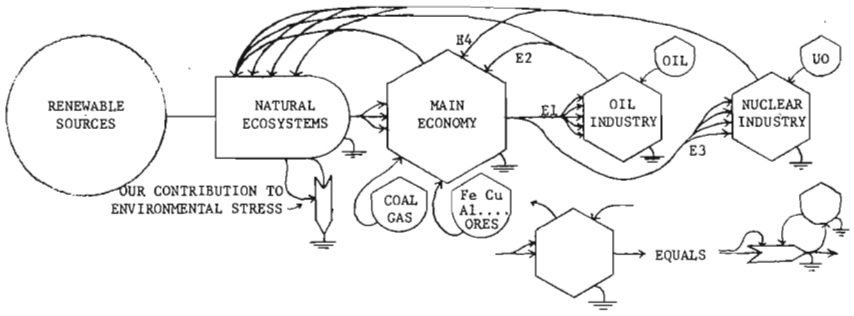


DIAGRAM #5.

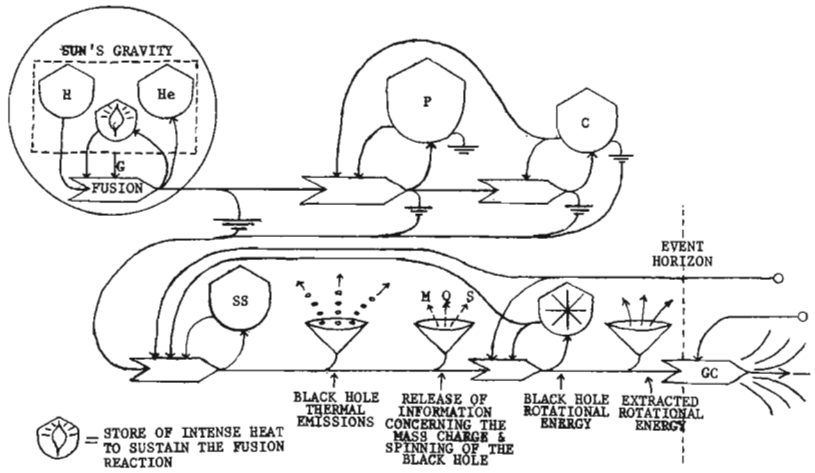


DIAGRAM #6. G equals sun's gravitational containment and control of the fusion reaction, P equals producers, C equals consumers including us, SS equals surrounding space of black hole, GC equals gravitational collapse.

TABLE #1

Activity	FFE of Energy Received	For Every	FFE of Energy Invested
Hand made solar cells generating electricity	1		456
Anvil Rocks oil shale pilot plant 1947-1975	1		82
Modern windmills generating electricity in a 16 kph wind	1		3.6
Fossil fuel subsidized agriculture in Florida	1.014		1
Strip mining coal and transforming it into electricity	4.82		1
Buying Mideastern oil in 1974 at $10 per barrel	6.5		1
Hydroelectric plant with 30 m dam	193		1

Scott Ready plans to be a free man of ideas. While immersed simultaneously in the worlds of electrical engineering, physics, math, and astronomy he managed to graduate from the University of Florida in 1966. Presently, he is in the CU department of mathematics and hopes to use the energy network diagrams used here to enhance quantum geometrodynamics.

NEWS

DEAN PETERS RESIGNS

Dr. Max S. Peters, dean of engineering, announced during the summer that he is resigning as dean in order "to return to his first love, teaching and research." He will leave office when a search committee has selected his successor, or at the start of a sabbatical leave next July 1.

The Dean is a member of the Department of Chemical Engineering. He has taught courses in the department during his tenure as dean. He has also directed continuing research on the role of nitrogen oxides as air pollutants.

During his 15 years as dean the value of research projects in effect in the College has risen from $.5 million in 1960 to $4.5 million in 1976. In 1960 the engineering faculty produced and published 15 professional papers. In 1976 it produced 124. Graduate enrollment in the College doubled during the period.

Dean Peters has also been very active with engineering professional and honorary societies, serving with accrediting agencies, federal advisory boards, and as national president of his professional society. He was the first engineer in the Rocky Mountain states elected as a member of the U.S. National Academy of Engineering. His many honors include one top award of the American Association for Engineering Education for teaching and another equally coveted for administration.

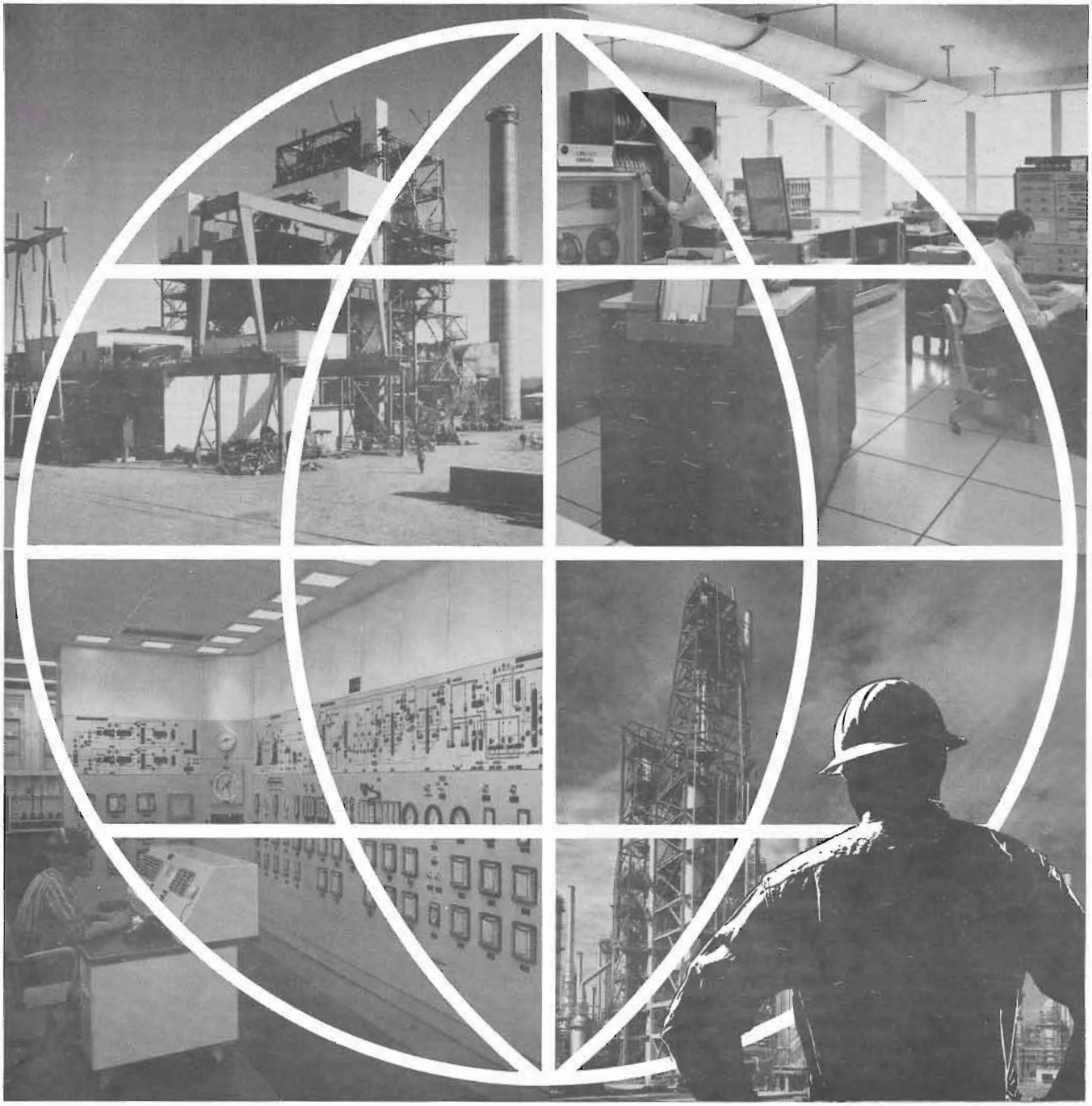
In a letter to engineering faculty members explaining his action, Dean Peters said in part:

"I decided that I would accept a final three-year term as Dean to 1980 only if I found strong faculty support in the College. I therefore had informed Vice Chancellor Corbridge that I would go through the new faculty administrative review procedure, but I would accept another term only if there was strong faculty support for me to do so. When I examined the faculty response to the question of reappointment as Dean, I concluded that the support was adequate but I did not feel that it was strong enough for me to be willing to consider another term. Accordingly, I submitted my resignation as Dean, and I will be joining you on the faculty after a sabbatical in the fall of 1978 for fulltime teaching . . .

"It has been a real pleasure for me to work with you during the past 15 years for the development of our engineering programs. I feel we have made progress, and I personally am now looking forward to continuing to work with all of you and the new administration in helping to further improve our engineering programs."

President Rautenstraus noted that "we are deeply grateful for his truly significant service to the University," and "Today, thanks to his dedicated efforts and leadership, it is a top quality, widely respected program."

A search committee which will include representatives of the engineering faculty and students is being formed to screen candidates for the deanship.



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AES ELECTIONS

If you have ever met an AES executive in person, you have probably been awed by the aura of confidence, ability, and total control surrounding him or her. Perhaps you have even thought to yourself, "Gee, I'd like to be a great statesman someday, too!" Well, if you have ever yearned to take the helm of Engineering's ship of state, your opportunity is coming soon, because elections for the three AES executive positions are going to be held November 16 and 17.

"Shucks," you say, "that's swell, but what do AES execs do?" Well, the executives, together with the Treasurer and Commissioners whom they appoint, are responsible for coordinating programs such as freshman orientation, speakers and brown bag seminars, special projects such as the tutoring program and hot food service, and activities such as the Engineer's FAC and E-days. In addition, the executives work closely with the faculty, administration, and student engineering societies as the student representatives in such matters as the Dean's search committee. Finally, one or more of the AES executives sits on the UCSU Executive Council as the representative of the College of Engineering.

If you're enthusiastic about running for office as an AES executive come down to the AES office in OT 1-6 and pick up an application. But hurry, the application deadline is Friday, November 11.

EDEE AND ME TO MERGE

As a result of cutbacks in resources allocated to the college, the Environmental Design and Economic Evaluation department will be merged into Mechanical Engineering.

continued

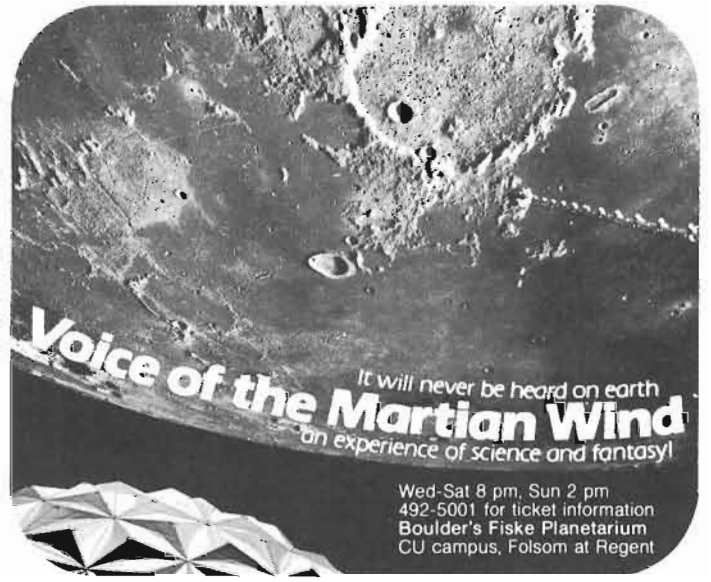
Over the past several years, various committees have been organized to study ways to absorb the continuing reductions in Engineering resources. The committee and the administration have concluded that a coordinated consolidation of present programs could avert any irreparable damage to individual departments in the future. It would also improve the college's bargaining position against further cutbacks.

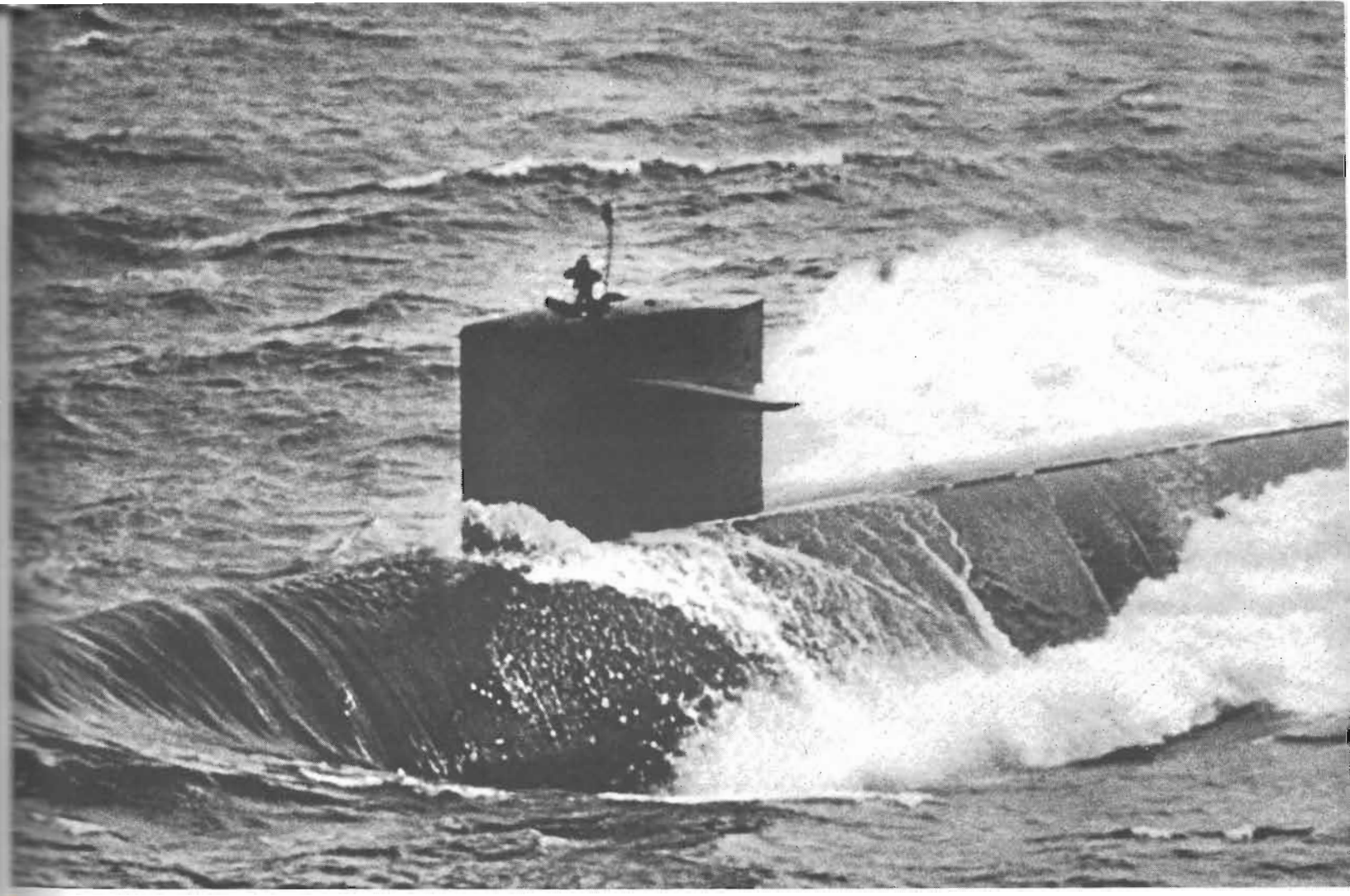
Dean Peters had originally suggested a merger of the Aerospace and EDEE programs into ME. This was revised to an ME/EDEE merger after the faculty expressed its disapproval.

There has been some controversy as to the method of the merger. Some faculty members have objected to the crucial faculty approval vote taken during the summer when some faculty members were absent. One department was allegedly intimidated into acceptance by threats to its own resources.

The present proposal hopes to maintain the EDEE strengths in computer and economic applications to design as an option in the mechanical engineering program. The majority of the present EDEE faculty will be transferred to ME, with the balance going to related areas such as Civil, Environmental, and Architectural Engineering.

A coordinating and advising group of EDEE faculty members will be retained for at least four years. This will allow present students to complete the normal EDEE degree program. □





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The Navy also has other opportunities in surface ships and aviation assignments. If you are majoring in engineering, math or the physical sciences, contact your placement office to find out when a Navy representative will be on campus. Or send your resume to: Navy Officer Programs, Code 312-B379, 4015 Wilson Blvd., Arlington, VA 22203.

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CALCULATOR UPDATE

by Mike Fricklas
and Dixon Hutchinson

Last June, Texas Instruments (TI) announced a new line of calculators which are not only a step above their old line but also a step ahead of all the scientific programmable calculators on the market today. While many producers made cosmetic changes, nominal performance improvements, or price reductions, TI blasted the market with a phenomenal display of hand-held calculator power.

Among TI's introductions are small printing machines, new memories, and a business calculator. The most significant new calculators are the TI 57, 58, 59, three of the most powerful scientific calculators ever made.

The TI 57 is the lowest priced programmable calculator available from a major manufacturer. It has a memory capacity of 150 keystrokes which is about half again as much as the HP 25, even with the HP's merged instructions. The TI 57 also has an insert key allowing the user to add program steps without disturbing the contents of the other registers. This calculator performs six different forms of branching and has two levels of subroutine access. To these add such features as logorithmic functions, trigonometric functions, statistical functions, nine levels of parentheses, and the ability to store up to four pending operations for handling complex functions quickly and easily.

The TI 58 and TI 59 are similar to the TI 57, but have more statistical functions and programming functions. The main difference between the calculators and larger computers is the limited amount of storage accessable to the calculator. Taking a cue from the large-scale computer systems, TI has developed an important innovation which greatly increases the memory available to the TI 58 and TI 59. This new innovation is the TI Solid State Software libraries. These libraries contain 5000 steps of pre-programmed routines which can be called from the key board or from user entered programs. The libraries are contained in small durable plastic modules which plug into the back of the calculator. These Master Library modules contain programs in math, statistics, and finance.

The TI 58 also has the magnetic card reader capabilities found in the earlier models. The TI 58 has 480 programmable steps or 60 memories which work individually or integrated with the Master Library modules. The TI 59 has 960 programmable steps or 100 memories which also interact with the Master Library modules. The TI 58 and TI 59 can be used with the PC-100A printer from TI which can print twenty characters to a line. The PC-100A also provides alpha and plotting capabilities.

All in all, Texas Instruments has put together a powerful line of calculating equipment for a price that would not have bought a simple four function calculator eight years ago.

	Hyperbolic Trig Functions	n!	Standard Deviation	Library Module	Programming Steps	Addressable Memory	Printer	# of Labels	Indirect Memory Addressing	Card Reader	Suggested Retail Price
HP-21						1					$80.00
HP-27		●	●			15					$175.00
HP-29C			●		98	30		10			$195.00
HP-19C			●		98	30	●	10			$345.00
HP-67		●	●		224	26		20	●	●	$450.00
HP-91		●	●			16	●				$325.00
HP-97		●	●		224	26	●	20	●	●	$750.00
SR-40						1					$29.95
SR-51-II	●	●	●			3					$59.95
TI-30						1					$24.95
TI-57					150	8		10			$79.95
TI-58				●	480	60	●	72	●		$124.95
TI-59				●	960	100	●	72	●	●	$299.95

Hewlett-Packard, the other major calculator manufacturer, has come out with three new models.

In the HP-10 calculator Hewlett-Packard has put the simplest of the old mechanical adding machines in an electronic model. This calculator also has a thermal printer with the four basic operations and a memory.

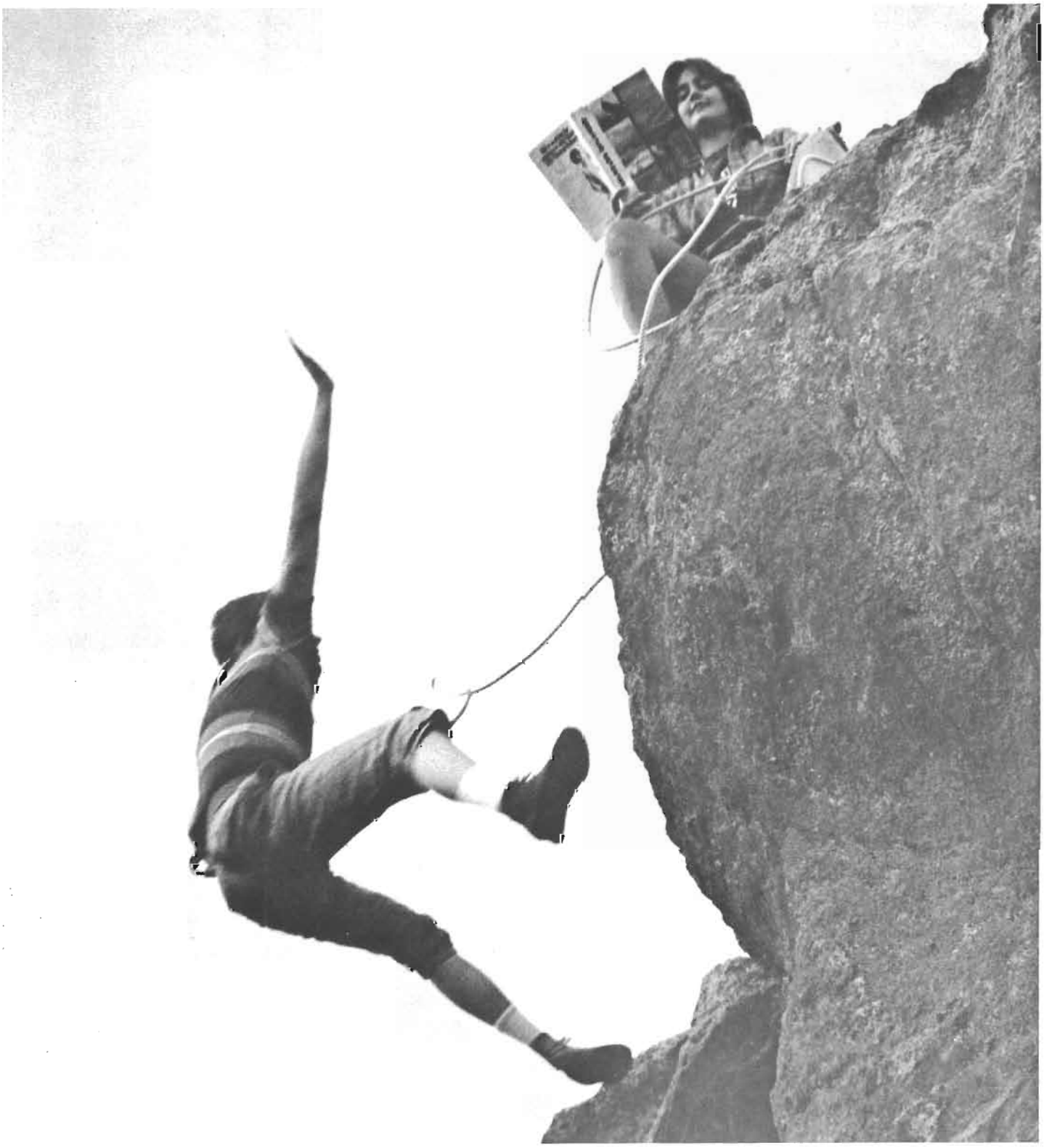
The HP-29C is an updated version of the HP-25C. It has several more programming functions including indirect addressing of memories. The total memory size has been increased to 98 steps and lets the programmer combine up to four keystrokes in a single step. Typical program lengths with this feature are 175 keystrokes. The HP-19C is the same calculator but has a built-in thermal printer for hard copy recording of calculations and programs. Both of these calculators have continuous memories so that programs and values stored in memory are not lost when the calculator is turned off.

All three of these models have HP's rugged, often drop-proof construction and the last two have Reverse Polish Notation for simple entry for complex equations.

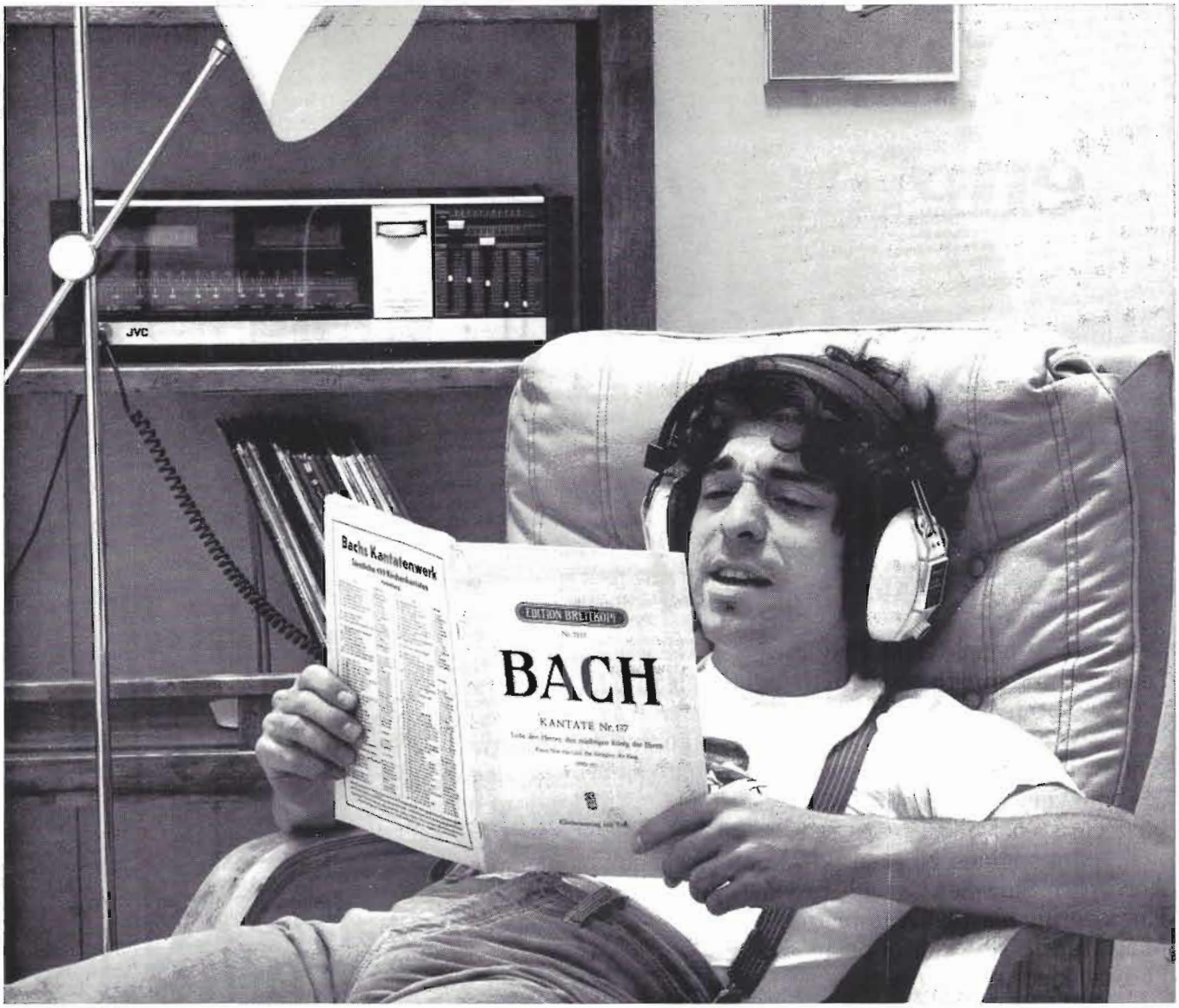
With these latest HP's and the gigantic capacity of the new TI's the calculator race should keep getting fiercer. □

Editor's note: The rumblings in the calculator business are that the downward spiral of prices is over. Both TI and HP plan to raise their prices early in 1978.

What Kind of Woman Reads *The* COLORADO *Engineer*?



. . . the Kind Men Fall For !



Enjoy college

Education not only makes life more interesting but eventually brings more influence in society than can be expected by those who have never bothered to read, study, listen, and reflect on the pleasure and pain of it all. That includes influence as articulate citizens, customers, and investors.

Nevertheless, the truth in this may not be apparent right out of college when a desire for steady income leads some B.A.'s to come to us with a major in, say, political science or Romance languages, seeking a start toward an executive career. We listen and then ask, "Are you a born salesperson and how can you prove it?"

In a way, that question reflects our own limitations. For a person well educated in something other than technical fields, it is usually only in sales that we can match qualifications to openings.

For you, who may have lost out on some of the pure pleasure and sheer fun of college because of the kind of technical courses you've had to grind away at, the choice can be wider. Sales is just one possibility. You can also consider research, development, design, manufacturing, and various combinations of those. Decision-makers throughout our organization, in work often far removed from the subject matter of a technical curriculum, first attracted interest by their success in coping with technical problems. Then, having demonstrated an ability to lead, they exercised their option to move on to broader responsibilities. That sort of choice, for the outset of a career and later, is earned in courses where quantitative thinking rather than personal opinion is demanded.

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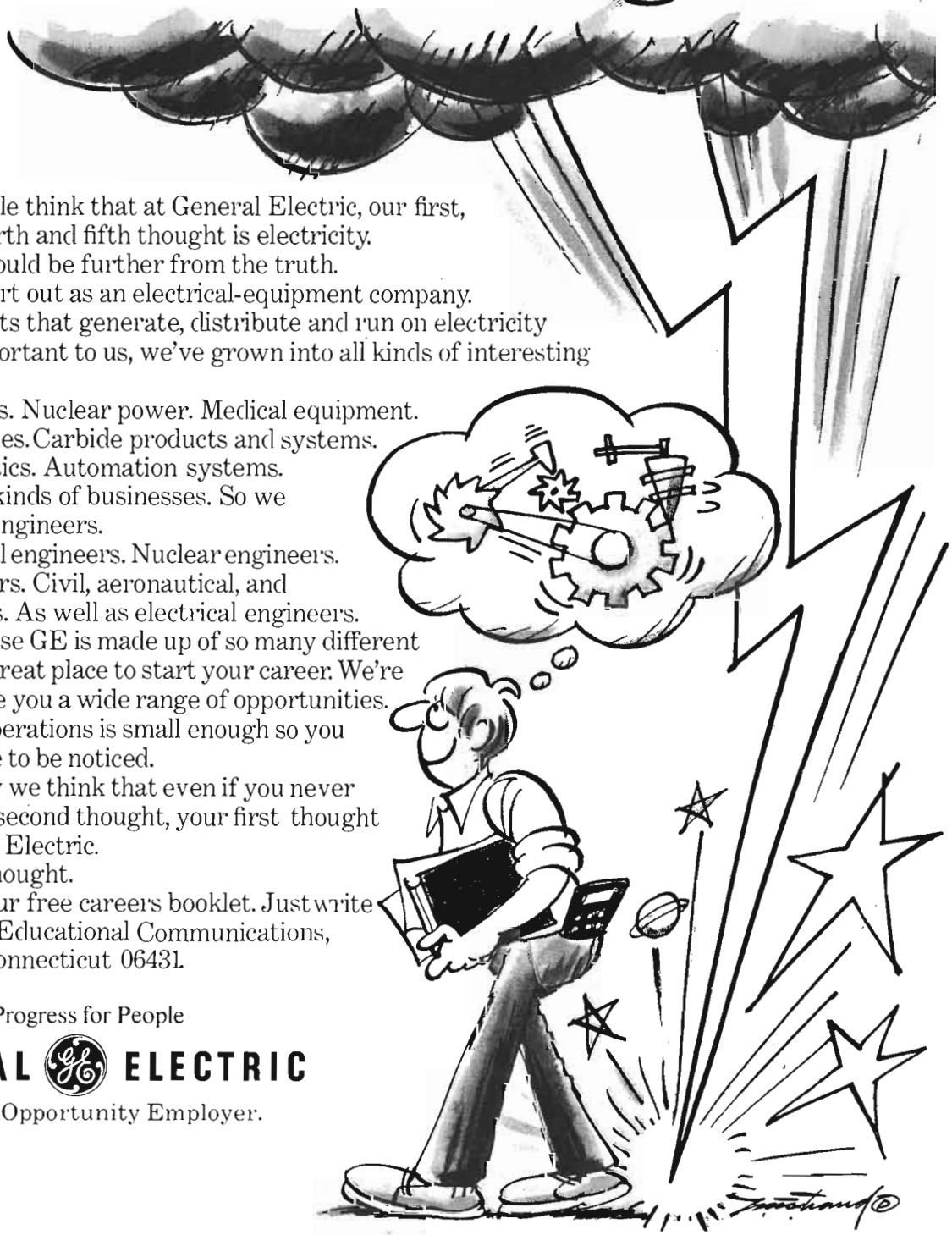

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