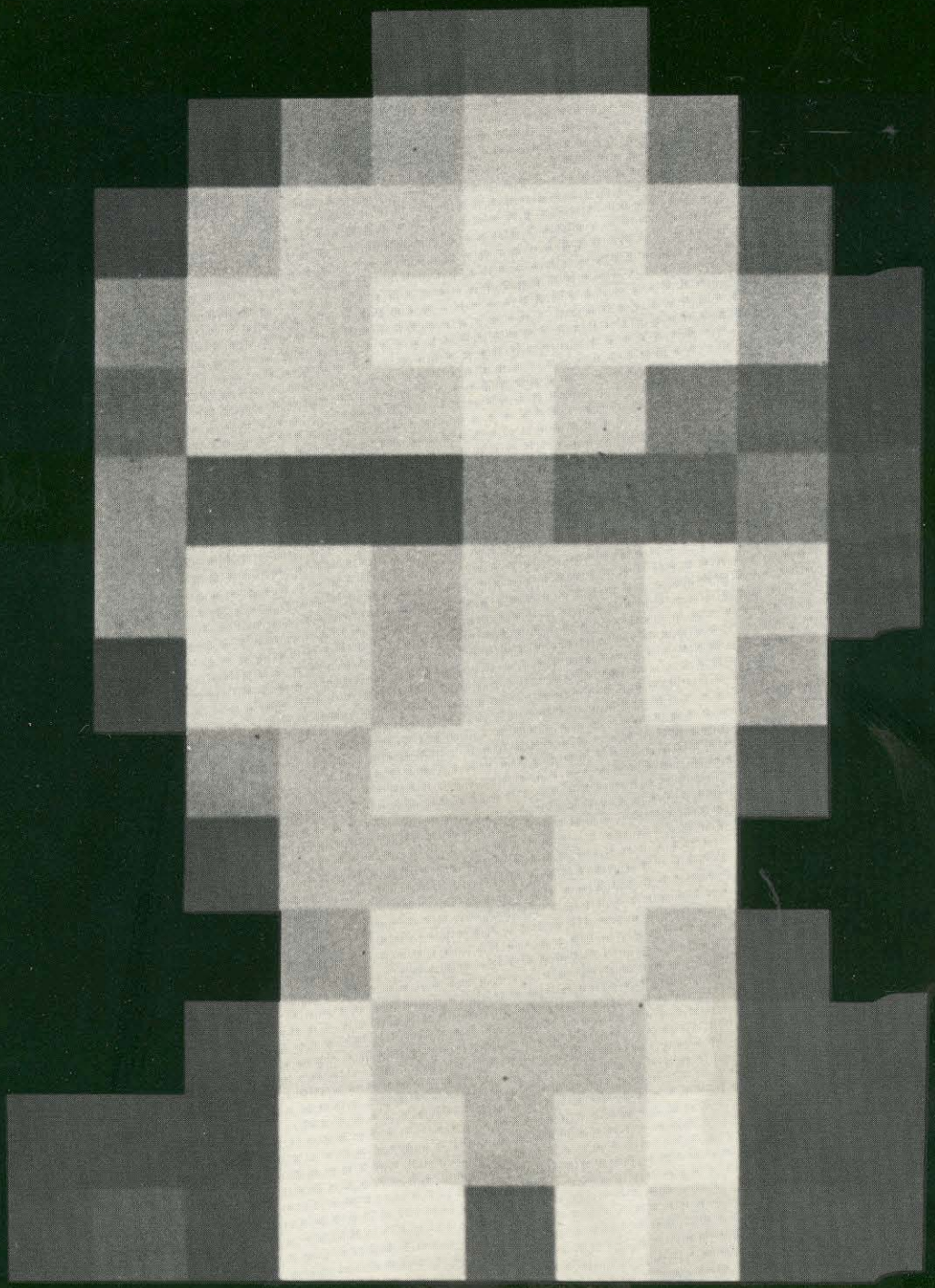
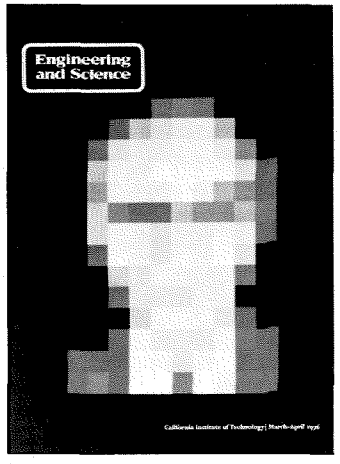
Engineering and Science



California Institute of Technology | March-April 1976

In This Issue



Anyone You Know?

On the cover—A picture of a well-known Caltech figure. Stumped? See page 15.

Promises to Keep

In the years since Paul Saltman picked up his Caltech degrees (BS '49, PhD '53), he's racked up an impressive record as a scientist, educator, and administrator—and as a dynamic spokesman for all three professions. Whether he's in person, on paper, or on radio or television, Saltman has a way of tailoring, but not trimming, his remarks to suit the occasion—keeping his audiences both stimulated and respectful.

Now vice chancellor for academic affairs at UCSD, Saltman still works at being also a teacher and a "card-carrying" biochemist. He earned those credentials in the 14 years he spent on the faculty at USC, where he also received an "Excellence in Teaching" award from the students along with plaudits from his peers for his work on the chemistry of iron metabolism. Caltech awarded him its Alumni Distinguished Service Award in 1973 in recognition of those accomplishments and his services to the development of excellence in undergraduate education at Revelle College, UCSD, where he became provost in 1967.

Saltman

Speaking out of both knowledge and experience, then, in "Promises, Promises" (page 4) Saltman assesses the obligations and limitations of today's university.

Levine

Consumer Advocate

The man with the most impressive title at Caltech may easily be Michael E. Levine, Henry R. Luce Professor of Law and Social Change in the Technological Society. As if that weren't enough, he also holds an appointment as professor of law at the University of Southern California. Titles are not the only impressive things about Levine; so are his experience and interest in applications of law to the solution of social problems.

After receiving his BA in philosophy at Reed College in 1962, Levine entered law school at Yale, receiving a JD in 1965. Since then he's worked as an attorney for the Civil Aeronautics Board, as special assistant to the task force on Economic Growth and Opportunity for the U.S. Chamber of Commerce, and as a law and economics fellow at the University of Chicago Law School. He came to Caltech in 1973, having progressed through a series of increasingly prestigious consulting and academic appointments at a speed resembling that of the aircraft he discusses in "Does Airline Regulation Benefit the Consumer?" on page 18. This article is taken directly from a transcript of Levine's Watson Lecture at Beckman Auditorium on January 19.

Material Resources

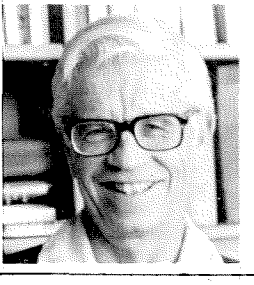
Alumnus James Boyd (BS '27), who is now president of Materials Associates, Inc., of Washington, D.C., came back to campus recently to deliver the 1975 John Peter Buwalda Memorial Lecture. He was introduced to the audience in Beckman Auditorium by Barclay Kamb, chairman of the division of geological and planetary sciences. Kamb listed an impressive array of academic, governmental, and industrial accomplishments by Boyd in the fields of both geology and mining, and he particularly singled out the fact that Boyd "was the executive secretary of the National Commission on Materials Policy, which was created by Congress three or four years ago 'to utilize present resources and technology more effectively, anticipate the future materials requirements of the nation and the world, and make recommendations on the supply, use, recovery, and disposal of materials.' This commission thoroughly investigated the problems of mineral and other natural resources of the country, giving Jim Boyd a broad perspective and background from which to draw for this talk."

Boyd

"Materials from the Earth: The Stuff Things Are Made Of" on page 22 is adapted from Boyd's talk.

How It Was

Nostalgia can be a tricky commodity, except in the hands of an expert like J. Kent Clark, professor of English. His reflections on the late Paul Eaton, associate professor of English and dean of students from 1947 until his retirement in 1969, resulted in a warm and lively letter to the editor of *E&S*, which we share with you in "Character and Action" on page 24.



Clark

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Engineering and Science

March-April 1976/Volume XXXIX/Number 3

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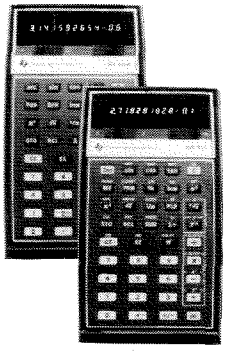

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TEXAS INSTRUMENTS
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Promises, Promises

by PAUL SALTMAN

It is time to articulate the promises the university can uniquely deliver

THERE is a crisis within the university. We face a pressing need to define and to articulate the institutional goals and purposes of the university and, having established these, to fulfill them.

A university is one environment, among many, dedicated to enlarging the intellectual and creative potential of those students and faculty who come to it committed to teaching and learning.

It is an institution that serves society by bringing to that society its powers of critical and constructive insight, in the form of its human resources and intellectual acumen, and it is dedicated to maximizing societal well-being.

As trite and trivial as these phrases may appear, if we in the university could only agree upon these fundamental goals and purposes, and demonstrate our progress toward their fulfillment, many of the traumas engendered by a lack of credibility might not exist.

Universities have been reactive rather than proactive. We are buffeted about by too many constituencies and have tried to please them all. "Student rebellion" seems to have run its course. But a far more serious rebellion and revolution is under way. I refer to the very powerful upwelling of the spirit of the counterculture. This includes not only anti-scientific and anti-technological forces, but total anti-intellectual forces as well. The need to know is replaced by the need to feel.

There are clarion cries for "relevance" from every quarter. Yet, relevance to a student is often irrelevance to a faculty member and vice versa. Research goals of one government agency may be antithetical to that of another.

Mediocrity, rather than meritocracy, has been forced upon us as our intellectual goal. I am deeply troubled by this Pass/Not Pass mentality. Excellence and adequacy are not synonymous. Why do we accept it in our institutions of education when it is unacceptable on our athletic fields and in our concert halls?

The anxiety and insecurity of the Academy runs parallel to the loss of credibility of so many citizens of our society. Indeed, the university has become the most effective scapegoat to be vilified by politicians in their quest for support from their electorate.

The causes of this loss of belief or faith in the university can be directly traced to the promises made that it could not and cannot keep. Perhaps these were not explicit promises, but in their implicit nature, they could never come to pass, given the various conceptual constructs in which students, faculty, and the society operate and relate. Let me explore a few examples of unkept promises.

Some universities implied there would be jobs for all who had degrees — not just any old jobs, but careers with security, high pay, and with interesting and challenging tasks to do. Universities provide few jobs in our society. There were some who believed that universities would feed, house, entertain, teach manners, and, ultimately, perhaps find a mate for each and every young adolescent male or female who would come to them — but the students wanted "freedom" and alternative lifestyles. There were others who believed that a professorial position with a university was a lifetime sinecure to do "one's own thing" with a license to go forth and garner all extramural grants and/or consultation fees that the traffic would bear — but the monies dried up and there were many, too many, students to teach. There were some who believed that the universities were contract research "think tanks" that, for a fee, would promise to solve such problems as creating and building atomic bombs, proximity fuses, radar, cures for cancer, health care delivery for all, transportation systems for complex cities, and solutions to problems of racism — but the "academics" did not have the governmental, political, social, and economic power to

bring about such changes. Nor did they necessarily have the wisdom or knowledge.

And what is most frightening is that we continue to make promises that we cannot keep. We continue to propose functions for the university that will appeal to the populations that we serve in "innovative" fashions, much like contemporary clothing manufacturers in America who must meet the four seasons with "new styles," much ballyhoo, and little lasting import.

It is time to articulate the promises the university can, and must, uniquely deliver. We must provide an environment for education of the highest quality. Despite the diversity of man's intellectual pursuits, there is a oneness of man's intellectuality. For that oneness, that wholeness, that integrity of man's learning and seeking, the university must provide a fertile and stimulating organization.

I have never been able to grasp the idea of the various areas of man's knowledge being separated in straight-line sequences. The intellectual disciplines are linked in a circular ring. Consider biology. How can a biologist be creative without understanding the nature of chemistry, physics, mathematics, without being aware of the psychological forces which function in the central nervous system, or how humans operate through socioeconomic units or tribes, or his own concern with language and communication. Indeed, a biologist must sense the aesthetic qualities of art, music, the theater, and be able to relate them to the identical artistry and the creativity that must exist within the field of biology. No discipline can or should be dissected into a historical perspective, a moral perspective, a social perspective, or a scientific perspective. To view biology in a fractured prismatic fashion is not to be a biologist.

The university must create an environment in which given disciplines can search, act, grow, and develop within the limits of the origin, nature, and methods of their own fields of knowledge — their own epistemologies — and yet be compelled to see the significance of their interrelatedness to all other disciplines. In part, a university is a physical environment of classrooms, laboratories, libraries, computers, instruments, studios, equipment, offices, hospitals, ships, experimental agricultural plots, wilderness areas, and all manner of physical spaces and facilities that allow creative expression and search.

At the same time, there must be an integration of these spaces, places, books, computers, test tubes, and rehearsal stages. The architectural design of a university environment must relate man to nature, bring people together to exchange ideas and stimuli, and must also permit that personal privacy which each of us requires in the acts of teaching and learning. Above all, the architecture must be flexible. It must have the ability to evolve to meet the changing needs and knowledge of a society.

The most important resources of a university are those human beings who live and work within it. A university must reach out to attract all people who are concerned, committed, creative, and intellectually dedicated, so that their collective endeavor of teaching and learning transcends the sum of their own personal abilities. Without such students, faculty, and staff, the finest physical environment in the most architecturally splendid state has no meaning.

Let us now examine the processes of teaching and learning. These two activities cannot be separated or decoupled. Light, when examined by some experiments, appears to be quantized; examined by other techniques, it appears as waves. In similar fashion, the processes of teaching and learning are two ways of looking at a single phenomenon called education.

The process of teaching has been given a great deal of rhetorical acclaim and attention but has received too little rational examination, quantification, and, above all, reward. It is time to give it the hard scrutiny and evaluation it deserves. The process of teaching takes place in many diverse settings, including lecture halls, seminars, laboratories, studios, yes, even dialogues on ends of logs, and most recently in the complex interactive computer-aided instruction. Yet the qualities of teaching excellence are universal in all of these settings. There is a hierarchical set of standards which can, and must, be applied to all of the teaching that takes place in our universities. These are set forth for examination in the hope that they will stimulate our thinking and discourse about this most important activity.

The first level of this hierarchical sequence is to measure the ability of the person or the system to communicate the facts. Our lives are filled with facts and knowing contained in small packets of information. These facts come in books, in computer tapes, stored in people's minds to be divulged orally or in graphic form. All great teachers can, and do, communicate facts. But libraries far exceed human sources in capacity and accuracy. However, without a teacher knowing facts and communicating them, teaching can never begin.

The second level of the hierarchy focuses on the teacher's ability to develop skills in the student. Skills come in various forms: the mathematical ability to manipulate numbers using the skills of addition, subtraction, multiplication, division, integration, and so forth; the physical ability to measure intervals of time, of space, of weight, of spins on electrons, of charges on

The universities must create an environment for teaching and learning about the problems that will optimize social change

protons, of the spectra of the stars and distances in light years; the literary ability to develop skills in the placing of words in sequence and in context to become poems, novels, short stories, and plays; the musical skills to bring forth pure notes from the gut of a violin, the brass of a trumpet, the sounding board of a piano, or the throat of a human and their fusion into music; and the artistic skills of two-dimensional lines drawn on paper that become three-dimensional artifacts of man's architecture, painting, sculpting, and weaving. Great teachers are themselves skilled, and above all they develop skills in their students.

The third level of the hierarchy of teaching is the ability of the teacher to communicate to the student an understanding of how we understand. Epistemology is too frequently ignored in the educational process. We communicate facts well; we even develop many skills in students. But it is rare that we develop an appreciation for the ways, and, indeed, there are many, of how to understand the nature of the universe in which we live and the value systems by which we live. There is, indeed, a unity of man's intellectual disciplines, but there is a diversity of the grounds and methodologies involved in each. The physical and biological sciences share a common epistemology. The social sciences have another common body of knowing and how one knows, which impinges on and overlaps the sciences. In the areas of the humanities, a different set of approaches is utilized. The strategies are related to, but not in any way identical with, those found in the sciences or the social sciences. Indeed, when one begins to examine how we know what we know, a true appreciation of the process of learning begins. Most crucial for good teaching is the ability of the teacher to impart to the student those strategies by which one can come to know, and find in that knowing, a richness of personal joy and satisfaction.

The fourth hierarchical level of teaching excellence is the ability to communicate and arouse in the students a sense of the joy of learning the teacher's discipline. Each of us has been touched and, thus, moved by a teacher or teachers who have brought that personal and existential sense of joy and excitement to the learning process. Often, when talking with colleagues, the use of the phrase, "joy of learning," is met with laughter and derision. There is an automatic confusion in the meaning of the terms joy and entertainment. The joy that must be aroused has to be an active sensation — one that comes from a personal commitment and involvement; one that can be seen in an honest and unhypocritical sense within the teacher and allowed to be experienced and encouraged on the part of the student.

The fifth level of the hierarchy of teaching excellence is manifest in the personal courage of the teacher to expose himself as one of many human models to be observed, dissected, challenged, fought, appreciated, loved, and hated by the student, and, ultimately, to be incorporated as a part of the being of the student. This is the most difficult and demanding task a teacher has. It is easy to dismiss the trivial grandstand plays of the popular teacher who arrogantly "struts his stuff" for an admiring audience of sycophants. But, it is not easy to dismiss the professor who, in knowing his discipline and in his desire to communicate that knowing, makes clear his sense of inadequacy in knowing enough, or his true modesty about knowing definitively what students should know. This is a rare courage — to manifest self in a fashion which cannot be judged "indecent exposure." The line between the obscene and beatific is, indeed, a thin one. Each of us owes a great deal to those few individuals who have been our models. The eclectic gathering of bits and pieces of those human beings who were our "teachers" has been essential to bring us together at this particular moment in time and to shape those ideas that we have to share.

The process of learning is equally important and takes place in countless settings. It is difficult to characterize learning in quite the same hierarchical way that has been applied to teaching. All great learning has related characteristics to all great teaching. There is a universality of great learning in diverse disciplines.

Great scholarship, great creativity, or great learning is initially characterized by an individual's ability to articulate the fundamental questions that must be asked as of that moment in time. All creative endeavor begins with questioning. In some respects, the asking of the question is the simplest aspect of the creative process. At the same time, it is the most complicated. For to ask profound, but unanswerable, questions and to be unable to take the next steps in the search is a sterile and futile endeavor.

The second characteristic of great scholarship is the

ability to formulate strategies for answering the questions that are raised or for communicating novel concepts and relationships through the forms of art or music. These strategies are highly complicated. They require the knowledge of facts, enormous skills, a thorough understanding of the epistemologies, and, above all, a keen awareness of all elements of human intellectuality that can be brought to bear upon the solution.

The third aspect of great learning is the ability to create and carry out that experiment, to bring to fruition that painting or statue, to write that poem or novel, to formalize that new relationship — in effect, to "do it." Each of us knows one or more remarkable individuals who are great critics but not creators. These individuals are characterized by their ability to know the great questions and even to formulate the strategies by which their answers can be arrived at, but they never take that personal creative step themselves, to "do it."

The fourth level in the process of learning is to hold up, for public scrutiny and review, the results of our creative acts. It is our peers in the populace who will, at best, give us constructive praise or, at worst, derisive criticism. It is here that one's own joy of creation must frequently transcend the pain of penetrating and scathing rebuke, where the courage of self-exposure must have been developed and our sense of self-worth be manifested.

We talk of excellence, quality, greatness, and find it difficult to define them. I will not reexamine those terms here but only will reiterate that they can be sensed, understood, appreciated, and agreed to by one's peers and superiors. What is needed, above all, is commitment to honesty when those values are examined.

But what have all of these remarks to do with the university in a contemporary society and the university's role as an agent of social change within the society? Everything! The university cannot accept the responsibility for being an agent for change and, at the same time, maintain its integrity as an environment for teaching and learning. Once we have agreed to make change come about, we have implied that we know what that change is to be and are committed to it. We are no longer, then, free to critically examine those changes which we seek to impose upon others.

A far more successful strategy for the university is to realize and to state that we are one of many important institutions within the fabric of our society. We must interact in a positive and constructive fashion in "parauniversity" systems in which we serve, along with others, in the bringing about of social change. Only when government, industry, civic groups, and the university combine their efforts can effective evolution be achieved.

Recently, the federal government has seized upon medical schools to become the direct instruments of health care delivery in the United States. Because the federal government has put large sums of money into the building and maintaining, as well as into the research efforts of medical schools and the training of young physicians, it has now decided to dictate educational policy within those medical schools. This is a terrible mistake. When some of the important members of the legislative government were asked why this was so, they replied, "We can get our hands on them." In reality, health care delivery is in the hands of practicing physicians, insurance companies, governmental agencies, city, state, and federal hospitals, the myriad of individuals and collectives who in their entirety provide health care. Whether or not the government can "get their hands on them" is not the issue.

In a parallel relation, universities alone cannot bring about more effective legal practice in the United States. But they can serve as part of a much larger group that is concerned with this activity and work with those individual members of the Legislature, the Bar, the courts, and other individuals in institutions concerned with justice and delivery of health care.

Universities cannot change energy policy in the United States. Universities cannot change attitudes toward race. Universities cannot alter the structure and function of our cities. Universities cannot bring us world order. The universities can, however, and must, create an environment for teaching and learning in which human beings will examine these problems, articulate cogent questions, and offer their knowledge and insights—together with those of other individuals in other agencies—to bring about social change.

All universities depend upon the largess of private individuals or governmental agencies. How can such support be justified? In many ways, universities are subversive organizations. They probe, question, and doubt and challenge the society within and without to think and rethink its values, ethics, morals, ideas, ideals, and, above all, the nature of the universe and the role of man within it. Our future rests, in great part, upon educated, creative, and dedicated individuals who grow and develop within the university. These same individuals, in turn, must recognize their debt to the society which creates and maintains the university, and they must repay it many times over in myriads of ways so that their direct service will maximize the human potential of all of us.□

BILL PICKERING is retiring as director of Caltech's Jet Propulsion Laboratory on April 1. It is not true that this means the U.S. space program is coming to an end.

Since 1958, when the U.S. sent up its first satellite, Explorer I, it has been generally accepted that William H. Pickering *was* the U.S. space program. This is an exaggeration, of course. He has only been the *unmanned deep* space program.

Pickering went to work for the Jet Propulsion Laboratory in its earliest days, 1944, and has served as its director since 1954. Small wonder, then, that at the mammoth retirement party given him by the Lab in March, most of the 3,000 guests wore outsized green buttons bearing a caricature of the boss, and the legend, "Mr. JPL." His career, like the Lab's, has spanned the whole history of space flight. His story and the Lab's story are synonymous.

Of course, *his* story started a little earlier. He was born on Christmas Eve, 1910, in the capital city of Wellington, New Zealand, where his father was a pharmacist. His mother died when he was very young, and Bill was sent off to live with his grandparents in the small country town of Havelock. Bill was a good student from the start, and he had an early interest in engineering, which the family considered entirely natural. After all, his great grandfather had built the first railway tunnel in England. At the age of 12 or 13 Bill read a magazine article about a new method of sending and receiving information called radio, and in no time at all he had built the first crystal set in Havelock. (The set came close to being permanently shut off, however, when Bill turned over the headphones to his grandmother for the first time, and she heard dance music coming from Sydney, on a *Sunday.)*

Bill started a radio club when he went to high school in Wellington a few years later, and the members built and operated their own ham radio station.

In 1928 Bill entered Canterbury College in Christchurch—the engineering school of the University of New Zealand. He only stayed through his freshman year, however, because his uncle, a mining engineer now based in Los Angeles, thought Bill would have a greater opportunity to develop his engineering talents at Caltech. So, after the summer vacation (which comes along in December in New Zealand), Bill came to the U.S. and to Caltech.

At that point in his life Bill wanted to be an electrical engineer, but at Caltech A. A. Noyes kept urging him to go into science. Bill did both. He got his BS in 1932 in science, and his MS (1933) and PhD (1936) in physics, with a minor in electrical engineering.

As an undergraduate at Caltech Bill won one of the coveted Junior Travel Prizes, along with Charles Jones,

now a consulting engineer in Pasadena. With two other students, they took the train to Detroit, bought a new Ford, drove it East, and shipped it to Europe, where, in six months, they drove 16,000 miles. (Total cost to Pickering—$900, the full amount of the Travel Prize.)

In his senior year the first student houses were built on the Caltech campus, and Bill was one of the first occupants of Dabney House, where he roomed with Gordon Bowler—which is how he met Gordon's sister Muriel. They were married on December 30, 1932. While Bill went on with his graduate work at Caltech, the young Pickerings lived in Los Angeles, where Muriel worked as a librarian.

Bill got his PhD cum laude in 1936 and stayed on at Caltech as an instructor in electrical engineering (doubling as an instructor in history in those depression days as well). Soon he was involved in the pioneer cosmic ray studies being conducted by R. A. Millikan, along with a couple of other bright young men—H. Victor Neher, and Carl Anderson. Each of them brought a special expertise to this research—Neher dealt with electroscopes, Anderson with cloud chambers, Pickering with Geiger counters.

Pickering's first job on the project was to build the Geiger counters to be used in investigating cosmic rays. (His research for his PhD degree had been on these rare new instruments.) The team flew these counters in balloons, as high as they would go. Cosmic ray information came back by radio and was recorded on the ground.

Because they wanted a worldwide record of cosmic ray intensity at various altitudes, Millikan and his helpers traveled in the late thirties and early forties as far afield as India and Mexico. The war kept threatening to shut the project down, but the young researchers soon learned what a lot of other people already knew—that it took more than a war to daunt R. A. Millikan. In 1939, for instance, Neher and Pickering were on their way to meet Millikan in India when war broke out in Europe. They might not be able to get through, they wired Millikan; should they go back home? Come ahead, said Millikan. On December 7, 1941, the group was making cosmic ray observations in Mexico when the Japanese attacked Pearl Harbor. Should they quit and get back home? We're here, said Millikan, so let's get on with the work.

For Bill Pickering, this cosmic ray research "led me into my interests in great heights above the earth, and sending back messages"—not to mention his interest in instrumentation and control problems for balloons and other vehicles in space.

By 1944, as an assistant professor of electrical engineering at Caltech, Pickering was deeply involved in wartime activities—teaching in the Navy V-12 program, training people in electronics for work in war industries in the national Engineering, Science and Management War Training Programs, working on radar development at the MIT Radiation Laboratory, and—later—serving on the Scientific Advisory Board of the U.S. Air Force, and directing the Army's investigation of Japanese incendiary balloon attacks on the West Coast.

Those Japanese incendiary balloons were a constant, nagging menace. Bill Pickering and Bill Nash (now Caltech's director of placements), in trying to find out how the balloons worked, and how to cope with them, had a standing order for anyone who found one to ship it to Caltech. The balloons were made of rice paper, and, aside from the bombs they carried, they contained a block of high explosives, to blow the whole thing up after the bombs were dropped. Consequently, the remnants that were delivered to the Pickering-Nash office at Caltech were usually beyond study.

One day, though, Pickering and Nash got a well-preserved balloon in their morning mail, and set about opening it with great excitement, which was only heightened when they uncovered the block of high explosives—still intact, and ready to blow. With the greatest of care, they carried their precious package to the roof of Bridge—and yelled for the Army to come and get it.

In one of their more ingenious experiments, they patched up one of the balloons, completely equipped except for explosives, and tethered it 1000 feet in the air at Oxnard, intending to make radar observations. But the rope broke and the balloon sailed away. Disappointed, but not too concerned, because the balloon carried a prominent sign that carefully explained its research nature, Pickering and Nash went back to Pasadena.

It was some time later that the Harbor Defense at Oxnard got a call from the Sheriff's Office in Flagstaff, Arizona. The balloon was down in their area and somebody better come and get it right away. Well, would they please *send* it back? They would not. But did they read the sign, about its being a U.S. experiment. Yes, and it was the most suspicious thing about it, because everyone knew that was a "typical Jap trick." The Army went and got it.

Despite all this wartime activity, Pickering was invited in 1944 by Theodore von Karman, director of Caltech's Guggenheim Aeronautical Laboratory, to join a new government-sponsored wartime project for research on long-range rocket vehicles and missiles.

This was the small-scale project that soon developed into the Jet Propulsion Laboratory, a government-owned research and development facility operated by Caltech for the benefit of the Department of the Army.

Von Karman and Pickering made a trip to Germany and Japan in October 1945 to study rocket development in those countries, and Pickering's first job on the rocket project at JPL was as chief of the Remote Control Section. His knowledge of electronics and instrumentation helped to produce such successful pioneer rocket vehicles as the Private and the Wac-Corporal—research rockets, built with various objectives in mind, and with varying instrumentation.

By 1949 Pickering, who was now a full professor of electrical engineering at Caltech, was spending most of his time at JPL on the development of the Corporal, which would become the nation's first ground-to-ground guided missile. In that year, the Army asked JPL if they could convert the Corporal from a research rocket into a weapon—which meant it would have to be operated by battlefield troops, not research engineers. Bill Pickering was put in charge of the project.

With this project, JPL moved from straight research to research *and* hardware development. The Lab had to develop the engineering capabilities to look at this rocket vehicle as part of a total weapon system. In fact, it now had to encompass everything from electronics to physics, chemistry, metallurgy, applied mechanics, and aerodynamics, and do everything right down to writing training manuals.

The Lab began to grow—fast. It had already come a long way from a graduate study project for Caltech aeronautics students—and it had a long way to go. In 1954 Pickering succeeded Louis G. Dunn (PhD '40) as director of the Lab.

JPL had been speculating about space ever since the war. As early as 1946, for example, it produced some reports on satellite orbits and associated rocket problems. By 1948 Pickering was serving on a high-altitude research committee, which had been set up to try and find ways to use rockets for upper atmosphere research. The satellite program did not get started until the International Geophysical Year was set up, however. In 1955 President Eisenhower announced that the U.S. would put up a satellite during the IGY in 1957-58, and Project Vanguard was established to do the job.

The Navy Vanguard project moved slowly. JPL was working with the Army at the time, on the development of the Jupiter reentry nose cone, and the Lab became more and more convinced that the Army might really be able to launch a successful satellite during the IGY.

The point was moot, though. On September 4, 1957, the Russians launched Sputnik.

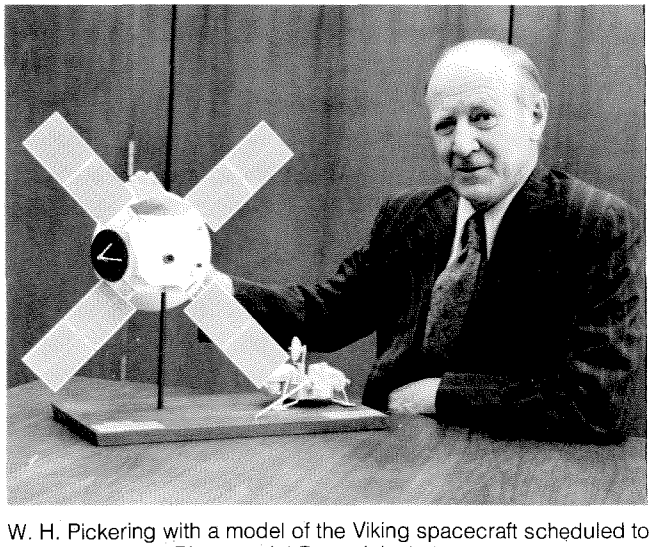
"An emotional trauma shook the land," Pickering wrote at the time. (Typically, he was not visibly affected by the shake.) "For the first time," he said, "we realized that American science and technology were not supreme in the world, and that what we regarded as a land of lumbering peasants could beat us into earth orbit.

"....There seems to be an unwillingness to face up to the obvious fact that the Russians are ahead of us. Let's admit this. They *are* ahead of us, so what do we do about it? What we need is strong leadership, good engineering, good management. We are not asking for a lot of scientific breakthroughs. We are asking for good management and good engineering on programs which already exist and are slowly coming to fruition."

In November 1957, JPL and the Army Ballistic Missile Agency were directed to prepare, and orbit, a satellite before March 1, 1958—and Pickering became a miracle man after he and the JPL staff managed to accomplish that spectacular feat in just 83 days.

Explorer 1, the first U.S. satellite, was launched on January 31, 1958. It was the beginning of the space age in American science. "The event was also symbolic of the mixing process between engineering and science," says Pickering, "between the world and the research laboratory. It had mixed rocket technology with the universe and reduced astronautics to practice."

It was the first of a long series of historic flights for JPL, which was transferred in 1958 to the National Aeronautics and Space Administration, the civilian space agency, and was assigned the basic responsibility for the unmanned exploration of the moon and the planets.



W. H. Pickering with a model of the Viking spacecraft scheduled to land on Mars on Bicentennial Day—July 4, 1976.

These are some of the highlights of that exploration to date:

Pioneer 4 (1959) was the first U.S. spacecraft to escape the earth's gravitational field.

Ranger 7 (1964) flew 240,000 miles to land on the moon—right on the spot selected for the landing—and transmitted back to earth the first close-up pictures (3416 of them) of the moon.

Rangers 8 and 9 (1965) brought to almost 17,000 the total number of close-up pictures of the terrain on which the U.S. astronauts would someday land.

Five Surveyor spacecraft (1966-1968), following Ranger in the orderly exploration of the moon, landed on the lunar surface and not only transmitted even more detailed pictures, but served as remote-controlled laboratories to examine the lunar soil and test its ability to support the manned Apollo 11 spacecraft that followed in 1969.

Mariner 2 (1962), the first successful U.S. planetary mission, gave us our first close measurements of Venus.

Mariner 4 (1965) took the first close-up pictures of Mars.

Mariner 5 (1967) flew within 2500 miles of the surface of Venus, observing physical properties of the atmosphere and collecting material for the mapping of its surface features.

Mariner 6 and 7 (1969) flew by Mars, taking pictures from an altitude of 2100 miles.

Mariner 9 (1972) flew to Mars and became the first space vehicle to be put into orbit around another planetary body—and yield more data than all other planetary missions combined.

Mariner 10 (1974), sent past Venus and on to Mercury, was the first spacecraft to use the gravity of one planet to speed it toward a second, and give us a close view of the planet nearest the sun.

Viking 1 and 2 are now on their way to Mars. Launched last August 20 and September 9, respectively, they are scheduled to land there on July 4, and sometime in September 1976, starting the search for evidence of life on Mars.

The Viking missions (with responsibility shared between Langley Research Center and JPL) are the most ambitious unmanned space ventures ever attempted. But then, in their time this has been true of every one of the unmanned space ventures directed by Bill Pickering since 1957. Some have been more memorable than others—most notably the 83-day wonder, Explorer 1, the first U.S. satellite.

The Lab knew it was on the firing line with Explorer. The whole world was waiting for our answer to Sputnik. Vanguard had already flubbed its launching. Everything was riding on Explorer.

For the launch, Pickering was at the Pentagon in Washington, with a small group of men including Wernher von Braun, director of the Army Ballistic Missile Agency, and James Van Allen of the State University of Iowa, who had designed the instrumentation for the satellite. The group was assembled in the tele-conference room on the third floor of the Pentagon when Explorer blasted off successfully at 10:48 p.m. on January 31, 1958. Minutes later the report came in that the second stage of the 70-foot Jupiter C rocket had been ignited. There were still two stages to go....How *did* they go? they finally asked General John Medaris, in the blockhouse at Cape Canaveral. "We don't know yet," he answered. "Have a cup of coffee, smoke a cigarette, and sweat it out with us."

An hour went by, and a half-hour more. At X-firing time plus 100 minutes they could expect word that Explorer had been tracked coming in over the Pacific Coast on its first orbit around the earth.

X plus 100 minutes—Nothing
X plus 104 minutes—Pickering is on the phone to his tracking men in California: "Have you got anything yet?"
X plus 107 minutes—A faint signal
X plus 108 minutes—Von Braun says someone must have heard an electric razor.
X plus 109 minutes—Pickering is shouting into the phone: "Frank, why the hell don't you have anything?"
X plus 110 minutes—Pickering is listening. "Yes? *Got* one! Give me another." A few seconds pass. "OK—*two*. Give me another one."

It had been agreed that when three stations reported in, they could be sure of an orbit. Then the phones began to ring all over the room. Reports were coming from everywhere. Explorer was in orbit.

"I suppose scientists have been just like other people all the time," Abe Mellinkoff wrote in his column in the San Francisco *Chronicle*. "But I certainly didn't know it. That's why I was shocked to learn what Dr. W. H. Pickering said over the long-distance phone to his spotter in California when the American Sputnik was a few

February 1, 1958—W. H. Pickering, James Van Allen, and Wernher von Braun happily display a model of Explorer 1 at a press conference held only minutes after this first U.S. satellite had gone into orbit.

minutes late on its first trip.

"Dr. Pickering didn't say: 'Perhaps we should recalculate our apogee.' He said: 'Frank, why the hell haven't you got something?'

"It seems to me this appeal should go down in American history with 'Don't fire until you see the whites of their eyes,' 'I've just begun to fight,' 'Remember the Alamo,' and 'Nuts.'"

Pickering's appeal to Frank should probably go down in JPL history too—as just about the most emotion the boss ever displayed in all the years he directed the Lab. Somehow he usually managed to meet the most horrendous crises with a quiet voice and a reserved manner. To the great good fortune of the Lab, and the space program, he was—and is—unflappable.

In a sense this was true of most of the other men gathered in the Pentagon tele-conference room. After they were assured of the success of Explorer 1, there wasn't any shouting and cheering; in fact, there was more of a feeling of relief than of triumph.

Despite the fact that it was about 1:30 a.m., the National Academy of Sciences had set up a press conference on Explorer. Van Allen, Von Braun, and Pickering piled into a car, were driven through the Washington night, and gamely went in the back door of what they confidently expected would be an empty hall—only to be greeted by a tremendous cheer from an overflow audience that convinced them for the first time that there were other people, after all, who thought they had accomplished something of importance. The press conference ran for almost two hours.

There were some low points in the Pickering career

too. Lots of them. The first five Ranger shots at the moon were failures. Khrushchev was scoffing at the U.S.–"They proclaimed for all the world to hear that they were shooting a rocket at the moon, but they missed every time....The Soviet pennant on the moon has for a long time been awaiting the American, but in vain, and it is lonely."

The Ranger troubles were not all of the Lab's making, but morale at the Lab was not the best in the world. After Ranger 5, NASA called a halt in the program and the Lab asked for a year to work on Ranger 6. Finally they were ready. The flight of Ranger 6 was perfect. Fifteen minutes before impact, the television cameras were scheduled to begin operating. Then we would begin to get our first close-up pictures of the moon. But the cameras never came on. After a year's work, and just fifteen minutes before payoff—there was nothing.

"I was proud of the Lab," Pickering says, "—because they didn't fall apart."

And the Lab must have been proud of him for the same reason. Shortly after the failure of Ranger 6, they had their big annual party, where they chose a Queen of Outer Space. Bill Pickering always got a round of applause when he came out to present the lady with her crown—but *that* year, they didn't just applaud; they tore the place apart.

The hard-luck spell was broken three months later when the Lab put up the successful Ranger 7.

On April 1, Bill Pickering turns over the directorship of the Lab to Bruce Murray, professor of planetary science at Caltech, and a geologist by training, who has served as a principal scientist in many JPL spacecraft explorations of the solar system. The Lab is now Pasadena's biggest industry, with 4000 employees and a $65 million annual payroll.

Pickering, who has actually only been "on leave" from Caltech for the past 22 years, will return to the campus as professor of electrical engineering, at the same time as he keeps a number of other activities going. The most notable of these are probably his chairmanship of a National Academy of Sciences committee that serves as an advisory group on research for the Navy, the development of a new research institute in Saudi Arabia, and the establishment of an International Solar System Decade, somewhat along the lines of the 1957 International Geophysical Year, which would draw together the people working on studies of the planets and the solar system.

With their son and daughter now grown, the Pickerings live in a spacious house high in the Flintridge hills. It is not at all a pretentious house, except for its view, which is commanding—and then some—overlooking a good portion of southern California, including the Lab. With a good telescope, in fact, Pickering could look right into the windows of his ninth-floor office at JPL—or vice versa.

Bill does his own gardening (which is practically unheard of anymore in southern California) and keeps a small but catholic vegetable garden going. Both Pickerings are stamp collectors, and they have comprehensive collections of space stamps and issues from New Zealand.

The honors and awards that have come to Bill over the years line the halls of the Pickering house—and they range all the way from his election to the National Academy of Sciences *and* the National Academy of Engineering to his selection as Grand Marshal of the Pasadena Rose Parade and membership in the

Concatenated Fraternity of Master Missileers
Pentagon Chapter
Kept vigil for 4 hours—2130, January 31 to 0130, February 1, 1958
Jupiter C–Satellite Explorer

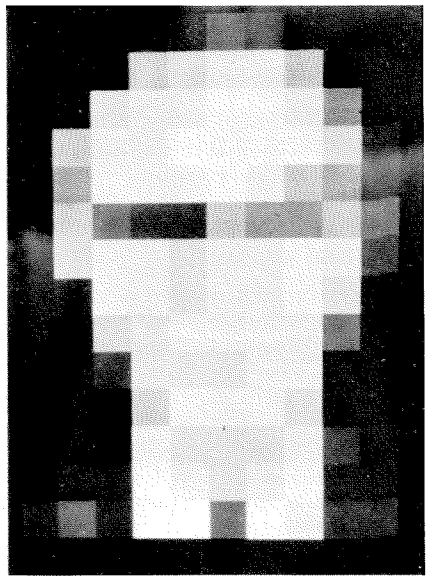
Accordingly, let it be proclaimed that he now has attained the exalted rank of Master Missileer and shall henceforth enjoy an AA-1 seating priority at all future Pentagon launchings, with the privilege of double oxygen rations on the first United States Army ship to penetrate the celestial frontier en route to the moon. Also, he is entitled to repeat ad infinitum to all and sundry persons every detail of all of the events leading up to, during, and following the launching of said Jupiter C–satellite Explorer (and to make any desirable elaboration thereon to suit his fancy, provided he adheres somewhat closely to the agreed facts).

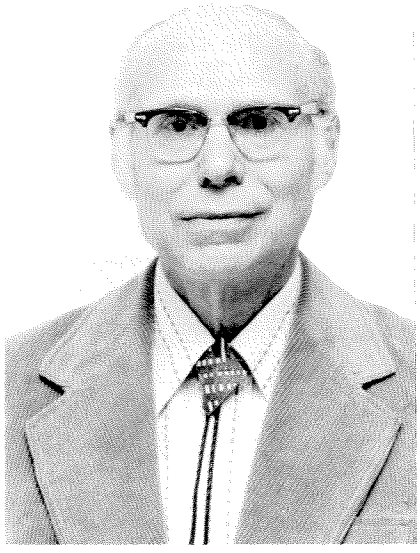
Suffice it to say that Bill Pickering is too forthright to elaborate on his space achievements, which have been impressive enough to need no elaboration anyway. In fact, his direct, unassuming, and understandable explanations of these achievements have made him a favorite of reporters. One of the rare critical comments he has drawn from a reporter came in an account of a press conference, held on one of his many visits to his birthplace, and printed in the Wellington, New Zealand, *Evening Post* on February 10, 1965: "Dr. Pickering, dressed in a quiet dark suit, showed that he has acquired few of the customary American mannerisms since he went to California in 1929....the Americanisation was only apparent when he launched into a rapid-fire delivery of space achievements and aspirations."

It's an Americanisation we can all be proud of—all over the world. □

Speaking of...

Anyone You Know?





Amateur attempts at drawing portraits, though often extremely detailed, are usually unrecognizable. The block picture at the right (and on the cover), though not at all detailed, is easily recognizable. Moral? It is more important to be right than to be detailed.

The block picture was one of many intriguing exhibits in Caltech's Baxter Art Gallery in February and March, in a show of "The Many Arts of Science," assembled by David R. Smith, associate professor of English. Believe it or not, it's a picture of John R. Pierce, professor of engineering, whose face is more readily available in the photograph at the far right. To bring him into focus in the block picture, try backing away from it until his face appears, or try squinting at the picture until it is sufficiently blurred.

The picture was made by Leon D. Harmon at the Bell Telephone Laboratories, where Pierce worked before coming to Caltech in 1971. The picture is produced by computer processing of a photograph. It contains 10x14 squares representing about 8 levels of light and darkness, or 3 bits of information — which means there are 420 bits in the picture. Since the teletypewriter uses 5 bits per character, the picture could be produced with only 84 characters — which seems to say that not much information is needed to describe a face.

A most happy fella on a most happy occasion — his 75th birthday party. Linus Pauling stands between son Crellin (left) and grandson Barclay Kamb. In the front row, from left to right, Anthony Kamb, Mrs. Pauling, Linus Kamb, Linda Pauling Kamb, and Linus Pauling Jr.

Happy Birthday

Linus Pauling, who has been on Caltech rosters since 1922, was back at the Institute on February 28 for a triple-treat occasion. Former students, colleagues, family members, and friends turned up for a scientific meeting, a family reunion, and to celebrate Pauling's 75th birthday.

Edward Hughes, senior research associate in chemistry emeritus, who planned the event, had to shift the afternoon lecture from Noyes to Baxter Lecture Hall to accommodate the crowd that came to hear E. Bright Wilson of Harvard talk on "The Nature of the Chemical Bond, 1976."

Dinner at the Athenaeum for more than 250 people featured Hughes's slide show of some of the more informal aspects of Pauling's career and tributes from two Nobel Laureates, each named Max. Max Perutz of Cambridge University was speaker of the evening, and Caltech's Max Delbruck presented Pauling with a volume of greetings from nearly 200 friends.

WE'VE BEEN WORKING ON FOR THE LAST 100 YEARS.

And we're still working on it.

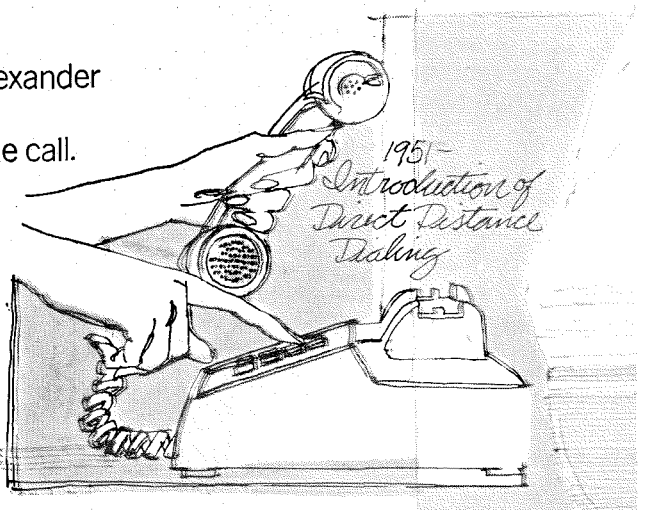
You see, the invention of the telephone didn't stop with Alexander Graham Bell. It just started.

Because the telephone is just the beginning of a telephone call. It's part of an intricate network of a trillion parts and nearly a billion miles of circuits.

To build this network, we at Bell Labs and Western Electric have long worked as a team with AT&T and your Bell telephone company.

As a result, America has the best telecommunications system in the world.

And the world has the benefits of such Bell System innovations as the transistor, the coaxial cable and direct distance dialing.



Working together, we've created entirely new communication systems. Like our latest switching machine that can route 550,000 calls an hour.

At the same time, we're constantly improving existing systems. Like tripling the capacity of our major microwave radio system in the last ten years.

Even the standard telephone that you probably think never changes has had virtually every major part improved since 1972.

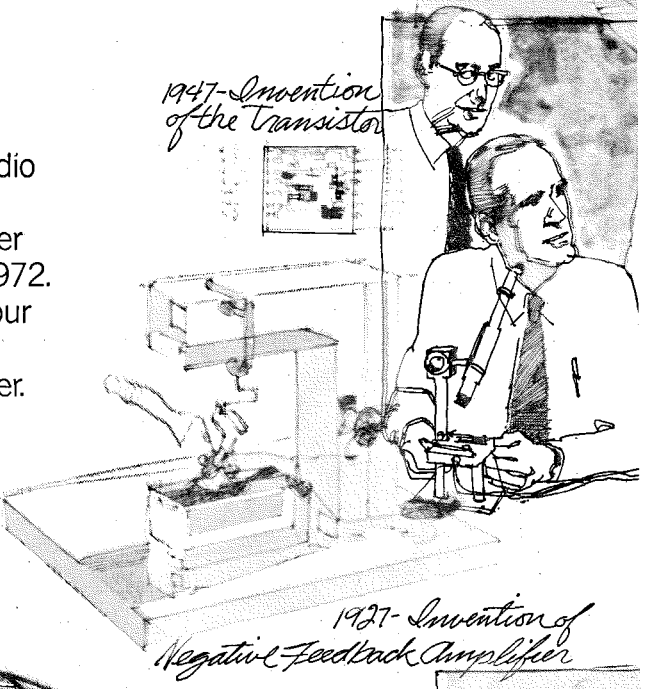
In fact, we've made more than 2,500 improvements in your phone in the last twenty-five years.

Not just to make it look different. But to make it work better.

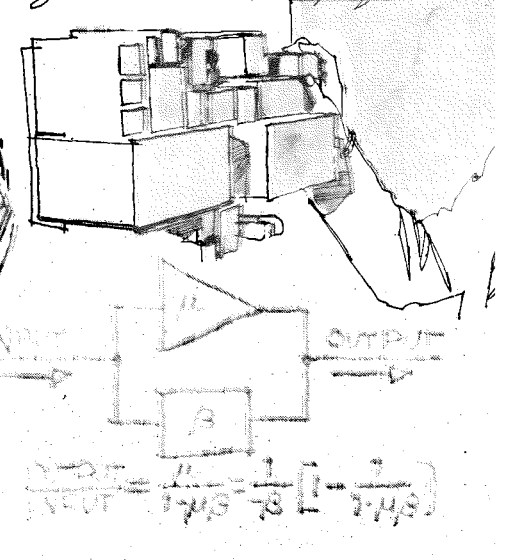
And to keep its cost down.

Improvements like these don't just happen.

The Bell System invests more than $750 million a year in research and development.



As an outgrowth, we receive an average of more than two patents every working day. And nearly half the things Western Electric will make this year didn't even exist four years ago.

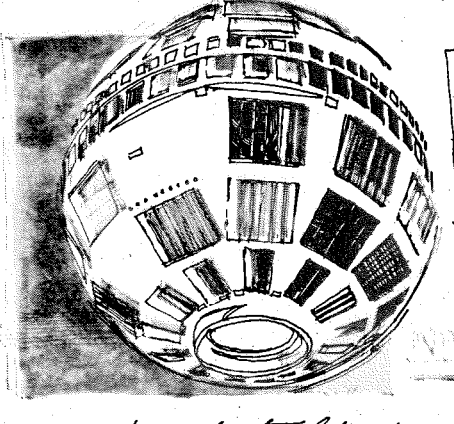


In the next 10 years, we plan to expand the capacity of the telephone network as much as we have in the past 100 years.

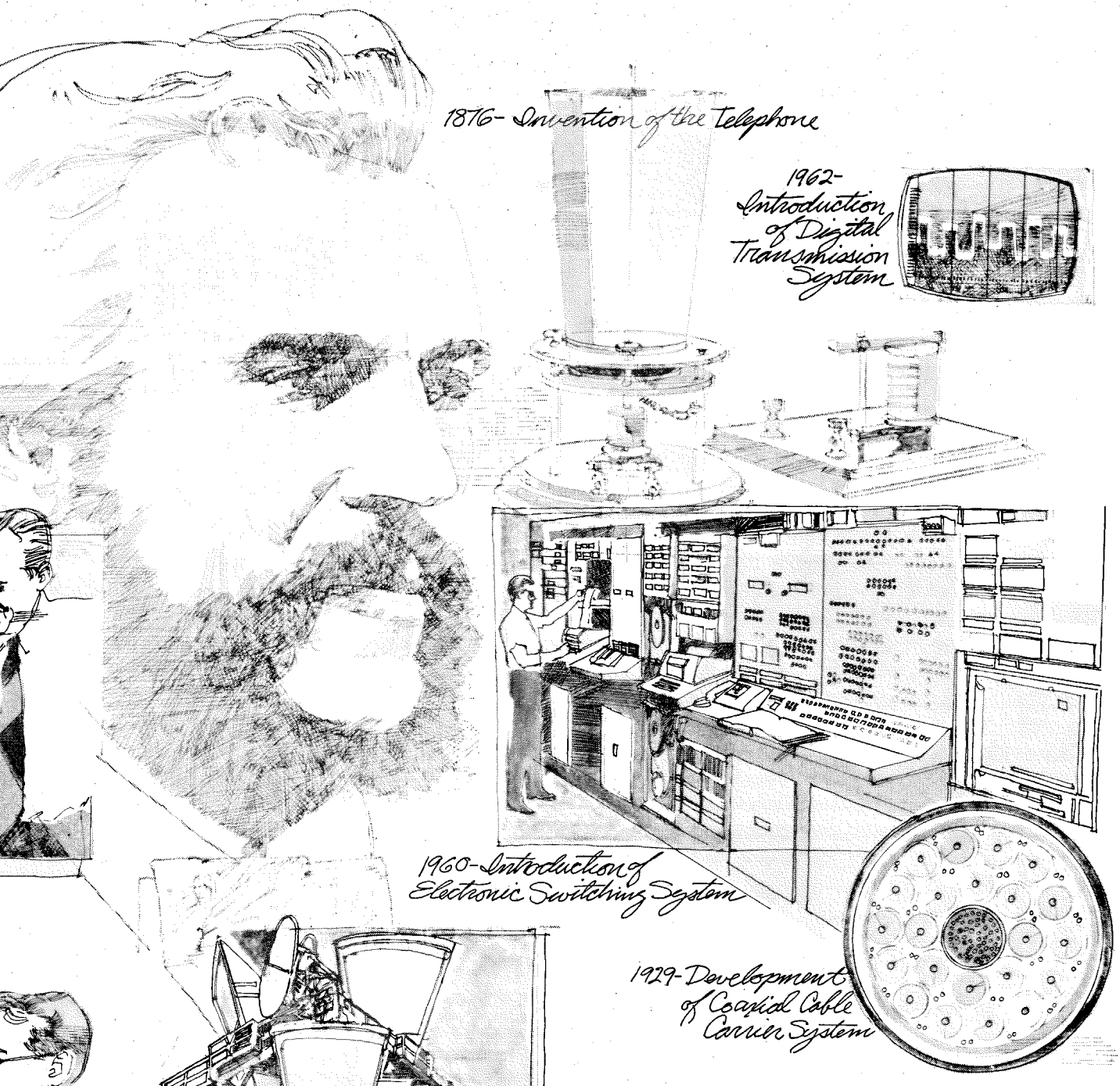
To keep this network operating and growing takes the innovative teamwork of Bell Labs and Western Electric.

The kind of innovative teamwork that makes us say:

One Bell System. It works.



YOUR NEXT PHONE CALL



1876- Invention of the Telephone

1962- Introduction of Digital Transmission System

1960- Introduction of Electronic Switching System

1929- Development of Coaxial Cable Carrier System

1948- Introduction of Microwave Transmission System

Bell Labs
Western Electric

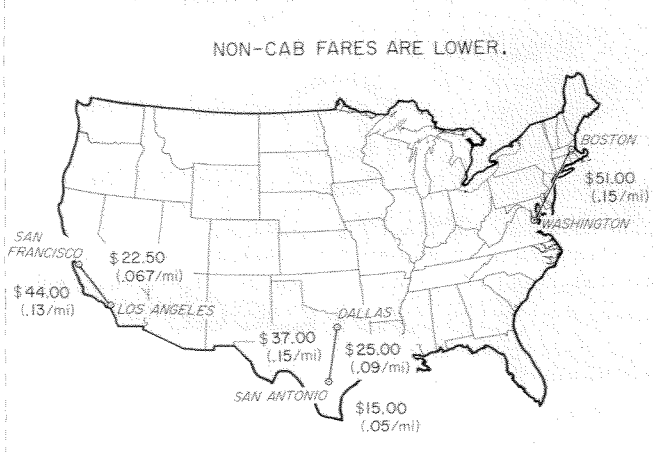
Does Airline Regulation Benefit the Consumer?

by MICHAEL E. LEVINE

The answer is no. Then why not go back to free competition?

SINCE this is Caltech, I suppose I should start with a few numbers. So let me note some fares established by the United States Civil Aeronautics Board, which has regulatory jurisdiction over the economic aspects of most aviation in this country. These fares are in contrast to those offered in states of sufficient size to have large cities far enough apart to support air service and to have rather independent policies toward the regulation of air transportation.

In California, for example, the fare between Los Angeles and San Francisco in January was $22.50. The fare established by the Civil Aeronautics Board for the same flight—and paid by anyone who is unfortunate enough not to live in California and to buy his ticket for the journey outside the state—is $44.00. In Texas, if you are not present in that sovereign jurisdiction, you pay $37.00 for a flight from Dallas to San Antonio. If you fly the local carrier, Southwest Airlines—in its modern jet equipment on the same route that the CAB-certificated carriers operate over—you pay $25 during the working part of the business day and $15 nights and weekends. To show the lamentable condition of life in the Northeast, the Boston-Washington fare, for a distance that is only slightly farther than from L.A. to San Francisco, is $51.



This is a rather interesting phenomenon. All of us learned in high school that we used to have rapacious businessmen who, left to themselves, charged high fares and robbed consumers. But then everything got better because of regulation. Regulation was designed to make sure businessmen curbed their greed for the benefit of the public. Well, it doesn't seem to have quite worked out that way in the airline business.

Following the lead of the truckers and the railroads before them, the airlines decided they needed a regulatory agency of their very own. They lobbied assiduously for a couple of years and eventually got one. Regulation was set up in 1938, using legislation drafted by a lawyer for the Air Transport Association. The first thing this regulatory agency did, of course, was to make sure no one else got into the business. The second thing it did was to carry out its mandate to make sure prices remained up rather than being competed down either by greedy new people who wanted to enter the industry or by a possible outbreak of competition among the lines who were already members of the club.

This legislation has had major impact over the years. The estimates of its cost to the public range from a half billion dollars per year to three billion dollars per year. Let's be moderately conservative and call it a billion and a half. This is an awful lot to pay for a regulatory

scheme, especially given that we had in mind that regulatory schemes were supposed to work for our benefit.

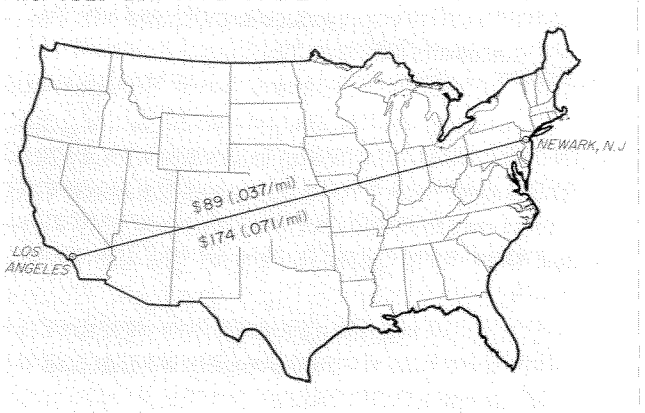
During the 38-year period of the CAB's existence the industry has grown well over a hundred times. Also during that period the CAB regulation has been so effective that not a single new long-haul domestic airline has been licensed. Existing carriers have been given new routes. Classes of carriers have sometimes been created whose rights to operate were limited in such a way that they would not compete directly with the so-called trunk lines. The local-service carriers such as Allegheny, the late unlamented Pacific, and some others are examples of carriers certificated in this way. Some charter carriers have been certificated, and one carrier was given a long-haul route from New York to San Juan—competition being something that we loose on peoples who are a little foreign to us, but something that we do not want too much of at home. But I repeat, in an industry that has grown more than a hundred times, not a single new carrier has been certificated to provide the sort of basic long-haul service that most of us associate with the airline industry—transcontinental service, service up and down the coasts, and service to major resort markets.

Now this is interesting, because the airline business, especially at the fares named by the Board, has been quite attractive to entrepreneurs. But there's a long history of the CAB uniformly turning down attempted applications, culminating in the suppression of the so-called large irregular air carriers that were mostly operated by World War II veterans who had learned to fly courtesy of Uncle, and who wanted to continue to do so. They were kept out of the business by some very odd devices, including a requirement that their operations be irregular; that is, that they not operate on a fixed schedule or hold themselves out to the public as regular carriers.

More recently, there has been an application by World Airways to provide transcontinental service at $89. Originally this supplemental carrier offered to provide the service from Long Beach airport to Kennedy, but in the hope that the CAB would be persuaded that they weren't really competitors, they have lately suggested service from Ontario, California, to Newark, New Jersey.

In 1966, when they first applied, the fare was to be $79. The Board did not hear this application in 1966 on the grounds that it duplicated existing air service—as you who have attempted to purchase a ticket to New York for $89 will know. Since, because of limited funds, the CAB cannot hear every application for new

PROPOSED LOW-FARE COMPETITION HAS BEEN SUPPRESSED.



service, the Board put this application low on its so-called priorities of hearing; it also had a rule that any application not heard within three years would be dismissed as moot. Thus, it had a sure cure for this particular outbreak of the competitive disease; it simply did not hear the application within three years. The application was dismissed, a result that World found most discourteous, so World reinstated it recently, offering to supply the service for $89.

I was an attorney at the Board around the time that application was made and, with an airline economist, I calculated that under the costs then prevailing and with only two-thirds to three-fourths of the seats full—a result that I think is conservative—World would have made a mere 30 to 40 percent on its investment. Incidentally, the current fare is $174.

From time to time, the CAB has gone to even greater lengths than fashioning *Catch-22* procedural rules. Recently, a businessman in Beverly Hills, a Mr. Pessis, who did not have the benefit of long acquaintance with the airline industry, decided he would offer air service from California to Europe at low fares. Since he rapidly discovered that he was unlikely to get a license to do that from L.A. to Europe, he hit on the clever expedient of offering service from Tijuana to Luxembourg. As you can imagine, the amount of locally originating traffic between Tijuana and Luxembourg is limited, and I have no doubt he hoped to attract people travelling from southern California to northwest Europe. But he proposed to make some inconvenience worth their while by charging a fare of approximately half the existing economy fare and about 40 percent below the then existing excursion fare. He was going to use the latest generation of aircraft, DC-10's. The aircraft were owned by a British carrier, which had bought them in the expectation of providing low-fare service to the

U.S. and which had then discovered that neither its own government nor the U.S. welcomed it. The aircraft were to be flown by experienced crews, and Mr. Pessis received numerous advance bookings.

Shortly before his company—Air Europe—was scheduled to carry its first happy passengers, a gentleman from the CAB solicited an interview with *Aviation Week* magazine, which soon quoted an unnamed CAB source as saying that this operation was probably illegal and that they were going to try to get the Federal Aviation Agency to stop the flight. The FAA, which is assigned the job of regulating safety, informed the CAB that it didn't see how it could possibly do that and left the matter in the CAB's hands.

Another interview appeared shortly thereafter saying that in the opinion of the CAB the flights were illegal. They were going to arrange for a sky marshal to board the inaugural flight at Tijuana, and if the plane flew over the U.S. on its immoral course to Europe, he would force it down at gun point, presumably to impound the plane and jail the passengers and crew. Somehow the threat of an armed encounter aboard the aircraft persuaded the passengers that perhaps a couple of hundred dollars was not too much to pay for peace and quiet, and they melted away. Poor old Pessis had a very large airplane on his hands that he was committed to lease. Through his lawyer, he attempted to get declarations from the various U.S. agencies involved that there was nothing illegal about the flight. But finally the Mexican government got tired of the embarrassment of having certificated a carrier which its friendly neighbor to the north was not going to allow to operate, and withdrew Air Europe's license. The operation collapsed.

In a few markets, however, entry has occurred. The principal one is New York to San Juan. In that case, a gentleman with very good political connections owned a nonscheduled cargo carrier called Trans-Caribbean Airways, which was operating between New York and San Juan. The airline received temporary authority to carry passengers, and in 1956 he managed to persuade the CAB to give him a permanent license. Fares in the market immediately dropped to half, and although that carrier is now merged with American Airlines, the fares in that market are considerably lower on a per mile basis than the fares on approximately similar flights within the U.S. This suggests strongly to me that in the absence of CAB regulation we could have much lower fares in the U.S.

Well, if this is such an expensive system of regulation, how has it survived for nearly 40 years? What can one possibly say in its defense? I can't help but regard that as a good question. The answers are less satisfactory, but I'll give you a few. When the industry and the CAB (and it's interesting that for these purposes the answers from both the industry and the Board tend to be rather similar) are asked why we have airline regulation, they give the following answers. If some of them seem a little inconsistent or far-fetched to you, I can assure you that I am not misrepresenting them.

One of the first answers is that without CAB regulation there would be cutthroat competition in the industry. By cutthroat competition the CAB means in this case the rather odd state of affairs in which everyone would compete and offer fares on which no one would make money, and they would all go out of business, and we would have no air service. This, as we know, is just what has occurred in the supermarket industry (which is unregulated) and in the rental car business (similarly unregulated) and in a wide variety of other businesses that have somehow managed to operate without the protection of a government agency.

"Well," you say, "it seems very unlikely that no one can survive. There are, after all, some millions of people each year who want to fly in airplanes. Wouldn't someone be around to carry them?"

"All right," they say, "you're probably correct. They won't *all* go out of business. One will survive. It will be a monopoly, and then you'll be sorry. They'll charge high fares."

And you say, "It isn't too hard to get into the airline business. In fact, you set up the CAB in the first place because it was awfully easy to get into the business. You can, in an afternoon, paint a new sign on the side of an airplane. You can arrange landing rights at a couple of airports and have an instant airline."

"Well," they say, "perhaps you're right, perhaps there'll be some air service around, but it will destroy the airline system as we know it today. We provide service to a great many cities. You can pick up your telephone and arrange by calling one carrier to go from L.A. to Montpelier, Vermont, or Sault Sainte Marie, Michigan, or wherever you feel like going, and it will arrange all the connections and even reserve you a window seat if that's your preference. And you will get a meal that, however dreadful it seems to you, is not as dreadful as it would be if there weren't a CAB. And this is the system that will go by the boards if we abolish regulation. Then airlines will be able to fly the routes they choose, and no one will choose to fly to Montpelier or Sault Sainte Marie. They will all want to fly from New York to L.A. [presumably in one direction only] and then where will we be?"

And finally, pressed to the wall, they will tell you

that the blood will be on your hands if the unregulated environment attracts unsafe carriers. In fact, at a recent symposium in Akron, Ohio, a man from the Air Transport Association looked at me accusingly and pointed out that airlines fly serum from drug companies to hospitals, that without the CAB the serum would never get through, and that, therefore, were we to deregulate airlines . . . . He never finished it exactly, but he seemed to be predicting widespread epidemics as the final result of dismantling this system.

"Besides," they say, "look how well we've done. Airplanes are kind of nice, and fares are lower than they used to be on a per mile basis [even these fares]. Undeniably air transportation has grown enormously since 1938, so we must be doing all right."

We could be discourteous and point out that the electronic calculator business seems to have done a lot better a lot quicker without the benefit of regulation and suggest that it's fairly easy to look good when you're riding the early part of a technological development curve. But this is all brushed aside on the grounds that, since things are all right as they are, change is likely to make them worse.

I didn't spend much time on the question of service to major cities only because it's a fairly complex argument that needs to be discussed at some length. But it is the major position to which the industry has recently retreated, so let's talk about it a little bit. Why would it be the case that air service would be provided only between New York and L.A.? This market would no doubt offer profitable opportunities, although not nearly as profitable as at present if the fares fell to what I estimate to be the market rate—about $50 each way. At $50 each way, New York to L.A. wouldn't be any *more* profitable than the other routes. The fare from Chicago to Sault Sainte Marie might be almost the same $50, but that would reflect the cost differences of flying relatively few people in small airplanes to a place where not many people want to go, as opposed to flying large masses of people in very large airplanes to places where lots of people want to go.

In principle it's no more profitable to own a supermarket in Los Angeles than to own one in Bakersfield. There may be fewer markets in Bakersfield, but there will be about as many as the market can support. There's no reason to expect anything different in the airline industry. You may get different fares or different cost relationships, but you should expect people, especially in an industry where the resources are as mobile as they are in the airline industry, to take advantage of whatever profitable opportunities are available. It's much easier to start an airline between L.A. and New York than it is to open a supermarket in Bakersfield.

What we can be sure of is that service will be offered in any market where it can be provided profitably. Even today much of the service provided in quite small markets is offered by carriers that do not have CAB certificates. Under an exemption program (Part 298 of the Board's regulations) the Board relieves of the requirement to get a license any carriers operating aircraft that don't hold more than 30 people and have a payload of less than 7,500 pounds. These very arbitrary restrictions are designed to make sure those carriers don't operate airlines very much like the airlines the Board exists to protect. Those carriers are now providing the great bulk of service to small towns in the U.S. If you want to go to Hutchinson, Kansas, you fly to Wichita, and you take Air Midwest from there to Hutchinson. If you want to go to Pittsfield, Mass., you fly first to New York and then take Command Airways. Or if you want to fly to San Luis Obispo, you fly to L.A. and take Swift-Aire. These airlines are not regulated by the CAB. They do not receive public subsidy. They do not benefit from the high cost-price margins on long-haul routes—and they provide the service. And, with deregulation, they would continue to provide the service.

In testing the claim by the airlines that under deregulation they would abandon many markets and that they need to make excessive profits in some markets to support service in others, we find the following: Since about the mid-1960's the Board has allowed any trunk line—that is, any unsubsidized long-haul carrier—to drop service to virtually any city it wanted to. The CAB did require some of the local-service carriers to serve some of those cities, but any trunk lines that wanted to delete service could do so. And at the beginning of the program there were deletions. American stopped serving Joplin, Missouri, for example.

Since that period, there have been virtually no deletions simply because on an added-cost basis the airlines make profits serving those towns. In fact, United fought like a tiger to keep its service up the Willamette Valley and up California's central valley when the Board suggested it be decertificated so as to allow Hughes Air West to monopolize those markets and thus make a little more money.

There are a few counter examples. United serves Elko and Ely, Nevada—holdovers from the days when you couldn't fly from Salt Lake to Reno without stopping at least once. They continue to provide this service, since the chairman of the Senate Aviation Subcommittee is one Howard Cannon, Senator from Nevada. Senator Cannon can make his wishes known to

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Materials from the Earth—

The Stuff Things Are Made Of

by JAMES BOYD

Man's ability to raise himself above grinding poverty depends on how he uses available material and energy

WHEN the astronauts looked back to the earth from their new perspective, they saw it as small and bounded. But is it really small, or only relatively so from a cosmic seat? Is the view that we are doomed to have perpetual shortages of materials realistic, or can man solve this problem through advanced technology and economic measures? Do we take our cue from the biblical lament, "Woe is me, for I am undone"; or from Gilbert and Sullivan's ironic, "Things are seldom what they seem"?

Although the earth *is* finite, the real limit to the availability of materials is self-imposed. Man's resources include his intelligence and curiosity, and they can provide a climate that will encourage him to conceive a positive solution to the problem of materials shortages, to pursue answers and not anguish.

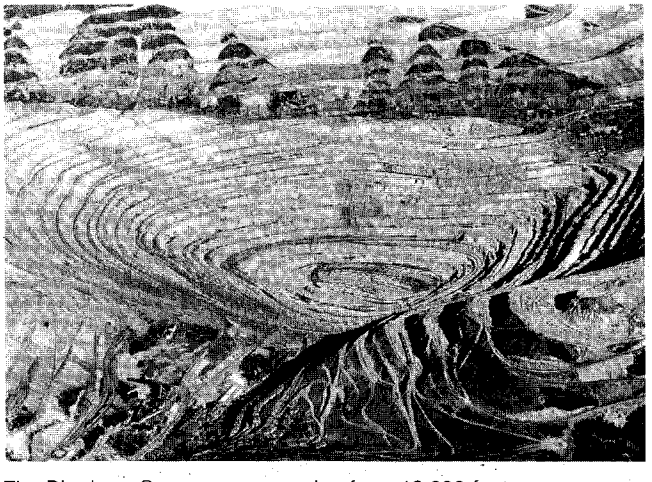
I am not suggesting that resources are infinite. But within and upon the surface of the earth there exists an unimaginably complicated dynamic system, and its capacity to supply men's needs will survive if it is treated with understanding and respect. In fact, the ability of man to raise himself above grinding poverty depends on his utilizing in a wise manner the material and energy sources that are available to him.

There are three basic premises that can relate resources to our daily experience: First, we use materials that have the properties to perform specific functions. For example, we use wood for houses because it is available, easily fabricable, and is a good insulator.

Second, there are few if any functions that cannot be performed by more than one material. Stone, brick, concrete, steel, glass, and aluminum can be used as well as wood for houses.

Third, new scientific discoveries and engineering applications frequently require the discovery of new sources of materials with new properties. The high-speed jet planes of today, for example, could not have been developed before materials scientists discovered how to produce titanium metal, or some other material of the same light weight, high strength, and temperature-resistant qualities. Titanium, and aluminum, iron, and silica are the most abundant elements in the earth's crust. As technology advances, demands for their use and for more exotic materials will continue to increase, but the earth can support those requirements from its vast resources if we use our intelligence in consuming them.

It is, however, one thing to say we have sufficient resources to meet our needs and quite another to make them available to the industrial structure that puts them to use. Engineers and businessmen are inclined to express resources in terms of those that can be produced profitably at the current level of prices and scientific development. They also tend to express reserves in terms of the years of life remaining in those reserves at present rates of consumption. For example, when I graduated from Caltech almost 50 years ago, it was estimated that only ten years of reserves of petroleum



The Bingham Canyon copper mine from 12,000 feet up.

remained in the United States. At that time we were consuming about five million barrels a day. Three or four years ago, our daily consumption was closer to 17 million barrels, and it was still estimated that we had ten years of reserves.

Industry, of course, spends vast sums of money in a search for raw materials that can be produced economically with current technology—but technology is steadily improving. At the turn of the century, the Bingham Canyon copper mine in Utah could mine economically only ore containing 2 percent copper, but by 1970 it was profitable to mine ore containing less than 0.6 percent copper. Through improved economic conditions and technology, we should find new sources of copper equal to those of Bingham Canyon every few months. Geologists have been finding new deposits of petroleum and natural gas at a faster rate than the world was consuming them until the last two to three years. It was only in 1968 that for the first time we discovered less oil in the United States than we used.

Obviously, there are limits to the availability of natural petroleum in the earth's crust underlying the United States and its boundary seas. We have now arrived at the point where it is not possible to find oil as fast as we require it to maintain the present profligate rate of use. But we will never run out of petroleum; it will just become too expensive to use it for the purposes for which we use it today. This does not mean that we will have to give up automobiles and airplanes and trains. We will not have to do without all the electricity which today is generated from petroleum and natural gas. We *will* have to develop industries that can convert other kinds of energy resources to our use.

Some of these other energy resources are extraordinarily large. For example, we have more energy stored in coal in the United States than exists in all of the world's petroleum resources. There are the sun's direct rays on the crust of the earth for the production of solar energy. Immense amounts of energy are stored in uranium and thorium, and in deuterium that will eventually be extracted from the sea. Geothermal energy may seem to be a more limited resource, but recovering the energy from vast masses of cooling rock within the earth's crust is potentially a very large source of energy. Developing it will test the ingenuity of future generations of scientists and engineers. Of course, we don't have to solve all these problems today; we just have to find those deposits or resources that can be put to human use within the present development of technology and economics.

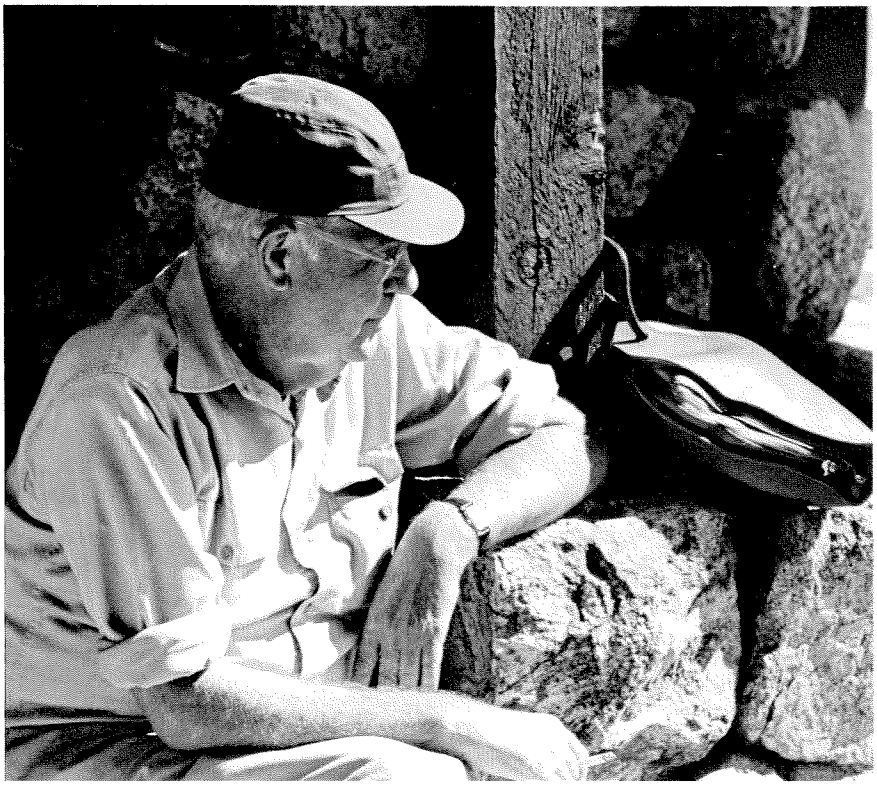
The geologic processes that have been taking place in the crust of the earth for the last four billion years have, almost by accident, concentrated our materials in specific locations. The geologists' task is to find them. Originally, ore deposits were found by the prospector with his trusty burro, but even as the prospectors discovered most of the easily accessible deposits in the earth, the technology for going deeper into the crust was developing.

As it becomes possible to recover material from lower grade ores, the demand upon the geologist to find less concentrated sources increases. This mandates the development of theories of geological events or processes and improved geophysical techniques. It also means that the geologist must explore the far corners of the world, searching for minerals in the deserts and the Arctic and Antarctic. He must take to the air to study the surface of the earth to find the slightest physical anomaly, and then relate it to his understanding of what lies beneath. He must take advantage of geophysical means of actually measuring physical anomalies beneath the surface. Eventually, he must drill into the crust to test his theories; then with the engineers he must determine whether the deposits he finds can be mined economically while preserving and enhancing the environment.

There are those who feel that the extraction of valuable resources for the use of men endangers man's very habitat, but this is not a new idea. It has always been a concern of thoughtful men. It is a rare deposit where the surface could not be temporarily disturbed for mining and then returned to the same, or more productive, use that it originally enjoyed. The preservation of the original contour is in many cases impossible, but the wastes from the mining of materials can be used to resculpture the land. Furthermore, there is misapprehension about the scale of mining. In the total history of mining in the U.S., less than one-third of 1 percent of the surface of the earth has been disturbed, and of that, a third has already been put back to use or returned to the wilderness.

Whether what we need to supply our wants comes from the forest, the farm, the seas, or the earth, great effort is required to put it in usable form. The best sources must be found, developed, and equipped to prepare raw materials for our use. All of this takes vast amounts of capital, and this must come from those who are able and willing to work harder than ever, not only to meet their own requirements but to share some of their affluence with the underprivileged.

But the resources are large enough to meet these needs. We need only use our growing knowledge of science to discover them, and then convert them into the required forms—always being aware of the obligation to use them wisely and conservatively. This is one of the major challenges to us all for the future. □



Character and Action

A letter from Kent Clark, professor of English

DEAR ED,

On September 8, 1975, Paul Eaton sat down, somewhere in Kennebunkport, Maine, and wrote me a letter. It seems that one of his friends had been reading my old historical novel, and Paul thought I should know that the book was still being read, though it is now out of print. He also thought I should be twitted for not having written another historical novel—for letting my typewriter and literary fame rust. I was joining him, he said, in the limbo of out-of-print authors. In the process of berating me and reminding me of the transience of literary renown, he quoted a drunken Scots marine engineer named Glencannon (the literary creation of Guy Gilpatric). Glencannon had a comment on fame in general: "Sick trampship the glory on Monday." This memorable phrase, Paul thought, applied to both of us.

Well, Ed, I very seldom answer letters right away—or at all. But this one charmed me. The thought of joining Paul anywhere—even in literary limbo—was fun in itself. The additional reflection that Paul was thinking about me was reassuring and flattering. But beyond all that, there was an oddball coincidence of experience. Till I got Paul's letter, I thought I might be the only eccentric left in the world who remembered Glencannon's sloshed comment on the fate of men and freighters. Paul's quote showed me that there were at least two of us. It was like finding out that we had both suffered from a rare youthful disease, like rickets (or Fleming, for that matter). So you see, Ed, I was practically compelled to write a quick response. Within a day or two I had a letter in the mail.

But the letter was not quick enough. By the time it got to Kennebunkport, Glencannon's trampship had already sailed; Paul was dead from a heart attack. In the jumble of sad thoughts that ran through my mind when I got the message was a childish disappointment that Paul never got my note—that he never knew that I knew Glencannon too. (If this sounds addled, it is.) Heaven knows, Ed, my letter was absolutely trivial; in missing it, Paul missed less than nothing. But the fact he didn't get it left me with the feeling that as usual he is one up on me—that I still owe him something. If you have Puritan ancestors, you're probably familiar with the feeling: There's something you ought to be doing; or, more likely, there's something you're doing that you'd better stop. In this case I thought I ought to be doing something for Paul.

Fortunately, those of us who are saddled with Puritan ancestors get pretty good at ignoring them. At least we don't very often do anything we ought to do. And left to myself, I would have done nothing more strenuous than drink a few ceremonial toasts with our friends. But then I had a long telephone conversation with Katherine Eaton. While we were reminiscing, Katherine asked me to write something about Paul—not a formal memoir but something informal and personal that his friends might enjoy. Katherine's request did it, of course. I can sometimes straight-arm the Puritans, but never the Cavaliers.

What follows, then, will be some of

my reflections on Paul, as we knew him at Caltech. They are not exactly random thoughts, since I have been mulling them over for a couple of months, but they are not researched either, in any conventional sense of the term—unless, of course, you call Winch Jones's stories or Chuck Newton's anecdotes research. (I call them slander.) I did indeed check out such vital facts as whether Paul's vintage convertible was a '39 Mercury or a '41 Ford (it was a '40 Ford) and whether his annual, personal Lent, when he gave up drinking, fell in March or April (it was in January); but I didn't even try to sort out such trivia as why he came to Caltech in the first place or who commanded the ships that he served on in the South Pacific campaign. The Paul that I am concerned with is the one that you and I (and several thousand students) knew personally; and for our purposes it would be more useful to find out where he got his saddle shoes and what possessed him to wear them (God only knows) than when he sailed on the *Ocelot*.

Paul's career at Caltech is, among other things, a refutation of a national cliché. The conventional patter says that during the 50's all college students slept quietly under Eisenhower, untroubled by creative thought or boat-rocking passions. This Sunday-supplement wisdom is probably false in general, and it is certainly wrong where Caltech is concerned. In the 50's and early 60's, Caltech students seemed never to sleep at all, except in class. Instead they spent their time devising ways to get into implausible kinds of trouble. Then, as now, they had a genius for what might be called creative destruction or constructive tort. When I mention the great plane robbery, the penetration of the SAC telephone system, the fake bank holdup, the burning palm trees, and the revival-meeting-cum-assault, you will remember what I mean. You will remember too that these, like the caper with the Washington rooters' cards, were only spectacular variants of a routine depravity—an ingenuity almost guaranteed to make a dean's life exciting, if not impossible. The most modest misdemeanor was apt to bring hot complaints from random citizens, and the more diabolical brought the Pasadena police, and, sometimes, the FBI. The Dean's Office, naturally, was the focal point of all the heat, both official and unofficial. There Paul, as Dean of Students, with his long-suffering colleague Foster Strong, separated the peccadillos from the felonies, soothed the injured or outraged, and sometimes arranged for bail.

Ingenious as it was, the planned misfeasance may have given Paul and Foster fewer headaches than the unintentional errors. Caltech students, it seemed, were just as apt to be ruined by their innocence as by their guilt. For one thing, few of them knew how to drink like gentlemen, and so they drank like trolls. They passed out in strange places, or showed up drunk and disorderly at very bad times. Whether horizontal or vertical, they were often sent back to the campus (and indirectly to Paul's office) along with a summons to appear, or else lodged in some Southland jail. This ritual was scarcely improved by the substitution (or addition) of pot. The new order of the late 60's merely added a legal complication to an established pattern. The stoned simply joined the plastered in the black books of hostesses, taxpayers, and police — and, of course, on Caltech carpets. Both types kept the deans well occupied.

So too did the unlucky or too-lucky lovers. In this area our Techers probably fared worse than they did as drinkers, and for the same general reason — social innocence. Though our raw troops fought gallantly they suffered grievous losses. Inevitably some of the walking wounded ended up in Paul's office. (Usually, I should add, they did not come for counsel or protection but because they were flunking out of school. At Caltech, an attack of love is even more lethal to grade point averages than a passion for bridge.) From time to time, then, Paul found himself treating some very advanced cases of emotional and academic gangrene.

For dealing with delinquents, whether intentional or inadvertent, Paul probably had the ideal bearing and temperament. Large, ruddy, and imposing, he was ordinarily something like twice the size of the weedy sinners he confronted. Beyond that, there was something in his air, perhaps a faint tang of salt, that suggested a vast fund of worldly wisdom. Without any words at all, Paul's manner could convey the essential message: "Don't snow me, Jack, I'm a fellow member." It also conveyed another vital fact. It said (truly enough) that Paul could *understand* almost anything and that he could forgive a great deal, if the accused was willing to begin by telling the truth. What it did not convey, immediately, except to the most perceptive, was the further fact that Paul cared much more about getting young men out of trouble than about confecting punishments or making examples. Though a veteran sailor (sometimes called "The Admiral" by George MacMinn), he was no relative of Captains Bligh or Queeg. This fact many Techers were to learn by experience.

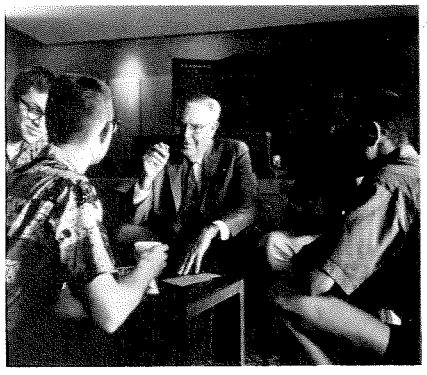
No doubt much of Paul's essential wisdom in dealing with people was instinctive — or buried so deep in a non-neurotic childhood that it might as well have been hereditary. Perhaps some of it — the part that was unsurprised by any possible depravity — derived from his Congregationalist ancestors, who had a great deal to say about original sin (though without a Caltech background, they could scarcely have suspected how original sin can be). And some of it probably came from books, or at least from the antecedent human interests that led him into history and literature. But he had two experiences that gave him a special advantage in coping with the problems of Caltech. One of these, of course, was his hitch in the wartime Navy; the other was his long association with MIT.

From the Navy he learned the standard military lessons: the evils of red tape, the boredom of long lines, and the soul shrinkage that comes from being reduced to a number. He also learned something about command responsibility and the art of selective blindness —

summarized neatly in the phrase, "Don't ask questions you don't want to know the answers to." Naturally he became thoroughly familiar with the standard brands of character deviation and the almost ritualized misdemeanors of young men cut off from their familiar environments. Perhaps more important than all this, he learned (or relearned) that 18-year-olds must be treated as adults, even when they are not. This is a lesson, by the way, that naval officers, who sometimes bet their lives on teenage gunners, find easy to remember. In any case, when Paul came to Caltech he did not confuse our students with Eagle Scouts, and he did not feel that he, or Caltech, was to serve *in loco parentis* (like a crazy parent). Long before the students of Berkeley attacked the "sandbox" principle in the streets, Paul was treating Techers as if they were both adult and responsible. Wes Hershey tells me, incidentally, that Paul's errors as a dean were all on the side of salutary neglect and non-intervention. In staying off the backs of the students, he sometimes missed telltale symptoms of ultimate trouble; and, on the other side, he sometimes let a young responsible adult stay overnight in a cold jail.

From MIT Paul learned the peculiar ways of scientific institutions and the even more peculiar ways of the people who inhabit them. Although his Caltech career was to show him a few elegant variations in exotic behavior, he had already encountered the basic types of the scientific egghead at MIT, where several of them were discovered, if not manufactured. At MIT he had also acquired a fundamental understanding of the unrelenting pressures—institutional, parental, and self-generated—that afflict students in science, and he had developed an abiding sympathy with the victims. At Caltech, Paul's sympathetic understanding often sent him to bat for some strange and unpromising characters — sometimes with happy results. He became, in fact, along with Foster, something like defense-attorney-in-residence for the battered and bruised.

This truth I learned the hard way. For three years it was my misfortune to serve as chairman of the Committee on Academic Standards—in other words as commander of Caltech's firing squad. This job, which transformed me almost overnight from a naive optimist to a naive pessimist, combined all the official joys of a judge and a county coroner. Before our Committee came Caltech's academic delinquents, and it was our task to reinstate the salvageable and to expel the hopeless. The problem



of deciding which was which, I hardly need add, used to give some of us nightmares, and our sessions sometimes resembled autopsies, except that the corpses kept talking. One might have supposed that Paul's long years of dealing with academic failures would have provided him with a thick layer of scar tissue and hardened him beyond mercy. In fact, however, he was at least as reluctant to give up on a student as any of us—and as a group, I like to think, we were the most reluctant band of executioners ever assembled. Furthermore, as chief investigating officer, Paul provided us, at times, with extenuating circumstances and found rays of hope that were practically invisible to less practiced eyes. I used to think he could do a good job in defending Jack the Ripper. (And I *know* he could do a good job in defending Benedict Arnold.) Paul's assurance that a student was a "good citizen" and that the academic errors were retrievable carried a great deal of weight with us. Sometimes, of course, he (and we) erred on the side of optimism, and we were later forced to expel our errors; but more often than not he was right. When at Commencement he presented the graduating seniors to Lee DuBridge (I hope you can visualize him doing it), they usually included one or two men who owed their Caltech degrees to Paul's understanding and support.

If so far I have made Paul appear as the superintendent of a sanitarium, the impression is essentially correct—and I have not even mentioned our hardcore weirdos. (An essay on this latter subject, incidentally, would be a real contribution to Caltech history. If the libel laws are not too stringent, maybe Jim Adams, Marty Tangora, or Brad Efron, or some other part-time genius, will write one for us—beginning, perhaps, with a sketch of Bernon Mitchell, boy defector to Russia.) But the funny-farm aspects of Paul's job are only a small part of the Caltech-Eaton story. As John Weir pointed out long ago, the Caltech students and faculty, though sometimes capable of behavior that would startle Sigmund Freud, are nevertheless on the average much *nicer* than most people. They may be, John implied, among the nicest people in the world. Among their many virtues, which include a high degree of honor and integrity, is a great toleration for individual differences, not to mention eccentricity. The fact that the students can tolerate their professors, and vice versa, is a good example of this, as is the fact that students and faculty often get along together as if the generation gap had never been invented. At most universities, the aim of right-thinking students is to go through college without ever seeing a dean; at Caltech, students sometimes go to see deans on purpose. In Paul's case, they used to invite him to parties and they were often seen hobnobbing with him in the halls or on the Olive Walk or on the fringes of some athletic field. No one, I hasten to

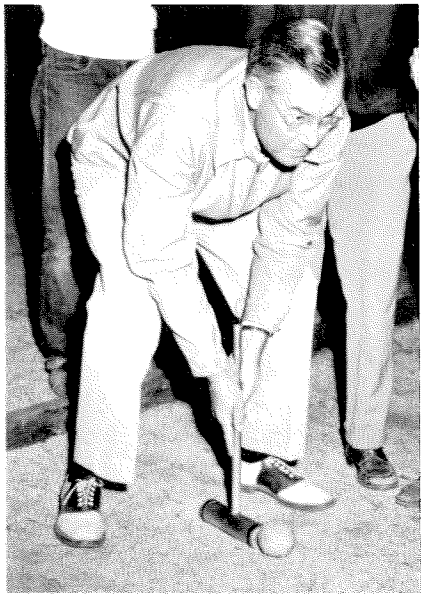
add, ever mistook Paul for Mr. Chips, or dreamed that he fancied himself one of the boys. But the qualities that made him a joy to his cronies—his wit, his uncommon common sense, his lack of pretense, and his quick perception—were obvious enough to anyone. Now and then, as a representative of Administration (with a capital *A*), Paul may have been regarded as a threat to romance, free enterprise and the good life, but generally he was perceived to be on the side of his troops. And any fool could see that he was a great addition to any licit social occasion.

If all this sounds idyllic, I must point out by contrast that Paul and his brave co-adjutors never succeeded in silencing the complaints about student-house food, and that Paul paid for his friendships and his enthusiasms with thousands of hours in committee sessions. This last subject is almost too monotonous to contemplate. I can see him now, stoical as Marcus Aurelius, trying not to yawn or let his eyeballs film over while one of the campus orators explained the obvious for the fifth time. When we remember how little patience he had with waste motion and what a good ear he had for detecting rhetorical Mickey Mouse, it seems there ought to be a way retroactively to relieve him from about twenty committees. In fact, however, he was practically indispensable—not only because of his official position but because of his good sense and general savvy. Everyone from Albert Ruddock to the janitors trusted him, and everyone seemed to feel safer when he helped make decisions, especially decisions that involved real live people. Perhaps some of us felt that any college dean who could marry an actress—and stay married—possessed a special brand of worldly finesse. At any rate, we all knew that we needed his judgment. If he was not always right (our feeling ran), he was always sane.

For anything like an adequate report on Paul's adventures as a professor of English, we would need to hear from his students. On this subject the impressions of his long-time colleagues, like Hallett Smith, Beach Langston and me, don't really count, except perhaps as testimony that Paul himself enjoyed his classes. On the subject of his literary tastes and enthusiasms, however, we could probably talk forever, especially since they help to define him. In literature as in life, Paul preferred substance to style and realism to undisciplined or egocentric imagination. Although he loved a well-turned phrase or a vivid metaphor and could produce an apt quotation at the drop of a pun, what he really cared about was character and action, and the ability of great artists to illuminate these. This taste is hardly surprising, since at Caltech he was forever dealing with characters in action, but it should be considered as a part of a more general view. The notion that art is an autonomous realm that deals only with esthetic values was as foreign to Paul as it was to Aristotle or Matthew Arnold. Paul would have subscribed, I'm sure, to Arnold's dictum that poetry (or literature) is a "criticism of life," although I hasten to add that Paul had more red blood corpuscles than Arnold and Aristotle put together.

Naturally, then, Paul loved great story tellers, great scenes, and great dramatic characters. Naturally, too, he had soaked up Shakespeare like a sponge. (Beach may remember how he baffled us one day by declaiming Rumor's long speech in Henry IV, Part II—a passage that neither Beach nor I, who had both taught the play, could even place, much less recite.) But along with the acknowledged masters of plot or characterization, like Chaucer and Dostoevski, he admired a lesser group of authors whose work seemed to have a special relevance to his own experience. These were apt to be sociological or historical novelists like Marquand, Kenneth Roberts, or C. S. Forester, and they were apt to write about New England or the sea, or both. It should not have surprised me, by the way, that Paul remembered Glencannon's phrase. Guy Gilpatric, the author, was not only a writer of sea yarns but a first-class wit; and Paul loved wit almost as much as he loved the sea. As all Paul's friends can attest, he was a formidable wit himself. His one-liner, for example, about a certain New England school probably deserves to be engraved somewhere in brass: "I didn't have a college education, " he quipped one day, "I went to MIT."

Paul's interest in character and action gave him a passion for biography and history to go along with his strictly literary interests. Here he had an advantage that he shared with many bright and sensitive Yankees. He seemed to have absorbed a great deal of history through his pores. Like his Mississippi counterpart William Faulkner, he was almost as familiar with the Civil War generation as with his own—with the difference, of course, that since the Yankees won and the Confederates lost, Paul didn't have to agonize over the subject. Significantly, Paul's absorption with history never threatened to derail him somewhere in the past, say in 1863; it seemed, in fact, to orient him in the present. Although (with a little help from his friend Carl Niemann) he could name General Meade's officers down through the colonels (and maybe



the majors), he seemed more solidly contemporary than many people whose knowledge of the past begins with the Kennedy Administration.

Where Paul got his knowledge of naval history I don't know. I can only testify that it was both detailed and technical, and that it was not limited in the least to the exploits of the Americans, or to the tales he picked up on stern and rockbound coasts. I remember with bemused admiration how he stunned me once by coming up with the name of the Dutch man-of-war that broke the boom across the Thames during the Anglo-Dutch conflict of the 1660's. For all I know he could have named the Carthaginian naval commanders in the Second Punic War. I'm sorry now I didn't ask him. Along with the military history, of course, went the stories of the fishing boats, the whalers, and the clipper ships—the things all good New Englanders are supposed to know, whether or not they ever read *Moby Dick*.

It is characteristic of Paul's temperament that although, in one sense, he was as New England as clam chowder, he was not in the least a professional New Englander. He moved outside all the stereotypes created by tradition or art. Even his accent was hardly identifiable. He could have stopped by the woods on a snowy evening without remembering that he had promises to keep and without wondering what his horse or the neighbors thought. He was not afflicted with ancestor worship, although he found Yankee characters endlessly interesting.

Perhaps he found courage and character essentially timeless; perhaps as a man of action and a solver of problems he could never take defeatism seriously. At all events, he loved New England, past and present, and particularly the seacoast towns. Every summer, as we all remember, he used to head for Maine, where he could forget committees and concentrate upon wind, weather, books, family and the New England scene.

It is tempting, Ed, to leave Paul at Bar Harbor or Kennebunkport, sipping a bourbon and discussing the deployment of the stunsail with one of his fellow experts, but that wouldn't be fair to his friends at Caltech. For us it would be better to picture him at one of the many Caltech social gatherings he enlivened, perhaps swapping stories with George Mayhew and Art Small. Or, if we want something absolutely typical, we might choose some random day at the Athenaeum lunch table. Fritz Zwicky (in a mixture of Swiss and "goddams") might be explaining, with many illustrations, what a great genius he was (and he was). Ernest Swift might be telling us, in a Virginia accent, some true stories about early life at Caltech; and Winch Jones, in a California accent, might be telling us some elaborate false ones. Boney, naturally, would be witty in his Americanized French, and Carl Anderson would look incredibly wise, without saying a word in any accent. Meantime Paul, who was a connoisseur of this polyglot nonsense, would be laughing at intervals, amending Winch's most outrageous statements, and adding a few wisecracks of his own.

But although the scene is typical, and though I suspect that heaven for Paul might include some Caltech dialogue, we can't leave him at the Athenaeum either—even if the food were twice as good as it used to be and his friends twice as witty as they are. Paul's great contribution to Caltech, after all, was not the aid and comfort he gave to his friends in the faculty, but the support he gave to his gallant battalions (often out-gunned, but never out-thought). And for this, one simple scene will do.

Paul, as you may remember, had nothing but contempt for "mature" baseball fans. He thought, in fact, that the phrase was a contradiction in terms; and he looked upon Bill Corcoran, Ray Owen, Bob Oliver, and me (for example) as more or less amiable cases of arrested development. Well, one afternoon ten or twelve years ago, when we still had a baseball stand on the west side of Tournament Park, I strolled over to catch the last few innings of a weekday game between Coach Preisler's squad and Pomona—if I remember rightly. Anyhow, when I walked around the south end of the stand, I saw a sight that stopped me in my tracks. The only person sitting among all the rows of empty seats was Paul Eaton. All alone there, he was something to contemplate; and even then I recognized a symbol when I saw one. Paul, I knew, hardly cared at all whether we won or lost, and he cared even less how we played the game. What he cared about was the fact that the troops were engaged, that they were having fun, and that for a couple or three hours the weight of Caltech was off their shoulders. I can't remember now, Ed, whether I even went up and spoke to him. At worst I didn't clutter up the scene very long. Laughing to myself and mentally saluting, I walked away and left him there, where I think we should leave him now—hearing the traditional yelps of encouragement to the batters and watching the outfielders lose fly balls in the afternoon sun.

Yours,
KENT

Airline Regulation

...continued

the CAB, and if regulation benefits *anyone,* we should not be surprised to find his constituents on the list. United finds this small investment in political peace to be well worth its while.

The required-service argument can reach preposterous proportions. Some years ago American Airlines claimed that they were losing money on all of their northeast corridor routes—Boston to New York, New York to Washington, Boston to Washington, and the like—and that they needed increased long-haul profits to make up for their losses. But they were operating many flights per day at the time, and they were making no effort to cut back service. They were not even petitioning the CAB to delete those cities or that service from their system. I would conclude from this behavior that they thought they were making an adequate profit on those routes. They could certainly have cut back service, and they could have requested to be taken out. I have no doubt that Allegheny would have been very happy to serve the routes, having struggled for a long time to get such plums as Baltimore to Boston.

The fact is that the carriers do not now use the profits on their long-haul routes to support their short-haul service, and that the system, such as it is, is not held together by the glue of regulation. Trunk airlines continue serving the cities they serve because by and large it is more profitable to serve them than not to serve them. This is precisely the regime I suggest should exist in deregulation; the only difference is that they would have a wider choice of routes and they might be different airlines—airlines that could operate at lower cost and offer lower fares.

In fact, one odd result of regulation is that the airlines are not making very much money even under the present system because they are free to add as many flights to profitable routes as they wish to, and it turns out that passengers who like frequent service are well worth competing for. The way you compete for them is by flying the planes with 30 to 40 percent of the seats full—at which point you cover costs but don't make very much money—rather than flying the planes in a way that's much more efficient, including fuel-efficient (namely, much fuller), on less frequent schedules. At $178 coast to coast, it doesn't take many passengers to pay for another flight. So you fly them frequently and mostly empty. If the rates were much lower, the planes would be fuller because airlines couldn't afford to fly them empty. Passengers would get what they prefer—namely, low rates; the airlines would make the same amount of money they do today, we would use many fewer resources, and everybody would be better off.

How do I know this? Well, I know that most people, when given the choice between frequent flights at $178 and infrequent and full flights at much lower rates, choose the latter. For example, they are willing to join bird-watching societies and Scottish-American friendship clubs, and all the rest of it, just to get a cheap ride to Europe. There's nothing quite so inconvenient as paying your dues to the bird-watching society and getting on a plane in Long Beach when you really want to get on at L.A. and getting off at Glasgow when you really wanted to go to London, but the fact is that people do it, and they do it because the fares are low. And they do it notwithstanding the availability of much more convenient service at higher prices. So I deduce that most people would prefer to pay less and suffer some inconvenience.

This is particularly true in vacation markets. Indeed, it is sometimes argued by the airlines that of course deregulation would work out very well for the bulk of people going on vacations, but it would not work out very well for the businessmen who need scheduled service. Well, I find businessmen, whose fares are after all tax-deductible and built into the cost of whatever products they sell, a rather odd object for public bounty—especially for bounty that is raised at the expense of steelworkers who want to go visit their families on vacation, or even starving academics who like to tour the culture spots of Europe.

I think people who want scheduled service should pay for it, and I think many of them will. Probably not as many of them as pay for it now and who don't need it very much, but indeed that is the very point of the deregulation argument: Many people are buying things they don't need because they don't have any choice. They're buying better meals than they want, they're flying in emptier airplanes than they choose to—and even the emptiness of the planes is understated. We read, for example, that only 50 to 55 percent of the seats are occupied. That's true, but what we don't state is that because of regulation we have many fewer seats in the airplane than we could have. The most common configuration for a DC-10 in the U.S. is with about 250 seats in it. It was designed to carry approximately 350 people. So to fly with 50 percent of 250 seats occupied is to fly with 125 or so people in a plane that was designed for 350, a 35 percent load factor.

How does regulation cause this? It keeps fares high so that the airlines can afford to operate flights with relatively few passengers aboard. This enables them to offer frequent service at high levels of amenity. Since no one can fly less comfortably and conveniently at a lower fare, passengers take the most comfortable and convenient alternative at the higher fare. If you have to pay the fare anyway, you might as well leave exactly when you want to, drink the champagne, and stretch your legs out. And since the fare is pegged at the high price, that is how the airlines compete for your business.

What would the system look like if we deregulated it? First of all, notwithstanding predictions of chaos, there would be relatively few firms in each market. There might be only three or four airlines operating between New York and L.A., but they would be chosen by the market instead of by the CAB. There would be many more firms in the industry as a whole, each serving

continued on page 30

Airline Regulation

...continued

fewer markets than at present. Because of the CAB's restrictive entry regulations, airlines right now are probably considerably larger than they would be under competition—in fact, inefficiently large. If you look at the cost levels of various airlines, you find that many medium-size lines have lower costs than large carriers. Continental and Braniff, for instance, have lower costs than larger ones like American and TWA. There probably is some maximum size level beyond which you get too many vice presidents to be worth paying for.

So there would be fewer firms in each market but many more firms in general in the business. This is very important because that is one of the keys to the success of the scheme. It suggests that if in any market there is not efficient service or prices are too high, there will be many others around, able and willing to offer service in that market. This will tend to make sure the consumer gets the service he wants at the lowest price consistent with the service he wants to buy. It's simply the fact that entry is so easy in the business that makes deregulated markets work. In fact, entry is easier in this particular industry than it is in many businesses that operate satisfactorily in unregulated fashion.

Generally speaking, we would ultimately have many more aircraft, but probably flown on less frequent schedules in any particular market. We would have some deluxe service for those people who are willing to pay very high rates for very high standards of service. There is no reason why they could not be accommodated, either in the front of an aircraft that is sort of like a cattle car in the rear, or in aircraft operated for their exclusive delectation. After all, we have both expensive hotels and Holiday Inns—and we have hotels less expensive than Holiday Inns. I imagine we would have lots of inexpensive airlines, or the same airline offering a choice of very high standard and very low standard service.

I predict that relatively few travelers would pay the rates that high standards of service cost, considering that they're only going to spend a few hours on the plane and that the plane is not a form of final consumption for most of them. It's just a way of getting where they want to go. Some of us like riding around in airplanes, but not many.

In terms of the system, we would see it tailored to the needs of the public. There would be immense amounts of service between cities like L.A. and Chicago, and probably less from, say, San Diego and Cleveland. If it was necessary to provide some service for social reasons, if you think someone living in Williston, North Dakota, or Sidney, Montana, is somehow deserving of a subsidy, then you could simply contract with firms to provide two round trips a day from Sidney to Bismarck, or wherever it is those folks go. This could undoubtedly be done less expensively than it is in the present scheme, where we restrict the operation of the whole market in an effort to insure service to Sidney.

Aircraft would be better tailored to the actual cost of providing service. In the history of the development of airliners we have had numerous aircraft that were developed for regulated markets that could not have existed in unregulated markets. An example is the DC-7, whose operating costs were 10 to 20 percent higher than its predecessor, the DC-6B, but which had the single virtue of being able to fly nonstop from coast to coast. An airplane like the Convair 990, which was ordered by American Airlines and on which General Dynamics lost a great deal of money, was ordered because it was to be 50 miles per hour faster than the competition, even though it had considerably higher operating costs. It should never have seen the light of day, and would not have if its higher operating costs were expected to be reflected in higher fares.

Needless to say, the Concorde would be very unlikely to succeed—to even be contemplated—if one had a deregulated international environment. The fare difference between its service and the subsonic alternative would be so great that it would be very difficult to persuade anyone to buy it.

As an aside, I think very few people are aware of just how cheap airplanes are—how efficient they are at providing transportation. The direct cost of moving large numbers of people in the large subsonic aircraft we have today and at today's fuel prices—including paying such costs as depreciation on the plane but not for things like the reservation system or the salary of the president of the airline—is about one cent per mile. We obviously need to allow for indirect costs. You have to have some sort of reservation system, you have to have someone running the airline, and you probably won't fly with all those seats full. So you have to make the appropriate adjustments. That's why I think that long-haul fares are probably in the neighborhood of 2½ cents a mile in a deregulated environment. But most people who are interested in deregulation think I'm a bit visionary about that, and I may be on the low side. It may only be 3½ cents a mile.

In a deregulated environment we'd certainly see some changes in fare relationships. We would see a reflection of the phenomenon that it's cheaper to haul 500 people over 1,500 miles than to haul 50 people over 500 miles. And the fare might well be cheaper for the long haul than for the shorter one. There's nothing immoral about that; it just reflects the economics of operating airlines.

Finally we'd see a simpler fare structure. There would certainly not be the enormous proliferation of excursions and special fares—stay 14 to 22 days and reserve 90 days in advance and travel only during the bicentennial year—as we have at present. You'd probably seek peak- and off-peak-hour structures, because you need to have the capacity to provide the daylight fare. You need to fly businessmen around in the daytime. And once you've paid for the airplane, all you have to do is pay for the fuel, additional maintenance, and the pilot; then you can fly around by night quite cheaply.

In vacation markets, actually, the reverse might be the case. The weekend fare might be higher than the weekday fare, as it is in the San Juan market, because people want to start their vacations on Fridays and end them on Sundays; and in those markets where you have some measure of cost-price relationship, it's cheaper to fly during the week than on weekends. In business-oriented markets the opposite would be the result.

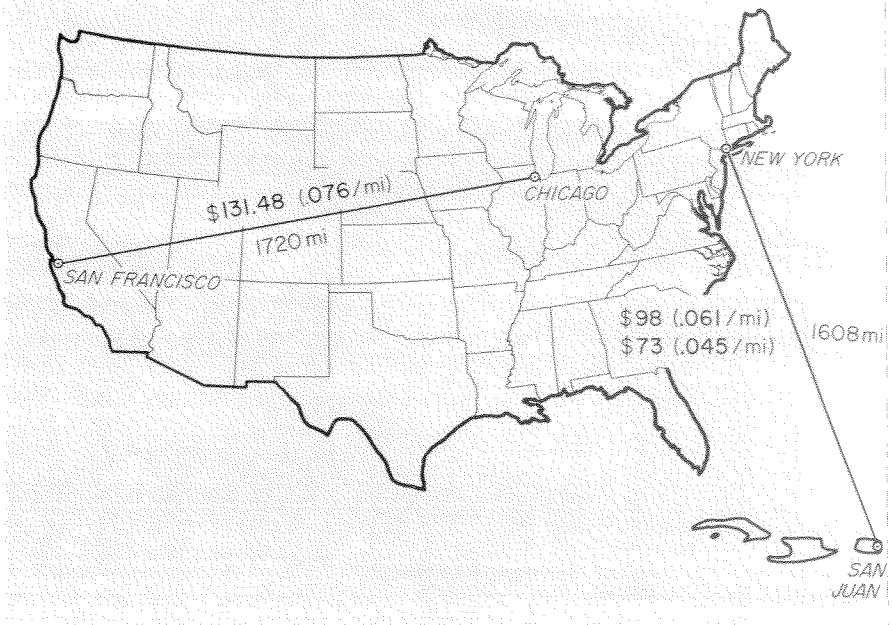
You would still see some fare differentiation, but you would not see promotional fares like the present ones, which are designed to keep the basic fare level very high (to force people without very many alternatives to pay the highest fares possible) and then to use restricted low fares to catch a few more people who are turned away by the high fares.

Is any of this likely? I don't think so. Having painted this vision of Beulahland, I'm sorry to report to you that we are unlikely to get there. There is just too much at stake in the present game for politically organized interests. The airlines like the present system because even limping along is better than going out of business for managements that would not survive in a deregulated environment. The aircraft manufacturers like regulation because in the short run they sell more airplanes that way. If you're going to offer too many flights, you need aircraft to provide those flights, so business will be relatively good for an airplane manufacturer.

I believe that, over the long run, people want to travel so much that if we were offering coast-to-coast fares for $50, we would see market expansion of a kind we can barely imagine now. So ultimately we would end up producing more airplanes, not less. But people with large investments in engineering staffs and facilities tend not to be comforted by the vision of a rosier future—especially when it's beyond a rather bleak near-term present—and they see deregulation as producing a rather bleak present.

The regulators like their jobs. And Congressmen like to be able to provide service for their small-town constituents, using subsidies difficult to quantify or trace.

EVEN WITH THE CAB'S REGULATION, WHERE NEW ENTRANTS HAVE BEEN PERMITTED, FARES ARE LOWER.



Only consumers are interested in airline deregulation—or ought to be. But unfortunately they have been taught that we need regulation to protect us from rapacious businessmen. People educated that way are unlikely to put much pressure on their elected representatives for deregulation. They will talk about regulatory reform and getting people in there who will really crack down on the airlines, but in my opinion the incentives of regulators and of airlines are such that it's very unlikely that any amount of regulatory reform will, over the long term, produce the kinds of results we want.

The Ford administration has sent an airline deregulation bill up to the Hill which doesn't do everything I'd like but which would undoubtedly improve things. It would make it easier for an airline to offer low fares, and it would make it a little easier to get into the business. But I think even President Ford has figured out that he is not going to beat Ronald Reagan for the Republican nomination on the issue of airline deregulation. So I don't think you'll see that bill pushed really hard. The committees that count—the Senate Commerce Committee and the House Public Works and Transportation Committees—are chaired by people who are firmly against airline deregulation.

So it seems to me that although we consumers would benefit greatly from airline deregulation, we will have to live with what we have for the moment. I would predict that perhaps the result of lectures like mine, articles that have appeared in the popular press, occasional letters to Congressmen, and the flurry accompanying the Ford bill will be that the Board will become a little tougher about fare increases and a little more lenient about letting some people marginally expand into the business.

Fundamental reform is what is needed, and unfortunately in this case fundamental reform would seem awfully radical. Free competition often sounds radical these days. It's rather interesting to hear people argue for free enterprise, the American way, and getting government off our backs, but it's very clear that in many cases the government is on our backs in a way that's very profitable to some of the people whose backs it's on. It's most unlikely that the airlines, at least, will be seen to stand up, shrug the government off their backs, and walk off into the new dawn of a free enterprise morning. □

Letters

Wrong Division

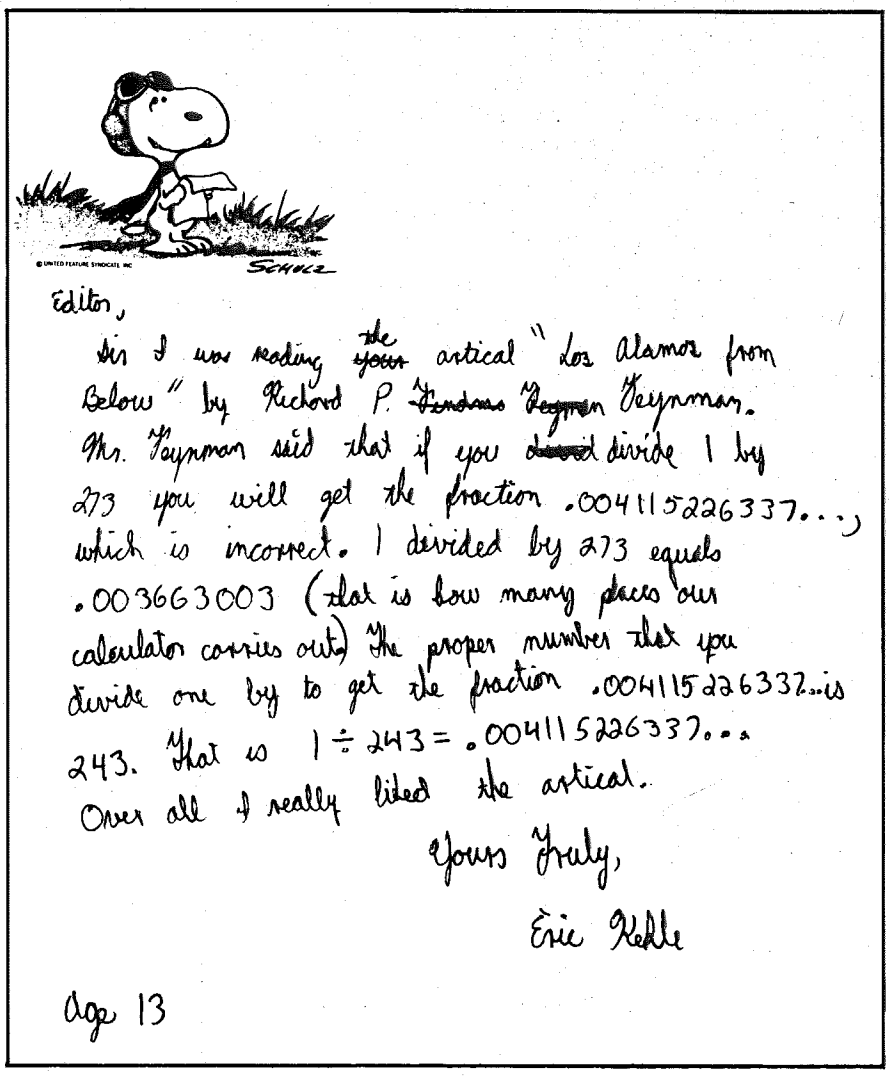
Philadelphia

Would you please ask Professor Feynman what kind of computer he used to divide 1 by 273 to get .004115226337? It doesn't appear that the 273 is a misprint, as it occurs again on the next page (page 18 of the January-February issue of *E&S*).

Digitally yours,

JERRY DONOHUE, PhD '47

Despite the fact that we got at least a dozen letters just like Mr. Donohue's, we did not ask Professor Feynman where he got the figure 273, because we *made the mistake when we were transcribing his talk. As to what the figure* should *have been–the best possible explanation came from Eric Kehle, whose letter is reproduced in full at the right.*



Great Men

Pasadena

Professor Feynman's "Los Alamos From Below" was a glorious and truly awe-inspiring account....But he is entirely too modest. Anyone smart enough to give the geniuses at Los Alamos the impression that he was a genius would have to be a genius to pull it off....

It is often forgotten that what makes the Great Men of Science the Great Men of Science in the first place is not so much a matter of having the right answers but of asking the right questions. You may not get the right answer, but you can't get any answer until you do ask—a point that is frequently forgotten by many young people. Feynman's reminiscences should be required reading for undergrads majoring in science.

It is too frequently forgotten that true genius is not a matter of IQ, but of personality and temperament as well....While Feynman professes to be mystified by Bethe and Bohr's lighting up like Christmas trees at his iconoclastic style, it must be borne in mind that that is exactly what the spirit of scientific inquiry is all about—the willingness to take nothing for granted and to challenge anything and everything....

The key to Feynman's greatness is precisely that he realized from the very beginning, down there at the bottom of the totem pole, that science by its very nature is not an answer but a question, and that the scneitist is not a person who has all the answers but one who is smart enough (and sometimes gutsy enough) to ask....

How did Feynman get to be Feynman? Simple. Feynman *was* Feynman, right from the start.

JAMES J. GLACKIN

Dear Hmmmmm

Garden City, Michigan

DEAR PERSON:

Would you please inform me of how I may acquire a copy of your June 1974 issue including R. P. Feyman's "Cargo Cult Science"?

Thank you,

TIMOTHY NORRIS

P.S. What is the proper salutation in this modern age?

We've sent Mr. Norris the copy of E & S he asked for–but we can't seem to come up with a satisfactory answer to the question in his P.S.

Any suggestions?

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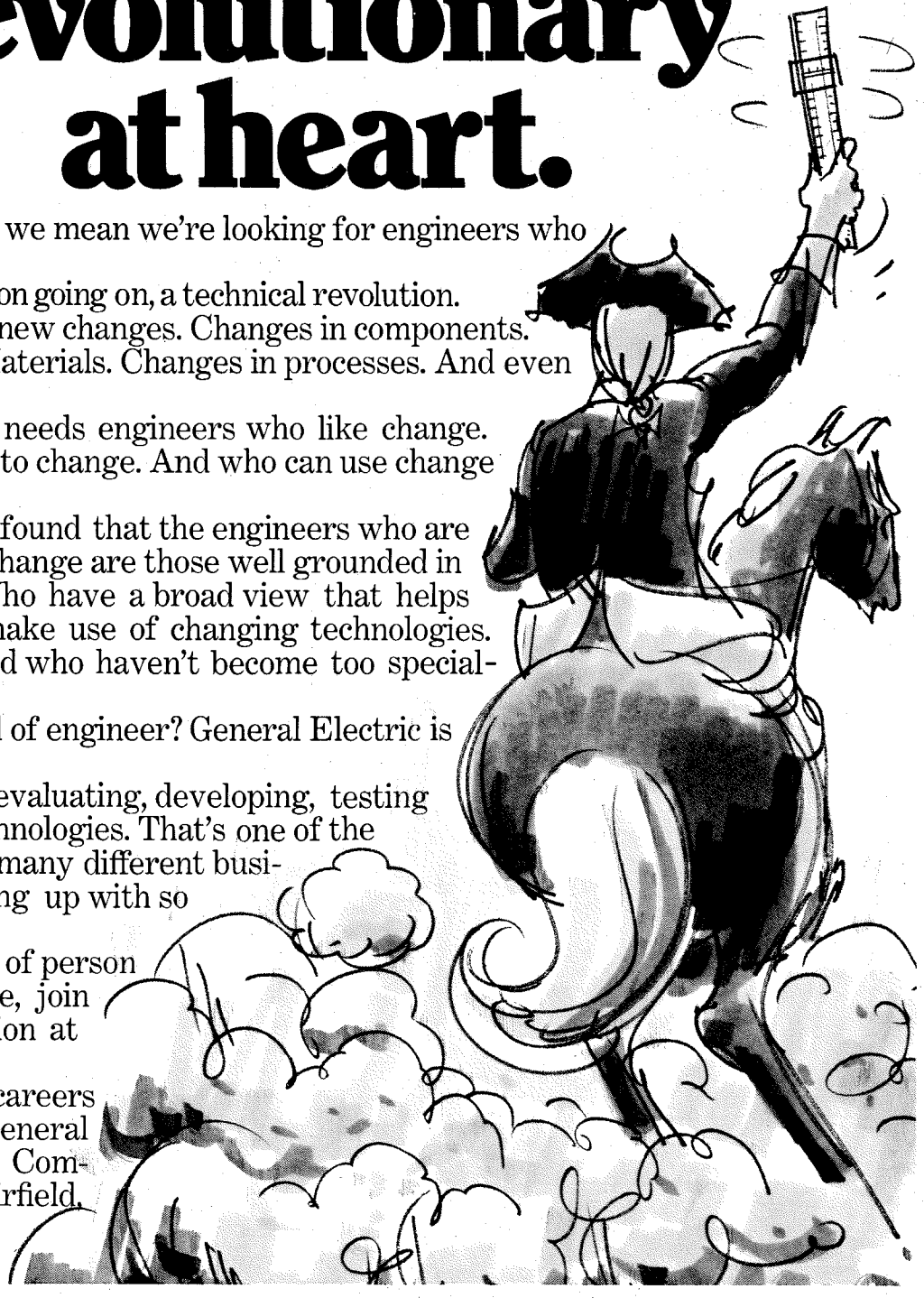

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