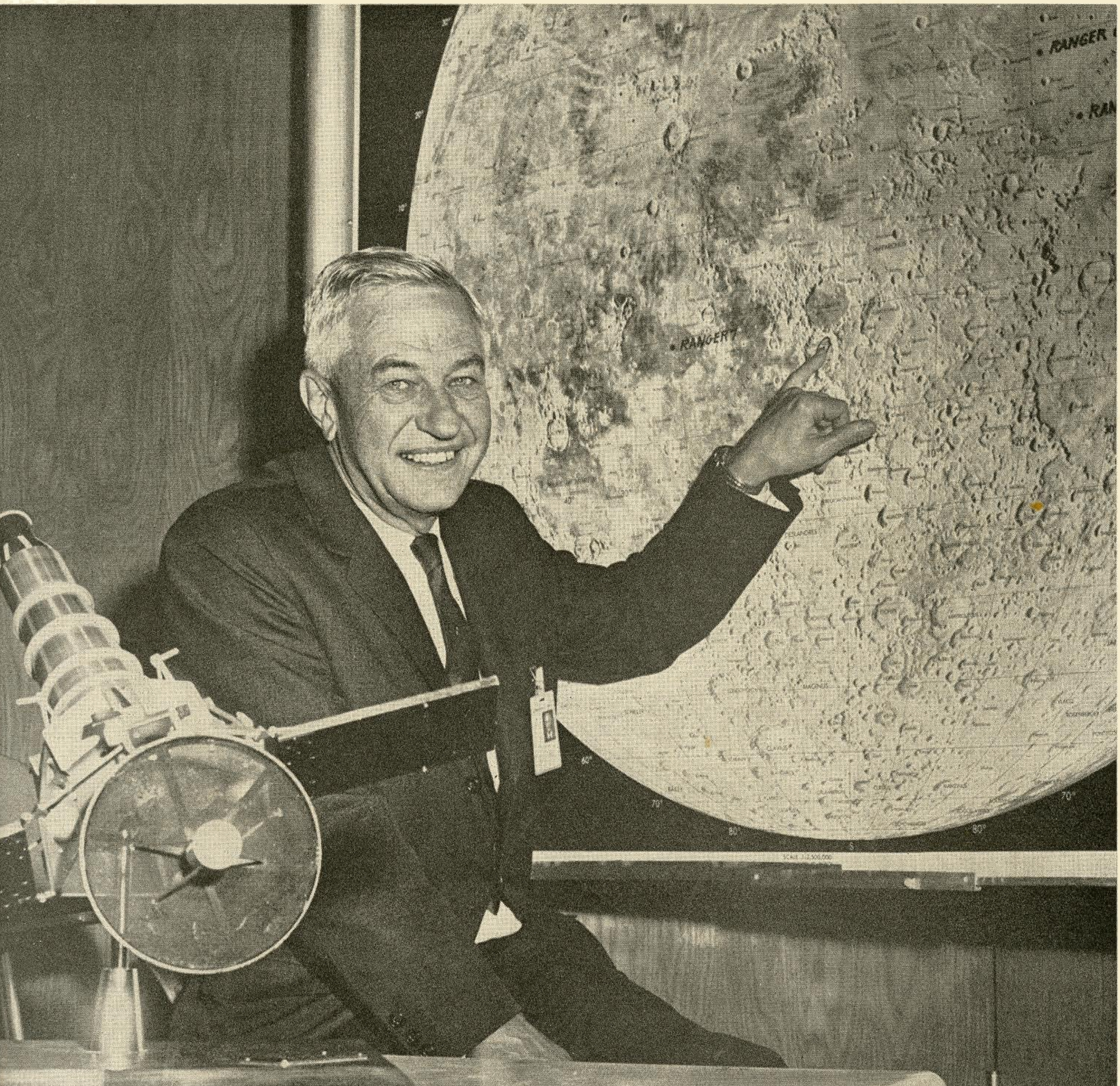
APRIL 1965

ENGINEERING AND SCIENCE



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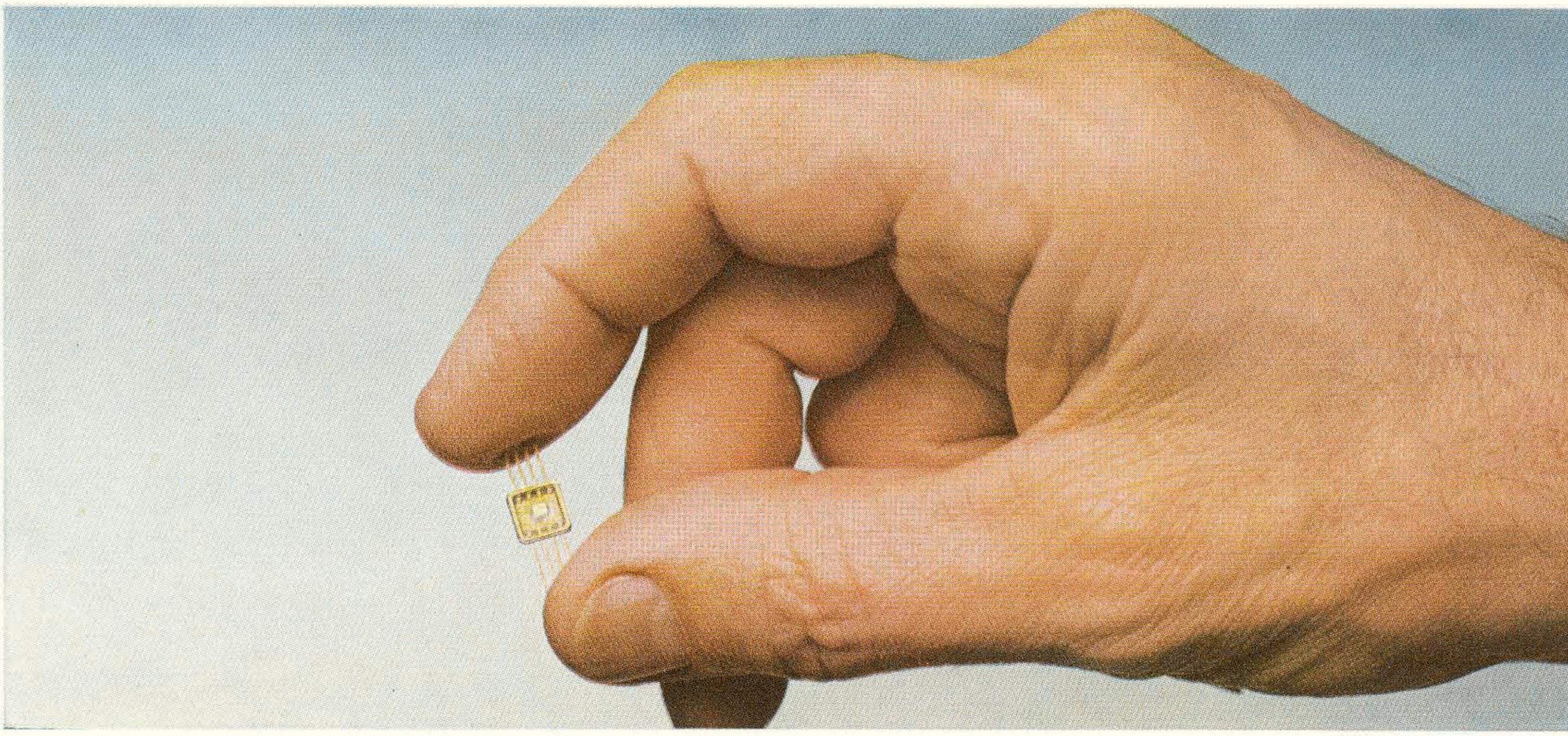
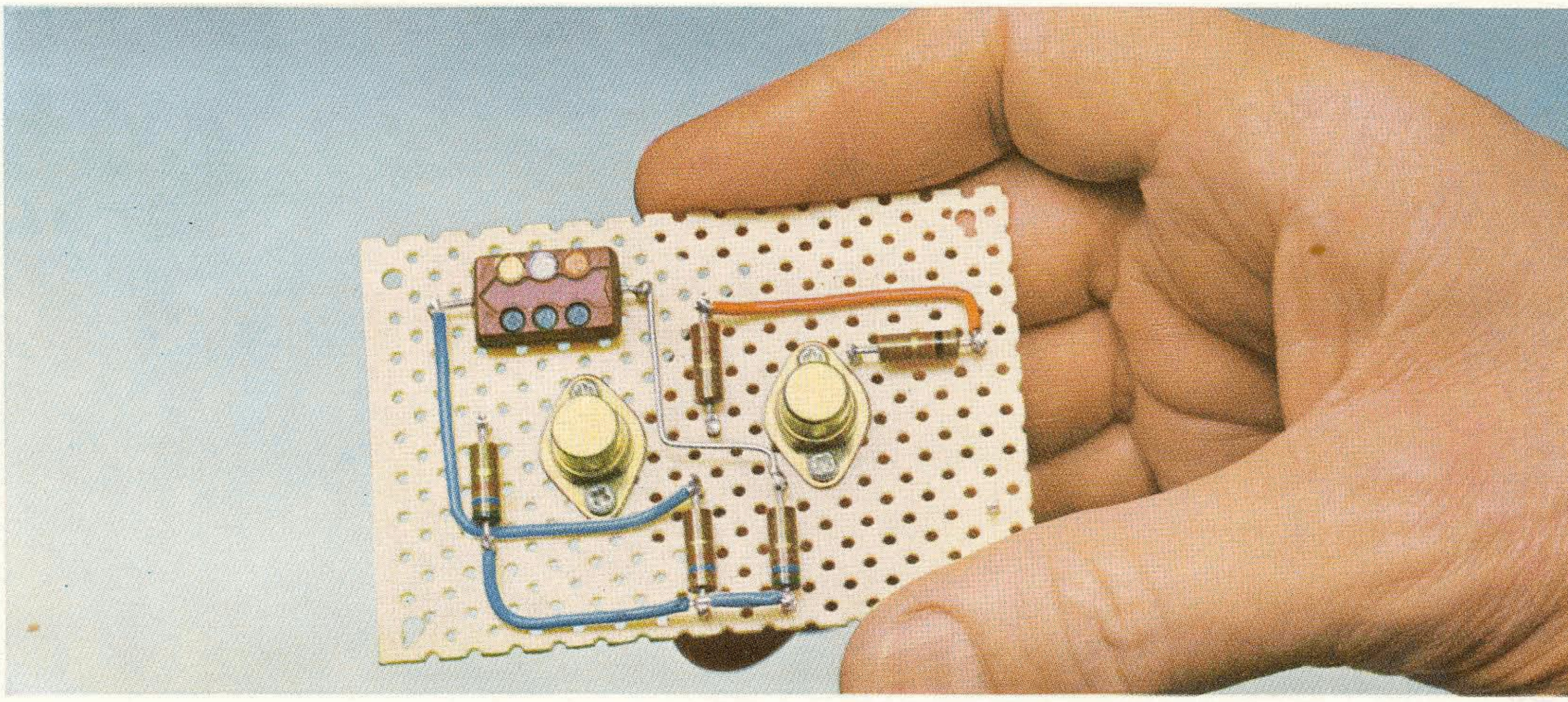


This tiny device is an ultra-reliable Westinghouse TV amplifier



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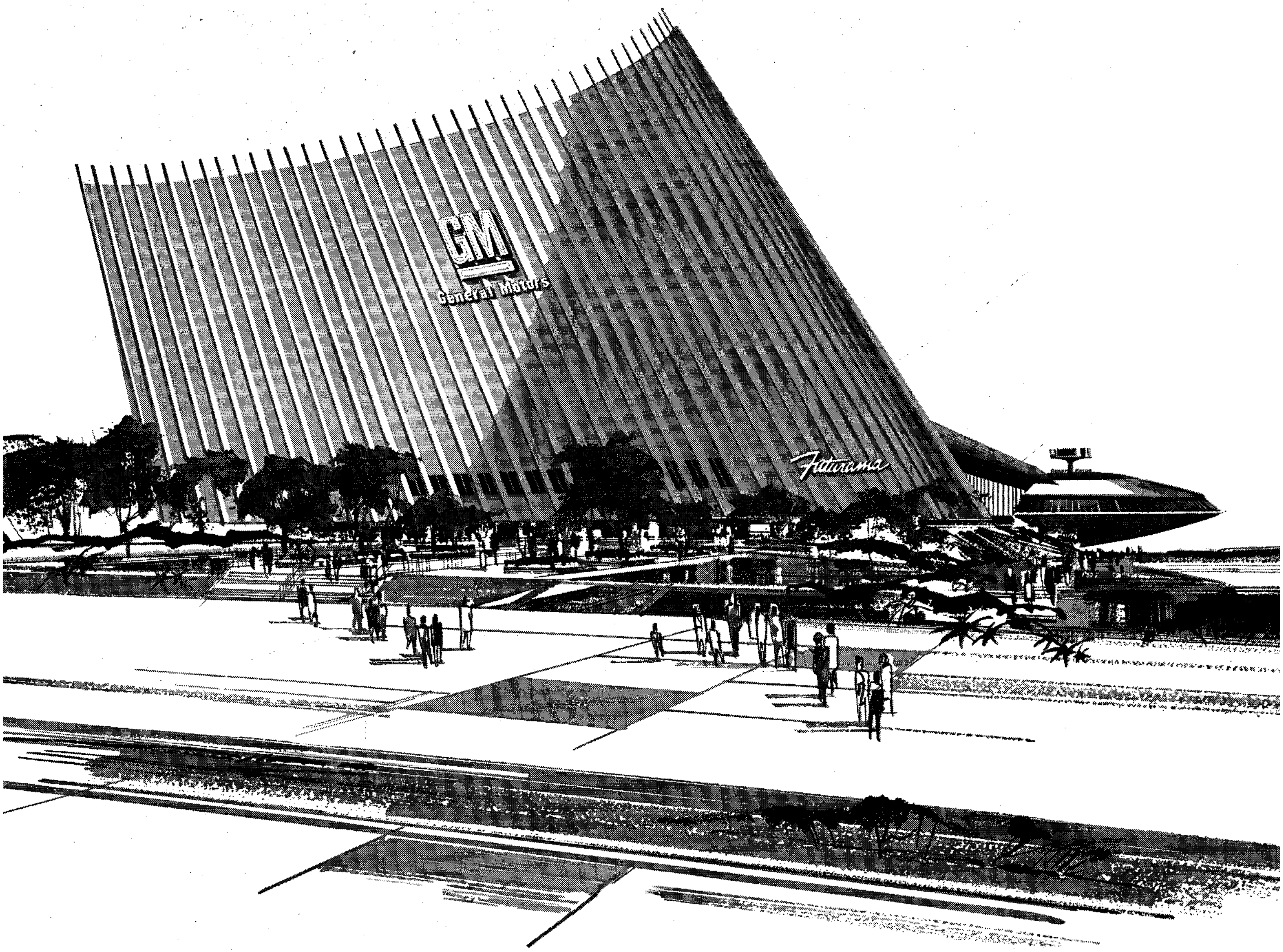

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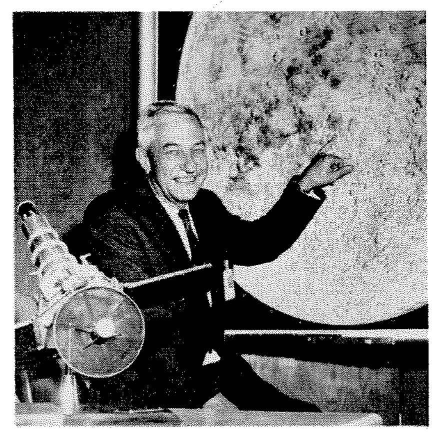


On Our Cover

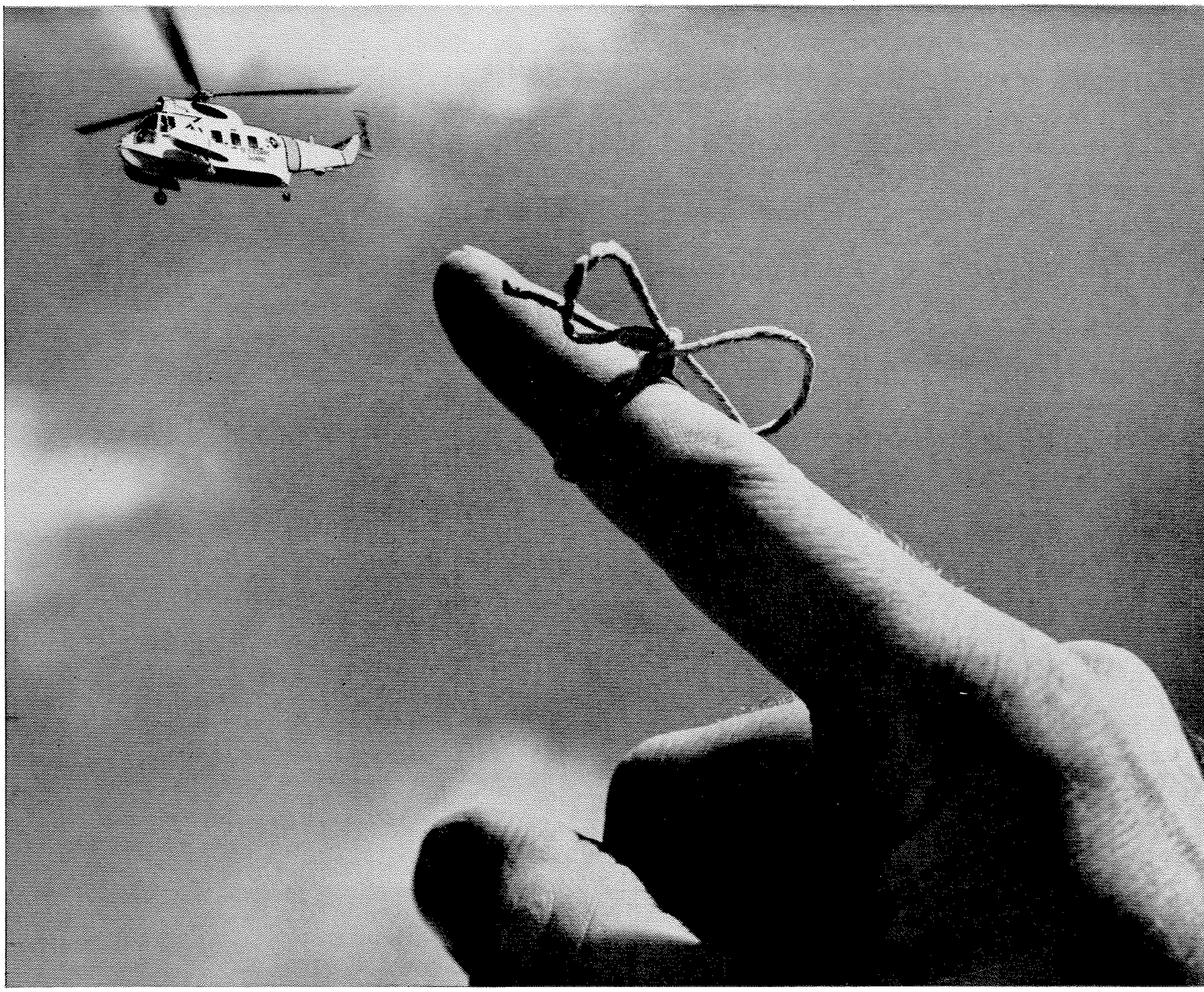
Caltech's President DuBridge happily points out the impact area of Ranger IX on a lunar map at the Jet Propulsion Laboratory. On March 24, Dr. DuBridge was on hand to watch the last minutes of Ranger's successful flight with JPL scientists and technicians, at the Laboratory's Space Flight Operations Facility.

Some notes on this final chapter of the five-year Ranger program appear on pages 11 and 12.

Dr. DuBridge is represented again in this issue, with "The Teaching Profession – Forty Years of Change." His article, on pages 6-10, has been adapted from an address given at the National Education Association conference in Washington, D.C., on April 8.

Computers and Humanity

were discussed at a YMCA-sponsored panel at Caltech on February 10, by Louis T. Rader, vice president of the General Electric Company and manager of its industrial electronics division; Simon Ramo, president of The Bunker-Ramo Corp; and Hallett D. Smith, chairman of the division of humanities at Caltech. G. D. McCann, director of the Booth Computing Center, served as moderator. Transcribed highlights of this stimulating discussion appear on pages 15-24 of this issue.



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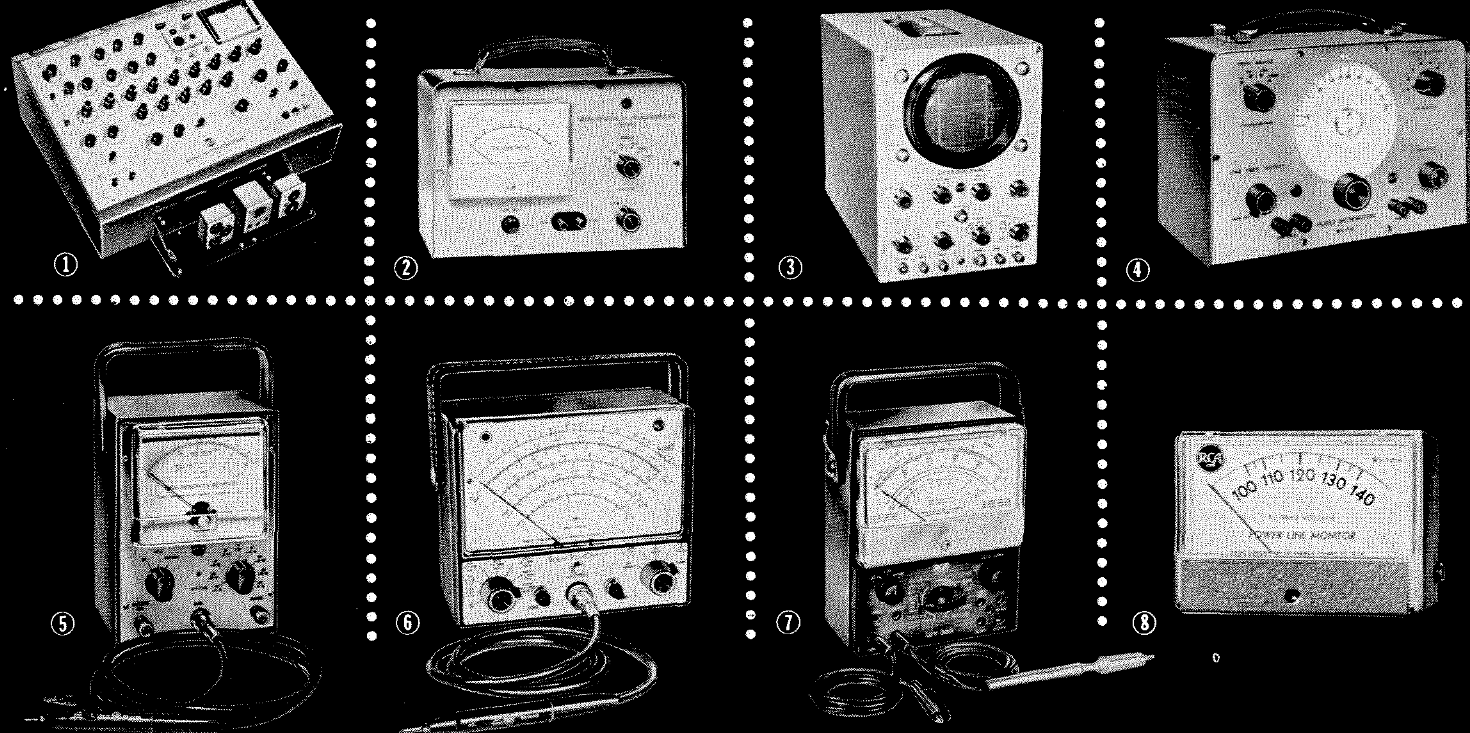

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The Teaching Profession – Forty Years of Change

Today, America is more alert to the values and problems of education than ever before in our history. As a nation we have always been devoted to education — but today the concern for more and better education permeates every aspect of our national life

by Lee A. DuBridge

During the past 40 years, the problems facing the American educational system have multiplied at a dizzy rate and have grown vastly more complex. Every time we think we have conquered one problem, we discover that a dozen new ones have appeared in its place. We are not even in the relatively happy position of the Red Queen in *Alice in Wonderland* who, by running very fast, could stay in the same place. In education, we seem to run twice as fast and still be going backward.

In the year 1925 there were about 750,000 students in colleges. Today there are 5,000,000. A good-sized state university might then boast of having 6,000 or 7,000 students, while today the same institutions would have 25,000. Nevertheless, I remember very vividly that for a young instructor in such an institution, which was small and cozy by modern standards, there was no nonsense about any eight-hour day or five-day week. I faced students in the classroom or laboratory for 20 to 22 clock hours each week, and graded papers and lab reports for maybe 150 to 200 different students. And *my* teaching load was fairly light because, between classes, and in the evenings and on Saturday afternoons, I was supposed to be carrying on some research – which, indeed, I did.

I am glad to say that at most major universities those days of excessive teaching burdens have passed. And yet, thereby hangs a tale which causes confusion and trouble to this very day.

In 1925 it was already painfully evident that the typical American university was no great shakes as a center of basic scientific or scholarly research. The tradition of teaching without research, and the

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This article has been adapted from an address given by President DuBridge at a conference sponsored by the National Education Association on "The Changing Face of the Teaching Profession" held in Washington D.C., on April 8, 1965.

tradition that the little research a university professor had time to do ought to be manageable on a budget of a couple of hundred dollars a year, had effectively prevented American universities from becoming the great fountainheads of new knowledge which the British, German, and French universities had become.

World War I had dramatically revealed this weakness, and by 1925 the winds of change were beginning to blow. The great American foundations (principally, then, Rockefeller and Carnegie) began making research grants and awarding research fellowships. Teaching loads were being lightened for those with interests and talents in basic research. And the spirit of scholarship was beginning to permeate the American university. The university was now *becoming* a university.

This was most fortunate, for, by the time of World War II, America had become a great scientific center, and our scientific talents proved a decisive element in winning that struggle. That very fact, in turn, stimulated the further encouragement of research and scholarship. Government funds became available in increasing amounts, until today they largely support our very expensive and extensive scientific research activities. Private and state funds for research have also increased greatly. Today the great American universities lead the world in the discovery of new knowledge in many fields and have at the same time become far more lively centers of learning.

A flight from teaching?

And here is where the confusion arises. The expansion of research and of graduate study has meant that the typical university professor no longer carries the formerly impossible burden of undergraduate teaching. As a result, many prominent writers and critics who long for the "good old days" have charged that there has been a "flight from teaching," that the undergraduate student is being neglected, that "publish or perish" is the universal motto of American universities.

I grant that in these years of rapid change some evils of this type have arisen, and in some cases the move from teaching to research may have gone too far. In some institutions the "weighing" of published papers has been used as an easy substitute for careful judgment of the quality of a young professor's total scholarly and teaching achievements. In some places trivial or useless research and publication will be found.

But, granting such abuses, it is grossly false to assert that the quality of undergraduate instruction in our great universities has declined in recent years. And the repetition of this charge by eminent persons who should know better has been sadly damaging to American higher education.

Actually, the reverse is true. The quality, liveliness, and freshness of undergraduate education (in the sciences, at least) in American universities has vastly improved in the past 40 years — and especially in the past 10 years. Heavy teaching loads led to bad teaching. The professor who had no time to participate in the advance of science, or even to keep informed about it, was teaching his students obsolete science. No matter how beautifully his lectures were delivered, the out-of-date professor was plainly a bad teacher. Furthermore, today some of the finest, most exciting, and most stimulating elementary science courses in our great universities are being taught by some of the nation's top research scientists. These men are willingly and gladly giving devoted attention to the challenge of bringing the best of modern science into the undergraduate classroom and laboratory.

Great teaching ability at any level is a very rare commodity. Far too few great teachers can be found. But to say that they are *only* found among those who do not, or cannot, carry on research or scholarly activities, is a gross misrepresentation. A healthy research program improves teaching — and not the reverse.

I do not believe in the "publish-or-perish, teaching-be-damned" theory. And I do not know of any other administrator in any university worthy of the name who believes this either. The *total* quality of a faculty member's contribution to the academic community is what we are always seeking to evaluate. True, we make some mistakes. True, our judgment of total quality may not agree with judgments reached by others — by students, for example. But when I see the devoted attention which faculty committees, deans, and presidents give to the undergraduate problem, and when I see the devoted attention which representative faculty members give to the improvement of undergraduate teaching, then I get pretty disgusted with those critics who decry the alleged decline of teaching, and who ask cynically, "Is there a *teacher* on your faculty?"

Graduate education

Let me add one more important factor. We often speak as though it is only the undergraduate who deserves to be taught. But please recall that in the last 40 years graduate enrollments have increased four times as fast as undergraduate enrollments. There are nearly as many graduate students today as there were undergraduates in 1920. Graduate teaching has thus become a major responsibility of a modern American university. And no one can pretend that graduate teaching can be done without a lively atmosphere of research. The number of PhD's now being produced in America is 23 times that of 1925, and the quality of their training is so far ahead of what it was when I took my PhD that those who long for the "good old days" would, if they knew the facts, hang their heads in shame. And it is a good thing for America and for the world that this vast change in this aspect of the teaching profession has taken place, because these young PhD's are the college and university teachers of tomorrow; the backbone of America's future scientific and scholarly leadership; a stimulus to our economy, our progress, and our intellectual excellence.

Changes in high schools

Great changes have been taking place in American high schools, too. In 1900 only 6 percent of American 17-year-olds were graduating from high school, and yet 70 percent of them were going on to college. In other words, the American high school of the late 19th century was a highly selective institution and was largely a college preparatory school. Curricula were substantially devoted to Latin, rhetoric, mathematics, and "natural philosophy" — or science.

By 1930 the situation had greatly changed. At that time 30 percent of our 17-year-olds were graduating from high school, but only 36 percent of these were entering college. A high school education had become a "must" for a larger fraction of our young people — but two-thirds of them had no intention of going to college. It was inevitable that the high schools should recognize this fact. Great curriculum changes took place — sometimes too slowly; often too rapidly. Since the academic subjects were of interest to a smaller fraction of the students, more attention was given to the "preparation for life" which the others required.

The American high school became a very different sort of institution than it had been a decade or so earlier. And the task of the teacher changed, too. The high school declared its independence of the college, which was in many ways a good thing. But where college preparatory curricula were neglected entirely, the results were bad.

For along came the 1950's and 1960's, again bringing vast changes — partly due to World War II, and partly due to the population explosion, but mostly due to a vast new interest in education. Today we find that nearly all of our young people are in high school and some 50 or even 75 percent of the graduates are going on to college. Forty-four percent of all our college-age young people are now *in* college.

Surely, the high school, and the teachers, now face the greatest challenge of all. College preparatory work has had to be brought back and improved. The gifted children and the average children are nearly all headed for college. Yet the below-average child and the disadvantaged child, who must still earn a living in a modern technological society, must also be taken care of in the same school or school system.

How can we possibly cope with this whole spectrum of problems, at a time when the population explosion is straining our school facilities, our tax funds, and our supply of qualified teachers to the very limit? Add to all this our long-delayed awakening to the civil rights problem in the schools, and the picture is complete. We are in deep trouble. It spills out all over: Teachers' strikes; student civil disobedience on the campus of a great university; utter confusion about the conflicting aims of life preparation and college preparation; a field day for the more intemperate critics of American education. We are expecting too much of our schools, too fast; and we blame the schools for problems for which they are not responsible.

Student unrest

Take the problem of student unrest on our university campuses. Why does unrest exist?

Partly it may be because universities are often too big, too impersonal, too inflexible. Also students are more sensitive about their independence and their "rights." However, most student revolt is a social phenomenon — a reflection of the troubles of society: the civil rights struggle; the relaxing of family ties and family discipline; a changing attitude toward certain moral codes on the part of adults as well as children; the uncertainty and fear, and the spirit of revolt which is found all over the world. And if revolt against authority is acceptable in the world of adults, why not also in the world of the student? If adults cheat, and apparently get by with it, why shouldn't the students?

But let us not get the idea that the picture is all black. A few students in open revolt can make more headlines than a million students who are quietly and earnestly going on with their studies.

Yes, some students cheat — and not only at Colorado Springs. The pressure to survive at any cost is very great. Yet, most students do not cheat, for they know that in so doing they are only cheating themselves. Is an honor system no longer possible? The answer is: *Yes,* it is! We have one at Caltech that has been working for 55 years and is now stronger and finer than ever – built by students, upheld by students, enforced by students, and heartily and thankfully supported by the faculty. What makes an honor system work? It works only when students themselves recognize its importance and pledge themselves not to violate it or to tolerate violations by others. It works best in small institutions where there can be a wholehearted commitment to integrity as a way of life. Maybe it works best in science, where integrity is a prime essential.

Yes, in the midst of confusion and turmoil there are many bright spots, where students and teachers are working together to improve our educational system.

Improving the curriculum

I have already noted that in recent years university scholars have taken a renewed interest in undergraduate teaching. A far more important thing has taken place. University scholars have been cooperating with *school* teachers to improve the quality of the curriculum and of teaching in elementary and secondary schools, too.

Everyone knows that there cannot be much research and scholarly work in a high school or in many small colleges. Possibly it was not surprising that high school and college courses in science were, by 1950, out of step with modern scientific advance. The student entering a university was wholly unprepared for what his teachers were talking about.

By 1950 it had become painfully evident that most high school and many college courses in mathematics, science, and other fields had stagnated during the previous 25 years. Textbooks in physics were being written and rewritten, but the only thing that was changed was the size of the type, the number of pictures, and maybe a new final chapter on atoms and electrons. There was no suggestion that atoms and electrons were at the very heart of science, not an appendix to it.

Someone was bound to do something about this, and they did. Many people participated, but the Physical Science Study at MIT brought the new movement into focus, and prepared a wholly new type of high school physics course, complete with textbooks, outside reading, new laboratory experiments, and teaching aids, such as films and demonstration equipment. And, through the National Science Foundation, thousands of high school teachers have been trained in this new approach and in the use of the new materials. This movement then spread to mathematics, to chemistry, to biology – and now to nonscience fields as well. About half of the high school students of physics in the country are getting real modern science – not just the pulleys and levers of the 1920's. This development, along with the concurrent expansion of advanced placement courses for college-bound students, has vastly improved the preparation of the freshmen we have been admitting in recent years.

This movement is not complete. It has only begun. To carry it on is, in fact, a never-ending task, for science changes every day, and ideas for better ways of presenting it to young people change also. The new courses and the advanced placement courses will be substantially changed and improved.

But the essential part of the new movement is this: For the first time in the past 50 years or more, the high school teacher, the college teacher, and the university scholar are working together on the problems of teaching and curriculum improvement – to the vast benefit of all teachers, and to the spectacular benefit of the American student.

A second important development has resulted from the improvement of high school courses. The better prepared high school graduates have produced a great stir in the colleges. The college freshmen of today demand more of their college teachers and their college courses. Hence, all over the country one finds a new spirit in undergraduate courses in science. They are vastly different and vastly better, and vastly more in tune with the times than they were even five or ten years ago. Again, the university research scholar, who is not supposed to be interested in teaching, *is* teaching and working with other teachers to improve what is offered to students.

The revolution in course content which is going on in high schools, colleges, and universities is spreading inevitably to the elementary schools. The best evidence of this is that all over the country parents are loudly complaining that they can no longer help their children with their homework! It is, I know, a pretty distressing experience for a parent to find he has become suddenly obsolete. But he should rejoice that the schools of today are moving ahead and not teaching the same material in the same way they taught it when he was young.

Learning aids

There has also, in recent years, been a rapid development of new teaching aids, or new *learning* aids, as I prefer to call them. Films, records, tape recorders, and educational television have provided a whole new array of tools to help the teacher do a better job. We are only beginning to learn how to use these tools effectively. They are too often regarded as devices to replace the teacher — a wholly false concept. A hammer and saw do not replace the carpenter; a typewriter does not replace a secretary. A new tool is a new opportunity for doing a better job, provided that we learn how to use it.

I have a special interest in educational television. I believe it can be the most powerful aid to learning since the invention of printing. We are barely learning to use it. We do not even know yet how to finance it adequately. But we shall learn, and the teacher, the student, and all Americans will benefit.

All of this, of course, means change. And rapid change means a certain amount of confusion and turmiol. And the turmoil, as I have said, is painfully evident. The task of the teacher, however, is not to resist change, but to promote it and guide it into the most effective channels. This makes the teacher's life exciting. Never again, I believe, will the task of the earnest and conscientious teacher be wholly dull and routine — though routine duties are, of course, always with us. The challenge and excitement of teaching today are greater than they have ever been before.

The concern for better education

Today, America is more alert to the values and problems of education than ever before in our history. As a nation we have always been devoted to education, far more so than most countries. But today, more than ever before, the concern for more and better education permeates every aspect of our national life. This is partly because we have more children; partly because our educational system is now very expensive (and Americans are always concerned about their pocketbooks); partly because education today is not only "nice" — it is essential. We now admit that the education of the gifted and the talented is necessary to our national welfare. But the education of everyone to the limits and in the direction of his abilities is also now an essential national goal. Masses of uneducated citizens are a drag on our society which we can no longer tolerate. We must have educated workers and educated voters.

The child in school is not only an important person in his own right; he is also a national asset. As President Johnson has recently reminded us, education is our most potent weapon against poverty, hopelessness, and racial discrimination. Education is, therefore, an overriding national concern. The total budget for all education in America will soon exceed our budget for national defense. In a few years we will have one-third of *all* Americans enrolled in our schools and colleges, and many of the others continuing their education at home.

There are many paradoxes in this enhanced national interest in education. We insist that every child be in school, but we do not build enough classrooms or employ enough teachers to take care of them all. We insist on high standards; but we don't want any dropouts. We insist on basic education; but we must, of course, have "practical" courses, vocational courses, driver training, and many other things. We know that children come to school with a wide range of abilities and talents and cultural backgrounds, but we often insist on treating them all alike — moving them all from grade to grade at the same speed and in the same array of subjects. We want local control of schools, yet we are a mobile people and, as parents, we complain loudly if the seventh grade in Poughkeepsie (where we have just moved) is not at the same level as the seventh grade in Fresno. We recognize the importance of teachers, but often pay them so poorly that they have to do "moonlighting" to maintain proper living standards for their families. We are in favor of equal educational opportunity for all, but we are only now beginning to recognize that *all* really means everybody — black or white, in slum or suburb. On this point Congress has now taken some action.

But every paradox is also a challenge. And the encouraging thing about these paradoxes is that they result not from indifference to education, but from a vast public commitment to it. We criticize our schools. Why? Because we are desperately anxious to make them better. We criticize the teachers, too. Why? Because we know they are such desperately important people. Because we know that the future of America lies in their hands and it is terribly important to us that they be competent and well-trained hands.

A supremely important profession

That was not true 40 years ago. Then, the teacher was commonly regarded as a person who could do nothing else. We forgot that there was nothing else he *wanted* to do. But, today, we congratulate, rather than feel sorry for, the able young person who chooses teaching as a career. And well we might — and well we must. Teaching has become a recognized, supremely important profession. And for anyone who has a spark of interest in being of service to his fellowman, teaching can be the most challenging of all careers.

Watching the TV monitors in the Space Flight Operations Facility at JPL while Ranger IX transmits "live" pictures from the moon – Harold C. Urey, of the University of California at La Jolla; Ewen A. Whitaker, of the Lunar and Planetary Laboratory, University of Arizona; Eugene Shoemaker, U.S. Geological Survey at Flagstaff.

RANGER IX – HAPPY ENDING

The successful flight of Ranger IX ended at 6:08 a.m. (Pacific Standard Time) on March 24 when the spacecraft, traveling at 5,977 miles an hour, crashed in the Alphonsus crater near the center of the moon, after sending back more than 6,000 photographs of the lunar surface.

From its launching at Cape Kennedy, Florida, Ranger IX covered a distance of 259,143 miles in 64 hours, 31 minutes and 12 seconds. The point of impact on the moon was only four miles from the original selected aiming point.

The 6,000 photographs obtained by Ranger IX were taken in the last 18 minutes of flight. In the final minutes Ranger's two TV cameras televised the approach to the moon to home television sets throughout North America. About 100 television pictures were flashed on home screens at five-second intervals, until a few seconds before impact, when the spacecraft was about 4,000 feet above the moon.

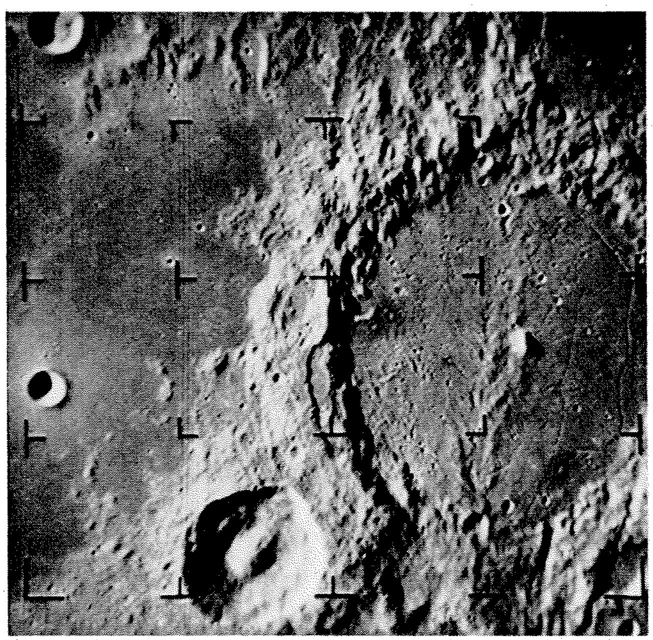
Caltech's Jet Propulsion Laboratory hopes to be able to repeat this spectacular feat by providing home viewers with surface pictures of Mars, transmitted by the Mariner spacecraft as it approaches the planet in July.

The five-year Ranger program, conducted by JPL for the National Aeronautics and Space Administration, comes to an end with the successful flight of Ranger IX.

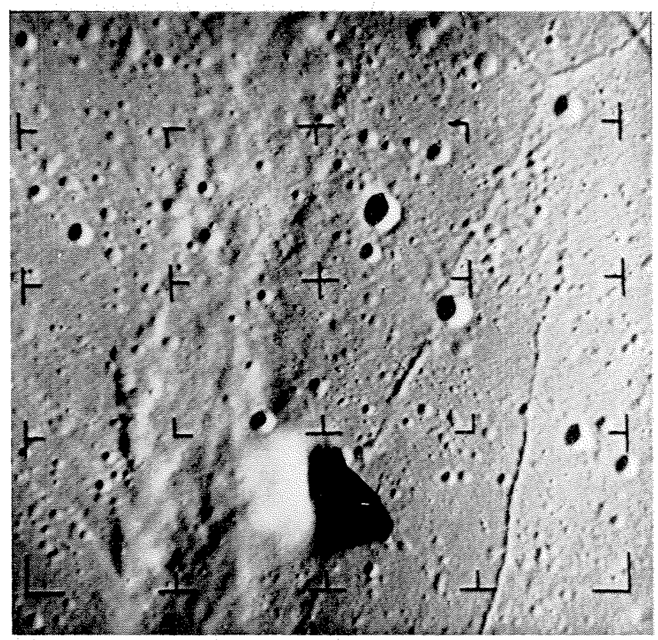
"The purpose of the Ranger program," says Dr. William H. Pickering, director of JPL, "was to get details of the moon and learn of possible landing sites. We have successfully achieved this."

This third and final success in taking close-up pictures of the moon sets the stage for the flight of the Surveyor, which will approach the moon at more than 6,000 miles an hour, then slow down to about 1 mile an hour to make a "soft" landing. Controlled by radio from the earth, Surveyor will then swing its television cameras around to photograph the nearby lunar landscape.

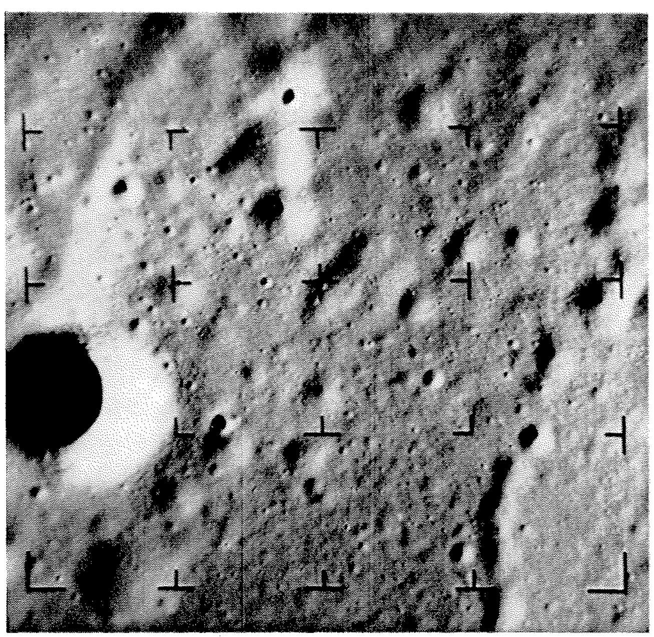
The moon – as seen from Ranger IX



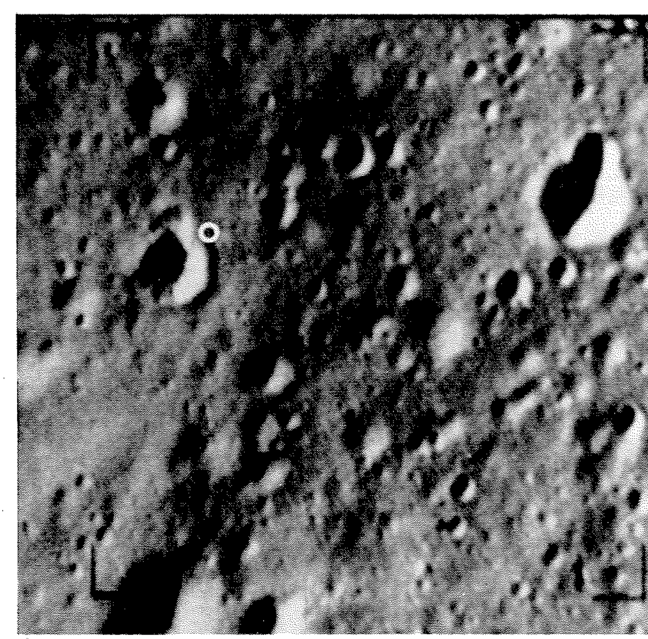
Television picture taken by one of Ranger IX's full-scan cameras (camera A) just 2 minutes and 50 seconds before impact. The spacecraft is 258 miles above the moon, heading for the crater Alphonsus, which fills the right half of the picture.



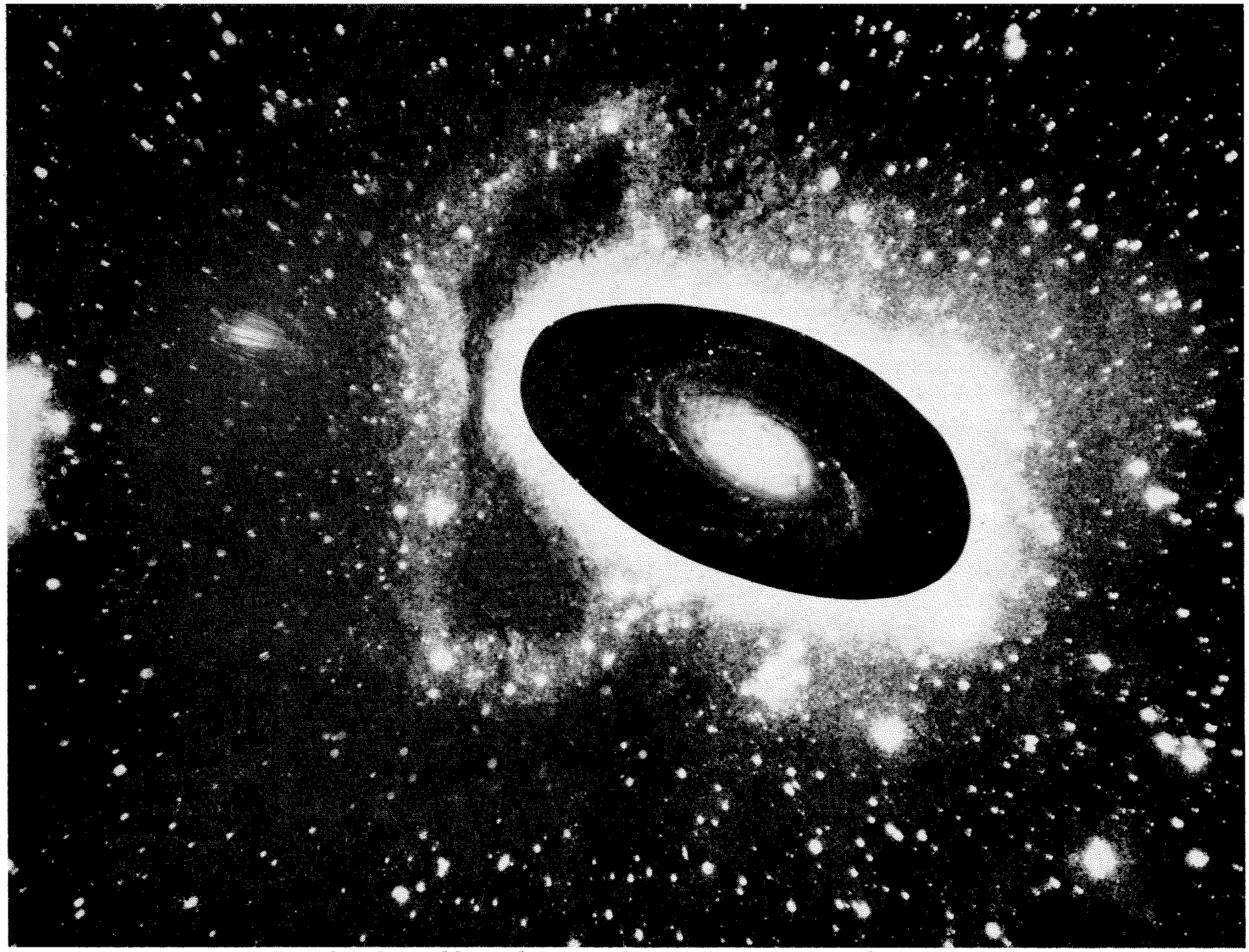
Picture taken 38.8 seconds before impact, when Ranger IX was 58 miles above the moon. The area shown here is 28 miles by 26 miles and is in the region of the central peak of Alphonsus, which has a rille or groove running through its shadow toward the upper right.



Picture taken 8.09 seconds before impact. Ranger IX is 12.2 miles above the moon. The area shown is 5.8 miles by 5.3 miles. The large crater seen at the left of the photograph is 1.6 miles across and is situated on the shallow rille running upward.



Last picture taken by partial-scan camera P-3, just about ¼ second before impact. The capital "O" marks the impact point. The area shown in this final picture is about 240 feet on a side and lunar features can be seen with a resolution of up to 1.6 feet.



The ring around M-81 is just barely visible at the upper left of the galaxy in this specially prepared photograph.

RING AROUND A GALAXY

A huge, faint, luminous ring, about 100,000 light years (or 600,000,000,000,000,000 miles) in diameter has been discovered around one end of the spiral galaxy M-81. It is theorized that the great ring, which apparently consists of a plasma of charged particles, was ejected from the galaxy M-82 by a titanic explosion and, as it moves out into space, is beginning to "light up" in the magnetic field of the neighboring galaxy M-81.

This is probably the first evidence of material from one galactic island universe being ejected through space to another galaxy. Even more important, this is the first evidence of an over-all magnetic field of a spiral galaxy.

The ring was discovered by Halton C. Arp, staff member of the Mt. Wilson and Palomar Observatories, while he was searching for unusually faint objects in the sky, such as bridges of gas, stars, and dust between galaxies, with the 48-inch Schmidt telescope at Palomar. To obtain a picture of the ring, Dr. Arp used a photographic technique that intensifies the image of a faint object and filters out unwanted light. He also took advantage of the fact that the night sky is the "darkest" it has been for 11 years, and made several long exposures of 50 minutes each.

Three of these long-exposure negatives were made into a composite negative by William Miller, staff photographer of the observatories. A print from the superimposed negatives, like that shown above, finally revealed the ring.

The faint but distinctly visible ring around M-81 is 100,000 light years from its "parent" spiral galaxy M-82. M-82, apparently in the act of exploding, was photographed last year by Allan R. Sandage of the Mt. Wilson and Palomar Observatories (*E&S* – March 1964). M-82 and M-81, are only 60 billion billion miles (10 million light years) from the earth, which is not far in astronomical terms.

"If indeed the ring is from M-82 and is impinging on the magnetic field of M-81, as it appears to be," says Dr. Arp, "then nature has set up for us an enormous experiment that can tell us a great deal about the magnetic field of M-81 and about the explosion of M-82."

Research Notes

Earthquake Records

More of the earth's surface was permanently distorted by the great Alaskan earthquake of March 27, 1964, than has been documented for any known earthquake, and the vertical extent of the faulting that triggered it was at least ten times greater than reported for any other quake.

This is revealed by Frank Press, director of the Caltech Seismological Laboratory, and David Jackson, Caltech senior, in an analysis of the land displacements reported by the U.S. Geological Survey and the U.S. Coast and Geodetic Survey. Some areas were uplifted as high as 50 feet, while others subsided as much as 7 feet.

The primary fault activity, which extended horizontally for some 500 miles, extended down 60 to 120 miles into the earth and came to within 10 miles of the surface.

For the 69-day period after the main shock, there were 12,000 aftershocks of magnitude 3.5 or more. The main shock and these aftershocks released the energy equivalent of a total of 100 underground nuclear explosions of 100 megatons each. The total is equal to 500,000 times the energy of the Hiroshima atom bomb.

As an indication of how far away the earthquake left its mark, it permanently compressed rock a measurable, although microscopic, amount some 4,000 miles away in the Hawaiian Islands. The compression was measured by strain gauges installed by Caltech in the islands.

Screaming Flames

A "screaming" flame produces up to 50 times more smog-creating oxides of nitrogen than a quiet, steady flame, according to Bruce Sage, professor of chemical engineering.

The phenomenon of the screaming, or roaring, flame has caused problems in industrial boilers for years. It also has been the cause of rocket-engine failures and is a problem in air pollution. The phenomenon produces oxides of nitrogen that trigger the formation of undesirable atmospheric compounds, including eye irritants. Also, the vibrations can result in serious damage to the metal and brick walls of combustion chambers such as boilers.

The noisy flame is caused by oscillatory combustion. In this kind of burning, the combustion is uneven and occurs in surges of high frequencies — commonly between 500 and 4,000 cycles per second. It becomes audible as the combustion frequencies reach those of sound waves.

Dr. Sage has been investigating oscillatory combustion for nearly ten years. The phenomenon was discovered in rockets in 1940 and occurs over a wide range of combustion conditions, including those found in automobile engines. Dr. Sage, aided by G. N. Richter and R. C. Seagrave, assistant professors of chemical engineering, and with the support of the U.S. Public Health Service, has been studying the factors in combustion that lead to the formation of oxides of nitrogen.

The fact that roaring flames produce more oxides of nitrogen was discovered by Dr. Sage and his colleagues in the course of recent studies of flames in an experimental combustion chamber in Caltech's chemical engineering laboratories. Oxides of nitrogen were found to form during periods of rapidly changing temperature. These changes are introduced by local perturbations in pressure.

The Hunting of the Quark

Murray Gell-Mann, professor of theoretical physics, explained last month how he happened to give the name "quarks" to the subatomic particles whose existence he first proposed in 1961.

In James Joyce's *Finnegan's Wake,* it seems there is a napping bartender who keeps being awakened by a striking clock, at which point he calls out, "Three quarks for Mr. Mark."

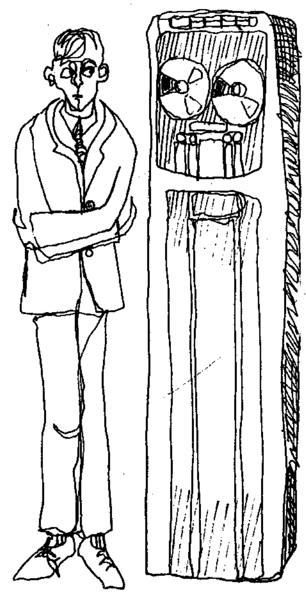
Dr. Gell-Mann's interpretation is that "quarks" is a combination of "quarts" (a word all too familiar to the bartender) and "hark" (which the man might naturally say when he was awakened by a striking clock).

Since it is Dr. Gell-Mann's theory that all the known particles today are manifestations of just three particles which will never be found, since they are actually nothing more than mathematical concepts — why, what better name for these particles than "quarks."

This esoteric information, revealed before the Joint Congressional Committee on Atomic Energy (which was hearing testimony to justify the AEC's proposed $6 billion program for high energy physics research), brought a surprising tribute from the Los Angeles *Times* national science correspondent. He called Dr. Gell-Mann "something of a nuclear Mort Sahl."

A panel of Caltech experts discusses the future of

Computers and Humanity



Some highlights from a panel discussion sponsored by the Caltech YMCA in Beckman Auditorium on February 10, 1965. Members of the panel were Louis T. Rader, a Caltech alumnus, who is vice president of the General Electric Company and manager of its industrial electronics division; Simon Ramo, president of The Bunker-Ramo Corp., and a member of the Caltech board of trustees; and Hallett D. Smith, chairman of the division of humanities at Caltech. G. D. McCann, director of the Booth Computing Center, served as moderator.

RADER: One of the questions most often raised is: Will computers cause unemployment?

First of all, the computer industry is one of fantastic growth. It is no more than 15 years old, but there are some 18,000 machines now in use in the United States — 10 percent of which are in the federal government. If you look at all the electrical goods that are sold to consumers — from electric light bulbs to radios, televisions, and refrigerators — then the computer industry is one-third as big as all of that. So it is a big industry already.

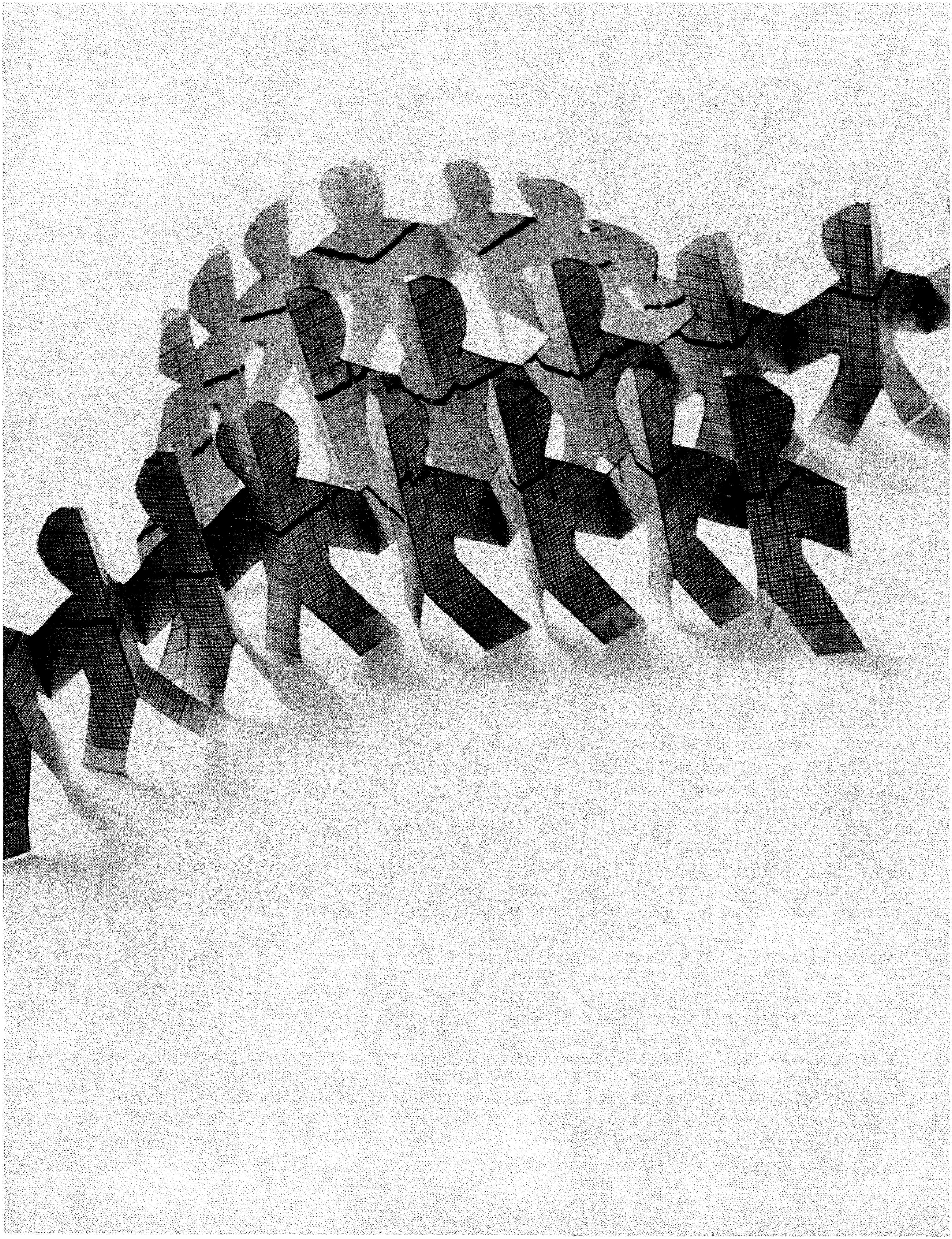
Some very good statistics have been accumulated in this country for the last 30 years or so by the Bureau of the Census, and I would like to cover some of them. As we look at the 20 categories into which our manufacturing is divided in this country, we can divide up these industries on the basis of those that turn out, say, a thousand dollars of goods at selling prices in terms of the man-hours required to go into them. And the four good industries are the ones that require the least labor — the chemical industry, petroleum and coal, tobacco, and instruments. These four industries will average 77 man-hours of labor per thousand dollars of output.

On the other side of the scale, the four poor industries, or the industries that require the greatest amount of labor, are textile, leather, lumber, and apparel. These industries require 270 man-hours of labor per thousand dollars of output.

You may ask: In which industries has employment grown? The first four I mentioned have the highest investment per worker also — from $30,000 per worker up to $100,000. These are the industries where we have put our money to improve the whole efficiency — with automation and computers as a part of it. And the statistics show that in the last 15 years, in the industries in which we have put the maximum amount of money for automation, employment has increased 51 percent.

The same statistics show that in the four poor industries (and I use my own definition of poor) employment has dropped 7 percent in the last 15 years. Why? Because the poor industries cannot compete with goods coming from Japan, Europe, and elsewhere. So the first thing the statistics tell us is that the industries into which we put the maximum amount of money are the industries that make

continued on page 18



the most profit, and have the greatest increase in employment.

Looking at the same figures, you say: Which industries compete best in the worldwide markets? Again, the ones that we have mechanized and automated export more than they import. The ones that are not automated import more than they export.

How do workers' salaries or wages or take-home pay compare in the industries where we put a lot of money into investment and the others? The answer is that the industries that have the greatest investment per worker pay the highest salaries.

Another way of saying this is: Is our productivity in the United States greater than Europe or Japan because we work harder? And the answer is no. Because we are smarter? No. Our productivity is greater because we give our people the tools with which to work. So, in the question of export vs. import, the question of employment, and the question of take-home pay, we can show pretty clearly that the industries in which we invest more money are the industries that do the best.

RAMO: I have been given, I believe, the favorable side of this subject. I have been asked to say a few words about the *future* impact of computers on society. When Dr. Rader talks about the situation *today,* you might challenge him, and he is in the position of having to prove that he is right. In talking about the future, you may find that everything I say seems unsound, but it is difficult for you to prove it, especially if I go far enough out in the future. And I shall – not only to make it difficult for you to ask a question that is impossible to handle, but also because I think it is essential to look out far enough, so that we can begin to appreciate some factors that are well beyond that which exists today, and which may give us the real clues as to how computers will affect society.

Since I am trying to do this in just a few minutes, I am going to do it by one example only, but I think it is a very broad one. I think it is meaningful, and typical, and substantive. But I will exaggerate a little and simplify in order to make a point quickly.

I am going to ask you to imagine that we have enough years in the past, and the use of a technology so mature and so advanced that in every aspect of our lives in which we use information, or we use our intelligence in order to achieve some useful purpose (or even just to think about useless things – just to enjoy ourselves, to produce art, to ponder and philosophize) we shall find ourselves able to do this better because we will have our brains extended by electronic devices and systems. And when I say extended, I mean we will have available the equipment of a much greater memory than is available to us today.

Picture, as this one example, what amounts to several national networks of information storage that will be continually updating the facts that apply to the professions, to education, to the running of businesses and industry, to transportation, to banking, to government. We will have the means for retrieving this information and displaying it and moving it about the country. Applied to education, this means it will be possible to introduce teaching aids that depend upon these national networks for the presentation of information. It will be possible to have statistics useful to those who are planning educational programs. In medicine, it will be possible for the individual's physician to introduce the information about his patient into the network and obtain almost instantaneously a certain kind of return information which will represent at least a fraction of what he could have gotten – in principle, at least – by consulting with thousands of other physicians who have had similar problems. This kind of thing could be used in research in disease, so as to create a relationship between cause and cure, between potentials of drugs and treatments, that could have an impact on medicine comparable with the impact of surgery.

In law, it will make possible the orderly processing of the kind of information which keeps everyone doing things according to the rules, whether it be buying and selling or forming interrelationships between corporations. In the running of companies, management will have information and, what is perhaps even more important, they will be able to create plans that are optimum, and efficient, and they will be able to create relationships between separate entities so as to assure the greatest smoothness of operation.

You might even imagine carrying this idea of

national informational intelligence one step further. The public, as a democratic public that participates in deciding issues, can be locked into the system by being asked to express their opinions — through devices that are in their homes, continually presenting issues and asking for reactions — so that the whole country can know the reaction on many issues with considerably greater competence.

All of this, of course, brings up the possibilities of informing the public, and, therefore, of having a better educated, more alert, more interested public (as well as having the possibilities of being misused, to mislead the public!).

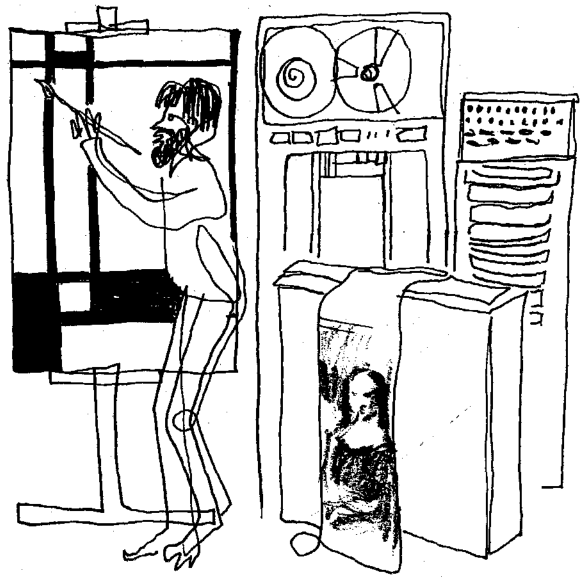
Now this is a quick-once-over-lightly on the idea of extending the human intellect and being in some respects, then, a smarter people who can do our jobs better. Because what makes the world go round is the information that controls it. And what really determines the way in which government reacts, the public reacts, and industry is run, is information — information acquired, presented, stored, processed, and used for decision-making.

SMITH: Every new machine is a threat and a challenge. It is also, in many ways, a reward. In the seventeenth century, the telescope and the microscope were felt to be, by some people, very inhuman and antihuman. You can imagine, perhaps, the reason for this. One could say: "If God had intended us to see that far he would have made our eyes as powerful as telescopes." This is a little like the old lady who said that, "If the Lord intended us to fly in jet planes he would have had the Wright brothers invent them."

The challenge of a machine to the human sense of values is most important when the response to it is one which makes us examine our own use of our minds and abilities. And I think that the computer is a machine of this sort.

I suppose people who read that a humanist was going to appear with two scientists on this program assumed that I would oppose the computer and its possible dreadful consequences. Quite the contrary. I think that its possibilities, from the point of view of the humanities, are very great indeed. I am particularly fascinated with what has been done at the Tempo Laboratory of the General Electric Company in enabling a computer to receive and return information in a natural language — namely English. This seems to me to be an extraordinary achievement and to open up many possibilities for the further understanding, not only of the nature of language, but of the way in which we think — in words.

Now, Dr. Ramo suggested that the computer



might be able to contribute something in the way of art. I am very skeptical about this. I think that, of course, you can teach a computer to reproduce any style of art. You can no doubt teach a computer to compose works in the style of Mozart. What you cannot do is to get it to create a style of its own, independent of the programming that has been put into it.

So I think there is a good deal of nonsense taught about the threat of the computer in this general area. One episode that has attracted a lot of attention in the press is the one in which a Scottish minister attempted to determine the long-debated problem of the authorship of the Epistles of the New Testament attributed to St. Paul. And, according to the papers, he put this problem on a computer and came up with the answer that five of those Epistles are by Paul, and that all the rest of them are by five other people, names undisclosed.

The sequel to this was that an American minister, who didn't like the conclusion, took the essays in which the Scottish minister had demonstrated his case, submitted them to the same test, and proved that his opponent had not written all of his own essays.

Now, what happens here, of course, is that people are using the tag of the computer for something which is really quite trivial after all. It is merely a matter of the statistics of literary style. There is a good book on that subject by an Englishman named G. Udney Yule. If you are interested in investigating, I would recommend that book to you.

But the answers that a computer gives to a question like this are no better than the material that is fed in. In this case, the statistics of literary vocabulary were inadequate to the problem.

Now, of course, people have been interested in finding out whether a computer can write poetry. And indeed it can. You feed in the words, and you program it so that they come up in any one of a number of ways, and you will get poetry. It can write beatnik poetry. When a computer writes beatnik poetry, it is called auto-beatnik, and perhaps you might be interested in a sample.

Few fingers go like narrow laughs.
An ear won't cheat jew fishes.
Who is that rose in the blind house?
And all slim, gracious, blind planes are coming.
They cry badly along a rose.
To leap is stuffy,
To crawl was tender.

I think, then, a warning is appropriate — that we should try to understand what the computer is capable of doing. And I think Dr. Ramo is quite right in saying that it will be capable of much more than we can visualize now. But we should not discount the computer because sometimes people give it trivial things to do, and because sometimes people get results from it that are nonsense.

McCANN: Before we open this for discussion, I want to add one comment, and that is that the actual principle of a digital computer, the mathematics which has so far been developed for it, really makes possible the simulation of *anything* that a human mind might conceive. Potentially, it will be possible to simulate any concept, any intellectual capacity, any creative capacity the human mind can understand.

That means a computer doesn't do just what you tell it to do; it can learn, it can teach itself — if we just knew these principles. Our big problem today, therefore, is the question not so much: What can a computer do — in breadth of intellectual activity? but: What can we learn about the principle of these activities so that we can use computers to their limit — good or bad?

QUESTION: I would like to ask what Dr. Ramo would reply to the consequences of too much leisure in society from the benefits of computers.

RAMO: I often read and hear about this concern over the relationship between the impact of computers on our society and the additional leisure time many people are going to have. I can only say, for myself, that I find it very difficult to put that anywhere near the top of my set of worries.

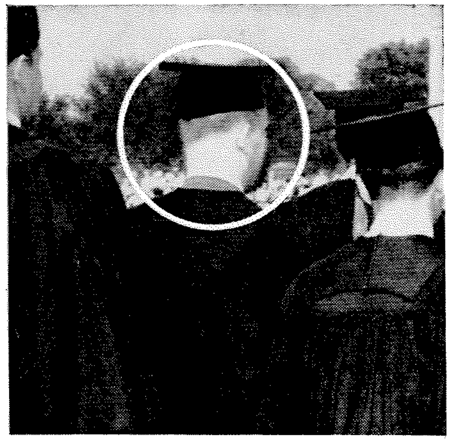
I find it much easier to believe that what the new electronics makes possible will so stimulate the human mind as to cause us to think up so many more things to do that it does not follow at all to me that the computer brings more leisure. It may, in effect, bring in that kind of fascinating thought and activity — impractical today and not conceived of today — that will use up more than enough time.

Take just this one thing for example: If, by proper use of electronics to aid in the educational process (and I don't mean just in schools; I mean education of the *public* on issues), we may find our public sufficiently interested in what is going on that the pondering of all the social issues will hold us busy for a good deal of the future.

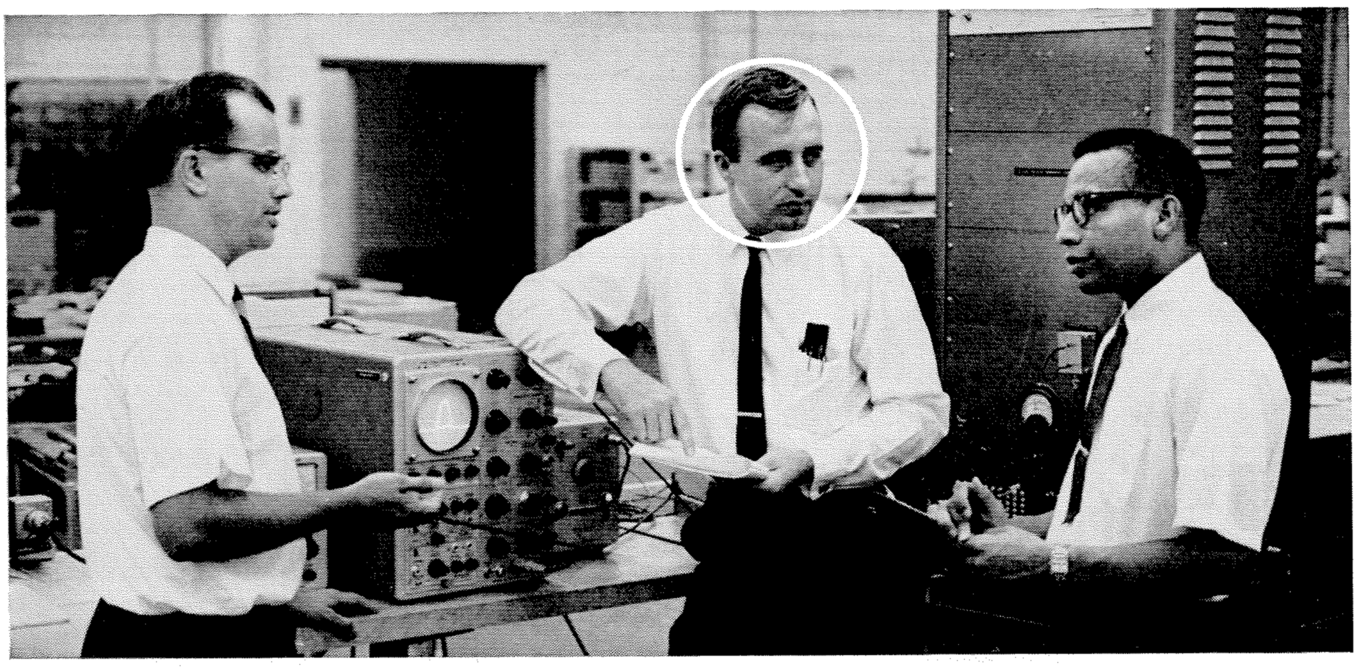
RADER: Another aspect to that is that we tend to think only in terms of the standard of living in the *United States,* because we live here. There is a fantastic amount of work that has to be done, that can be done to improve the standard of living throughout the world. If we just extend our own ability, for example, in agriculture, to grow food and see to it that we find some way of developing an equivalent standard in China, Russia, India, and so on, then I think a lot of the tensions that exist in the world today will disappear. So, just because we have two cars per family, and are beginning to have two homes and so on, doesn't mean the *end* of work. We ought to have some responsibility, and I think properly *can* have some responsibility toward helping the rest of the world achieve even only a fraction of our own standard of living.

SMITH: I am not really worried about leisure. I think that there is good use of leisure and there is, of course, misuse of leisure. I suppose the sociologists would be most concerned about the rate at which this leisure became available. It is perfectly true that the industrial revolution caused by the computers is taking place at an extraordinarily fast rate, and I agree that it is a subject of some concern. I, myself, think that the notion that work is virtuous and leisure is dangerous is an inheritance from the Puritan ethic that you might just as well get over. Myself, I am in *favor* of leisure.

QUESTION: This question is directed to Dr. Rader. After the last industrial revolution we saw our number of work hours decrease from 80 hours to 40 hours per week as a result of increased productivity. So, no matter how one might advocate that more auto-



Tom Huck sought scientific excitement



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Ohio University conferred a B.S.E.E. degree on C. T. Huck in 1956. Tom knew of Western Electric's history of manufacturing development. He realized, too, that our personnel development program was expanding to meet tomorrow's demands.

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This undoubtedly will come about as a result of automation, but it will also produce severe social dislocations in the transition period. What adaptations will our social institutions have to make so that no people go completely unemployed?

RADER: Well, there are several aspects to that question. First of all, it's an unwarranted assumption to say that increased automation creates unemployment, or that we can produce all the goods we want in, say ten hours a week instead of forty. There are no statistics at all to back up that particular statement. For example, in the last 17 years in the United States we've had an increase in employment of 13,000,000 people, and in the last 17 years we've put the maximum amount of money into our productive equipment. And the same figures are showing up in other countries of the world – Germany, France, Italy, Scandinavia, and even Japan. In fact, in some of those countries they have *over*-employment: Switzerland has to import several hundred thousand of workers to produce the goods that they want. So I don't forsee any serious economic dislocation, any massive unemployment, because all the statistics for the last 200 years say that there's more and more work as we extend our capability to do things.

RAMO: I've had occasion in the last several weeks to attempt to put down the cost, and to translate it into man-hours of employment, of updating the United States, so that it makes full use of technology in every aspect of our physical operations – transportation, banking, every form of manufacturing, even education and the professions. If you take what now appears to be both technologically and economically feasible, and if you could bring yourself to make the investment, then the payout in terms of the return on the investment would be such that the investment would be a good economic as well as engineering decision.

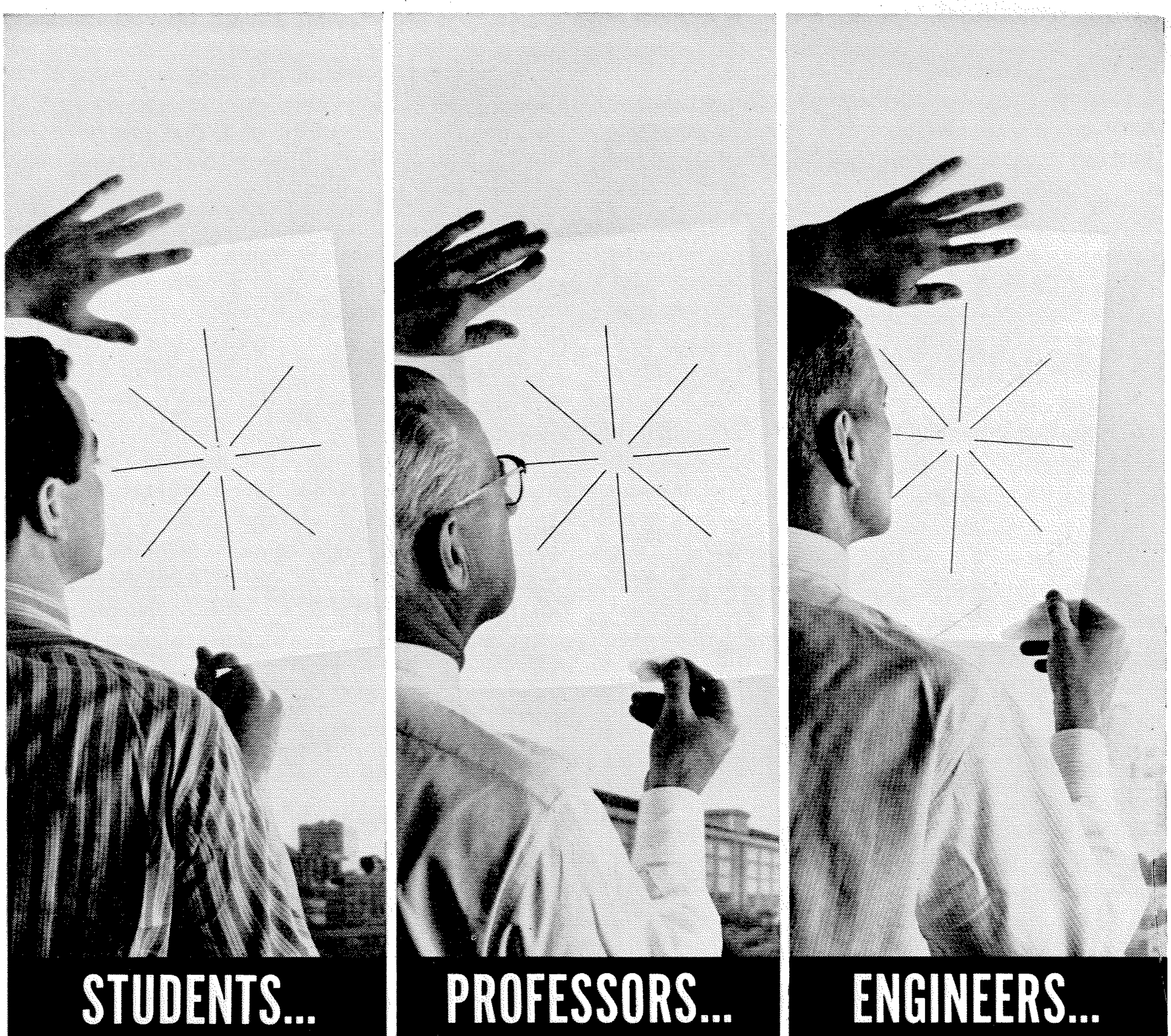
If you went ahead over a period of time to update the American plan and forget the rest of the world for the moment, it gets into so many trillions of dollars that it dwarfs the gross national product for any one year. The number of man-hours required are so far beyond our present total employment that it will take us many decades to get this updating accomplished – and by that time I'm sure it will be out of date.

I grant there are many problems of a political and social nature. But I just want to make it clear that, aside from these, the technological and economic aspects, put together into a calculation of what you could do that would pay off for the world, would keep everybody terribly busy creating things that we all want, could use, would enjoy having – and it would greatly raise the standard of living in the process.

QUESTION: I want to pose a kind of science-fiction question. All the things that I've read about computers that tend to make me quiver are the ideas of where computers are advanced enough so that they can actually think from original raw materials. That is, a human being is not necessary to put materials in; the computer can do everything a human being can, and is sort of self-reproductive. Now, at the present time, it seems as though the human being is the sensing element which is necessary to observe facts and put them into a thing which computers can use. Is it possible that at a future date a computer will be able to have all the sensing capabilities that we have – parallels to sight, hearing, and so forth – and will be able to take initial raw data and transpose it into usable information and thus actually think as we do, and be able to do things all by itself?

RAMO: Well, first of all, if you want to theorize about what we as human beings can conceivably and eventually cause computers to do and to be like, then you have to say that what you suggest is at least possible.

But what do we mean by the word "think"? Surely we will grant that a good bit of what we do with our minds is pretty clear and rather mundane. In data processing we have some stored facts in our minds. We put that together in certain patterns that we've learned, against information that comes in, and we arrive at certain conclusions. Now, when you understand what it is that you do with your mind and can lay it out clearly, quantitatively, or in a logical sequence, then of course you can arrange for a machine to do it. It may be, in today's technology, a complicated and impractical machine, and one that would be expensive to build and use for that purpose – since the human being is created with relatively cheap labor and costs only $20,000 or so a year to maintain. It would be foolish to set



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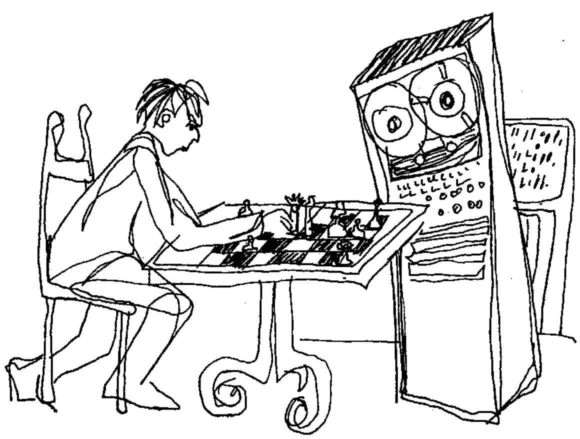
Then you have a more complex thing that we don't understand. We speak of it as intuition, or the thinking that our wives do, but what's really at the core of this is that we don't understand it well enough to set out to simulate it.

You have learning; you can certainly give a machine a few rules about the game of chess and let that machine play against a good chess player, and we know that in principle the computer can have a memory beyond that of a human being, even of the best chess player, so it could remember many more moves and keep track of possibilities in great detail, and eventually it could beat the best chess player.



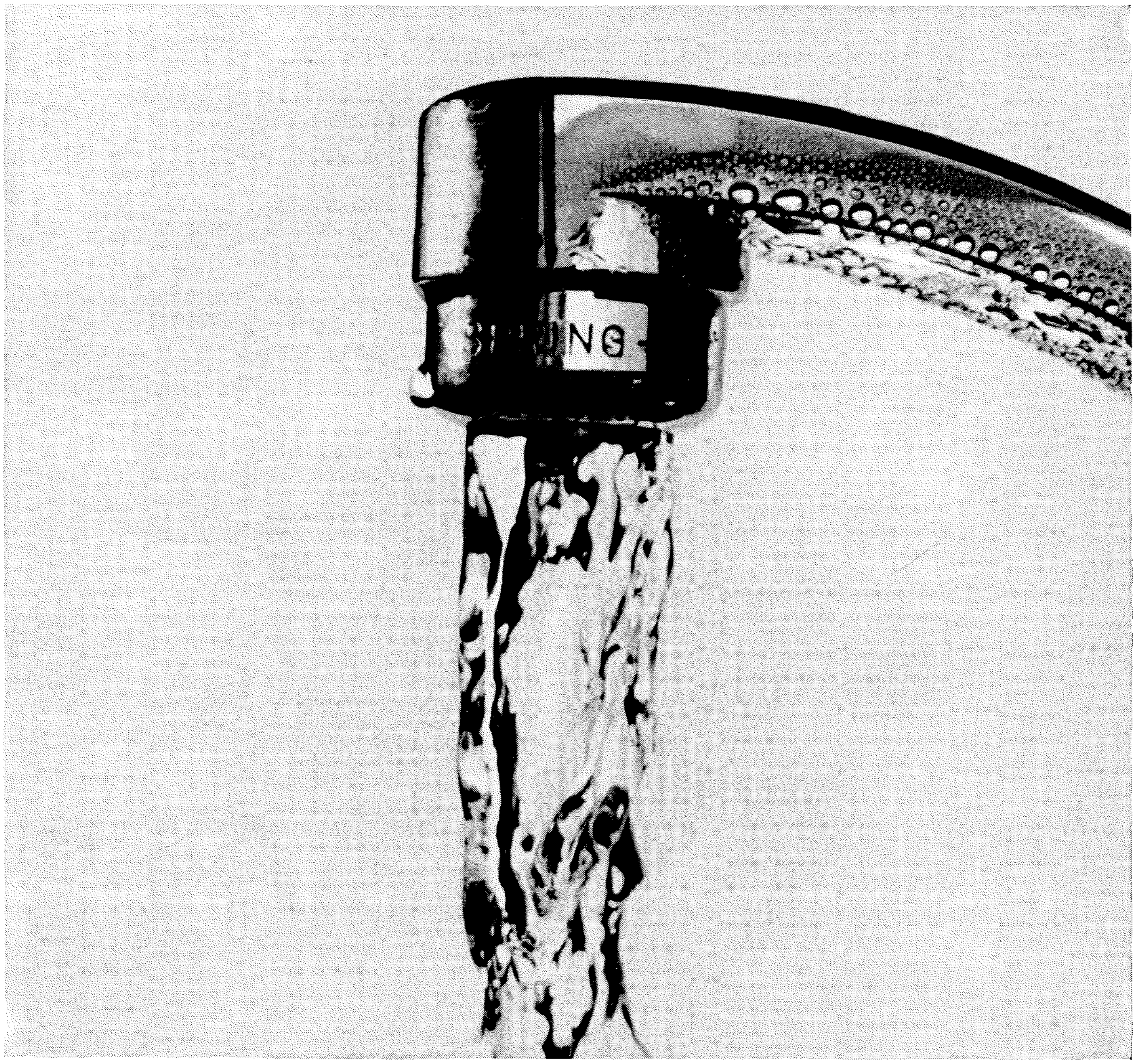
And now would the chess player argue that the machine can't think and hasn't learned how to play chess? He might so argue, but he'd be in the position of one of those who might be among the first to have his brains replaced by the computer. He's really lost his case by the actual action. So, a lot depends on your definition.

Even in the writing of music, what do we mean by the creative thought process? We don't understand it – what a composer or a true artist goes through. (I'm speaking now of the use of the computer as a tool to *help* the artist; not a replacement for the artist.) We don't really understand invention and creative thought. We don't quite know what it is that takes place.

RADER: All I'd like to say is that it's very hard for the engineers to keep up with the science writers, but we do try. There are some techniques which have derived from the transistor, from the solid state physics, which of course have changed our capability in doing things fantastically, and these techniques are constantly being extended so that we now see ways of making very large memories at low cost. We're getting closer, for example, to simulating the amount of information that can be stored in the human brain, although we're many, many degrees away from it. And we also see rather unique ways of putting together electrical circuits, so that the engineer's ability to simulate or to make a machine which can do things is progressing quite rapidly. As Si says, nothing is really impossible. So, it is possible in the far future that we can have this automatic machine that thinks – subject, of course, to the right definitions of the word think.

SMITH: With respect to the heart of the original question and its science-fiction aspects, I am not very much alarmed about the possibility of the machine sensing through various senses, and relating that to any amount of stored memory. I'm not alarmed about its ability to form concepts and to use them. I *would* be alarmed if I thought the computer could fall in love; if I thought a computer could suffer; if I thought a computer could die and understand the meaning of death, I would be very much alarmed. I don't think there's any chance of that whatever.

My favorite science-fiction fear about the computer is: You know, it's perfectly possible to get computers into this decision-making, information-gathering business so much that the computer could wage war, could press the button, collect all the information, make the decision to press the button at the right time, and so on. And presumably there would be computers on both sides. The only difficulty is that the computers would keep on fighting each other long after everybody on both sides was dead.



Who's helping make water come clean again?

The same Union Carbide that helped develop a new stainless steel used in subway cars.

Streams and rivers in many parts of the country were being plagued with foam, partly due to detergents. In some areas foam even came through the faucets . . . because old detergents kept on foaming after they went down the drain.

Now things are changing—the result of ten years' work by detergent manufacturers. We've helped by being the first to come up with new kinds of detergent chemicals that let the suds do their work in the wash and yet allow foam to be broken down quickly after use.

We've been busy improving many things. Our research work on stainless steel helped develop a new grade of steel that has recently been used to reduce the weight and cost of subway cars. We came up with new kinds of corrosion-resistant alloys for use in the chemical industry. And recently we introduced a plastic drinking straw that won't turn soggy.

To keep bringing you these and many other new and improved products, we'll be investing *half a billion dollars* on new plant construction during the next two years.

Union Carbide Corporation, 270 Park Avenue, New York, N. Y. 10017. In Canada: Union Carbide Canada Limited, Toronto • Divisions: Carbon Products, Chemicals, Consumer Products, Fibers & Fabrics, Food Products, International, Linde, Mining & Metals, Nuclear, Olefins, Plastics, Silicones, Stellite

UNION CARBIDE

The Month at Caltech

National Academy of Engineering

George W. Housner, professor of civil engineering and applied mechanics at Caltech, has been elected to membership in the newly-formed National Academy of Engineering. One of 17 distinguished engineers to be so honored, he will attend the Academy's first annual meeting April 27 to 29 in Washington D.C.

Three other Caltech men are among the original 25 founding members of the Academy: Clark Millikan, professor of aeronautics and director of the Graduate Aeronautical Laboratories; William H. Pickering, director of JPL; and Simon Ramo, who is a member of the board of trustees, and a research associate in electrical engineering at Caltech.

The National Academy of Engineering was established in December 1964, under the charter of the 100-year-old National Academy of Sciences. It operates autonomously, but in cooperation with the NAS. Members are selected on the basis of their contributions to engineering theory and for their achievements in engineering. They share with the NAS the responsibility of advising the federal government, upon request, in all areas of science and engineering.

Humanities Option

Beginning next fall, and for the first time in its 74 years, Caltech will offer undergraduates a Bachelor's degree in the humanities. Students will be able to major in English, history, or economics.

"Our aim," says President DuBridge, "is no less than that of developing a new kind of graduate – one devoted to the humanities but excellently grounded in science and engineering. Such a man should bring to any career he pursues – teaching, literary, or business – a breadth of view that is sorely needed in these times."

While the great majority of Caltech students will continue to specialize in science and engineering, there is a small group whose interests will lead them to take advantage of the new program. It consists of students who, after one or two years at the Institute, decide to change their majors from science or engineering to the humanities. Formerly, this entailed transferring to another college or university. The group, it is hoped, will also include a number of students who intend from the outset to major in the humanities, but who also want considerable exposure to science and engineering.

"It is worth noting," says Hallett D. Smith, chairman of Caltech's humanities division, "that in past years a fair number of our students have followed a program much like the one we are now formalizing – without, of course, receiving the degree we now offer. We have had no trouble placing them in the best graduate schools and anticipate no trouble in placing our new humanities majors. On the contrary, we expect that there will be a lively demand for them."

Dr. DuBridge points out that the new policy is a logical outgrowth of Caltech's traditional respect for the liberal arts, as reflected in its curriculum:

"From the beginning, we have required all of our undergraduates to spend at least one-quarter of their time in the humanities. Most of them are intensely interested in these subjects and do very well in them. It is not surprising that some of them choose to seek careers in related fields. Now they will be able to do this and still get their degrees at Caltech – a desirable thing from our standpoint as well as from theirs."

Honors and Awards

Richard P. Feynman, Richard Chace Tolman Professor of Theoretical Physics at Caltech, has been elected a fellow of the Royal Society of London, Britain's top scientific body, for his contribution to quantum field theory and the theory of liquid helium.

Dr. Feynman becomes a foreign member of the Royal Society. Only four such members are chosen annually. Also honored this year is Theodosius Dobzhansky, professor of population genetics at the Rockefeller Institute in New York, and onetime assistant professor of genetics at Caltech.

Arie J. Haagen-Smit, professor of bio-organic chemistry at Caltech, received the 1964 Richard Chace Tolman Medal from the Southern California Section of the American Chemical Society at an awards banquet in Los Angeles on April 7. Dr. Haagen-Smit was honored for his work in plant physiology and air pollutants; for his long interest in teaching; for loyal service to the United States government; and "for exemplifying the academic man by the integration of his talents for teaching, research, and administration."

Robert J. Parks, '44, has been appointed manager of the Jet Propulsion Laboratory's Surveyor Project of soft moon landings, the Laboratory's highest priority flight project. Parks has been assistant director for Lunar and Planetary Projects. The first of Surveyor's seven planned launches is scheduled for next fall.

H. M. Schurmeier, Ranger Project Manager for Caltech's Jet Propulsion Laboratory, received the National Aeronautics and Space Administration's Exceptional Scientific Achievement Medal from President Johnson, in a White House ceremony on March 26. Before pinning the medal on Schurmeier, the President described the close-up lunar photos taken by the Rangers as the most dramatic advance in our knowledge of the moon. At the ceremony, Schurmeier shared honors with astronauts Virgil Grissom and John Young.

Frank Press Appointment

Frank Press, director of Caltech's Seismological Laboratory, and professor of geophysics, has been appointed head of the department of geology and geophysics at the Massachusetts Institute of Technology, effective September 1.

Dr. Press came to Caltech as professor of geophysics in 1955 from Columbia University, where he was associate professor of geophysics. He has been prominent in the study of the structure and internal motion of the earth through the detection, measurement, and analysis of shock waves, and is chairman of a special panel, set up by President Johnson, to study the possibility of predicting earthquakes.

Visiting Lecturer

C. H. G. Oldham, British geophysicist and a fellow of the Institute of Current World Affairs, spent two weeks on the Caltech campus this month as a visiting lecturer, under the auspices of the humanities division. Dr. Oldham, who has lived in Hong Kong for the past four years, and spent a month in Red China at the end of last year, spoke to student and faculty groups about science and the scientist in Asia, particularly in China.

In 1960 Dr. Oldham accepted a fellowship with the Institute to study Chinese science. He spent a year at the University of London studying the Chinese language before moving to Hong Kong, where he became interested in the broader field of science and technology for underdeveloped countries.

Twenty-Eighth Annual Alumni Seminar

Saturday, May 8, 1965

Dinner and Evening Programs

Huntington-Sheraton Hotel, Pasadena

THE MOON AND THE ACROPOLIS
Eberhardt Rechtin

In philosophizing on the position in history of our nation's space effort, Dr. Rechtin will establish a parallel with the major national program of Greece at the time of its greatness. The economies of project support, inevitable social changes, and political implications will be discussed, and a few predictions will be added.

Dr. Rechtin received both his BS (1946) and his PhD (1950) degrees in electrical engineering from Caltech. He started working with Caltech's Jet Propulsion Laboratory in 1949 as a research engineer and is now Assistant Laboratory Director, Tracking and Data Acquisition.

Special Exhibits

Space Instruments from JPL – Throop Hall, west steps

Model of projected campus – Throop Hall, lobby, west entrance

Special Lecture

Beckman Auditorium, 11:45 A.M.

BREAKING THE POVERTY BARRIER – *John H. Rubel, Vice President and Director of Technical Planning, Litton Industries, Inc.*

America has taken a sharp interest in poverty. President Johnson has announced an all-out war against poverty. This suggests a number of important questions. How is poverty defined? Is it even theoretically possible to eliminate it? What are the mechanisms that might work? What steps is the government taking now and how do these relate to the normal economic activities of the private sector?

Seminar Lectures

THE NEW, NEW BIOLOGY
9:30 A.M. and 2:15 P.M.
James Bonner, Professor of Biology

The old, new biology has revealed to us the basic logic and strategy of cell life. It has shown us that all cells of all creatures use the same replication process. Biology may now turn to the determination of what enables different cells to exist in the same creature and how such differences arise. Dr. Bonner will describe the new, new biology which is concerned with the molecular basis of development and differentiation.

THE WHITE DWARFS
9:30 A.M. and 2:15 P.M.
Jesse L. Greenstein, Professor of Astrophysics

When stars no longer have nuclear energy sources, gravity compresses them to densities reaching a thousand tons per cubic inch. Dr. Greenstein will discuss observations of 200 such stars, the "White Dwarfs". He will describe studies of their chemical composition, temperature, brightness and age. These studies have led to an understanding of how the "White Dwarfs" represent the final stage of stellar evolution.

continued on page 30

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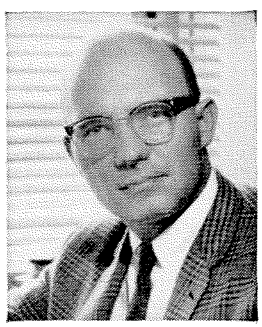
stimulation



James E. Mercereau
B.A., Physics, Pomona College
M.A., Physics, Univ. of Ill.
Ph.D., Calif. Institute of Tech.

What does it take to "spark" a man to his very best . . . to bring out the fullest expression of his ability and training? At Ford Motor Company we are convinced that an invigorating business and professional climate is one essential. A prime ingredient of this climate is the stimulation that comes from working with the top people in a field . . . such as Dr. James Mercereau.

Jim Mercereau joined our Scientific Laboratory in 1962. Recently, he headed a team of physicists who verified aspects of the Quantum Theory by creating a giant, observable quantum effect in superconductors. This outstanding achievement was the major reason the U. S. Junior Chamber of Commerce selected Dr. Mercereau as one of "America's Ten Outstanding Young Men of 1964."

Your area of interest may be far different from Dr. Mercereau's; however, you will come in contact with outstanding men in all fields at Ford Motor Company.

We believe the coupling of top experience and talent with youth and enthusiasm is stimulating to all concerned. College graduates who join Ford Motor Company find themselves very much a part of this kind of team. If you are interested in a career that provides the stimulation of working with the best, see our representative when he visits your campus. We think you'll be impressed by the things he can tell you about working at Ford Motor Company.

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BETTER SAFE THAN SOLID
9:30 A.M. and 3:15 P.M.
H. E. Ellersieck, Associate Professor of History

The abandonment of Stalinist and Marxist-Leninist rigidities in the Soviet Union and the simultaneous splintering of the so-called "Socialist Camp" internationally are matters of the greatest import, and may be advantageous to us. Soviet interests, however, are also served and the emerging fluid "mess" may well be their dish more than ours. Soviet security and possible future supremacy lie in their leading lightly now.

SENSORS IN SPACE
9:30 A.M. and 3:15 P.M.
Robert V. Meghreblian, Manager, Space Sciences Division, Jet Propulsion Laboratory

The exploration and definition of space depends upon man's ability to create, fabricate, and calibrate specialized instrumentation that can operate for an extended duration under extreme environmental conditions quite different from any experienced by man to date. Dr. Meghreblian will describe a few of the JPL Space Science Division's experiences in developing the sophisticated instrumentation used in deep space flight programs.

MAN AND HIS MACHINES
10:45 A.M. and 3:15 P.M.
Dino A. Morelli, Professor of Engineering Design

The average man still wages a continuous war against the laws of nature. Dr. Morelli will review some of the more common encounters. Since the machine most familiar to people is the automobile, most of the examples will be from that field. Other fields which produce a large number of basically similar and sometimes humorous accidents will be covered briefly.

SOME MATTERS OF CONSIDERABLE GRAVITY
10:45 A.M. and 3:15 P.M.
Thane H. McCulloh, Research Associate in Geology

Removal of the effects of altitude and latitude from precise measurements of gravity permits observation of small differences related to topographic irregularities, rock inhomogeneities, and solar and lunar tidal forces. Measuring and interpreting these small differences in the force due to gravity in all the earth's media provides unique insights in petroleum and mineral exploration, in broad areas of geology, geodesy, and inertial navigation.

LIGHT ON THE DARK CONTINENT
10:45 A.M. and 4:15 P.M.
Thayer Scudder, Assistant Professor of Anthropology

Presented with a bewildering series of African news releases concerning agricultural, educational, and industrial progress on the one hand and economic, social, and political upheaval on the other, the average American may throw up his hands in helpless confusion. Dr. Scudder will share some recent African experiences with us and demonstrate why it is so vital for us to try to understand these most important developments.

SOLAR FLARES and INTERPLANETARY STORMS
10:45 A.M. and 4:15 P.M.
Harold Zirin, Professor of Astrophysics

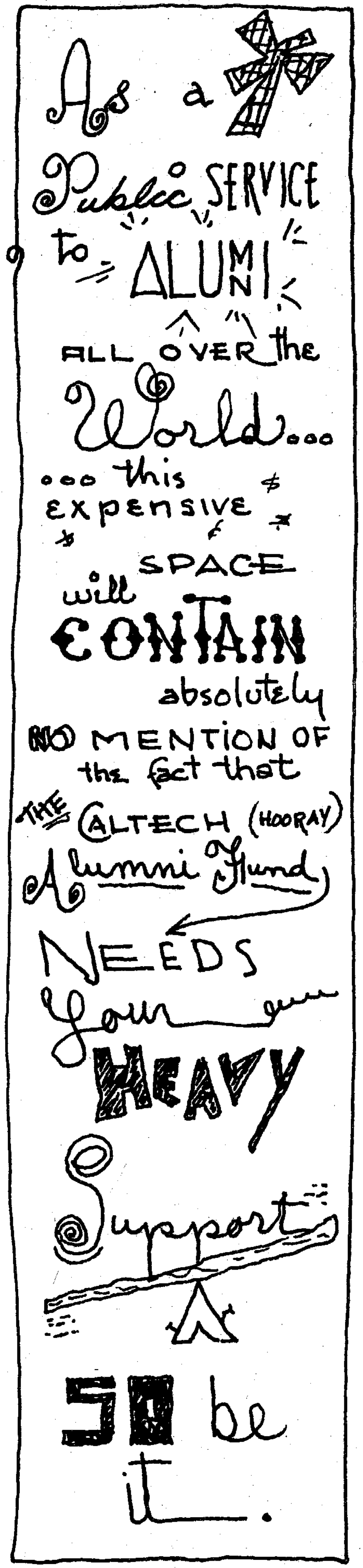
Solar flares, a part of sunspot activity, cause most important effects on the earth and interplanetary space. Direct observation of these eruptions and satellite studies of the storms they produce in interplanetary space have given a new picture of the "pond" through which our planet swims. Dr. Zirin will present motion pictures of solar flares and related phenomena and will discuss his recent observations and research.

NATURE'S VERSATILE MOLECULAR ARCHITECTURE
2:15 P.M. and 4:15 P.M.
John H. Richards, Associate Professor of Organic Chemistry

In the creation of antibiotics, or deadly poison, or substances that make carrots orange, orange trees smell, or steroids such as cholesterol which in excess apparently can accelerate man's mortality, or hormones which cause sexual differentiation, nature continually performs synthetic activities of incredible versatility. We are learning that behind this architectural diversity there exists a unifying biosynthetic theme of great simplicity.

FRESH FIELDS IN AVIATION
2:15 P.M. and 4:15 P.M.
Peter B. S. Lissaman, Assistant Professor of Aeronautics

New concepts based on advanced modes of lift generation and augmentation aimed at freeing the aerial vehicle from its dependence on speed for support, signal a virtual rebirth of aviation technology. Professor Lissaman will present slides and a short movie to illustrate his discussion of some of the more promising developments, such as boundary layer control, jet flap, ducted fan, and the ground effect machine.



Personals

1921

E. FELTON TAYLOR, insurance agent and broker, and owner of the E. Felton Taylor Company of Pasadena, died on January 4. He is survived by his wife, Margaret Rae, and daughter, Sally Taylor King.

1924

E. DALE BARCUS retired last June after 40 years with the Pacific Telephone and Telegraph Co., and has moved to Orchard Bay on Lake Arrowhead. He writes that he plans to do consulting engineering in the technical field of communications in the future.

1926

THEODORE C. COLEMAN, chairman and board president of the Coleman Engineering Company of Los Angeles, has been elected a member of the board of trustees of the Pasadena Playhouse Association.

1930

DEANE E. CARBERRY, MS '31, has accepted the position of resident engineer for Parsons, Brinckerhoff, Quade & Douglas in Peru. His work includes port expansion for Callao, the port for Lima. Carberry is a former captain of the U.S. Navy.

1933

J. STANLEY JOHNSON, MS '34, research engineer for the Taylor Forge and Pipe Works in Los Angeles, has been appointed to the board of trustees of the Pasadena Playhouse Association.

1935

FRED C. KING, JR., has been named project manager in the Socony Mobil Oil Company's engineering department, and is assigned to a refinery project in Tokyo. King joined Mobil in 1941 and was manager of the company's industrial engineering section prior to his new assignment.

DONALD N. CHAMBERLAIN is the new vice president and manager of the Southern Pipe and Casing Company in Azusa. He was formerly vice president and manager of sales.

KENNETH S. PITZER, president of Rice University, has been appointed to President Johnson's Science Advisory Committee.

1944

GEORGE G. SHOR, JR., MS '48, PhD '54, a research geophysicist at the Scripps Institution of Oceanography in La Jolla, writes that he spent some time last summer off the coast of Alaska, mapping the subsurface structure of the sea floor by seismic methods. Shor says he averages a couple of months a year at sea — in 1963, near Central America; in 1962, near India and Hawaii. The Shors have three children — Sandy, 13, Lyn 10, and Don, 8.

1945

RICHARD C. TEITSWORTH has been appointed planning manager for the Mobil Oil Company's manufacturing department in New York City. He has been with Mobil since 1943, and his most recent assignment was as a regional programs manager in the supply, distribution and traffic department.

1947

DARWIN L. FREEBAIRN, JR., will receive his MD degree from the Washington University School of Medicine in St. Louis, in June. He has been awarded an internship appointment at the San Diego County General Hospital.

1948

CHARLES SUSSKIND, professor of electrical engineering at the University of California in Berkeley, has been named assistant dean of a new office of research services in the college of engineering, in charge of the administration of about $4.5 million of engineering research grants and contracts with outside agencies, and the supervision of the university's Richmond Field Station. Susskind has been a member of the Berkeley faculty since 1955.

1949

ALLEN E. PUCKETT, PhD, has been appointed executive vice president of the Hughes Aircraft Company. He has been vice president and executive head of the company's aerospace group. Under his direction the company developed the Syncom communications satellites for NASA and the Early Bird, commercial communications satellite launched early this month. Before going with Hughes in 1949, he was research consultant in aerodynamics at Caltech and section chief of JPL's wind tunnel.

FRED D. ORDWAY, JR., PhD, has joined the physical electronics laboratory of Melpar, Inc., Falls Church, Virginia, as senior scientist. He had been with the National Bureau of Standards. At Melpar he will develop a research program on structure and crystallization processes in amorphous materials and thin-films.

JACOB F. DEWALD, PhD, member of the technical staff of Bell Telephone Laboratories in Murray Hill, New Jersey, died in January, 1964, according to an announcement just received by the Caltech Alumni Office. He is survived by his wife, Dorothy; a son, Steven; and a daughter, Rebecca.

1950

JAMES R. ALLDER has been named associate head of the guidance systems department at the Aerospace Corporation in El Segundo. Allder, who joined Aero-

Personals . . . *continued*

space in 1960, also continues as acting manager of the department's advanced systems section.

RICHARD S. FAIRALL has been elected director of honors and awards for the American Society of Mechanical Engineers for 1965. He also sends news of a new son, Timothy John, who will be one year old in May.

1953

JOHN C. BEHNKE, JR., MD, has returned to Pasadena after a twelve years' absence, to practice orthopedic surgery with Dr. Ellis W. Jones and Dr. Russell F. Compton. The Behnkes have four children.

1955

JOHN S. NIEROSKI, MS, has been named manager of the program and evaluation techniques section at the Aerospace Corporation, El Segundo. Nieroski, who joined the company in 1962, will be working on cost estimations of potential military space systems.

1956

VINCENT O. MOWERY, MS, has been named head of the operations research department of the Bell Telephone Laboratories at Holmdel, New Jersey, and will be responsible for the study and detailed analysis of telephone system operations. He has been with Bell Labs since 1956.

1960

DONALD H. VOET, who is working on his PhD in chemistry at Harvard, was married January 30 to Judy Greenwald. Mrs. Voet is a graduate student in biochemistry at Brandeis University in Waltham, Massachusetts.

1961

MARTIN H. SCHULTZ, who is at Harvard working on a PhD in mathematics, was married to Beverly Thalberg on February 21.

1962

JOHN HUISMAN, MS, PhD '64, has been appointed chief process engineer at the Jacobs Engineering Company in Pasadena.

1964

WILLIAM R. BUSH, PhD, specialist in hypersonic aerodynamics, recently joined the faculty of the University of Southern California as assistant professor in the department of areospace engineering. He will work with JOHN LAUFER, MS '43, AE '44, PhD '48, chairman of the department, who went to USC from Caltech's JPL a year ago to develop the curricula and recruit faculty for the new department.

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There are two ways in which the Placement Service may be of assistance to you:

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This service is provided to Alumni by the Institute. A fee or charge is not involved.

If you wish to avail yourself of this service, fill in and mail the following form:

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☐ An Application for Placement Assistance

☐ A form to report my field and operation so that I may be notified of any outstanding opportunities.

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Address .... Year (s) ....

....

This is one of our mechanical engineers making a mistake

They are to wed in June, and the guy had better shut up before she gets miffed. A gal has every right to resent the implication that the betrothed outpoints her in understanding of sewing and fabrics and what's good or bad about them. Even if it's true. Which it is. We have made him a pro at it.

It is our crafty intent to stop at nothing in our efforts to make garments or fabric furnishings that carry our identification tag (as for KODEL Fiber) so pleasing to the ultimate buyer in every way that she will attribute the satisfaction all to the fiber and look for that tag evermore.

This means we put mechanical engineers, chemical engineers, chemists and—yes—physicists to work freshening up the technology of dyeing, knitting, weaving, sewing, and the other elderly arts practiced not by us but by our customers' customers.

As in all the other industries in which we participate and for which we seek scientific and engineering recruits – photography, information retrieval, aerospace, plastics, graphic arts, x-ray, chemicals—there is much to challenge the intellectually ambitious in satisfying the common yearnings of mankind for adornment of the person and the home. Past technical accomplishments in fibers and fabrics, weak by comparison with what can be anticipated when fresh, better informed minds pitch in, have sufficed nonetheless to create the present affluence where there is plenty of money on hand to do what smart people will tell us to do. All we need are more smart people.

Drop us a line. From polymer theory to workable yarn and from workable yarn to clothes on the back, rugs on the floor, and curtains on the windows extends a long row of assorted disciplines and aptitudes.

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