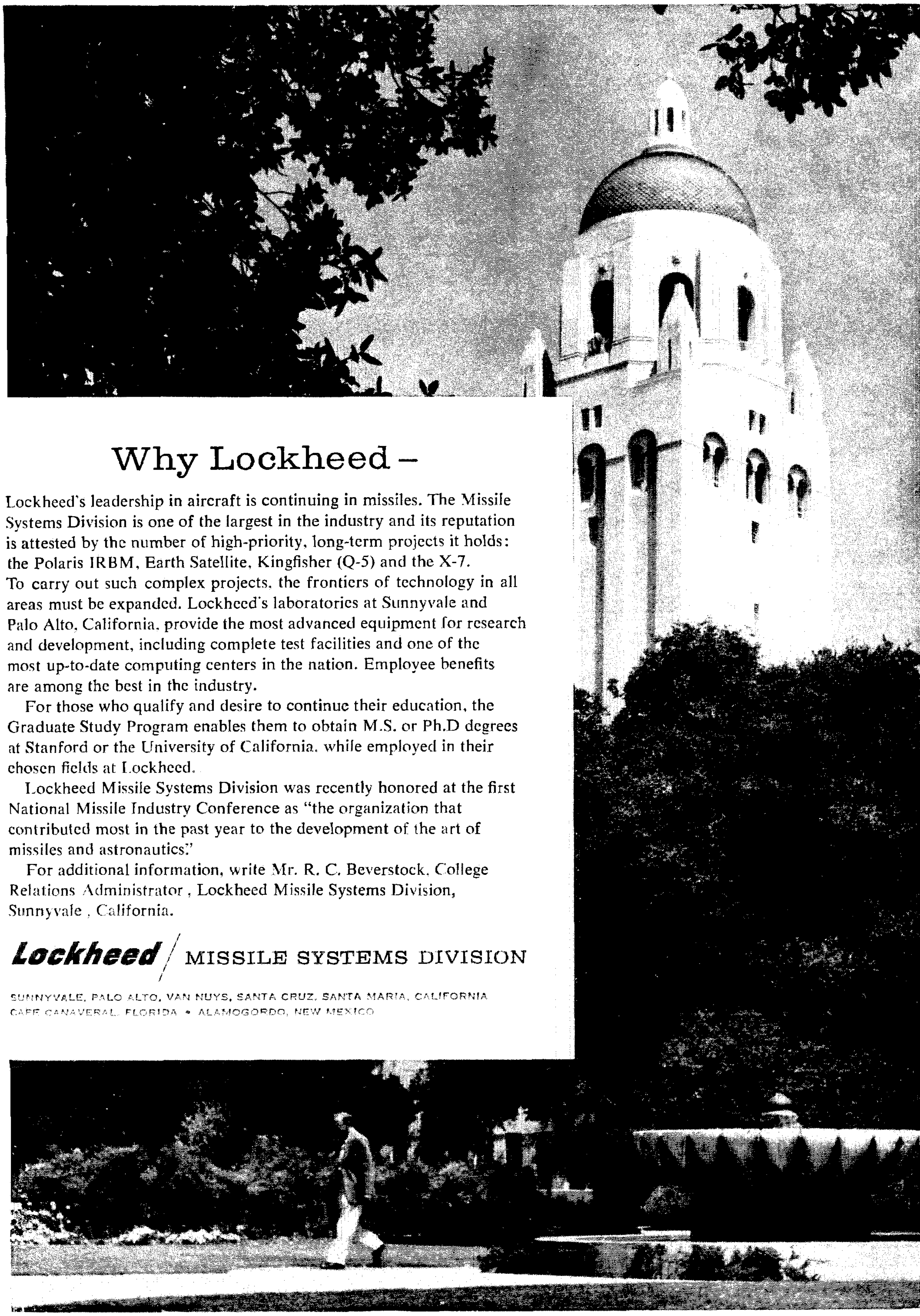
ENGINEERING | AND | SCIENCE

February 1959

Engineering Education . . . page 13

Published at the California Institute of Technology




wherever there's electronics...
there's Transitron
Advanced electronics is helping to open new frontiers in space. Vital to the reliability of rockets are their electronic guidance systems which depend on the tiny semiconductor. Maker of the industry's broadest line of advanced silicon and germanium semiconductors is Transitron. In rockets, missiles, industrial computers, long-distance communications, radar, atomic subs, jets — *wherever there's electronics* — there's Transitron, known the world over for leadership in semiconductors.
127
U. S. moon-shoot vehicles depend on Transitron products in their instrumentation and guidance systems.
TRANSISTORS • RECTIFIERS • DIODES • REGULATORS • VOLTAGE REFERENCES
Transitron
electronic corporation • wakefield, massachusetts
SALES OFFICES IN PRINCIPAL CITIES THROUGHOUT THE U. S. A. • CABLE ADDRESS: TRELCO

ENGINEERING | AND | SCIENCE

On Our Cover

Frederick C. Lindvall, chairman of the division of civil, electrical and mechanical engineering and aeronautics, holds a conference with five prominent Russian engineering educators (and members of the U.S. State Department) who visited the Caltech campus this month (see page 22).

The Russians were making a tour of U.S. engineering schools in return for a recent visit by eight American engineering educators to various engineering institutes in Russia. Dr. Lindvall headed the mission to Russia, and he gives an enlightening report on the trip on page 13, in "Engineering Education in the U.S.S.R."

G. D. McCann,

Caltech professor of electrical engineering, has been the guiding spirit in creating the comprehensive computing facilities at Caltech. His article, "Caltech's Computing Center," on page 24, gives some impressive facts about these versatile machines which are now being used by practically every department on the campus.

Dr. McCann is an alumnus of Caltech – he received his BS here in 1934, his MS in 1935 and his PhD in 1939 – and he has been a member of the Caltech faculty since 1946.

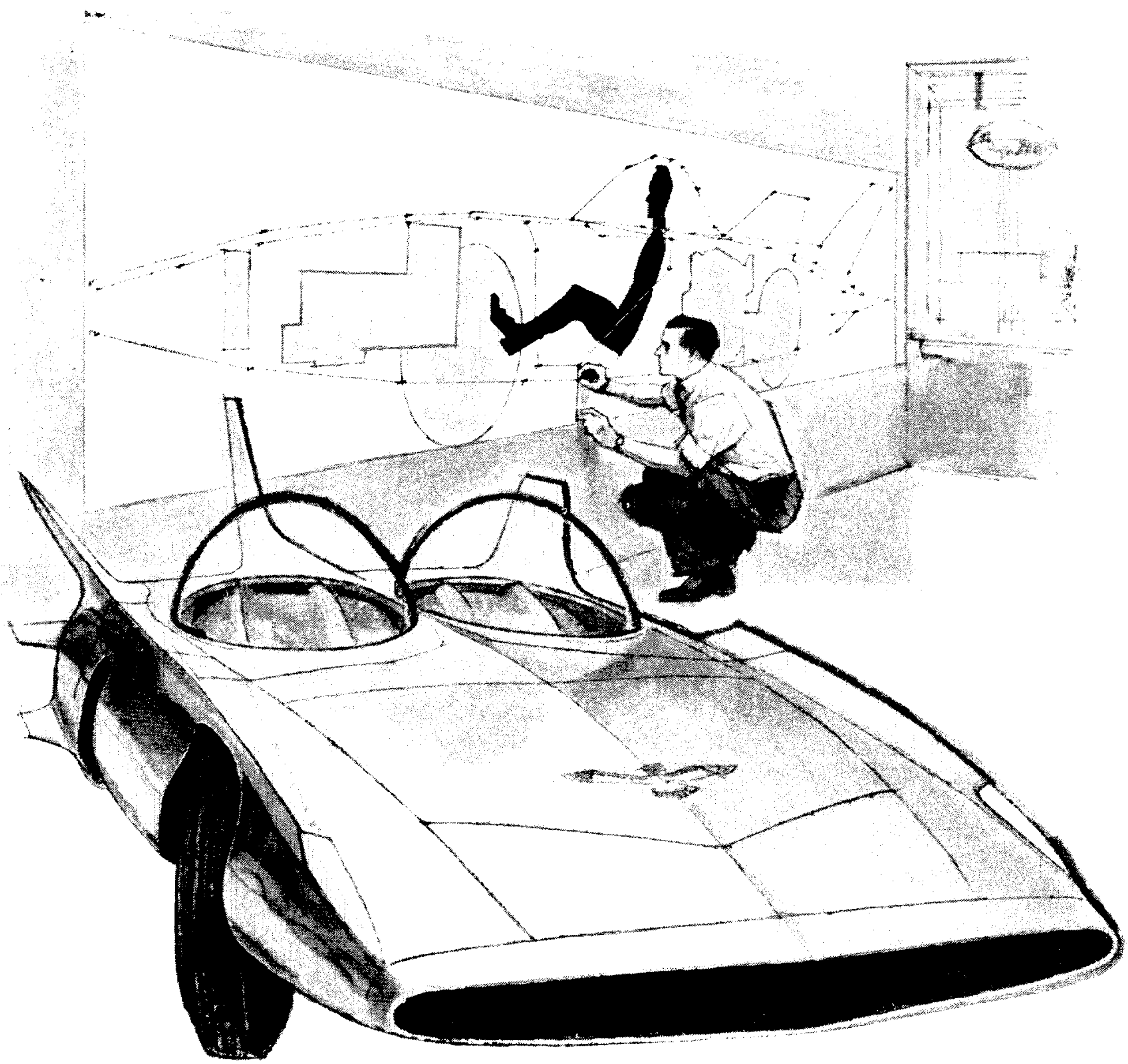
Photo Credits:
Cover – Graphic Arts
18-19 – Graphic Arts
20 – Mount Wilson-Palomar photo
22 – Mount Wilson-Palomar photo
23 – Graphic Arts
24-25 – Graphic Arts

FEBRUARY 1959 VOLUME XXII NUMBER 5

STAFF

Publisher..........Richard C. Armstrong '28
Editor and Business Manager..........Edward Hutchings, Jr.
Editorial Assistant..........Gerda Chambers
Student News..........Brad Efron '60
Joel Yellin '61
Martin Carnoy '60

Published monthly, October through June, at the California Institute of Technology, 1201 East California St., Pasadena, Calif., for the undergraduates, graduate students and alumni of the Institute. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Entered as second class matter at the Post Office at Pasadena, California, on September 6, 1939, under act of March 3, 1879. Manuscripts and all other editorial correspondence should be addressed to: The Editor, *Engineering and Science*, California Institute of Technology,



Books

The Scientists

by Eleazar Lipsky

Appleton-Century-Crofts, Inc. . . . $4.95

Reviewed by Robert S. Edgar

In the last few years, achievements in the domain of science and technology, and our keen competition with the Russians in this area, have made the scientist much more important as a public figure. At the same time, much has been written and said about the public's misconception of the scientist as an ivory-tower misfit. In spite of – or perhaps because of – this notoriety, few scientists, and even fewer convincing ones, have lived in the pages of the novel.

The battle of Biocin

A novel dealing with scientists has appeared at this propitious time and, significantly, been selected by the Book-of-the-Month Club. The book, *The Scientists*, focuses attention on a lawsuit between David Luzzatto, an impetuous young geneticist, and his rather weird professor, Victor Ullman. David, during his graduate student days, had discovered a mutation inhibitor called "Biocin" which, for reasons unconvincing to this reader, increases the effectiveness of all antibiotics. Ullman contests David's rights to the large royalties from Biocin. Thus David's reputation, and that of the college which has capitalized on his rising prestige, are in jeopardy. Nearly everyone who becomes involved in the ensuing complications – the sly, fence-sitting president of the college; the frightened or calculating faculty members; David; Ullman; and the reader – comes out soiled by the experience.

Movie material?

Although the spirit of science does occasionally enter, it is of little consequence to the central theme of the book which, following a recent and popular literary trend, manages to convey that money is money, work is the manipulation of one's colleagues, and the scientist and the Madison Avenue ad-man are brothers under the skin. The book will probably make a successful movie.

Robert S. Edgar, research fellow in biophysics, received his BS from McGill University, Canada, in 1953, and his PhD from the University of Rochester in 1957. He is working at Caltech on the genetics of bacteriophage.

The Search

by C. P. Snow

Charles Scribner's Sons $3.95

"Most writers write about scientists as if they were either men from Mars or earnest boy scouts intent on a meaningless task which may nevertheless blow us all sky high. Snow's characters are gifted human beings with every degree of commitment to the enterprise of discovering new knowledge."

This is the distinguished physicist, I. I. Rabi, commenting on *The Search*. First published in 1934, this novel has maintained a certain reputation over the years for its sensible and accurate treatment of science and scientists. Now it has been revised and reissued.

"It made a deep impression on me," says Rabi, "as a novel which described the world of science as lived by scientists from the inside. I have since recommended it as the one novel which I knew which was really about scientists living as scientists . . . It is even more timely now than it was when first published."

The Search is not only a good novel about science – it's a good story too. As a result, it ought to give a lot of laymen some idea of what a scientist's life is like.

C. P. Snow should know. He was trained as a physicist and did some research at Cambridge before he started on what has now become a distinguished literary career. In an impressive introductory note to this new edition of *The Search* he gives some of his reasons for writing this kind of book:

"We are living," he says, "in the middle of two cultures which have scarcely any contact at all – the traditional non-scientific culture and an up-and-coming scientific one. They are startlingly different, not only in their intellectual approach, but even more so in their climate of thought and their moral attitudes. This divide exists not only in the U.S. and Great Britain but all over the Western world . . .

". . . It is mildly funny to observe the stereotypes which each side has of the other. The scientists' stereotype of the literary culture: defeatist, unvirile, profoundly selfish, unconcerned about their brother men, indifferent to the social condition, intellectually un-

continued on page 10

Books . . . *continued*

truthful. The literary culture's stereotype of the scientist: brash, shallowly optimistic, indifferent to the individual condition, lacking all sense of tragedy, unemotional naive, asexual. Well, we could laugh that off if it didn't mean a lack of communication at a much deeper level. That is, however, precisely what it does mean. . . . This is serious. It is hard to believe that a society whose intellectual life is so deeply split can be healthy for long.

"What can we do about it? There is only one answer, and it is a prosaic one: sensible education. Nearly all intelligent people can learn something about science and scientists if they are brought up against them properly. It is very stupid to attempt to make everybody into technologists; but it is essential that everybody, including the technologists themselves, should understand something of the intellectual and human meaning of what the technologists are about. I don't think that that task is beyond us, though it will need a drastic rethinking about education, both in the U.S. and Great Britain.

A basic difficulty

"There is just one basic difficulty. All children have a dash of the scientist in them . . . The urge to investigate . . . isn't anything very special or academic . . . But all children are not mathematicians, and that is the core of the difficulty. I don't know how many people are mathematically blind to the extent that some of us are tone deaf, but I suspect a larger proportion than the educational psychologists usually allow. Thinking of twenty acquaintances, who have all done pretty well in various sorts of intellectual life, I should say that at least five were, if not mathematically blind, at least grossly deficient in mathematical sense. That means that though, sensibly educated, they could have got a good working idea of how physical science goes about its business, they would never have reached the fundamental concepts. I suggest we have got to accept the fact that, for a lot of people of high intelligence and imagination, this is as near as they are going to come to the real stuff. It is much better than nothing, but there are limits, and it is just as well to be clear-sighted about them in advance.

"Don't we know enough now of the way different kinds of intelligence work? Oughtn't we to be able to construct an education from which anyone of ability can get enough not to feel that the scientific experience is alien to him for ever?"

MEN AND IDEAS IN MOTION: AERONUTRONIC

This is Aeronutronic—men, ideas, and the tools for research. Aeronutronic—a dynamic new name in science—created by the Ford Motor Company to meet the demanding technological needs of a nation on the move.

Aeronutronic is moving into the future and moving fast. Space sciences, missile technology and space vehicles...computers, electronics...tactical weapon systems... these are major research, development and manufacturing activities conducted at ASI's modern 200-acre Research Center under construction at Newport Beach, California.

Exceptional engineers and scientists are needed now. If you are forward-looking and want to be an important part of a forward-moving organization, you'll find a new challenge and rewarding future at Aeronutronic — *where men set ideas in motion.*

For information regarding positions, interests, facilities or products, write to Mr. K. A. Dunn, Aeronutronic Systems, Inc., Bldg. A6, 1234 Air Way, Glendale, California, or call CHapman 5-6651.

AERONUTRONIC

a subsidiary of FORD MOTOR COMPANY

NEWPORT BEACH, GLENDALE, SANTA ANA AND MAYWOOD, CALIFORNIA

OFFICE OF ADVANCED RESEARCH • SPACE TECHNOLOGY DIVISION • COMPUTER DIVISION • TACTICAL WEAPON SYSTEMS DIVISION

Engineering Education in the U.S.S.R.

by Frederick C. Lindvall

Someone made a very profound remark when he said, "There is no expert on Russia; there are merely degrees of ignorance." Russia has always been an unknown country. And there has always been suspicion and doubt as to whether what is seen by visitors is a piece of "show," or a true situation.

Concerning engineering education in the U.S.S.R., a great deal of information already exists in our country, in the form of published documents, or from occasional visits that people have been able to make to the U.S.S.R. We know a good deal about the formal structure of their engineering education, and their elementary education through their so-called middle school — or what we would call high school. But we are a little bit in the position of anyone who, in this country, reads our college catalogues. All engineering schools sound equally good. However, if teams of observers go to the different schools — as happens in this country, in our procedure known as accreditation of engineering curricula — we find that there are real differences and that we have good, bad and indifferent engineering schools.

So, when the State Department asked me last year (while I was still president of the American Society for Engineering Education) to set up a mission to visit engineering schools in Russia, we organized a group of eight people who represented various kinds of engineering schools in this country, and various fields of engineering. We did our best to determine which Russian engineering schools would be good, bad, or indifferent, and we asked to visit all three kinds.

We went under the auspices of the American Society for Engineering Education. The State Department arranged it through what is known as the Lacey agreement, which was instigated about a year ago for the exchange of cultural and scientific personnel. The object is to have U.S. groups and Russian groups interchange visits in the same general field. In the Lacey agreement, engineering education was one of the items specifically mentioned. The National Science Foundation financed the exchange.

Other groups have been on recent educational visits to Russia. But they were concerned with the general structure of education and, more specifically, with elementary and high school education — in other words the so-called ten-year school, which is the Russian pattern.

Of course, the development of Russian education has been phenomenal. In one sense, the Soviet Government abolished religion and substituted education for it, because education is almost a religion for the people now. They all believe in it, they respect learning, and they honor accomplishment in scholarship in a way that we don't even approach.

The object of many Russian youngsters is to do well enough in the first four years of school to be able to go on to the next three years of schooling and, at the end of seven years, to go on to the *next* three, which will prepare them to enter a university or a professional school. After seven years of school, the less-good students have a chance of going into what are called the *technicums*, for training of the technician

---

"Engineering Education in the U.S.S.R" is a transcript of a Friday Evening Lecture given by Dr. Lindvall, chairman of Caltech's division of engineering and aeronautics, on January 23, 1959.

"They respect learning, and honor accomplishment in scholarship in a way that we don't even approach."

type, as against the analytical or engineering approach.

The same pattern exists in many European countries, but the graduate of the technical school has no opportunity of going beyond this point. In Russia, this is not so. An honor student from a technicum may enter a university; it is not a dead-end street. So, for this particular feature, I think the Russians deserve a little praise.

After this ten-year school, there is, for the better students, a chance either at the university, or one of the professional schools. Engineering in the Russian system is not taught in the university. One finds science there, along with liberal arts, but engineering is taught in polytechnic institutes, or specialized institutes. The schools concerned with engineering education are directly under the Ministry of Higher Education — as are the universities. It is true that, within the universities, one can find research and instruction going on which, at Caltech, we would call "engineering," but this is incidental to the Russian pattern. Hence, our group confined itself to the polytechnic institutes and the technical schools.

Our group visited schools in Moscow, Kuibyshev, Frunze, and Leningrad. The trip from Moscow to Kuibyshev was by train — 22 hours, continuous; this is a big country. The remainder of the trip was by air — to Tashkent, where we stayed a day and visited with some of the people of the polytechnic institute there. Then over to Frunze, which is the capital of the Kirghiz Republic which borders on Chinese Turkestan. We were at that point very close to China and directly north of Central India.

The object of our mission was to try to assess the quality of engineering education as nearly as we could. Of course, we could look over the catalogues and read what they *say* they are doing, but are they really doing it? We wanted to sit down with the professors and talk about the class work: "What do you assign the students as problems? What is the textbook? Do you cover the whole book, or skip parts of it?" We were trying to get at these details at the working level.

We found it difficult to make the Russians understand. They were used to missions that had only an hour or two to look at a school. So what happens? Some general talk, a look around, a visit to some laboratories, "hello," "goodbye," and that's it. It took a great deal of time, working through interpreters, to convince our hosts that laboratories were fine but that we would like to sit down and talk to a professor of electrical engineering, a professor of thermodynamics, or a professor of physics.

Language was a handicap, of course, but fortunately in this kind of assessment the Russians print mathematics the same way that we print mathematics and they draw diagrams the way we draw diagrams, so it is possible to thumb through a textbook and see familiar things, then get the interpreter's attention and ask the question, "Do you really give problems on this particular subject?" "Oh, yes, yes." Then buttons are pushed and telephones are rung and assistants bring in the problems to show us.

We did get around to the laboratories and found that in some ways the Russians use their laboratories as teaching devices more effectively than we do. There are some routine experiments with rather detailed instructions for the beginning students, but as they progress, the instructions are less definite and the students are given more opportunity to use their own initiative. In several of their major subjects students do what are called course projects. These are small theses, or term studies that may occupy several weeks of the student's time in the laboratory. The student presents quite a comprehensive paper on the subject. This is a little bit comparable to what happens in our schools for a few students who decide to enter students' prize competitions for the American Institute of Electrical Engineers or the American Society of Mechanical Engineers, for example. But only a few of our students do this, whereas all of the Russian students have the experience.

But there is no use talking about engineering education and trying to make a comparison with the United States or Western Europe without getting into a completely different frame of reference. The U.S.S.R. has made phenomenal progress through a series of five-year plans. Over here, we simply don't realize the thoroughness and comprehensive character of these plans. We live in an unplanned society in the United

States – but the U.S.S.R. is completely planned.

Overall objectives are established by the Council of Ministers. A central planning bureaucracy works out details so as to establish that, five years from now, steel production will be so many million tons per year; aluminum production will be so much; the miles of railroad built in this period will be so many; the miles of electrification of existing railroad will be so many; or so many millions of kilowatts of generating capacity will be brought on the line. This general planning determines steel allocation to military and civilian needs, for example. With quotas and priorities established, then further detailed planning follows. Ministries participating in this overall planning then determine what these objectives mean to their operations.

The steel people will decide that five years from now a certain number of new metallurgical engineers trained in steel metallurgy will be needed to enter new plants which will be ready by that time. The railroads will decide how many new engineers are needed. These needs all go to the Minister of Higher Education and he totals requirements for the thousands of graduates in different types of engineering specialties.

Engineering specialties

Some of us are unhappy with the large numbers of designated engineers that *we* have: civil, electrical, mechanical, aeronautical, refrigeration, heating and ventilating, ceramic, agricultural, industrial, and so on. But in Russia the specialties now number about 177, not counting those in the military area, which are not published and which we didn't observe.

For example, there will be a specialist for the electrical equipment of hydroelectric stations. There will be a mechanical engineer whose specialty is materials handling, and he will be concerned with overhead cranes, conveyor belts, lift trucks, and other things that move materials. He stays inside the factory; he doesn't worry about transportation to the factory.

This kind of specialization would be considered to be completely wrong for our free economy. We would think we were doing a disservice to a student to give him such specialized education – to circumscribe his choice of jobs so narrowly. We want him to be free to move into any job opportunity that appeals to him.

How do the boys – and girls – get into engineering school in Russia? (30 percent of the engineering students in Russia are girls, and in some specialties the ratio is as high as 50 percent.) The schools have their particular quotas in the various specialties and these quotas are generally known to the students. The schools do a certain amount of "advertising" to attract the best students. For instance, the Moscow Power Institute gets out a little booklet which shows the swimming pool, the happy life of the girls in the dormitory, the dancing and the masked ball, the glee club and other extra-curricular activities. Moscow Power Institute wants to have a choice of the best students – and, indeed, they can choose from among the best.

There is a general examination at the end of the ten-year school, conducted on a state basis. All of the engineering schools use the scores of the students on this state examination, much as we use the college board exams. Moscow Power Institute will take a cut of the upper two or three percent and schools that are less good will dig a little deeper.

The students know what specialties are open and they apply for these. A student can apply for any one specialty in any one year; there is none of the multiple application that we have here. If he misses and is not admitted he can go to work and apply another year. The best students apply for the most glamorous specialties; the less-good students, the less-glamorous; and the poorer students take whatever they can get.

Night school programs

The man or girl who applies and isn't admitted need not mark time, because the U.S.S.R. has very comprehensive night school programs at the collegiate level, as well as correspondence programs. In the night school programs a man works full-time in industry and goes to school three or four evenings a week. He has an opportunity in this night school program, and in the correspondence program, to be examined in the same way that the day school students are, and to benefit from laboratory experience as well. Students have a month's leave to the particular polytechnic institute that is supervising their night programs or their correspondence programs. In that month, they get a concentrated dose of laboratory work and take their examinations, a portion of which are oral. These are the same examinations the day students take. The night program student who stays with it in Russia will take about six and a half years to complete his course as against about five and a half years in full-time day residence.

Let's look at Ivan, who did succeed in getting into the Moscow Power Institute. He has reasonably good grades, he looks promising, and he fills out forms as we do here for scholarship aid. A faculty committee passes on his application, basing the decision on a combination of indicated ability and need. After all, some people in Russia have high incomes and can well afford to send their children to school. But there are also a few students whose scholastic records are so high that they are honored with scholarship grants regardless of need.

In all, about 85 percent of Russian students receive grants. The minimum grant is 300 rubles per month – enough to pay for board and room. If Ivan does well in school and goes on to the second year and the third year, his salary goes up each year; if he gets high marks, he gets a bonus amounting to 25 or 30 percent of his pay. So, the superior students in a school such as Moscow Power Institute are paid in the range of 700 to 800 rubles a month by the time they graduate. (In comparison, workers in the steel industry in Russia average about 1200 rubles per month.)

The starting pay for a young engineering graduate is about 800 to 900 rubles per month, so that, looking over the whole picture, one can say that when Ivan has been admitted to the school, he has started to work for the state. If a student doesn't do well in school, of course, the bonus system works in reverse and his pay is docked; and if he is doing very badly, his assistance is canceled.

Program of study

The program of study for Russian students is quite regimented. Each specialty has a published curriculum known as a study plan. A study plan for a specialty in mechanical engineering would have the general title, Mechanical Engineering, but the specialty might be Hydraulic Turbines and Other Hydraulic Machinery.

The plan includes "Foundations of Marxism and Leninism," "Political Economy," "Foreign Language," "Economics, Organization and Planning of Enterprises" and "History of Engineering." These represent the non-technical content of the curriculum.

Students in a specialty are not conscious of narrow education. They know that if they finish the specialty in Hydraulic Turbines and Other Hydraulic Machinery, there will be a job waiting for them in a plant that manufactures such things, because this is all part of the plan.

For three years, students take what we might call general or core subjects which are quite thorough in physics, mathematics, chemistry, foreign language, basic mechanics, fundamental electricity and magnetism. In the fourth year, they have more advanced phases of these subjects and they begin to pick up a little of their specialty. The fifth year concentrates on the specialty. In the first half of the sixth year, an entire semester is spent on a "diploma project" — what we might call a thesis. This is a very comprehensive design study involving theoretical calculations, an actual design layout, and a sheaf of detailed drawings that might drive some of our students away from engineering altogether.

A typical engineering curriculum at one of the better schools such as Moscow Power Institute takes five and a half years plus six months of obligatory industrial experience. This means that there are six years of engineering education and training following a quite thorough high school preparation. These students graduate about two years older than bachelor of science students in this country, and have a good deal more maturity, together with a certain amount of art and practice of engineering. In this country we expect industry — rather than educational institutions — to furnish this kind of experience and training.

Again, we must remember the Russian economic framework. The industry concerned with hydraulic machinery develops non-competitive designs. So, if the student learns how to design some hydraulic machinery in school, he follows standard practice and not the standards of one of several competing manufacturers. Consequently these students of the polytechnic institutes are quite useful immediately in the particular industry of their specialty.

Do graduates have a choice of jobs? The better students do, because the managers of the different plants concerned with this segment of industry send representatives to interview the top quality students and sell them on the idea of coming to work in Minsk or wherever the plant happens to be. The good students have a choice — as they do all over the world. The good students get concessions during the course of their education. They can omit certain required subjects and take others. They are allowed to take electives which the average or poor students are not permitted to take. Everywhere in Russia there are rewards for achievement and praise for success.

Each school we visited had a huge bulletin board, usually with a fancy gold frame, and with the red star, the hammer and sickle and Lenin's picture above it. And on these bulletin boards were almost lifesize photographs of the honor students — about 30 or 40 of them. If a student's work slips, down comes his picture. Also we saw student work in the hallways — cartoons and student newspapers, poking fun at students who do poorly.

One of the functions of the Young Communist League is to prod the laggards a bit, to find out why they are not getting along, and give them some honest-to-goodness coaching if this is what is required — or to make life miserable for them until they get busy and work. The atmosphere is that of striving toward success, and everywhere there is a feeling of pushing forward toward some kind of a goal and some kind of achievement.

Work experience

A new factor which threw a bit of confusion into our study of Russian engineering education is the principle recently enunciated by Khrushchev that all students who go on to higher education must have two years of work experience. A number of explanations are offered for this. One is that industry is short of hands. There is no unemployment in Russia, and workers are needed in the factories. Then, at the end of the two years, those who have worked their two-year period and who had good marks in school not only have priority for admission to higher education at the universities and the polytechnic institutes, but also will approach their advanced studies with greater maturity and purpose.

This principle has been suddenly thrown at the whole school system and the Ministry of Higher Education hasn't completed plans for adapting to it. (One can just imagine what would happen here if suddenly all the high school students graduating in June put off going to college for two years.) In the entire U.S.S.R. the night school and correspondence programs will be expanded considerably so that students will not be marking time, going stale intellectually while they work in the foundry or the machine shop.

The schools themselves may find other ways. Many of the polytechnic institutes, having specialties which are directed toward what we might call industrial engineering (production control and subjects of that sort) have large work shops, where students as well as full-time employees work, turning out products which go into the general economy. Many such colleges are planning to enlarge their shops so they can employ their students — or those who *will* be their students. Then ways will be found for adjusting the work in the factories to permit study periods.

Higher degrees

Now, just a brief word about education beyond the diploma. The diploma graduate has an education which is roughly equivalent to a level between our master's degree and our doctor's degree — from the better schools. But the advanced work is on quite a different basis in Russia than ours. The next degree beyond the diploma is the so-called *kandidat* degree. After working two years beyond the diploma in some industry (and this industry may, for the better students, be a research project in the college that is trying to hang on to him) a student may register for advanced work. He will then study additional subject matter, pass certain comprehensive examinations, and do a very thorough thesis for the kandidat degree.

This degree is not within the power of the particular school to award; the school can only recommend. All degrees beyond the diploma are under the control of what is called the Higher Attestation Commission, which operates on a national basis. The man who prepares his kandidat dissertation does so under the supervision of some school having a Chair which is authorized to look after this kind of subject matter. When the dissertation is ready, the man publishes a rather fat abstract of the paper — several hundred copies — and these are distributed widely throughout the schools of the U.S.S.R. well in advance of the time of his final examination. The Higher Attestation Commission appoints two or three examiners who are supposed to question this dissertation. Then, at a scheduled time, there is a public examination and a defense of the thesis. Any objector can come to this meeting and if there is enough objection the candidate is required to modify his work or prove its validity. If this is a successful examination, the particular school recommends to the higher commission that the degree be awarded. The thesis is then further screened by a committee within the Commission, and if this committee likes it, it is approved and the candidate gets his certificate.

The same procedure is followed for the Doctor of Science degree. This degree is not possible, normally, immediately following the kandidat degree, but is usual after several years of teaching or research, or work in industry, and a substantial number of publications. The degree is for a suitable dissertation, with no additional course work in school. There will be certain qualifying examinations, plus the defense of the thesis. Occasionally the Attestation Commission considers a kandidat dissertation to be of such excellence that the Doctor of Science degree is awarded without further formality!

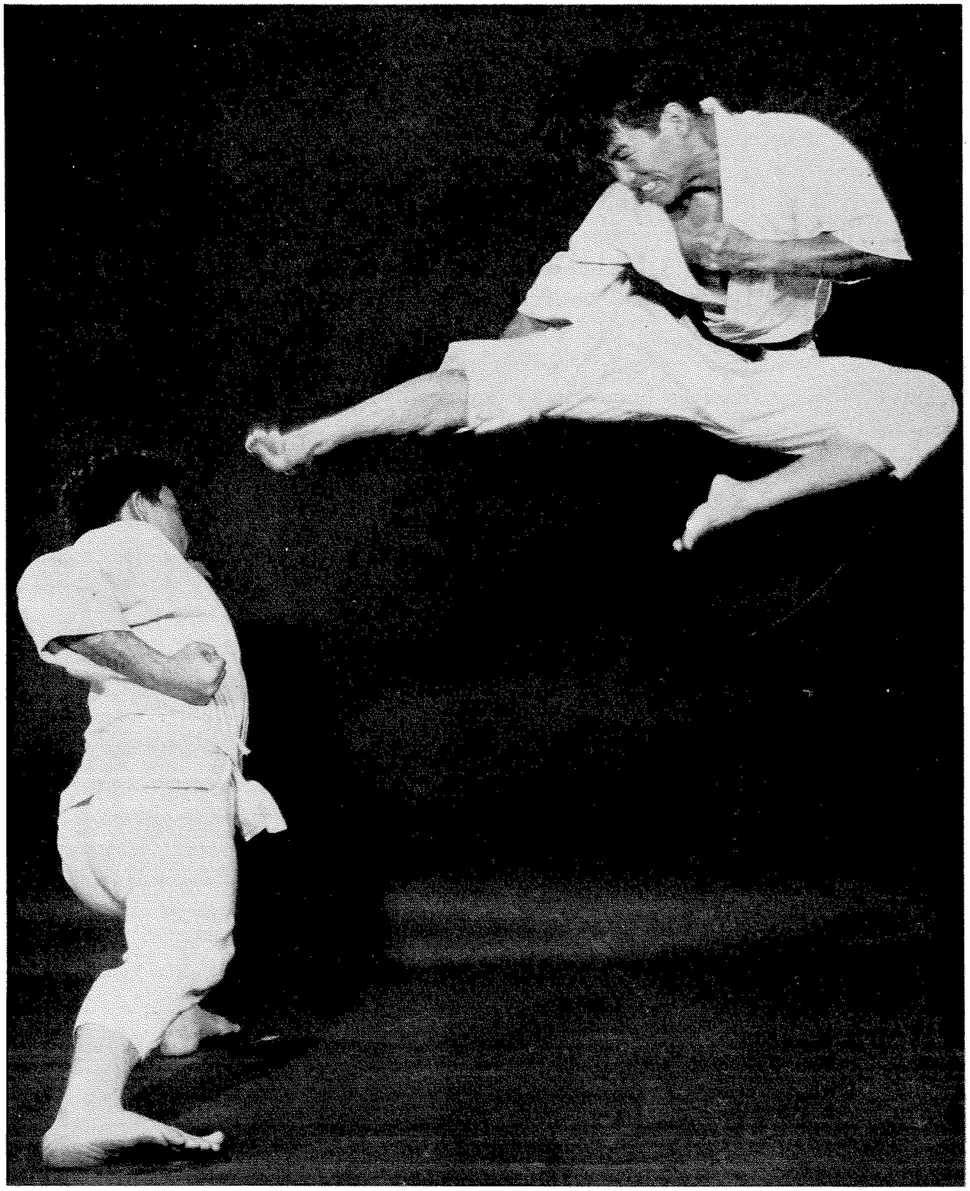
The word "science" in this sense really means "higher learning." The Russian Academy of Sciences in turn is much broader in scope, and greater in influence, than our National Academy of Sciences here: it includes subjects in the liberal arts and engineering. A Doctor of Science degree may be awarded for work in language, history, engineering, physics, biology, or philosophy.

This high degree of Doctor of Science is more or less a prerequisite for a position as professor. Professors are very well paid in Russia. The standard professor's salary is 5000 rubles a month. Hence, it is possible to attract good engineers from industry for professional jobs on the basis not only of prestige, but also of salary. That isn't the way it works in this country.

Summing up

To sum up very quickly, we found excellent, good, and fair engineering education in Russia. We found that there were at least four times as many students wanting to get into engineering schools as the schools could take. The Russians are graduating more engineers than they immediately need in their present economy. Hence, they will be in a position very soon to export engineers to developing countries throughout Asia and the Near East. They will have plenty of engineers to help build up their internal economy. The production rates of the basic things that concern engineers are high.

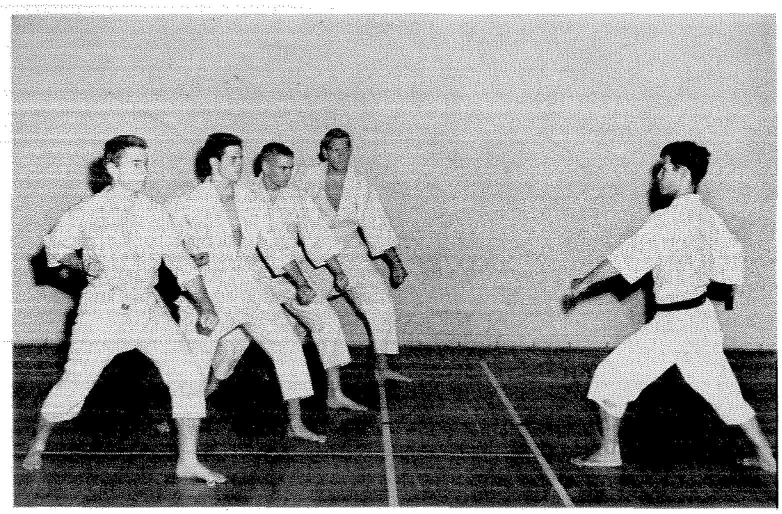
Throughout Russia there is the great objective to pass the United States in everything. Much of this is friendly and not bitter at all. Everywhere we went, we were well received; the professors were eager to talk about their students and their problems. The Russian students are no different from other students. They have their troubles and their fun and their successes, just as our students do; and the professors like to talk about them and to talk about ways of improving engineering instruction. Everywhere we went, there was the hope expressed that there could be many such exchanges because if we know each other better, we will have less fear of each other.



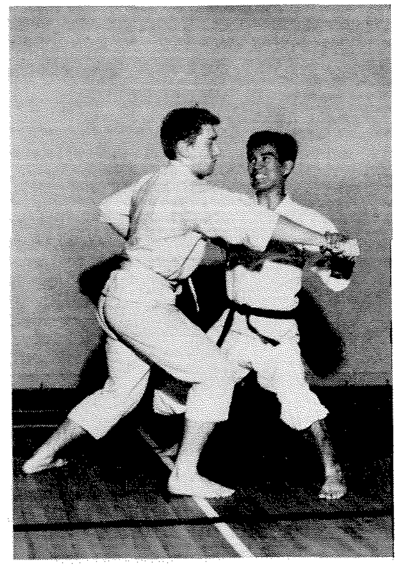
Karate instructor Ohshima leaps high in midair as he prepares to launch a side kick to the neck or temple of his opponent.

Karate at Caltech

Karate, an ancient art of self-protection, has now been added to Caltech's athletic program. This is its first appearance on a U.S. college campus. Caltech students practice this lethal art once a week under the direction of Tsutomu Ohshima from Tokyo, Japan. Karate, which means "without weapons," is a form of self-defense which was used by unarmed wandering monks as far back as the Fifth Century A.D. About 300 years ago it spread to the islands of Okinawa and then to Japan, where Karate is still enthusiastically studied at most major universities.

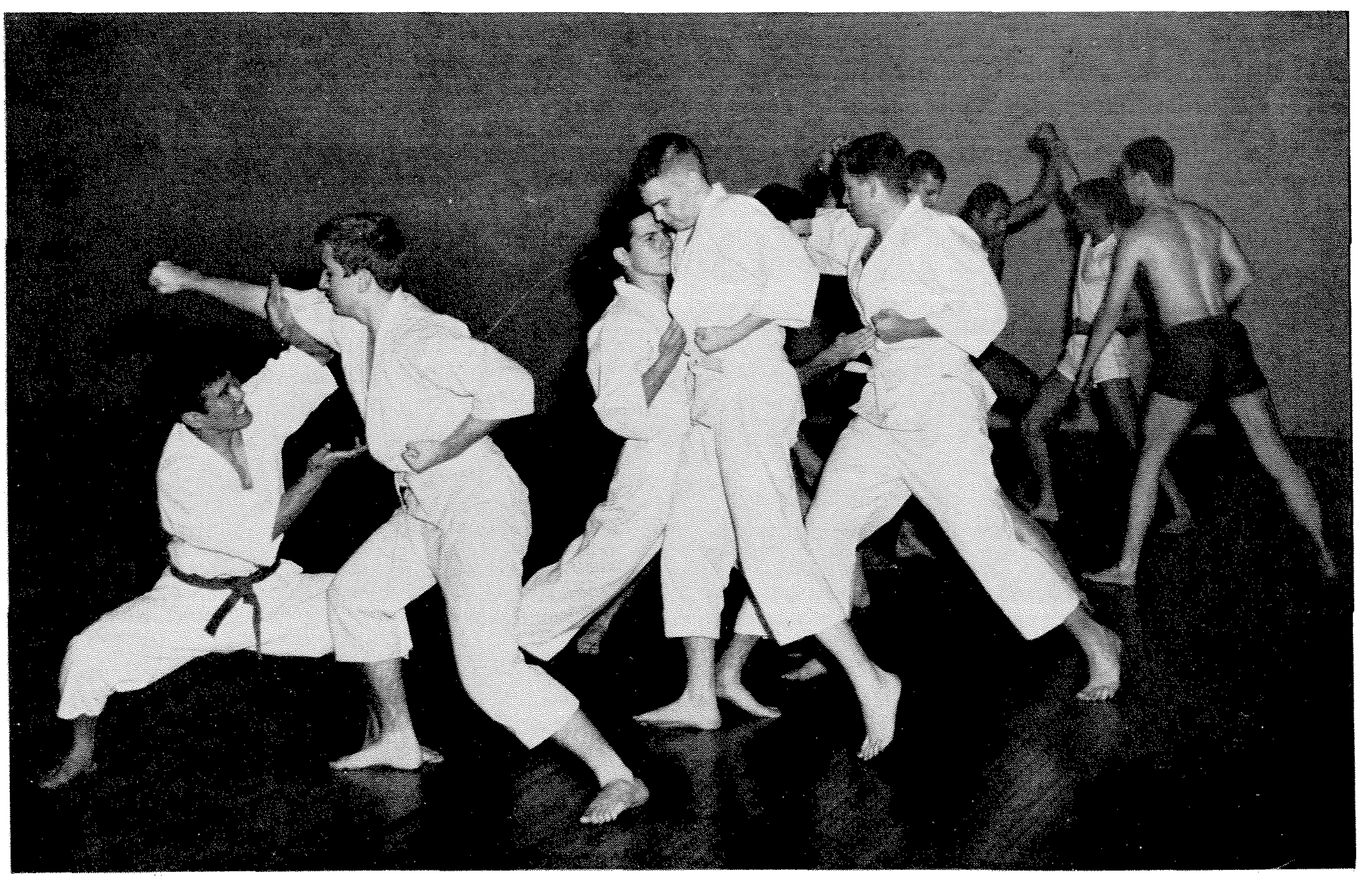


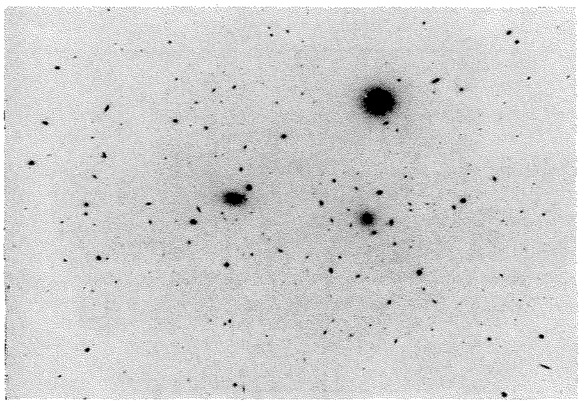
Ohshima instructs Caltech students in the correct form for the basic front attack.



An attack is blocked by the instructor, who is using a round kick while warding off a possible punch.

The row of students on the left blocks attackers with open-fingered jabs at eyes and stomach.





The Coma Cluster of Galaxies. Dr. Zwicky's studies of distant galaxies like these have led him to question the universality of Newton's law.

A New Cosmological Theory

by Fritz Zwicky

In our endeavor to extend the frontiers of science it is important to check on the range of validity of the laws of physics and to search for new laws in the realms of experimentally established new phenomena. One new finding has come from the study of the gravitational interactions between bodies which are separated by ever-increasing distances.

Observations on galaxies and on clusters of galaxies at the Palomar Observatory have led to the conclusion that, in all probability, Newton's universal law of gravitational attraction ceases to be valid when distances of the order of 10 million light years or greater are considered. The analysis of the interactions of massive bodies which are separated by such distances indicates that, either there is no force acting at all between such bodies, or this force is much smaller than would be expected on the basis of Newton's law of gravitation. Actually, according to the observations available at the present time, the force of attraction for very widely separated bodies might even have to be replaced by a force of repulsion.

Newton's law of gravitational attraction was originally derived from observations of the motions of the moon and of the planets. Newton postulated that "every particle of matter in the universe attracts every other particle with a force varying inversely as the square of their mutual distances and directly as the mass of the attracting particles." Newton, combining his law of gravitation with his famous laws of motion, successfully accounted for all of the observations available to him on the motions of planets, their satellites, and the motions of comets.

It later became possible, with the aid of exceedingly sensitive recording instruments, to verify Newton's law in the interaction between bodies on or near the earth's surface, as well as in their interactions with the earth itself.

The only strict proof of the validity of Newton's laws in the spaces beyond the boundaries of the planetary system was given in connection with the motions of the components of *double stars.* A great many of these systems have been studied since the French astronomer Felix Savary first showed in 1830 that the motions of the components of certain double stars observed by Sir William Herschel and F. G. W. Struve, could be interpreted on the basis of Newton's law of gravitation and his laws of motion.

Kepler's laws of motion were checked for many double stars which lie at distances nearer than 700 light years. The components of double stars were proved to interact according to Newton's law. This proof is restricted to separations between the component stars not exceeding the dimensions of the solar system. From observations on double stars we therefore know only that Newton's law of gravitation, within the limited observational accuracy, describes the interactions between stars separated by distances not greater than one thousandth of a light year and that these interactions are the same for double stars within a sphere of 700 light years radius.

Beyond these proofs for the validity of Newton's universal law of gravitation, however, no further fundamental progress was made for a period of almost a hundred years. For instance, no one succeeded in proving decisively that the billions of stars within the Milky Way system, or within any other galaxy, interact accurately in accordance with Newton's law —although it is of course quite apparent that forces of attraction operate between these stars. They indeed show an obvious tendency for clustering, and the rotation of the Milky Way does not make them fly apart and disperse into interstellar space, as they would if the "centrifugal forces" were not held in check by forces of attraction directed toward the center of our galaxy.

Quite recently, however, and peculiarly enough, the study of the internal structure of clusters of galaxies led to a new proof for the near-universality of Newton's law of gravitation. The writer showed, about 20 years ago, that the distribution of bright and faint galaxies within globular clusters of galaxies, as well as their velocity distribution, can only be explained if it is assumed that Newton's inverse square law regulates the interactions between galaxies in clusters of galaxies. A study of the physical conditions within clusters of galaxies thus led to a proof that Newton's law governs the interactions among galaxies separated by distances as large as several million light years, although it has not been possible to demonstrate decisively that the law really holds good for the interaction of stars separated by intermediate distances of only a few thousand light years.

For the past ten years the writer has attempted to extend his analysis from the clusters of galaxies to larger units—that is *clusters of clusters of galaxies*, which were expected to measure 10 millions of light years in diameter or more. The surprising fact, however, realized right at the start, was that the 50 or 100 nearest clusters of galaxies are distributed quite uniformly and randomly in cosmic space and that there are neither any double nor multiple clusters of galaxies among them.

No real clusters of clusters

A more extended analysis of about 10,000 of the nearest rich clusters of galaxies in cosmic space led to the same result. In contradistinction to the behavior of galaxies, and in violation of the expectations to be derived from Newton's law of gravitation, there are *no* real clusters of clusters. (It could be definitely shown that some slight apparent clustering was actually due to properties of optical projection and to effects of intervening clouds of interstellar and intergalactic dust.) In addition, from Newton's law we should expect *a large velocity dispersion* among the peculiar velocities of the centers of clusters of galaxies. This velocity dispersion was likewise found to be completely absent or much too small. These combined facts can easily be explained only on the assumption that the inverse square law of Newton ceases to be valid at distances greater than about 10 million light years.

The proof for the non-validity of Newton's law at very great distances will have grave consequences for all cosmological theories, as well as for the theory of the expanding universe. Although some of the theories, such as Einstein's theory of general relativity, envisaged possible deviations from Newton's law of gravitation as distances greater than about one *billion* light years (as well as quantitatively insignificant deviation at very small distances) the conclusion drawn here—that Newton's law needs a radical modification at the relatively small distance of 10 million light years—is in contradiction with all cosmological theories so far proposed.

The limits of gravity

Summarizing, we may say that in contradistinction to expectations, neither clustering of clusters of galaxies, nor a large dispersion of peculiar velocities of the centers of clusters of galaxies exists. These observational results are complementary and interrelated. Some possible explanations of these results:

1. Both results could be explained by assuming that gravitation ceases to act over distances greater than about 5 to 10 million light years, or at least that the mutual gravitational energy of two masses separated by such distances is smaller than about one-tenth of the energy computed from Newton's law of gravitation. If we assume this interpretation of the observations, the general theory of relativity in its present form will have to be abandoned, since the adjustment of the Einstein field equations to Newton's law for the limiting case of weak fields would not be correct.

2. Modifications of Einstein's field equations might be caused by the following effects:

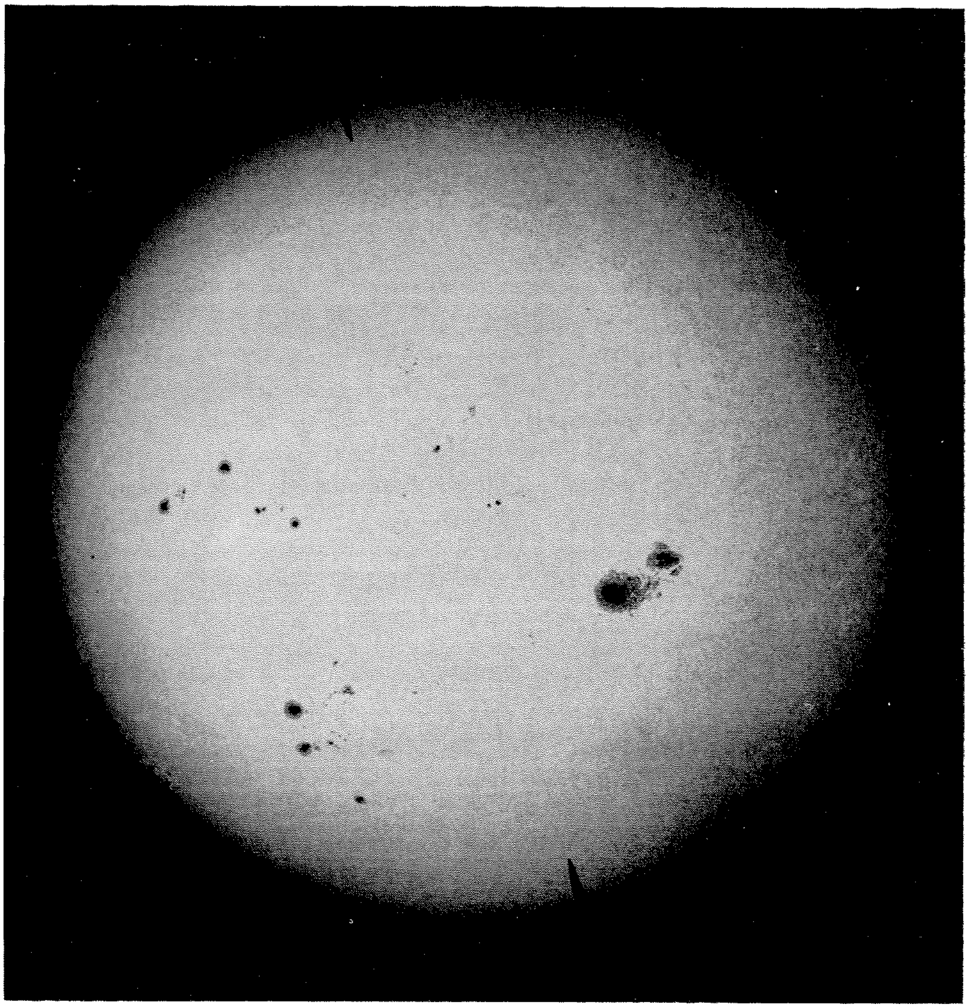
(a) The gravitational field of a mass might be subject to shielding by matter surrounding this mass, the shielding being of a kind not so far considered.

(b) A term of the type of the cosmological constant in the present field equations might be more important than presently assumed.

(c) Contraterrene matter (now called anti-matter) might be the main constituent of, say, one-half of the clusters of galaxies—a situation in line with a suggestion made by the writer more than 20 years ago. If anti-matter has negative gravitational mass, then clusters and anti-clusters would repel each other and our observations can be explained. In this case, hard gamma rays, with energies up to 10^{18} electron volts, should be found in the primary cosmic rays.

(d) Attention must be called to the fact that, whatever hypothesis is finally found to be correct, the finiteness of the speed of propagation of gravitational interactions may be expected to limit the size of individual globular clusters of galaxies in some decisive manner. This effect alone, however, cannot be responsible for both the non-existence of clusters of galaxies and for the low velocity dispersion among clusters of galaxies.

The writer suggests that the assumption of the complete breakdown of Newton's law of gravitation for bodies separated by distances of 10 or more million light years be adopted for the present as a heuristic hypothesis, from which further conclusions should be derived and observationally tested.



The largest sunspot cluster recorded since 1951, as photographed at 8:10 a.m. on January 9. The two pointers indicate the North and South Poles.

The Month at Caltech

Sunspots

The largest cluster of sunspots since 1951 was recorded at the Mount Wilson Solar Observatory on January 9. The spots extended 100,000 miles across the face of the sun (which is 886,000 miles in diameter and 93,000,000 miles from the earth). Observers estimated that 50 disks the size of the earth would just about cover the spot clusters. The spots, which are gigantic magnetic disturbances, look black only because they are as much as 1,000 to 2,500 degrees cooler than the more incandescent areas around them. The sun itself is believed to be about 25,000,000 degrees Fahrenheit at its core. Sunspots are often accompanied by solar flares. These luminous hydrogen clouds have shot out to heights of several hundred thousand miles above the sun's surface. The largest sunpot cluster on record was observed in April, 1947; it extended some 152,000 miles across the surface of the sun.

Russian Visitors

Five prominent Russian educators visited the Caltech campus on February 6 and 7, as part of a three-week tour of American engineering schools sponsored by the American Society for Engineering Education and the U.S. State Department. The tour was arranged in return for a recent visit made by eight American engineering professors to Russia. The American group was headed by Frederick C. Lindvall, chairman of Caltech's Division of Civil, Electrical and Mechanical Engineering and Aeronautics (who tells something about the tour on page 13 of this issue). Dr. Lindvall was host to the Russian engineering professors at Caltech.

The Russians toured the Caltech campus, talked with engineering professors, through interpreters, and saw some of Pasadena's industrial and cultural points of interest. Though Pasadena has been a closed area to Russian visitors up to now, the State Department removed the restriction for the Russian engineering group.

Caltech on TV

Caltech's television series, "The Next Hundred Years," started on its second 13-week run on February 8. The programs are now presented on Sunday afternoons at 4 p.m. over KRCA-Channel 4 in the southern California area. Henry Hellmers, senior research fellow in biology, opened the new series with, "Why Plants Grow Where They Do." Programs to come include:

February 15 –
"The Air and You"
A. J. Haagen-Smit, professor of bio-organic chemistry

February 22 –
"This Trembling Earth"
Frank Press, director of the Seismological Laboratory
Hugo Benioff, professor of seismology
Charles Richter, professor of seismology

March 1 –
"Desalting the Pacific"
Jack E. McKee, professor of sanitary engineering

March 8 –
"Building From the Ground Down"
Ronald Scott, assistant professor of civil engineering

March 15 –
"Nuclear Engineering"
Harold Lurie, associate professor of applied mechanics

March 22 –
"What Good Are Cosmic Rays?"
Victor Neher, professor of physics

March 29 –
"Metals for Mankind"
Donald S. Clark, professor of mechanical engineering

April 5 –
"Measuring the Universe"
Halton C. Arp, staff member, Mount Wilson and Palomar Observatories

April 12 –
"Living with Earthquakes"
Frederick C. Lindvall, professor of electrical and mechanical engineering
George W. Housner, professor of civil engineering and applied mechanics

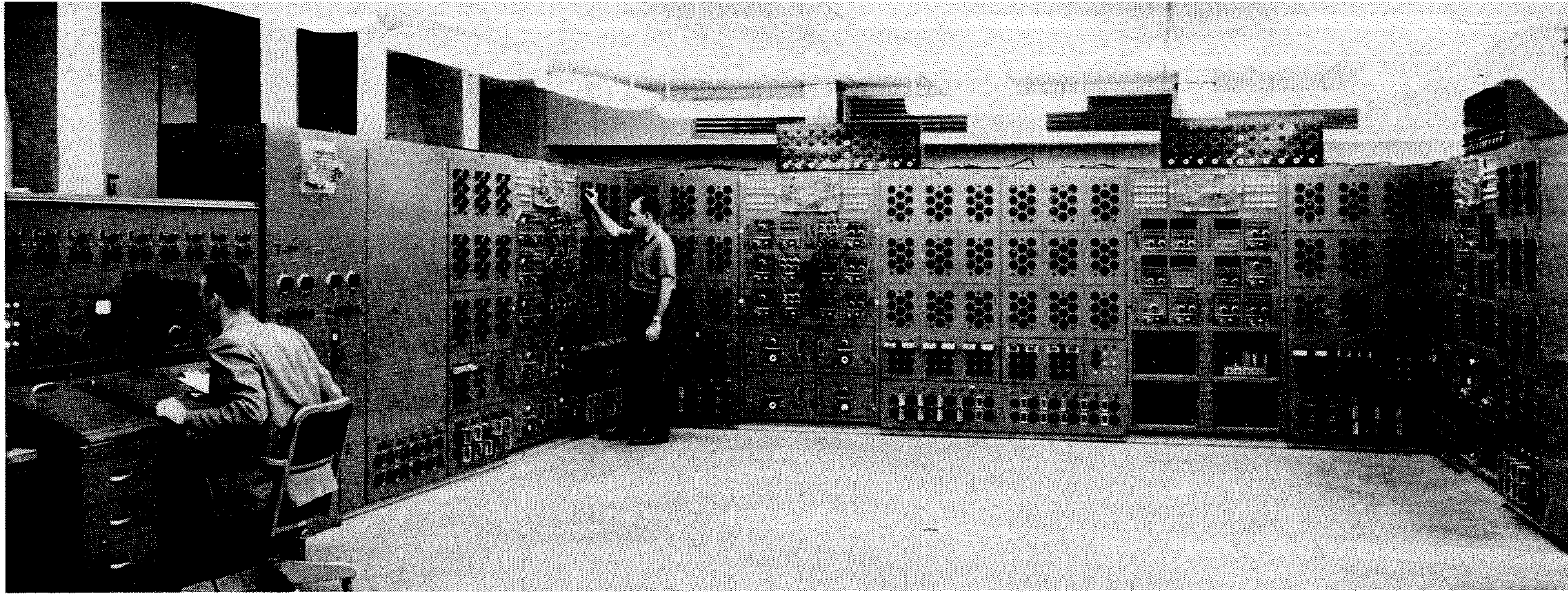
April 19 –
"Rivers – World's Biggest Earth-movers"
Norman H. Brooks, associate professor of civil engineering

April 26 –
"Mutations – The Raw Materials of Evolution"
Norman Horowitz, professor of biology

May 3 –
"Solid Rocketry Into Space"
Chester McCloskey, senior research fellow in chemistry
Peter L. Nichols, division chief of propellants, Jet Propulsion Laboratory
Thor L. Smith, section chief, Solid Propellant Chemistry, Jet Propulsion Laboratory

May 10 –
"Scientists of Tomorrow – The Caltech Story"
President DuBridge and the Caltech Glee Club

Dr. James B. Conant talks with Caltech undergraduates during his three-day visit to the campus last month as a guest of the Caltech YMCA's Leaders of America program. Dr. Conant, President Emeritus of Harvard, and former Ambassador to West Germany, has just completed a two-year study of American high schools.



The direct electric analogy computer, developed largely through research in Caltech's Computing Center.

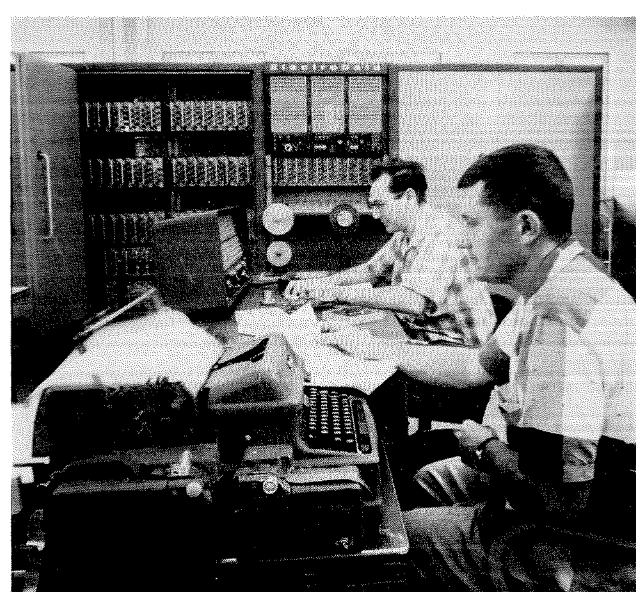
Caltech's Computing Center

by G. D. McCann

The importance of large-scale machine computing techniques to engineering and science has been growing steadily for the past ten or twelve years. These techniques have become an essential element of our modern technology, making possible the rapid analysis and development of the complex systems and machines of today.

This has placed new emphasis on a number of basic disciplines – including such theoretical subjects as Boolean algebra and symbolic logic, and their application to switching theory and the logical design of computers. The need for higher-speed, more compact methods of physical instrumentation has spurred research in such basic areas of solid state physics as semiconductors, ferromagnetics and the superconductivity of materials at low temperatures. Of particular importance at present is the study and application of the physical properties of very thin films, a few hundred angstroms in thickness. The similarity between computer logic and human brain functions has brought together mathematical and biological research in this area, and such fields of mathematics as numerical analysis and engineering analysis have also taken on greater importance.

Caltech's interest in this general field became significant towards the end of World War II, and actually started in two areas. The physical chemists developed a need for a digital computing facility more comprehensive than the conventional desk calculator, and a small IBM computing facility was set up. Also, the engineering division became interested in the development and application of machine computing

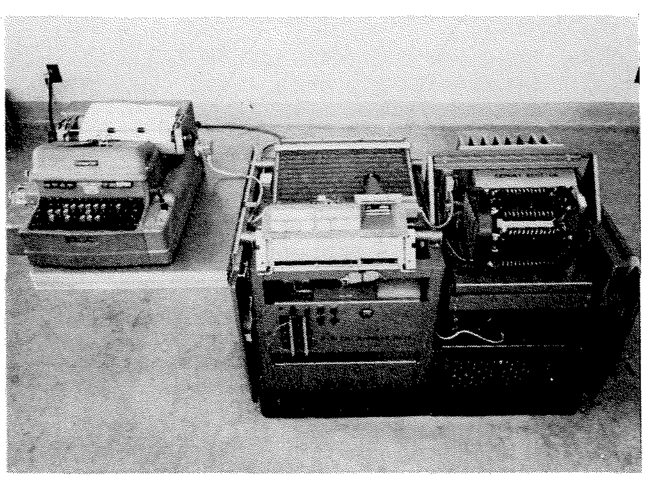


The ElectroData Datatron – 205 digital computer.

techniques to complex system design problems, and an analysis laboratory was established in 1946. The initial efforts of this laboratory centered around analog computing techniques. From 1946 to 1956, extensive work was conducted in electric circuit synthesis and instrumentation, which resulted in the development of a new computer, the direct analogy computer. Applications of this computing technique were made to design analysis problems in the fields of solid mechanics, fluid mechanics, and heat transfer. Methods of structural stress analysis, vibration analysis, and the aeroelastic analysis of airframes were developed. This research was carried out primarily by Charles H. Wilts, Richard H. MacNeal, B. N. Locanthi and by the writer.

By 1956, the need for a more comprehensive computing facility that would include a large-scale digital computer had grown to the point where plans were made for the addition, as a general campus facility, of the ElectroData Datatron 205 computer. This, along with a Librascope LGP-30 computer developed from research here at the Institute, and the direct analog computer, now constitutes Caltech's Computing Center facility, on the first floor of the Spalding Laboratory of Engineering.

Among the professors of mathematics who have recently joined the faculty to work in these areas are John Todd, in the mathematics department; and J. N. Franklin, in applied mechanics. Others engaged in this program are Robert Nathan, Kendrick Hebert, Charles Ray, and Robert Harder. They, along with Charles Wilts and the writer, are engaged in research and instruction in the new courses which have been developed in numerical analysis, machine design, and in engineering analysis and synthesis. The computing facility has come to be widely used on the campus, and each year, through coding courses, about 75 to 100 students and staff learn the Datatron programming techniques. The scope of its applications to general campus research is indicated in the table at the right.



The Librascope LGP-30 digital computer.

CAMPUS RESEARCH USING THE COMPUTING CENTER

Astrophysics

- Satellite orbit calculations
- Reduction of photoelectric spectrum observations
- Calculation of the rate of expansion of the universe

Biology

- Mathematical modeling of plant growth
- Simulation of brain functions

Chemistry

Physical Chemistry

- Crystallography, chemical-molecular structure determination of compounds
- Calculations for X-ray and electron diffraction
- Chemical kinetics through classical chemistry and through shock wave reaction
- Molecular orbital calculations

Chemical Engineering

- Chemical kinetics
- Simulation of pilot plant operations

Applied Physics and Engineering

- Network synthesis
- Noise and auto-correlation
- Switching circuit design and analysis
- Information theory
- Pattern recognition
- Servomechanism analysis
- Solid mechanics – dynamics and vibration analysis
- Thermal heating – radiation and conductivity transport
- Aeroelasticity – flutter and aircraft design analysis
- Thermal – aeroelasticity in high speed flight
- Fluid mechanics and cavitation
- Linear and nonlinear ion diffusion analysis
- Microwave tube analysis and design – calculation of electromagnetic field problems with interacting electron beams
- Plasma calculations and magnetohydrodynamics
- Antenna and artificial dielectric problems

Mathematical and Numerical Analysis

- Development of new methods for aeroelasticity stability calculations
- Development of new methods for solving linear and nonlinear diffusion equations
- Monte Carlo methods for nuclear physics
- Determination of largest circles within which the basic special functions of mathematical physics are univalent

Physics

- Electromagnetic field calculations
- Nuclear partial path calculations
- Molecular distribution in centrifuges

Since machine computing has become so important to most fields of engineering and science, the basic principles of computers and their applications should become more commonly known. Here is a brief description of the more important analog and digital computers.

Analog Computers

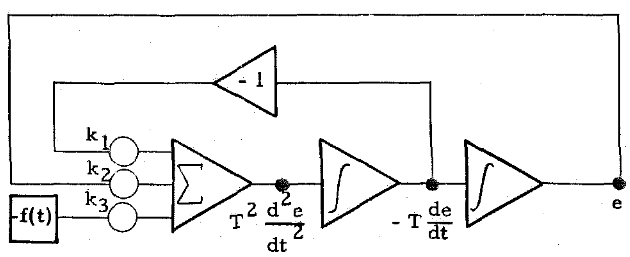
Analog computers are based on the general principle of measuring the performance of some physical system whose properties can readily be changed to simulate a variety of other physical systems, or their defining mathematical equations. These are usually algebraic or differential equations. The more common analog computers today use electrical systems whose electrical parameters can be quickly varied, and whose circuits are easily hooked up in different forms. Currents and voltages represent the exciting functions and are measured as solutions to the problem under study. Two of the most important of our modern electric analog computers are the electronic differential analyzer and the direct electric analog computer which was developed largely through research in Caltech's Computing Center.

In the electronic differential analyzer, electronic voltage amplifiers with simple resistor-capacitor feedback circuits can be used to produce the integral of a voltage with respect to time, or to sum several voltages. The diagram below illustrates how a circuit can be built up with these two elements in order to simulate a simple ordinary differential equation with constant coefficients. In this circuit the voltage e at the output of the right hand integrating amplifier simulates the function y in the original differential equation. Differential analyzers are in extensive use today, both as analytical tools for the development of (or as actual component parts of) complex systems—for guidance control, for example, or for commercial process control. The annual production of such equipment runs into the hundreds of millions of dollars.

The direct analog computer is an extension of the concept of synthesizing mathematical equations with electrical components, using many passive circuit components in addition to amplifiers. The more important of these are inductors, transformers, resistors, and capacitors. Since this concept provides direct analogies between both voltages and currents in the computer and such variables as velocity and force in a mechanical system, the comprehensive extension of the method to the use of amplifiers for simulating non-conservative elements also requires a current generator. This type of computer has been used extensively at Caltech and in the aircraft industry for the design analysis of airframes.

Simple Ordinary Differential Equation

$$\frac{d^2y}{dx^2} + A\frac{dy}{dx} + By = f(x) \qquad \text{or} \qquad \frac{d^2y}{dx^2} = -\left[A\frac{dy}{dx} + By - f(x)\right]$$



$$T^2\frac{d^2e}{dt^2} = -\left[k_1 T\frac{de}{dt} + k_2 e - k_3 f(t)\right]$$

How amplifiers are used for transferring between routines.

Digital Computers

In distinct contrast to analog computers, digital computers deal directly with symbols which may be both alphabetic and numeric. They process the symbols at high speeds in various ways, including such logical operations as arithmetic, "bookkeeping," and "decision making." To understand their operation, consider a relatively simple general purpose computer, the Librascope LGP-30, in the Institute's Computing Center. This machine is based on research carried out in our laboratory several years ago under the direction of Stanley Frankel.

It is described as "a 4096 word magnetic drum memory, 32 'bit' (binary digit) word, single address, fixed decimal point, stored program computer using vacuum tube flip-flops and diode logic circuits." Its input-output device is a Flexowriter and paper tape.

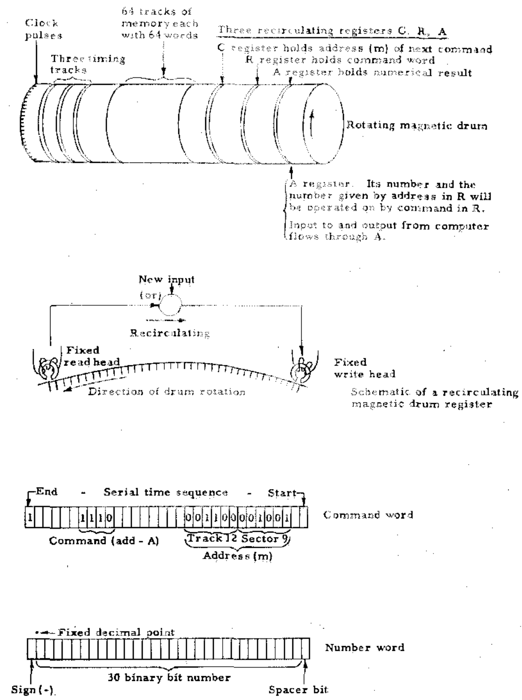
The basic principles of this computer are illustrated on page 27. The magnetic drum has 64 tracks of main storage memory, each track having a magnetic head which can write into the track with current pulses or read out the contents of the track as voltage pulses which control flip-flops. Sixty-four 32 bit words can be stored on each track, which may be either a number or a command word. The computer is serial because each word is presented in time sequence, one bit at a time. On the left end of the drum there are four permanently magnetized timing tracks for controlling its operation. One of these produces "clock pulses" for timing each individual bit. On the other end of the drum there are three recirculating registers, each using two separate heads to permit recirculatory storage of a word. The functions performed by these registers are indicated in the diagram, and by the command list on page 27.

It is known as a single address-stored program computer because command words consisting of a 4 bit command and a single 12 bit reference address (6 bits for track number and 6 bits for sector number) are taken in sequence out of memory and executed. As shown by the four modes of operation in the diagram of the digital computer at the right, the computer searches for the memory address given in the C register, places the command found there in the R register (also adding one to the C register number), performs the command indicated in the R register, and then repeats with the new C register address.

All commands involve the word whose address is in the R register and the word in the A register. These commands are of three general classes: arithmetic, transportation or bookkeeping, and decision making. A typical example should show how a comprehensive set of commands can perform useful computing.

Let us develop a program for the LGP digital computer which will enable it to compute the stopping time and distance of a vehicle which is traveling at a series of velocities, for a fixed reaction or delay time in applying the brakes, and for decelerations that are some function of the vehicle velocity.

DIAGRAM OF A SIMPLE "GENERAL PURPOSE" DIGITAL COMPUTER



Four normal modes of operation

1. Search for word in memory whose address (m) is held in C register.
2. Transfer this command word to R register and add "1" to C.
3. Search for word whose address is held in R register.
4. Perform command indicated in R register on this word and contents of A register.

COMMANDS FOR THE LGP-30 DIGITAL COMPUTER

Instruction

A*m+	Add contents of m to that of accumulator A and retain results in A.
S m	Subtract contents of m from that of A and retain results in A.
M m	Multiply number in A by that in m retaining the most significant 30 bits of results in A.
D m	Divide number in A by that in m retaining the rounded quotient in A.
B m	Place the contents of m in A.
H m	Store contents of A in location m but also retain it in A.
C m	Store contents of A in m and clear A.
R m	(Return address) — Add "one" to address held in C register and record this in the address portion of instruction held in memory location m.
U m	Transfer control to m unconditionally or get next instruction from m. This m is put in C.
T m	Test or conditional transfer. Transfer control to m only if number in A is negative, otherwise continue in sequence.
E m	*Extract. Clear contents of A to zero in* those bit positions for which m has zeros.

* Symbol for command defined by "4 bits" A=1110

\+ Address or location in memory for which word involved in command is to be found

Let: t=time
d=*fixed time delay*
a=acceleration (negative in this case)
v=velocity
s=distance traveled
$a=f(v)$

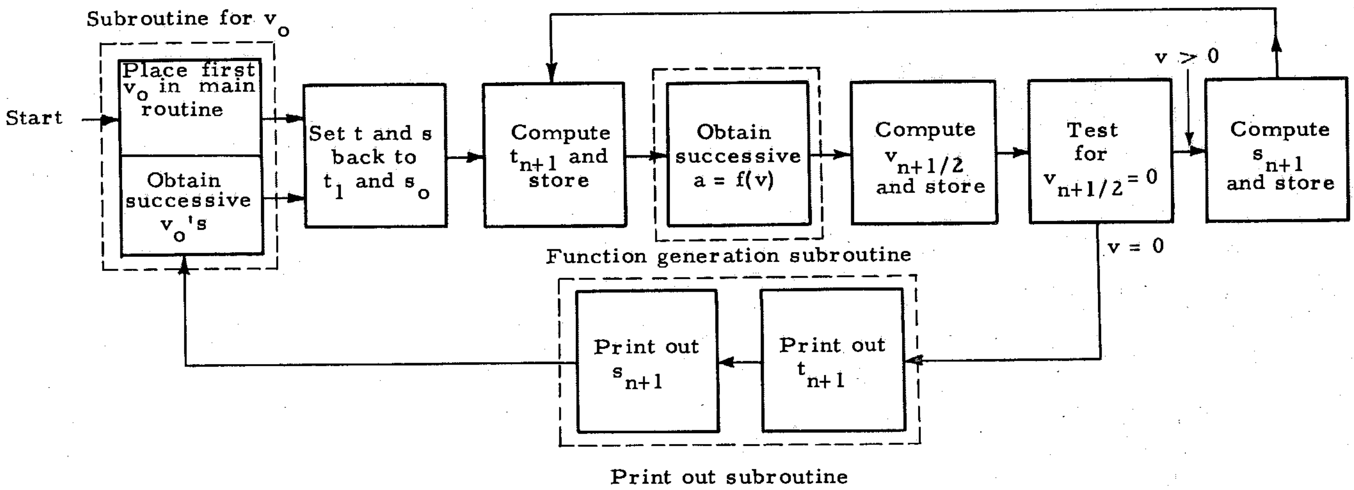
$$v(t)=v_o+\text{Integral } (adt)\Big|_d^t$$

$$s(t)=v_o=\text{Integral } (vdt)\Big|_d^t$$

These are integral equations of calculus. The process of converting equations of this type to a form *suitable for the computer, which only knows how to* do arithmetic, falls in the realm of numerical analysis. In this simple problem a fixed time interval will be assumed and the equations for *t*, *v* and *s* approximated as follows:

$$t_{n+1}=t_n+t;\ t_1=d$$
$$v_{n+\frac{1}{2}}=va_{n-\frac{1}{2}}+a\Delta t$$
$$s_{n+1}=s_n+(v_{n+\frac{1}{2}})\Delta t;\ s_1=v_o d$$

FLOW CHART INDICATING THE COMPUTER PROGRAM FOR VEHICLE DECELERATION CALCULATIONS



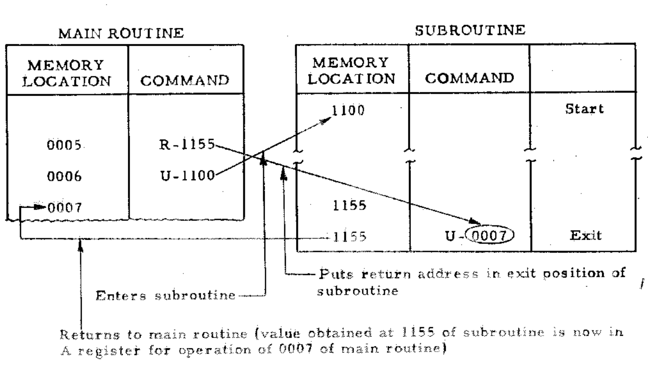
t = time
d = fixed time delay
a = acceleration (negative)
a = a function of velocity
v = velocity
s = distance

$$t_{n+1} = t_n + \Delta t \quad ; \quad t_1 = d$$
$$a_n = f(v_{n-1/2})$$
$$v_{n+1/2} = v_{n-1/2} + a_n \Delta t$$
$$s_{n+1/2} = s_n + v_{n+1/2}\Delta t \; ; \quad s_1 = v_o d$$

The operations of successively solving these equations are shown in the flow chart above, which illustrates some of the essential commands of such a machine.

In preparing a program from this chart, it will be assumed that the processes of obtaining each successive value of the initial velocity v_0, the acceleration a as a function of v, and printing out the desired answers, are "subroutines" already prepared and stored in tracks 11, 12, 13. Therefore, a program will be given only for the main routine of this specific problem, and this will be written to be stored in track 00.

HOW R AND U COMMANDS ARE USED ON THE LGP-30

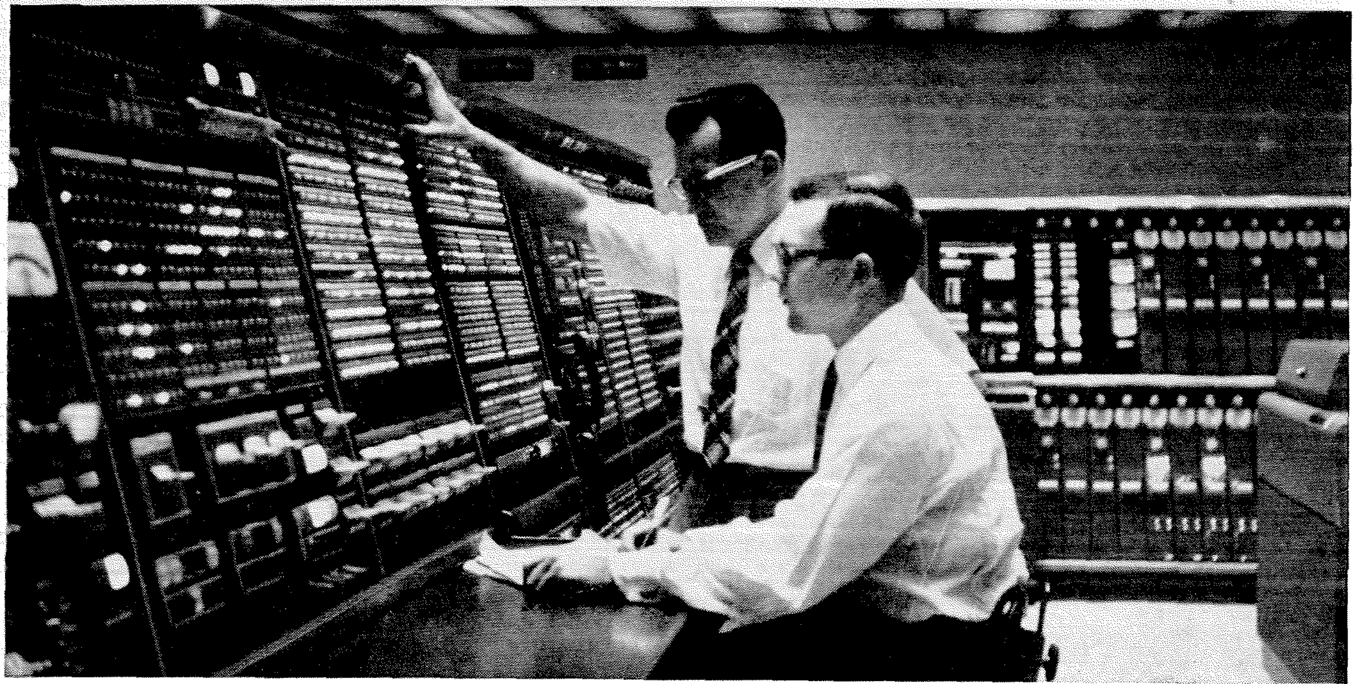


There are two commands (page 27) for the specific operation of splicing subroutines into a main routine. These are the R and U commands and their application to this type of program transfer is illustrated at the left below.

The complete program of commands for the main portion of this problem is given on page 32. The application of the one decision-making command given on page 27 is that of either repeating the *t.v.s.* calculations if v is still positive, or printing out the final t and s if v has reached zero. This is performed in steps 17 and 18 on page 32. In step 17, the smallest positive number is subtracted from v. If still positive, the test command of step 18 is ignored and step 19 is executed next. If the resulting number is zero, the command is transferred to step 24 to start the print-out operations.

The fact that this is a binary computer offers little complication to the user because it is quite practical to devise a routine to interpret and translate numbers written on the Flexowriter in decimal form, and commands written in alphabetic form. Such a translation code can either be kept permanently in part of the memory or stored on paper tape for input during translation. Permanent storage of a given type of routine in binary code can easily be affected by punching out on tape the actual routine placed in the machine by the translating program.

continued on page 32



W.E. DEFENSE PROJECTS ENGINEERS *are often faced with challenging assignments such as systems testing for the SAGE continental air defense network.*

ENGINEERS explore defense frontiers at Western Electric

If guided missiles, tropospheric radio defense communications and airborne radar sound like exciting fields to you, a career at Western Electric may be just what you're after.

Defense projects like these are among our most important assignments . . . and engineers are right in the thick of it. There are the Nike and Terrier guided missile systems . . . advanced air, sea and land radar . . . anti-aircraft gun-control equipment . . . the SAGE continental air defense system . . . DEW Line and White Alice in the Arctic. These and other defense jobs offer wide-ranging opportunities for all kinds of engineers.

Western Electric engineers also discover plenty of made-to-order opportunity in our work as manufacturing and supply unit of the Bell System. Here they flourish in such new and growing fields as electronic switching, microwave radio relay, miniaturization. They engineer the installation of telephone central offices, plan the distribution of equipment and supplies . . . and enjoy, with their defense teammates, the rewards that spring from an engineering career with Western Electric.

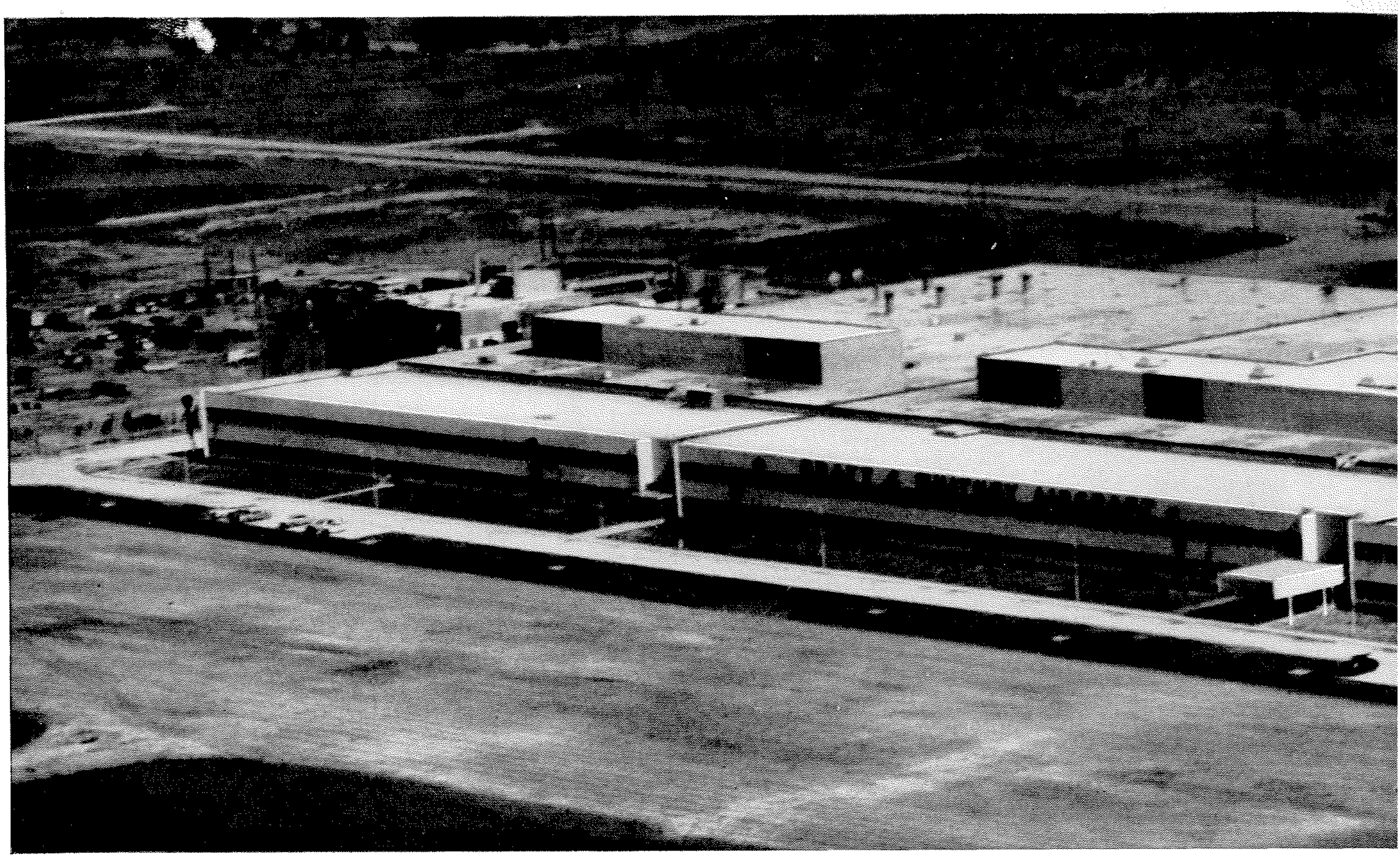
Western Electric technical fields include mechanical, electrical, chemical, civil and industrial engineering, plus the physical sciences. For more detailed information pick up a copy of "Consider a Career at Western Electric" from your Placement Officer. Or write College Relations, Room 200D, Western Electric Company, 195 Broadway, New York 7, N. Y. And sign up for a Western Electric interview when the Bell System Interviewing Team visits your campus.

TELEPHONES OF THE FUTURE—Making telephone products for the Bell System calls for first-rate technical know-how. Tomorrow's telephone system will demand even more imaginative engineering.

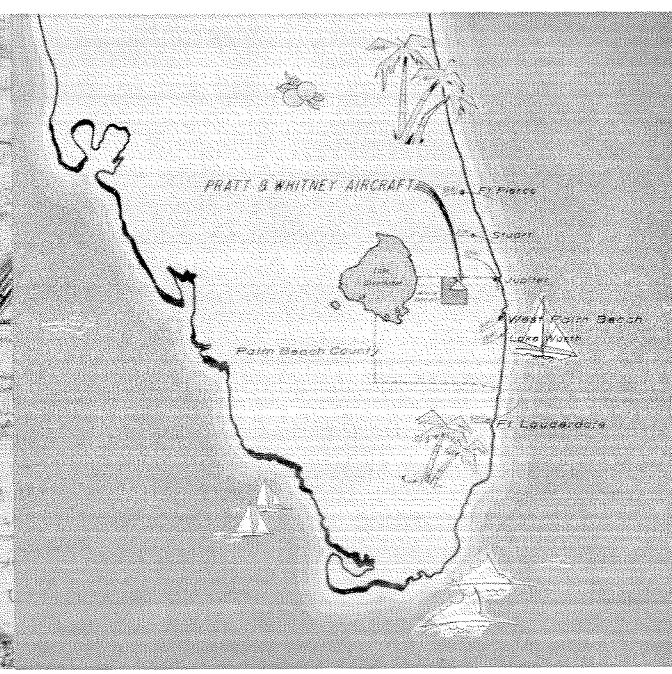
Western Electric

MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

Principal manufacturing locations at Chicago, Ill.; Kearny, N. J.; Baltimore, Md.; Indianapolis, Ind.; Allentown and Laureldale, Pa.; Burlington, Greensboro and Winston-Salem, N. C.; Buffalo, N. Y.; North Andover, Mass.; Lincoln and Omaha, Neb.; Kansas City, Mo.; Columbus, Ohio; Oklahoma City, Okla.; Teletype Corporation, Chicago, Ill. and Little Rock, Ark. Also Western Electric Distribution Centers in 32 cities and Installation headquarters in 16 cities. General headquarters: 195 Broadway, New York 7, N. Y.

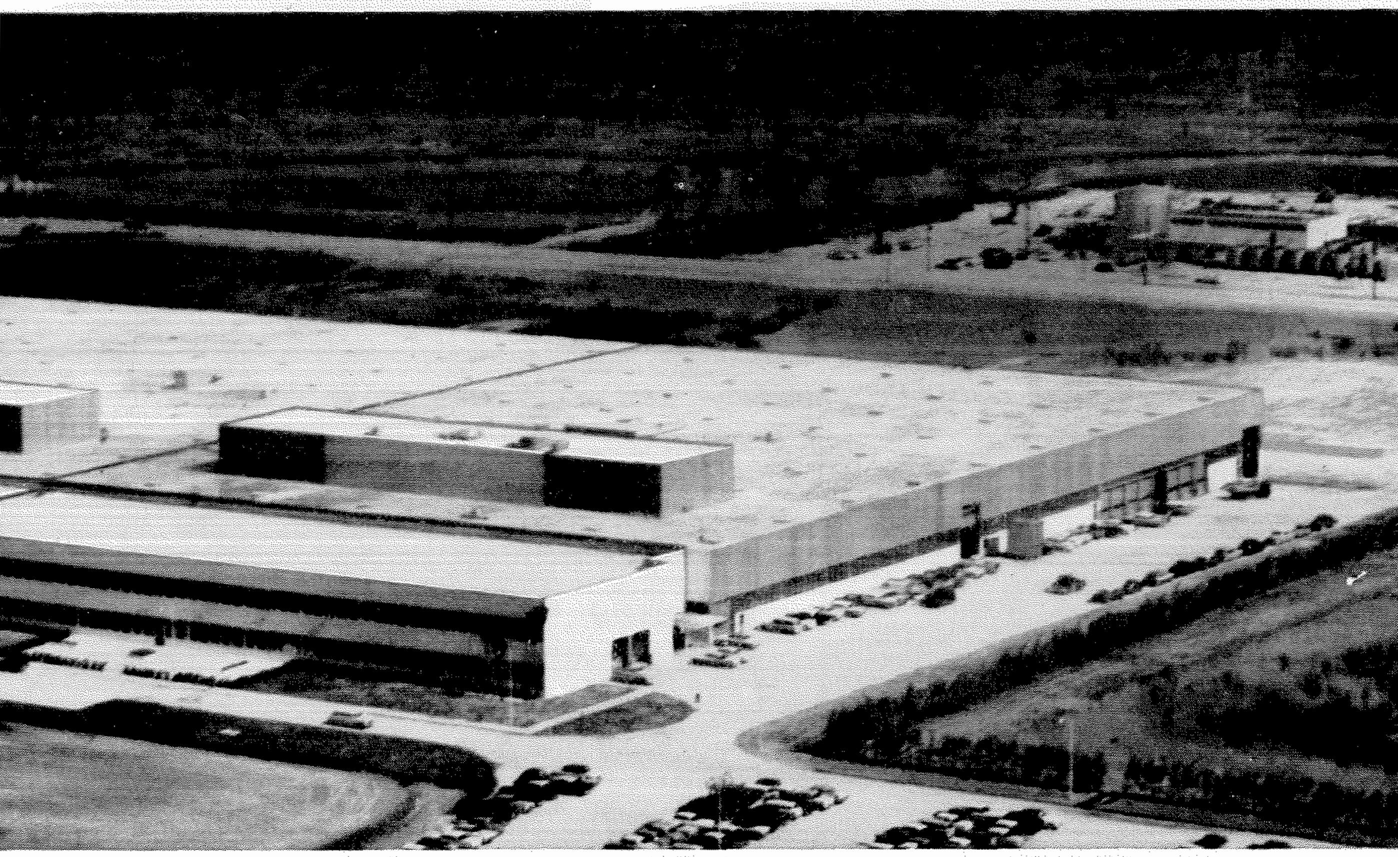


FLORIDA RESEARCH AND



ISOLATION—Ten square miles comprise the site of Pratt & Whitney Aircraft's new Florida Research and Development Center. Experimental shops and offices covering some 17 acres are in the foreground, while the tests areas, barely visible in upper left, lie four miles in the background.

LOCATION—The new Center is located at United, Florida, midway between West Palm Beach and Lake Okeechobee, in the upper Everglades area. It is almost surrounded by a wildlife sanctuary. Most employees live in the cities and towns along the east coast of Florida, driving to the Center on excellent new highways.



Larger digital computers

The LGP-30 has a total of only 16 commands but is capable, in principle, of doing any problem possible on any digital computer. It is used extensively for student training. However, large problems such as complex partial differential equations would require a long computation time. The Datatron 205 is actually used for most of the service computing performed for the Institute. This, like almost all of the existing larger, higher-speed computers, is also of the stored program type. These computers achieve greater power because they have:

1. Higher operating speeds
2. Larger command lists
3. More memory
4. Higher-speed input and output

Automatic Indexing—The Datatron has several important additional features not found in the LGP-30. One of these is the B register, a device for providing automatic indexing. By adding to the complexity of the command structure, it is possible to have any command which is processed to have its address adjusted at the same time by one or more other numbers. Thus, without using any extra commands, such operations as successive calculations can be stored successively in different locations, or successive numbers for a repetitive calculation can be brought up for the calculation. The Datatron can also perform "floating point" arithmetic in addition to fixed decimal arithmetic and it has a supplementary magnetic tape memory for the storage of 800,000 words.

Automatic Coding—The simple program on vehicle braking at the left gives some indication of the tedious and complex jobs of preparing a suitable program for each problem. Including the three subroutines, that problem requires about 160 commands. Truly comprehensive programs frequently have as many as a thousand or even ten thousand commands. The coding problem is therefore an important part of the operation of a practical computing center, and in the past many man-hours of coding time have been required for each computer-hour of calculation. Along with numerical analysis, coding research has constituted an important part of the research activity of our Computing Center. This work has been conducted largely by J. N. Franklin and Kendrick Hebert. They have been concerned with the development of methods for making the computer do the bulk of the actual detailed coding. Two general methods have been developed at a number of research centers for accomplishing this. One of these, developed by Franklin and Hebert, is known as a compiler routine.

A Compiler Routine—The most complex part of preparing a program such as the vehicle deceleration problem is in specifying the exact location of each word being processed. Each machine command must refer to a specific memory location. If a set of commands could be devised which pertain to a given

MACHINE LANGUAGE ROUTINE

for Solving Vehicle Deceleration Problem on the LGP-30

Memory Location	Command	Explanation
0000	R-1155	Place first v_o in
0001	U-1100	A register
0002	C-0041	Store v_o in main routine
0003	B-0047	Store $d=t_1$ as first t_n
0004	C-0042	
0005	B-0041	Bring v_o
0006	M-0047	Compute $s_1=v_od$
0007	C-0043	Store s_1 as first s_n
0008	B-0042	Bring t_n
0009	A-0044	Compute $t_{n+1}=t_n+\Delta t$
0010	C-0042	Store new t_{n+1}
0011	B-0041	Bring v
0012	R-1395	Place a=f(v) in A
0013	U-1300	
0014	M-0044	$a\Delta t$
0015	A-0041	New $v_{n+\frac{1}{2}}=v_{n-\frac{1}{2}}+a\Delta t$
0016	H-0041	Store and hold $v_{n+\frac{1}{2}}$
0017	S-0046	Test for $v_{n+\frac{1}{2}}=0$
0018	T-0024	
0019	B-0041	Bring $v_{n+\frac{1}{2}}$
0020	M-0044	$(v_{n+\frac{1}{2}})\Delta t$
0021	A-0043	$s_{n+1}=s_n+(v_{n+\frac{1}{2}})\Delta t$
0022	C-0043	Store s_{n+1}
0023	U-0008	Return to calculation of new *t*
0024	B-0042	Bring t_{n+1}
0025	R-1261	Print out t_{n+1}
0026	U-1200	
0027	B-0043	Bring s_{n+1}
0028	R-1261	Print out s_{n+1}
0029	U-1200	
0030	R-1155	Place next v_o in A
0031	U-1106	
0032	U-0002	
°		
°		
°		
0041	–	Storage space for v
0042	–	Storage for t
0043	–	Storage for s
0044	–	Storage for Δt
0045	–	a
0046	+.00000001	Smallest number greater than zero
0047	–	Storage for d

. . . a hand in things to come

Unlocking the secrets of the universe

Amazing textile fibers spun out of natural gas . . . wonder drugs squeezed from coal . . . shining stainless steel forged from drab, brownish earth. These man-made marvels were born in the minds and hands of research scientists.

Never satisfied with things as they are, the research scientist takes apart the raw materials of nature to capture the basic "building blocks" of the universe. Then he rearranges and combines the pieces into new and better things that help improve our lives.

Research is a living thing to the people of Union Carbide—for it is the foundation upon which their work is built. They have created hundreds of useful products from such basic substances as oil, natural gas, ores, air, and water. And the wonders yet to come, the completely new things of tomorrow, are being sought and found in Union Carbide's laboratories today.

Learn about the exciting work going on now in alloys, carbons, chemicals, gases, plastics, and nuclear energy. Write for "Products and Processes" Booklet A, Union Carbide Corporation, 30 East 42nd St., New York 17, N.Y. In Canada, Union Carbide Canada Limited, Toronto.

UNION CARBIDE

. . . a hand in things to come

set of symbols that can represent variables in a given problem, and the computer could be made to keep track of these quantities by internal programming, this difficulty could be overcome. Suppose we devise a set of compiler commands such as:

$c=a \times b$

a, b and c are quantities to be defined for the computer, and it always knows where to find them. The operator does not concern himself with this. For the LGP-30 the following "machine" commands could produce this compiler command.

1 – Bring (address of a)
2 – Multiply (address of b)
3 – Clear (address of c)

For such an operation, a compiler routine must be devised where the computer first takes each symbol such as a, determines a space for its storage and then remembers it. It will next prepare a subroutine of machine commands as shown above for each abstract compiler command. The compiler routine developed by Franklin and Hebert has 1200 machine commands. It is stored permanently on the magnetic tape memory of the Datatron together with the subroutine library of our Computing Center. Some of the 18 abstract commands it recognizes and processes are listed below.

PARTIAL COMMAND LIST FOR A SIMPLE COMPILER ROUTING

	Command	Explanation
1	x=a+b	a, b and y must be defined by input data or in previous commands. Computer has thus already assigned memory locations for them. In these operations mem. loc. is assigned for results which are stored there.
2	x=ab	
3	x=a/b	
4	x=y	
5	Go to s*	Unconditional transfer
6	x;y:s,s′,s″	If x<y go to s; x=y go to s′; x>y go to s″
7	Read input	Reads next block of input tape
8	Car. ret.	Move typewriter carriage to left-hand edge and advance roller one row
9	Car. ret., print x	Also prints word in location of x
10	Tab. and print x	Moves carriage to next tab stop and prints x
11	y=f(x)	Places in y its value as function of x for those function subroutines stored in magnetic tape such as $y=\sqrt{x}$, y=tan x, etc.

* In preparing the final machine language routine the compiler routine assigns a number (s) to each compiler command identifying its location in the program.

COMPILER ROUTING FOR VEHICLE DECELERATION PROBLEM

Program

1 s=tv
2 t=t+T
3 $a=\sqrt{v}$
4 a=ka
5 b=aT
6 v=v+b
7 v;o:11,11,8
8 c=vT
9 s=s+c
10 go to 2
11 Cr print t
12 tab print s
13 read input

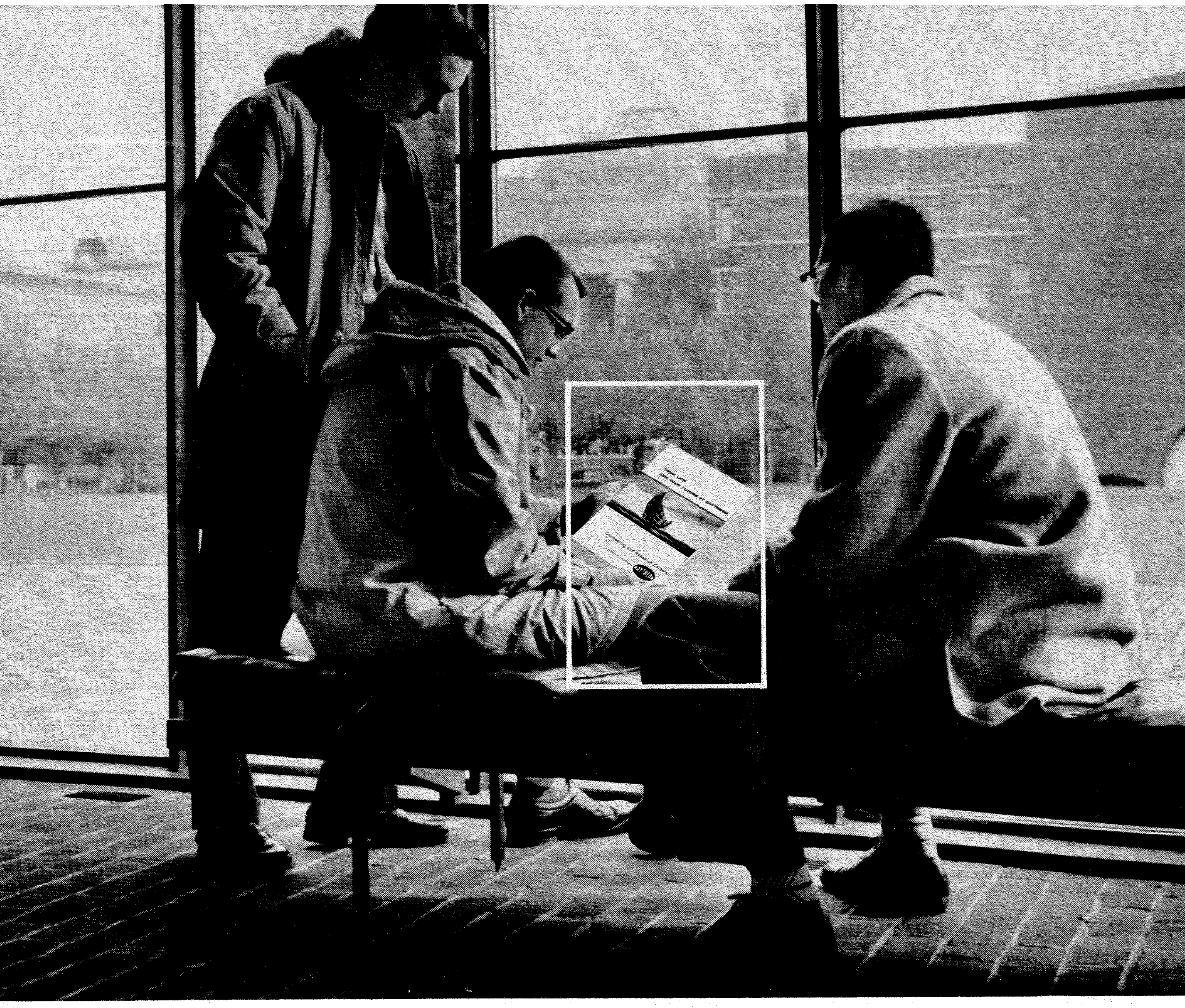
Input Data

The constant k
t=magnitude of d, the delay time
T=Δt
v=initial velocity–successive values to be used are in subsequent blocks of input

An actual program, as prepared for the Datatron, will be put on two paper tapes. One will have a numbered list of the commands describing the problem. The other will list the initial values of all given quantities in one block of data, and subsequent new values of data to be used in successive blocks. The person originally devising the code will write it from the partial command list at the left. This is turned over to someone who punches the two Flexowriter tapes using a simple standard format. The code tape is put into the computer with the compiler preparation routine stored in its main memory. The computer then prepares its own "machine language" program which can be printed out on tape ready for use at any time.

Compiler Routine for the Vehicle Deceleration Problem – To compare this method with that of the direct preparation of a code in machine command language, the vehicle deceleration problem described before has been written in compiler form above. To illustrate the format for the function command (No. 11 in the partial command list) the specific square root function has been assumed for the acceleration. The list above shows that only 13 commands need be written by the user instead of the 160 needed for the complete machine code which is prepared automatically by the digital computer.

This is but one small example of the various areas of research being conducted in the Caltech Computing Center.



The Properties of Steam

Caltech engineers are pushing steam up to new high pressures and temperatures in an attempt to squeeze more energy and greater efficiencies from this prime source of the world's industrial power.

The project is part of an international steam research program by industrial nations – especially the United States and Russia – looking for new ways to step up their power output.

In Caltech's chemical engineering laboratory, steam is gradually being heated to an ultimate high of about 1500 degrees Fahrenheit and 15,000 pounds per square inch (psi) pressure. Top operating levels in industry are now about 1000 degrees and 3000 psi.

Higher pressures will mean that smaller equipment can be used. And higher temperatures will produce higher efficiencies – or more electricity per pound of oil in a steam power plant. Engineers are also interested in the development of smaller steam power units for nuclear engines such as are used in submarines, where the space factor and efficiency are vital.

Caltech's role in the international project is to study the behavior of steam at various extreme temperatures and pressures. The results are reduced to sets of figures which make up the international steam tables. These are used in the design of boilers, turbines, and heat exchange units of nuclear reactors.

The international steam tables now in use were compiled in 1936, and they are based on data that only go up to 850 degrees F. and 5000 psi. But engineers throughout the world are beginning to build equipment for steam that goes well beyond these figures.

So Caltech engineers are extending the tables, as part of a $350,000 program instigated by the American Society of Mechanical Engineers. The U.S. Commission on the Properties of Steam is cooperating in this research program. Under the international study, Russian engineers are also extending the tables, though they are using a different method.

The Caltech steam project is under the direction of Bruce H. Sage, co-director of the chemical engineering laboratory and an international authority on steam. George N. Richter, assistant professor of chemical engineering, is in charge of the actual test program.

Caltech's study has been under way for four years. It may be completed by the end of this year, though the work has been slowed considerably by metallurgical problems. The engineers have found that, as pressures and temperatures go up, steam becomes increasingly corrosive to steels. This is partly due to the fact that some of the steam decomposes into oxygen and hydrogen. And the oxygen quickly reacts within the steel chamber.

Of course, this problem might be solved by lining the chamber with gold, which does not oxidize – but this would cost something like $10,000. Research in metals to resist the oxidization by high temperature steam has been in the direction of chrome nickel steels.

At present, Caltech engineers are studying steam in the range of 800 to 1000 degrees and at 7000 psi and a little above. Several metals are being tested at the same time for corrosive-resistant qualities.

To do the job, the engineers have built a huge and intricate steam temperature measuring device called a calorimeter. This massive piece of equipment consists of two chambers, one inside the other, to enable it to withstand the pressures.

Between the two chambers is a "wall" of helium gas, whose pressure is maintained equal to that of the steam in the inner chamber. Helium pressing inward prevents the red-hot inner chamber from expanding outward. The inner chamber is 22 inches tall by 8 inches in diameter, and the outer one – which has 5-inch-thick walls – is 23 inches in diameter by 54 inches long. Electric coils put heat into the inner chamber. Oil circulating in a pipe coiled around the outer chamber carries off excess heat and thus maintains an even temperature.

An eight-stage centrifugal pump, with heat-resistant titanium carbide bearings, forces the superheated steam through its cycle. The steam moves slowly through a porous, thimble-shaped piece of aluminum oxide which, like gold, does not tarnish when in contact with steam. It is near the thimble that temperature and pressure-measuring instruments are located. Attempts are made to measure the temperature within an accuracy of 0.0005 of a degree.

Steam is observed at each temperature for about a month and then the temperature is elevated 100 degrees and the study is resumed.

Landmark on The American Road

950,000 square feet of ultra-modern office facilities for 3,500 employees, including a cafeteria seating 638 and auditorium for 500.

Architects: Skidmore, Owings & Merrill, New York
General Contractor: Bryant & Detwiler

equipped with

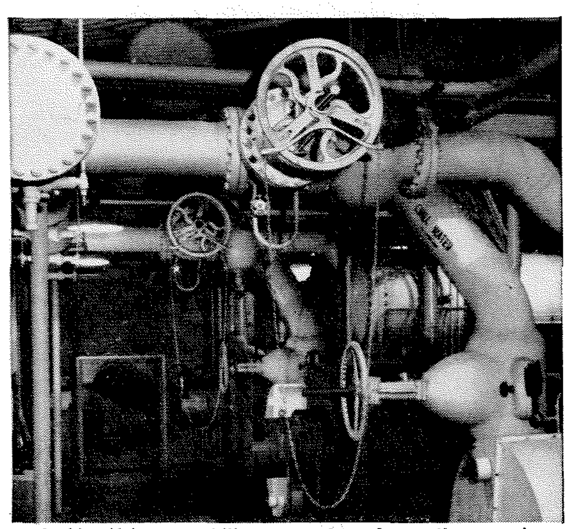
JENKINS VALVES

because efficiency is a part of the over-all design

Beauty, comfort, efficiency — Keynote in the planning of Ford cars, this combination also was sought and clearly achieved in the Central Office Building of Ford Motor Company, Dearborn, Michigan.

With efficiency a part of the over-all design it is not surprising to see Jenkins Valves on the plumbing, heating and air conditioning pipelines in this superb building. For almost a century the name JENKINS has meant reliability . . . valves with the enduring quality to last the life of a building. It will pay you to have this important assurance when you specify or install valves, especially since Jenkins Valves cost no more. Jenkins Bros., 100 Park Ave., N.Y.17.

Sold Through Leading Distributors Everywhere



Jenkins Valves on chill water and condenser lines serving Ford building's 2,200-ton air-conditioning system.

JENKINS
LOOK FOR THE JENKINS DIAMOND ®
VALVES
JENKINS SINCE 1864
Jenkins Bros

Alumni News

Golden Beavers

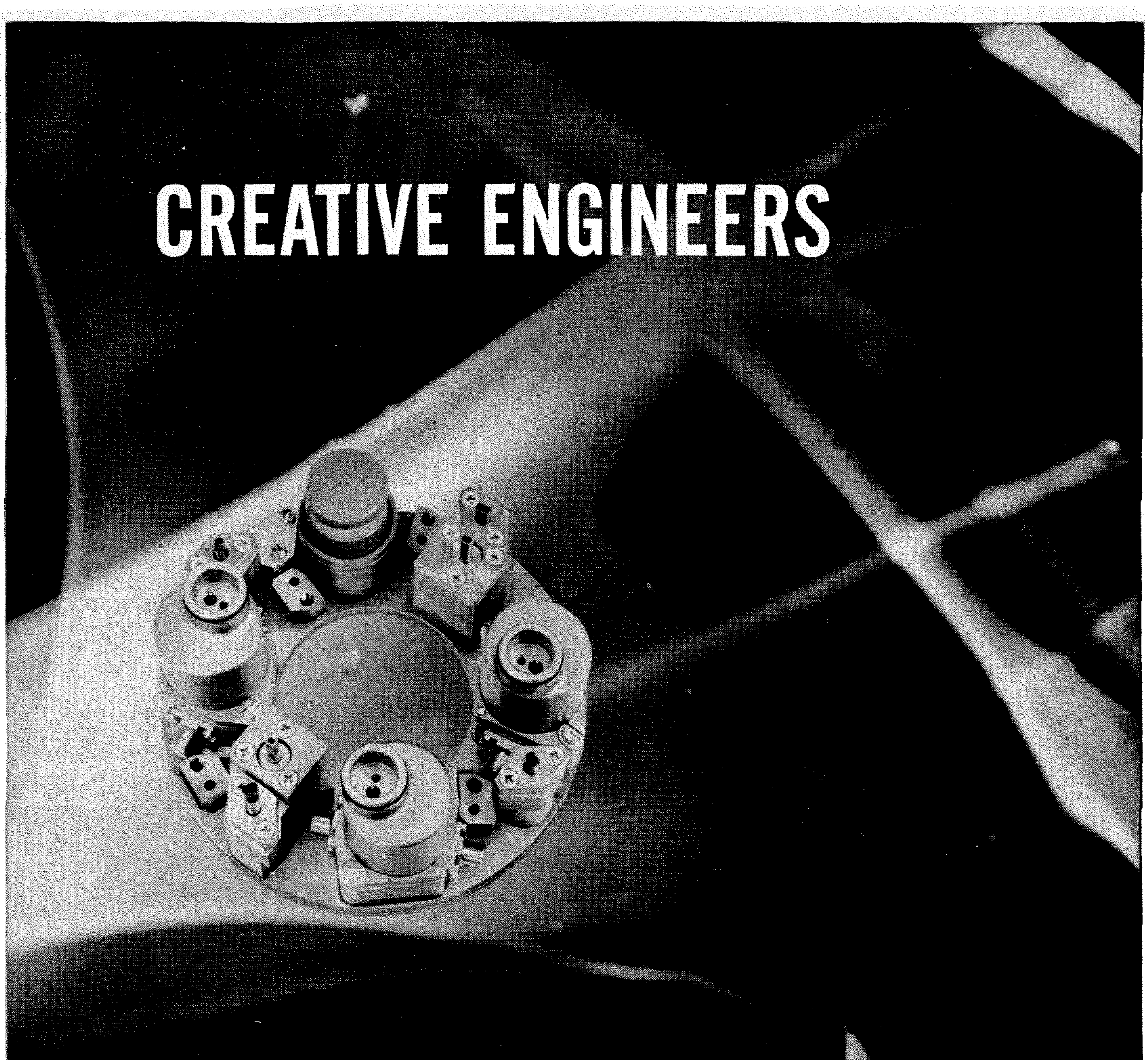
The Alumni Committee of the Caltech Development program has organized a Golden Beavers Club, whose members will include the top ten percent of alumni contributors. Membership will be reviewed each month, and the list will be updated so that only top contributors belong. A man who receives three consecutive memberships remains in the club for life. Announcement of the first membership list will be made this month.

Save the date of April 11 for the

Annual Alumni Seminar

It will be stupendous this year!

And don't forget the Alumni Dinner Dance on March 7!



AiResearch engineered and produced this electro-hydraulic servo system—the most reliable and responsive steering control system for missiles yet produced. Extremely lightweight, it consists of three control valves and six actuators.

This unique system represents but a part of the challenging, important work under way at AiResearch in missile, electronic, nuclear, aircraft and industrial fields.

Specific opportunities exist in system electronics and servo control units; computers and flight instruments; missile auxiliary power units; gas turbine engines and turbine and air motors; cryogenic and nuclear systems; pneumatic valves; industrial turbochargers; air conditioning and pressurization; and heat transfer, including electronic cooling and nuclear applications.

Intensified engineering is conducted by small groups where individual effort and accomplishment are quickly recognized, providing opportunity for rapid growth and advancement. An eight-month orientation program is offered prior to permanent assignment to help determine your placement from a variety of analytical or development projects.

Advanced education is available through company financial assistance at outstanding nearby universities.

• ***For full information write to Mr. G. D. Bradley***

THE GARRETT CORPORATION

9851 S. SEPULVEDA BLVD., LOS ANGELES 45, CALIFORNIA

DIVISIONS: AIRESEARCH MANUFACTURING, LOS ANGELES • AIRESEARCH MANUFACTURING, PHOENIX • AIRSUPPLY
AIRESEARCH INDUSTRIAL • REX • AERO ENGINEERING • AIR CRUISERS • AIRESEARCH AVIATION SERVICE

Personals

1914

Virgil F. Morse writes that "I retired from my job in the L. A. City Engineers' Van Nuys office in March 1956 and moved to Cottage Content at Boulder Bay on Big Bear Lake. My wife and I are both in excellent health. We have 13 grandchildren and 3 great grandchildren. We're planning on a long trip with a car and trailer this summer to Iowa and back. My advice to the younger generation might be: 'Have your fun as you go along in life and then you will know how to enjoy retirement'."

1916

Kenneth Rich retired two years ago after having completed 40 years of teaching, 18 of them as principal of the East Bakersfield High School. "I now find that I'm busier than ever," he says. "The only difference is that no one pays me in cash. Took a European trip last spring, play golf, am a camera bug, am moderator of a new church, and have numerous committee responsibilities – and am enjoying all of it."

1925

Caryl Krouser writes from Barstow that he is a vice president and associate editor of Courier Enterprises, which publishes newspapers in Colton, Barstow and Big Bear, Calif., and Parker, Arizona. In the spring of 1958 he went around the world in 38 days along with 30 other newspaper people. They interviewed the heads of all foreign governments including Nasser and Nehru. In September 1958 he was official recorder for a group of publishers invited by the Belgian government to visit the World's Fair. Last month he started on an extended tour of Mexico to make TV travelogues and colored movies.

1932

Brig. Gen. William R. Shuler is now on a three-year tour of duty as division engineer of the United States Army Engineer Mediterranean Division, with headquarters in Leghorn, Italy. He recently completed a four-year tour in the Pentagon as chief of construction for the army worldwide. He will be responsible for all construction for the Army, Air Force, and Navy, and all foreign aid from west of Africa to Pakistan.

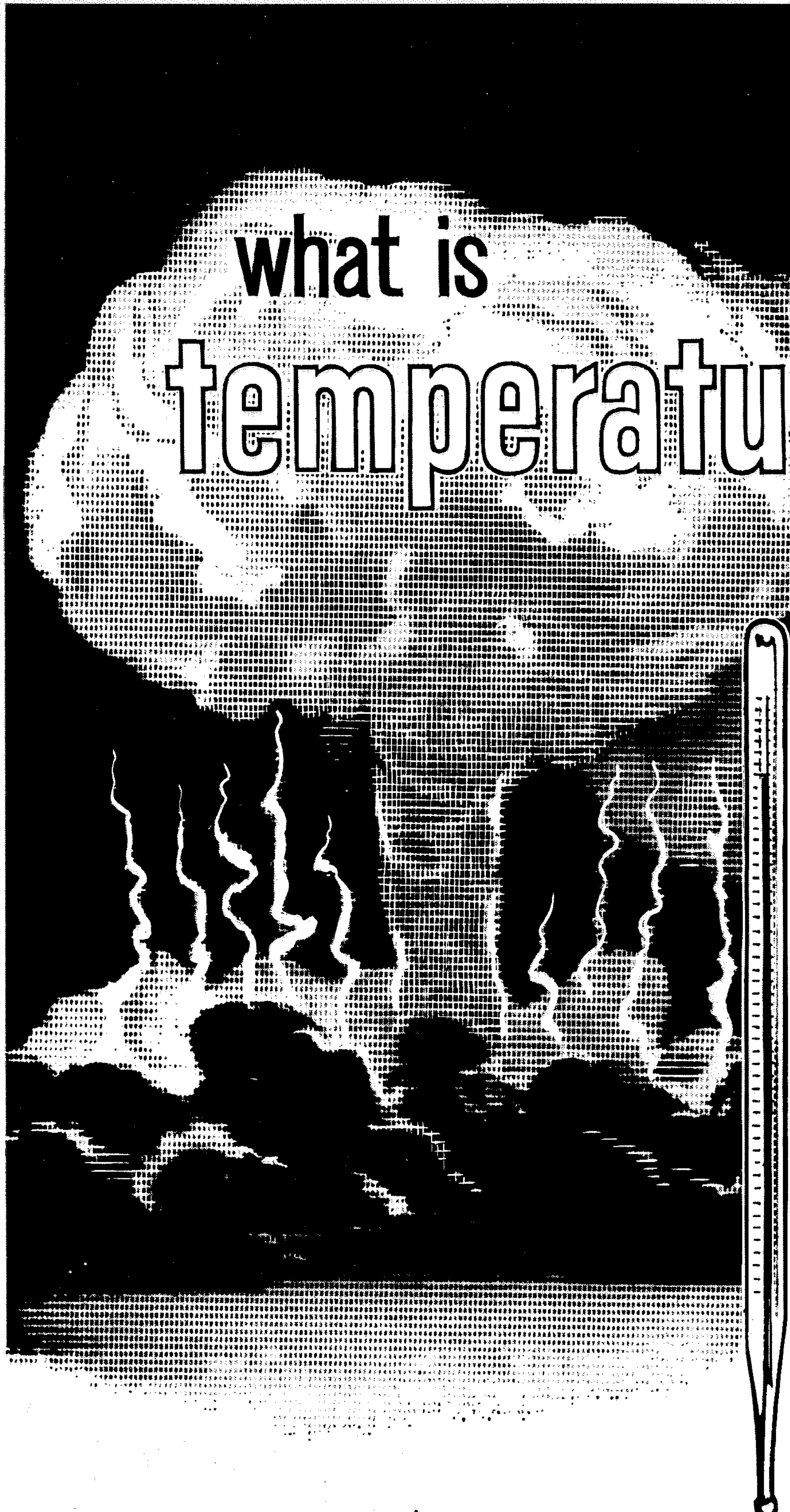
Last September Bill narrowly escaped death when the plane which was taking him and other Army staff members to Tehran crashed on take-off at the Khaneh construction site in Kurdistan. The pilot and all passengers were trapped in the wreckage when the door jammed. Bill crashed open the exit door for the party's escape. No one was seriously injured.

1934

Edward B. Doll, MS '35, PhD '38, has been elected a vice president of Space Technology Laboratories, Inc., in Los Angeles. He will assume new responsibilities as associate director of STL's systems engineering division and will continue to serve as program director for the Air Force's ATLAS -- a position he has held since 1956. He has been with STL since 1955. Ed played a key role in the recent Project Score which placed the missile called the "talking satellite" in orbit around the earth.

1937

John R. Austen is now assistant to the general manager of the Phillipsburg, Pa., plant of the Ingersoll-Rand Company. He had been assistant superintendent of the compressor manufacturing division. John has been with the company since his graduation from Caltech. The Aus-


what is
temperature?

tens, who live in Palmer Township, have two children – John, 13, and Stephen, 11.

Martin H. Webster, who has his own law practice, has moved his offices to Beverly Hills. His specialty is still tax and business law. He's now rounding out his year as chairman of the 48-man taxation committee of the Los Angeles Bar Association and his three-year stint as a member of the 10-man committee on taxation of the California State Bar. Martin's wife is also a lawyer and they have two children – Felice, 10, and Larry, 8.

1938

Joseph Westheimer writes that "we now have our second adopted child – Katherine June, 8 months old. Our first adopted child, Jody, is 3½ years old. I am starting the fifth year of operating the Westheimer Company in Los Angeles where we make motion picture titles and optical effects for feature films and television shows, and commercials for T.V."

1939

David H. Scott is opening a geophysical-geological consulting practice in Los Angeles. Former chief geophysicist for the Hancock Oil Company and chief geologist for the Signal Oil and Gas Company, he also served with the Texas Company – as geologist and division geophysicist of the Pacific Coast Division, and as head of the gravity department at Houston for U.S. and Canadian operations.

1940

James E. LuValle, PhD, who is project director of Technical Operations, Inc., in Arlington, Mass., is also a visiting lecturer in thermodynamics and kinetics at Brandeis University; vice chairman of the Town Meeting Members Association; and president of the Harrington Parent-Teachers Association in Lexington, Mass. The LuValles have three children – John, 8; Phyllis, 6; and Michael, 3.

Frederick C. Brunner, MS '41, writes that "after more than two years in Germany as project engineer for the design and construction of Esso's new Cologne refinery, my family and I are returning to Braun's home office in Alhambra, Calif. On the way, we hope to visit *Ken Gold*, '42, chief engineer for Caltex Services in London. Also a note for the Class of '65 – one of the Brunner sons won a prize at the European Science Fair in Heidelberg with a homemade motor generator set."

1941

William S. Stewart, PhD, will be the honor guest at a reception being held in the Descanso Gardens in La Canada, on February 22. He is director of the Los Angeles County Department of Arboreta and Botanic Gardens, which includes the Los Angeles State and County Arboretum in Arcadia and the Descanso Gardens. Bill is also a research associate at Caltech.

1942

George P. Sutton, MS '43, writes that "I have taken a nine-month leave of absence from my job as manager of advanced design at Rocketdyne to accept the Jerome Clark Hunsaker professorship of aeronautical engineering at MIT. This is one of the few endowed honorary chairs at the Institute. During 1958 I had the wonderful experience of serving the American Rocket Society as its president. With the aid of Sputnik, the membership increased during my term of office by almost 40% to a record high of 12,200. This appears to be an unprecedented growth for a professional engineering society.

"In your November, 1958, issue of *E&S*, you had a list of lost alumni. I am happy to report that one of them, my classmate *Joe Sternberg*, '42, is working for the U.S. Army as a division chief at the research laboratory at Aberdeen Proving Grounds, Maryland."

1944

Jurg Waser, PhD, Caltech professor of chemistry, has been elected vice president of the American Crystallographic Association for 1959, and also secretary of the National Committee of Crystallography set up by the National Research Council of the National Academy of Sciences. Jurg came back to Caltech last fall, after teaching for ten years at Rice Institute in Houston, Texas.

Ronald S. Johnson writes that he's enjoying management consulting with Arthur D. Little, Inc., in Cambridge, Mass.

John H. Gardner is "still with the Richfield Oil Corporation in Bakersfield doing reservoir engineering and production laboratory work. As for our family, we have three boys; the oldest is 7. My wife and I have played several seasons in the Kern Philharmonic Orchestra and are all wound up in community theatre and miscellaneous culture. I'm secretary of the local soaring club and also I'm working toward a glider pilot license."

1945

Mark M. Macomber received his MS from Ohio State University in Columbus last December.

continued on page 51

Personals . . . *continued*

1946

Nateson Srinivasan writes from Madras, India: "After my return from Caltech to India in 1948 I joined Hindustan Aircraft, Ltd., and worked on the design and development of a trainer aircraft called HT-2. I then joined the Madras Institute of Technology at Chromepet, Madras, as director. I have worked on the organization and development of graduate study in specialized fields such as aeronautical engineering, automobile engineering, electronics, and instrument technology. I expect to take another assignment in April when my first five-year contract ends at the Institute."

E. Richard Cohen, MS, PhD '49, research advisor at Atomics International in Canoga Park, will be lecturing on nuclear reactor power plant control in the statewide series of lectures presented by the University of California in February.

Bennett Bovarnick writes that he's bought a new home in Newton Center, Mass. – and that he got his PhD in physics from Boston University last June. The Bovarnicks have three children – Debbie, 7; Ellen, 5; and Danny, 2.

1947

Fernand de Percin, MS, chief of the Polar and Mountain Section of the U.S. Army Quartermaster Research and Engineering Command in Natick, Mass., has just returned from a 3-month trip to northeastern Alaska. The work was concerned with collecting data for the International Geophysical Year and the expedition was sponsored by the Terrestrial Sciences Laboratory Geophysics Research Directorate of the Air Force Cambridge Research Center under contract with the military geology branch of the U.S. Geological Survey. The de Percins and their three children live in Framingham, Mass.

David O. Caldwell is now associate professor of physics at MIT. A Christmas baby, Diana, arrived last December 23 to join brother Bruce, 2.

Richard C. Gerke, MS, is now assistant director of sales at the Herrick Iron Works in Hayward, Calif., after ten years with Bethlehem Steel in Los Angeles as contracting engineer.

1948

Lawrence Dahm writes that he and his brother are farming 1,000 acres of ground in the Imperial Valley. They grow alfalfa, cotton, sugar beets, wheat, flax, barley and corn. They own and operate all their equipment and also have a feed lot in which they fatten out about 500 head of steers a year. Larry was married in 1949 and his family currently

continued on page 53

Personals . . . *continued*

numbers six — three boys and three girls, including a set of twins. Right now, he's busy building a new home. "So far," he says, "we've outgrown four."

1949

Paul Harris was recently transferred to Bakersfield as district geologist for the Texas Company. The Harrises also have a new son, Jeffrey Paul; they already have a daughter.

Irwin Pfeffer, MS, manager of the mechanics and simulation department of the Space Technology Laboratories, is one of the lecturers in the statewide series of lectures presented in February by the University of California. He is lecturing on the analog computer theory.

1950

Richard R. Carhart, PhD, who died two years ago, was posthumously awarded the first annual prize for outstanding contributions in the field of missile electronics reliability and quality control last month. The award was accepted by Dick's widow, Mary, on January 13 at a dinner meeting in Philadelphia, sponsored by the ASQC, the Institute of Radio Engineers, the Electronics Industries Association and the American Institute of Electrical Engineers. Dick had been with Lockheed Missile Systems Division since 1955. He died of cancer on December 9, 1956.

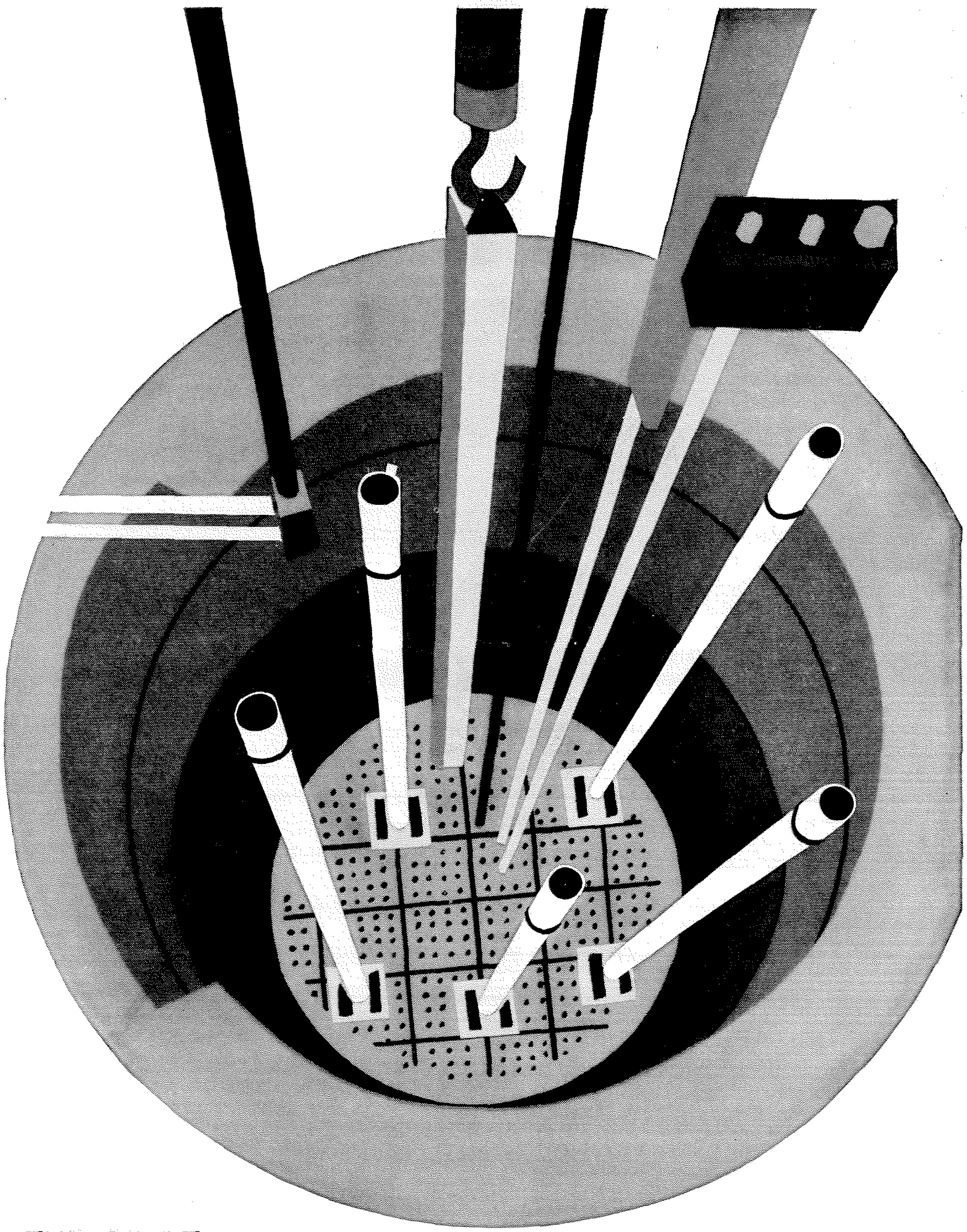
1951

Graydon D. Bell, MS, PhD '57, writes that "since the fall of 1957 I have been assistant professor of physics at Harvey Mudd College in Claremont. This is a new college of science and engineering and I am finding my job both challenging and exciting. I am continuing my research with Dr. Robert King, professor of physics at Caltech. Last February our second child, Stephen, was born. Kathy is now 27 months old."

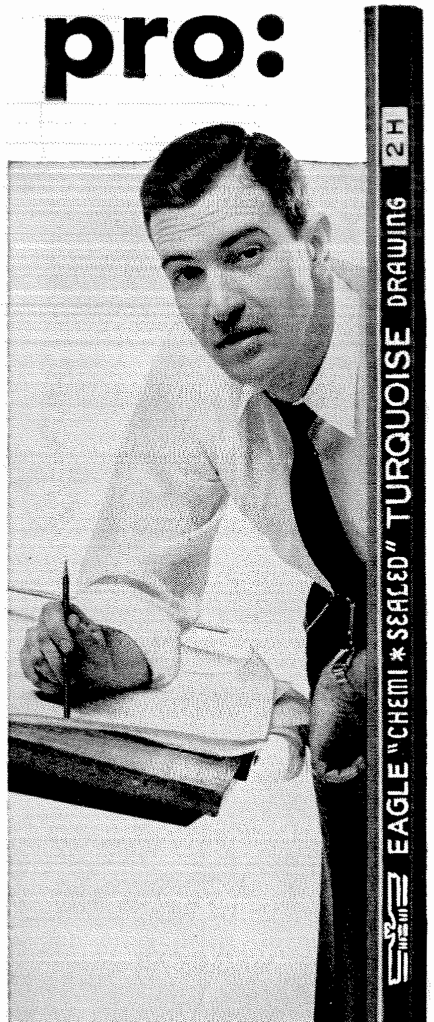
Robert L. Waid, operations engineer of the supersonic wind tunnel at Caltech's Jet Propulsion Laboratory, will teach a University of California engineering course during the spring semester at John Muir High School in Pasadena. His course, which begins on February 11, is part of some 400 evening classes to be offered by University Extension in Los Angeles and 16 other southern California communities.

Robert E. Trudel, MS, has been appointed manager of systems engineering in the Tactical Weapon Systems Division of Aeronutronic Systems, Inc., in Maywood, Calif. Aeronutronic, formed in 1956, is a subsidiary of the Ford Motor Company and specializes in the research, development and manufacture of highly

continued on page 57



Tip from a pro:

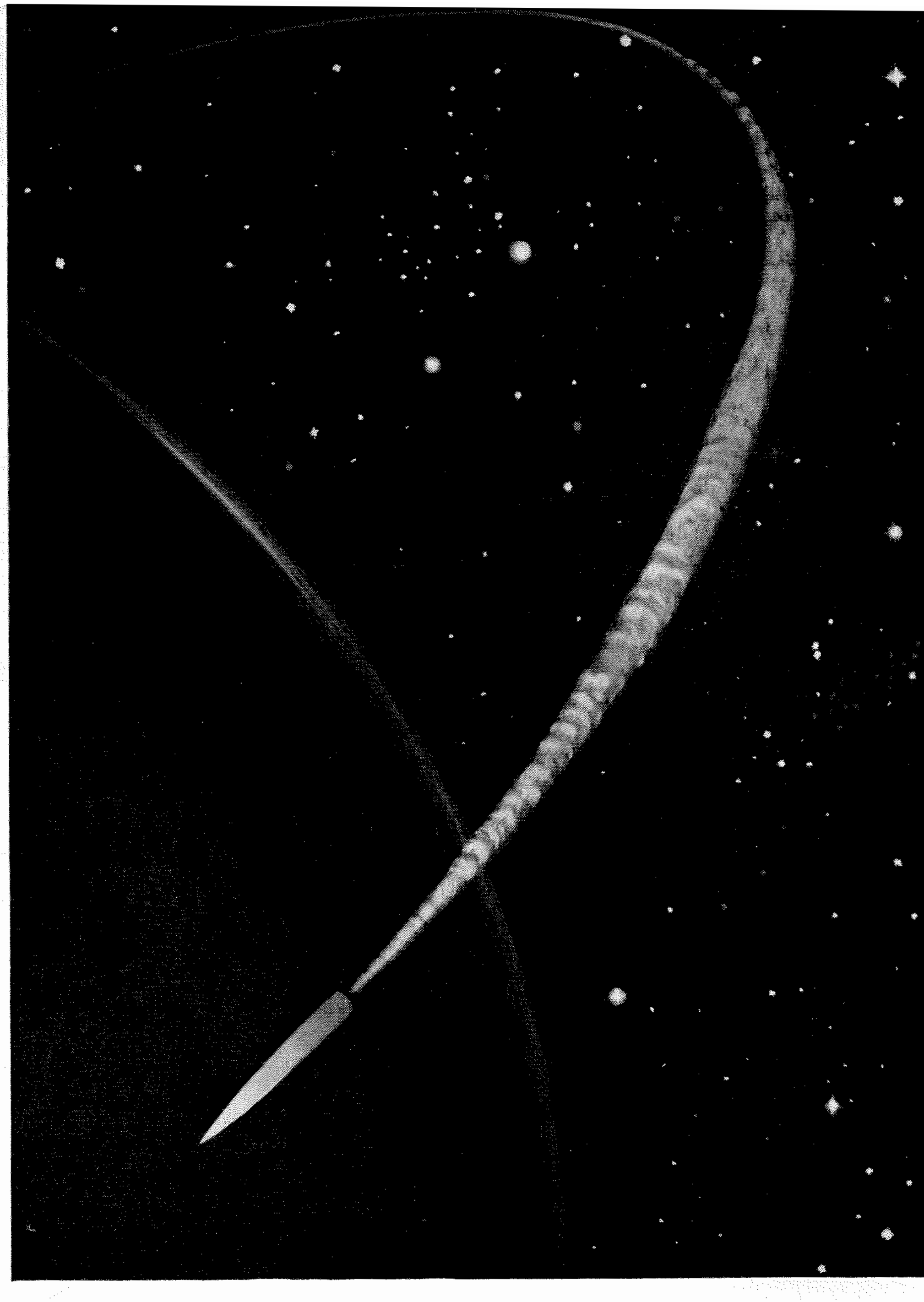


"Takes top-quality tools to do top-quality drawings. Top-quality pencils, particularly . . . like EAGLE TURQUOISE. TURQUOISE holds its strong, non-crumbling point for line after line of unchanging width. Its smoothness is unequaled. And 17 uniform grades give you just the black you want...every time. Like most pros, I bank on TURQUOISE."

FREE SAMPLE! Write Eagle Pencil Company, Danbury, Connecticut, for a free sample TURQUOISE.

EAGLE TURQUOISE

PENCILS · LEADS · HOLDERS



Westinghouse develops new skin for space craft...so they won't burn up re-entering earth's atmosphere

At 6,000 mph, air friction is a problem for space craft re-entering earth's atmosphere, because skin temperatures can exceed 2,500°F. Without adequate thermal protection, the incoming space vehicle will burn itself up like a meteor.

Westinghouse has developed a new ablative material for use as the protecting outer skin for space craft. It has already been service-proven in actual re-entry tests involving firings of ballistic missiles equipped with nose cones of this material.

This new Westinghouse development should do much to help advance our nation's space exploration effort.

YOU CAN BE SURE...IF IT'S **Westinghouse**

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS-TV MONDAYS

STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

In this fast-moving age we find that we can no longer insure leadership... or even survival... by doing things the traditional way. If there's a better way, we must find it.

Our DC-8, C-133, Thor, Nike-Hercules, Genie, Sparrow and other aircraft and missiles are all the finest of their type and time. But their success, and that of our many new projects, depends on superior engineering.

That's why I'm looking for engineers dedicated to quality work. Only through such dedication can the extra performance and reliability of our products be attained. If you feel as we do about this principle, we'd certainly like to hear from you in regard to a future at Douglas.

Write to Mr. C. C. LaVene,
Douglas Aircraft Company, Box 600-E,
Santa Monica, California

Personals . . . *continued*

technical military and commercial systems and components.

1952

Philip S. Thayer, PhD, writes that he has been employed by Arthur D. Little, Inc., in Cambridge, Mass, since 1955 in consulting and research in the biology group. The Thayers have three children – Philip, Jr., 10; Margaret, 6; and Elizabeth, 3.

1953

David Johnston sends a skeleton report of the past few years: "I'm still with Western Geophysical; moved from Shafter to East L.A. to Colusa in 1956; got married to Margarita Günther (formerly of our L.A. office) in 1956; moved to Billings, Montana, in January, 1957; to Roswell, N.M., in March; to Tyler, Texas, in July; baby boy born in Tyler in August; to Lima, Peru, for a two-month vacation in December, 1957; back to Tyler; to Shreveport, La., in May and finally back to Bakersfield in July – a total of 7,550 miles, not counting the 9,000 to Peru and back. David Wayne is now 17 months old and delightful."

George R. Dubes, PhD, writes that he's still doing research on polio viruses and a little on ECHO and Coxsackie viruses at the medical center of the University of Kansas. George is assistant professor of pediatrics there.

Philip K. Bates is now attending the graduate school of industrial management at MIT for two years.

1955

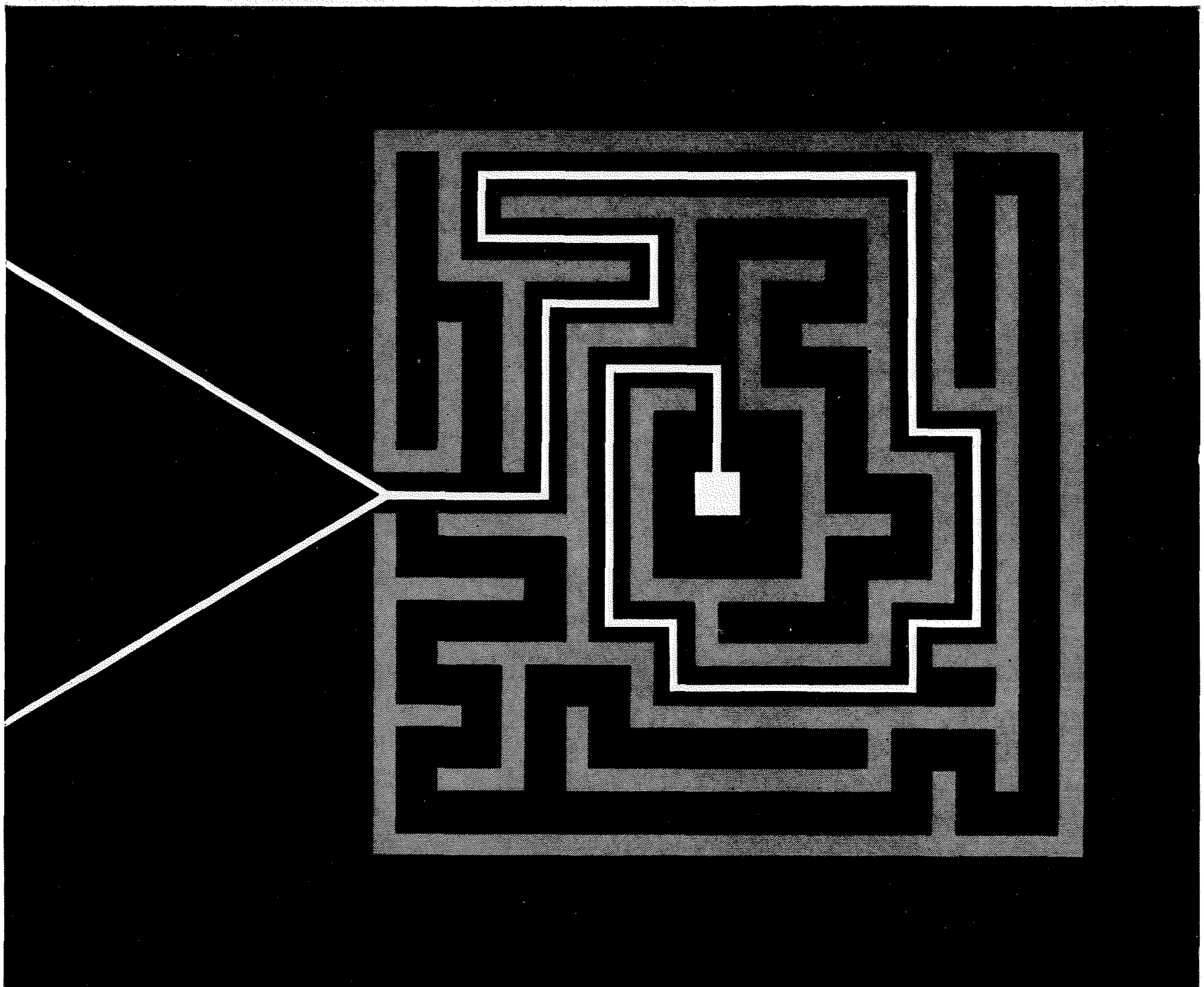
Alfred A. Barrios is now at UCLA working for his PhD. He has changed from chemistry to psychology. "As for money," he writes, "I have a very convenient room-and-board job – I'm a hasher in a sorority house."

1956

Jan L. Arps writes that "in September I left my job with Shell in Louisiana to come to Harvard Business School. I'm looking forward to two very pleasant years in the Boston area. Also in my class are *Dick Kirk*, '58, and *Vincenzo Cestaro*, BS '55, MS '55. *Ted Johnson*, 56, who just graduated from the Business School, was very helpful in providing the 'true scoop' on how to keep one's head above water at the school."

1957

Charles V. Goebel writes that he's at Harvard in the chemistry grad school "along with *Gerald O. Dudek* '54, my roommate; *Kyle Bayes* '56; *Bob Blakely* and *Dennis Peters* '58, and *Will Richards* '54. The weather here is taking its toll of Californians – we walk around Boston with a continuous sinus drip."



CALTECH CALENDAR

ATHLETIC SCHEDULE

Tennis

February 16
Pasadena CC at Caltech

February 21
Occidental at Caltech

February 26
UC, Riverside at Caltech

February 28
Pomona at Pomona

March 5
Pasadena CC at Caltech

March 7
Whittier at Caltech

Basketball

February 18
Occidental at Occidental

February 21
Whittier at Whittier

Swimming

February 20
San Fernando State at San Fernando

February 27
Long Beach State at Caltech

March 4
Conference relays at Redlands

March 13
Santa Barbara at Caltech

Baseball

February 21
San Fernando State at San Fernando

February 25
Cal Poly (Pomona) at Caltech

February 28
Claremont-Harvey Mudd at Caltech

March 4
San Fernando State at Caltech

March 7
Claremont-Harvey Mudd at Claremont

FRIDAY EVENING DEMONSTRATION LECTURES

Lecture Hall, 201 Bridge, 7:30 p.m.

February 20
Liquid Air
– Earnest C. Watson

February 27
Solar Magnetic Fields
– Robert P. Leighton

March 6
Psychobiology
– Harbans Arora

March 13
Facts and Fiction
– J. Kent Clark

ALUMNI CALENDAR

March 7	Annual Dinner Dance
April 11	Annual Seminar
June 10	Annual Meeting
June 27	Annual Picnic

ALUMNI ASSOCIATION OFFICERS

PRESIDENT
Edward P. Fleischer, '43

SECRETARY
Donald S. Clark, '29

VICE-PRESIDENT
Frank C. Bumb, '51

TREASURER
George B. Holmes, '38

BOARD OF DIRECTORS
Frank E. Alderman, '30
L. Fort Etter, '35
John E. Fleming, '46
William W. Haefliger, '50
Ralph W. Jones, '38
Francis E. Odell, '44
Nick T. Ugrin, '34

ALUMNI CHAPTER OFFICERS

NEW YORK CHAPTER

President — Frank F. Scheck, '48
Pennie, Edmonds, Morton, Barrows & Taylor
247 Park Avenue

Vice-President and Treasurer — Dudley B. Smith, '45
Cluett, Peabody & Company, 530 Fifth Avenue

Secretary — E. Morton Holland, '36
A. G. Edwards & Sons, 485 Lexington Avenue

WASHINGTON, D.C. CHAPTER

President — Frank H. Shelton, '49
Armed Forces Special Weapons Project

Secretary-Treasurer — Richard G. King, '49
Applied Physics Laboratory, Johns Hopkins University
Silver Springs, Maryland

SAN FRANCISCO CHAPTER

President — Jules F. Mayer, '40
Standard Oil Co. of Calif., Chemical Division, Richmond

Vice-President — Norman Bulman, '52
Shell Oil Company, Martinez

Secretary-Treasurer — James A. Ibers, '51
Shell Development Co., Emeryville

Meetings: Fraternity Club, 345 Bush St., San Francisco
Informal luncheons every Thursday

CHICAGO CHAPTER

President — Laurence H. Nobles, '49
Department of Geology, Northwestern University, Evanston

Vice-President — Philip E. Smith, '39
Eastman Kodak Co., 1712 Prairie Avenue

Secretary-Treasurer — Thorne J. Butler, '51
Medical Center, Northwestern University

SACRAMENTO CHAPTER

President — Charles M. Herd, '30
State Division of Architecture, 1120 "N" Street

Vice-President — Kenneth M. Fenwick, '28
State Division of Highways, 1120 "N" Street

Secretary-Treasurer — Joseph A. Dobrowolski, '49
Portland Cement Association

Meetings: University Club, 1319 "K" St.
Luncheon first Friday of each month

SAN DIEGO CHAPTER

Chairman — Maurice B. Ross, '24
3040 Udal Street

Secretary — Frank J. Dore, '45
Consolidated Vultee Aircraft Corp.

Program Chairman — Herman S. Englander, '39
U. S. Navy Electronics Laboratory

One of a series

General Electric interviews Dr. Richard Folsom, President of Rensselaer Polytechnic Institute, to explore . . .

Teaching— A Career Opportunity For the Engineer

Leading educators, statesmen and industrialists throughout the country are greatly concerned with the current shortage of high-caliber graduates who are seriously considering a career in the field of science or engineering education. Consequently, General Electric has taken this opportunity to explore, with one of America's eminent educators, the opportunities and rewards teaching offers the scientific or engineering student.

Q. Is there in fact a current and continuing need for educators in technical colleges and universities?

A. Colleges and universities providing scientific and engineering educational opportunities are hard pressed at the present moment to obtain the services of a sufficient number of well-qualified teachers to adequately carry out their programs. Projected statistical studies show that this critical need could extend over the next 15 or 20 years.

Q. Why is this need not being met?

A. There are probably three main reasons. These might be classed under conditions of financial return, prestige associated with the position, and lack of knowledge and understanding on the part of the college student of the advantages and rewards teaching as a career can afford.

Q. What steps have been taken to make education a more attractive field to engineering students?

A. Steps are being taken in all areas. For example, we have seen a great deal in the newspapers relating educators' salaries to the importance of the job they are doing. Indications are that these efforts are beginning to bear fruit. Greater professional stature is being achieved as the general public understands that the youth of our nation is the most valuable natural resource that we possess . . . and that those associated with the education of this youth have one of the most important assignments in our country today.

Q. Aside from salary, what rewards can a career in education offer as opposed to careers in government or industry?

A. The principal rewards might be freedom to pursue your own ideas within the general framework of the school, in teaching, research and consulting activities. As colleges and universities are normally organized, a man has three months in the summer time to engage in activities of his own choice. In addition, the educator is in direct contact with students and he has the satisfaction of seeing these students develop under his direction . . . to see them take important positions in local and national affairs.

Q. What preparation should an engineering student undertake for a teaching career?

A. In college, the engineering student should obtain a basic understanding of science, engineering science, humanities and social sciences with some applications in one or more professional engineering areas. He should have frequent career discussions with faculty members and his dean. During graduate work, a desirable activity, the student should have an opportunity to do some teaching.

Q. Must an engineering student obtain advanced degrees before he can teach?

A. It is not absolutely necessary. On the other hand, without advanced degrees, advancement in the academic world would be extremely difficult.

Q. How valuable do you feel industrial experience is to an engineering or scientific educator?

A. Industrial experience for a science educator is desirable; however, with a senior engineering educator, industrial experience is a "must". An ideal engineering educator should have had enough industrial experience so that he understands the problems and responsibilities in carrying a project from its formative stages to successful completion, including not only the technical aspects, but the economic and personal relationships also.

Q. What do you consider to be the optimum method by which an educator can obtain industrial experience?

A. There are many methods. After completion of graduate school, perhaps the most beneficial is a limited but intensive work period in industry. Consulting during an academic year or summer is a helpful activity and is desirable for older members of the staff. Younger educators usually need experience in "living with the job" rather than providing consultant's advice to the responsible individual.

Q. Based on your experience, what personal characteristics are possessed by successful professors?

A. Primarily, successful professors have an excellent and growing knowledge of their subjects, are interested in people, and transmit enthusiasm. They have an ability to explain and impart information with ease. They generate ideas and carry them out because they are devoted to developing their fields of knowledge. They desire personal freedom and action.

For further information on challenging career opportunities in the field of science and engineering education, write to: Mr. W. Leighton Collins, Secretary, American Society for Engineering Education, University of Illinois, Urbana, Ill.

959-10

GENERAL ELECTRIC