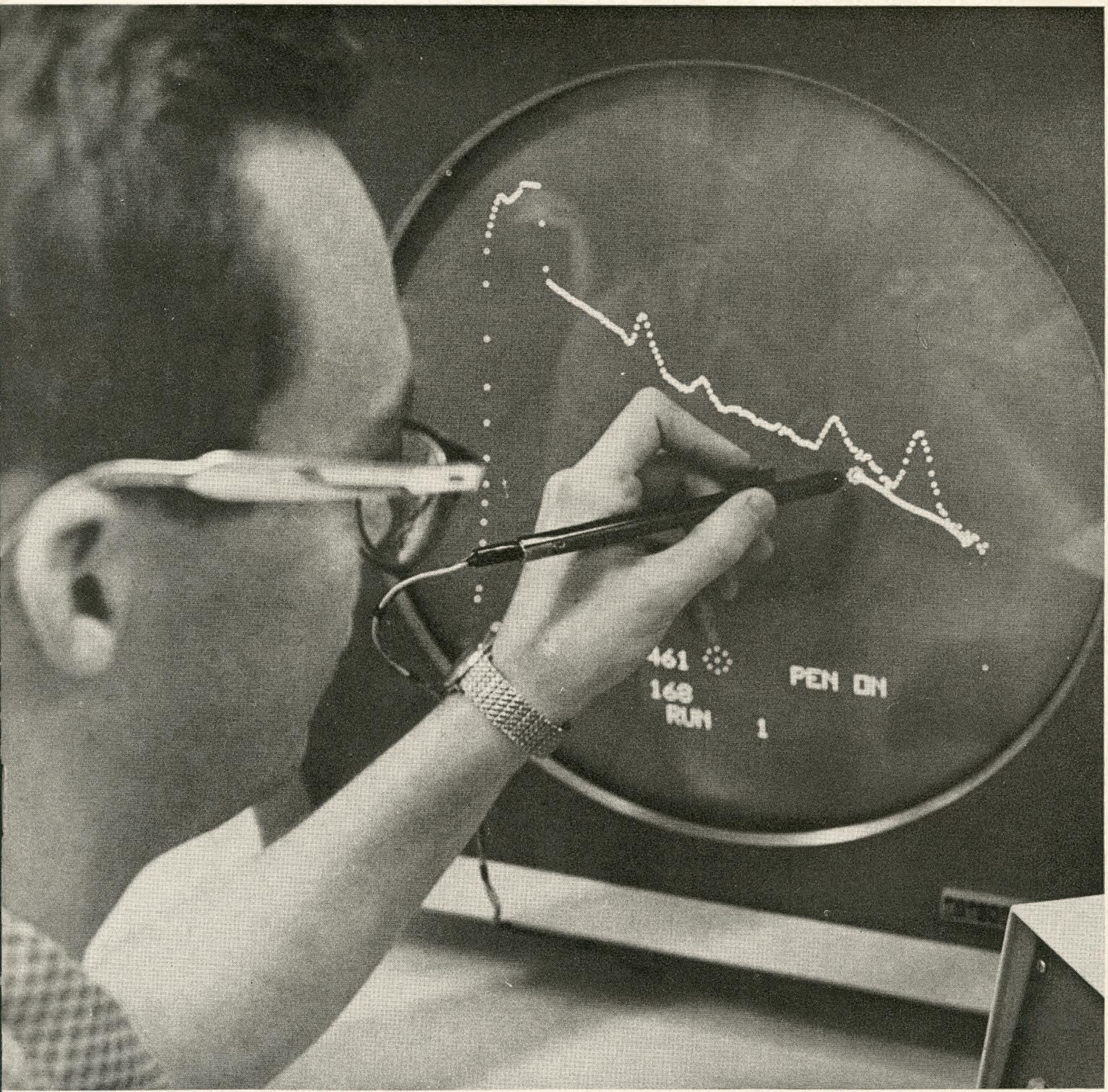
MAY 1965

ENGINEERING AND SCIENCE



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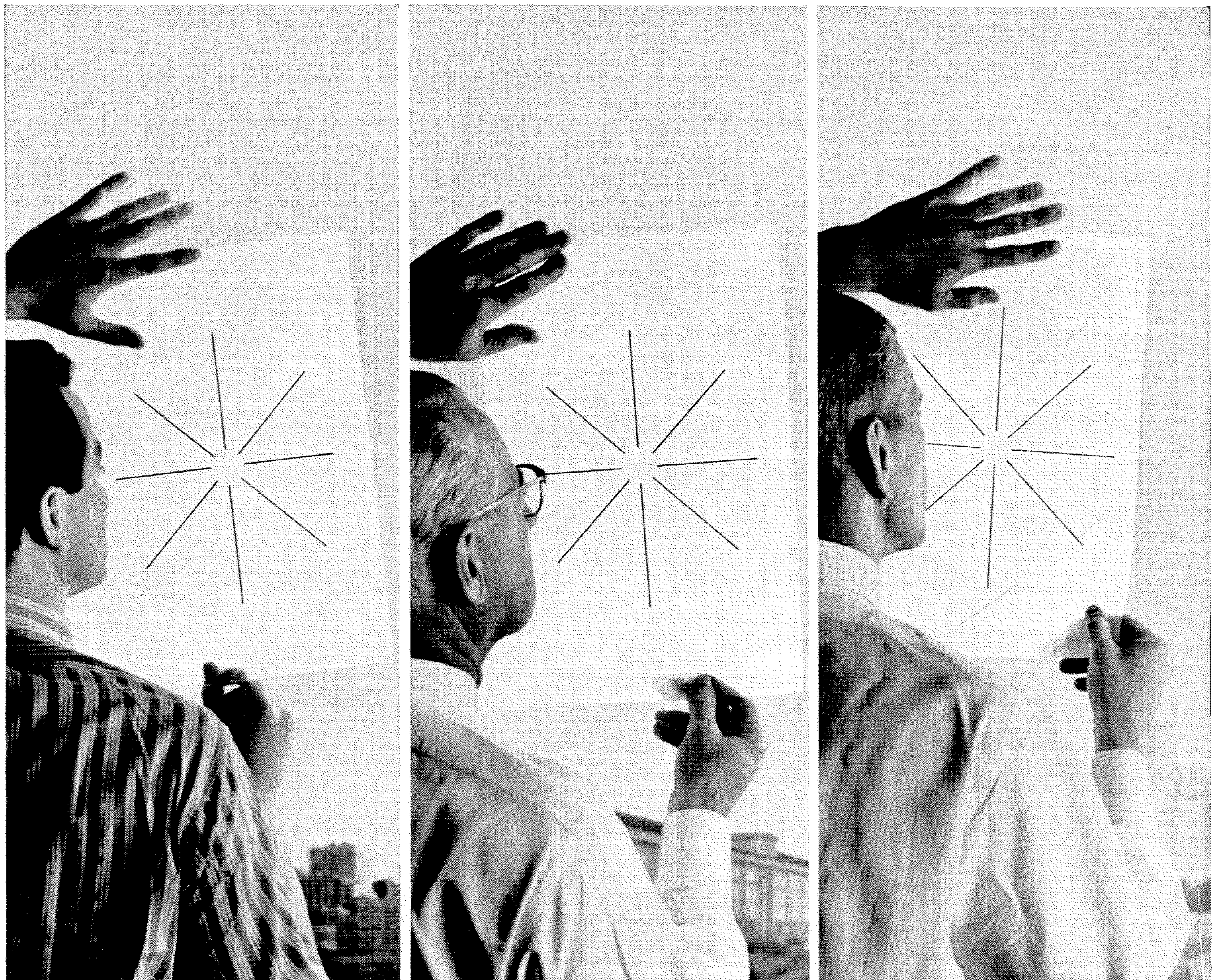

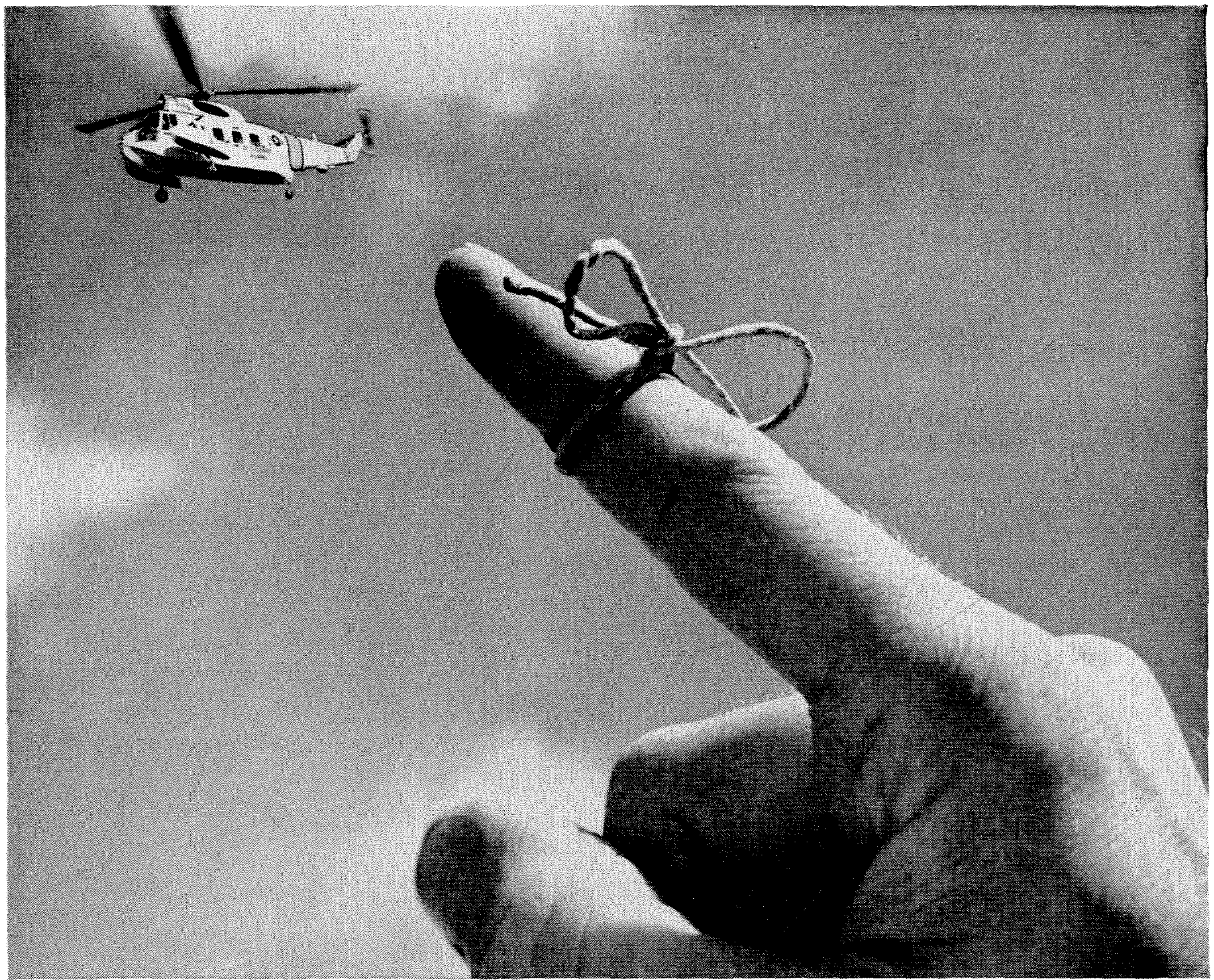

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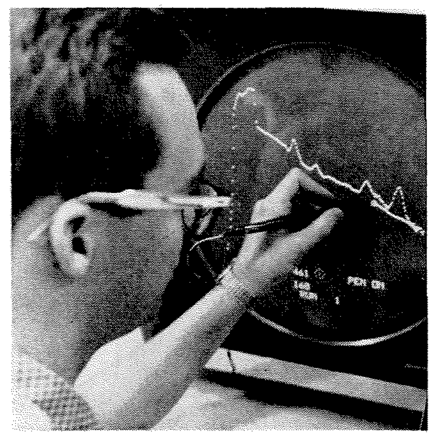

On Our Cover

Michael Mahon, graduate student in physics, works at a cathode-ray tube display console in Caltech's Booth Computing Center. The console, an electronic device connected directly to the computer, flashes information to its operator from the computer in both graphical and literal form, at extremely high speeds. The operator uses a light pen to enter additional data into the computer and reads the results immediately on the face of the console. This rapid two-way communication between computer and operator is a tremendous help in speeding up research projects.

On pages 7-10, further news of Caltech's rapidly developing computer system by Dr. G. D. McCann, director of the Booth Computing Center.

Maarten Schmidt,

professor of astronomy at Caltech and staff member of the Mount Wilson and Palomar Observatories, has just discovered five of the most distant known objects in the universe. How he located these quasi-stellar radio sources and what astronomers know about them is described in "Extending the Frontiers of Space" on pages 11-14 of this issue.

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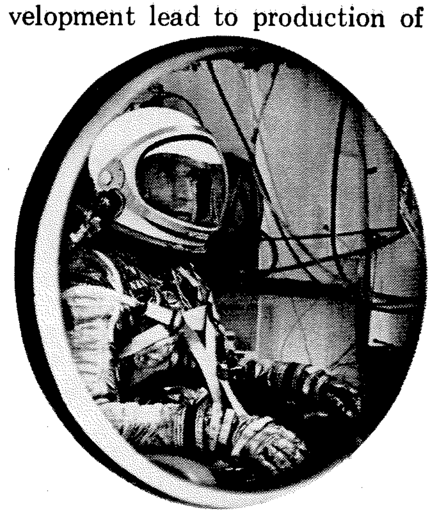

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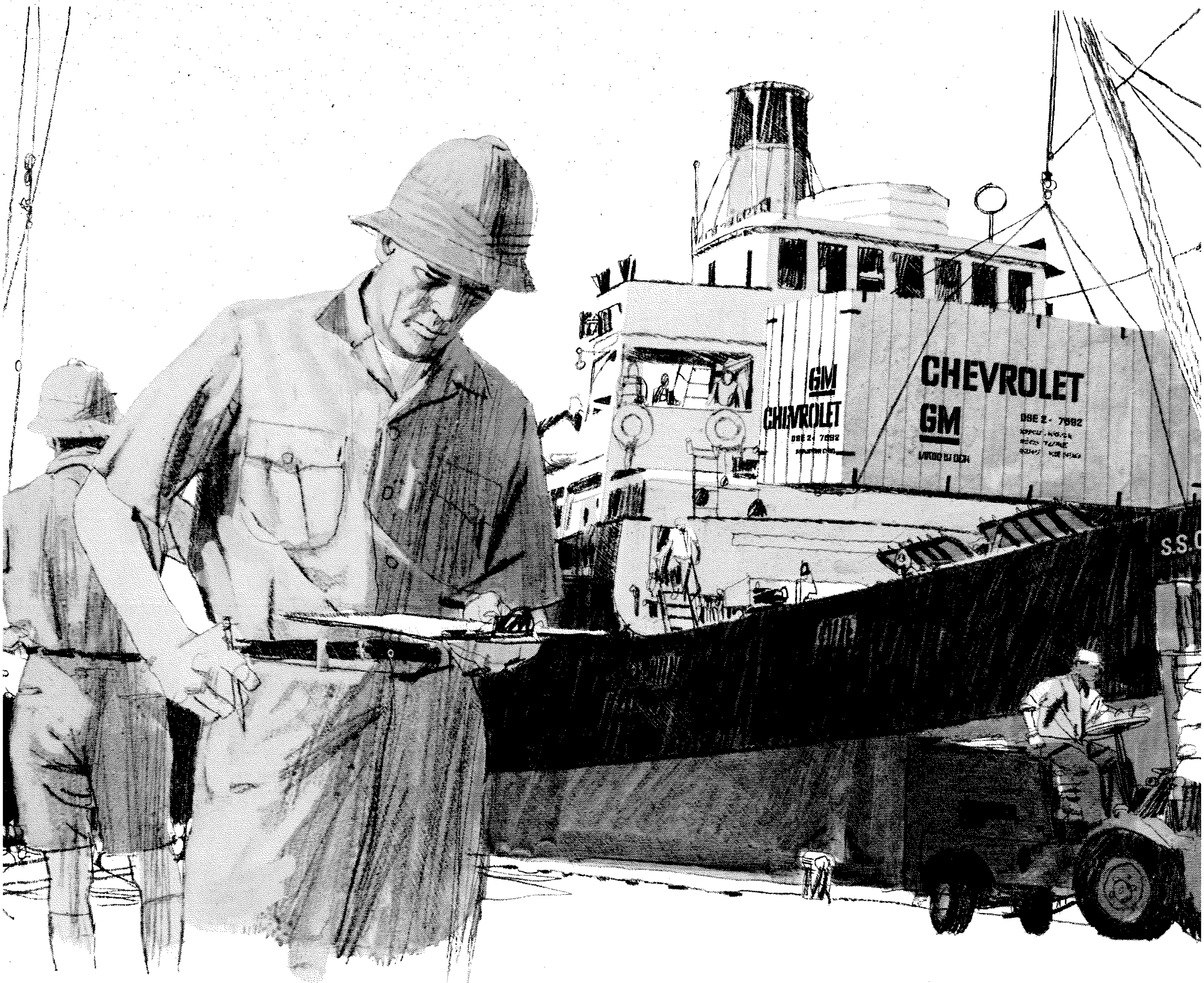

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May 1965, Vol. XXVIII, No. 8

Caltech's Developing Computer System

by G. D. McCann

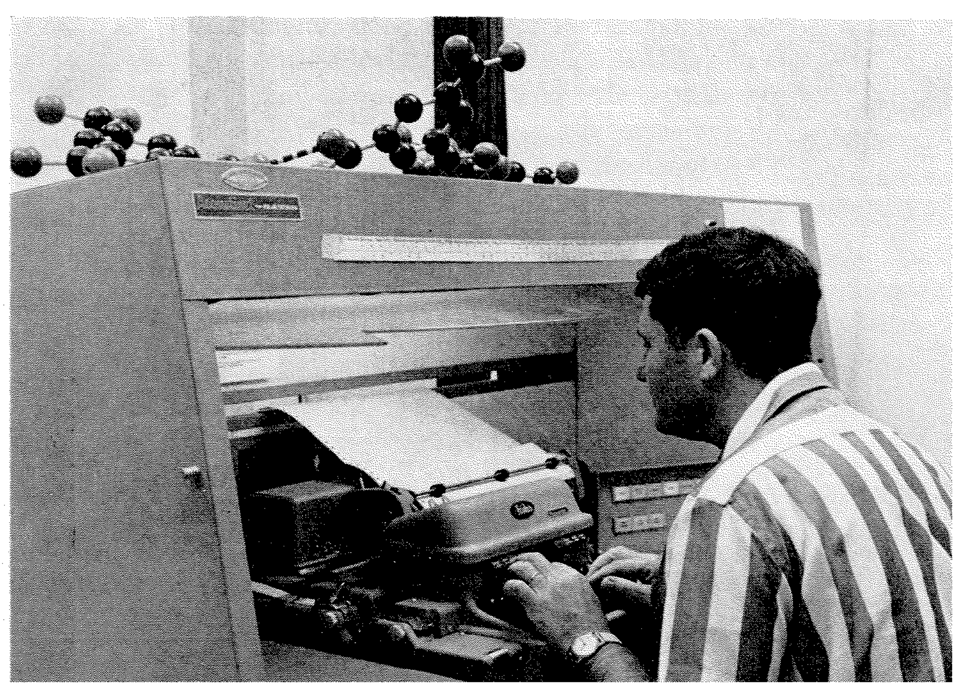
We define as "intelligent thought" all of man's efforts to derive orderly concepts or laws from observations of himself and the world around him, by focusing attention successively on small segments of the total body of information, and attempting to enlarge the field of his concepts by correlating these studies.

In certain areas of scientific investigation, such efforts have resulted in the development of formal mathematics, with their concise algebraic languages. In many fields, however — and most notably in the life and behavioral sciences — man has been forced to grope through complex masses of information without any suitable way of reducing his observations to orderly concepts.

From World War II technology has come a tool which adds a new dimension to this quest for intelligent understanding — the general purpose digital computer. This computer has two principal components. One component is a data processor which, with a fixed number of relatively simple algebraic algorithms, can simulate any intelligent information-processing function by the proper serial combination of these algorithms. The other component is a complex hierarchy of memory structures capable of storing vast amounts of information, which can be recalled and reprocessed in an infinite variety of ways. Because the rules or programs for this serial series of data-processing can also be stored in memory and processed, it is possible for the system to modify its own programs and thus simulate learning — an essential property of true intelligence.

Digital computers were first applied effectively only to formal mathematics — arithmetic, algebra, calculus, and stochastic processes. However, during the past ten years significant progress has been made in their use to simulate non-formal information processing — such as the modeling of game playing, problem solving, and theorem proving. These efforts have resulted in the development of important new concepts of information storage and retrieval and of information manipulation. Such computer systems can be particularly useful in our studies of actual living nervous systems.

The basic concepts emerging from the formalization of modern information-processing tech-



Richard Marsh, senior research fellow in chemistry, communicates with the computer from a remote users console in the chemistry laboratories. A crystallographer, Marsh uses the computer in studies to determine molecular structure by means of x-ray diffraction. There are four remote users consoles on campus now; next fall there will be 25; and within two years there may be as many as 100.

Stewart Smith, associate professor of geophysics, feeds data into a remote console connecting the computer and the Seismological Laboratory. The computer aids in determining the magnitude and location of earthquakes.

niques reach directly into the fundamental meaning of information and the precise mathematical structures of languages as related to both syntax and semantics. The precise description of language structures, and the simulation of a wide variety of languages on digital computers, provides material for research and instruction in the information sciences. Expansion of the concepts of the formal algebraic languages of mathematics is the role of modern applied computer mathematics. These concepts are also producing more precise and sophisticated methods for understanding and simulating natural or conversational languages on computers. Such methods lead directly to the simulation of creative thought processes as a mathematical basis for psycholinguistics and other areas of experimental psychology.

A new form of language structure suitable for describing and understanding experimental data in all fields of science is also emerging in the computer research at Caltech. This type of language, which also possesses true syntactic structure, is being applied to research on sight-sensory nervous systems.

Suitable computer systems now offer the possibility of completely new techniques for experimental research. This promises to be particularly important in all areas of living nervous system research, where it is being applied extensively at Caltech in work ranging from molecular studies, through neural network analysis, to studies of thought processes at the natural-language cognitive-process level.

Computers can play two roles in this activity. They permit completely new methods of modeling theories, even in areas where formal mathematics has not been applicable. They also play a perhaps even more important role by greatly extending the complexity of experimental research by interacting directly in a complex experimental environment, performing such tasks as (1) controlling complex experimental functions, (2) recording and documenting complex measurements, (3) providing rapid preliminary analyses of results so as to facilitate the progress of the experiment, and (4) performing sophisticated analyses for conceptual interpretations.

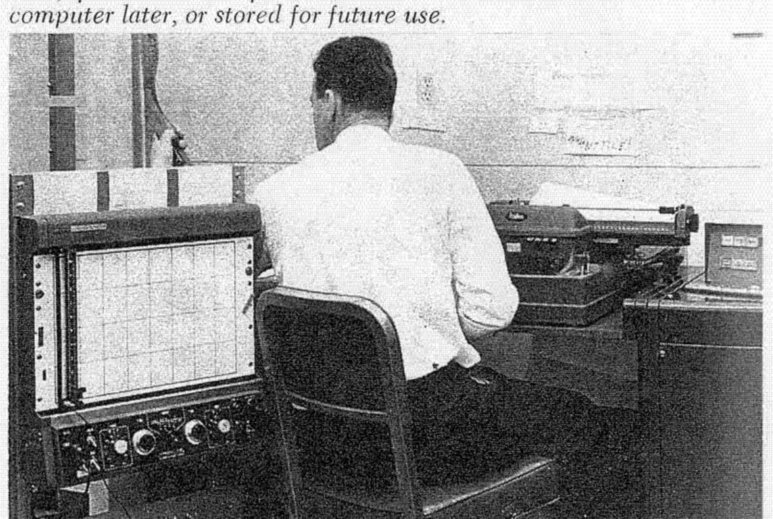
When the computer system that is now installed in Caltech's Willis H. Booth Computing Center was under development, the emphasis in computer usage was on the features of high data-processing speed and large fast-access memory. Of equal importance, however, is the enhancement of communication between the user and the computer, in terms of rapid simultaneous communication for several users, or rapid "turn-around" times for a large number of diversified uses.

To produce new methods of communication and uses, the Computing Center staff developed the "shared-file" system concept, illustrated in the diagram on the opposite page. This is actually one integrated system of three computers and a variety of communication-control and input-output devices – some at remote locations.

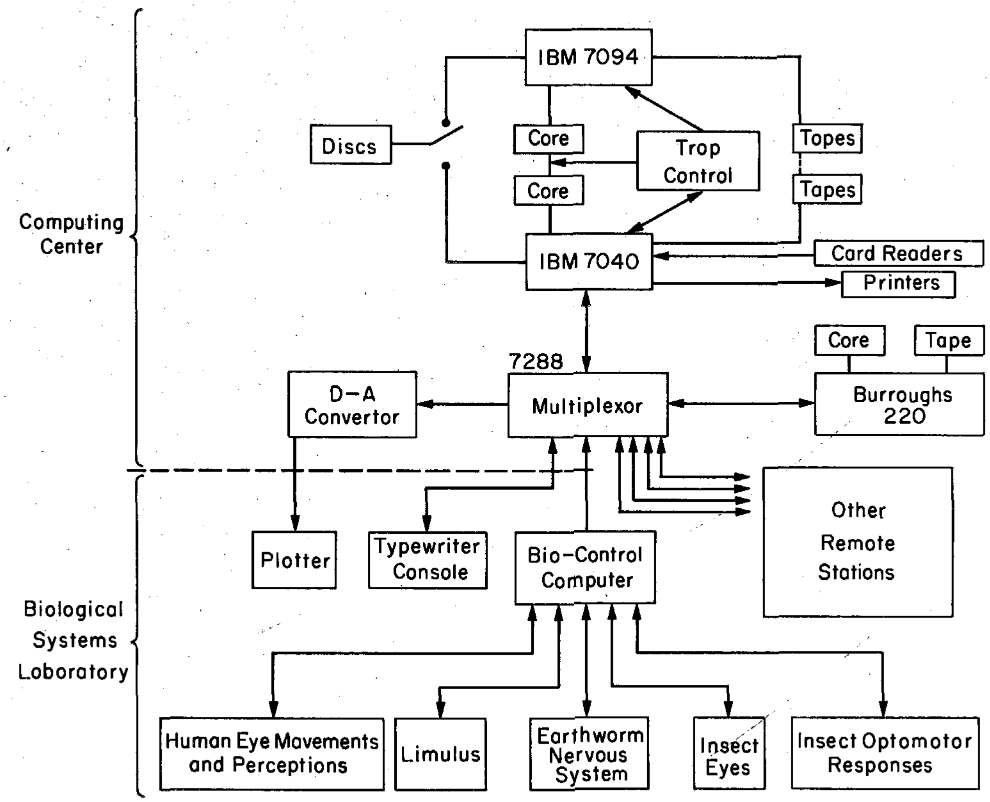
The three main computers are the IBM 7094, the IBM 7040, and the Burroughs 220. Simultaneous communication with the system effected through the 7288 multipelxor, a special-purpose core-memory to hold messages temporarily, or to keep data long enough for it to be accepted by the IBM 7040 as imput, or to be received from the 7040 by the various output devices.

The IBM 7040 and the IBM 7094 work together as a system through three memory interconnections and a "trap" control. The interplay between the

Ralph Kavanagh, assistant professor of physics, at the remote users console in the Tandem Accelerator Laboratory. Messages typed on paper are, at the same time, punched on tape which can be read into the computer later, or stored for future use.



PRESENT
COMPUTER
SYSTEM



two computers is achieved by four interconnections; the computers are interconnected through 25 million words of tape memory, 18.5 million words of disc memory, 64,000 words of core memory, and an instantaneous trap control.

In a typical application, the IBM 7040 will set up the proper programs and data for each new problem in the disc memory, periodically interrupting the IBM 7094 to send it (via the core memory) an updated disc map and priority listing. As the IBM 7094 finishes each job, it stores the output in the disc memory and interrupts the IBM 7040 with instructions for the removal of the output data.

It is important to note that this system concept was developed largely through a cooperative effort with major departments of the Institute interested in computer applications. In the original planning, three major modes of system usage were envisioned:

1. Collection and analysis of direct experimental data by major research facilities.
2. Rapid production computing using pre-developed programs stored in the main disc memory.
3. New program development through the use of compilers. These are programs that translate problem descriptions from some form of formal algebraic language into the machine language of the computers.

Some months after the system had been placed in operation, a fourth mode of interaction between people and the system was implemented. This is called QUIKTRAN and was originally developed by the IBM Corporation.

This mode of operation enables the human user and the computer to work together on the problem of creating a useful program. A remote typewriter console is the medium of communication, and many such stations can be used simultaneously. In its simplest application the remote typewriter can be used as a desk calculator. By typing in a statement asking for a function (such as a cube root or cosine function), together with the number to be used, one obtains the desired function. In its more sophisticated mode of operation, QUIKTRAN permits one to type in any series of algebraic statements that might form a given problem program.

The computer checks each statement for format consistency, looks for omission or illogical statements, and immediately types back its comments. The user can then ask the computer to carry out the statements, either singly or in groups, with certain trial data to test it for correctness, and can quickly correct any errors found by the computer in the process. Solutions can then be run off. Higher-order "conversational" modes are now under development by the Computing Center staff.

The progress which the Institute has made in the application of the present computer system has induced the IBM Corporation to make a completely new and much more advanced system available to the Institute. This system, scheduled for installation in October 1965, is illustrated below. For convenience, the diagram is divided into four sections. Section A, the central computer system, represents the expansion of the shared file shown on p. 9. Here the IBM 7040-7094 system is replaced by a 360/50 and probably a 360/70. The shared file becomes a high-speed bulk core with a random access time of 8 microseconds instead of the 7 milliseconds of the present disc memory.

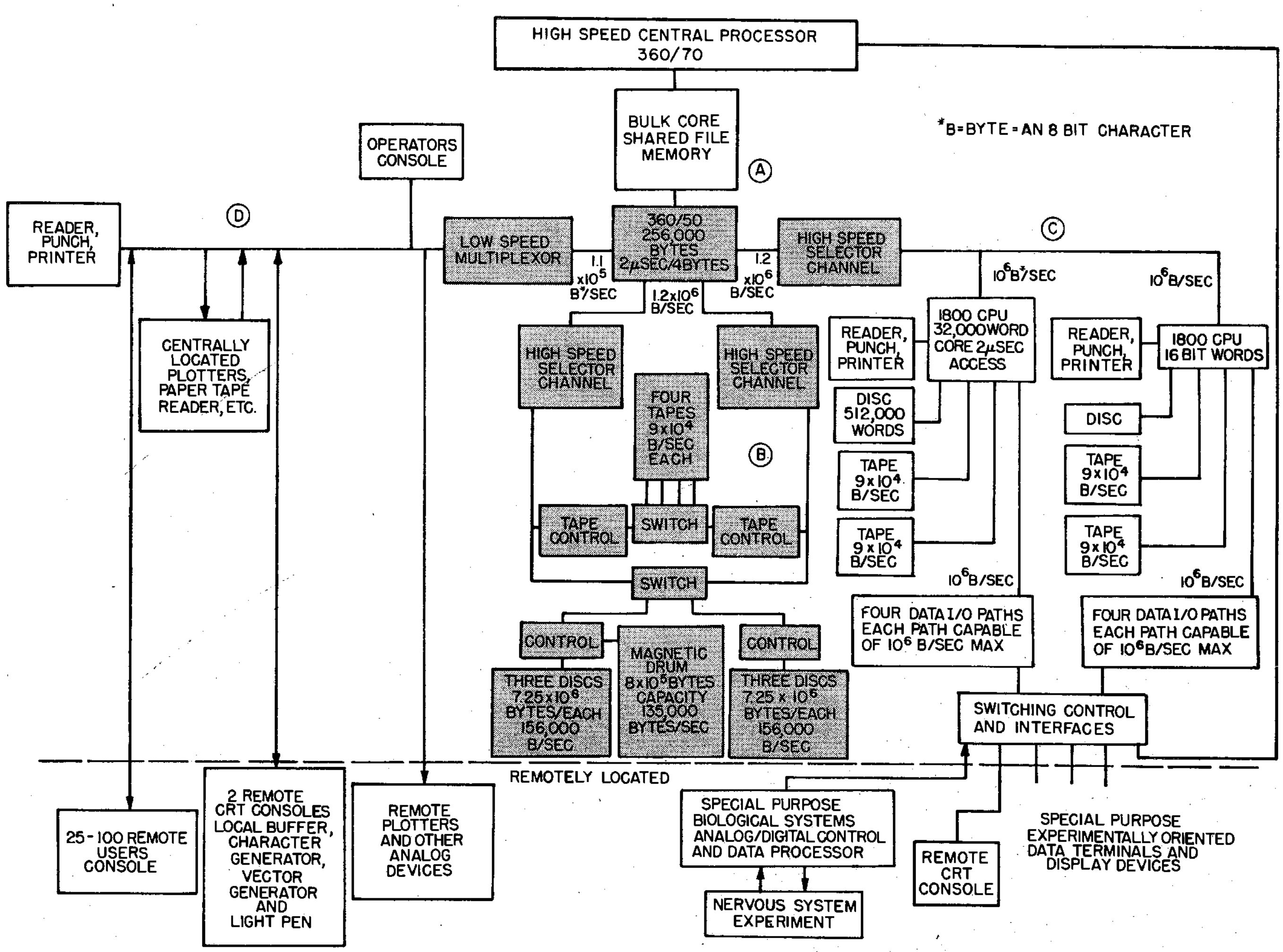
Section B (the shaded areas) functions as (1) the primary bulk library storage, and (2) the expanded form of algebraic conversational modes.

Section C shows a series of two 180 digital computers designed for experiment data collection and "on-line" preprocessing of experimental data.

Section D shows the large number of remote typewriter consoles and cathode ray display devices which are being provided for a variety of uses, including formal course instruction.

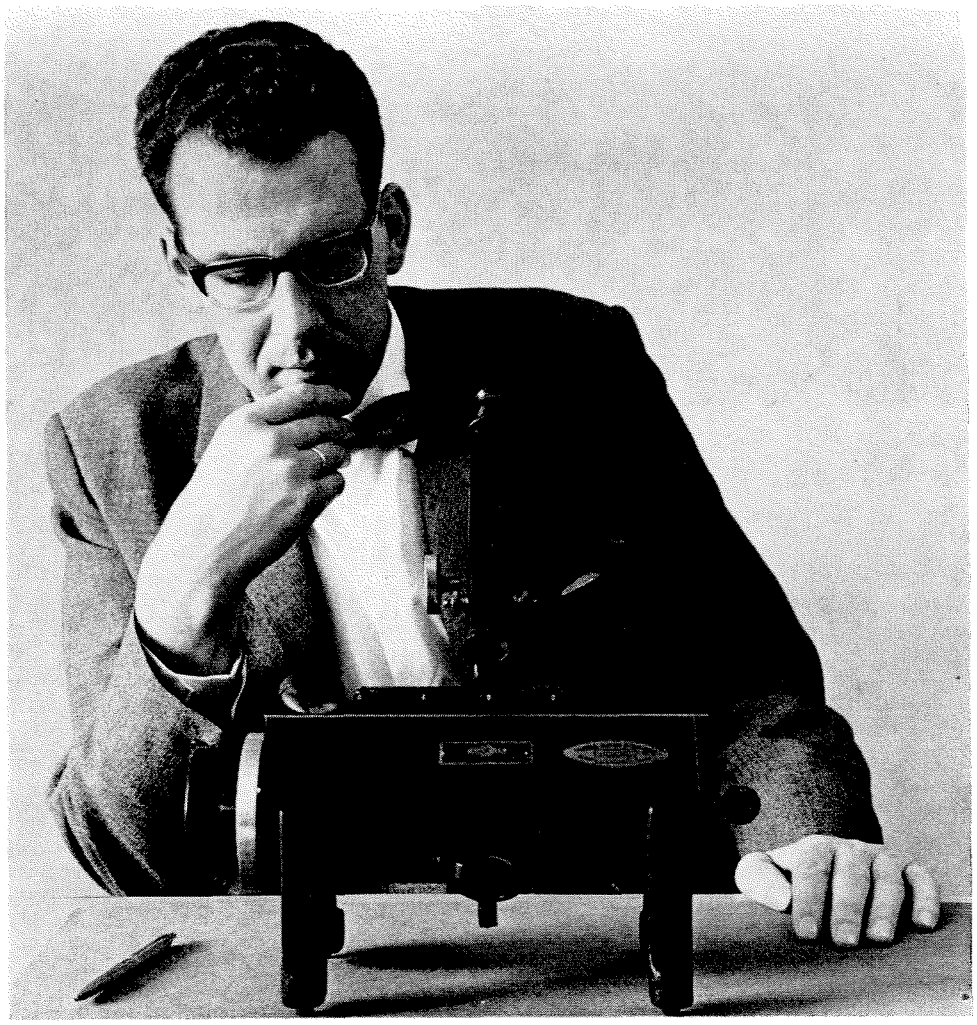
In the present system, the QUIKTRAN mode must be operated independently of other system modes. It is presently being run one hour per day. In the new system, the new form of algebraic conversational mode will actually be interflexed with the other modes in which the system can be used. Furthermore, there will be a generalized "translator" in the system which will enable a user to specify any consistent algebraic language to the computer. Once this has been done, the computer, having immediately learned this new language, works with the user, helping him to write and execute his program in his own language.

The very large bulk core memory of the new system also permits the development of a higher order of conversational modes or methods by which the computer and humans can work together on high-order thought processes. One form of these modes makes use of such natural conversational languages as English, and is suitable for the simulation of cognitive processes and research in linguistics and psychology.



Caltech's new computing system, to be installed in October 1965.

Maarten Schmidt, professor of astronomy at Caltech and staff member of the Mount Wilson and Palomar Observatories, uses a microscope to measure wavelengths in photographic spectra.



by Graham Berry

Extending the Frontiers of Space

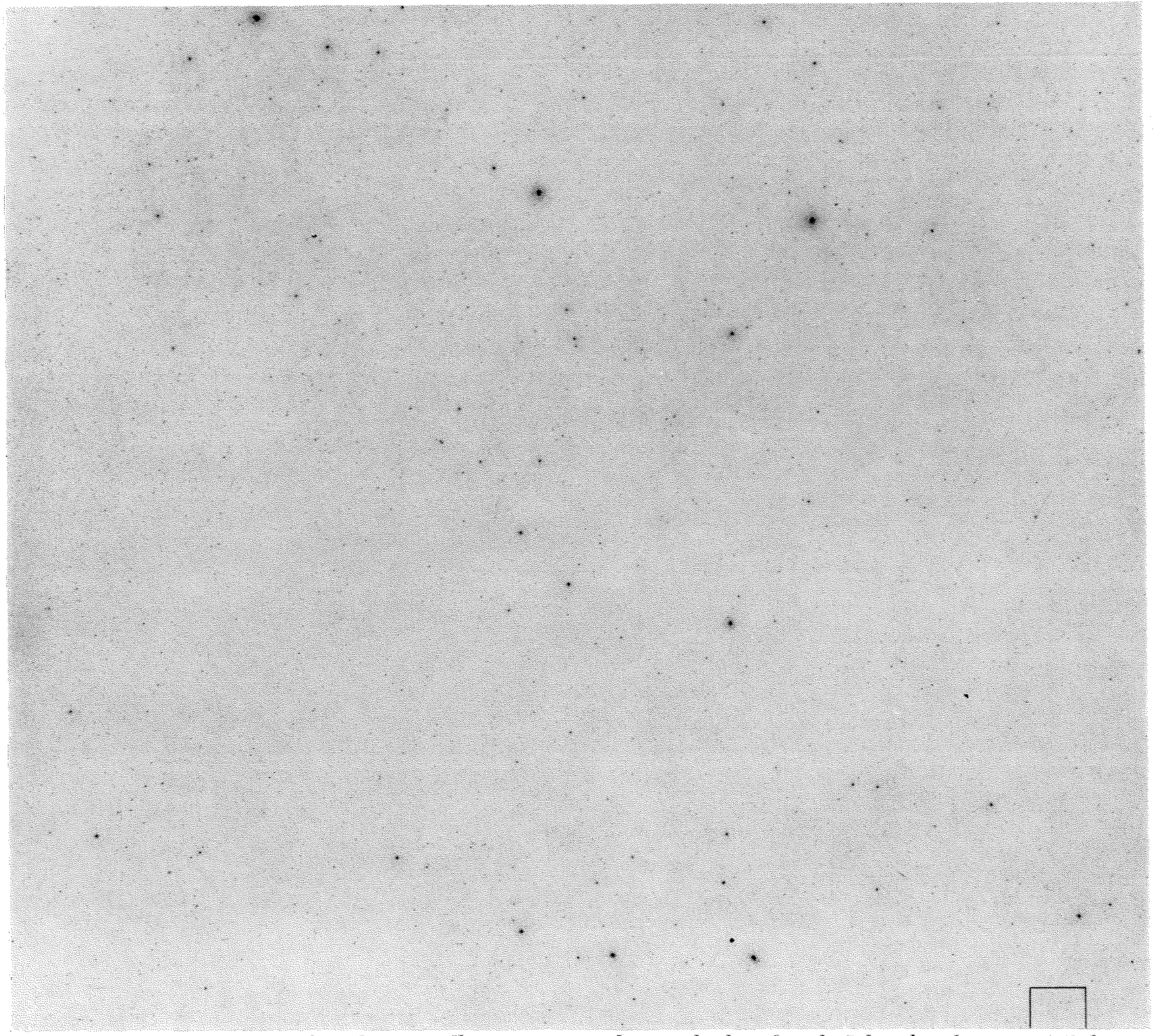
Maarten Schmidt, professor of astronomy at Caltech, and staff member of the Mount Wilson and Palomar Observatories, has found that five quasi-stellar radio sources are farther away than any other known object in the universe. The discovery is described by the Observatories as a breakthrough in determining relative cosmological distances.

The most distant of the five objects, 3C-9, is so remote that it appears to be receding from the earth at 80 percent of the velocity of light – 149,000 miles a second. Under the expanding universe theory, the faster an object recedes from the earth, the farther away it is.

"The light we now see from 3C-9 left it many billions of years ago, before the sun and the earth were born and when the expanding universe was only a third as large as it is today," says Dr. Schmidt. "It started from 3C-9 only a few billion years after the universe was born." The universe is considered to be ten to fifteen billion years old.

Although all five quasi-stellars are many billions of light years away, their exact distances cannot be stated because that would require accurate knowledge of the evolution of the universe. What we have are their relative distances.

As is true of other objects far beyond our Milky Way Galaxy, their relative distances are inferred from their red shifts. The greater the red shift of its spectrum, the farther away an object is believed to be. However, the relationship of red shift to distance is still uncertain for objects that are more than a billion light years away. At such distances the un-



A negative print of a star field in the constellation Pisces, taken with the 48-inch Schmidt telescope at Palomar. The area marked at the lower right is enlarged in the photograph on the opposite page.

known geometry of the universe may affect this relationship. It is hoped that these uncertainties will be resolved by studying the red shifts, brightnesses, and sizes of many more quasi-stellars.

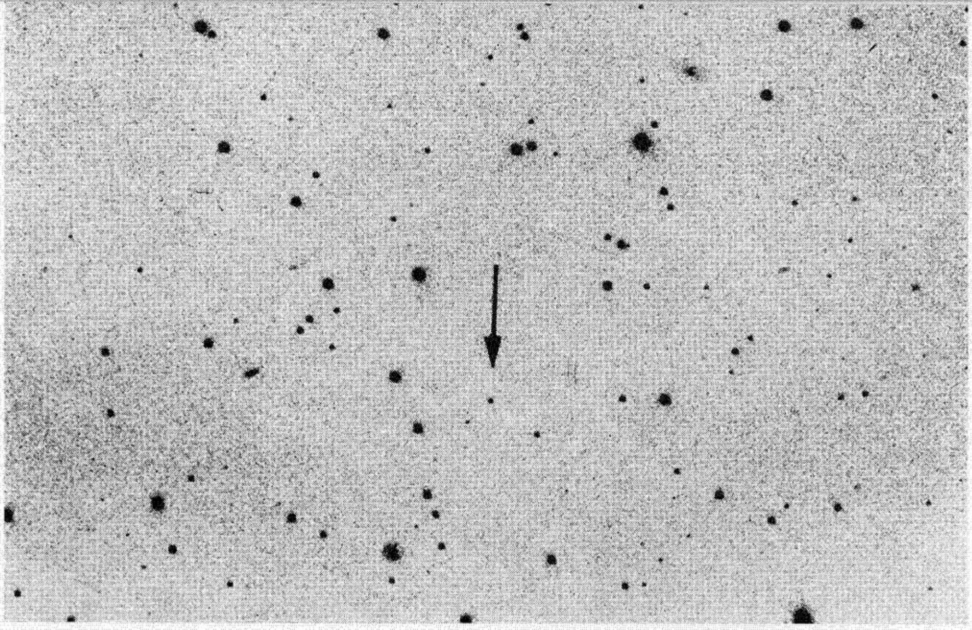
Previous to this announcement, red shifts had been obtained for four quasi-stellars. Dr. Schmidt obtained three of them. The largest was that of 3C-147, whose red shift corresponds to a recession rate of 76,000 miles a second. For such large red shifts, the corresponding velocities are computed according to Einstein's special theory of relativity proposed in 1905.

The five new red shifts which the astronomer has obtained are for the following five quasi-stellars and correspond to the following recession rates: 3C-254—93,000 miles a second; 3C-245—113,000 miles a second; CTA-102—114,000 miles a second; 3C-287—115,000 miles a second; and 3C-9—149,000 miles a second. The "3C" designation indicates a listing in the third Cambridge catalog of radio sources. The "CTA" prefix indicates inclusion in the "Caltech List A" of radio objects.

The red shifts of the new quasi-stellars are so large that three spectral lines from the far ultraviolet are shifted into the visible part of the spectrum. One of these is the Lyman alpha line of hydrogen, which never before had been observed from a ground-based observatory.

Last month some Russian astronomers reported that one of the five new objects, CTA-102, emits a radio signal that varies in a 100-day cycle. A Moscow report said the variable signal might be evidence of a super civilization. However, Drs. Allan Sandage, staff member of the Mt. Wilson and Palomar Observatories, and John Wyndham, Caltech radio astronomer, said they believe the signal comes from a natural source. They had previously identified CTA-102 as a quasi-stellar. Dr. Schmidt's de-

Enlargement of the marked area in the photograph at the left shows the location of the quasi-stellar radio source 3C-9. Negative prints are used almost exclusively by astronomers because much more detail is visible and faint objects show up better.



termination of CTA-102's large red shift confirms their statement.

What are these mysterious quasi-stellars that have intrigued astronomers so much for the past three years? They used to be considered ordinary stars within our galaxy. In 1960 it was discovered that they emitted energy as radio waves as well as in the form of light. In 1963 Dr. Schmidt obtained a large red shift for one of them, 3C-273, which indicated that it was a very distant object, far beyond our galaxy.

With their large red shifts indicating great distances, it became evident that they must be very bright intrinsically, although, because they are so far away, they appear only as faint stars of 17th or 18th magnitude. Being up to 100 times brighter than an entire galaxy, they can be observed farther away than any other objects.

Although little is known about their structure and energy-producing mechanisms, several theories have been advanced to explain them. Currently, astronomers think a quasi-stellar is a distant object with a mass of at least 100 million suns. It is believed that its energy-producing core is surrounded by two cloud layers. The inner, visible layer is of luminous gas, the outer, optically-invisible layer consists of fast-moving electrons, emitting energy as radio signals as they spiral in a magnetic field.

The over-all information on the composition of these objects is meager. There are no indications that the composition of the extremely far away ones is different from that of other quasi-stellars. They are the oldest visible objects in the universe. They probably lived only a short time — perhaps a million years — as very bright quasi-stellar sources.

"When we have determined the red shifts for enough of them," says Dr. Schmidt, "they should become invaluable in studying the geometry and evolution of the universe. I believe the red shifts will be determined shortly for many of them because we now know what to look for."

The five new red shifts mark a breakthrough in spectroscopy — the astronomical technique which makes it possible to learn something of an object's composition, motions, and temperature, and to infer how far away it is.

Before spectroscopist Schmidt undertook the difficult, meticulous task of attempting to obtain a red shift for one of the objects, it already had been identified as a quasi-stellar source. Several radio and optical astronomers such as Drs. Wyndham and Sandage are currently engaged in identifying quasi-stellars.

The exact sky positions of radio sources are pinpointed at Caltech's Owens Valley Radio Observatory and at other such installations. Astronomers try to match these locations with star-like optical objects. If, in addition, considerable ultraviolet light is radiating from such a radio-optical source, then astronomers are virtually certain it is a quasi-stellar. More than 40 of them have been located. Now red shifts for a total of nine have been reported.

Obtaining red shifts is very difficult. So little of the quasi-stellar's ancient light reaches the earth that there isn't much left to split into a spectral pattern of lines, each line representing a specific wavelength of light. This must be done to obtain a red shift.

A grating mirror was used with the big 200-inch Palomar telescope to separate the light from these objects into its color components. The light was admitted through a slit and deflected from the mirror-grating into a camera. Exposures of four to five hours each were required to obtain the faint tracing on a photographic plate.

To make certain that the barely-observable trace marks represented actual spectral lines, Dr. Schmidt obtained at least four spectral photographs of each object. Two or more spectral lines were required on each spectrum to determine the red shift at all.

Great as are the difficulties in obtaining the spectral lines, they are small in comparison with those of interpreting them. Dr. Schmidt describes the problem as follows:

Interpreting spectral lines

A red shift is produced by a light source moving away from the observer, just as a blue shift is produced if the light source is approaching. The light waves from a receding source are stretched out, lengthened. The faster the object's motion away from the observer, the more its light waves are stretched and the greater the shift toward the redder end of the spectrum, where the light waves are the longest.

Sound waves are affected similarly by motion. A train's horn is higher in pitch as it approaches, because the sound waves are shortened, and lower as it recedes, when the sound waves are lengthened.

Now imagine a locomotive with ten horns on it, each with a different pitch. The tones of three horns, say, are too high in pitch for the human ear to detect (like the special dog whistles; dogs can hear tones that are higher than 20,000 cycles per second, but humans can't). If the train were moving away fast enough, the sound waves of the normally inaudible horns would be stretched out enough to move into the audible range. We would hear them.

This is what is happening in the spectra of the quasi-stellars. For instance, the wavelengths of the light from 3C-9 are three times longer than they would be if that quasi-stellar were at rest in relation to the earth. Each wavelength is represented by a spectral line which normally has a specific location in a spectrum. However, for 3C-9 a line normally located in a spectrum at 1,550 angstroms would, if the wavelength were thrice as long, be located at the 4,650-angstrom mark. An angstrom is equal to one 254-millionth of an inch. A wavelength that is 1,550 angstroms in length is too short to be visible on the earth's surface. That is because our atmosphere absorbs all wavelengths of less than 3,100 angstroms. However, a wavelength of light that is 4,650 angstroms long is visible as blue light.

In observing the two or more lines in the spectrum of a fast-receding quasi-stellar, Dr. Schmidt suspected that these lines represented wavelengths that normally are invisible. The problem then was to identify that quasi-stellar's spectral line pattern with part of the laboratory spectrum, which is made up of the prominent lines of the more abundant elements. Once the identification is made, the red shift follows from the difference in the wavelengths of the quasi-stellar line pattern and the laboratory line pattern.

For the nearest of the five new quasi-stellars, 3C-254, Dr. Schmidt obtained five spectral emission lines. The lines disclose two forms of neon (III and V), and one each of carbon III, magnesium II and oxygen II. The Roman numerals represent the degree to which the chemicals were ionized. Neon III denotes neon atoms with two fewer than a full complement of electrons. Neon V signifies neon atoms with four less than the full complement of electrons.

For the next most distant objects – 3C-245 and CTA-102 – the astronomer obtained the same two lines on each of their spectra – those of carbon III and magnesium II. The lines of CTA-102 were shifted a little more than those of 3C-245, indicating that CTA-102 was farther away.

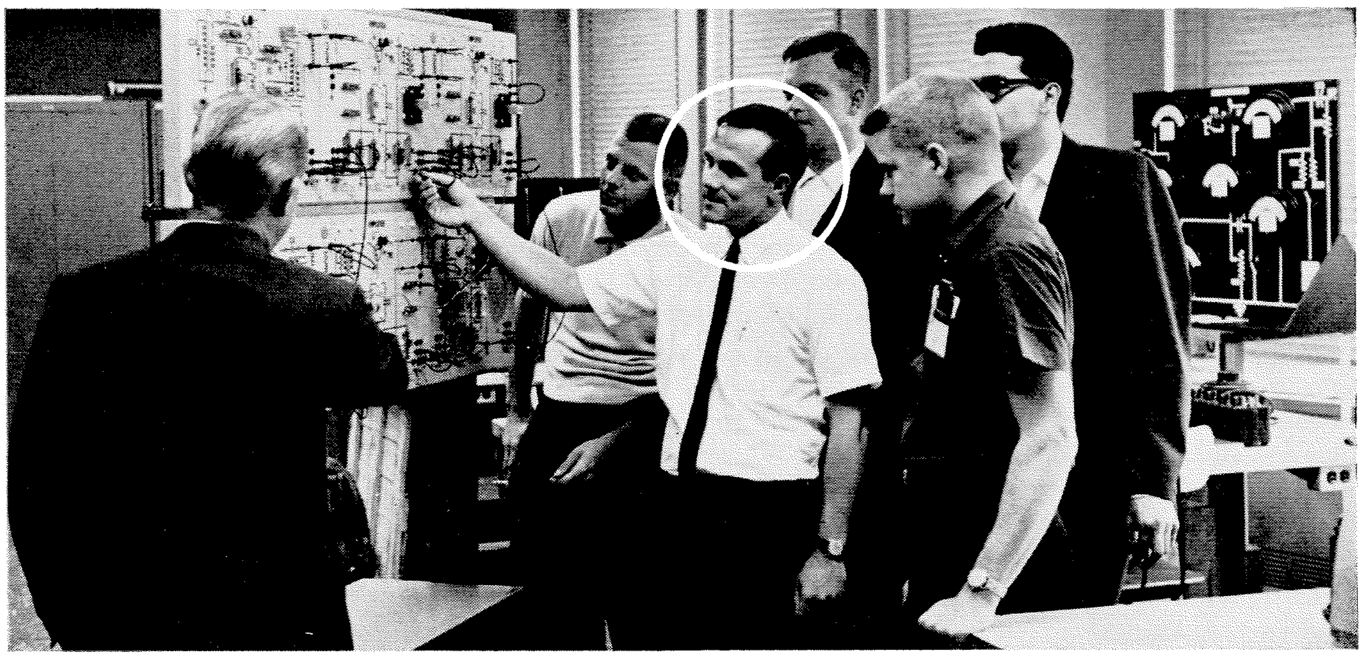
In the spectrum of the second most distant of the five objects, 3C-287, Dr. Schmidt obtained three lines – the two that had been found for 3C-245 and CTA-102 (carbon III and magnesium II), plus another one, that of carbon IV. This is the first time that carbon IV's line has been obtained for an astronomical object. That is because the wavelength of its light normally is 1,550 angstroms – too short to be visible. However, in the spectrum of 3C-287 the wavelength has been red-shifted (lengthened) to 3,192 angstroms.

Getting the carbon IV line in 3C-287 was vital in obtaining a red shift for the most distant of the objects – 3C-9. Dr. Schmidt got two lines for 3C-9 – that of carbon IV and that of Lyman alpha. In 3C-9, the carbon IV line has been red-shifted to 4,668 angstroms, which is slightly more than three times its normal (at rest) wavelength of 1,550 angstroms.

A new method

In determining the red shifts for these five far-out objects, Dr. Schmidt has discovered the key to unlocking the red shifts of other quasi-stellar objects that may be even farther away. The key is this step-wise method of uncovering new spectral lines that never before have been visible because the wavelengths of their light were too short.

Graduation was only the beginning of Jim Brown's education



Because he joined Western Electric

Jim Brown, Northwestern University, '62, came with Western Electric because he had heard about the Company's concern for the continued development of its engineers after college graduation.

Jim has his degree in industrial engineering and is continuing to learn and grow in professional stature through Western Electric's Graduate Engineering Training Program. The objectives and educational philosophy of this Program are in the best of academic traditions, designed for both experienced and new engineers.

Like other Western Electric engineers, Jim started out in this Program with a six-week course to help in the transition from the classroom to industry. Since then, Jim Brown has continued to take courses that will help him keep up with the newest engineering techniques in communications.

This training, together with formal college engineering studies, has given Jim the ability to develop his talents to the fullest extent. His present responsibilities include the solution of engineering problems in the manufacture of moly-permalloy core rings, a component used to improve the quality of voice transmission.

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The Month at Caltech

Sloan Foundation Grant

A new phase of growth at the Institute is heralded this month with the announcement by President L. A. DuBridge of a gift of $5,000,000 from the Alfred P. Sloan Foundation of New York.

To be known as The Alfred P. Sloan Fund for Research in the Physical Sciences, the grant will be devoted over a period of years to what Mr. Sloan, former head of General Motors, describes as "the pursuit of knowledge for knowledge's sake."

While intended primarily for research in the physical sciences, including mathematics and engineering, the fund may also be applied where basic development in the physical sciences impinges on others, such as the life sciences.

In acknowledging the grant, Dr. DuBridge said: "This is not only one of the largest single contributions ever made to Caltech, it is also one of the most significant, for it comes precisely at a time when we are shaping up plans for an expansion of our activities that will entail the raising of many millions of dollars during the coming few years. It is thus a source of great encouragement to us to have this generous initial gift, and we trust it will inspire others to provide the additional support we will require."

Dr. DuBridge noted that this is Caltech's second large gift from the Sloan Foundation, the first having been $1,166,000 donated in 1958 for the construction of the Sloan Laboratory of Mathematics and Physics. Numerous other gifts for research and scholarships have also come from the Foundation.

The latest grant was accompanied by a statement from Mr. Sloan:

"It has long been my conviction that if this nation is to keep ahead in the competitive race for survival there must be not only greatly increased funds for basic research, but also competent and imaginative management of such funds. With this grant, the Foundation is seeking to help the California Institute of Technology further strengthen its already considerable efforts to advance American scientific knowledge and train young scientists. It is my hope that this Fund will stimulate other private sources to make support available for these purposes, at Caltech and elsewhere."

Dr. DuBridge said that developments in science and engineering have accelerated so greatly in recent years that they are now no less than "explosive."

He cited a number of areas in which he believes Caltech is especially qualified to provide leadership, including optical and radio astronomy, nuclear physics, molecular biology, genetics, geochemistry and geophysics, and chemical physics. Also aeronautics and space science, applied mathematics, materials science and engineering, and computer technology.

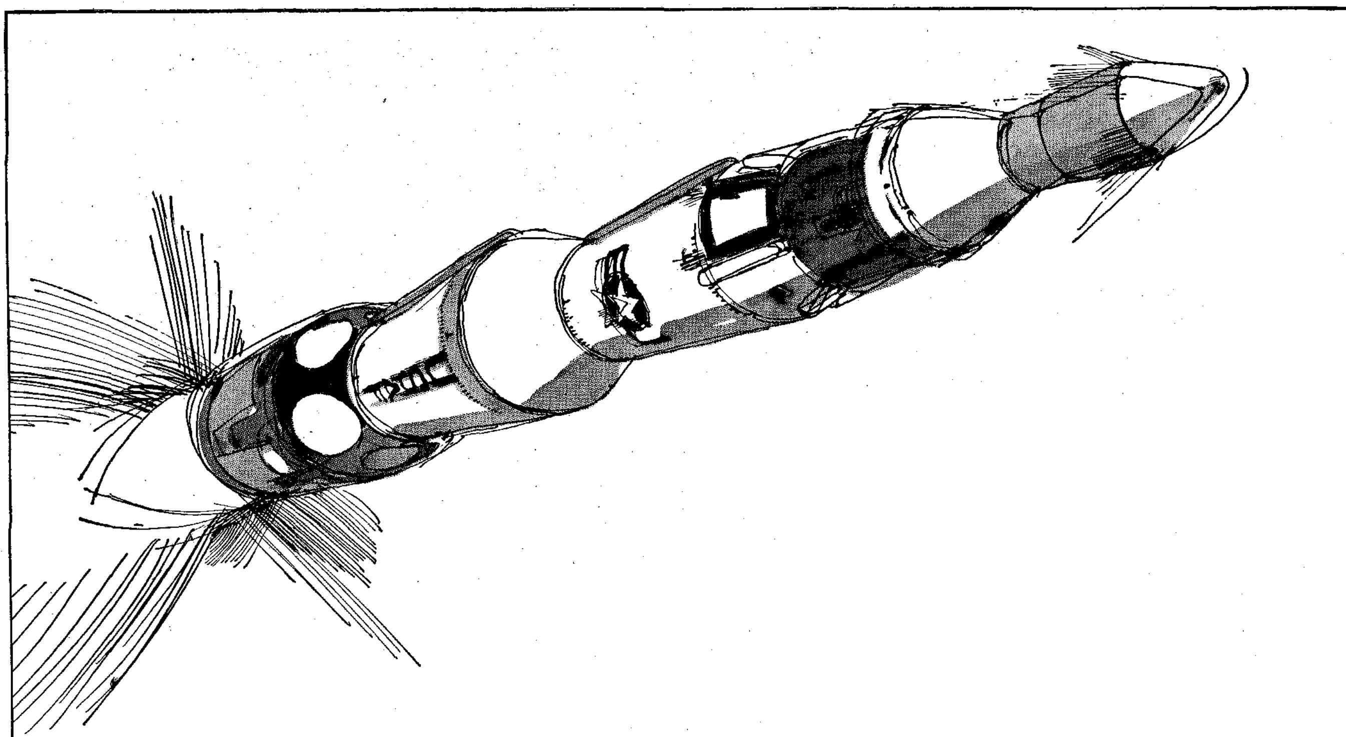
"In looking forward for the next ten years," he said, "it is clear that these are the fields in which we must expand our programs and initiate new ones.

"This, then, is the spirit that prevails at Caltech today — a spirit of rapid growth, of adventure, and of optimism. We are confident that the Institute is entering upon what will be a hugely productive era, and we are particularly grateful for the timely vote of confidence we have received from the Sloan Foundation."

National Academy of Sciences

Robert F. Christy, professor of theoretical physics at Caltech, was elected a member of the National Academy of Sciences at its annual meeting in Washington, D.C., last month. Election to the Academy, one of the highest scientific honors in the nation, is in recognition of outstanding achievement in scientific research. With 32 members, Caltech has the highest percentage of members of any university faculty.

Dr. Christy has made important theoretical con-

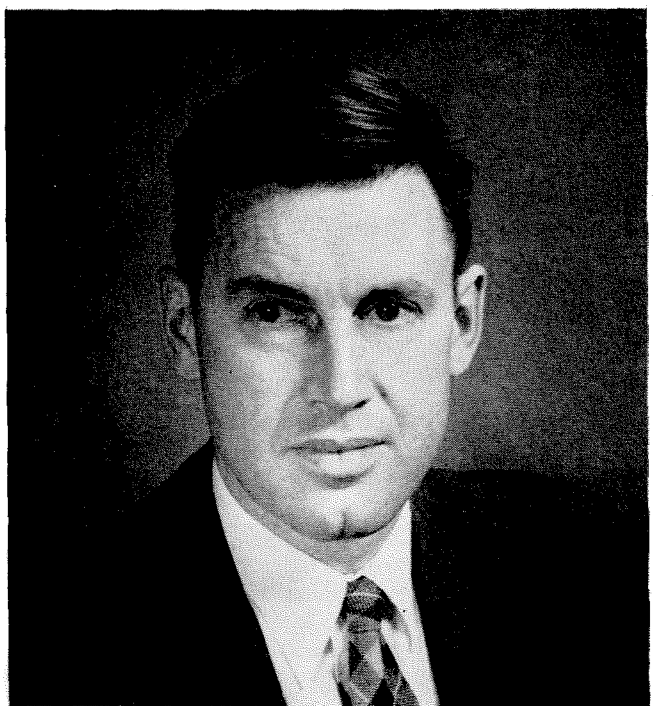


tributions in nuclear, high energy, and cosmic ray physics, and in astrophysics. He has made extensive studies of the reactions, energy levels, and structure of the light atomic nuclei in Caltech's Kellogg Radiation Laboratory. His work in theoretical physics, throughout his career, has always been closely associated with parallel work of experimentalists in the laboratory.

During World War II Dr. Christy was a member of the University of Chicago group that developed the first atomic pile, and of the team at Los Alamos, New Mexico, that produced the first atomic bomb. His contributions to the theory of neutron diffusion and nuclear reactors were significant, and the first atomic weapons incorporated features suggested by him.

Recently Dr. Christy has extended his studies to astrophysical problems, and has made substantial contributions to the nonlinear theory of stellar pulsations. His theoretical results are the first to show correspondence with the details of the light variations of pulsating stars.

Dr. Christy came to Caltech in 1946 from the University of Chicago. He also had taught at the Illinois Institute of Technology in Chicago (1941-42), the University of California at Berkeley (1937-40), and the University of British Columbia in Vancouver, Canada (1935-37). He received his BA and MA degrees from the University of British Columbia, and his PhD from the University of California.



Robert F. Christy, NAS member

Molecular Biology Award

Robert S. Edgar, associate professor of biology at Caltech, has received the fourth annual United States Steel Foundation Award in Molecular Biology, administered by the National Academy of Sciences, in recognition of his development and application of the method of "conditional lethal mutants" to determine how genes control the development of a virus.

The development of the method of conditional lethal mutants for studies of viral genetics had its roots in earlier discoveries that mutant genes are both sensitive to temperature, and dependent in their behavior on the host material.

In 1960 Dr. Edgar and Richard H. Epstein, then a research fellow in biology at Caltech, formulated the principle that mutations of a virus which prevent its growth under one set of conditions (high temperature or restricting host) but not under another (low temperature or permissive host) should occur in almost every gene whose product is a protein. From this principle they reasoned that mutations could be used to identify, by function, the individual genes in a virus, by determining the step in viral development that is blocked in a mutant under the growth-preventing conditions.

Dr. Edgar, in collaboration with Dr. Epstein and other scientists at Caltech and at the Laboratory of Biophysics of the University of Geneva, has played a leading role in developing this work, which has produced some of the most important advances in physiological and molecular genetics.

Carty Medal

Alfred H. Sturtevant, Thomas Hunt Morgan Professor of Biology, emeritus, was awarded the Carty Medal of the National Academy of Sciences at the 102nd annual meeting of the Academy in Washington, D.C., last month, "for noteworthy and distinguished accomplishment."

A major contributor to modern genetic theory through his analysis of hereditary patterns in the common fruit fly, Dr. Sturtevant was the first to map the locations on chromosomes of the genes associated with particular inherited characteristics, and to demonstrate the simple linear ordering of genes on chromosomes. His discoveries have led to better understanding of heredity and evolution, and they occupy a prominent position in modern genetics textbooks.

A member of the National Academy of Sciences, Dr. Sturtevant received its Kimber Genetics Award in 1957 "for his distinguished career as discoverer and interpreter of fundamental genetic phenomena."

Dr. Sturtevant came to Caltech in 1928. He became professor emeritus in 1962.

William Bowie Medal

Hugo Benioff, Caltech professor of seismology, emeritus, received the highest award of the American Geophysical Union – the William Bowie Medal – in Washington, D.C., on April 20, at a special ceremony at the National Academy of Sciences.

Dr. Benioff is the designer of the Benioff seismograph, used throughout the world in earthquake study. He has also developed sensitive microbarographs, magnetovariagraphs, underwater sound transducers, oscillographs and galvanometers, and was the first to suggest that the acceleration spectrum was the important constant in antiseismic design.

Dr. Benioff joined Caltech's Seismological Laboratory in 1924, received his PhD degree in geology at the Institute in 1935, and joined the faculty in 1937. He became professor emeritus in 1964.

AAAS Members

Three Caltech professors have been elected to membership in the American Academy of Arts and Sciences: William A. Fowler, professor of physics, for his contributions in the fields of astronomy and the earth sciences; George S. Hammond, Arthur Amos Noyes Professor of Chemistry, for his outstanding work in chemistry; Robert L. Sinsheimer, professor of biophysics, for contributions to the biological sciences.

Industrial Associates Director

Richard P. Schuster, Jr., associate director of development at Caltech, has been appointed executive director of the Institute's Industrial Associates. He succeeds Emory L. Ellis , who will become a consultant for The RAND Corporation.

The Caltech Industrial Associates is a group of research-oriented corporations which help support the Institute's teaching and research programs through substantial annual contributions and which benefit through Caltech seminars and faculty visits.

Schuster received a BS in electrical engineering in 1946 and one in applied chemistry in 1949 from Caltech. Before joining the Caltech development office this year he worked at JPL with the Arms Control Study Group, and as special assistant to the director in a study of cost reduction.

Personals

1924

E. HAROLD GANDY died of a heart attack on April 29 in Pasadena, at the age of 63. He was application engineer with Sterling Electric Motors, Inc., of Los Angeles, where he had worked since 1948. Gandy is survived by his wife and two sons.

1927

ROBERT F. HEILBRON is now president of San Diego Mesa College, newest and largest of the junior colleges in San Diego County. He was formerly director of the San Diego city schools' Secondary Institute.

1930

NORRIS JOHNSTON, PhD, sends news of his activities and of his Caltech sons – John, whose activities appear in the Personals section of this issue under 1951; and David, who appears under 1953. Norris retired in 1962 but is keeping busy organizing a company to stimulate recovery of heavy oil. Since 1930 Norris has worked for the Union Oil Company, Firestone's Physics Research, General Petroleum, and Socony. In 1948 he set up his own laboratory company, Petroleum Technologists. After his *first* retirement in 1960, he put into operation a gamma ray surveying device to locate oil pools, which, he reports, predicts wildcats with a "batting average of 83 per cent."

O. FRANKLIN ZAHN, JR., recently spent 22 months in India in charge of a Fellowship of Reconciliation program to provide low-cost housing for village families. A former mechanical engineer, Zahn spent 10 years prior to this assignment building and improving low-cost housing for minority families in the Pomona, California, area. A volunteer for the Indian project, with only his transportation paid, Zahn says he was able to spend less than $9 a month for groceries, heat, and light.

1932

JOHN A. HUTCHISON has been elected vice president and chief engineer of the West Texas Utilities Company, which provides electric service to 5,300 square miles of west Texas. He has been chief engineer of the company since 1960. Son David is completing his second year of medical school at Stanford University; son John will begin law studies at the University of Texas in Austin this June; daughter Bunny and her husband (Dr. and Mrs. Robert W. Hampton) "have the main one, – grandson R.W.H. Jr., 2½ years old."

1933

L. EUGENE ROOT, MS '33ME, MS '34 Ae, president of the Lockheed Missiles & Space Company in Sunnyvale, has been named a member of an international committee of 29 business, labor, education, and government leaders, (including Caltech's President Lee A. DuBridge) to evaluate the social, economic, and political effects of technology on our society. The study program has been established at Harvard under an IBM Corporation grant.

1935

ALAN BEERBOWER, research associate


FORGINGS—HOW THEY IMPROVED THE RELIABILITY OF THIS CROSSHEAD . . .
TOWMOTOR

We once said:
$100,000
is a lot of money . . .
And it is!
It's also our goal this year.
As of press-time we have
$86,500
from 1600
very generous alumni.
WOW!!!
only $13,500 to go!
keep it up—
PLEASE

Personals . . . *continued*

in the products research division of the Esso Research and Engineering Company in Linden, New Jersey, was honored for outstanding achievement as an inventor at a dinner given last month by Esso, in commemoration of the 175th anniversary of the signing of the first U.S. patent. Beerbower has been issued 31 patents for his inventions.

1936

BERNARD M. OLIVER, MS, PhD '40, vice president of research and development of the Hewlett-Packard Company of Palo Alto, has been elected president of the Institute of Electrical and Electronics Engineers, Inc., for 1965.

1942

JOHN W. MILES, MS '43 EE, MS '43Ae, AE '44, PhD '44, has accepted an appointment as professor of aerospace engineering and geophysics at the University of California at San Diego. For the past three years he has occupied the chair of applied mathematics at the Institute of Advanced Studies in the Australian National University in Canberra. Among his colleagues at UCSD are HUGH BRADNER, PhD '41, WALTER H. MUNK '39, MS '40, and Sol Penner, faculty member in the engineering division at Caltech from 1950 to 1963. The Miles's have three daughters, who are 8, 11, and 15.

1943

DAVID A. LIND, MS, PhD '48, professor of physics at the University of Colorado at Boulder, is a project director of the university's Nuclear Physics Laboratory, which contains the Atomic Energy Commission's $2 million cyclotron.

1945

JOHN K. LEYDON, MS, AE, Rear Admiral in the U.S. Navy, is now serving as Chief of Naval Research.

1946

ROBERT D. BONNER, MS, project engineer with the Standard Oil Company of California in San Francisco, recently completed a two-year assignment in Tokyo for the design of a chemical plant. The Bonners live in Orinda, and have a seven-year-old daughter, Patty.

JOHN J. BURKE, MS '48, formerly senior vice president of Lear Siegler, Inc., of Santa Monica, has been elected president, chief executive officer, and a director of the Howe Sound Company of New York City. Before Burke went with Lear Siegler in 1956, he was at Caltech's Jet Propulsion Laboratory in charge of the guidance and electronic division.

The Truth – After 23 Years

Meredith M. Nyborg, '42, owner of the Nyborg Engineering Company of Camarillo, Calif., writes to say that "if a touch of nonsense is tolerable, you are welcome to print the enclosed rhyme which I wrote down almost exactly 23 years ago, under conditions which made graduation seem a forlorn hope."

SADNESS OF THE SNAKE

by M. M. Nyborg

In winter I stay up all night
And snake by sickly yellow light.
In summer, just the same old way,
I have to sit and snake by day.

Now does it not seem hard to you,
When all the sky is clear and blue,
To be an engineering stude
And snake in lonely solitude?

To have to snake, while all around
The grass is growing on the ground,
While birds, and bees, and little flowers
All go to bed at decent hours?

My teacher said, if I were good
And snaked my eyes out as I should,
A nice diploma I would earn
To show "To Whom it May Concern."

I cannot bide that happy day
When Uncle Bob to me will say
"You've finished up your college span!
"You've earned your rag! Go rest, young man!"

Then, blind and dull and pale and weak,
My fortune I will go to seek.
I'll go to work for some old guy
Who never finished Junior High.

I'm tempted, now, to take a stance
In stout support of ignorance.
But no! I'm sure this toil and strife
Will bring rewards in later life.

If so, then when I'm old and gray,
I'm going to stay in bed all day,
And mumble, soft, in senile glee,
"The Truth, at last, has set me free!"

1947

CHRESTEN M. KNUDSEN recently became vice president of The Conner Company, Inc., of Alhambra, after 13 years as consulting design engineer with the Riverside and American Cement Corporation. He writes that C. HARRIS ADAMS, JR., '49, is also a vice president at Conner, and that both are officers of the Antelope Valley Ranch Corp.

1948

FREDERICK B. BURT, MD, died on April 20 in Los Angeles. He was a specialist in urology and was associate professor in the department of surgery at UCLA. He leaves his wife, and his mother and father (ROBERT C. BURT, PhD '26).

1951

JOHN B. JOHNSTON, PhD '55 associate professor of mathematics at the University of Kansas at Lawrence, on a leave of absence, is working at the General Electric Research Laboratory in Schenectady, New York, on computer systems design, involving simultaneous development of language and hardware. The design is an outgrowth of Johnston's formal language studies, and the system, as developed so far, has powerful recursive parallel processing and multiprogramming capabilities.

1953

R. KEITH BARDIN, PhD '61, who is a research associate at Columbia University working on a double beta-decay experiment, writes that he is planning a June wedding to Tsing Tchao, a graduate student at Columbia also in the beta-decay group. He adds that he finds "New York City smog different from the Pasadena variety, but no improvement in either quality or quantity."

DAVID JOHNSTON is exploring the oil-bearing potential of the North Sea for the Western Geophysical Company of America. Currently based in London, he writes that he spends his spare time during the cold winter months learning German and Spanish and building a hi-fi tape library. The Johnstons have four sons: David Wayne, 7 (a Texan); Thomas Kevin, 5 (a Californian); John Bryan, 2 (a New Mexican); and Robin Keith, 10 months born in Switzerland.

1954

GEORGE A. BAKER, JR., accompanied by his wife and three daughters, is spending a year in England as a visiting professor of theoretical physics at King's College, University of London. He is on a sabbatical leave from the Los Alamos Scientific Laboratory.

continued on page 24

Personals . . . *continued*

1956

G. LOUIS FLETCHER, MS '57, recently became chief engineer of the Hydro Conduit Corporation of Colton. The Fletchers live in Redlands and have two daughters, Laurie 4, and Cheryl 1½.

ALAN M. POISNER, MD, assistant professor of pharmacology at the Albert Einstein College of Medicine in New York City, received a five-year U.S. Public Health Service Research Career Development Award in January. He writes that he and his wife recently visited the H. MARK GOLDENBERGS '56, along with the DELBERT C. McCUNES '56, in Princeton.

1960

FRED G. RUETER, MS, an exploration geologist with the Shell Oil Company in Abilene, Texas, writes that he was married last August to Janet Ledbury, in Branford, Connecticut.

JAMES A. WOOSTER, MS '61, a research engineer with the Boeing Airplane Company in Seattle, writes that he plans to be married on June 19 to Patricia McNulty of Seattle.

1961

DONALD GARY SWANSON, MS, PhD '63, is assistant professor of electrical engineering at the University of Texas in Austin. The Swansons have a son, Christopher Jon, born last summer.

JOHN P. STENBIT, MS '62, has been awarded an advanced study fellowship by the Aerospace Corporation in El Segundo. Stenbit, who is a member of the technical staff in the communications department of the electronics division, is one of five fellowship winners for 1965. He plans to use his award to complete his doctoral thesis at Technische Hogeschool in the Netherlands, which he attended under a Fulbright fellowship in 1962.

1962

CARL W. HAMILTON and his wife announce the birth of their first child, Mark Alan, on March 24, in Los Angeles. Carl is a systems engineer with IBM in Inglewood, and is working on his masters degree in economics at UCLA.

BRUCE T. KUJAWSKI, MS, a first lieutenant in the U.S. Air Force, was graduated last month from Squadron Officer School at the Air University, Maxwell AFB, Alabama. He has been reassigned to an Air Force unit in San Antonio.

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(2) To inform you when outstanding opportunities arise.

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Please send me:

☐ An Application for Placement Assistance

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

Name .... Degree (s) ....

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

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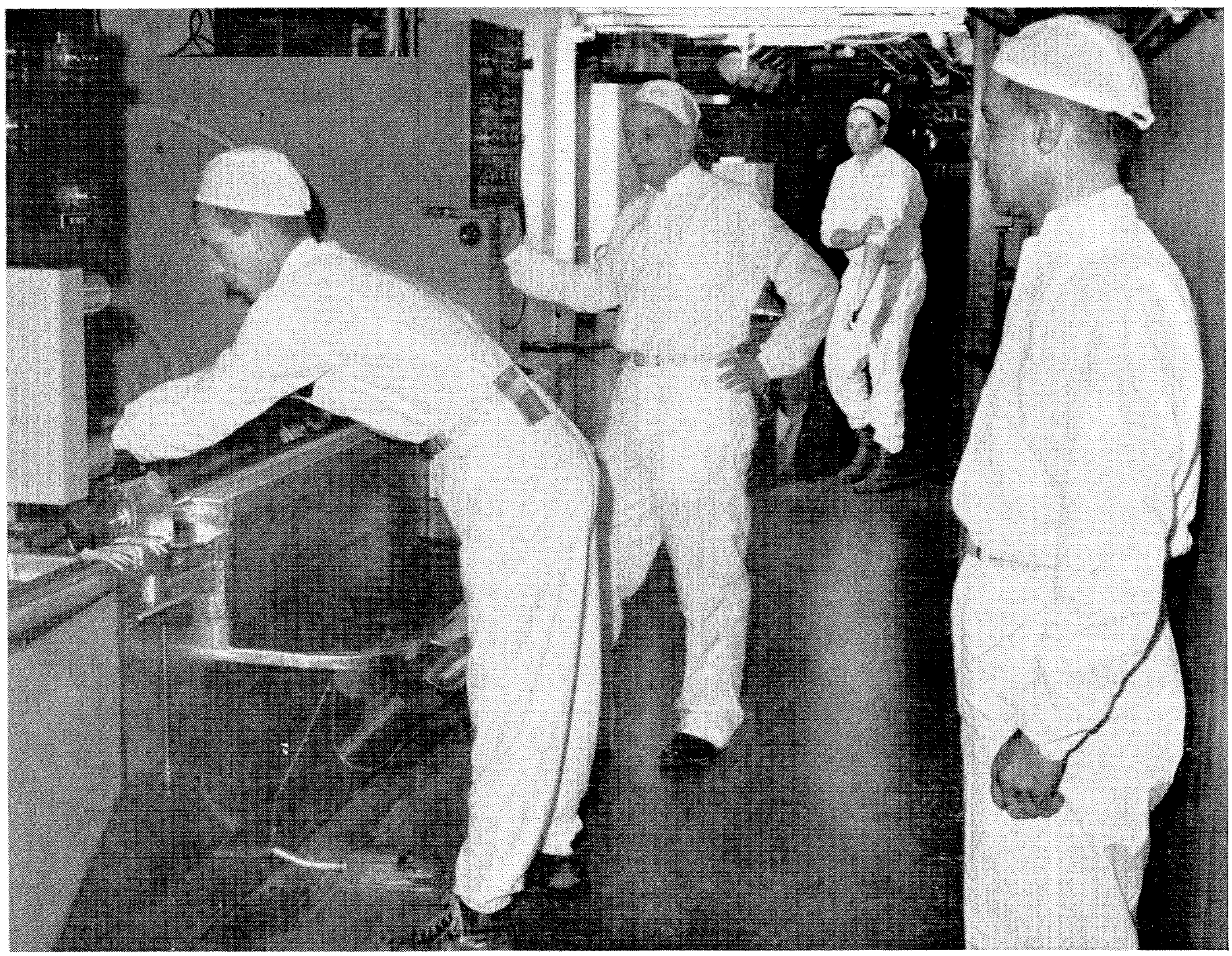

Art of creating photo-film manufacturing machines taught here

That's sure no professional ad model posing up in the foreground of the picture but a real pro of an engineer looking over his handiwork some six years after drawing the assignment.

The first three years he spent picking the best location for the thing with regard to capital cost, operating cost, and operating convenience. This means he actually put it together in a scant three years, which isn't bad, considering that it amounts to a huge integration of mechanical engineering, electrical engineering, chemical engineering, hydraulic engineering, instrumentation engineering, structural engineering, industrial engineering, and just about every other category of engineering in the catalog of a big college.

Of course, no college teaches men how to design and assemble a complex like that. You learn by doing. Not at every large company can you learn. Come to think of it, *is* there any other company whose production is of a nature and volume that demands such neat and thoroughgoing co-ordination of engineering disciplines?

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Care for an application blank?

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