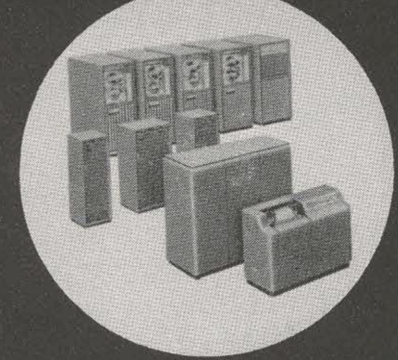
ENGINEERING | AND | SCIENCE

May 1960

Geologists in the field . . . page 17

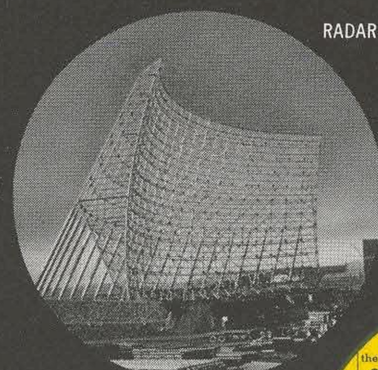
Published at the California Institute of Technology



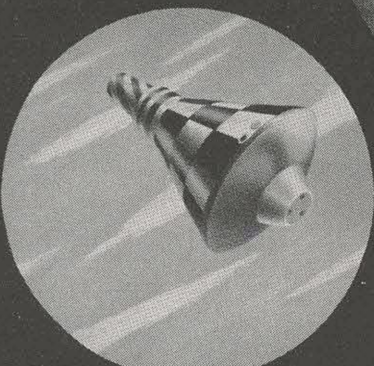
DATA PROCESSING

AVIATION CONTROLS

MISSILES AND ROCKETS

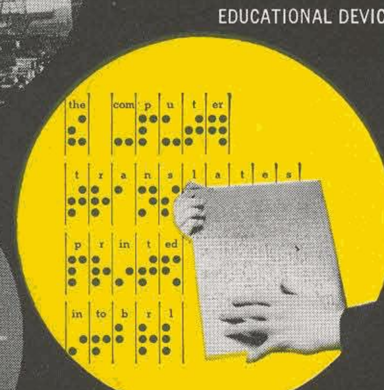


RADAR SYSTEMS

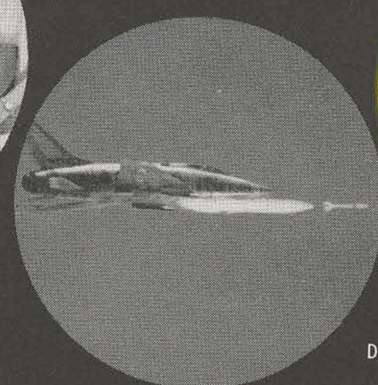


SPACE EXPLORATION

MEDICAL INSTRUMENTS



EDUCATIONAL DEVICES



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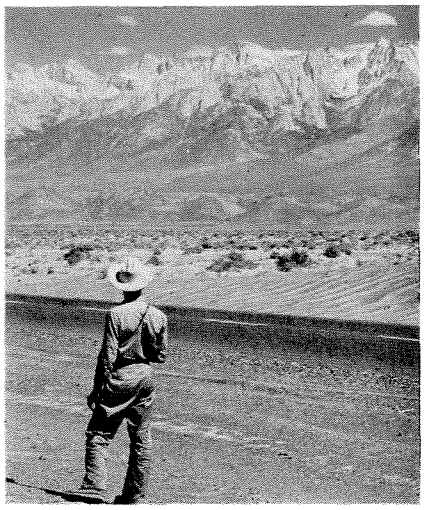
MAY 1960 *VOLUME XXIII* *NUMBER 8*



On Our Cover

a Caltech geologist, on the division's Spring field trip, takes in a spectacular view of the Sierra Nevada near Lone Pine, Calif. On page 17, a colorful account of this year's field trip by graduate student Bevan M. French.

Linus Pauling,

professor of chemistry, makes some provocative "Observations on Aging and Death" on page 9. Dr. Pauling's concern with this subject results from his current research on chemistry in relation to mental disease. "I do not know a great deal about the subject of aging and death," he confesses, "but I am talking about it, despite this fact, because I learned a few years ago that nobody knows much about the subject."

Ronald Scott,

assistant professor of civil engineering, is the author of "Soil Engineering in the Arctic" on page 22. His interest in arctic engineering stems from two years spent as a research engineer with the U.S. Army Corps of Engineers in their Arctic Construction and Frost Effects Laboratory in Boston, and from other arctic soils consulting work in Canada and the U.S.

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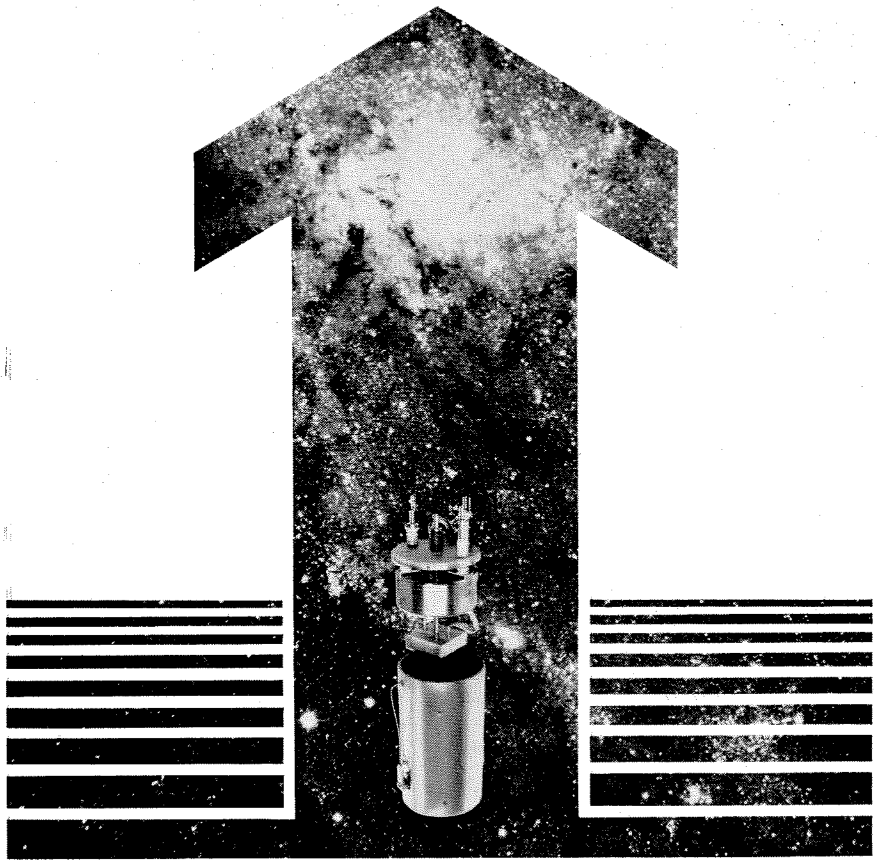


Books

Introduction to Space

by Lee A. DuBridge

Columbia University Press . . $2.50

Reviewed by James D. Burke, deputy director of the Jet Propulsion Laboratory spacecraft program.

This brief book contains the four inaugural George B. Pegram lectures given by Dr. DuBridge last fall at the Brookhaven National Laboratory. The lectures deal in non-technical terms with trends in the relationship of science and society. Dr. DuBridge begins by setting out some physical and engineering facts of rocketry, together with a short account of the U. S. Army space program in which the von Braun team and Caltech's Jet Propulsion Laboratory collaborated to launch the first American satellite and the first American escape vehicle.

In the second lecture Dr. DuBridge considers the kinds of scientific measurements that can be made using space vehicles, and some of the associated problems such as power supply, communications, and reliability and long life of equipment. The author also mentions military uses of space vehicles; some readers may draw unwarranted inferences from his mild lampooning of superficial ideas in this area. He then tells the story of the discovery of the great Van Allen radiation belts about the earth.

In the third and fourth lectures Dr. DuBridge takes us outward to the moon and planets, and finally to stars, galaxies, and the question of the origin of the universe. It is in these final sections that he best communicates the wonder and excitement that lie in store for us as we learn to probe the nearby bodies, to look for extraterrestrial life, and to search deep into space using astronomical telescopes placed outside the atmosphere.

Anyone familiar with Dr. DuBridge as a lecturer will recognize his lively style. Together with the plentiful illustrations, the lectures create a pleasing little book. The language is purposely elementary and many readers will find nothing new, but the subject is rich in fascination and the story well bears repeated telling.


Boyle

ENGINEERING AND SCIENCE
May 1960, Volume XXIII, No. 8

Observations on Aging and Death

by Linus Pauling

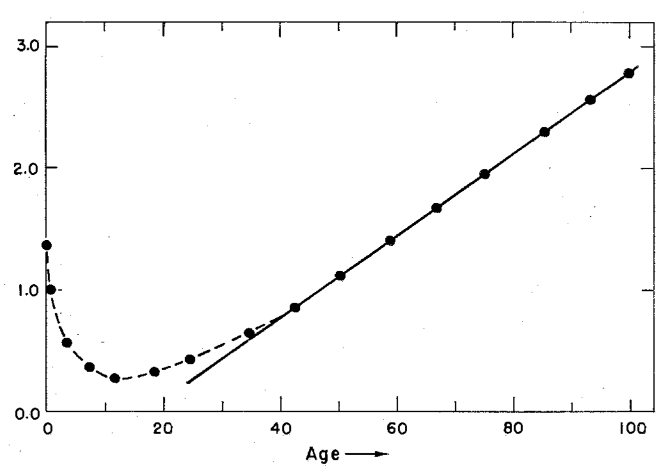
About three years ago we began our research program at Caltech on chemistry in relation to mental disease, with support of a grant from the Ford Foundation. Our attention has been directed largely toward mental deficiency. An important disease that involves mental deficiency is mongolism. One child in six hundred who is born is a mongoloid. Mongoloids are mentally deficient and also show physical stigmata. It has been suggested that they age more rapidly than other people, and we decided to check up on their physiological age, as a possible way of learning something about the nature of their biochemical abnormality. However, when this investigation was carried out (by the late Dr. Richard W. Lippman, medical consultant on our Ford Foundation project, and his co-workers) it was found that there exists no reliable way of measuring the physiological age of an adult human being. The best way seems to be to look at him, and then to say how old he appears to be.

Our work on mongolism was stopped, last year, when the apparent cause of mongolism was discovered. It was found by investigators in England and France that mongoloids have 47 chromosomes per cell, instead of 46. The extra chromosome, which is the small chromosome number 22, probably contains a thousand genes, and, since this chromosome is present three times, instead of twice, as in normal people, the mongoloid probably manufactures a thousand different enzymes in 50 percent greater quantity than normal persons do, and thus has a thousand quantitative biochemical abnormalities. It may well be very difficult to find a treatment for this condition.

Although it is hard to measure the physiological age of an individual human being, it is possible to make some statements about the physiological age of populations. An Englishman named Gompertz discovered, last century, that the age-specific death rates of adults are an exponential function of the age. Infants and children have a rather large mortality, and the mortality reaches a minimum at about age 12 (below). From age about 40 on, the age-specific mortality (the fraction of living persons of that age who die during the year) increases exponentially, with a doubling time of about 8.5 ± 0.5 years. A plot of the logarithm of the age-specific mortality against age is a straight line on the chart below, with slope 0.3 (the log of 2)/8.5 years. The Gompertz relation holds for species of animals other than man, also, and in general the doubling time is about 12 percent of the mean life expectancy.

Professor Hardin Jones of the Donner Laboratory of the University of California in Berkeley has made much use of Gompertz curves in his analyses of factors that affect mortality. Much of the information that I have about this matter has been obtained from him.

Gompertz curves can be plotted for mortality from individual diseases. For example, in the diagram



Gompertz mortality diagram for U.S. residents. The vertical coordinate represents the common logarithm of the age-specific mortality (number of deaths per thousand people of that age), and the horizontal coordinate represents the age. (Diagram by Professor R. M. Sutton).

"Observations on Aging and Death" presents the substance of a Friday Evening Demonstration Lecture given by Professor Pauling on April 8, 1960.

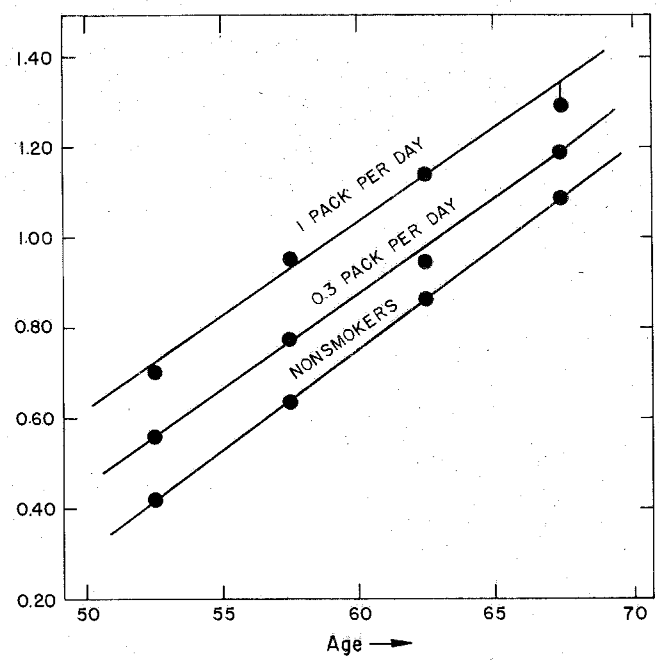
at the right, the Gompertz curves are shown for coronary heart disease; the logarithm of the death rate from coronary heart disease is plotted against age. The values indicated in the diagram are from a statistical study by E. C. Hammond and D. Horn, published in the *Journal of the American Medical Association* 166, 1159 and 1295) in 1958. Closely similar results have been reported by other investigators. The points in the curve represent the average mortality, over five-year periods, for three populations; non-smokers, smokers of 0.1 to 0.5 packs of cigarettes per day, and smokers of about 1 pack per day. For each population the points lie reasonably close to a straight line in the semi-logarithmic diagram. The slopes of the curves correspond to a doubling time of about seven years. The curve for the 1-pack-per-day smokers is shifted by seven years from the curve for non-smokers – that is, the probability that a cigarette smoker will die of coronary heart disease at age 55 is the same as the probability that a non-smoker will die of coronary heart disease at age 62 and is about twice the probability that a non-smoker will die of coronary heart disease at age 55. With respect to this disease, the cigarette smoker behaves as though his physiological age were seven years greater than his chronological age.

Professor Jones has reported that for all diseases the increased mortality of 1-pack-per-day cigarette smokers corresponds to an increase in physiological age of eight years, and that of 2-pack-per-day smokers to sixteen years, relative to non-smokers.

There has been much talk about the increased incidence of lung cancer for cigarette smokers. It has been reported that the incidence of lung cancer for 2-packs-per-day smokers living in the city is 300 times that for non-smokers living in the country. There is a difference in the Gompertz curves for city dwellers and country dwellers, corresponding to a five-year decrease in life expectancy for city dwellers, relative to country dwellers, and part of the decrease in life expectancy may be attributed to an increase in lung cancer, presumably resulting from atmospheric pollution.

Even though the increased incidence of lung cancer among cigarette smokers is very striking, lung cancer is not the principal cause of increased mortality of smokers. R. W. Buechley, R. M. Drake, and L. Breslow, of the California State Department of Public Health, have published a paper on the relationship of amount of cigarette smoking to coronary heart disease mortality rates in men *(Circulation*, 18, 1085 (1958)), in which they have reported results closely similar to those of Hammond and Horn. They also mention that there are four times as many excess deaths associated with cigarette smoking from coronary heart disease as from lung cancer.

As people become older, the incidence of various diseases increases, doubling about every 8.5 years. At my age, when the ills that the flesh is heir to begin to make themselves increasingly evident, one begins to appreciate one's youthful period of good health and vigor. As I grow older I must expect to suffer more and more from physical frailty and disease.



The logarithm of the age-specific mortality from coronary heart disease (deaths per year per thousand persons), as given by Hammond and Horn, from a study of 187,783 men. Values are given for three populations: non-smokers, smokers who average 0.3 packs per day, and smokers who average 1 pack per day.

One might accordingly ask if it would not be wise to eliminate the period of ill-health and suffering that may be expected to come toward the end of one's life. Would it not be sensible to smoke cigarettes at the rate of 1 pack a day, and die eight years earlier than otherwise, thus cutting off the last eight years of suffering – or even to smoke 2 packs of cigarettes a day, and thus escape the last sixteen years of ill-health and misery of old age? The answer is that this trick will not work. Smoking the cigarettes simply ages you prematurely, shortening the period of health and vigor; the cigarette smoker reaches old age more rapidly than the non-smoker, and only through the turn of the die that might cause an especially early death from lung cancer or coronary heart disease or other disease can he escape the period of failing health.

Analysis of the Gompertz curves for populations in different countries shows some interesting differences. The mortality in the United States is such as to correspond to a mean life expectancy of about 70 years. In other countries the life expectancy is somewhat greater, by three or four years – countries such as Norway, Sweden, Denmark, Holland, and England. It is possible that this difference is the result of a difference in the medical treatment available on the average to people in the United States and in these countries. There are other countries, to be sure, in which the mean life expectancy is less than in the

United States; for example, in Northern Rhodesia it is only 28 years. But the United States still holds the record, for one population: the life expectancy of the Papagos Indians in Arizona is only 17 years.

The nature of the Gompertz relation permits some analysis to be made of the question of the relative importance of various causes of decrease in life expectancy. For example, what would be the result if, through the efforts of investigators in the field of medical research, complete control were to be obtained over cancer, so that no more deaths from cancer would occur?

At the present time cancer causes about 20 percent of deaths in the United States. If cancer were to be eliminated the age-specific mortality would drop to 80 percent of the present value, and the Gompertz curve would be shifted vertically by minus 0.1, the logarithm of 0.8. A shift of 0.3 (the log of 2) corresponds to a horizontal shift of 8.5 years, and accordingly the shift of 0.1 corresponds to a horizontal shift of 8.5/3=2.8 years. Hence the mean life expectancy of Americans would be increased by 2 years and 10 months if complete control over cancer were to be obtained.

Increasing life expectancy

However, cancer is not the principal cause of decrease in life expectancy for Americans. A better effort towards lengthening the average life of Americans could be made by eliminating cigarette smoking. In 1959 Americans smoked 5×10^{11} cigarettes, which is about one-half pack per day for adult Americans. This amount of smoking corresponds to a decrease in life expectancy of four years for the average American. To eliminate cigarette smoking would increase the health and longevity of Americans by 50 percent more than to obtain complete control of cancer.

It may turn out, of course, that it is easier to control cancer than to control cigarette smoking. About 50 percent of adult Americans now smoke cigarettes. From my own observations I conclude that it is to a large extent a matter of chance — environmental circumstances during puberty and early adulthood — that determines whether or not a young man or woman becomes a cigarette smoker. Having become a smoker, however, he finds it hard to stop. The Swiss investigators Hegglin and Keiser have said that "smoking is now the most dangerous drug addiction." Neverthless, it is possible to stop. Between 1954 and 1959 a marked change occurred in the smoking habits of physicians in Massachusetts; the number of cigarette smokers decreased from 52 percent in 1954 to 39 percent in 1959, with a still greater fractional decrease in the number smoking more than one pack a day.

If both cancer and cigarettes were to be controlled, the life expectancy of Americans would be increased by 6.8 years.

I remember reading a statement some years ago that automobile accidents are the principal cause of decrease in life expectancy for Americans. This statement is not true: cigarettes are five times as important. Neverthless, automobile accidents produce a significant decrease in life expectancy, in part because of the long period of life lost by the victims. About 40,000 Americans per year are killed in automobile accidents. This means that an infant at birth has the chance 1 in 64 of being killed in this way. The average age of death in automobile accidents is 22 years, and accordingly about 50 years is lost for each person killed. The mean decrease in life expectancy for Americans because of automobile accidents is accordingly 50/64=0.8 years.

Professor Hardin Jones has estimated that the effect of high-energy radiation, such as x-radiation, cosmic radiation, and the radiation emitted by radioactive substances, is to cause a shortening of life by 10 days per roentgen of full-body exposure. This estimate permits us to make an estimate of the decrease in life expectancy of Americans due to exposure to background radiation, caused by cosmic rays and natural radioactivity. The background radiation amounts to about 0.1 roentgen per year, which comes to 7 roentgens per lifetime. Accordingly we may conclude that a reasonable estimate of the decrease in life expectancy resulting from exposure to background radiation is 70 days.

The Committee on Genetic Effects of Atomic Radiation of the U. S. National Academy of Sciences-National Research Council reported a few years ago that the average exposure of the reproductive organs of Americans to medical x-rays is about 50 percent greater than the exposure to background radiation. If this figure applies to the body as a whole, then the decreased life expectancy due to medical x-rays can be estimated to be about 100 days.

Effects of high-energy radiation

The exposure of Americans to high-energy radiation from the radioactive fallout of the atomic bombs exploded during the last 15 years has been estimated by various people, including scientists with the Atomic Energy Commission, to be approximately five percent of background radiation. If no more bomb tests are carried out the amount of exposure will begin to decrease after a few years, and the total effect may be approximately five percent of background radiation for one generation of human beings. For these people the decrease in life expectancy would thus be about five percent of 70 days, about 3 days.

A considerable amount of suffering may be caused by the exposure of unborn children to high-energy radiation from various sources. An important report was published a year ago in the British Medical Journal by Drs. Stewart, Webb, and Hewitt. These investigators studied all cases of death by childhood cancer, during the first ten years of life, in England and Wales for the period 1953 to 1955. They found, on comparison of the histories of the children who had died with those of a control population of children who had not died, that the only factor correlated with death by childhood cancer was exposure of the child to x-radiation before he was born when the mother had an x-ray investigation made of the pelvic region. The average exposure of the fetus was estimated to be 2 roentgen, and the statistical information showed that this exposure doubled the chance that the child would die of cancer during the first ten years of his life – it increased it from 1/1200 for unexposed children to 1/600.

The dangers of air travel

While considering the effect of automobile accidents on life expectancy, I decided to make a somewhat similar calculation about airplane travel. In 1959 there were 0.67 deaths per 100,000,000 passenger miles on American commercial planes, and in 1958 there were 0.34. The average of these is 0.50 per 100,000,000 passenger miles. I am not sure how many passenger miles were flown by Americans, but I believe that it was approximately 3×10^{10}. A simple calculation indicates that travel by commercial airlines is associated with a mortality at the present time such as to lead to about one day decrease in life expectancy for Americans. Moreover, it is found that, per mile traveled, travel by commercial airlines is about five times as safe as travel by automobile.

How much chance of decreasing your life expectancy do you take when you decide to make a trip by air? A jet plane now travels about 500 miles per hour. The number of deaths in commercial air travel leads at once to the conclusion that the decrease in life expectancy resulting from the decision to make the trip by air is about 1 hour per hour traveled. On the other hand, smoking a pack of cigarettes per day for 40 years decreases life expectancy by 8 years; smoking one pack accordingly decreases life expectancy by one fifth of a day, 4.8 hours – which is 14.4 minutes per cigarette smoked. I have measured the length of time required to smoke a cigarette, and have found it to be about 4.8 minutes. Accordingly the process of smoking a cigarette involves a decrease in life expectancy for the smoker which is three times the time required to smoke the cigarette: smoking cigarettes is three times as dangerous as traveling in a jet plane. Traveling in a jet plane while smoking a cigarette is four times as dangerous as traveling in a jet plane and not smoking. If you fly in an airplane and don't smoke cigarettes you are three times as safe as if you stay at home and smoke cigarettes, or four times as safe as if you fly in an airplane and also smoke. I think that this is a very interesting comparison, which all people – all young people especially – ought to know: for whatever length of time they devote to smoking cigarettes they are losing three times that much time from their life.

From our discussion so far, we might reach the conclusion that at the present time cigarette smoking is the principal cause of decrease in life expectancy of Americans. I shall now present an argument indicating that this is wrong – that, instead, it is the existence of stockpiles of nuclear weapons in the world that is the principal cause of decrease of life expectancy of Americans.

The United States has about 100,000 atomic bombs in its stockpile at the present time, and Russia may be estimated to have about 50,000. Of these, I judge that about 20,000 for the U. S. and 10,000 for the U.S.S.R. are in the megaton class. On April 20, 1960 Major General John B. Medaris, in an address before the AFL-CIO Conference on Foreign Affairs, stated that the United States stockpile of great bombs amounts to 30,000 megatons, and we may estimate that if there were to be a nuclear war about 12,000 megatons (80 percent of the Russian stockpile) would be dropped on the United States. The area of the United States is 3,000,000 square miles, so that an attack with 12,000 megatons would correspond to 250 square miles per megaton. The local radioactive fallout from the fission products (with fission assumed to provide 50 percent of the total explosive energy) would be such that during the first day unprotected people in the United States would receive on an average 40 times the amount of radiation needed to cause death by acute radiation sickness. Entirely aside from the blast, fire, and immediate radiation effects, local radioactive fallout from the bombs used in such a great nuclear attack would be expected to cause the death of most of the American people, and an average decrease in life expectancy of about 35 years per person.

War or peace?

This quantity, 35 years, must be multiplied by the probability that there will be a nuclear war. In the absence of reliable information about this probability, I might, as the simplest hypothesis, equate it to the probability that there will not be a nuclear war, and thus evaluate it as one half. Accordingly, the decrease in life expectancy for Americans resulting from the existence of nuclear stockpiles in the world is calculated to be approximately 17.5 years, and thus to be larger than the decrease attributable to any other cause.

I myself believe that there will not be a great nuclear war. I believe that the United States will succeed in its present policy of making international agreements with the U.S.S.R. and other nations so that international control over nuclear weapons is achieved and general disarmament is achieved. I believe that the future will be a future of peace. Nevertheless, we must recognize that the nuclear stockpiles that now exist in the world constitute a great source of danger to all of us.

The Month at Caltech

Jupiter's radiation belt

Radio astronomers at Caltech's Radio Observatory in Owens Valley have discovered the existence of a Van Allen radiation belt on the planet Jupiter. The belt is about 200,000 miles above the surface of the planet. Jupiter is about 85,000 miles in diameter.

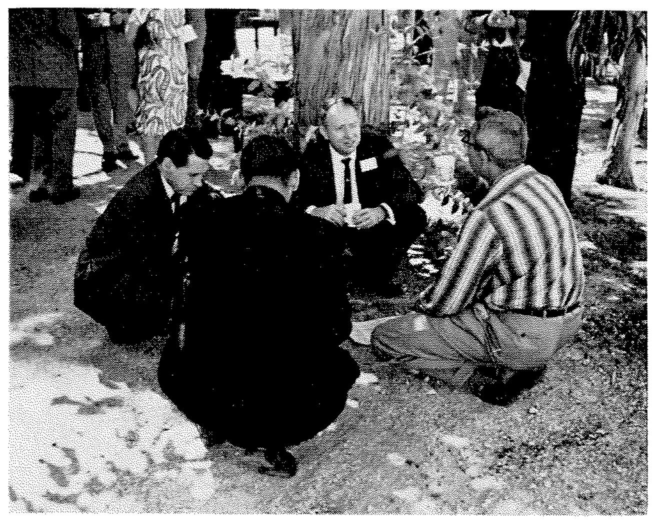
The belt was detected from the unexpectedly high radio emission at a wavelength of 10 centimeters (3.9 inches), first noticed by scientists at the Naval Research Laboratory in Washington, D.C., two years ago. Their findings were confirmed last year at other short wavelengths both at Caltech and at the National Radio Observatory. The Van Allen type belt was suggested as a possible origin. The Caltech radio astronomers have now established almost conclusively that the belt exists.

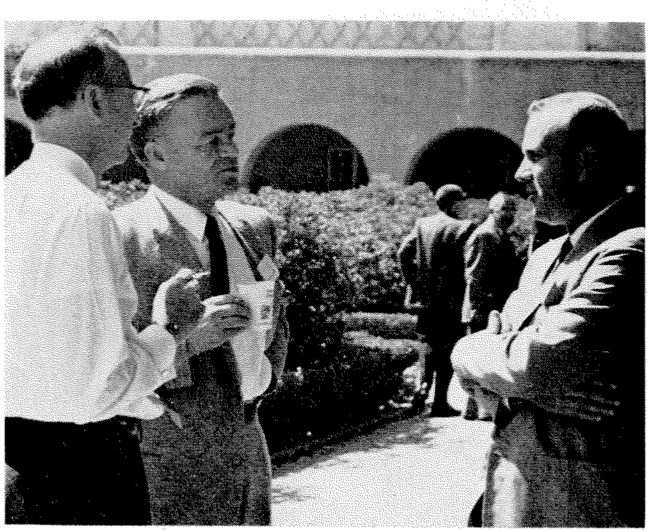
The finding is due to the fact that high speed electrons trapped in Jupiter's magnetic field emit radio waves as they spin back and forth along the lines of magnetic force in a synchrotron mechanism. In trying to prove the existence of a belt, radio astronomers try to detect linear polarization of the radio emission and its region. Like light waves, radio waves may be polarized. In one experiment, this type of polarization has been detected, which indicates the presence of a magnetic field on Jupiter with its axis almost parallel to the planet's rotation axis – as in the earth's mag-

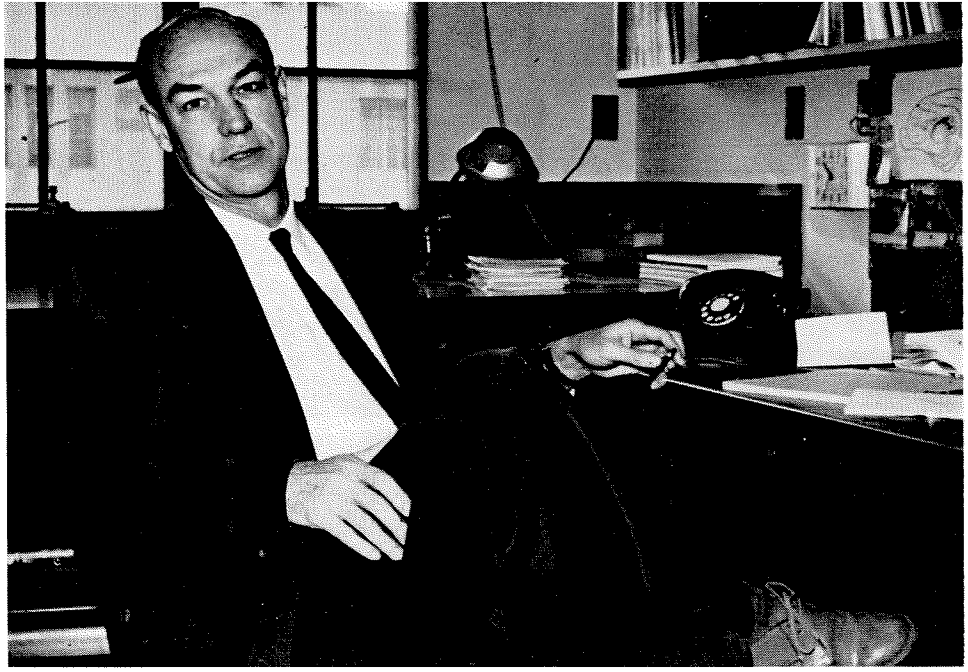
SEMINAR DAY

More than 1,050 alumni, wives and guests came to the Caltech campus for the 23rd Annual Alumni Seminar on May 7. Thirteen lectures and a series of special exhibits were featured on this year's program.

At right, alumni exchange vital statistics between Seminar talks. Below, lecturers take a coffee break – Horace Gilbert (left center), professor of business economics; Kent Clark (right), associate professor of English.







Roger W. Sperry, Hixon professor of psychobiology.

netic field. In a second experiment the diameter of the source of radiation has been measured. This indicates that, in a direction parallel to the planet's equator, the radio source is between 400,000 and 500,000 miles across.

Calculations show that the radio energy from the Jupiter belt is 100 trillion times that expected from the earth's Van Allen belt. This makes Jupiter's belt even more hazardous to space travel than the earth's.

Work at the Caltech Radio Observatory is supported by the Office of Naval Research.

National Academy of Sciences

Four Caltech professors were elected members of the National Academy of Sciences last month – Norman R. Davidson, professor of chemistry; Murray Gell-Mann, professor of theoretical physics; Roger W. Sperry, Hixon professor of psychobiology; and Olin C. Wilson, staff member of the Mt. Wilson and Palomar Observatories.

Election to the Academy, one of the highest scientific honors in the nation, is in recognition of outstanding achievement in scientific research, and membership is limited to 500 American citizens and 50 foreign associates. There are now 36 Caltech staff members in the Academy.

Dr. Davidson received his BS from the University of Chicago in 1937, his BSc from Oxford in 1938, and his PhD from the University of Chicago in 1941. He was a member of the staff of the uranium separation project at Columbia University during the war and later joined the plutonium project at the University of Chicago. He has been on the Caltech faculty since 1946.

Dr. Davidson's principal research interest during the past 10 years has been the study of the rates of very fast reactions. He has pioneered in the development of two new techniques in this field. In both of these techniques, a system at rest is rapidly disturbed by a pulse of energy. The chemical reactions initiated by the disturbance can then be observed by rapid photoelectric observations. He has also been active in the study of the physical-chemical properties of the nucleic acids – the giant molecules that transmit hereditary information from generation to generation.

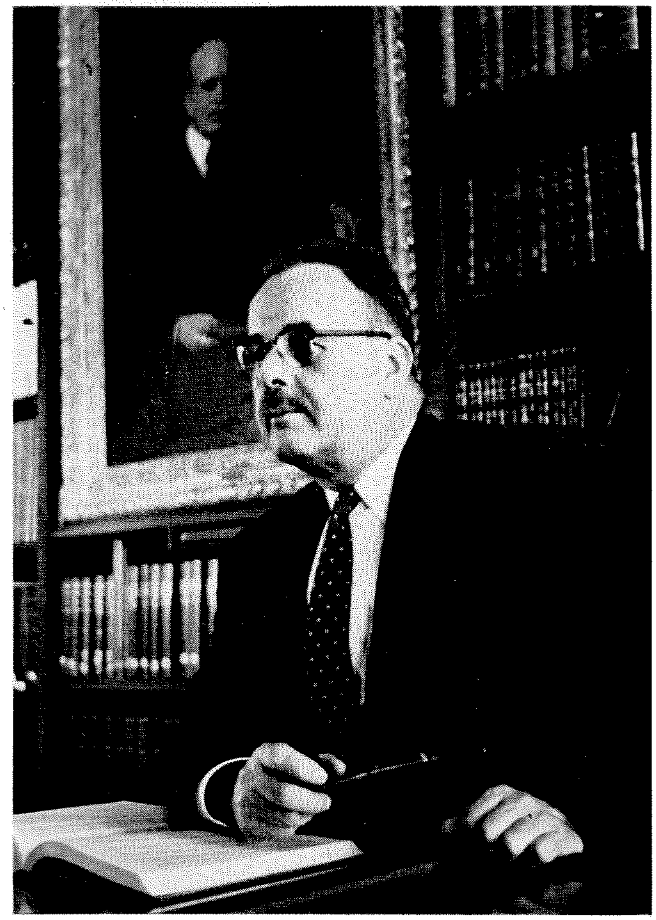
Dr. Gell-Mann received his BS from Yale University in 1948, and two years later (at the age of 21) received his PhD from the Massachusetts Institute of Technology. He came to Caltech as associate professor in 1955. His main field of study is nuclear physics, in particular the study of the lifetimes, decay modes and other properties of sub-atomic particles. Dr. Gell-Mann is presently on a year's leave from Caltech,

Murray Gell-Mann, professor of theoretical physics.

serving as visiting professor of theoretical physics at the University of Paris on a senior postdoctoral National Science Foundation Fellowship.

Dr. Sperry received his BA in 1935 and his MA in 1937 from Oberlin College, and his PhD from the University of Chicago in 1941. He came to Caltech in 1954 as Hixon professor of psychobiology. He has been outstandingly successful in applying a combination of surgical, anatomical, and neurological techniques to the solution of some of the basic problems of the neural mechanisms of animal behavior and their coordination.

Dr. Wilson, a graduate of the University of California in Berkeley, received his PhD from Caltech in 1934. He has been a member of the Mt. Wilson and Palomar staff since 1931. Dr. Wilson has developed spectroscopic techniques that have enabled him to study the internal motions of the planetary nebulae and – in collaboration with Dr. Guido Munch, Caltech professor of astronomy – to map the motions of the gases over a large part of the brighter areas of the Orion Nebula. Dr. Wilson's observations of more than 250 stars has enabled him to construct a color-magnitude diagram for late-type stars near the sun. He has developed a method for determining the absolute brightness of stars from the width of the H and K emission lines in late-type stars. This method is powerful enough to get determinations of the luminosities and therefore the distances of these stars.

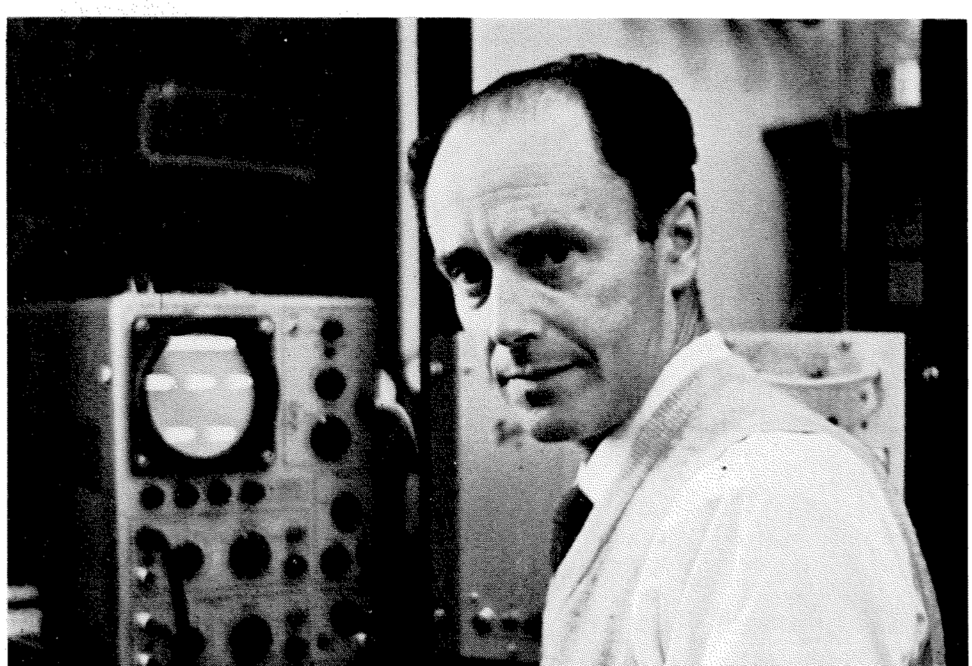


Olin C. Wilson, staff member, Mt. Wilson and Palomar Observatories.

Guggenheim Fellowships

Three Caltech professors have been selected to receive 1960 Guggenheim Fellowship Awards – Richard M. Badger, professor of chemistry; William A. Baum, staff member of the Mount Wilson and Palomar Observatories; and Paco A. Lagerstrom professor of aeronautics.

The Guggenheim Foundation was established in 1925 by the late Simon Guggenheim, U.S. Senator from Colorado. The awards are designed to aid scholars to advance themselves to higher levels of accomplishment through research. The 1960 awards are the 36th annual series; this year $1,400,000 was



Norman R. Davidson, professor of chemistry.

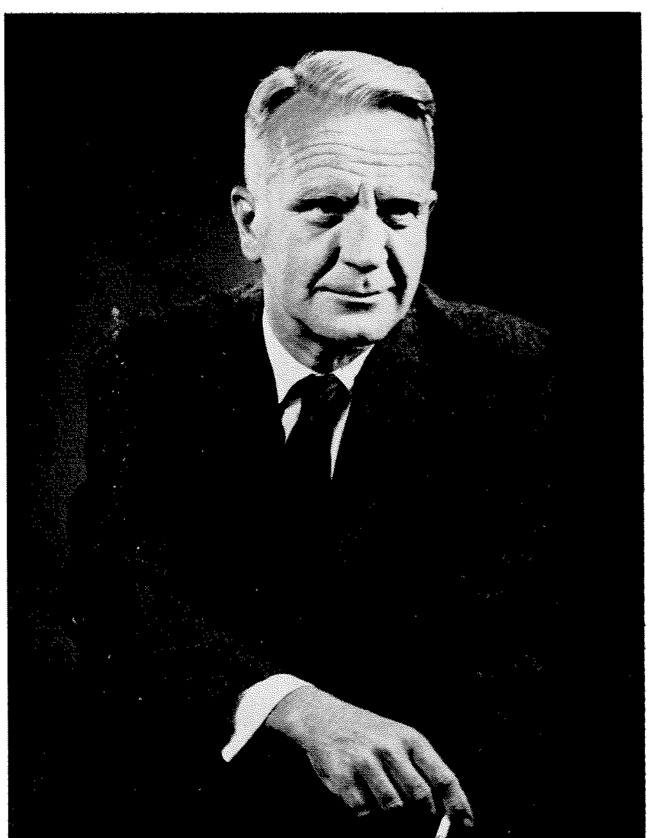
William A. Baum, staff member, Mt. Wilson and Palomar Observatories.

granted to 303 scholars and artists throughout the nation.

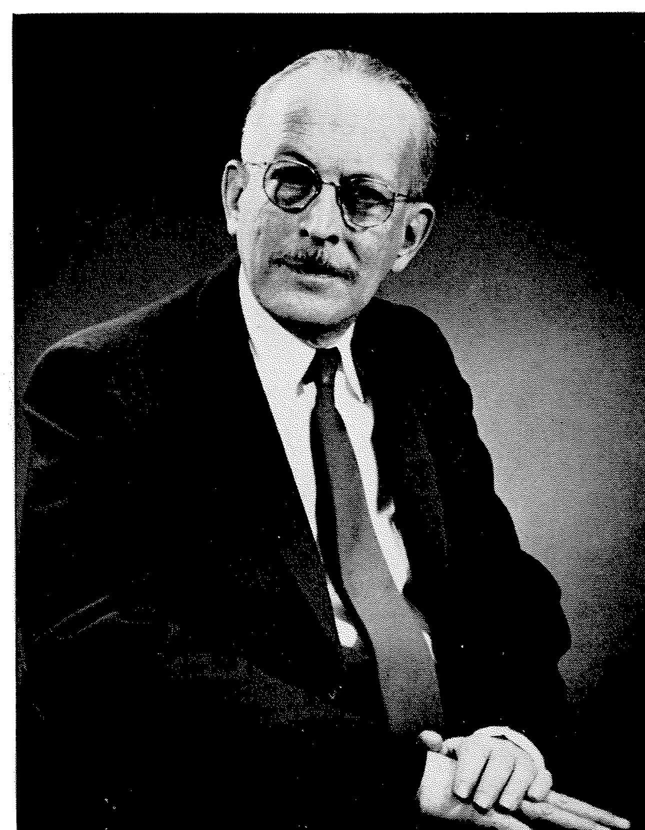
Dr. Badger will use part of the grant to visit a number of laboratories in Canada and the eastern part of the United States. The remainder of his grant will be used in research on the structure of molecules by infrared spectroscopy at Caltech. Dr. Badger received his BS in 1921 and his PhD in 1924 from Caltech. He has been a member of the Caltech faculty for 36 years.

Dr. Baum plans to participate in studies of the development of photoelectric image tubes for use in astronomy at the Imperial College of Science and Technology in London. Investigators there are trying to find a method of exceeding the sensitivity of the photo emulsions currently used in telescopes. A graduate of the University of Rochester, Dr. Baum received his MS in 1945 and his PhD in 1950 from Caltech. He has been on the Mt. Wilson and Palomar Observatories staff since 1950.

Dr. Lagerstrom will spend a year at the University of Paris as a visiting professor. He will give a course in mathematical fluid dynamics and will also conduct research in this field with advanced students. Dr. Lagerstrom is a graduate of the University of Stockholm. He receive his PhD from Princeton University in 1942, and has been at Caltech since 1946.



Paco A. Lagerstrom, professor of aeronautics.



Richard M. Badger, professor of chemistry.

Death Valley Confidential

Caltech geologists on a spring odyssey through the back country of California

In the Spring, it has been observed, a young man's fancy turns variously to love, baseball, loafing, or all three. However, when Spring arrives in the Los Angeles Basin, bringing warmer nights and smoggier days, a small group of individuals, concealed in the California Institute of Technology's Division of Geological Sciences, turn their interests to the beautiful geology and scenery to be found in the country around them. This scientific wanderlust, perhaps explained by realizing that there is a little beatnik in the most scientific of us, has resulted in the annual institution known as the Spring Field Trip. During this golden time, with finals over and the new term too far ahead to think about, caravans of geology students and faculty have ranged far afield through the Southwest, seeing some geology, photographing a lot of scenery, and in general having a whale of a good time.

Given this background, it was no surprise that Dick Jahns' casual and offhand announcement that he might lead a small outing through the Panamint Mountains and Death Valley during Spring Recess fell on fertile soil. Three days after a discreet notice inviting travellers was posted there were twenty signatures.

The end of the second-term finals was the signal for the beginning of preparations suggestive of the Normandy landings. On Monday evening, March 21, the mountains of supplies and equipment were loaded into the Carryalls. H-Hour was 8 a.m., March 22.

The account below has been somewhat laboriously deciphered from the author's original trip notes, most of which suffered somewhat from having been written in a bouncing Travelall with an erratic pen.

First Day

Leave at 8 a.m. in two Travelalls. Carryalls (and food) will meet us (we hope) at Mojave.

Stop #1: Mile-wide trench of the San Andreas fault zone, south of Palmdale. Various lines of evidence suggest a movement of about 25 miles since middle Miocene time. (Translation: The other half of the outcrop we're standing on is somewhere over by Cajon Pass). The fault looks so peaceful now. Ducks swimming on the pond, trucks roaring by. Guess it isn't going to move; we may as well go on.

Stop #2: Tropico Hill gold mine at Rosamond. The ore is located in and near volcanic rocks, but the mine is shut down, waiting for a rise in prices. Jahns draws maps and stratigraphic sections in the dirt to make the "big picture" clear.

Lunch: Like all lunches of the trip, a grab-as-you-can affair, constructed from sandwich makin's placed on the tailgates of the trucks. Bob Zartman has most lethal-looking knife, remains well-fed. Jahns tells anecdotes. Now heading north on Route 6.

Pass by Jawbone Siphon of L.A. Aqueduct. Jahns gives a fascinating summary of the tangled history of Owens Lake water in Los Angeles, replete with lawsuits, fraud, dynamitings, and other skulduggery.

Stop #3: Red Rock Canyon, cut into a series of volcanics, tuff beds, and colorful sandstones. A photographer's delight, with beautiful "badlands" features developed by erosion.

Turn east toward Randsburg, past Koehn Dry Lake.

Camp: The Pinnacles, south of Trona, on the south end of Searles Lake. The Pinnacles are spires of tufa, a form of calcium carbonate probably deposited by springs in the bottom of Searles Lake at a time when the lake covered the valley and was linked to other now-dry lakes in the region. The spires add a weird touch to an already strange scene.

Tufa is sharper than it looks. Jahns' air mattress, punctured in three places, quietly expires at 3 a.m., easing him down onto the hard ground.

Second Day

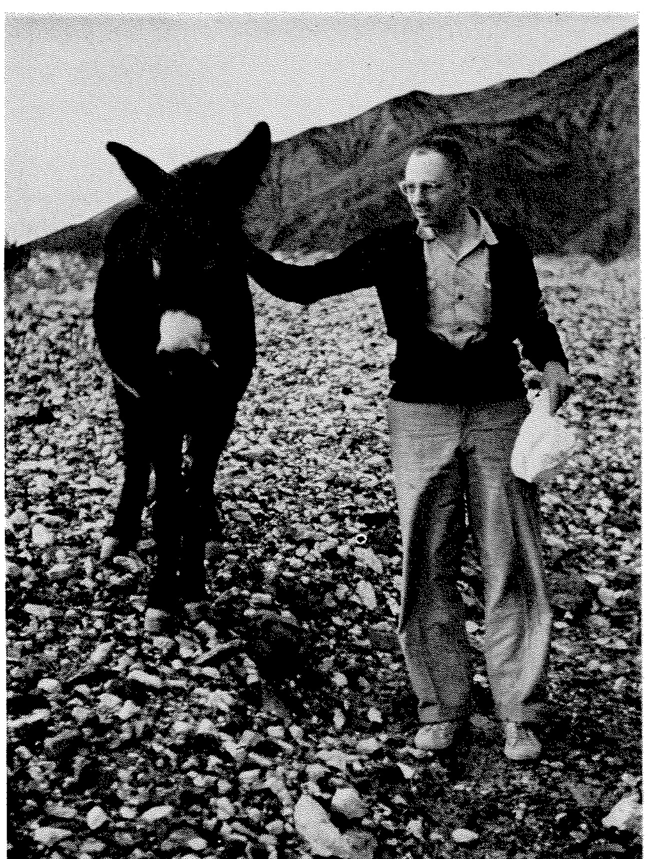
Drive across Searles Lake toward the Slate Range on the east. The road (a pair of ruts across a scoured surface of salt on the lake) is fortunately dry. The salt is barren and lifeless, a uniform pinkish-gray, sometimes coated with gravel.

Stop #1: Top of Layton Pass. We study the coarse pink gneiss that forms the core of the Slate Range, photograph the beautiful desert flowers, and view the Panamint Range to the East.

Stop #2: American Potash and Chemical Co. plant, a thriving concern which extracts an amazing number of useful chemicals from the brines of Searles Lake. We are given a fine tour through the plant, which remains etched on the memory as an unbelievable maze of intricate pipes, valves and channels. At each step in the process, another chemical is precipitated, and when the whole process is complete, the incoming brine from the lake has given up quantities of sodium chloride, potassium chloride, borax, sodium carbonate, lithium carbonate, and bromine.

Stop #3: Old silver camp of Panamint City. Once the center of wild night- and day-life, active until about 1930, now nearly deserted. A crumbling smelter, made of carefully-dressed stone, testifies to the importance of the town at one time. Now the brick walls topple easily – if shoved at a little. ("Well, it could have fallen on somebody sometime . . .")

Return trip down the canyon. Three wild burros suddenly appear in front of us and careen wildly down the road in front of the lead car. We stop and they study us coolly. Jahns converses with one, to the delight of photographers. The burro, no doubt expecting a handout instead of polite conversation, finally



Professor R. H. Jahns (right) pauses to chat with an old resident of Panamint City, presumably about non-political topics.

leaves. We swing west into the gathering darkness and head for the campsite at Darwin Falls.

Camp: In a narrow canyon. A slight trickle of water from a spring brings nervous remarks about flash floods. Dinner setup in the darkness. A water-bomb descends from above onto Jahns' Travelall, innocent expression on all . . . Raccoon climbs down toward food. Chased away, food locked up in the Carryalls. All crawl into sleeping bags. Still prowling raccoon crawls over sleeping student; both startled.

Third Day

Head west toward Darwin, through the Argus Range. Roads graded but disturbingly zigzag.

Stop #1: Summit of Argus Range. Beautiful view of Panamints to east. Interesting structures in the Paleozoic rocks. A few lead mines nearby, where much of the ore is oxidized, so that worthless-looking "dust" runs about 40 percent lead. On past Darwin, heading into Lone Pine.

Stop #2: Route 190, south of Keeler. First view of Owens Lake and the Sierra Nevada, a magnificent sight in any season, no less so now.

Nobody seems to want to say much. Recalling Jahns' comments about Owens Lake being 90 feet deep with packet steamers on it makes one wonder about the worth of the L.A. aqueduct. It seems a shame to lose the reflections of sunrise on the Sierra in the lake to bring water to several millions of people who couldn't care less about scenery.

Stop #3: Into Lone Pine for supplies. Water cans filled, Popsicles eaten. Some students stroll across the road to make the acquaintance of a large desert tortoise, the pet of a little girl not much bigger. Impulse shopping in the nearby delicatessen: "What kind of wine is good with hot dogs?"

We turn our backs on the Sierras, each man planning to return someday. Head onto a dirt road up to Cerro Gordo. Here is where the two-wheel-drive Carryalls get their first test. The road is steep, but well-graded. We make the summit without trouble.

Stop #4: Cerro Gordo mine, at the head of San Lucas Canyon. It started out as a "bonanza" silver mine, later an important lead-zinc producer. We head down San Lucas Canyon, eventual destination Saline Valley.

Camp: We bounce over Saline Valley toward the mineral springs where we will make camp. We pass a pile of shattered rubble that looks like a mine dump. It isn't; it's a small part of a gigantic landslide, 800 feet thick, extending two miles back into the mountains, where the scar gleams whitely.

Camp at the mineral springs. Brave souls try the hot mineral water coursing out of a pipe, find it wonderful. Everyone in camp has a shower, decides that the rough outdoor life isn't so bad at that.

Fourth Day

Sun comes up magnificently for the third consecutive day. Photo devotees shake themselves awake, grab cameras, and "shoot" the Inyos in the early light. Pack up and load Carryalls. Frank Tuttle startled when a poisonous scorpion scuttles out of his (Tuttle's) sleeping bag; the desert isn't all scenery and fun . . .

Stop #1: Lippincott Lead Mine. A copper-lead-zinc deposit, with a lot of colorful, interesting minerals for the mineral collector. A brief stop, then we head up the road toward the Racetrack Playa.

Road? Ha!

The Travelalls shift to four-wheel drive and groan up a rutted, serpentine track that lines the canyon wall. The Carryalls shift down to low-low and pray. "Are they still there?" one student asks as we round a 160-degree curve. Shaken, we arrive at the summit intact, head east again on the road (now fairly reasonable) toward the Racetrack Playa.

Stop #2: Racetrack Playa. A flat, smooth, dry lake surface, gaining publicity from the boulders and stones that are apparently blown across it, making slight depressions in the surface. Our caravan debouches onto the playa and the Carryall cavalry makes charges at nothing, intoxicated with the feeling of doing a smooth 50 mph thirty miles from the nearest paved road. Jahns points out some genuine depressions or "racetracks," as distinct from the false ones that certain depraved human beings like to construct by dragging rocks behind their cars. Head north from the Playa toward Death Valley National Monument.

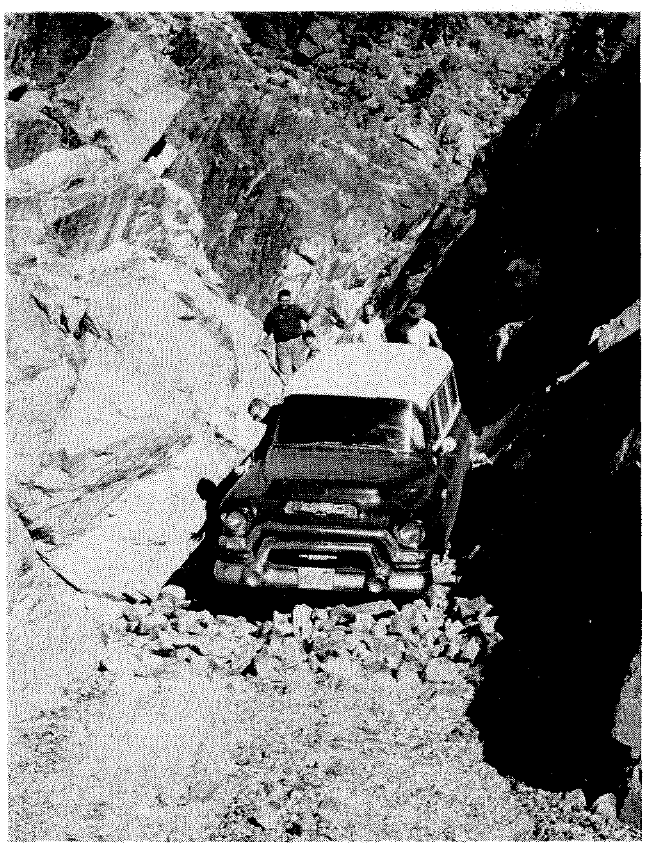
Stop #3: Ubehebe Crater. A gigantic hole, hundreds of feet deep, produced by a volcanic "blowout" which shattered the lake beds above it and strewed lava "bombs" on the surrounding country. No lava flows are present. The already-colorful beds are further changed by "baking," producing an impressive spectacle. Even the geologists, who can affect a certain blasé familiarity with the mechanisms, stand in awe of the results.

Stop #4: Harmony Borax Works. An early attempt to secure borax by scraping ulexite accumulations from the playa in the valley. A seasonal business, because of the summer temperatures that pass 120 degrees.

Stop #5: Badwater, beneath a steep cliff in "basement" Precambrian, the boundary of a profound fault zone.

Excellent example here of so-called turtleback faults, where the fracture is a curved surface resembling the carapace of a turtle. A lively debate still rages as to whether the faults now show their original shape or were originally flat and bent at some later time. Our discussion, though animated, does nothing to settle the problem. Head south again.

Camp: Ashford Mill site, on the location of a stamp mill for gold ore brought down from the Black Mountains to the east. Dinner and talking by the light of Coleman lanterns. Then to bed, while the clear sky passes overhead, Milky Way and all.



The techniques of non-freeway travel in the Panamints are demonstrated by Carryall drivers, nervously inching down the lower part of Goler Wash.

Fifth Day

Carryalls packed for the last time. We head east, to look at parts of the so-called Amargosa chaos.

Stop #1: Heading up Jubilee Wash, into the "chaos." The "chaos" is a gigantic area of jumbled blocks and boulders, some as large as a city block. Earlier interpretations have suggested that this is the result of grinding and shattering along a gigantic Amargosa thrust fault. Later studies seem to indicate, however, that the origin is largely in place, with the blocks broken off nearby cliffs and moved into the valley by mudflows. The rocks in the outcrop we are looking at are automobile-sized.

A small but vituperative rattlesnake is turned up and carefully avoided by all concerned.

Turn around and head west across dirt roads on the valley floor toward Warm Springs Canyon.

Stop #2: South end of Butte Valley. Striped Butte sits startlingly in the center. Its appearance is due to an alternating black-and-gray section of Permian rocks. No one knows how it got there or where it came from; movement along hidden faults is suspected. The valley is beautiful: no developments, freeways, or billboards. One small winter home of some lucky guy.

We move up to Mengel Pass. The road has never been graded, and is mainly ruts, occasionally passing over piles of rock.

Striped Butte, made of a contorted series of sharply contrasting rocks, dominates the center of Butte Valley in the Panamint Mountains, west of Death Valley.

Stop #3: Mengel Pass. The grave of Charlie Mengel, an old-time prospector who now lies looking back over his country. We look back toward Striped Butte, half-shadowed in cloud, and at the Amargosas to the east, decide there are worse places to be buried. Not many pass by, but those who do are probably the same type of person he must have been.

We move on, down the canyon into Goler Wash.

Stop #4: Lower Goler Wash. We cross the boundary between the young Tertiary volcanics and enter the shadow world of the ancient Archean rocks. The road becomes increasingly bad, and at some point in our descent ceases to justify the term. We lurch down the stream bed and inch the cars over rock ramps, built up over dry waterfalls.

We end our creeping down the wash and come into Panamint Valley. The remainder of the trip is on dirt roads down Panamint Valley, up Layton Canyon, down into Searles Lake, and home. As we climb up Layton Canyon toward the summit, the sun sets and rainbows appear in the clouds above.

We come onto the summit in time to see the sun set again, this time behind the Sierra Nevada. Below, Searles Lake is dim in the twilight. Then we descend onto the lake as a few clouds in the west flare red in the darkness.

The rest is homeward. Dinner in Ridgecrest, where we become reacquainted with such essentials of civilization as beer, rock-n-roll, and television. We arrive in Pasadena about midnight, with the rest of our lives remaining to sort over the events of the past five days.

What do we remember?

We remember a lot of the geological knowledge that poured into us during the trip, but clearer are the sharp mental photographs of individuals and groups during the trip: a small group singing around a campfire, passing a heritage of folk songs into the night . . . the way that sleep came easily under the stars, as an end to a fine day . . . Jahns' inimitable file of jokes and style of telling them . . . Grant and Schleicher telling Cockney jokes ("But don't you 'ave just a little bit of an onion for 'arry's stew?") . . . the Carryall drivers, who calmly essayed roads that would have panicked the average motorist . . . in short, the company of individuals who needed no more than the world and themselves to give them satisfaction.

What did we learn?

The main lesson may have been one that Lord Chesterfield passed on to his son when he said, "The study of the world is to be found in the world, not in the closet." Geology is the study of the earth, and, no matter how much time we spend in the laboratory, it is to the world around us that we must turn for our information. And more than this. We saw how the lives of countless people had been shaped and modified by the geology of their country, though they may have been unaware of its effect. We learned that geology is people, travel, beauty, and a lot of things that don't find their way into textbooks.

We gained a sense of what has been done in the area we traversed, and of what geological problems remain for study, and how some of us could study them. If every man in his life must face the question, "Why am I what I am?" some of us found some answers on the trip.

So, there is a great deal beneath the casual comment, "It was a great trip. You should have gone." We found many things on the trip: a good time, a nice way to spend Spring Recess, a little more reason to enjoy geology, a little more appreciation for the country we live in, perhaps even a thesis problem, or a renewal of faith for sustaining over the rough spots of a scientific career-to-be.

Many have gone into the desert and come out with less.

— Bevan M. French

Soil Engineering in the Arctic

A developing area requires the study of some old foundation problems from a new point of view

by Ronald F. Scott

The achievement of statehood for Alaska has drawn the public's attention to another region in which engineers have had a growing interest since the Second World War and, more particularly, in the last decade. The construction of various radar warning lines in the Far North brought home to us the importance of developing construction techniques under extremely arduous conditions. Behind the field erection and construction work which was carried on in the Arctic lay less spectacular engineering studies of the behavior of structures in climatic extremes. In the Far North, as elsewhere on the face of the globe, buildings, highways, radar towers, and airfields must be built on foundations based on or in the ground; the behavior of soil frozen all or part of the year under such structures has therefore assumed a growing importance.

In temperate climates, the soil or foundation engineer has several standard worries: the looseness or softness of the soil and its relation to its bearing capacity, the compressibility of the soil and the settlements which may ensue if a structure is built on compressible soil without precautions, and the important part played by water in the ground – its effect on sheer strength and its influence on the preliminary excavations which are usually made for buildings.

Testing methods and techniques of analysis have been developed to the state where a present-day soil engineer can give a builder or owner a fair assurance of the stability of his structure. The properties of the soil enumerated above are all essentially mechanical ones, and the same concern over their proportions is manifested by the arctic soil engineer. However, he has one further difficulty generally not shared by his warmer brother: the thermal properties of the soil.

Anything that human beings, bent on construction, do to soil modifies its thermal regime. In temperate areas of the world this is not especially important (except below cold storage warehouses or brick kilns) and we don't pay too much attention to it. It is obvious, though, that a frozen soil is an extremely hard material possessing good bearing capacity abilities. The same soil in a thawed condition may not be so able to support a structure adequately or even at all, and before structural designs are very far advanced some attention must be paid to the possible thermal influence of the structure on the underlying soil.

Before describing some of the possible effects of man's interference with frigid nature, some mention should be made of typical soil profiles in arctic areas. If we go north in Alaska to, say, the neighborhood of Point Barrow and bore a hole into the ground in summer, we will find that the soil is only thawed to a depth of a foot or two below ground surface. Below that upper or "active" layer the ground is perennially frozen; this is permafrost, the soil engineer's term for soil frozen all the year 'round. The active layer thaws in summer and refreezes again in winter.

It is generally considered by geologists that permafrost is, in a sense, a fossil remnant of the last ice age, during which the soil was frozen to great depths. Boreholes have indicated that permafrost exists to depths of 1100 to 1200 feet in Alaska; and, of course, somewhat greater depths are reported in Siberia. We can see, therefore, that permafrost is no shallow surface phenomenon.

The southern limit of continuous permafrost in North America corresponds very roughly to the 25°F mean annual isotherm; not, as might be expected, to the 32°F mean line. Part of this difference may be due to a gradual long-period climatic change; part may be due to the fact that soil moisture does not always freeze at 32°F. Near the southern limit of con-

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tinuous permafrost we begin to find sporadic permafrost where the frozen ground occurs in patches or islands surrounded or joined by areas of unfrozen soil.

If a perennially frozen soil occurs in a region where the climate is slowly but steadily getting warmer, the annual summer depth of thaw increases each year, and may eventually, with the rising temperatures, reach a magnitude greater than the depth of freezing which takes place the following winter. Consequently, islands of frozen ground may be found below the surface of otherwise thawed materials in certain areas. In other areas, the reverse situation may hold. Little tricks of nature like this can play havoc with building foundations if the areas of frozen or unfrozen ground have not been thoroughly investigated before construction.

Where the frozen ground consists of a dense tightly-packed sand or gravel, no undue movement of the structure to be built on it is likely to ensue should the permafrost eventually melt under the heat emanating from the building foundation. Our problem is more concerned with frozen soils which, in a thawed state, are soft or compressible. Silts, clays, loose sands, and organic materials all enter into this category.

Generally speaking, there are two problems connected with such soils. The first one is that if such soil is frozen and is later thawed by the heat from a building, the building will settle and may eventually fail as a result of the compressibility of the thawed soil.

The other difficulty is that many of these finer-grained soils possess what we call "frost-susceptibility." When they are refrozen after thawing they can take up water from any available source (which is usually the water table below) to form ice layers or lenses in their mass. These lenses grow in thickness, expanding the soil vertically – the only direction in which it can go freely – and can exert enough pressure to lift up footings or foundations and crack floor slabs or distort pavements. This "frost heaving" phenomenon is a familiar one to highway construction men in the New England states. It is possible for such soils to adhere to piers and piles placed in the ground and to force them up with the expansion of the freezing soil layers. The worst types of such frost-susceptible soils can take up enough water in the form of ice lenses to increase their volume 50 percent.

What happens to permafrost when a construction crew appears upon the scene is illustrated in the diagram below. Proceeding from left to right across the sketch the various stages in the work of clearing a site (in this case a highway) are shown. First of all, where it exists, the natural cover of trees is removed. While the trees existed at the site the normal depth of the active layer may have been two or three feet. The type of vegetation at any particular site is usually a function both of the soil type and the annual depth of thaw, so that the experienced arctic engineer can get a rough idea of the normal depth of thaw by an examination of the vegetation in aerial photographs. Removal of trees brings the effective air-surface interface closer to the actual ground surface, with the result that greater heat penetrates into the soil from the sun's radiation, and consequently the annual depth of thaw is increased.

Removal of the scrub and underbrush also brings about an increase in depth of thaw; a typical amount is shown in the diagram. Following a good temperate climate construction practice, the next stage in construction would be to remove the organic surface moss and peat cover. This alone would virtually double the depth of the active layer and would cause great enough changes in the thermal regime of the ground so that a highway constructed on the ground surface (especially a black-top highway) would have little or no hope of lengthy survival if the underlying soil was a compressible or frost-susceptible one.

In spite of the thermal insulating properties of the gravel fill usually used for highways, the effect of the

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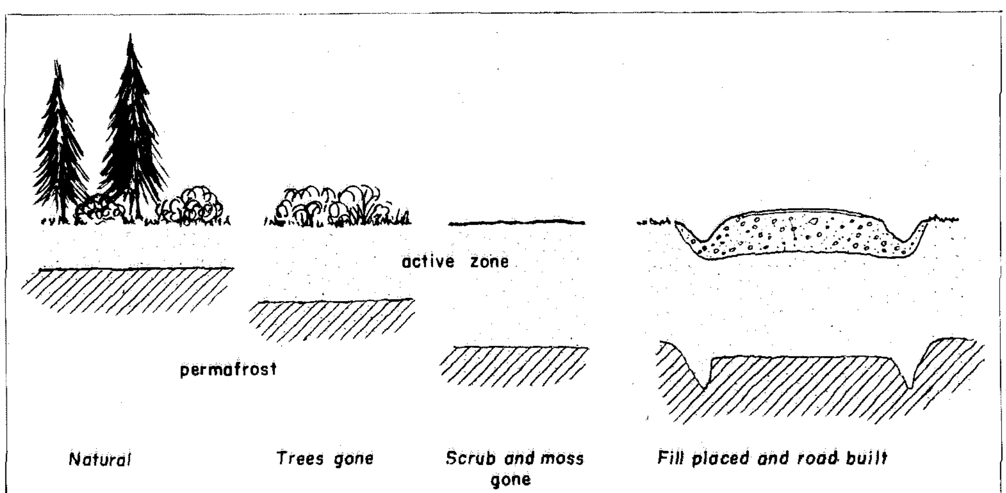
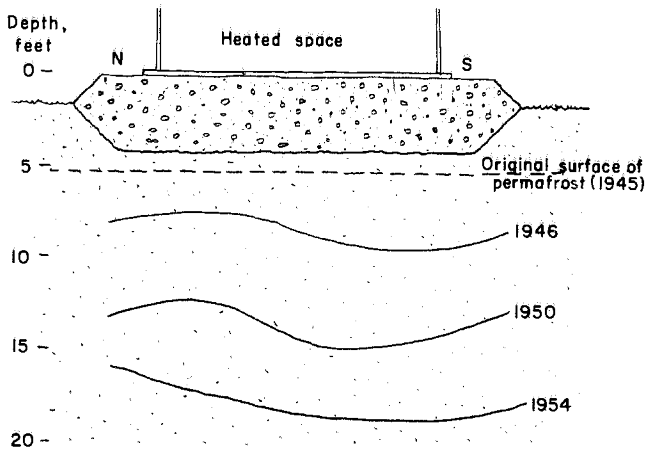


The traditional process of highway construction requires the progressive removal of the natural vegetation, resulting in a lowering of the permafrost surface.



Heat flowing into the ground through the uninsulated floor of a small building causes an increasing degradation of the permafrost surface.

blacktop surface and percolating water from ditches at the side of the road is to degrade the permafrost underneath the highway still further, as shown at the end of the sketch.

In an arctic area, in general, it would be expected that the winter freeze-up would completely freeze the soil profile from the surface down, in which case frost-susceptible soils would respond happily with winter pushups. In the spring the lenses of ice under the surface of the road thaw out — leaving, at worst, little ponds of water or, at best, soil with very low bearing capacity near the surface of the road. Spring traffic provides the only necessary factor remaining to complete surface deterioration.

In the case of buildings, even an unheated structure placed on a pad of gravel at or just above ground surface can cause considerable changes in the underlying thermal regime. If, however, the building is heated and, in addition, inadequate insulation is provided in the floor, changes in the depth of thawed soil underneath the building can be substantial. The diagram above shows a profile through the soil underneath a test structure which was erected at Fairbanks, Alaska, in 1945. Thermocouple strings were established in drill holes before the structure was erected. The heavier lines in the diagram indicate the progressive downward movement of the permafrost upper surface in the years following the construction of the building. It will be seen in general that the failure of such a structure would not be an immediate result, but that, if the soil is not capable of taking the building load satisfactorily, progressive movements will take place, increasing the distress of the structure from year to year.

To combat this type of behavior, arctic construction men long ago discovered that a useful solution was to place the building on piles or short piers, leaving an insulating air space underneath the structure through which air could pass to carry away the building heat and prevent it affecting the underlying soil.

If this is done properly, and if adequate precautions are taken, it will usually be found, owing to the shading influence of the building, that the permafrost surface will rise underneath the structure. If this is the case, and the structure has not been placed on piles but merely on, say, small footings at ground surface or near ground surface, frost-heaving may result and it may be economical to replace any frost-susceptible materials with a clean gravel fill.

These structures are occasionally supplied with flaps at the end of the building which are lowered in summer to shade the soil surface, and lifted in winter to allow the maximum circulation of cold air under the building. For economy in heating and to keep the occupants feet warm, the floors of such structures should be adequately insulated. Piles, if they are used for supporting the structure, must be sunk into the permafrost to such a depth that periodic heavings of the ground in the active zone as it freezes in winter will not jack the piles out of the soil.

The type of solution described above is successful from a thermal point of view, but it does not result in a structure able to sustain heavy floor loads. If we want to build a warehouse, a hangar, or storage building for heavy materials, then a stronger form of construction is necessary. The diagram below shows a type of design which has been successfully used in construction of large hangars. Rectangular ducts are placed underneath the floor and connected to air in-

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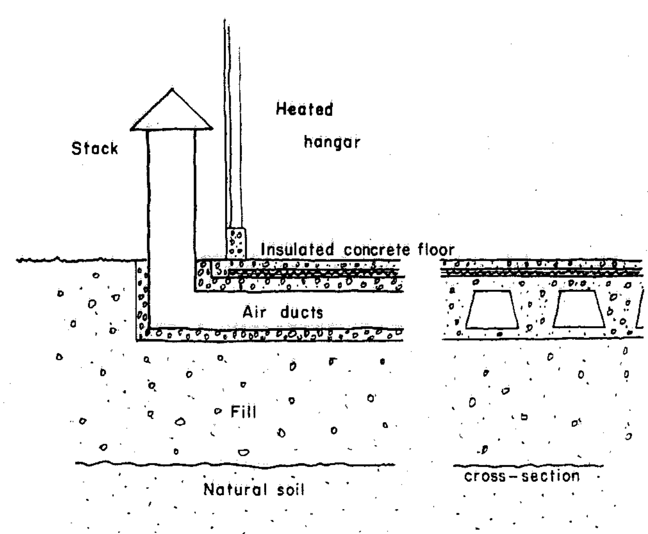

To prevent excessive thermal changes in the foundation soil, heavily loaded structures are built with air ducts below the floor slab.

takes at one end and stacks at the other. Air flows underneath the hangar, preventing the loss of excessive heat into the underlying soil. To all existing problems of construction, one more difficulty is added by this method: the intakes and ducts should be aligned along the direction of the prevailing wind, if sufficient records are available to indicate its direction.

In the design of highways in permafrost areas the cardinal rule to be followed is: do not disturb the existing terrain if possible. Cuts are not usually made, and all construction, if possible, uses fill material so that a substantial insulation is provided beneath the highway surface. This raises one further problem in the North. How does one get sufficient supplies of good quality fill material when the ground is frozen below a depth of maybe a foot or so?

Attempts have been made in the past to maintain ponds of water in proposed borrow areas so that the water has a thawing effect on the underlying soil. Various attempts have also been made to thaw out borrow pits by means of steam jets or even electrical heating elements. However, most of these methods, particularly in typical areas far from civilization and its conveniences, are highly uneconomical.

The usual construction technique resorted to is to permit the ground to thaw to a depth of a foot or so, when the foot of borrow material is stripped, baring a new permafrost surface which begins to thaw further. Later on another foot can be stripped off. Quite frequently when this is carried out borrow-pit depths of six or seven feet can be obtained where the former depth of thaw in the undisturbed soil amounted only to perhaps two or three feet. If the soil has any appreciable moisture content it is purposeless to attempt to stock the borrow or fill material in piles for a future year's construction since one winter is usually sufficent to convert a stockpile into permafrost.

To provide safe, more economical solutions to the problems associated with construction in permafrost areas, we need to know more about the behavior of frozen soils from the points of view of stress, strength, and thermal analyses. Studies and laboratory work are being carried out by a number of agencies to this end on the stress-strain characteristics of frozen soils, their thermal properties under different conditions, and on the penetration of freezing and thawing into soil under the influence of both natural climatic conditions and man-made structures.

ANNUAL ALUMNI PICNIC

Saturday, June 25, 1960
Tournament Park

Yes, this year a real live picnic will be held in centrally located Tournament Park. Come see your friends (or bring them with you). Activity (or inactivity) to suit all. Don't be a no-show.

Price of admission includes:

1. Kiddyland rides—safe, sane, entertaining — the kids can ride all day.
2. Carnival booths—for young and old. Prizes for everyone.
3. Exclusive use of swimming pool. (Small additional charge for towels.)

Also available:

1. Catered hot lunch (Reservations must be made in advance.)
2. Sno cones, popcorn, cotton candy and soft drinks on sale.

Announcements, with details, will be in the mails early in June. Save the date and bring the family and friends.

REMEMBER, that's June 25

PATRICK J. FAZIO, '53
Chairman, Picnic Committee

Alumni News

Alumni Literary Club

Five years ago this month, an idea was born which might be of interest to Caltech alumni everywhere.

The idea: to get together ten couples interested in literature, to meet once each month at the home of a different member couple, there to discuss the assignment of the month, and after such discussion to have beer and cheese amidst the convivial atmosphere thereby generated.

The lubricant and constant inspiration: Dr. Harvey Eagleson.

The theme and subjects covered:

First year: Modern American Fiction (Faulkner, Dos Passos, Thomas Wolfe, Steinbeck, Hemingway, Gertrude Stein, Saroyan, James Branch Cabell)

Second year: Modern European Fiction (Camus, Virgina Woolf, Kafka, Evelyn Waugh, Henry James, Graham Greene, Sartre, Gide)

Third year: World Drama (Sophocles, Seneca, Racine, Shakespeare, Jeffers, Corneille, Victor Hugo, Moliere, Congreve, Wycherley, Otway – done with each participant taking a part in a reading of a play)

Fourth year: Miscellany (Pasternak, Tennessee Williams, Kerouac, T. S. Eliot, Yukio Mishima, Colin Wilson)

Fifth year: The Ulysses Theme (*Iliad, Odyssey,* Campbell's *Hero with 1000 Faces,* Kazantakis' *The Modern Odyssey)*

The couples are predominantly Caltechian (on the non-distaff side, that is). Most are loquacious. All are sociable, enjoy beer or a highball with the meetings and have an affection for Doc Eagleson (referred to by some of the women – most strangely to Caltech ears – as "Harvey"). Once a year we have a swimming and dinner party without literature, and all members enjoy this event too. Occasionally, as with Tennessee Williams' *Sweet Bird of Youth,* the group both *reads the work and sees it. The turn*over in member couples has been negligible.

For those other alumni who might evince an interest in setting up a similar group, these words of advice: be sure to get someone of Dr. Eagleson's caliber to help guide and instruct; obviously try for couples who will clearly do their reading and who will participate in the group discussions; and (except in rare cases) have only one assignment outstanding at any one time.

All of the participants in the group agree that without what is by now affectionately referred to as "The Caltech Alumni Literary Club" their lives would be very much less interesting, and the extent of their reading very much curtailed.

Caltech Alumni: Be pleased to copy!

– Martin Webster '37

Personals

1922

Hallan N. Marsh, manager of the production engineering and equipment section of the Mobil Oil Company in Los Angeles, retired last month after 37 years of service. He joined General Petroleum (which merged into Mobil Oil in 1959) as a draftsman after a year of graduate work at Caltech.

Hal was responsible for many inventions which modernized oil drilling procedures and had 11 patents granted during his years with the company. He has his license as a private aircraft pilot, owns an auxiliary sloop, and one of his main hobbies is color photography. The Marshes have one son and two daughters, all married.

1927

James Boyd, formerly vice president of the Kennecott Copper Corporation in New York, is now president and chief executive officer of the Copper Range Company. He had been with Kennecott Copper since 1951. He is also president of the Mining and Metallurgical Society of America.

1929

T. H. Evans, MS '30, dean of the graduate school of engineering at Colorado State University, has been on leave to serve as dean of the SEATO Graduate School of Engineering at Chulalongkorn University of Bangkok, Thailand. The school, which opened in September 1959, is the only graduate school of engineering in southeast Asia. It is sponsored by the South-East Asia Treaty Organization — the counterpart of NATO in Asia. Students come from Pakistan, the Philippines, and Thailand. The present faculty is from Thailand, New Zealand, and the United States. *Norman Brooks*, PhD '54, associate professor of civil engineering at Caltech, has just returned from a three-month stint as an instructor at the University in Bangkok.

1930

Thomas Hiyama, director of manufacturing of the Nippon Columbia Company, Ltd., in Kawasaki, Japan, writes that "last year I visited the States for the first time after leaving the Institute about 30 years ago, and had a most impressive and happy time. I had the honor of staying at Professor Sorensen's home and also visiting professors on the campus. At the Bell Telephone Labs in New York, *Hallam E. Mendenhall*, PhD '27,

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Personals . . . *continued*

and many other Caltech graduates showed me great hospitality. I visited most of the big record manufacturing plants in the States, and came back with many new ideas. I am now engaged in reconstruction and modernization of our whole record organization."

1932

Patrick B. Lyons, formerly superintendent of the relay and capacitor shops at the Western Electric Company in Chicago, has been transferred to the company's Columbus, Ohio, branch where he is superintendent of manufacturing engineering. He has been with the Bell System for 17 years.

1934

Henry B. DeVore, PhD, physicist at the RCA Laboratories at the David Sarnoff Research Center in Princeton, N.J., died on April 9 at Princeton Hospital following a sudden heart attack. He had been with RCA since 1934 when he joined the technical staff as a research physicist in Harrison, N.J. In 1945 he left RCA to join Remington Rand, Inc., but returned to RCA in 1947. He leaves his wife and two children, Nancy and Richard, both students at Princeton High School.

1948

John P. Davis, MS, has rejoined Capitol Records, Inc., in Hollywood as director of the electronic engineering department. He was formerly on the technical staff of the air defense laboratories at the Hughes Aircraft Company. Prior to that, he was assistant to the chief engineer with CBS-TV in Hawaii.

Lt. Col. James N. Hall, MS, died of a heart attack on February 11 at the Wright-Patterson Air Force Base Hospital in Dayton, Ohio. He was 42. Jim was a native of Martin, Tenn., and was a graduate of the Martin Branch of the University of Tennessee. During World War II, he flew cargo planes from the Assam Valley in India to Kumming, China. After the war he served with the Ferry Command until he came to Caltech. He leaves his wife and two children, Jimmy and Cindy.

1953

Peter Goldacre, PhD, senior research officer in the division of plant industry of the Commonwealth Scientific and Industrial Research Organization in Canberra, Australia, died of cancer on April 23 in Sydney, Australia. Peter leaves his wife and two children, Lesley Ann and Philip.

1959

Michael Bogost, 22-year-old graduate student at Columbia University in New York, was found dead in his room at John Jay Hall on April 18.

ANNUAL ALUMNI MEETING

June 8, 1960

Reunion of the Classes of
1900, 1915, 1920, 1925, 1930, 1935, 1940, 1945, 1950, 1955

Speaker: Ruben F. Mettler, BS '44, MS '47, PhD '49, executive vice president of Space Technology Laboratories, Inc.
Subject: "A Search for Perspective of Space."

Cocktails at 6 – Dinner at 6:30

Rodger Young Auditorium
936 West Washington Blvd. – Los Angeles

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Visiting alumni cordially invited—no reservation

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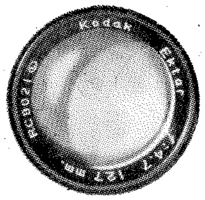

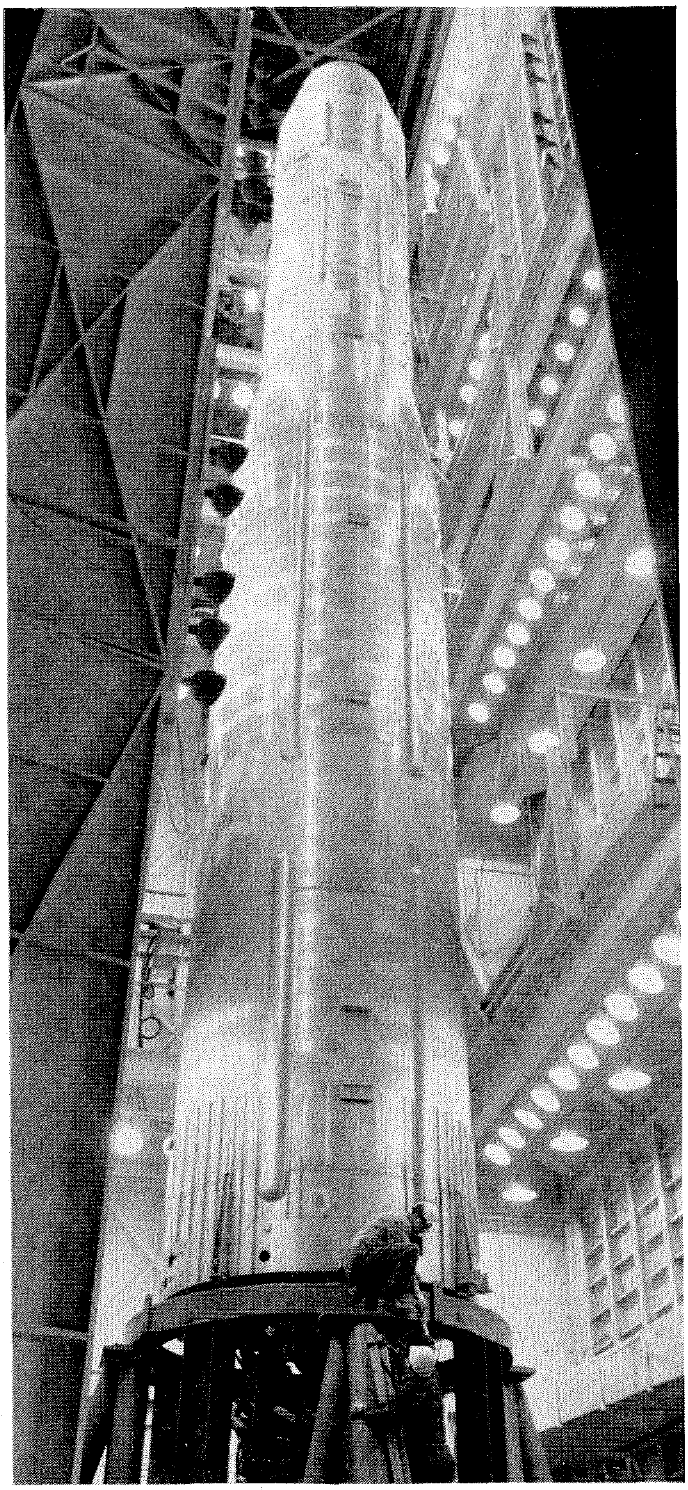

Mr. Thomas V. Davis
2183 Pinecrest Dr.
Altadena, California

One of a series

Interview with General Electric's Byron A. Case Manager—Employee Compensation Service

Your Salary at General Electric

Several surveys indicate that salary is not the primary contributor to job satisfaction. Nevertheless, salary considerations will certainly play a big part in your evaluation of career opportunities. Perhaps an insight into the salary policies of a large employer of engineers like General Electric will help you focus your personal salary objectives.

Salary—a most individual and personal aspect of your job—is difficult to discuss in general terms. While recognizing this, Mr. Case has tried answering as directly as possible some of your questions concerning salary:

Q Mr. Case, what starting salary does your company pay graduate engineers?

A Well, you know as well as I that graduates' starting salaries are greatly influenced by the current demand for engineering talent. This demand establishes a range of "going rates" for engineering graduates which is no doubt widely known on your campus. Because General Electric seeks outstanding men, G-E starting salaries for these candidates lie in the upper part of the range of "going rates." And within General Electric's range of starting salaries, each candidate's ability and potential are carefully evaluated to determine his individual starting salary.

Q How do you go about evaluating my ability and potential value to your company?

A We evaluate each individual in the light of information available to us: type of degree; demonstrated scholarship; extra-curricular contributions; work experience; and personal qualities as appraised by interviewers and faculty members. These considerations determine where within G.E.'s current salary range the engineer's starting salary will be established.

Q When could I expect my first salary increase from General Electric and how much would it be?

A Whether a man is recruited for a specific job or for one of the principal training programs for engineers—the Engineering and Science Program, the Manufacturing Training Program, or the Technical Marketing Program—his individual performance and salary are reviewed at least once a year.

For engineers one year out of college, our recent experience indicates a first-year salary increase between 6 and 15 percent. This percentage spread reflects the individual's job performance and his demonstrated capacity to do more difficult work. So you see, salary adjustments reflect individual performance even at the earliest stages of professional development. And this emphasis on performance increases as experience and general competence increase.

Q How much can I expect to be making after five years with General Electric?

A As I just mentioned, ability has a sharply increasing influence on your salary, so you have a great deal of personal control over the answer to your question.

It may be helpful to look at the current salaries of all General Electric technical-college graduates who received their bachelor's degrees in 1954 (and now have five years' experience). Their current median salary, reflecting both merit and economic changes, is about 70 percent above the 1954 median starting rate. Current salaries for outstanding engineers from this class are more than double the 1954 median starting rates and, in some cases, are three or four times as great.

Q What kinds of benefit programs does your company offer, Mr. Case?

A Since I must be brief, I shall merely outline the many General Electric employee benefit programs. These include a liberal pension plan, insurance plans, an emergency aid plan, employee discounts, and educational assistance programs.

The General Electric Insurance Plan has been widely hailed as a "pace setter" in American industry. In addition to helping employees and their families meet ordinary medical expenses, the Plan also affords protection against the expenses of "catastrophic" accidents and illnesses which can wipe out personal savings and put a family deeply in debt. Additional coverages include life insurance, accidental death insurance, and maternity benefits.

Our newest plan is the Savings and Security Program which permits employees to invest up to six percent of their earnings in U.S. Savings Bonds or in combinations of Bonds and General Electric stock. These savings are supplemented by a Company Proportionate Payment equal to *50 percent* of the employee's investment, subject to a prescribed holding period.

If you would like a reprint of an informative article entitled, "How to Evaluate Job Offers" by Dr. L. E. Saline, write to Section 959-14, General Electric Co., Schenectady 5, New York.

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