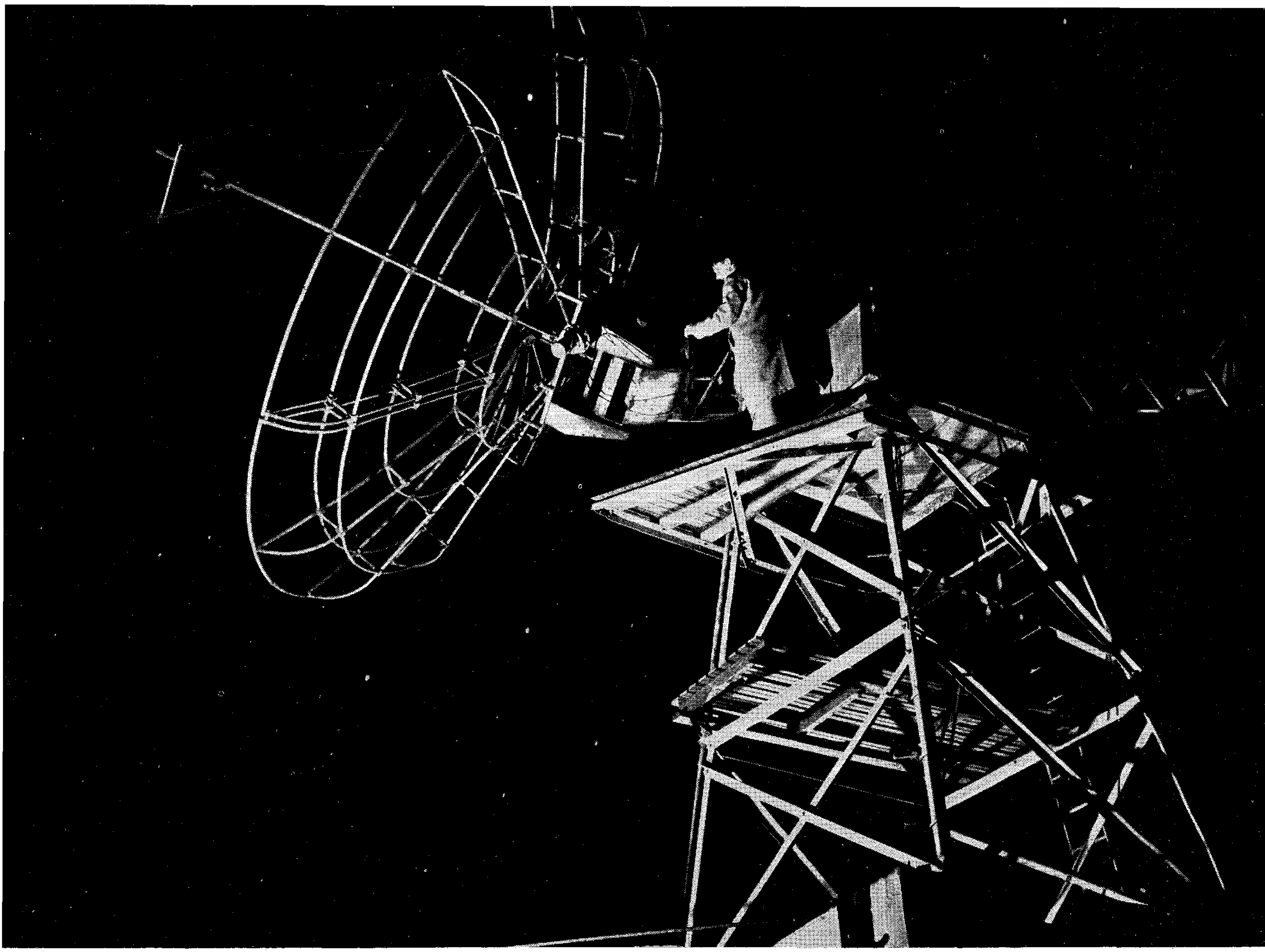


Dr. John G. Bolton works with a 16-ft. radio telescope in Australia; he'll have 90-ft. ones at Caltech's new site.

RESEARCH HIGHLIGHTS

THE PLANNING of a new radio-astronomy facility last year has resulted in a site for the large antennas, in a location which is level and free from radio interference, located near Big Pine, California, in the Owens Valley about 250 miles north of Pasadena. About 275 acres have been leased from the City of Los Angeles and construction of facilities has begun. Two 90-foot antennas — dish-shaped radio "telescopes" — have been ordered for installation next spring. They will be mounted on flatcars and will be movable on rails to give a variable interferometer. A smaller antenna is now in operation on Palomar Mountain. The rapid development of the field of radio astronomy and its relation to many problems under study at the Mount Wilson and Palomar Observatories add assurance that the new program will be an important one.

Of very great interest to physical science generally has been the recent work of Professor W. A. Fowler, and Dr. and Mrs. Geoffrey Burbidge (visiting from Cambridge, England), in clarifying the nuclear reactions which take place in the stars and which account for their energy, serving at the same time to build up all the chemical elements from primordial hydrogen. An interesting feature of the new theory is that the heavy elements of the periodic table (i.e. heavier than iron) are probably formed principally in gigantic explosions of stars known as supernovae — explosions similar in many ways to an H-bomb. The debris of these explosions is scattered into interstellar space, there to be picked up by other stars or possibly to be condensed into new stars. The existence on the earth of all of even the heaviest elements—up to uranium—means then that our sun and solar system must have picked up (or have been built from) such debris produced by a great explosion which took place more than five billion years ago.

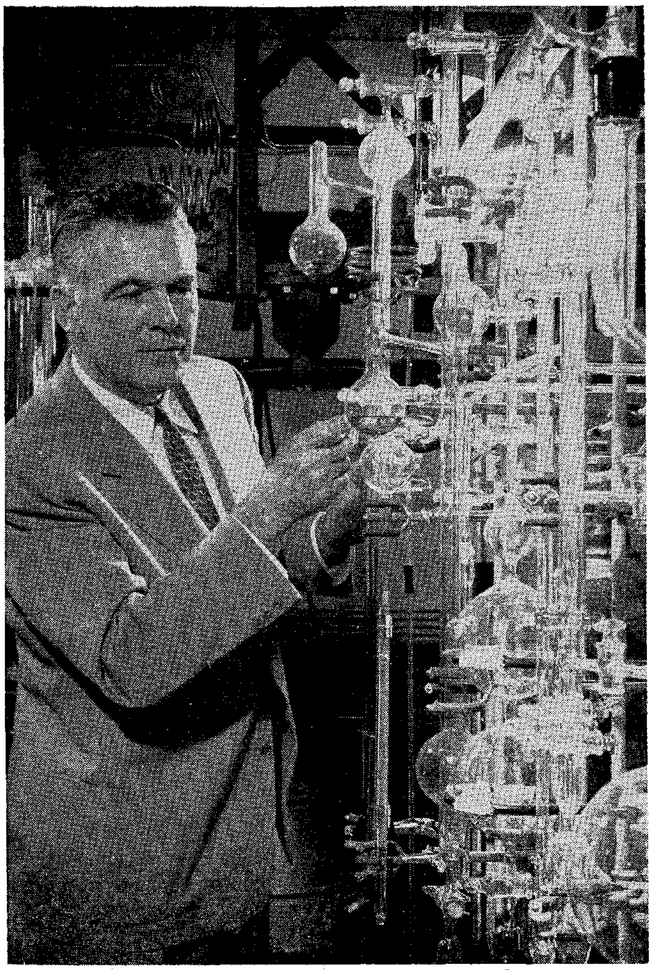
Astronomy, the oldest of sciences is undergoing a rebirth, caused partly by new advances in physics and electronics, partly by imaginative new ideas built on a growing basis of observations and theory. It is a satisfying example of the interactions between scientific groups that here at Caltech we see the coming together of astronomy, electronics and nuclear physics to contribute to the advance of understanding of the age-old questions.

Physics

LAST YEAR the electron synchrotron which had been operating for several years at an energy of about 500 million electron-volts was shut down for alterations designed to boost the energy to above a billion electron-volts. The alterations and delicate adjustments took longer than expected, but in August 1956 a beam was obtained of 1.2 billion electron-volts energy. Experimental work with this, the highest energy electron beam available in the world, is starting at once and much new information about nuclear phenomena will surely result. An eventual electron energy of about 1.5 billion electron-volts seems feasible. (The huge nuclear machines at Berkeley and Brookhaven accelerate protons, not electrons, to energies of several billion electron-volts.)

Professor J. R. Pellam's research at low temperatures has carried him down to .004° Absolute, and he can maintain his experimental chamber for several hours at temperatures around .07° to .14°. The properties of matter at temperatures so near the absolute zero are of great interest to physicists.

Another example of the way new discoveries of physics throw light on astronomical problems is the suggestion by Professor Fred Hoyle and others as to the source of energy of certain supernovae (exploded stars) which, after a bright initial flash, are growing dimmer with a half-life of 55 days. It is proposed that the great flood of neutrons released in the original explosion acted, as in the thermonuclear tests at Bikini, to produce great quantities of the element Californium —element number 98, which does not exist in nature, and whose isotope of mass 254 undergoes spontaneous fission with a half-life of 55 days. It appears quite possible that the radiant energy from these supernovae comes from the fission energy of this unstable element first discovered at Berkeley in 1950.

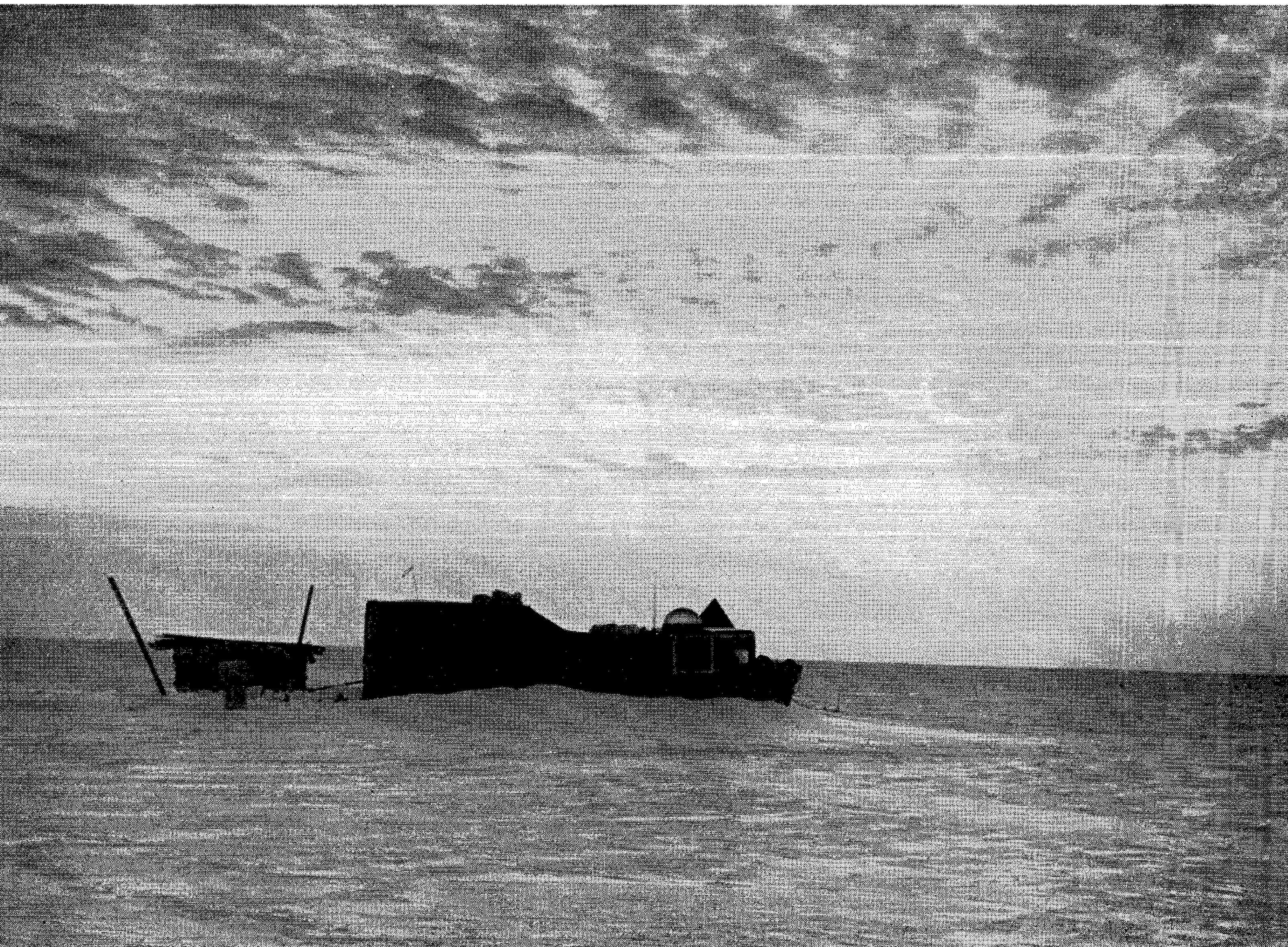


Physics Professor John R. Pellam studies the properties of matter at temperatures close to the absolute zero.

Geology

THE DISCOVERY of ore bodies bearing useful mineral deposits is a practical problem of great interest to geologists—and to everyone else too. Often the discovery of an ore body is a matter of pure luck, for there may be nothing in the surrounding region to indicate the presence of ore. The normal ore body has a sharp edge; the concentration of metal does not diminish gradually over a great distance, thus furnishing a handy clue. However, Caltech geochemists have found that since the original intrusion of a mineral-bearing body into the surrounding rock caused a heating of the rock for a considerable distance, the traces of this temperature gradient can be observed by measuring the ratio of abundance of the two isotopes of oxygen, 0^{18} and 0^{16}. Thus it is possible that a wholly new method of ore exploration may have been opened up, since detectable differences in this ratio are observed far outside the actual boundaries of the ore deposit itself. How an old-fashioned prospector would snort at the modern one—armed with a mass spectrometer!

Interestingly enough, the temperature sensitivity of the $0^{18}/0^{16}$ isotope ratio has also yielded data on the cyclic variations through the years of the temperature at which snow fell on the Greenland ice cap, the 0^{18} ratio varying with depth below the surface in such a way that it is possible to measure the relative depth of snowfall over each of many past years.



This is home to Caltech geophysicists making glaciological and seismic studies on a Greenland ice sheet.

Biology and Chemistry

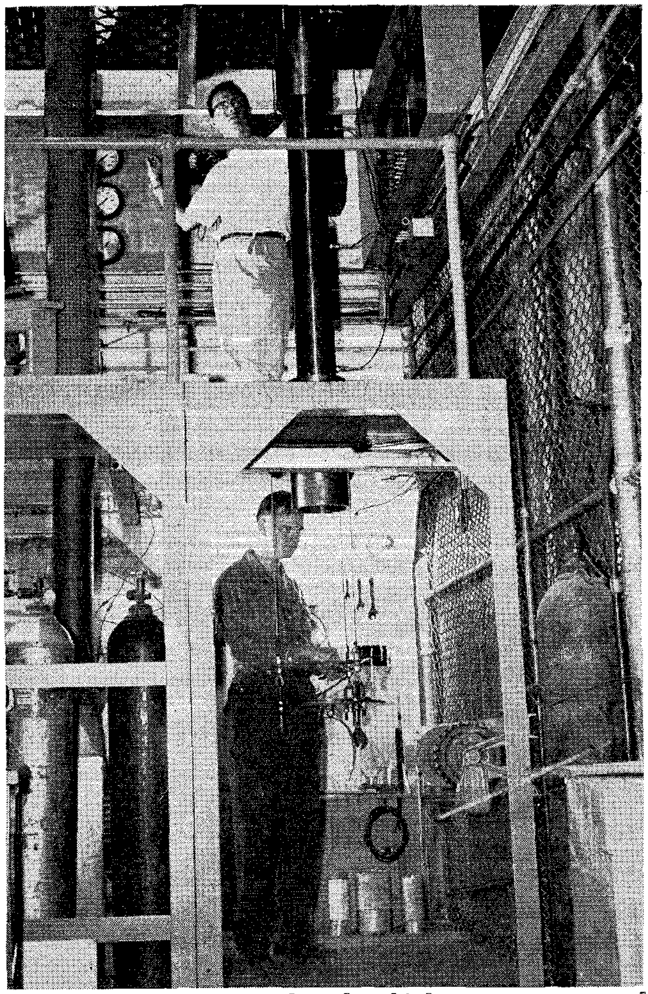
THESE TWO DIVISIONS are now jointly occupying the new Norman W. Church Laboratory for Chemical Biology and hence have more adequate facilities for their teaching and research programs. These programs continue to develop rapidly.

The success of Professors Linus Pauling, R. B. Corey and others in elucidating the structure of many protein molecules has led to encouraging progress in understanding the structure of viruses and genes which, though living, are yet very much like super molecules. A great mystery of "life" is the way these particles can reproduce their kind, and yet even this process is now becoming comprehensible, although still uncertain in detail.

There is evidence that abnormal molecules in the blood not only can cause specific types of blood disease, such as sickle-cell anemia, but also may result in impairment of certain brain processes. The announcement was made in August 1956 that a grant of $450,000 had been made to Caltech by the Ford Foundation to support a five-year study of this problem—whose great and fundamental importance is obvious. The project will be directed by Professor Pauling.

The techniques of studying animal and bacterial viruses which have been in use in the virology laboratory here now make possible accurate studies of the genetics of these bodies. Because of their relatively simple structures and the ease of growing them quickly in large numbers, they are good "experimental animals" for genetic research. Thus the "fine structure" of an individual gene has now been established and its molecular structure can be examined.

An important new instrument for studying structures of complex molecules is the nuclear magnetic resonance spectrometer, based on a discovery in physics made only ten years ago that molecules will undergo a transition from one magnetic state (or orientation of the magnetic axes of its various nuclei and electrons) to another, under the action of a radio-frequency field. The required frequency is sharply characteristic of each such transition and hence may be employed as an identifying mechanism. In other words, the series of fre-



Chemical engineers study ultra-high temperature and pressure reactions with the new ballistic pendulum.

quencies at which various transitions can be induced constitutes a unique "signature" for each type of molecule, often revealing subtle aspects of its structure not easily recognized in chemical or even in X-ray studies. Fortunately it was possible to purchase such an instrument last year, to be used by Professor J. D. Roberts in his research, and he has found it a versatile and powerful addition to the array of tools available for examining molecular structures.

Another new instrumental technique of growing interest in chemical research is the ballistic pendulum as developed by Professor B. H. Sage and his co-workers. A heavy, free-falling piston compresses a gas mixture, raising its temperature momentarily to possibly 15,000°F. Reactions taking place within from a hundred to a few thousand micro-seconds can be studied. Needless to say, ingenious electronic timing and measuring devices are employed.

Engineering

IN RESEARCH, in both pure and applied science, the occasional discoveries of exceptional interest are separated by long periods of laborious accumulation of information, the building and testing of equipment, the operation of calculating machines and the analysis and interpretation of data. It is not anticipated, for example, that a revolutionary discovery will come from the study of air flow around a flat plate, the analysis of the vibrations of a gasoline engine, or of the response of a building to earthquake waves. Yet more and better information on these and many other subjects is vital to the development of modern technology. Caltech does not manufacture airplanes, missiles, submarines, automobiles or vacuum tubes. But the design of all these things may be profoundly affected in the future, as it has been in the past, by the knowledge accumulated and the new ideas developed in the science and engineering laboratories on this campus.

The Guggenheim Laboratory of Aeronautics continues its difficult and important studies of air flow at speeds up to ten times the speed of sound. The mechanical engineering laboratory—before its old quarters were torn down to make room for the Spalding Engineering Laboratory—measured the vibrations of sonic frequency (noise) in a high-compression engine. In the hydraulics laboratory studies were made of sedimentation in stream beds, accumulating information necessary to the design of flood-control projects. The cause of water conservation in arid regions was advanced by the development of new methods for purifying and reclaiming sewage wastes, for a huge quantity of potentially usable water is frequently used in carrying away such wastes. The metallurgists obtained new data on the fracturing of steel and the corrosion of nickel-chromium alloys.

Almost every field of engineering is profiting from the development of electronic computing techniques, vastly speeding up the solution of analytical problems, and making possible the performance of design calculations never previously attempted. The Spalding Laboratory is to house a modern Computing Center which will be the focus of a campus-wide interest in new computational methods. Four major computing machines will be installed, including a new Datatron digital computer which has an exceptionally wide range of capabilities.

Jet Propulsion Laboratory

THE INSTITUTE'S largest single unit in terms of funds expended is the Jet Propulsion Laboratory. The Laboratory has now become one of the major research centers for the development of rocket and missile techniques for the United States Army Ordnance Department. The wind-tunnel work, the studies of fuels, motor design and guidance techniques are essential to the development of all types of missile systems—including the earth satellite project now being planned as a part of the scientific program of the International Geophysical Year.