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Associated Universities, Inc: A Client profile

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'There really are no answers — only a never-ending chain of questions that, when answered, lead to other questions.'

–Anon.

Their work is a study in contrasts. At Brookhaven National Laboratory the talk is of accelerators that can boost the energy level of protons to hundreds of billions of electron volts. At National Radio Astronomy Observatory scientists study radio emissions from space that are as small as a millionth of a billionth of a watt.

NRAO's huge parabolic antennas probe the sky for radio signals from sources light-years away – a light-year is the distance light travels in one year, or about six trillion miles – while Brookhaven researchers probe the inner universe of atomic structure itself in a determined effort to find the smallest particles that make up all matter.

Photo above: Contour lines representing radio emissions from the Crab Nebula confirm general configuration of the optical photograph of the nebula, which is the result of an explosion of a star. The radio waves are emitted by high-energy electrons produced during the explosion of the star located some 5,000 light-years from earth

Top photo: Dr. Per Dahl (r.), resident physicist at Brookhaven National Laboratory, and staff technician George Stenby check functioning of the Isabelle half-cell. This is a working model of the vacuum and magnet operation of Isabelle, a proposed $173 million proton accelerator to be built at BNL on Long Island.

Both NRAO and BNL are operating arms of Associated Universities, Inc., a client of Haskins & Sells since its formation shortly after the end of the Second World War. Nuclear research during the war opened a vast new area of scientific investigation with enormous potential. It became clear very early that the complexity, size and cost of the equipment and facilities needed to pursue this research virtually demanded a joint or cooperative effort of various federal agencies and private universities.

By the end of 1945, thanks largely to the war effort, regional laboratories devoted to nuclear research already were in operation in Berkeley, California; Los Alamos, New Mexico; Oak Ridge, Tennessee; and Chicago. A comparable regional laboratory located in the northeast was proposed at a meeting of twenty-one major research institutions, including universities and industrial organizations, in January 1946. By March of that year it had been decided that the new lab would be sponsored by nine universities: Columbia, Cornell, Harvard, Johns Hopkins, Massachusetts Institute of Technology, University of Pennsylvania, Princeton, Rochester and Yale.

Agreement was reached earlier that university-type management of the laboratory would probably be most effective in promoting the project's research goals, with Associated Universities operating the facilities under contract with the federal government.

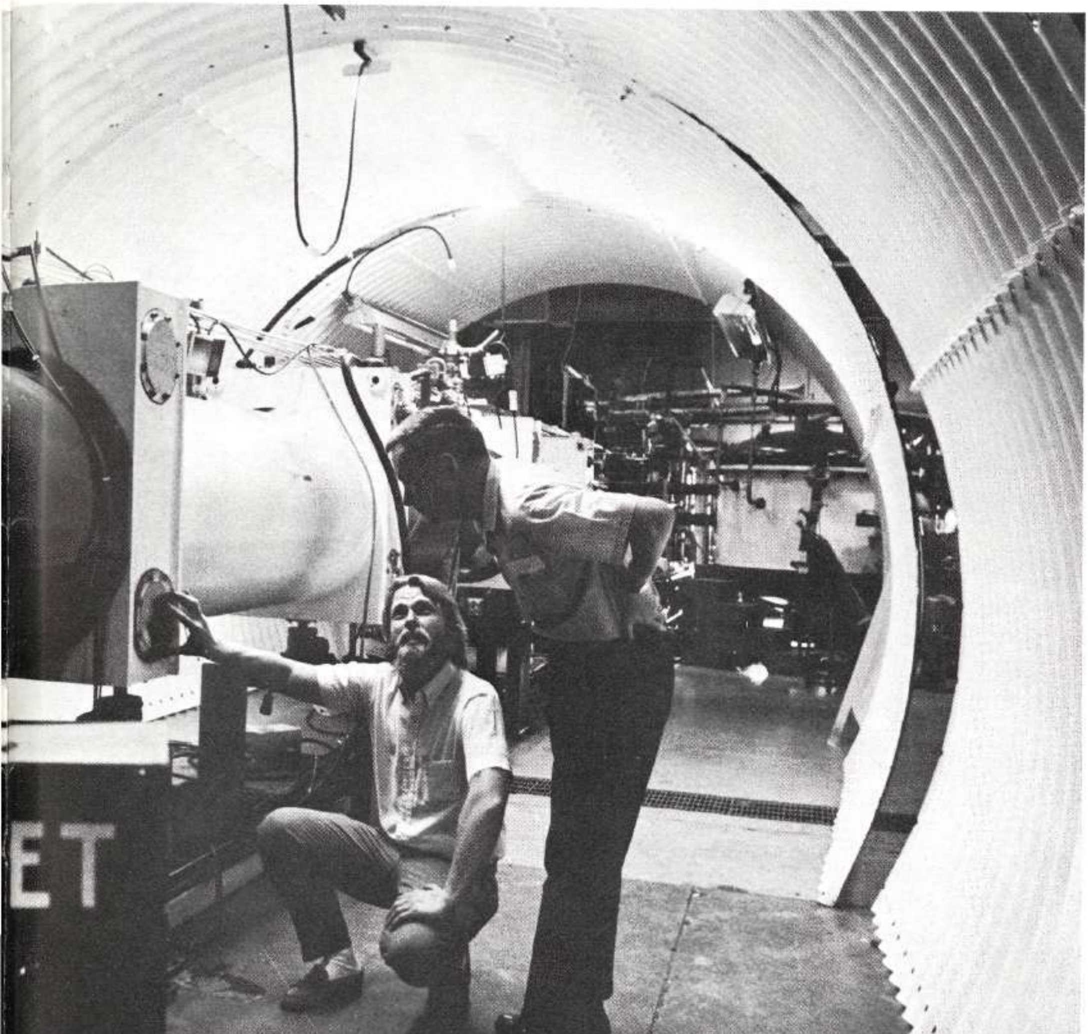
The work toward establishment of the laboratory was speeded when the government turned over Camp Upton to Associated Universities. Located on Long Island about sixty miles east of Manhattan, Camp Upton was originally developed in 1917 as an army training center and used during the Second World War first as a reception center and later for rehabilitation of returning veterans.

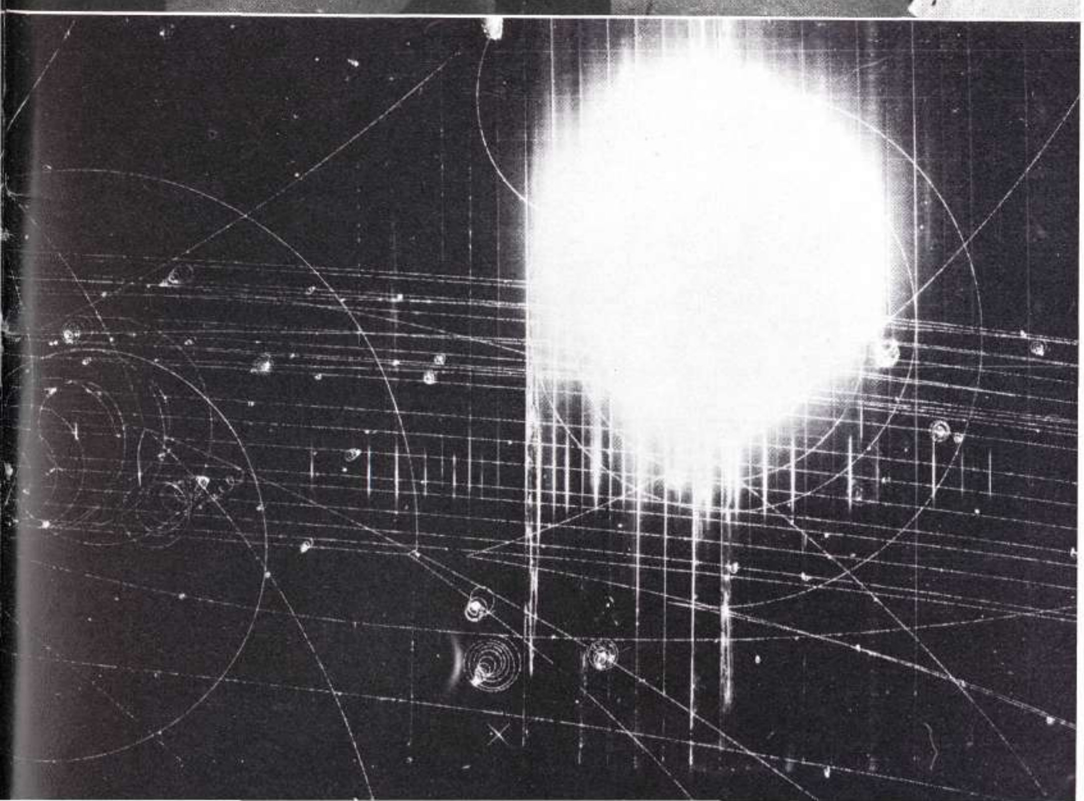
On July 18, 1946 the New York State Board of Regents, acting on behalf of the State Education Department, issued a charter making Associated Universities, Inc. a corporation under the Education Law of the State of New York. Haskins & Sells was engaged in May 1947 to perform systems services, basically to review the accounting and property records of AUI in order to recommend any changes that might be necessary before the first audit and to install all records necessary for that audit. Ralph S. Johns, then a partner with the New York office, was partner in charge of the engagement. Two months later H&S was engaged to do the initial audit for AUI, which signed a formal contract with the Atomic Energy Commission late in 1947. AUI presently operates Brookhaven National Laboratory under a contract with the U.S. Energy Research and Development Administration and, of course, is funded by ERDA.

In the light of the success of Brookhaven, AUI's Board of Trustees was receptive to accepting responsibility for the establishment and operation of National Radio Astronomy Observatory. Preliminary studies on the project began in 1954, with funding from another federal agency, the National Science Foundation. On November 17, 1956 the National Science Foundation and AUI entered into a contract for the organization, construction, maintenance and operation of NRAO.

Based in Washington, D.C., Associated Universities is governed by a Board of Trustees made up of twenty-five members, of whom two are designated by each of the original nine sponsoring universities. At least one of each pair chosen by a university must be a principal administrative or corporate officer, while the second is usually a member of the faculty engaged in pertinent research. Trustees are chosen for three-year terms on a rotating basis, with eight vacancies occurring each year. There also are six trustees-at-large, elected by the

Bottom photo: The delicate tracery of subatomic particles in BNL's 80-inch liquid hydrogen bubble chamber, resembling a study in abstract art, permits scientists to study particle actions and interactions by the trails they leave in liquid hydrogen. Brookhaven's 80-inch chamber is the largest in the world. This photograph shows a negatively charged pimeson interacting with a proton.





board, who may represent any field of endeavor in which the corporation may become involved. In addition to these twenty-four representatives, the president of AUI is an ex officio member of the Board of Trustees.

AUI, a not-for-profit institution, is an audit client of our Long Island office. John Cardis is partner on the engagement and Arthur Dulik, Jr. the manager. John recently took over the engagement from New York partner Frank Ascher. The engagement involves the efforts of some five to seven H&S people during the year.

The research being done today at Brookhaven by resident and visiting scientists covers a broad spectrum of projects, some highly theoretical but many involving practical applications of current technology. Both BNL and NRAO have resident scientific and support staffs, but any scientist from the United States or abroad may submit an experiment proposal. If accepted, he is given the use of the necessary equipment and assistance. Professor Samuel C. C. Ting of MIT, in fact, was co-winner of the 1976 Nobel Prize for Physics for his discovery of the "J" particle in experiments conducted at Brookhaven.

Work at Brookhaven includes high-energy or elementary-particle physics and solid-state physics; applied mathematics; medical research, much of which is devoted to irradiation techniques aimed at determining the causes and possible cure of human cancer; energy and environment studies, with emphasis on the development of new sources of energy, techniques for improving the environment and energy conservation; chemistry, with much effort being put on basic energy research; and biology, where experiments range from those probing the structure of complex biological molecules to sophisticated studies into the metabolism of living animals and plants.

Brookhaven today boasts some of the most advanced facilities used in

Top photo: Officers of Associated Universities, Inc. discuss recently concluded Board of Trustees meeting at Brookhaven National Laboratory with H&S people on the engagement. Shown (l. to r.) are Dr. Charles Bockelman, AUI chairman; partner John Cardis; Dr. Gerald Tape, AUI president; H&S manager Arthur Dulik; Carl Amthor, AUI vice president for administrative affairs and controller; and H&S senior Peter Quinn.

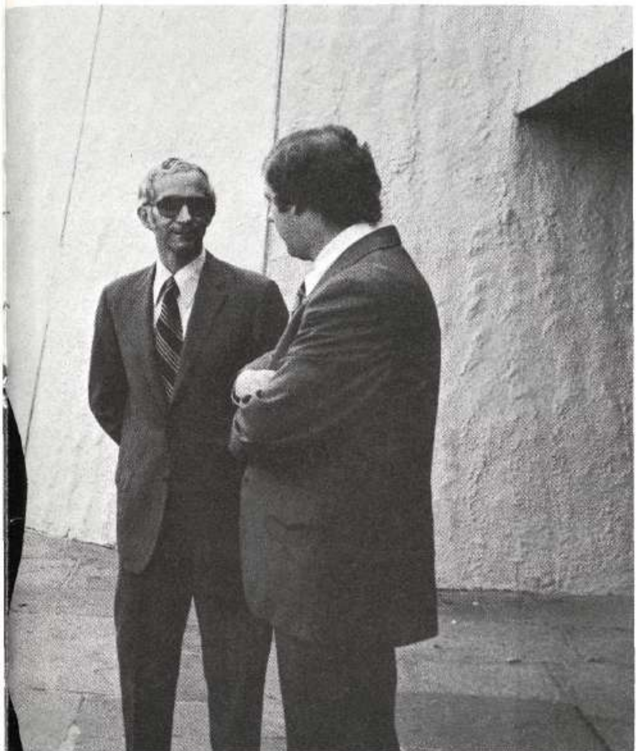
the study of high-energy and solid-state physics. The Alternating Gradient Synchrotron, known familiarly as the AGS, is one of the key research tools. A unit called a Cockcroft-Walton pre-accelerator feeds a stream of protons, actually hydrogen ions, to a long linear accelerator, or linac. Using a series of magnets, the linac boosts the energy level of the protons to 200 million electron volts, or 200 MeV. The proton stream is then fed into the half-mile-diameter circular track of the AGS, boosting the protons to an energy level of 33 billion electron volts (33 GeV) and bringing their speed to within 1 percent of the speed of light – 186,000 miles per second. Parts of the proton beam are magnetically diverted at various stations where they bombard different targets, usually selected metals, and the particle collisions are observed, recorded and studied.

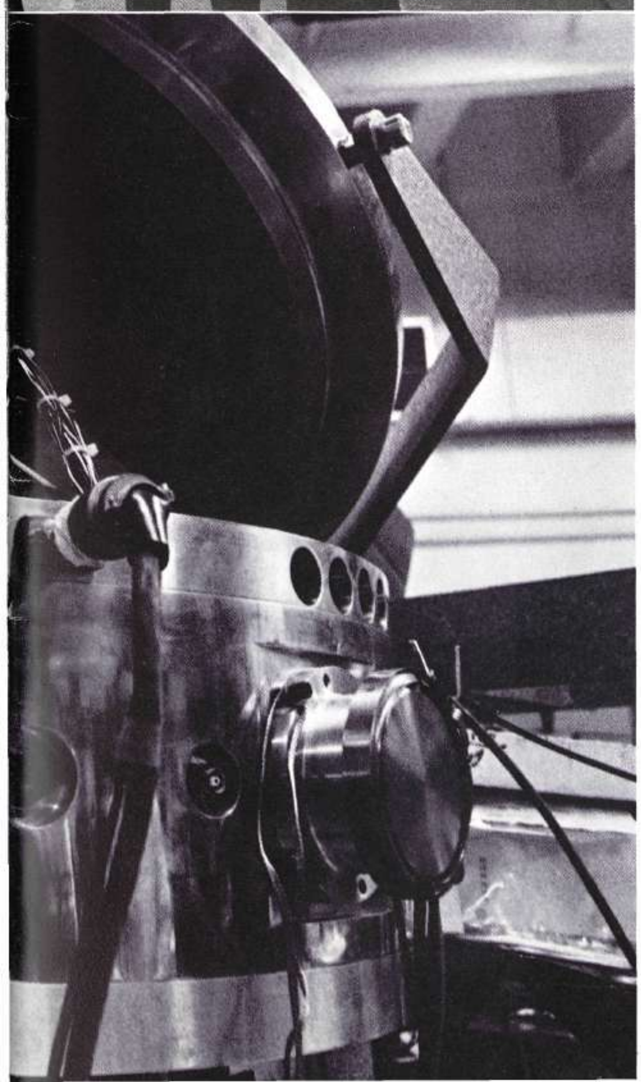
Brookhaven operates the largest tandem Van de Graaff generator in the world – electrostatic accelerators each eighty feet in length which can accelerate the nuclei of heavy atoms such as oxygen, iodine and twenty-five other elements as heavy as lead from 100 to a recently set world record of 320 million electron volts. The accelerated nuclei, or ions, are used in particle research as well as in chemical and biological studies.

The laboratory's high-flux beam reactor, which cost $12.5 million, uses uranium-235 in a controlled nuclear chain reaction to obtain an intense beam of thermal neutrons. Sixteen experimental stations ring the shielded reactor and provide shuttered windows, through which the neutron stream is fed for experiments outside the reactor, or access for irradiation experiments within the reactor itself for studies in nuclear and solid-state physics, metallurgy, nuclear and structural chemistry, biology and medicine.

Isabelle is a lovely name, and it is to Isabelle that many scientists at Brookhaven are looking for the answers to today's questions and

Bottom photo: Joel Karp, a third-year graduate student at the Massachusetts Institute of Technology, prepares scattering chamber for a particle experiment he is conducting at Brookhaven National Laboratory. When the chamber is ready, a beam of ions from the tandem Van de Graaff accelerator will be directed into it. MIT is one of the nine sponsoring universities of AUI.





the answers to the questions that will be raised by those very answers. Isabelle is an acronym for Intersecting Storage Accelerator coupled with *belle* for beautiful. In more down-to-earth terms, Isabelle is a proposed $173 million proton-proton colliding beam facility, a new proton accelerator.

One of the limitations of the AGS is the relatively small number of protons that actually collide with other particles in the target compared with the actual number of protons in the stream. The problem is somewhat analogous to what would happen if you launched a rocket from your backyard into space. Try to calculate the odds on whether the rocket would ever collide with anything in space, or how long it might take for such a collision to occur. To the average proton in the AGS stream, the target is mostly empty space.

Isabelle is actually designed as a continuation or additional stage (in simplest terms) of the AGS. When Isabelle is completed, protons will be fed into the AGS, brought up to 33 GeV, and then directed into Isabelle, whose tunnels form a circle more than 8,600 feet in circumference. A series of some 900 magnets will keep the protons traveling in the proper path and accelerate them to a level of at least 200 billion electron volts. ("I think that figure is very conservative," one physicist working on the project said. "It's quite possible we could actually find ourselves working with up to 400 GeV once the accelerator is in operation.")

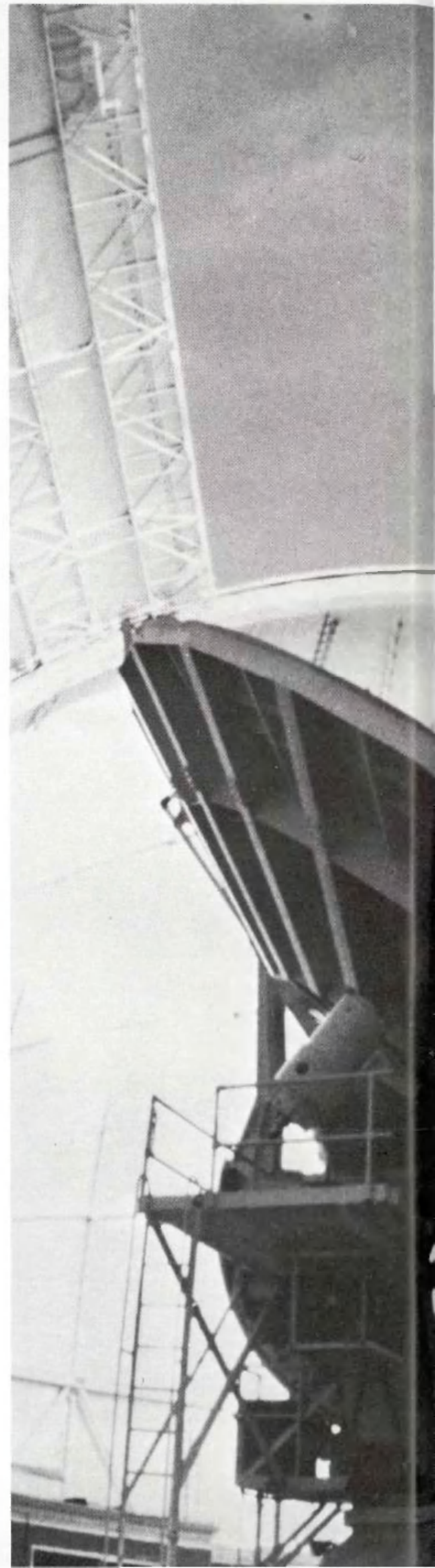
One major difference is that in the AGS all the protons stream around the circle in one direction. When Isabelle is completed, the AGS will feed the protons to Isabelle where they will be split into two streams, which will revolve in opposite directions. At designated experimental stations the two beams will be bent by magnets (since they carry a positive charge, protons can be deflected by magnetic currents) so that they collide. This, in effect, not only doubles the "impact" force – as compared with protons hitting a stationary target – but will greatly increase the number of particles colliding with other particles.

Although the completion of Isabelle is at least five years away, the pure research is already providing some practical applications. The power requirements of Isabelle are so great that the area's largest utility, Long Island Lighting Company, would be incapable of supplying the tremendous load necessary to operate it if current power-handling technology were employed. As a result, much of the research involving Isabelle has gone into superconductivity, a method of using very low temperatures to reduce electrical resistance.

Much of the power generated by an electric utility is lost simply as a result of the inherent resistance of wire and cable. It takes power to push power through a wire. Scientists have known for some time that most conductors gain efficiency (i.e., the amount of resistance is reduced) as the conductor is cooled. Scientists on the Isabelle project will be using magnets wound of a special metallic braid (an alloy of niobium and titanium), cooled by helium gas to 4.3° Kelvin, or some 4° above absolute zero. (Absolute zero, or −459.69° Fahrenheit, is the theoretical point where there is an absence of all heat.) Reducing the temperature of the magnets will lower the power requirements of the Isabelle accelerator to the point where its operation is feasible.

Long Island Lighting Company has been working with Brookhaven scientists on the practical applications of superconductivity of metals. For the utility the implications are obvious; if a practical method could be found to use similar technology for electrical distribution, total power consumption would be greatly reduced. Brookhaven personnel say there is no question that superconductive buried cable lies in the near future, thanks, at least in part, to the work being done at BNL.

The 140-foot radio telescope at Green Bank, West Virginia, is the largest equatorially mounted (fully steerable) telescope of its kind. The instrument, which took seven years to design and build, was completed in the spring of 1965 at a cost of $14 million



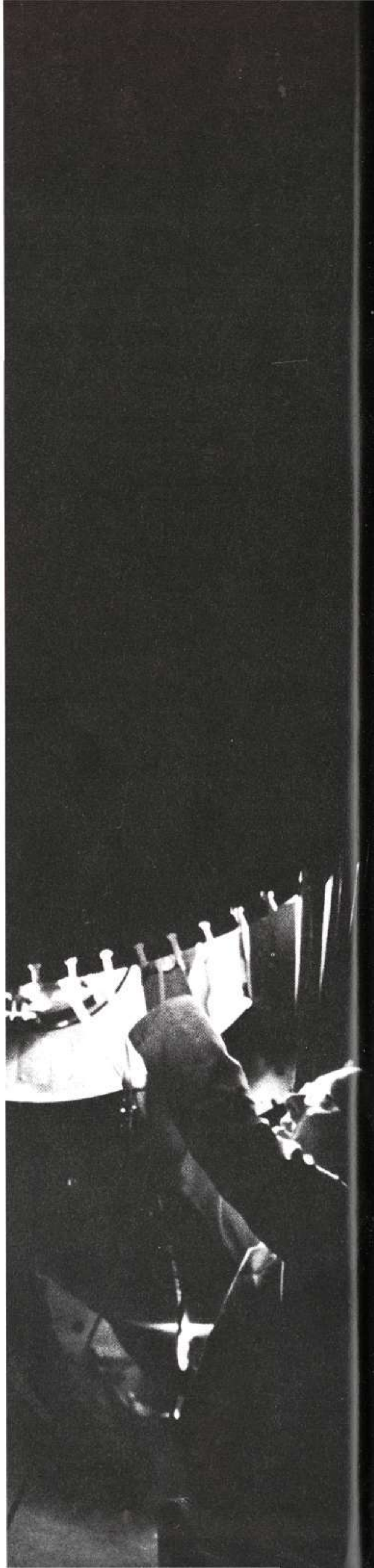
Long before scientists began scanning space for sound, the philosophers spoke of the music of the spheres. Today we know that space is not a vast, silent void. It is "alive" with sounds that radio astronomers can detect and interpret to understand our universe better.

One of the leaders in the field is National Radio Astronomy Observatory, the second operating unit of Associated Universities, Inc. Optical astronomers use light waves to make their measurements; radio astronomers use radio waves, which are similar to light waves but differ in wavelength. (For example, we cannot see the infrared and ultraviolet optical wavelengths except with special film or equipment, nor can we hear radio wavelengths without electronic circuitry to detect and amplify those signals.)

The mathematical theory of the propagation of radio waves was developed by the Scottish physicist James Clerk Maxwell in 1873, but it was not until the early 1930s that Karl Jansky, an engineer with Bell Telephone Laboratories in the United States, made the first measurements of radio signals coming from beyond the earth's atmosphere.

By the 1950s radio astronomy was being studied in several places in this country. In 1954 a group of radio astronomers met in Washington, D.C. and, following the meeting, sent a request to the National Science Foundation for the establishment of a national observatory at which large instruments could be built that would be available to all qualified scientists. The NSF asked Associated Universities to make the first study of the feasibility and usefulness of such an observatory. Following AUI's positive report, the National Science Foundation contracted with AUI to build and operate National Radio Astronomy Observatory.

Because radio telescopes are so sensitive to any form of electrical radiation, a relatively isolated location had to be found. The first site chosen was in Deer Creek Valley, near Green Bank, West Virginia. This site was chosen because of the shielding provided by the mountains bordering the valley, the small population of the valley and the limited amount of industrial development in the area. With the agreement of the Federal Communications Commission and the Inter-Services Radio



Technician and shift supervisor Chuck Carlson makes adjustment in interior of Brookhaven National Laboratory's tandem Van de Graaff accelerator. The electrostatic accelerators (two Van de Graaffs are used in tandem) recently boosted heavy ions to a new record high of 320 million electron volts.

Advisory Committee, a National Radio Quiet Zone was established which gives the observatory a voice in deciding whether new sources of radio transmission should be permitted to operate in the Quiet Zone. Further protection was given to the Quiet Zone by a special act passed by the State of West Virginia.

Although the bulk of NRAO's equipment is located in Green Bank, it also operates a thirty-six-foot radio telescope (the size refers to the diameter of the parabolic antenna) on Kitt Peak, near Tucson, Arizona, site of Kitt Peak National Observatory. The central offices, laboratories, library and computing center for NRAO are located on the grounds of the University of Virginia at Charlottesville, about 120 miles from Green Bank.

The science of radio astronomy has taken vast strides within the past fifteen years. While it has complemented optical astronomy and confirmed much of the knowledge gained from it, radio astronomy also has shown that there are many radio sources in the universe, including the sun, the moon and most of the planets, clouds of "excited" hydrogen and other gases within our galaxy, pulsars and double stars. Although at the surface of the earth the atmosphere tends to shield us at the short-wave end of the radio spectrum while the ionosphere shields us at the long-wave end, radio telescopes can still make good observations from about one millimeter (.039 inches) at the short end to thirty meters (98.4 feet) at the long end. The objective, of course, is not just to pick up the signals, but to convert these to the radio astronomer's equivalent of photographs.

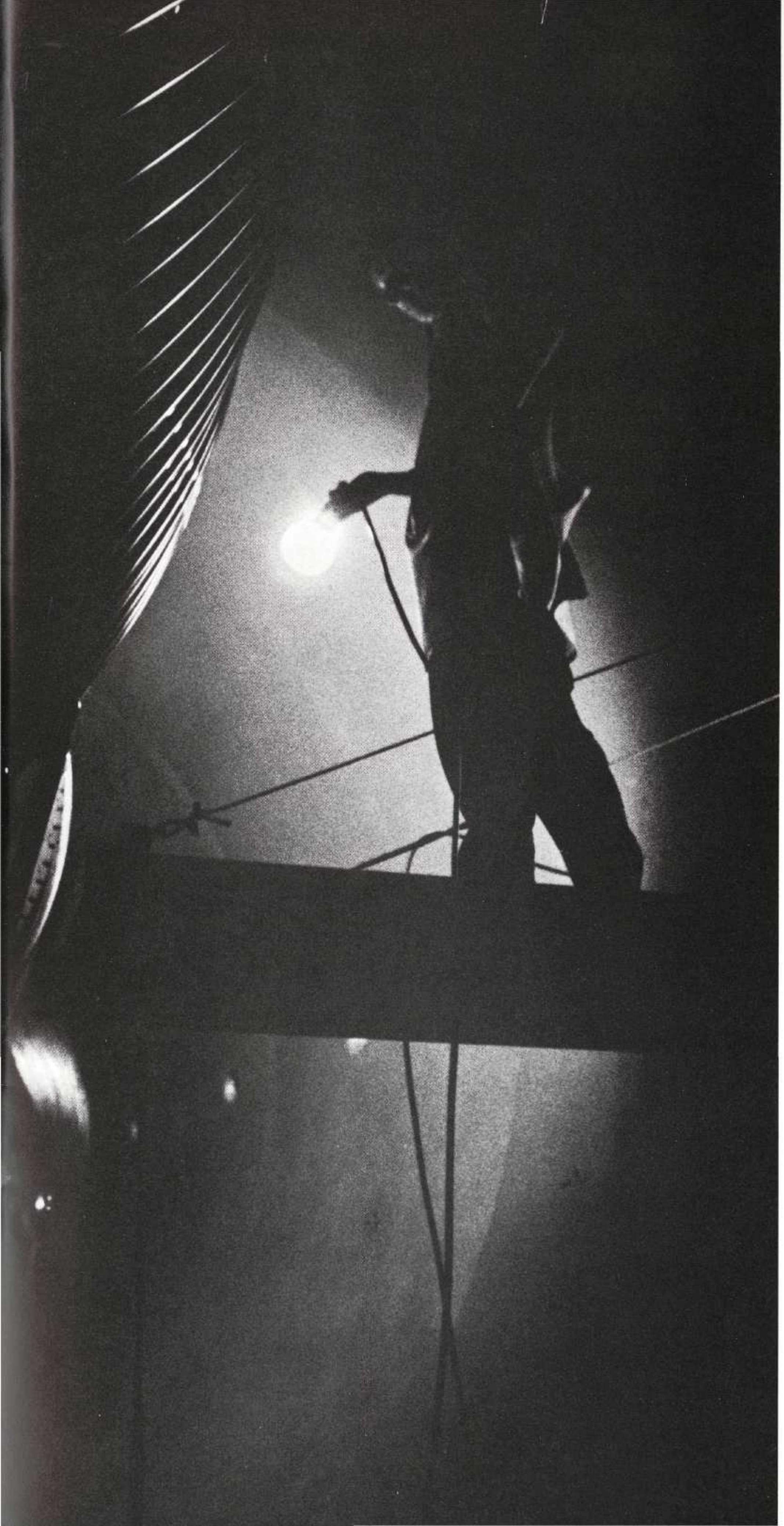
The effectiveness of the radio telescope is limited first by its size – the larger the size the greater the gathering power or sensitivity – and then by the smoothness of the surface of the reflector and its freedom from distortion. The 36-foot telescope on Kitt Peak, for example, is designed to work at wavelengths of a few millimeters, while the 140-foot telescope in Green Bank, the largest equatorially mounted (fully steerable) telescope in the world, has been used successfully at wavelengths near one centimeter (0.5 inch).

In addition to the 140-foot telescope, NRAO's Green Bank facilities include the 85-foot Howard E. Tatel telescope, first used in 1959; the 300-foot transit telescope, completed in 1962 and having an antenna surface area of 1.8 acres; and a movable 45-foot telescope used with a three-element interferometer.

The interferometer system, based on a rather simple mathematical principle, has proved one of the more flexible tools for the radio astronomer. If two or more radio telescopes are placed apart and each aimed at a source of radio waves (other than directly overhead), the waves will arrive at the antennas at slightly different times since the waves have to travel different distances to reach each antenna. These signals are then combined, "decoded" and interpreted. The advantage of the system is that it provides the ability to use a number of smaller telescopes to obtain signal resolution equal to that possible with a single, much larger antenna.

At Green Bank, the interferometer system uses three steerable 85-foot radio telescopes. One is the Howard E. Tatel telescope, which is fixed, while the other two can be moved on dollies along a 5,000-foot baseline to any of seven observing stations where they are anchored when in use. With such a system it is possible to get results that are said to be as complete in detail as would be obtained from a single telescope 5,000 feet in diameter.

The interferometer technique lies at the heart of NRAO's equivalent of Brookhaven's Isabelle, the Very Large Array (VLA) telescope being constructed at Socorro, New Mexico. The location was chosen because it offers a broad, flat valley about fifty



miles west of Socorro, surrounded by mountains, at a high altitude, with low radio noise and low water-vapor content in the atmosphere. Full operation of the facility, which will cost about $78 million, is expected by 1981.

When completed, the VLA telescope will consist of twenty-seven antennas, each having a diameter of twenty-five meters (approximately eighty-two feet) and weighing 210 tons. The antennas will be distributed along three arms of railroad tracks arranged in the shape of an equiangular Y. Two of the arms will be twenty-one kilometers long (about thirteen miles) and the third nineteen kilometers.

The railroad tracks permit the antennas to be transported to and from the seventy-two observing stations distributed along the arms, and the entire antenna system will be under the control of a central computer.

According to NRAO, "the great flexibility, versatility and power of the VLA will make it the premier instrument in the world for scientific research on the physics of radio sources beyond the Milky Way, on cosmology or the structure of the universe, on the structure and evolution of stars, and on the chemical constituents of gas clouds that lie between the stars." The VLA is, in fact, expected to produce within half a day radio "pictures" comparable in sharpness to optical photographs taken with the 200-inch Mt. Palomar telescope.

If the work done at Brookhaven and National Radio Astronomy Observatory presents dramatic contrasts, a reaching out to the universe and a search within the atom itself, the results are strangely parallel. The harmony and balance of atomic structure repeat those of the universe; the laws appear to hold for subatomic particles as well as for galaxies stretching to infinity. In the end, perhaps, it is the oneness that impresses the most, not the contrasts. ○