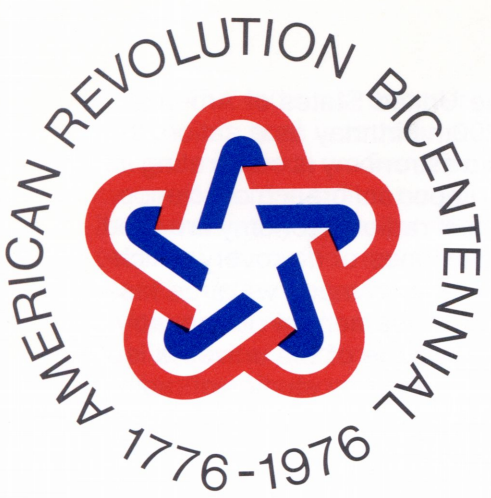


Historical Radio Telescopes at the National Radio Astronomy Observatory in Green Bank, West Virginia

Introduction

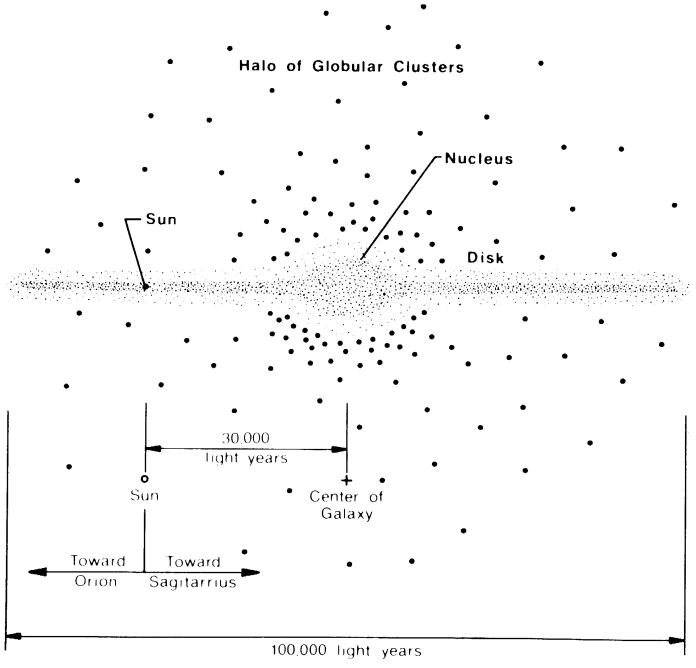
While the United States of America celebrates its 200th birthday as a nation, the new field of radio astronomy is celebrating its 44th year as an important branch of science. The early stages of radio astronomy are filled with exciting milestones of discovery which carry a history that is in many ways as fascinating as the development of our country.

Man's knowledge of the universe is gained almost entirely from studies of radiation emitted by celestial bodies. This radiation, ranging from gamma and x-rays, through ultraviolet, visible and infrared light to millimeter, centimeter and meter radio waves, constantly bathes our earth, carrying with it important information about the sources emitting the radiation. Radio astronomers attempt to collect, amplify and study this radiation at radio wavelengths in order to discover the nature of objects like quasars, pulsars, galaxies, stars, and clouds of interstellar gas. They are particularly interested in the origin and the evolution of these celestial systems and desire to gain an understanding of the physical mechanisms that make them "shine". Among the goals of modern research in radio astronomy is the knowledge of how life originates in the universe and how the universe itself was formed, how it expands and, ultimately, how it will end.

The radio astronomer does basic research; his goal is to map and describe the universe in which we live. The ultimate application of his research to everyday life may not be immediately apparent. Yet certain very practical "spin-offs" have recently taken place, chief among which are the application of low noise receiver systems for the detection of cancer and forest fires, the development of radio sextants for navigation in bad weather, and the application of radio interferometers to aid in earthquake forecasting.

It is appropriate at this Bicentennial time to present three early radio astronomical antennas and to point out the contributions that each has made to the science. These three instruments are the Jansky Antenna, the Reber Antenna and the Ewen-Purcell Horn Antenna. The National Radio Astronomy Observatory is fortunate to have these historical structures located near the entrance to its site in Green Bank, West Virginia.

The purpose of each of these antennas is to collect radio waves from space. In general, a larger antenna collects a greater signal strength from a radio source and is more highly directional in order to locate the source in the sky. Early antennas and receivers were barely adequate to make discoveries. Modern antennas, such as the main research instruments seen elsewhere at Green Bank, enable radio astronomers to observe fainter sources, far out in the universe.

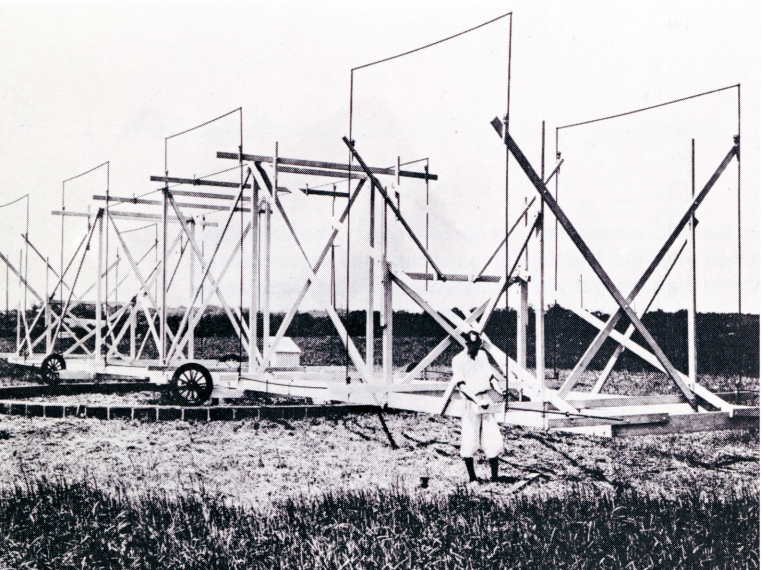


A schematic representation of our own galaxy, the Milky Way, viewed edge-on. The dark area indicates the region where most of the stars, gas and dust are concentrated. Both Jansky and Reber demonstrated that cosmic radio waves were concentrated along the Milky Way and were most intense in the direction of the galactic center toward the constellation Sagittarius. In 1951, Ewen and Purcell first observed the 21-cm spectral line of hydrogen located in the space between the stars.

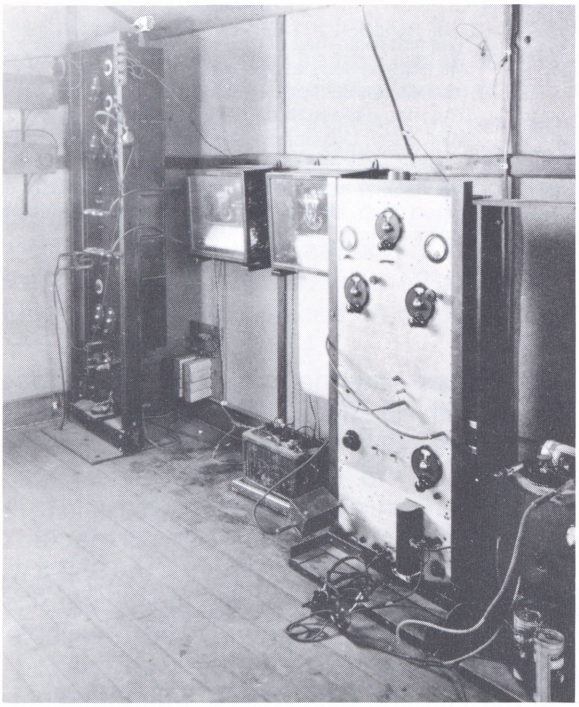
The Karl Guthe Jansky Antenna (Replica)

This antenna, 100 feet long and 12 feet high, is located to the right of the Green Bank site entrance. It is mounted on four wheels and runs on a circular, horizontal track in order to locate a source on a particular compass bearing. Designed in 1929 and used in 1930-32 by Karl G. Jansky at the Bell Telephone Laboratories to study sources of radio interference on transoceanic radio telephone circuits, this antenna first detected local and distant thunderstorms. In January 1932 Jansky discovered a weak, steady, hissing static at 20.5 MHz whose direction of arrival travelled across the sky at the same rate at which the stars moved. The maximum intensity of the new radiation increased as the Milky Way passed through the beam. Jansky's discovery founded the science of radio astronomy and opened a radio window in the electromagnetic spectrum that now extends from 1 millimeter to 30 meters wavelength, from 150 to 300 times as wide as the visible spectrum window. The replica of Jansky's antenna was dedicated at Green Bank by the Bell Telephone Laboratories in 1966.

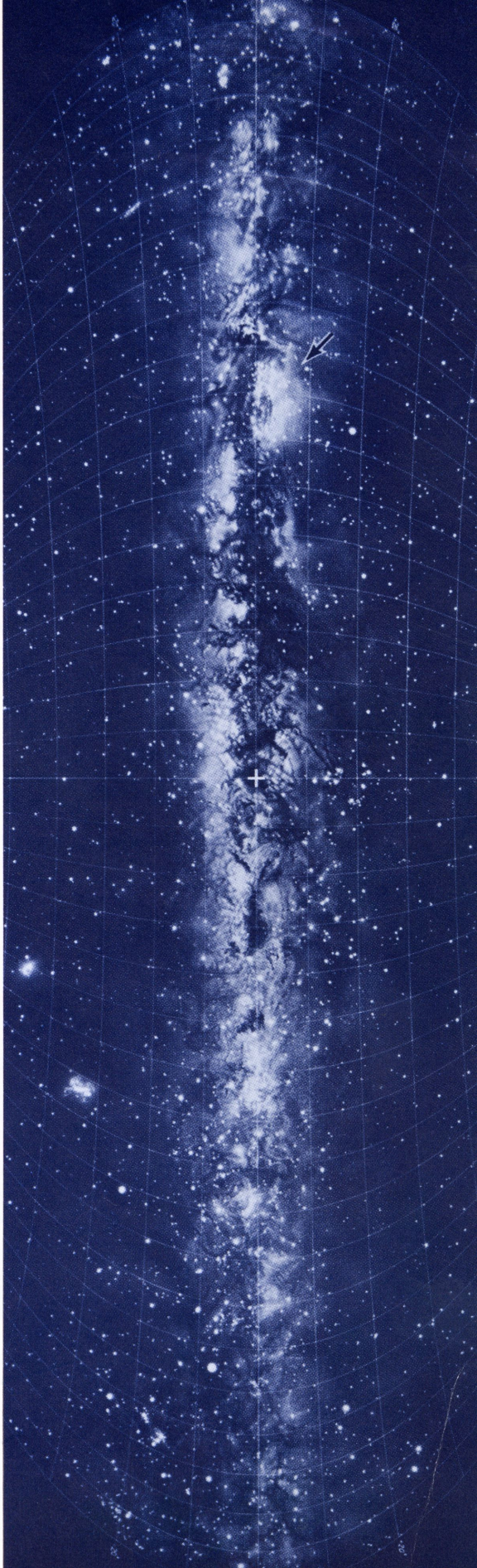
Historic photograph of the late Karl Guthe Jansky and the short-wave rotating antenna array with which he made the first observations of radio waves of extraterrestrial origin at the field site of the Bell Telephone Laboratories in Holmdel, New Jersey. (courtesy Bell Laboratories)



Jansky is shown pointing to the position on a chart where radio noises from space were first recorded. Jansky's original radio field measuring apparatus appears below, with the short-wave receiver on the right and the recorders in the center. (courtesy Bell Laboratories)

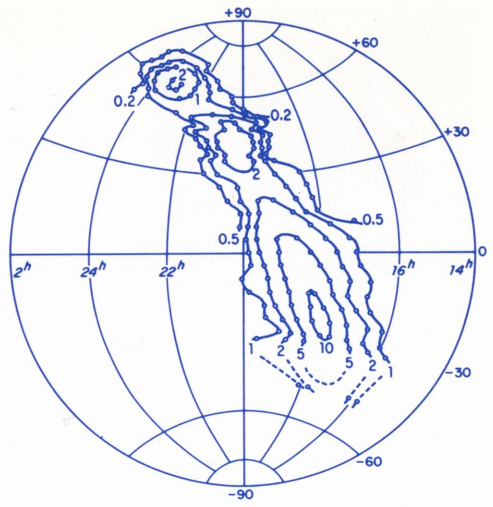


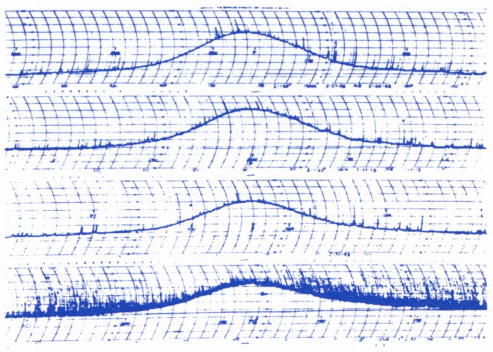
The intricate and beautiful structure of the Milky Way is displayed in this drawing made in Sweden . The course of the Milky Way around the entire sky is shown. Near the top of the picture are the bright regions in Cassiopeia and Cygnus. In the middle is Sagittarius and the direction of the galactic center. (courtesy Lund Observatory, Sweden)



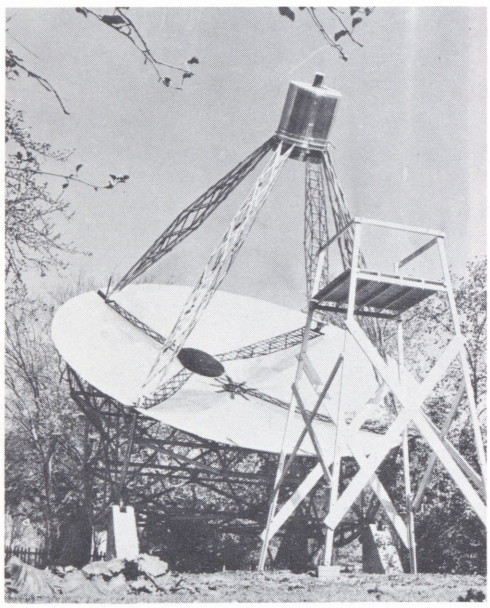
The Grote Reber Parabolic Antenna

This 31.5 foot, alt-azimuth antenna was originally constructed as a transit telescope by an electrical engineer, Grote Reber, in his back yard in Wheaton, Illinois. Built for about $4000 in 1937 in order to further Jansky's discovery, the Reber Antenna achieved its first success in 1939 at 160 MHz. Reber observed mainly at night and on weekends, and conducted a survey of the sky during 1941-44, switching to 480 MHz in 1944-47. His parabolic antenna had the ability to investigate cosmic static at different frequencies and at different directions in the sky. Reber confirmed that radiation comes from the Milky Way and his maps also showed intensity maxima at various parts of the sky, now known to be discrete sources such as Cygnus A. Reber detected solar bursts that became more frequent as the sunspot maximum approached.





The first radio map of the sky, plotted by Reber from his observations at 160 MHz in 1943, and four records of galactic radio emission, are shown above. The map defines three distinct radio sources in the Milky Way: Cassiopeia A is at the upper left, Sagittarius A (a strong radio source toward the center of the Galaxy) at the lower right, with Cygnus A between them, all superimposed on the general radio emission from the Milky Way.

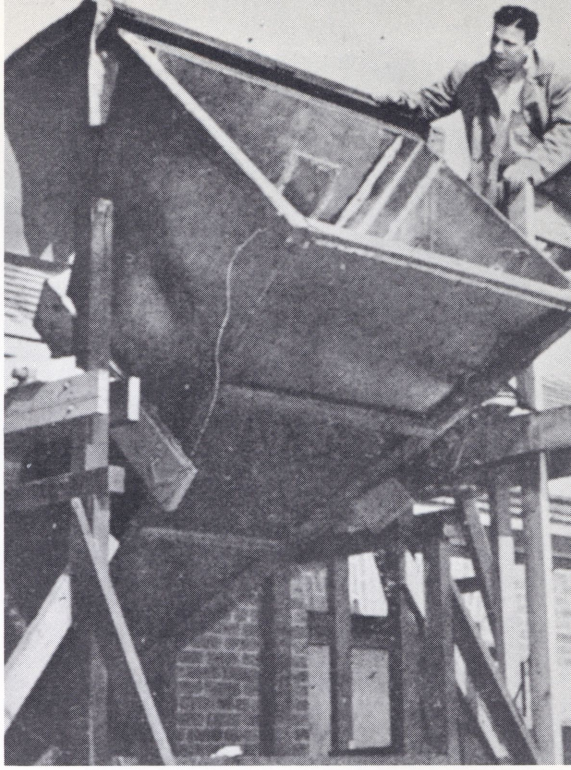


Reber's telescope, shown in its original location in his back yard in Wheaton, Illinois, was the first parabolic antenna specifically designed for radio astronomical observations. Many modern radio telescopes bear a striking resemblance to this early instrument.

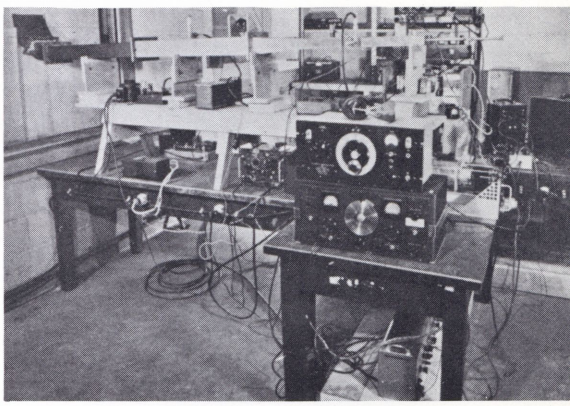
The Reber Antenna, mounted on a wooden frame with a surface of 26 gauge galvanized iron sheet, has a moving weight of almost two tons above the turntables. The telescope ceased observing in 1947 and was sold to the Bureau of Standards where it was erected on a turntable in Sterling, Virginia. In 1952 it was disassembled and shipped to Boulder, Colorado. Finally in 1958 it was made available to NRAO, where, in 1959-60 it was erected under Reber's supervision. Many original pieces were duplicated and it now stands on its 1947 turntable to the left of the Green Bank site entrance. In 1972 the antenna was listed on the National Register of Historic Places by the Antiquities Commission of the State of West Virginia.

The Ewen-Purcell Horn Antenna

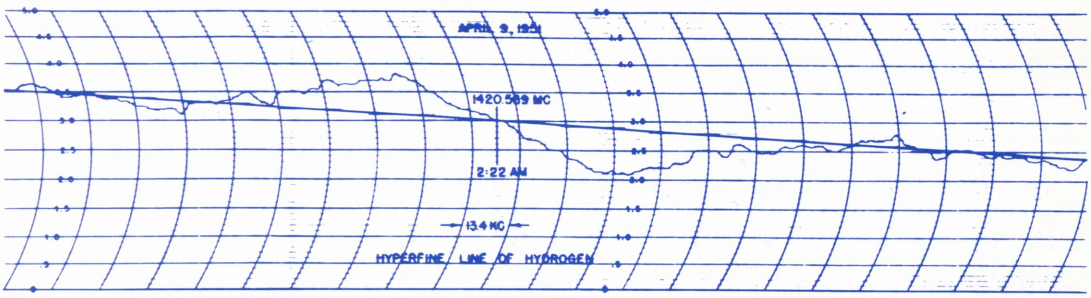
The celestial 21-cm spectral line of neutral, atomic hydrogen gas was discovered by a Harvard graduate student, Harold I. Ewen, and his thesis advisor, Nobel Prize winner Edward M. Purcell in March 1951. The Horn Antenna located on the lawn of the Jansky Laboratory at Green Bank was used for the discovery. For twelve years it was the only celestial radio spectral line known. Hydrogen is the most abundant element in the universe and is the predominant gas lying between the stars in the Milky Way. In 1944 the Dutchman H. C. van de Hulst predicted that this gas should emit a discrete spectral line at 1420 MHz (21-cm wavelength). Seven years later the line was discovered and radio astronomers began to map the intensity, velocities, and locations of hydrogen gas clouds throughout the Milky Way. Unlike light waves, radio waves are not absorbed by interstellar dust and hydrogen gas can be mapped to the far reaches of our Galaxy. Today, through studies of many dozen molecular lines emitted from gas clouds in space, radio astronomers are able to determine the masses, motions and physical conditions in gas concentrations not only in the Milky Way, but also in other galaxies. After the discovery of the hydrogen line in 1951, the Ewen-Purcell Horn spent a number of years at Harvard's Agassiz Station after which it was sent to NRAO in the early 1960's. It was placed on display in Green Bank in late 1974.



H.I. Ewen adjusts the pyramidal horn antenna with which he first detected 21-cm radiation from the Milky Way. The horn, on the fourth floor of Harvard's Lyman Laboratory, was fixed in position and pointed south at a declination of -5 degrees. Below is a view of Dr. Ewen's equipment set up for the 21-cm experiment. The waveguide connecting to the horn shown above comes in the window to the left. (courtesy Sky and Telescope)

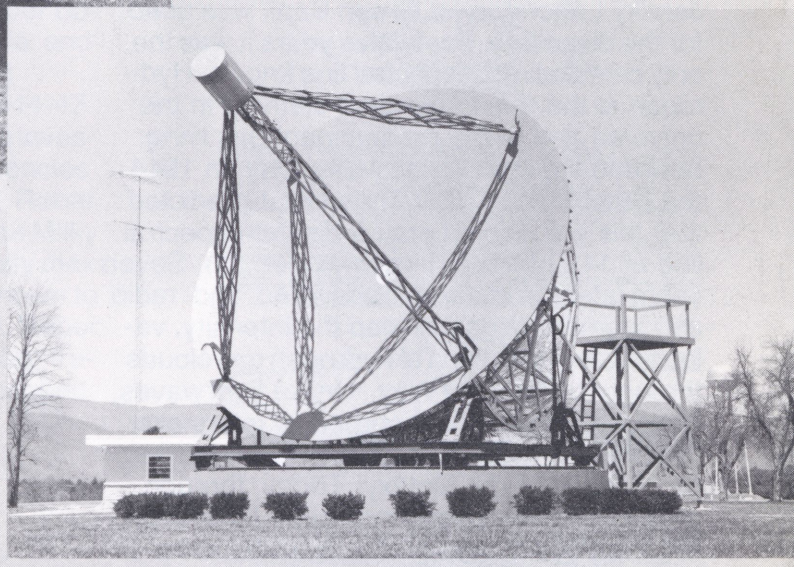


Below is a chart recording of the 21-cm radio spectral line of hydrogen, taken on April 9, 1951, 2:22 a.m., at 1420 MHz. The line was first detected on March 25, 1951. (courtesy Harvard University)



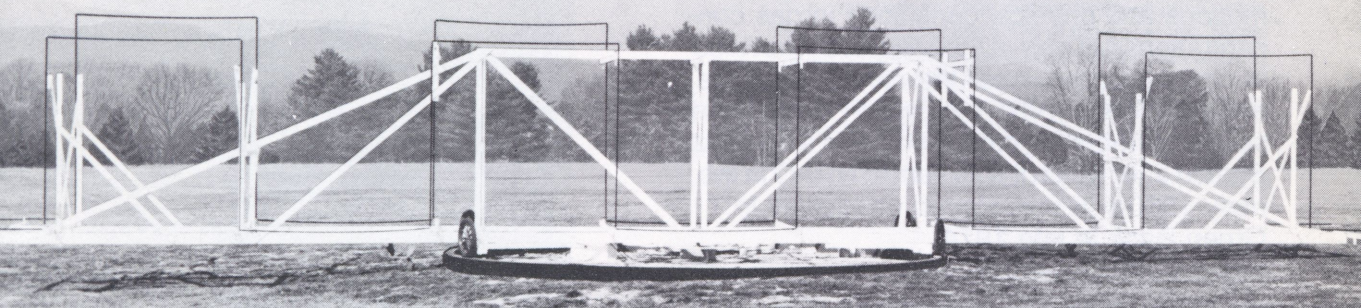
EWEN

PURCELL



JANSKY

REBER



HISTORICAL RADIO TELESCOPES ON SITE
IN GREEN BANK, WEST VIRGINIA

ASSOCIATED UNIVERSITIES, INC.
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