

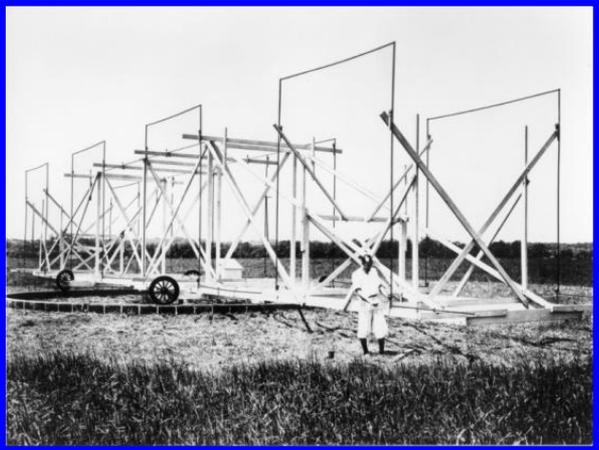


Bell Laboratories



AT&T
Bell Laboratories

Bell Labs



**and
its**



Radio Astronomy Legacy



Lucent Technologies
Bell Labs Innovations

Bob Hayward
NRAO Senior Engineer (Retired)
Socorro, NM

30 November 2013



Alcatel·Lucent

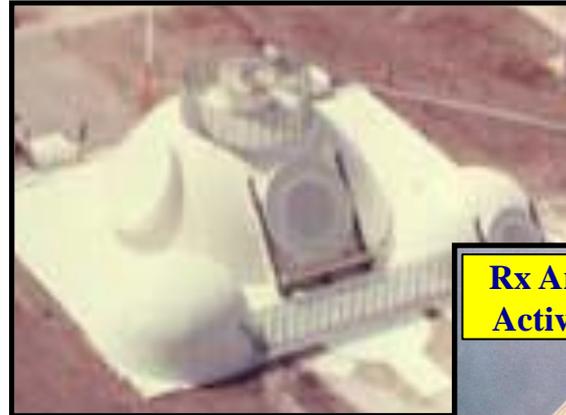
My interest in Bell Labs stems from researching...

MUSA (5-20 MHz)...

Multiple Unit Steerable Antenna

...and the Colgate Paramp

Nike-X MAR-I
Multifunction Array Radar (Prototype)
WSMR, NM (1963)



To England

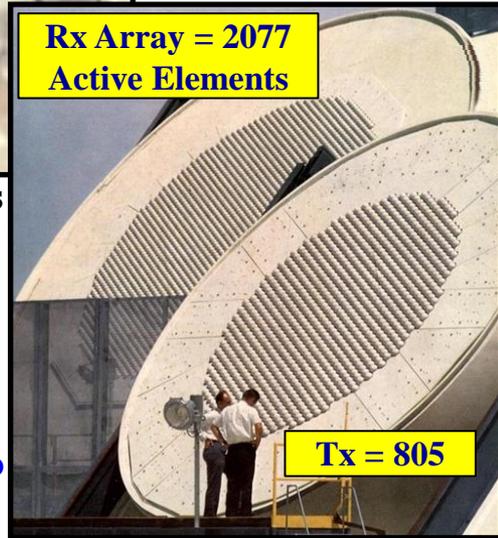
1935

Steerable in Elevation

3/4 mile Array

6 Rhombic Antennas

Terminal Building



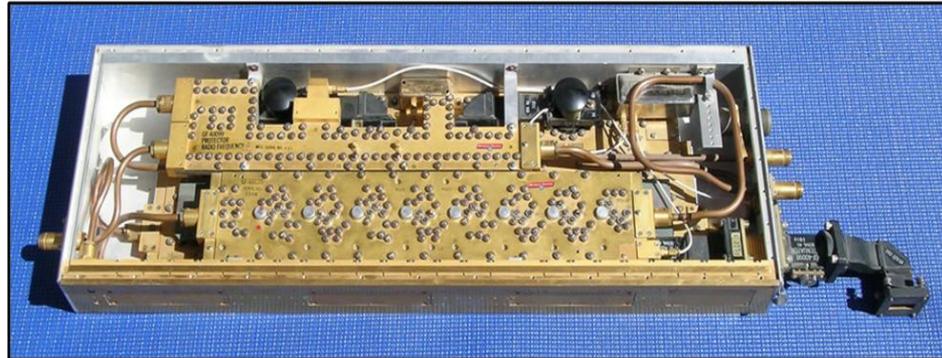
Rx Array = 2077 Active Elements

Tx = 805

It was designed at Bell Labs & built by Western Electric

The MAR-I was the first "hardened" ABM phased-array radar (1.2-1.4 GHz).

It was the source of the 280 "Colgate Paramps" that were distributed by NMT to radio observatories around the world.



MAR-I Photo courtesy of Doyle Piland, WSMR Archive
What Price Nike-X?, FORTUNE Magazine, Nov 1965
Paramp Photo by R. Hayward

The first electronically steerable antenna which was used for transatlantic telephony was built by BTL.

It was also the first radio interferometer to (accidentally) detect emission from a celestial source (Cygnus).

A Multiple Unit Steerable Antenna for Short-wave Reception, H.T. Friis & C.B. Feldman, Proceedings of the Institute of Radio Engineers, Vol. 25, No. 7, July 1937, p. 841-917

Karl Jansky & “Star Static”



Karl Jansky with his antenna

- Karl Jansky joined Bell Labs in 1928.
- He was assigned to investigate sources of atmospheric static that might interfere with short-wave (3-30 MHz) telephone radio links that were being used for transatlantic telephone communications.
- While listening for the noise coming from thunderstorms, he discovered...
 - *“noise of extraterrestrial origin”*
- He was to refer to it in his published papers as *“star static”*.
- His famous - albeit serendipitous - discovery was made in 1932.
- Karl Jansky is now recognized as the *Father of Radio Astronomy*.

Jansky's Antenna

DIRECTIONAL STUDIES OF ATMOSPHERICS AT
HIGH FREQUENCIES*

KARL G. JANSKY

(Bell Telephone Laboratories, New York City)

December, 1932

Frequency

14.6 meters

OR

20.5 MHz

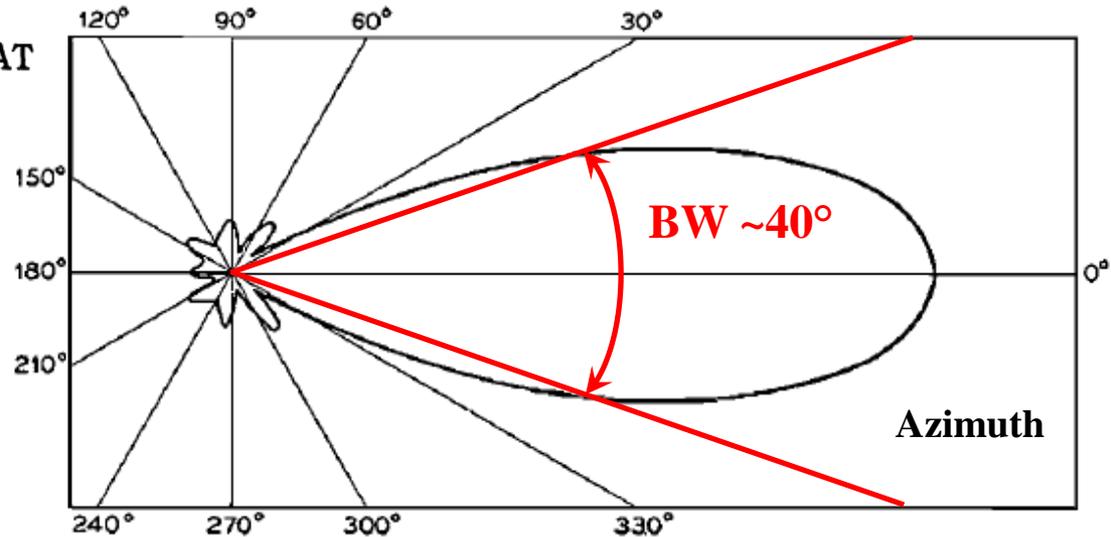
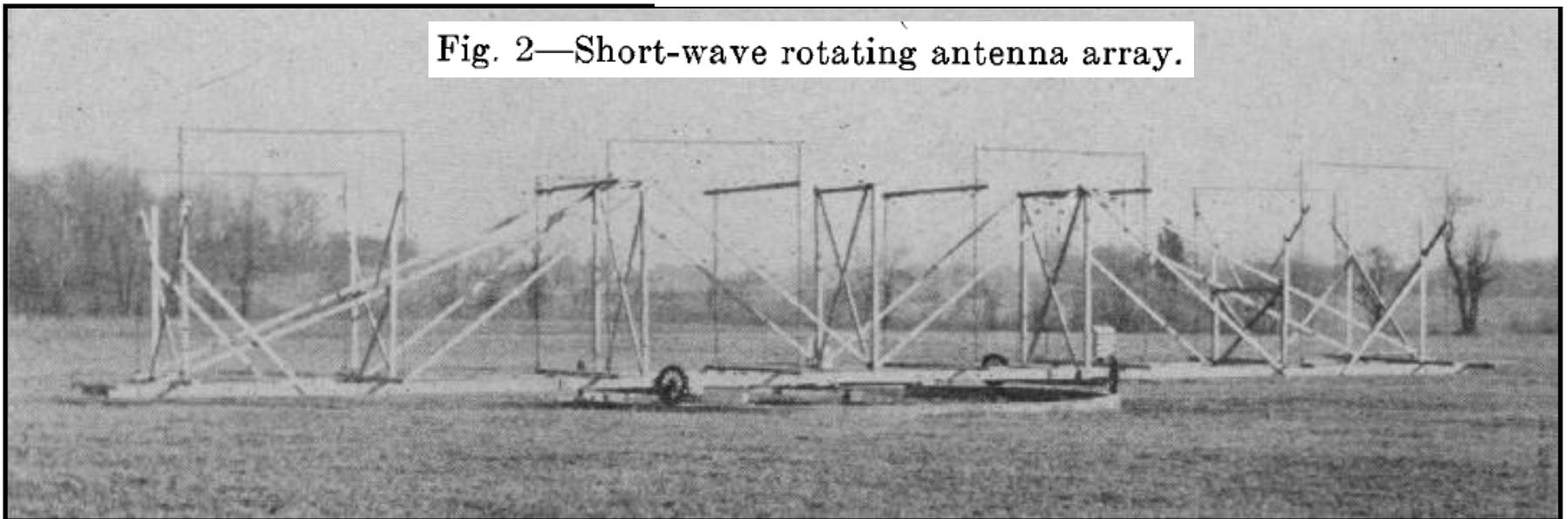


Fig. 3—Directional characteristic of array at 14.6 meters.

Fig. 2—Short-wave rotating antenna array.

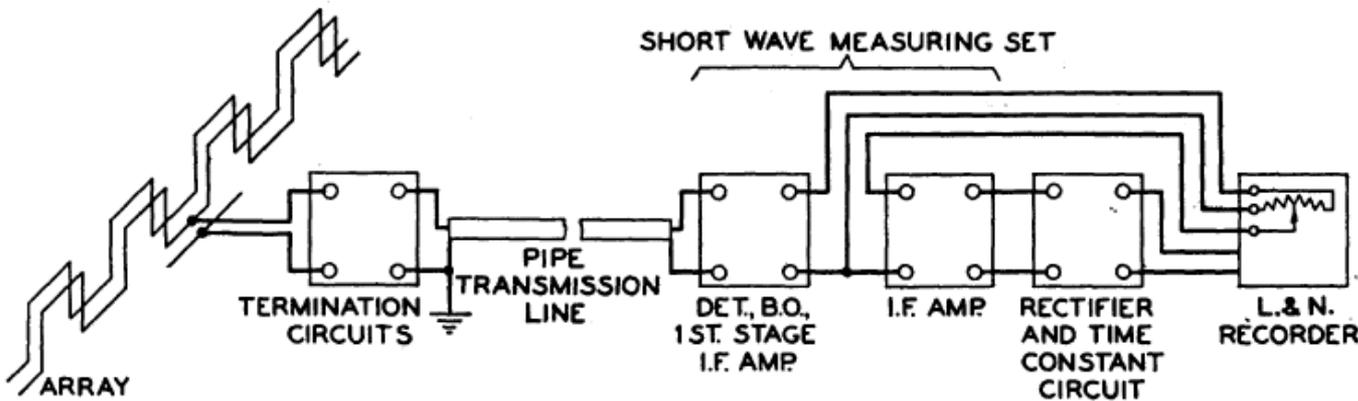
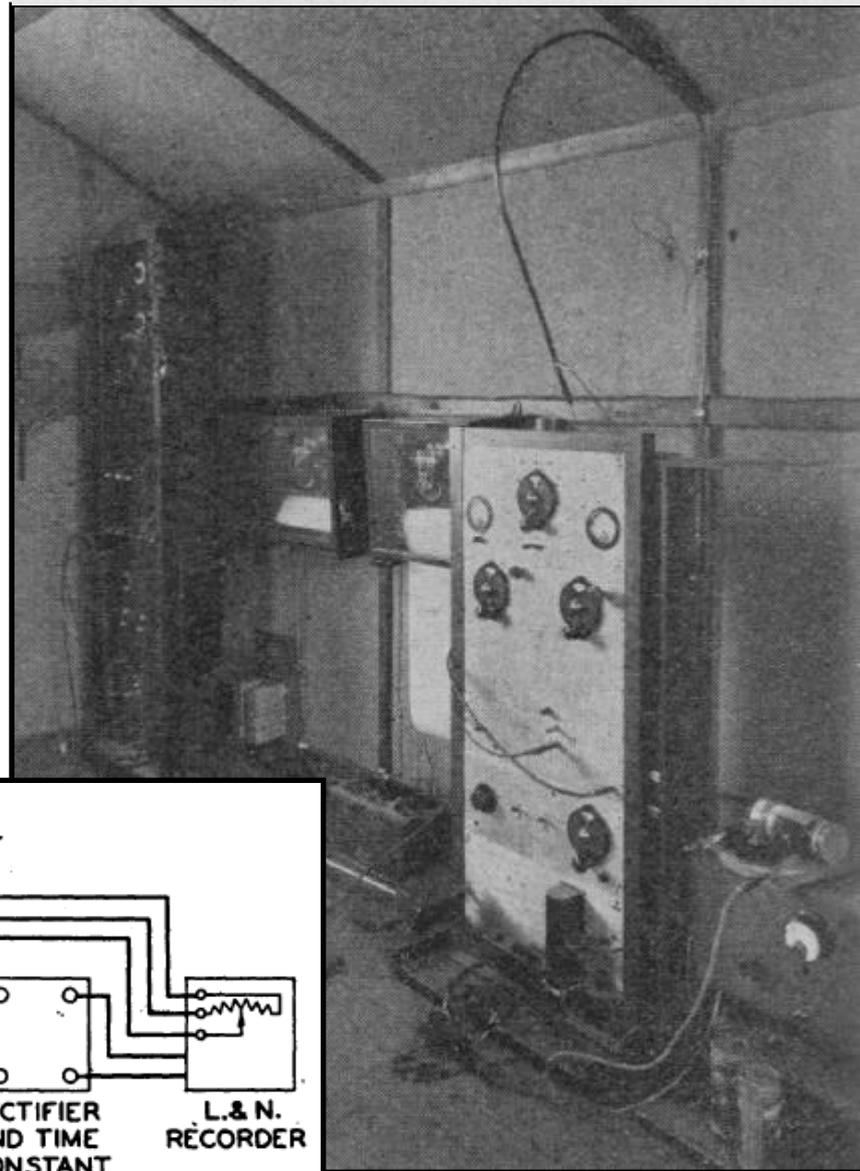


Jansky's Receiver

DIRECTIONAL STUDIES OF ATMOSPHERICS AT HIGH FREQUENCIES*

While Jansky's equipment was very primitive by today's standards, it was still up to the task for his serendipitous discovery of what he was to call "*star static*".

The experiments which have been described in this paper were carried out at Holmdel, New Jersey. The writer wishes to acknowledge his indebtedness to Mr. Friis for his many helpful suggestions.



SCHMATIC DIAGRAM OF SHORT WAVE STATIC RECORDING SYSTEM

SERENDIPITOUS DISCOVERIES IN RADIO ASTRONOMY

W. T. Sullivan, III
University of Washington

20.5-MHz Recording for September 16, 1932

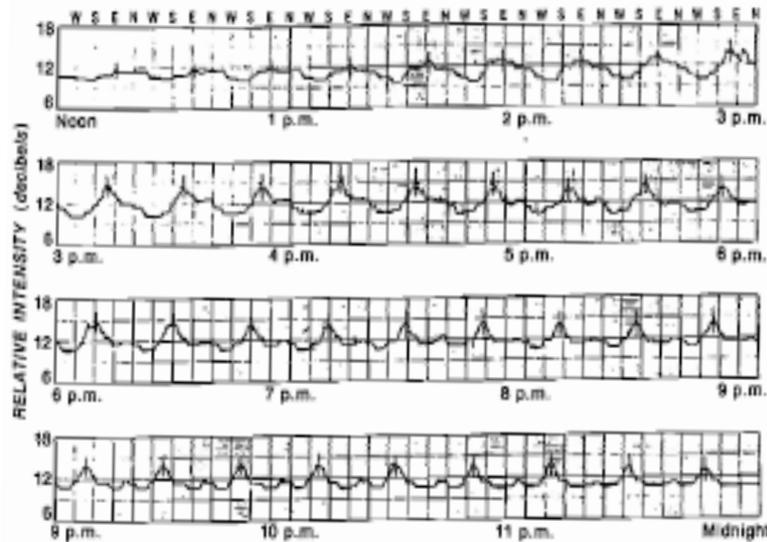
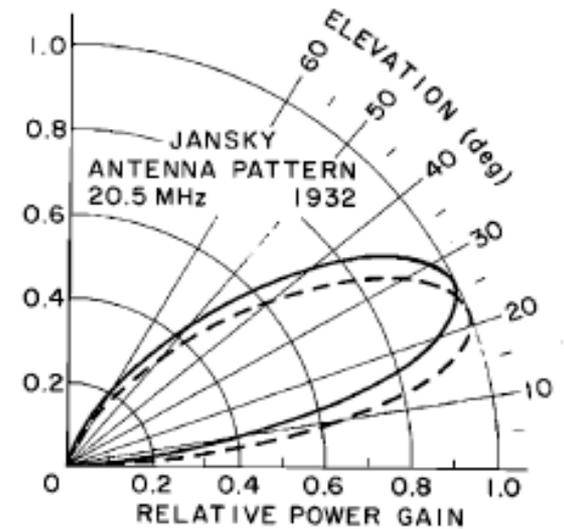


Fig. 5. Strip chart recording of Sept. 16, 1932.

Fig. 6. Top: calculated vertical antenna pattern



JANSKY
20.5 MHz
16 SEPT 1932

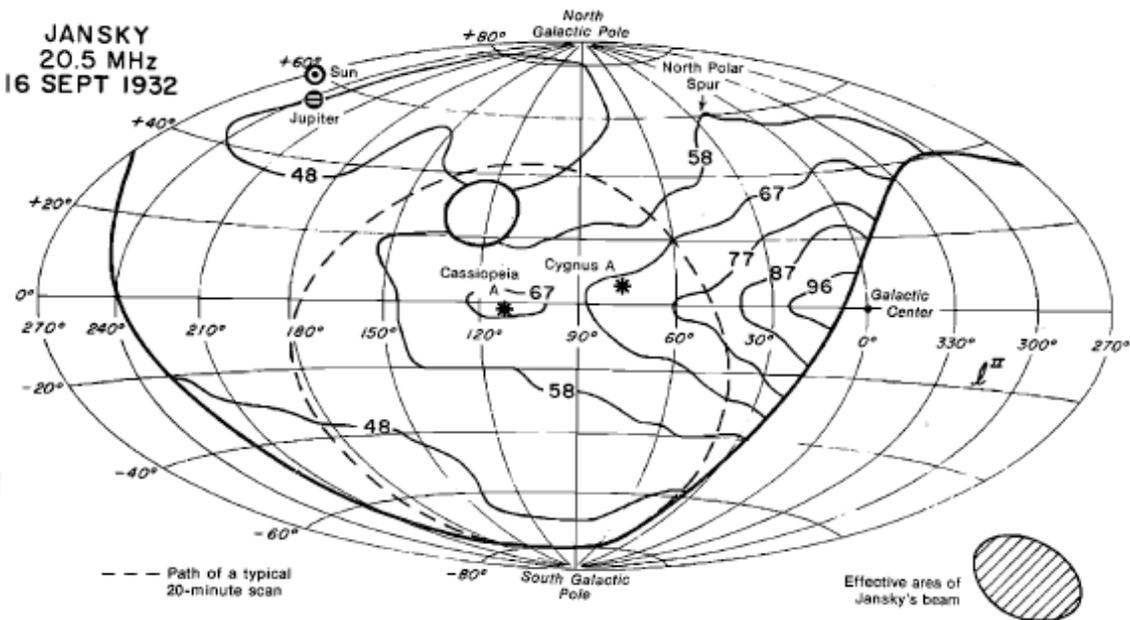


Fig. 7. Sky brightness temperature distribution derived from one day's observations. Each contour level corresponds to ~ 1000 K in brightness temperature.

Karl Jansky and the Beginnings of Radio Astronomy,
W. Sullivan, in *Serendipitous Discoveries in Radio Astronomy,*
K. Kellermann & B. Sheets, NRAO, 1983, p.39-56

The New York Times

LATE CITY EDITION
WEATHER—Fair today; tomorrow cloudy, probably rain.
Temperature—Friday, 61, 66, 61.

Copyright, 1933, by The New York Times Company.

VOL. LXXXII... No. 27,498.

Printed at No. 107 West Street, New York, N. Y.

NEW YORK, FRIDAY, MAY 5, 1933.

F

TWO CENTS

THREE CENTS IN THE COUNTRY
FOUR CENTS OUTSIDE THE COUNTRY

NEW RADIO WAVES TRACED TO CENTRE OF THE MILKY WAY

Mysterious Static, Reported by K. G. Jansky, Held to Differ From Cosmic Ray.

DIRECTION IS UNCHANGING

Recorded and Tested for More Than Year to Identify It as From Earth's Galaxy.

ITS INTENSITY IS LOW

Only Distance Recorder Is Able to Register—No Evidence of Interstellar Signaling.

Discovery of mysterious radio waves which appear to come from the centre of the Milky Way galaxy was announced yesterday by the Bell Telephone Laboratories. The discovery was made during research studies on static by Kurt G. Jansky of the radio research department at Morristown, N. J., and was described by him in a paper delivered before the International Scientific Radio Union in Washington.

The galactic radio waves, Mr. Jansky said, differ from the cosmic rays and also from the phenomenon of cosmic radiation, described last week before the American Philosophical Society at Philadelphia by Dr. Vesto M. Slipher, director of the Lowell Observatory at Flagstaff, Ariz.

Unlike the cosmic rays, which come from all directions in space, does not vary with either the time of day or the time of the year, some may be either a pulsation or an electron, the galactic waves, Mr. Jansky pointed out, seem to come from a definite source in space, vary in intensity with the time of day and time of the year, and are definitely electromagnetic waves that can be picked up by a radio set.

New Waves Show High Frequency

The waves radiation discovered by Dr. Slipher is a mysterious form of light apparently radiated independently of starlight, and is

Flier Asks Blame in Crash, But Inquest Absolves Him

By The Associated Press.
LONDON, May 4.—A distraught attempt to secure responsibility for the fatal crash of a Royal Air Force plane on May 1, in which Lieutenant Kneeborn, pilot, and Aircraftman Harrison lost their lives, was made by Flight Lieutenant Eric Hobson at the inquest today. Despite Lieutenant Harrison's assertion, a verdict of "death due to mechanical failure" was returned.

Lieutenant Hobson, the leader of the section of which Lord Kneeborn was a member, described how he unconsciously lost his height and at the end of a 1,000-foot dive got dangerously near the ground.

KIDNAPPERS URGED TO ANSWER PLEAS

New Yorker Named to Act as Secret Agent for Return of McMath Child.

FRIEND READY AS HOSTAGE

Watch Kept at Detroit and in Tryon, N. C.—Massachusetts Police Refuse 'Armistice.'

News in the New York Times.
NEW HAVEN, Conn., May 4.—Dependent on the failure of all attempts to establish a contact with the kidnapers of Margaret McMath, abducted from her school here Tuesday, William Lee, spokesman for the family, tonight offered himself as a hostage to those who had taken the girl.

BIG NEW INVASION PLANNED BY JAPAN ON ROAD TO PEIPING

Larger-Scale Offensive Than Last Is Announced to Open Soon in North China.

CHIANG RUSHES AID NORTH

Famous Units That Fought at Shanghai Are Dispatched to Help 50,000 at Front.

BRITISH QUIT MANCHURIA

Concerns Avert the Open Door in Commerce to Be Being Rapidly Shut Against Foreigners.

By HALETT AREND.
News in the New York Times.

TIENTSIN, May 4.—Partially replying Japan's plans for renewed military invasions in North China, as official spokesman at the headquarters of the military attaché said today.

"Active preparations are under way for an attack on a much larger scale than ever before, especially through the participation of airplanes."

The main invasion is planned from Kopei Pass through Miyak, said the spokesman, frankly revealing that the advances principally sought were 50,000 of General Chiang Kai-shek's own troops at present in the Miyak area under the direct command of General Ho Ting-ching, the War Minister.

Including the Japanese assault was included for "a very early date," the spokesman admitted that another simultaneous engagement was likely south of other portions of the Jehol frontier.

"Defensive action has become necessary," he added. "The present ambiguous situation has lasted long and become intolerable."

Hope was expressed that the United States and Europe would not misinterpret the motives for Japan's actions.

Tientsin Is Charged.

League Reserve Cut Million By Drop in Dollar Value

World Gold in Two Year Test Runs.
GENEVA, May 4.—The League of Nations supervisory committee approved today after finding its already difficult task of balancing the League's \$4,000,000 budget made much harder by the dollar leaving gold.

Practically all of the League's reserves, totaling \$1,000,000, are kept in dollars. When the bank conversion was proclaimed, League officials after consulting bankers, decided to trust in the dollar. They have now sustained a paper loss of nearly \$1,200,000 and have had to exchange part of the reserve at a loss of between 12 and 20 per cent.

FARM BILL CLAUSE BLOCKS AGREEMENT

Conferees Reach Accord on All Except the Cost-of-Production Section.

PEEK SLATED FOR TASK

Illinois Equipment Maker Is Roosevelt's Choice to Be Administrator.

News in the New York Times.

WASHINGTON, May 4.—Senate and House conferees reached a complete agreement on all parts of the farm relief bill today except the cost-of-production section. The clash over the one section will force reconsideration of the measure in the House on Monday, with consequent delay of the legislative program contemplated in an amendment to the measure.

While the conferees were discussing the measure it became known that administration of the broad powers contained in the bill is expected to be entrusted to George H. Peck, a farm equipment manufacturer of Moline, Ill. Mr. Peck

ROOSEVELT ASKS PAY RISE FOR WORKERS; PROMISES TO HELP BUSINESS END CHAOS; HE SENDS RAILROAD BILL TO CONGRESS

RAIL PROGRAM WIDENED

Recapture Repeal Made Retroactive Under a Far-Reaching Plan.

RATE-MAKING RULE EASED

And I. C. C. Jurisdiction Would Be Extended to Embrace Holding Companies.

HEARINGS TO OPEN SOON

President Asks Swift Action, but Amendments in Senate Are Indicated by DILL.

News in the New York Times.

WASHINGTON, May 4.—Broadened to provide retroactive repeal of the recapture features of the interstate commerce act, a more flexible rule of rate-making and extension of the jurisdiction of the Interstate Commerce Commission to include holding companies, the administration's emergency railroad program was introduced in Congress today, along with a message from President Roosevelt asking adoption during the present session.

The President cited in the message the lack of available traffic to utilize fully existing railway facilities, together with the supplementary services provided by new forms of transportation. The former, he said, "will constitute the main articles of commerce in the United States," although all transportation agencies would eventually have to be so conditioned to

Features of Railroad Bill

WASHINGTON, May 4.—High lights of the administration's emergency railroad bill, transmitted to Congress today, are as follows:

Title I provides for the creation of the office of Federal Coordinator of Transportation, the coordinator to be appointed by the President with the advice and consent of the Senate or designated by him from the membership of the Interstate Commerce Commission.

The primary purpose is to provide the railroads with means for remedying their problem by themselves through joint agreements. To this end the bill sets aside the application of the anti-trust laws and all other Federal and State statutes which would operate to prevent accomplishment of its purpose.

The railroads are divided into Eastern, Southern and Western groups, with a coordinating committee of five members selected by the railroads for each group.

Where agreements on pooling were not voluntary, the committee would recommend to the Federal coordinator orders requiring compliance by the roads. Appeals to the Interstate Commerce Commission against such orders are provided for.

The rights of collective bargaining are preserved for the labor unions and the bill would not modify contracts entered into under the railway labor act.

The bill extends the jurisdiction of the Interstate Commerce Commission to include holding companies, and authorizes the commission to require the divestment of securities when their possession is subversive of the consolidation plan.

It provides for the retroactive repeal of the recapture provisions of the Interstate Commerce act, under which the railroads have incurred an excess income liability of some \$40,000,000. Over \$10,000,000 of such revenues in excess of the fair return of 4 per cent recaptured by the government would be returned to the roads.

A more flexible rule of rate-making is provided under which rates should enable the railroads to earn a "fair return" on their investment. The new rule would enable the commission to take into consideration the effect of rates on the movement of traffic and "the need of revenues sufficient to enable the carriers, under honest, economical and efficient management, to provide such service."

BRITISH DEMANDING TARIFF SAFEGUARDS

ITALIANS NOW BACK BRITISH ARMS PLAN

MacDonald Tells Commons He Jung Tells Roosevelt Rome

PRESIDENT TELLS OF GAINS

Chamber of Commerce Is Asked to Cooperate on Three Points.

NATIONAL UNITY URGED

Prosperity Held Possible Only if All the Branches of Industry Recover.

GOVERNMENT AID PLEDGED

Unfair Competition and Out-thrust Prices Must Be Fought, He Says.

Part of President Roosevelt's speech is printed on Page 1.

News in the New York Times.

WASHINGTON, May 4.—President Roosevelt took an optimistic view of the industrial situation based on the recent rise in commodity prices and industrial output, in a speech tonight before the Chamber of Commerce of the United States. He also renewed his promise of providing the leaders government cooperation in strengthening and modernizing industry, wages, production and working conditions.

Coming after many of the outstanding business men of the country had expressed their doubts but a greater industrial cooperation to stimulate industrial activity, and the restoration of their hope for the legislation of trade agreements

May 5, 1933

The New York Times

"WWWH" - Headlines:

**NEW RADIO WAVES
TRACED TO CENTRE OF
THE MILKY WAY**

**Mysterious Static, Reported
by K. G. Jansky, Held to
Differ From Cosmic Ray.**

**DIRECTION IS
UNCHANGING**

**Recorded and Tested for
More Than Year to Identify
It as From Earth's Galaxy.**

**Only Dedicated Receiver is
Able to Register**

**No Evidence of Interstellar
Signalling.**

ITS' INTENSITY IS LOW

<http://daggy.name/cop/effluvia/jansky.htm>

Discovery of mysterious radio waves which appear to come from the centre of the Milky Way galaxy was announced yesterday by the Bell Telephone Laboratories. The discovery was made during research studies on static by Karl G. Jansky of the radio research department at Holmdel, N.J. and was described by him in a paper delivered before the International Scientific Radio Union in Washington.

The galactic radio waves, the announcement says, are short waves, 14.6 meters, at a frequency of about 20,000,000 cycles a second. The intensity of these waves is very low, so that a delicate apparatus is required for their detection.

Unlike most forms of radio disturbances, the report says, these newly found waves do not appear to be due to any terrestrial phenomena, but rather to come from some point far off in space — probably far beyond our solar system.

A preliminary report, published in the Proceedings of the Institute of Radio Engineers last December, described studies which showed the presence of three separate groups of static: Static from local thunderstorms, static from distant thunderstorms, and a "steady hiss type static of unknown origin." Further studies this year determine the unknown origin of this third type to be from the direction of the centre of the Milky Way, the earth's own home galaxy.

The direction from which these waves arrive, the announcement asserts, has been determined by investigations carried on over a considerable period. Measurements of the horizontal component of the waves were taken on several days of each month for an entire year, and by an analysis of these readings at the end of the year their direction of arrival was disclosed.

"The position indicated," it was explained, "is very near to the point where the plane in which the earth revolves around the sun crosses the centre of the Milky Way, and also to that point toward which the solar system is moving with respect to the other stars."

There is no indication of any kind, Mr. Jansky replied to a question, that these galactic radio waves constitute some kind of interstellar signalling, or that they are the result of some form of intelligence striving for intra-galactic communications.

Why did *Jansky's Star Static* discovery make the Front Page of the *NY Times* ?



- Perhaps May 5th, 1933 was an exceptionally slow news day.
- It may be unrelated, but it is significant to note that the *Cullen-Harrison Act* had become law less than a month earlier. Why was this notable?
- Remember that not only was the US in the depth of the Great Depression, it had been living under Prohibition since 1920 and this law was becoming increasingly unpopular.
- The Cullen-Harrison Act was signed by President Roosevelt on March 22, 1933. It allowed the manufacture and sale of beer with an alcohol content of 3.2% (or “3.2 beer”) as well as wine with a low alcohol content.
- Upon signing the amendment, FDR made his famous remark, “*I think this would be a good time for a beer.*”
- The Cullen-Harrison Act became law on April 7, 1933.
- The very next day, Anheuser-Busch, Inc. sent a team of Clydesdale horses to the White House to deliver a case of Budweiser.
- Around the country, crowds gathered outside breweries & taverns for their first legal beer in 13 years.
- Perhaps when life is good, or at least getting better, people’s imaginations become free to wander towards more abstract interests and flights of fancy.... like “star static”.

http://en.wikipedia.org/wiki/Prohibition_in_the_United_States

http://en.wikipedia.org/wiki/Cullen-Harrison_Act

<http://assignment1-5.blogspot.com/>

Coaxial Cable (1929):

- [Espenshied](#) & [Affel](#) invent coaxial cable for wide-band high-speed long-distance data transmissions.

Circular Waveguide (1932):

- [Southworth](#) studies circular waveguide with the goal to use them as a broad-band transmission media for high-capacity telecommunications. In late 1950's [Pierce](#) developed helical waveguide (which was used on the VLA).

Cosmic Noise (1937):

- [Jansky](#) measures and characterizes galactic noise as a component of total receiver noise at Holmdel, NJ. This work eventually opens the field of radio astronomy.

Noise Figure of Radio Receivers (1945):

- [Friis](#) (Jansky's boss) presents the analysis of multistage receivers and introduces noise figure as a measure of receiver performance. He provides a quantitative theory, showing the limits to sensitivity which are imposed by signal losses, by external thermal noise, and by noise generated in the receiver.

Transistor (1947):

- [Bardeen](#), [Brattain](#) & [Shockley](#) invent the transistor & are awarded the Nobel Prize in 1956.

Wire Bonding (1956):

- [Anderson](#), [Christensen](#) & [Andreatch](#) develop the technique of thermo-compression bonding of gold wires to semiconductor circuits.

Parametric Amplifiers (1957):

- [Hines](#), [Uhlir](#), [Elder](#) & [Uenohara](#) develop the microwave parametric amplifier for very low-noise receivers. The paramp soon replaced the more expensive maser amplifier in radio astronomy & satellite receivers.

Laser (1958):

- [Schawlow](#) & [Townes](#) describe the concept of the Laser (light amplification by stimulated emission of radiation).

Cosmic Microwave Background (1964):

- [Penzias](#) & [Wilson](#), while tracing the source of radio noise on the horn antenna at Crawford Hill, NJ, detect a relatively high level of isotropic radiation at a wavelength of 7.3 cm and conclude it is the residue associated with the birth of the universe following the Big Bang. They were awarded the Nobel Prize in 1978 for their work.

Charge Coupled Device (CCD) (1969):

- [Boyle](#) & [Smith](#) invent a solid-state chip that transforms patterns of light into useful electrical information.

UNIX Operating System (1969):

- [Thompson](#) & [Ritchie](#) develop the UNIX operating system. It is the first software system designed to run on computers of all sizes, making open systems possible. UNIX later became the foundation for the Internet.

Fiber Optics (1976):

- The first experimental Bell Labs Lightwave Communications System begins in Atlanta, followed by the first commercial installation of fiber-optic system is installed under the streets of Chicago.

Bell Labs & the Jansky 1953 Advertisement

Which Appeared 3 years after his death

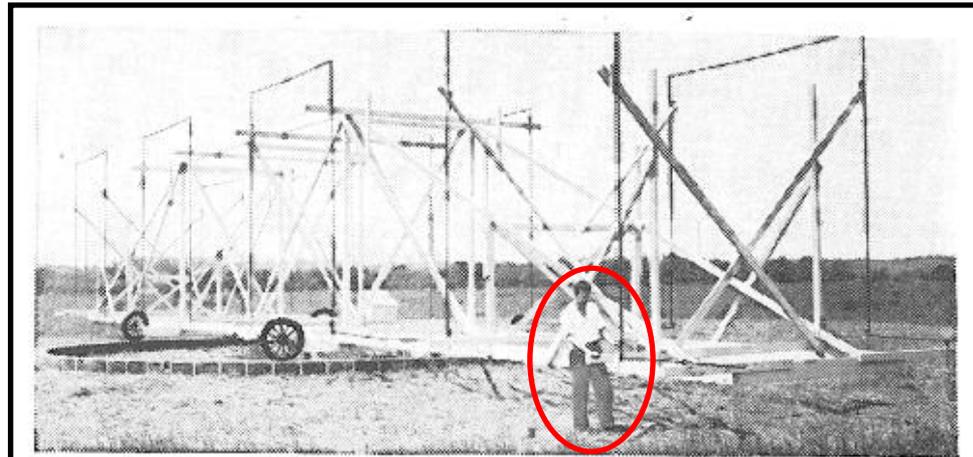
How silent is the night?

Watching the serenity of Christmas skies, we are conscious of deep silence. Yet the stars are talking to us all the while—talking in radio waves that are full of meaning to scientists probing the depths of space.

The important discovery that some stars produce radio waves was made by a Bell Laboratories scientist while exploring atmospheric disturbances which might interfere with transoceanic telephone service.

His discovery marked the birth of the fast-growing science of radio astronomy. It is telling us of mysterious lightless stars that broadcast radio waves, and it promises new and exciting revelations about the vast regions of space concealed by clouds of cosmic dust.

It is another example of how Bell Telephone Laboratories scientists make broad and important discoveries as they seek ways to make your telephone serve you better.



Directional radio antenna used by Karl G. Jansky, in the discovery of stellar radio signals at the Holmdel, New Jersey, branch of Bell Telephone Laboratories. In 1932 he detected waves of 14.6 meters coming from the direction of Sagittarius in the Milky Way.

**BTL Advertisement - *How Silent is the Night?*,
Scientific American, Dec 1953**

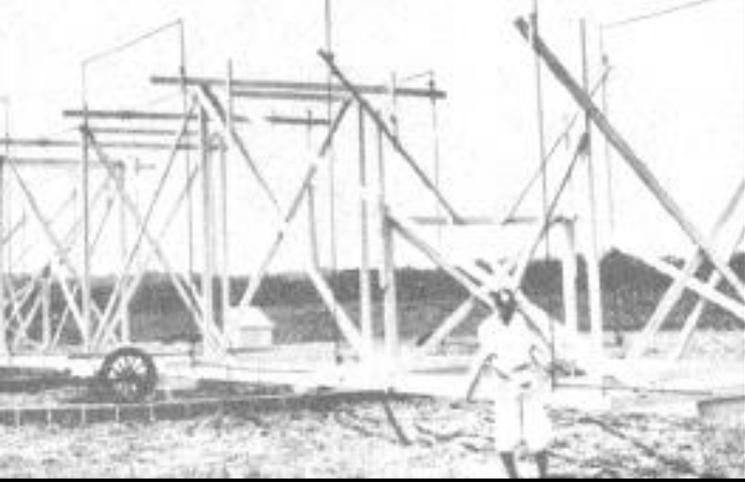


Fig. 2. Karl Jansky with his antenna.

The BTL Jansky Ad and His Knickers

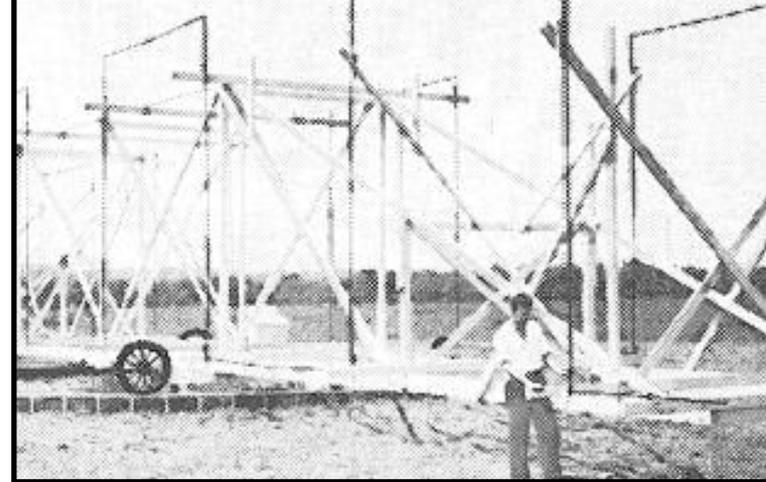


Fig. 4. Picture used in 1953 BTL ad.

**Recollections
from his son,
David, along
with comments
from his
daughter, Alice
Jansky Knopp
(AJK) and
Bob Wilson,
co-discoverer
of the CMB**

Figure 2 has been shown to death, and really I imagine the reason is because not too many pictures of Karl exist with the actual antenna to make it a logical presentation to the uninitiated. But it was a good one. And I show it because I'm going to show you another picture later on.

The picture shown in Figure 4 is from the ad, December 1953, by BTL, which appeared in 22 scientific publications and look what they did to him.

AJK: Changed the knickers to long pants!

And gave him a full head of hair! We can all laugh. This appeared in 1953; I can understand why it was done. My apologies to Bob Wilson and the rest of Lab people who are here, but they're going to hear it! This was a very small picture in the ad, by the way, because the title of the ad was "How Silent was the Night?", and the top half, I should have shown it I guess, had a silhouette of a man, a dog and a boy looking at the stars, and it was a very clever ad.

R. Wilson: David, I've seen another copy of this same picture, or two copies together, one is the original picture with a circle around Karl, and it says "Remove Man!"

Bell Labs & Jansky

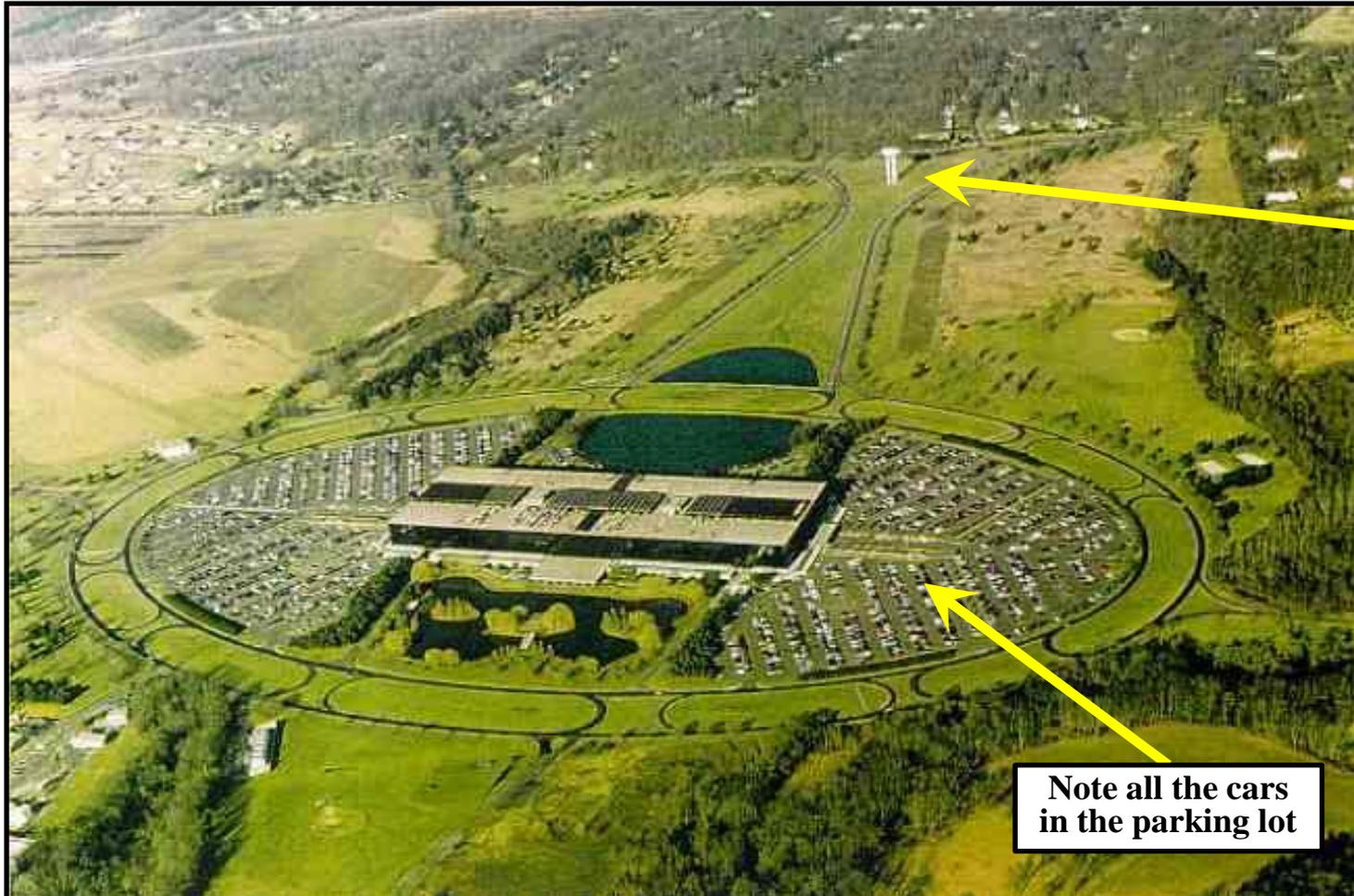
- If in later years AT&T was so proud of the role that *Bell Labs* had played in the field of radio astronomy, why wasn't Karl Jansky encouraged, back in the mid 1930s, to further his studies of "star static"?
 - Jansky performed some follow-up studies on it waves for several years -- mostly in his spare time -- he largely abandoned those efforts to pursue wartime research.
 - He had hoped to build a 30-meter steerable antenna but was unable to garner enough support.
- In retrospect, *Bell Labs* loss of interest is not surprising:
 - First, Jansky's discovery was a purely serendipitous one. He had been tasked with investigating terrestrial sources of interference which might adversely affect short wave communications.
 - What he found was very weak emission. Since he hadn't detected the Sun, the noise from the rest of the galaxy was unlikely to interfere with the long distant radio links that were a source of income for AT&T.
 - Second, Jansky was carrying out his work in the depth of the *Great Depression* when economic times were very hard. In 1933, unemployment was at 25%.
 - AT&T's mandate was to provide telephone communications for the U.S.
 - *Bell Labs* was the R&D arm and was involved with any scientific development that might impact telecommunications, and thus it tried to maintain a vigorous program of both applied and pure research.
 - While AT&T was one of largest monopolies and biggest employers in the world, it was not rich enough at that time to be altruistic to a fault.

From Harald Friis' Autobiography

In the thirties, the depression hit us badly. Our five and half working days per week were cut down to four and our salaries reduced correspondingly. More important, we were told to lay off 20 per cent of our people at all levels.

The Bell Labs Holmdel Complex in its Heyday (1970s)

- Where Karl Jansky and Harald Friis had – serendipitously - discovered “star static” and radio astronomy was born, 30 years before the famous *Bell Labs* research complex was built in the early 1960’s.
- The *Holmdel Labs* was designed by Eero Saarinen (who had also designed the Gateway Arch in St. Louis).
- The 2 million sq. ft. building contained over 4000 *Bell Labs* scientists & engineers.
- After the government enforced divestiture of AT&T in 1984, Bell Labs was taken over by Alcatel-Lucent, who eventually closed the facility in 2006 and sold it. The world’s largest lab now sits abandoned.



Note all the cars
in the parking lot



The water tower
on the 472-acre
complex was
designed to look
like a transistor,
the most famous
Bell Lab invention.

The Jansky Marker & Memorial at the Holmdel Labs



**The Jansky Marker,
101 Crawfords Corner Road,
Holmdel Township, New Jersey**

**Erected by the state during the 1960s,
about 1/2 mile from the original antenna.**

***“Unfortunately, it's unsafe to stop and
read the sign without getting
hit from behind” - Bob Wilson***



**Jim Moran (CfA)
“Standard Ruler”
January 2006**

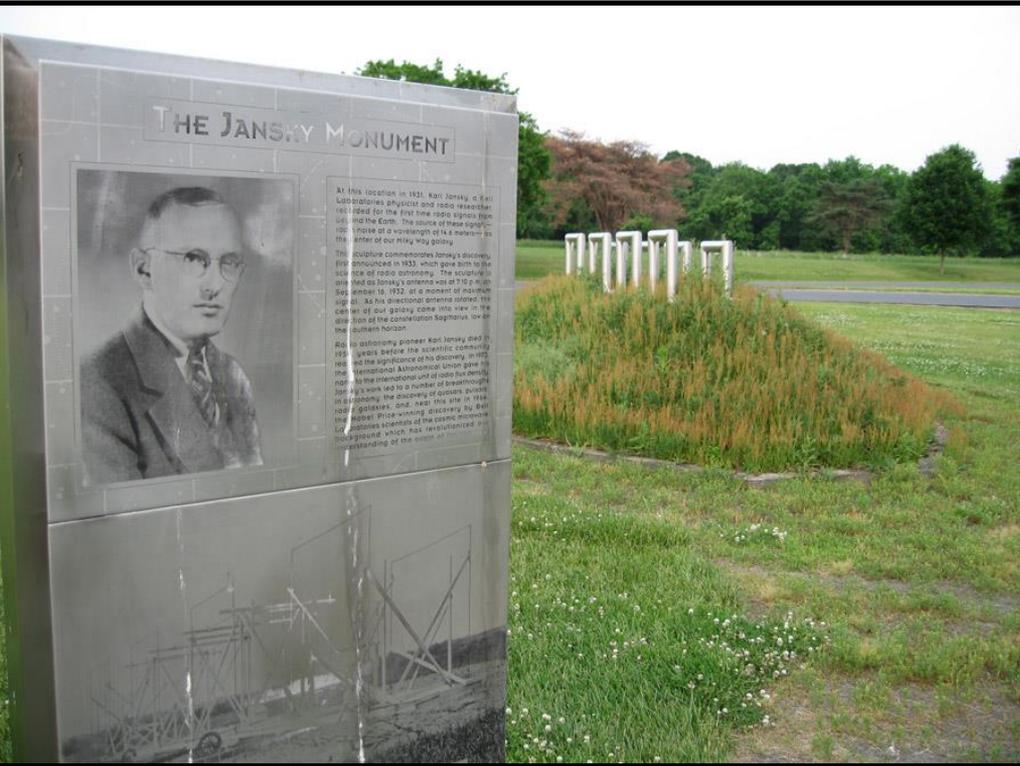
Just how BIG is the Jansky Memorial?



The Jansky Memorial at Holmdel Labs

<http://www.hmdb.org/marker.asp?MarkerID=17386&Print=1>
http://www.waymarking.com/waymarks/WM103K_Jansky_Antenna
<https://www.cfa.harvard.edu/~jmoran/photos/JimsWanderings/wanderingsindex.html>

Jansky Marker Today



Bell Labs moved out of the Holmdel building in 2006 and the marker is now inaccessible.

Lucent, the successor to Bell Labs, had fallen on hard times, and the monument has been left to the elements.

Who knows when it will be accessible again.

<http://www.simplyquality.org/ho/2-12-09-Presentation.pdf>

At this location in 1931, Karl Jansky, a Bell Laboratories physicist and radio researcher, recorded for the first time radio signals from beyond the Earth. The source of these signals -- radio noise at a wavelength of 14.6 meters -- was the center of our Milky Way galaxy.

This sculpture commemorates Jansky's discovery, first announced in 1933, which gave birth to the science of radio astronomy. The sculpture is oriented as Jansky's antenna was at 7:10 p.m. on September 16, 1932, at a moment of maximum signal. As his directional antenna rotated, the center of our galaxy came into view in the direction of the constellation Sagittarius, low on the southern horizon.

Radio Astronomy pioneer Karl Jansky died in 1950, years before the scientific community realized the significance of his discovery. In 1973, the International Astronomical Union gave his name to the international unit of radio flux density.

Jansky's work led to a number of breakthroughs in astronomy: the discovery of quasars, pulsars, radio galaxies, and near this site in 1964, the Nobel Prize-winning discovery by Bell Laboratories scientists of the cosmic microwave background which has revolutionized our understanding of the origin of the universe.

Bell Labs Holmdel Complex Today



Note no cars
in the parking lot

**Alcatel-Lucent sold the facility in 2006.
The world's largest lab now sits abandoned.**

**Despite initial plans to keep the complex as a
corporate office park, there was an attempt
to re-zone the complex as residential.**

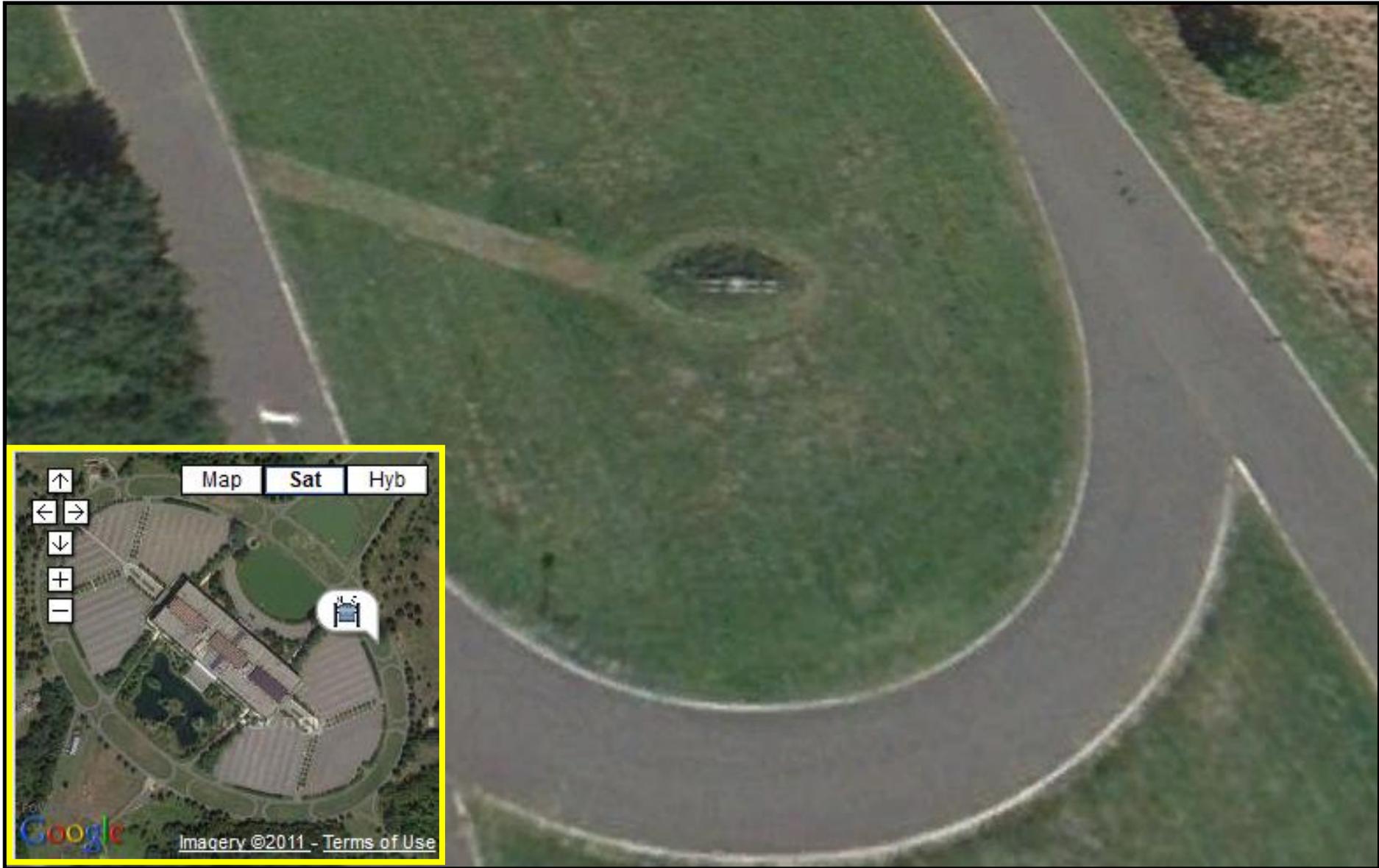
**It has since been added to list of the *10 Most
Endangered Historic Sites* in NJ by the
Cultural Landscape Foundation.**

**A citizen's group has been created by former
Bell employees to lobby to keep the complex
as it was, perhaps as an university or
recreational complex.**

Detective Work Leads to Jansky Memorial

- The search for the location of the Jansky Memorial was carried out by Tony Tyson, then a Bell Labs astrophysicist, and Bob Wilson, who was now a senior scientist at the Harvard-Smithsonian CfA. It began in the late 1980's and lasted nearly a decade.
- It was unveiled on 8 June 1998 at the Bell Labs Holmdel facility. A 13-foot-long stylized replica now resides on the former location of Jansky's original 100-foot-long antenna.
- When Jansky died of a stroke in 1950 at the age of 44, he had received no formal recognition from Bell Labs or the scientific community. The International Astronomical Union would adopt the "jansky" as the radio flux density unit in the 1970s.
- Wilson and Tyson began searching Bell Labs records but they soon discovered Jansky's lab notebooks from 1928 to 1937 were missing. Those notebooks would, they hoped, provide a crucial clue to the antenna's original location. The antenna itself vanished sometime during the 1950s.
- A summer student majoring in archeology found an old box of papers at a former Bell Labs facility on West Street in New York. The papers had been slated for a corporate museum but for some reason had remained in the possession of a company executive.
- The notebook provided the location of Jansky's office in the original *Radio Research Lab*, as well as the antenna's angular position. Using a survey of the former Holmdel building, an old map of the Holmdel Township, which showed the building's location near a stream, and an old aerial photograph that faintly showed the antenna itself, along with the stream and a nearby tree line that partially exists today.
- The original antenna was then determined to be about 1,000 feet from the old building, placing it on a grassy patch near the current Holmdel building's main parking lot.
- Luckily the actual location on the Jansky Antenna just missed ending up on a modern asphalt road. The Memorial sits happily on a grass lawn.

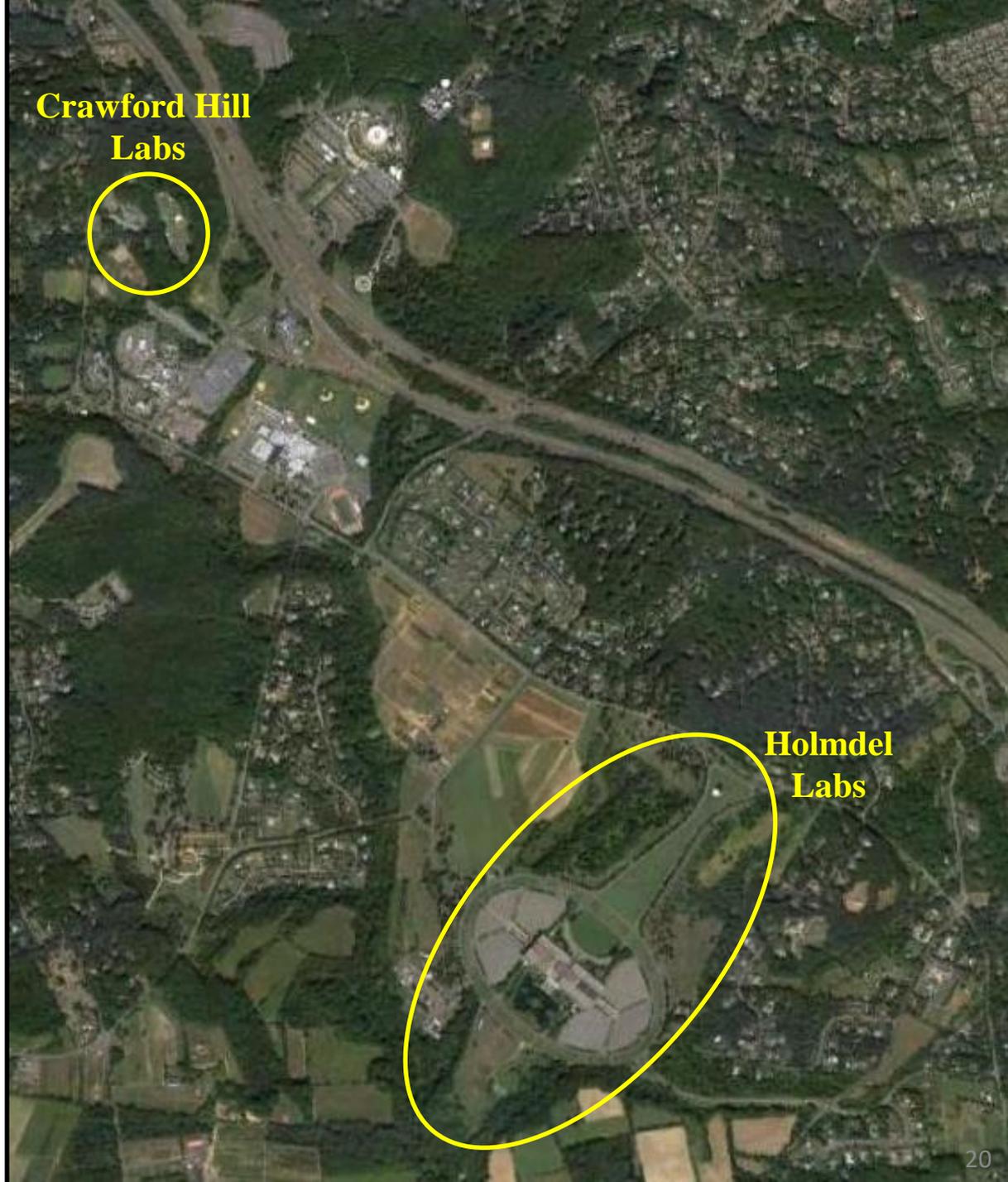
The Jansky Memorial from Space (1998)



http://www.waymarking.com/waymarks/WM103K_Jansky_Antenna
Google Earth

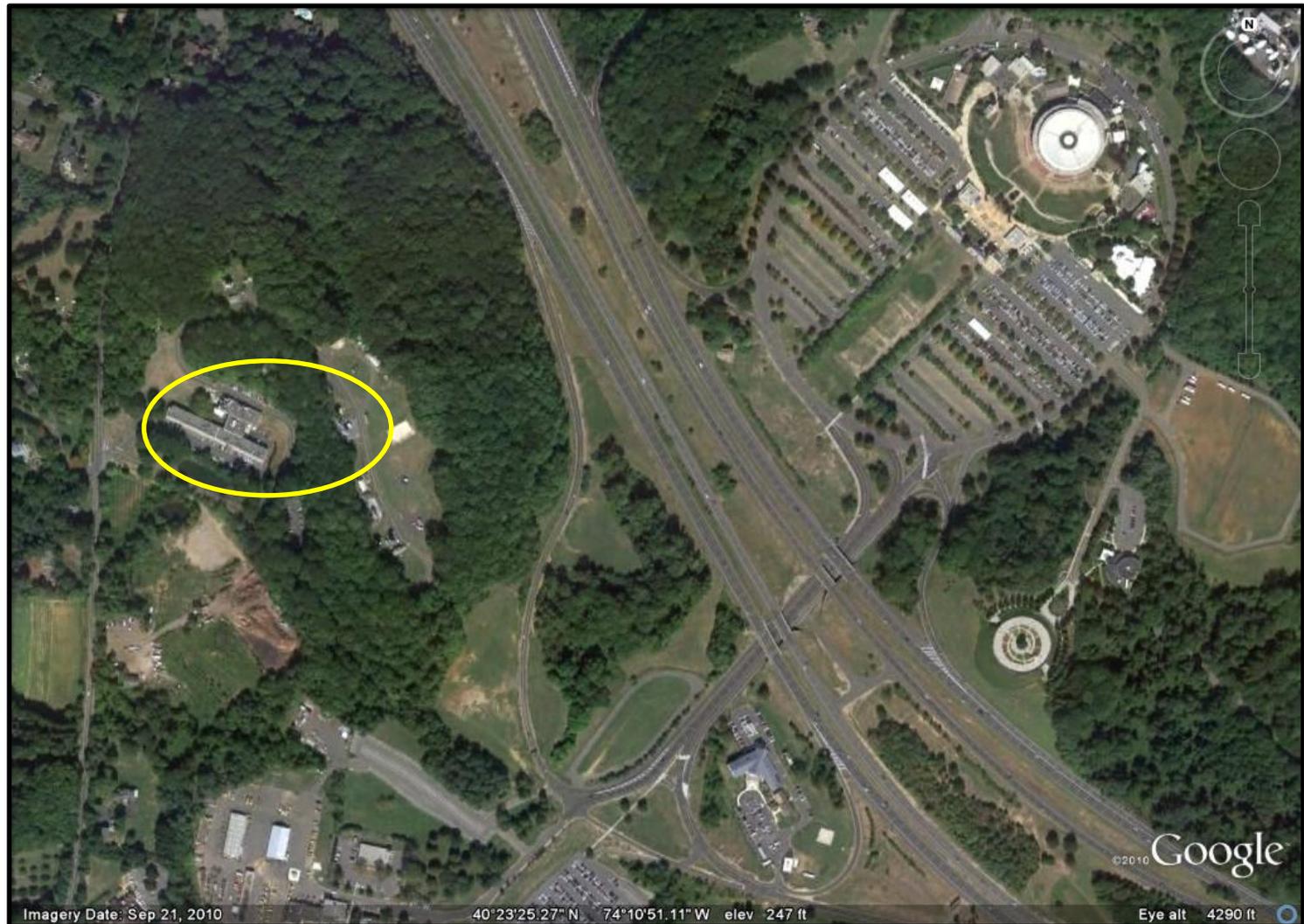
Bell Labs, NJ *Holmdel & Crawford Hill* Laboratories

**The two most famous
Bell Labs facilities,
at least as far as
radio astronomers
are concerned,
are located within 2
miles of each other
(as the crow flies).**



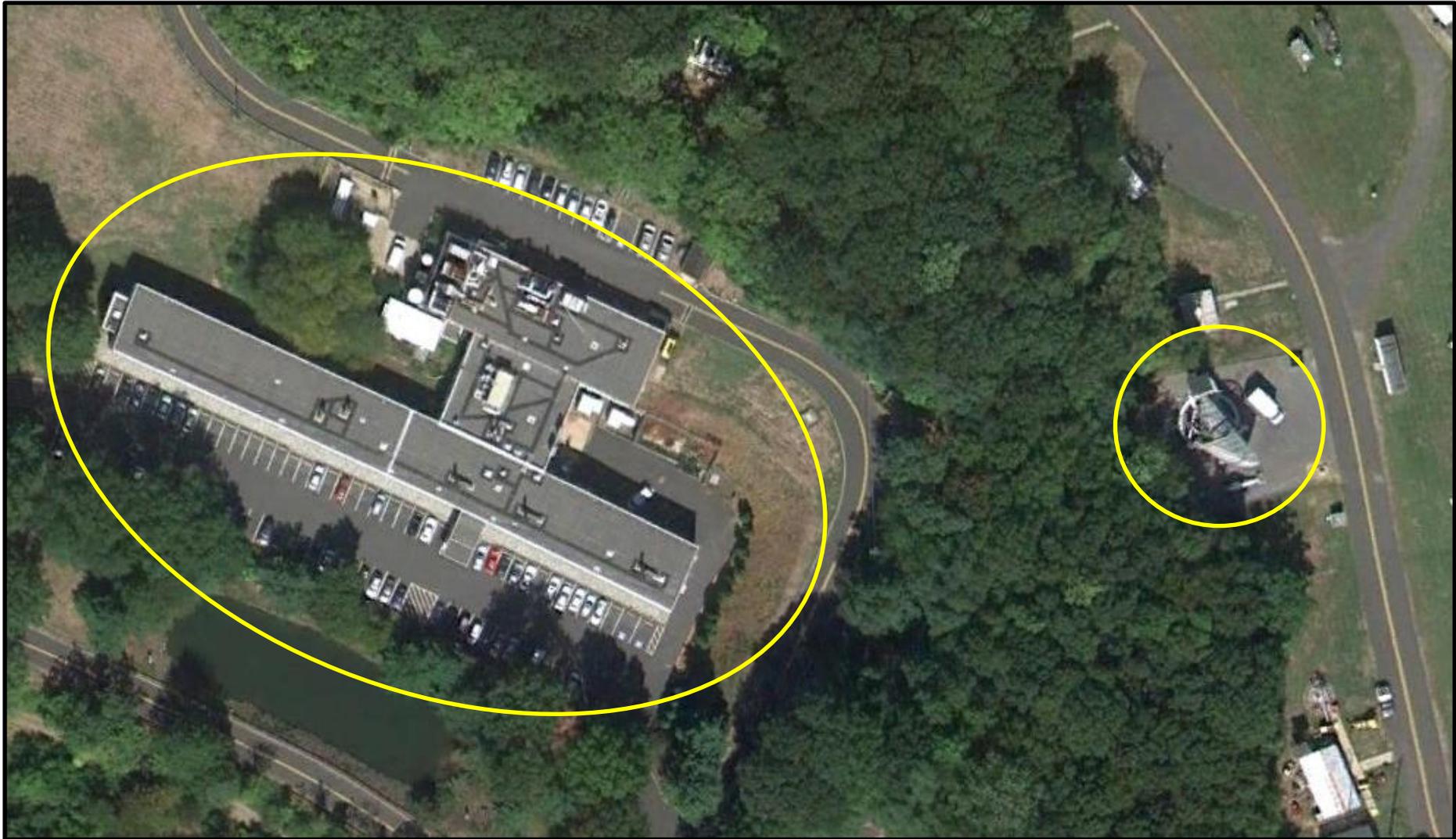
Bell's Crawford Hill Lab, Holmdel, NJ

Where Penzias & Wilson discovered the Cosmic Microwave Background

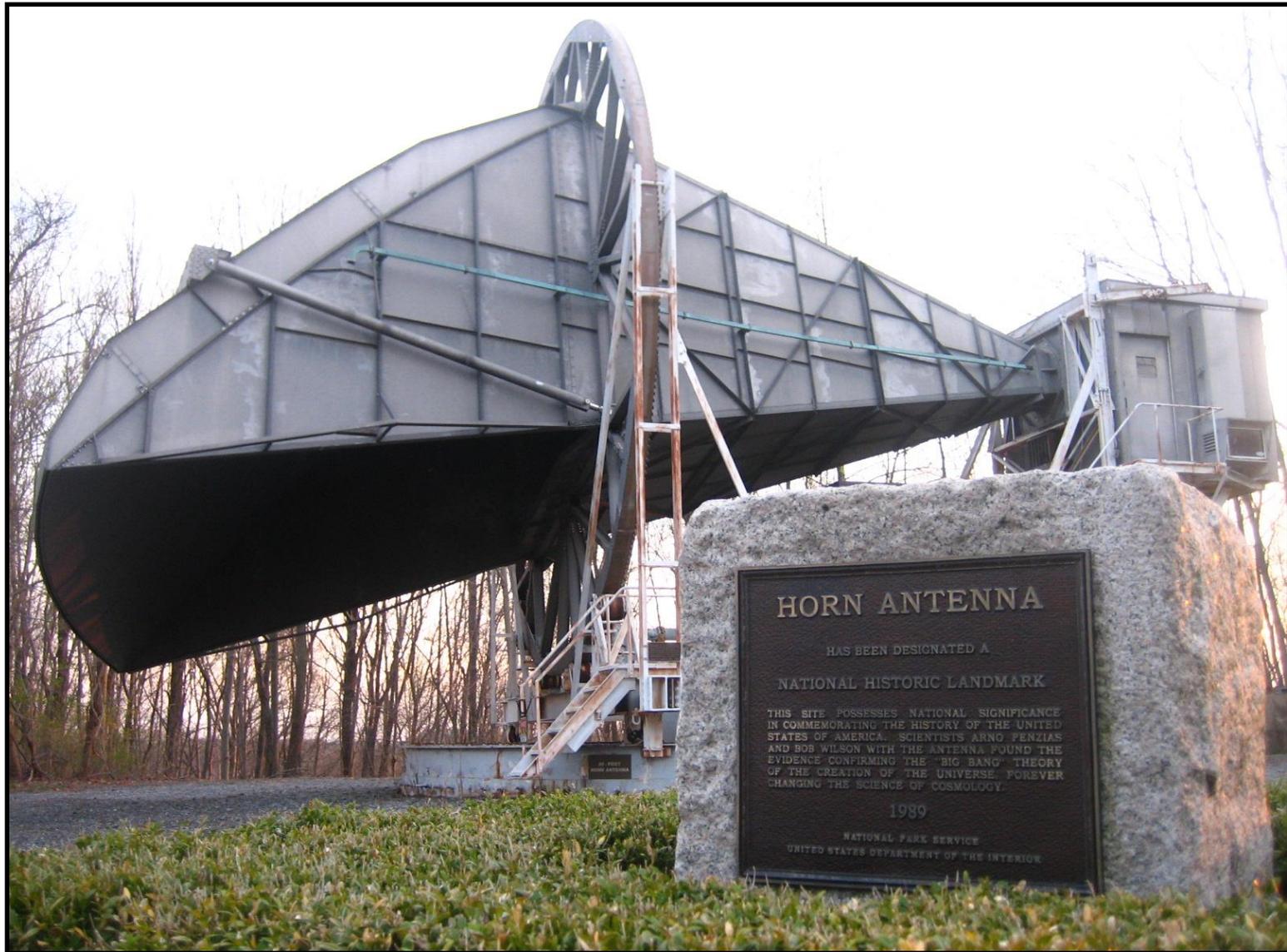


The Famous Hogg Horn is still there...

The sole remaining presence of Bell Labs in Holmdel is a small research group of Alcatel-Lucent working on optical networking and wireless technologies.



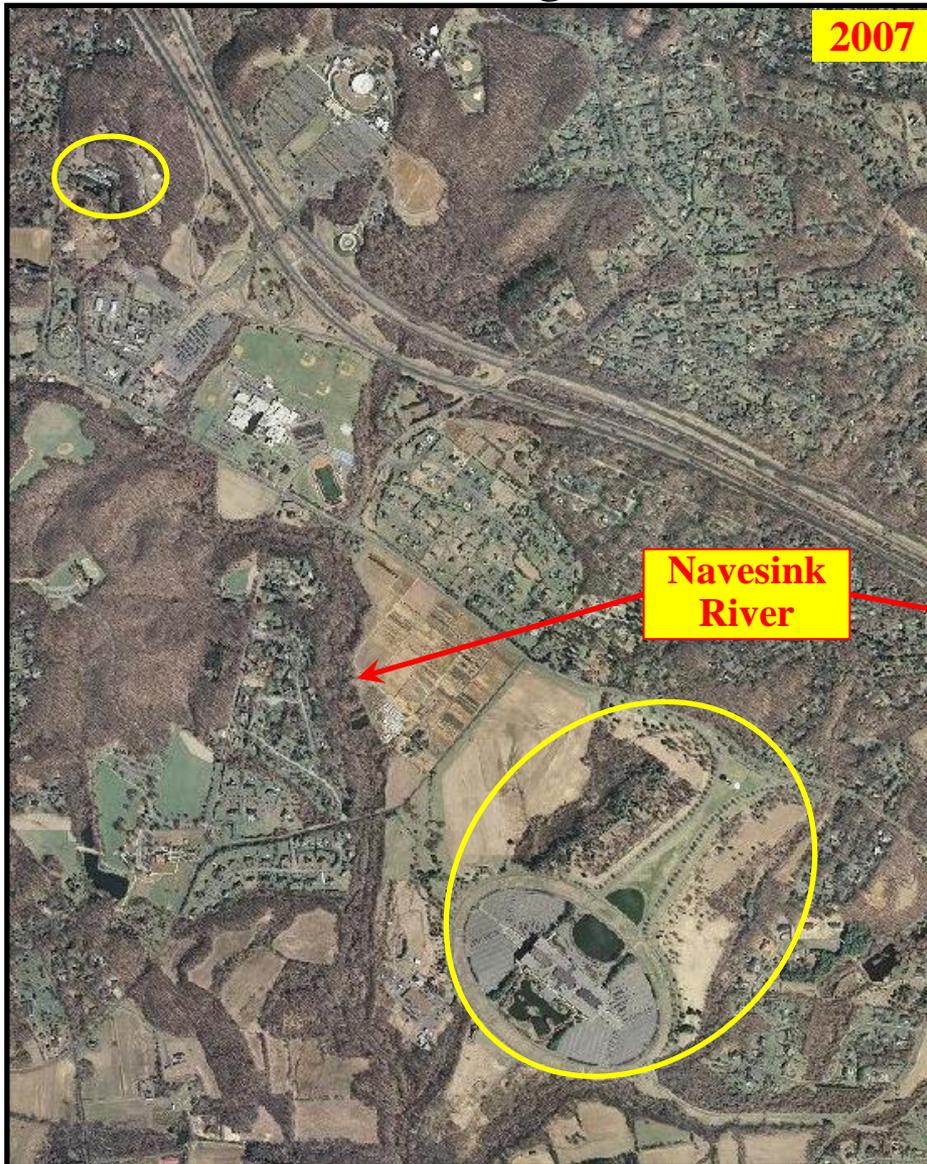
In 1989 the CMB horn antenna was designated a National Historic Landmark.



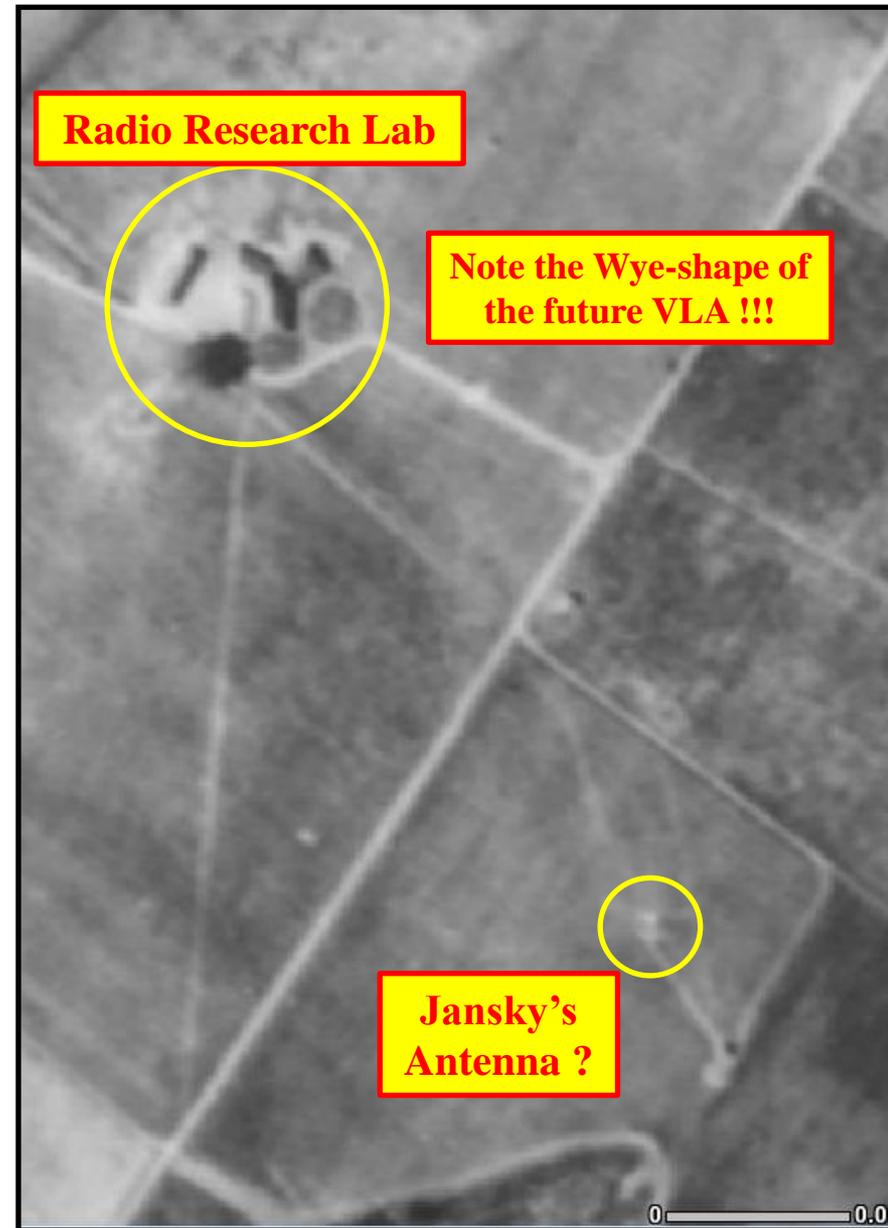
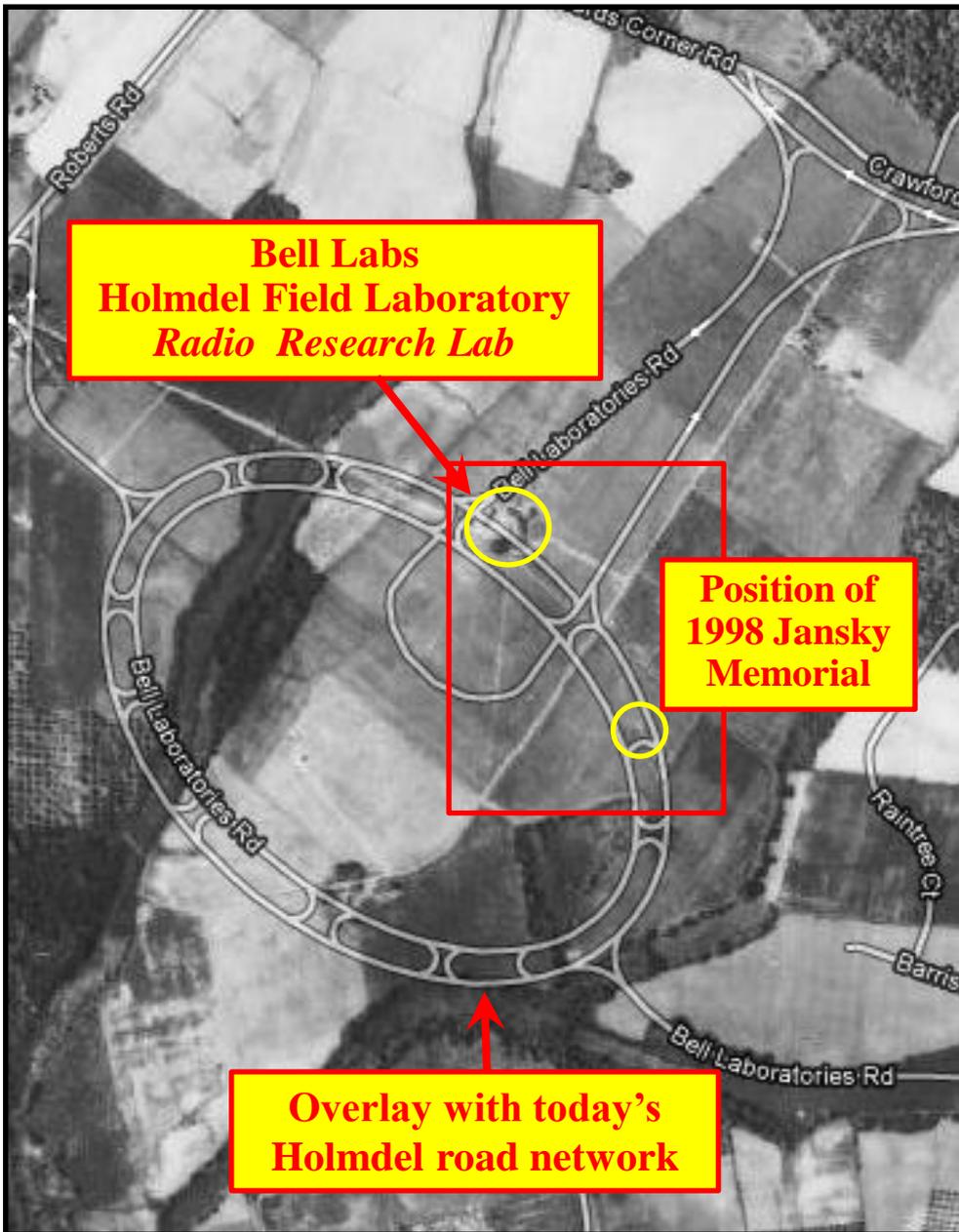
Holmdel & Crawford Hill Bell Labs

Satellite Image-2007

Aerial Photo-1931



Aerial Photo of Jansky's Lab & Telescope - 1931



Holmdel – As Time Goes By



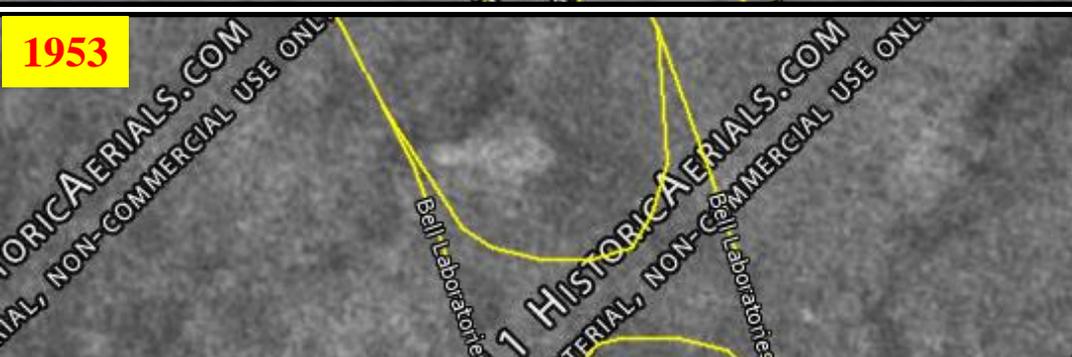
1940

Jansky's antenna is clearly seen...



1947

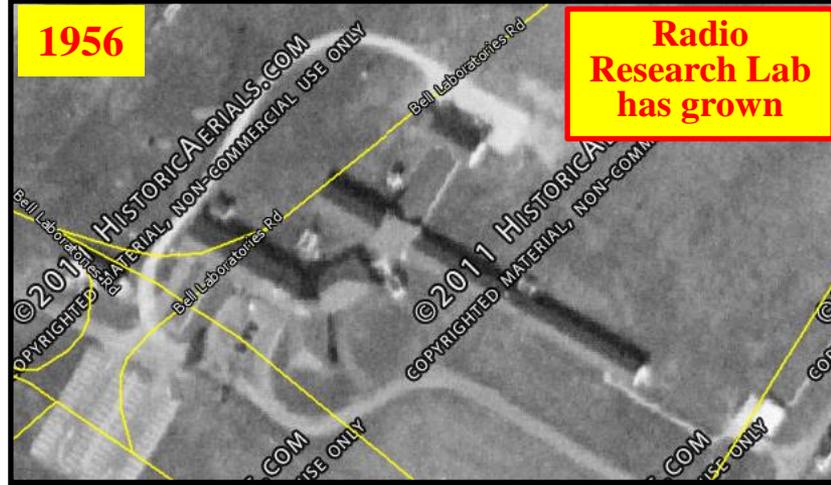
...but appears to have vanished



1953



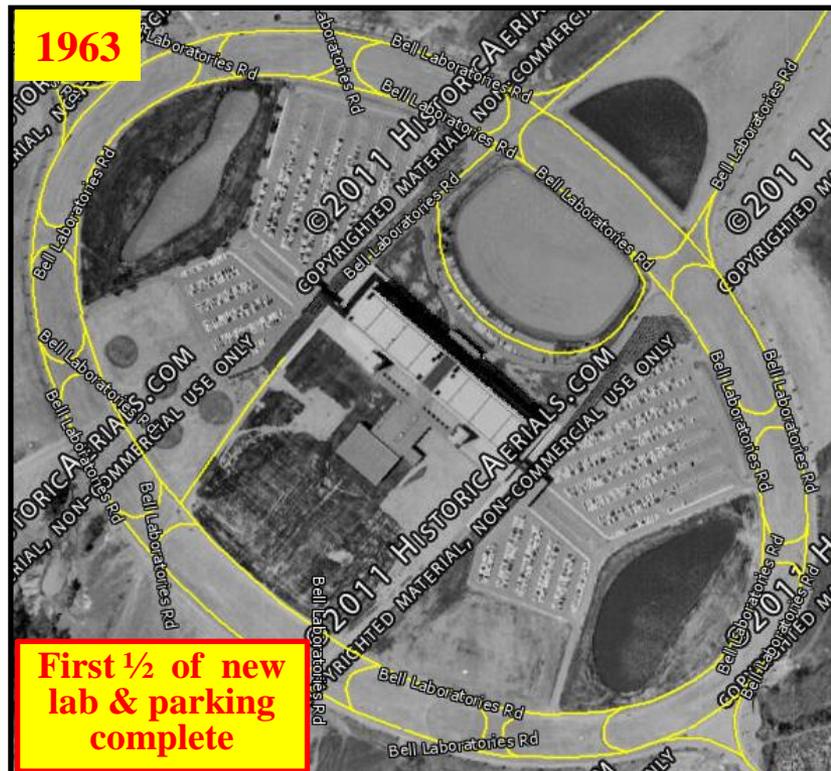
2007



1956

Radio Research Lab has grown

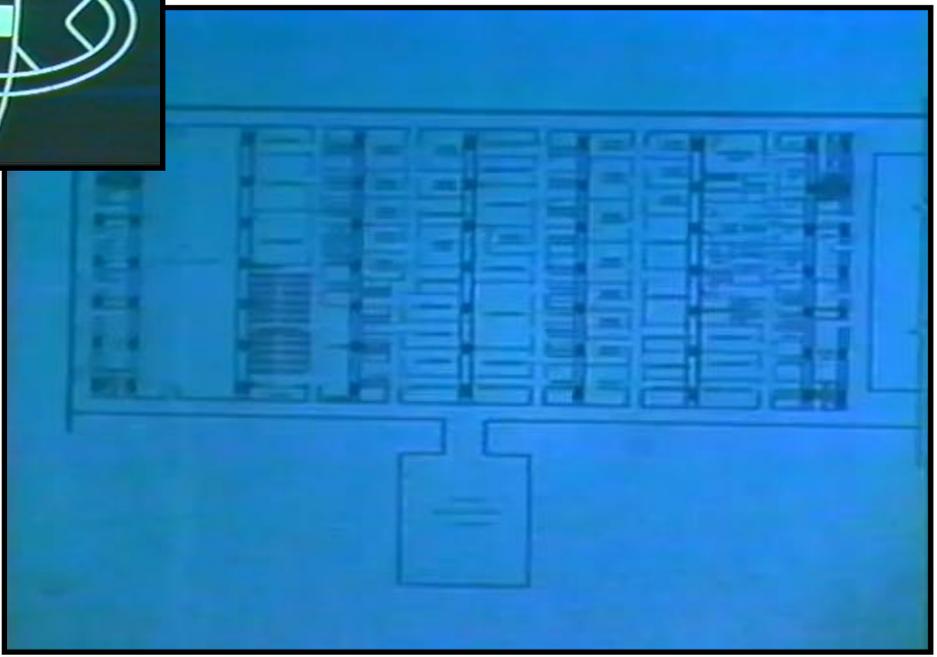
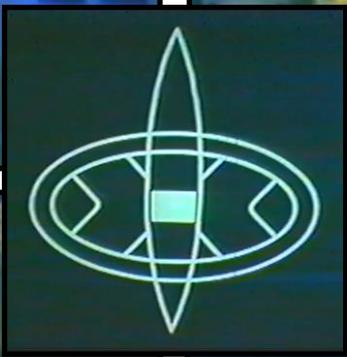
<http://www.historicaerials.com/>



1963

First 1/2 of new lab & parking complete

BTL Presents *New Lab at Holmdel* (~1962)



Eero Saarinen - Bell Laboratories Holmdel – Early Videos (3)

<http://www.youtube.com/watch?v=v3BbfdIKz6k> ; <http://www.youtube.com/watch?v=HMQKfskkIQM>

MUSA Location

High-altitude 1930s photo taken before MUSA built.

Identifying features like the Navesink River, a pit, two large buildings & the road network, the approximate location of the MUSA can be determined.

Radio Research Lab

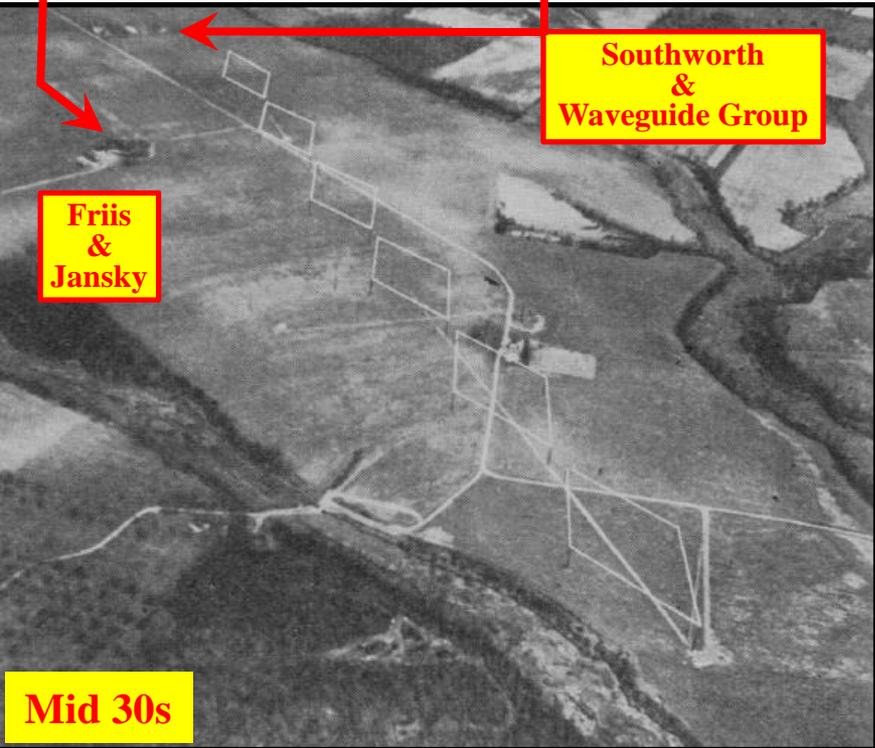


Roberts Farmhouse Lab

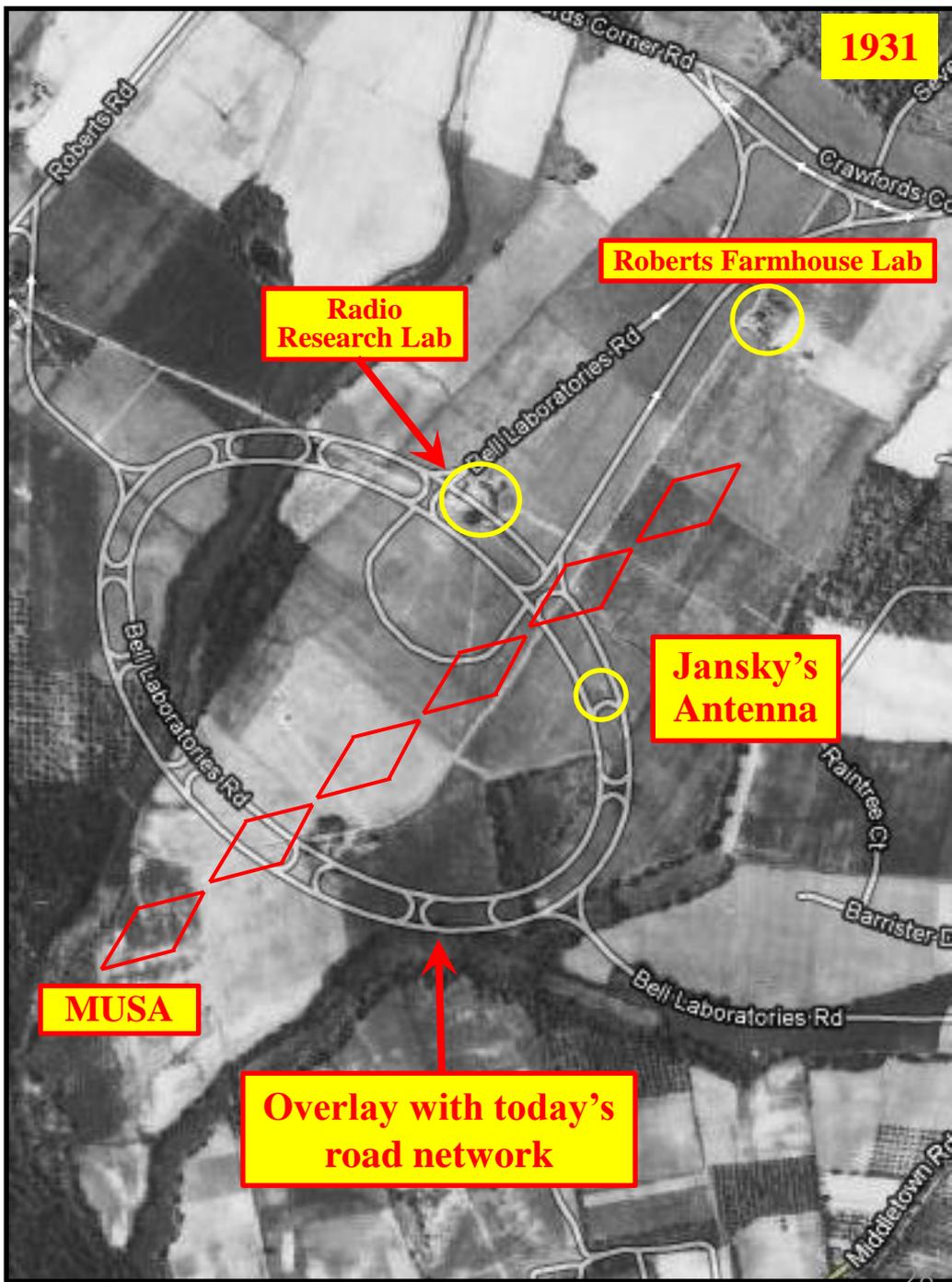


Southworth & Waveguide Group

Friis & Jansky



1931



A Multiple Unit Steerable Antenna for Short-wave Reception,
H.T. Friis & C.B. Feldman, Proc IRE, Vol. 25, No. 7, July 1937, 841-917

<http://njstateatlas.com/1930/>

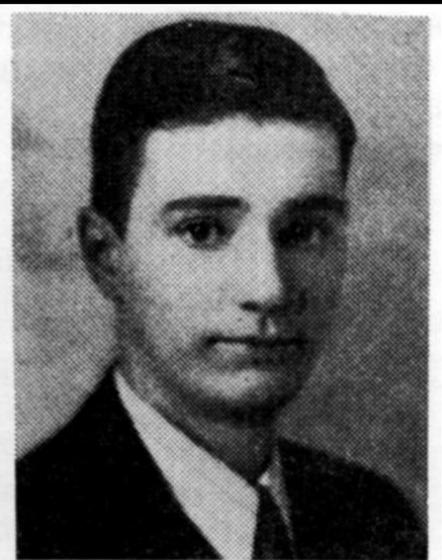
Tangent - Grote Reber & *Cosmic Static* 1939

- Grote Reber, a radio engineer & avid radio amateur, had read Jansky's articles. By 1938, he had constructed a 31-foot parabolic dish in his back yard in Wheaton, IL, and had begun his own observations of the celestial sky.
- Drift scans at both 9-cm & 33-cm produced negative results, so he built a new 1.9-m receiver. In April 1939 he found what he termed *cosmic static* from the center of the Milky Way. He then embarked on the first survey of the radio sky in 1941.
- Reber worked by day designing radio receivers at a factory in nearby Chicago. Taking the train was an hour each way. After supper he slept until midnight, and then sat in his basement and recorded the output meter readings of his receiver at one minute intervals until he left for work the next morning.
- By 1941 he had purchased an automatic strip chart recorder.
- Reber is considered to be the *world's first radio astronomer*.

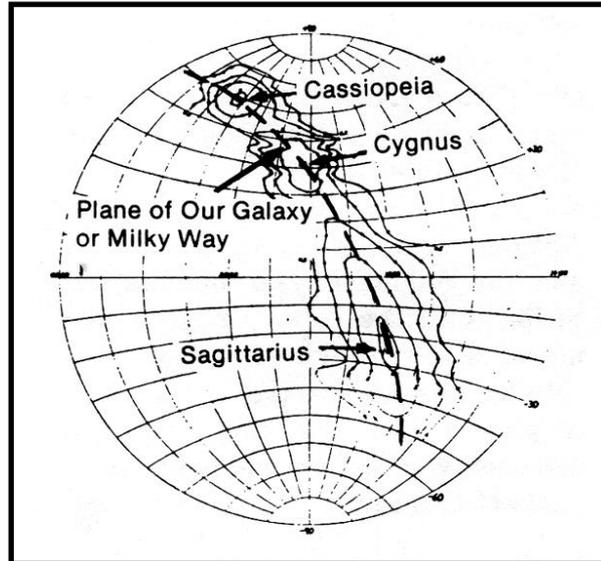


<http://www.bigear.org/CSMO/HTML/CS13/cs13p14.htm>

Grote Reber : A Radio Astronomy Pioneer, K. I. Kellermann, in *The New Astronomy - A Meeting to Honor Woody Sullivan on his 60th Birthday*, edited by W. Orchiston, Springer, 2005 29



Grote Reber circa 1940.



Reber's 1944 Radio Sky at 1.9m

The World's 1st Parabolic Radio Telescope

Reber with his 31-ft Transit Antenna built in his Mother's Backyard

His mother found the dish to be a convenient place to hang out her wash to dry.

Reber stated that the cost of parts for the antenna was \$677.

He spent an additional \$1,050 on instrumentation.

Total of ~\$27K today



**Rare picture of the dish in the vacant lot next to his mother's house.
(Printed in *Time Magazine*, Dec 1962.)**

Aerial Image of Grote Reber's Dish in 1939

Wheaton, IL – 25 miles west of Chicago
Population then ~7,400 ; today ~55,000

212 W. Seminary Street
The home of Grote Reber & his mother



Site of Reber's Telescope – Then & Now

(1939 Aerial Image “Discovered” by Bill Higgins)



Reber used the Wheaton dish from 1937 to 1947.

W. Seminary Street 200 Block now Kariskoga Ave

- When his mother died in 1945, Reber had little reason to stay in Wheaton.
- In 1947, he accepted an offer from the *National Bureau of Standards* (NBS) to set up a radio astronomy program at the *Central Radio Propagation Laboratory* (CRPL).
- He sold his Wheaton dish to the government along with all of his instrumentation, including a 1400 MHz amplifier and feed, for the sum of \$18,570.
- Everything was moved to the NBS in Sterling, VA, near the location of the current Dulles Airport.

212 W. Seminary Street, Wheaton, IL

Through the Decades



The Wheaton

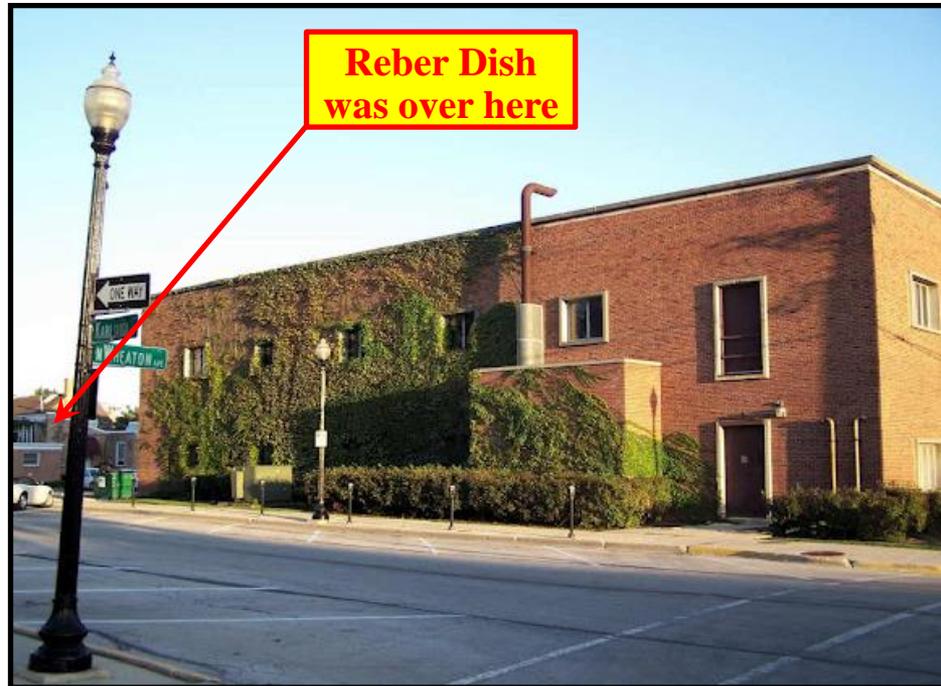
Antenna Site Today

The Reber home was demolished in the 1950s and was developed for commercial business.

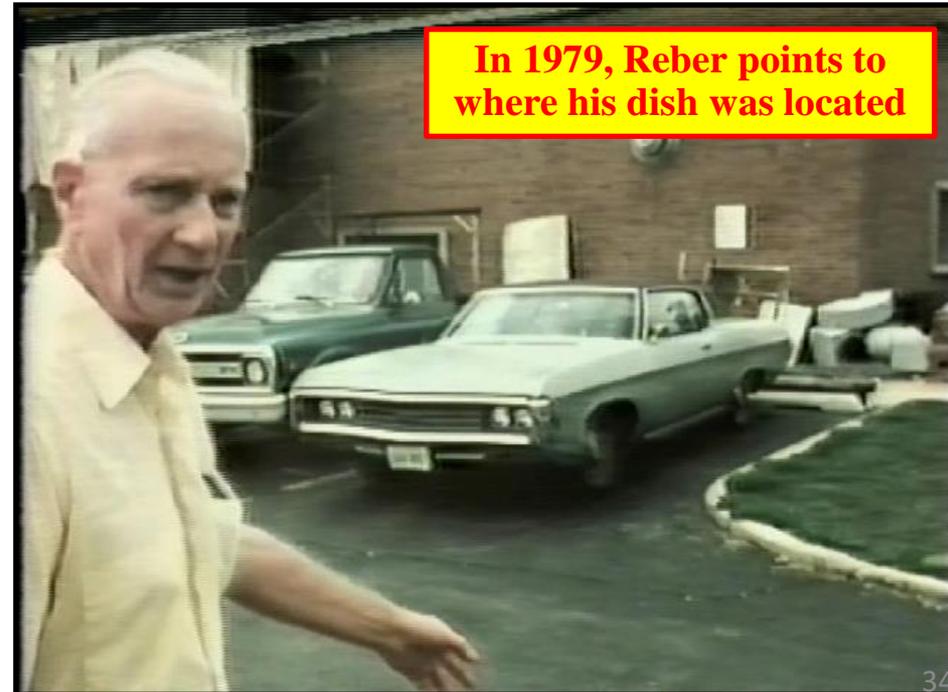
In yet another “cosmic connection”, the site of the antenna became the parking lot of the local Bell Telephone Company.



Reber Dish
was over here



In 1979, Reber points to
where his dish was located



<http://beamjockey.livejournal.com/155909.html>

Grote Reber – The Wildcat Astronomer, The Scientists, Australian Broadcasting Corporation, DVD, 1979

The Reber Marker in Wheaton



The Reber Antenna Legacy

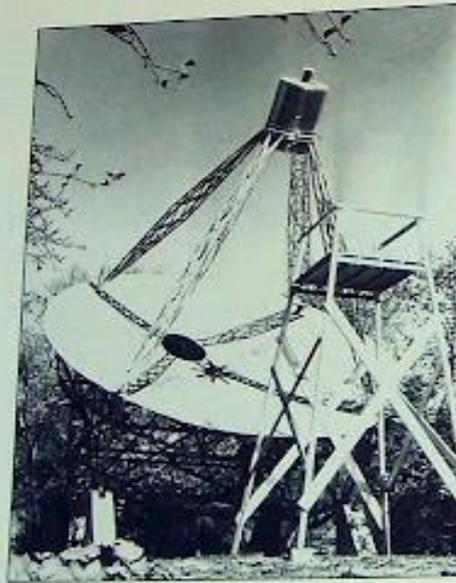
- After the Wheaton dish was moved to the NBS field site in Sterling, VA, in 1947, Reber was finally able to mount it on the turntable he had designed years before, turning the transit instrument into an alt-azimuth telescope.
- Reber participated in multiwavelength observations of the radio Sun.
- Reber was soon frustrated by working as part of a government bureaucracy, by the lack of support for building a large radio telescope, and by the growing influence of McCarthyism.
- In 1951 he left his dish with the NBS and without warning departed for Hawaii.
- The dish was used to bounce the first radio signals off of the moon in the fall of 1951.
- In 1952 the telescope was disassembled and shipped to another NBS site in Boulder, Colorado, where it remained in storage.
- Finally, in 1957, it was acquired by NRAO, where it was reassembled in Green Bank, WV, under Grote Reber's supervision in 1959-60.
- The Reber antenna was listed on the National Register of Historic Places in 1972 and declared a National Historic Landmark in 1989.

<http://beamjockey.livejournal.com/155909.html>

Historic WHEATON SITE OF THE WORLD'S FIRST RADIO TELESCOPE

In 1937 Grote Reber, a 26 year old radio engineer, built the world's first radio telescope in the side yard of his home that stood here at 212 West Seminary Street, now Karlskoga Avenue. For ten years he conducted experiments at night surveying the sky for radio waves with his home-built 31 foot diameter dish antenna, to the wonderment of many in town. His discoveries during that decade established him as one of the founders of radio astronomy.

Born in 1911, Reber built a transmitter receiver for amateur radio communications at age 15, using it to contact more than 60 countries, on all continents. He graduated from Wheaton Community High School in 1929 and completed a B.S. degree in electrical engineering at the Armour Institute of Technology in 1933.

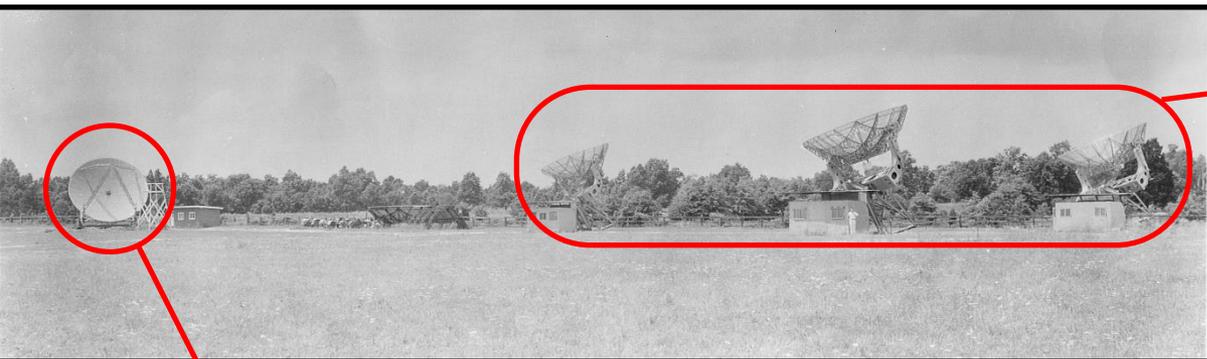


While employed as a radio engineer in Chicago, Reber devoted his free time to following up on a scientist's discontinued work concerning static from space. When a price quote to build the radio telescope he had designed proved too costly, Reber built it himself using wooden rafters, galvanized sheet metal, and spare parts from a Ford Model T truck. At some 20 feet high and 31 feet across, it was naturally the subject of great speculation and interest. The local newspaper ran a front page article May 7, 1938 detailing Reber's project, entitled "No Wild Scheme From Mars—But Planned Scientific Experiment." Reber used his radio telescope until 1947, when it was moved to The U.S. Bureau of Standards.

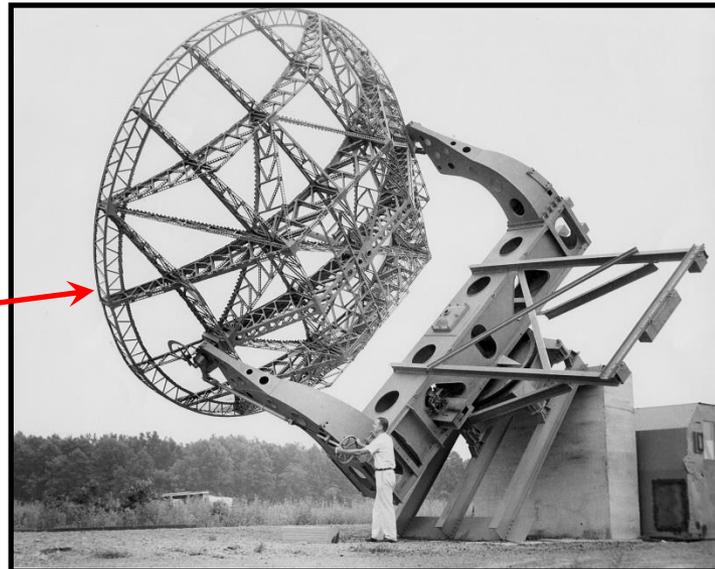
**Historic Marker in Wheaton
which commemorates
Grote Reber's telescope.
(photo credit - Bill Higgins)**

Reber has continued his work on radio astronomy in a field much changed—and influenced—by his endeavors. His original telescope is on exhibit at the National Radio Observatory in Green Bank, West Virginia as a historical monument.

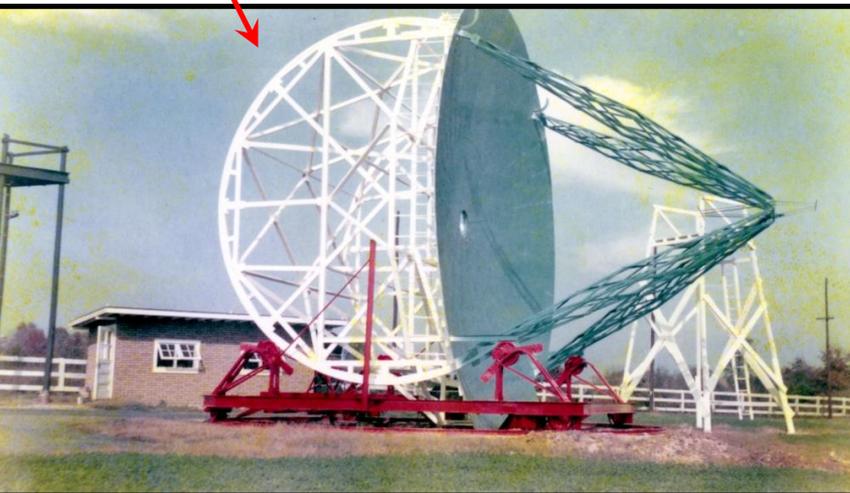
Grote Reber and the National Bureau of Standards *NBS Site at Sterling, VA*



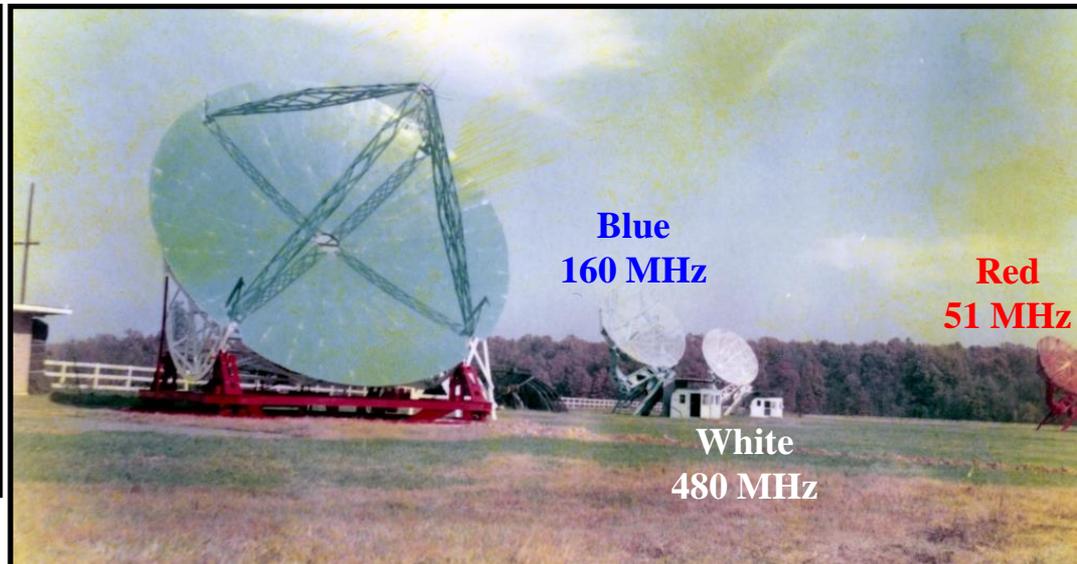
NBS Sterling antennas, 1949



Reber at one of the 3 equatorial mounted German WWII Wurzburg 7.5-m antennas



Reber's reassembled Wheaton antenna



Reber's antenna with the 3 "Red, White & Blue" Wurzburg antennas used for Solar observing in the background

http://www.nrao.edu/archives/Reber/reber_item_photos.shtml

http://jump.cv.nrao.edu/dbtw-wpd/Textbase/Imagefiles/Wurzburg_Sterling.jpg

http://jump.cv.nrao.edu/dbtw-wpd/Textbase/Imagefiles/Reber_at_Sterling-3.jpg

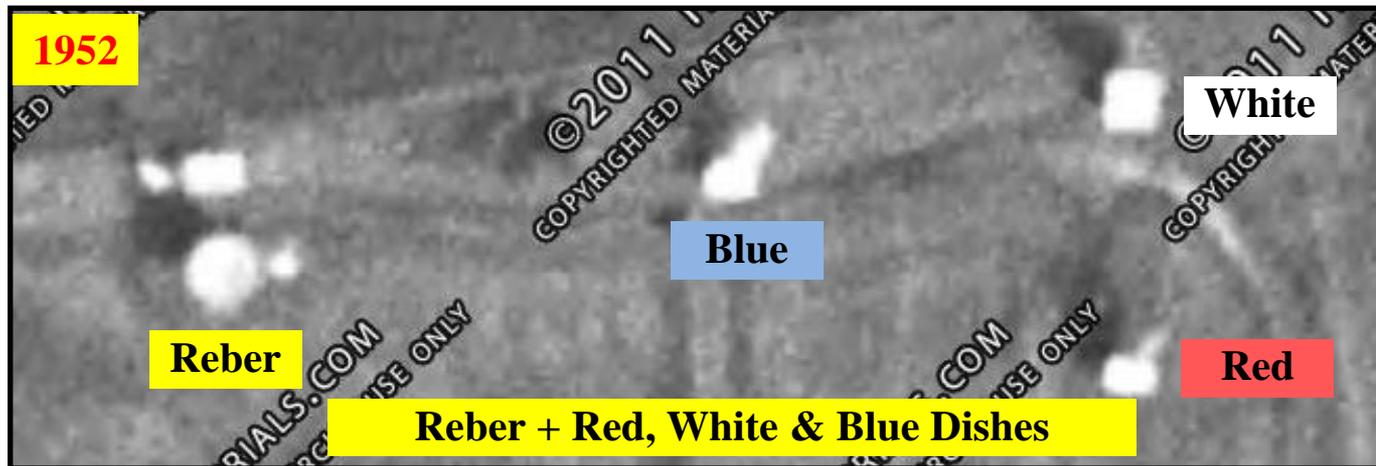
http://jump.cv.nrao.edu/dbtw-wpd/Textbase/Imagefiles/Sterling_1949-4.jpg

http://jump.cv.nrao.edu/dbtw-wpd/Textbase/Imagefiles/Sterling_1949-1.jpg

National
Bureau of
Standards
Sterling Site
*Aerial Photo
Chronology*

Sorry about the
watermarks, cost of
unmarked photos
= \$20/each

<http://www.historicaerials.com/>



Aug 2010

Sterling Site Today *Dulles Airport*



The NBS's original ionosphere and field intensity equipment was located at its field station at Meadows, Md., until 1942 when the Air Force took over the site to build *Andrews Air Base*.

The Bureau found another meadowland area, 450 acres in size, at Sterling, Va. That too was lost when in 1954 when it became the site of the *Dulles International Airport*.

The telescopes at the Sterling facility, once a radio quiet zone, were moved to Boulder, CO, in 1952. The three Wurzburg antennas were installed on Gunbarrel Hill just outside of Boulder. They retained their red, white and blue colors.

The Reber Dish remained in its crates and was not reassembled

Google Earth

Measures for Progress: A History of the National Bureau of Standards, R.C. Cochrane, US Dept of Congress, Washington DC, 1966, p.406

Wurzburg Update..., S. Stitzer, *Reflections*, Historical Electronics Museum, Vol. 17, Issue 3, Fall 2006

Aug 2010

Reber's Sea Interferometer

He was interested in the sea interferometry techniques being used by Australian radio astronomers, and, in 1951, abandoned his dish and the NBS, and went to Hawaii to work independently.

From 1951 to 1954 he worked on top of Mt. Haleakala on Maui, building a huge rotating antenna.

His observations were hampered by ionospheric refraction and terrestrial interference, so he ended up getting useful data for only a few strong radio sources.

http://jump.cv.nrao.edu/dbtw-wpd/Textbase/Imagefiles/Kolekole_framework-1.jpg

http://jump.cv.nrao.edu/dbtw-wpd/Textbase/Imagefiles/Kolekole_framework-16.jpg

http://jump.cv.nrao.edu/dbtw-wpd/Textbase/Imagefiles/Ice_damage_1957-3.jpg



Framework for Reber's antenna at Kole Kole on Haleakala, Maui, Hawaii.



The completed antenna with its control building to the left.

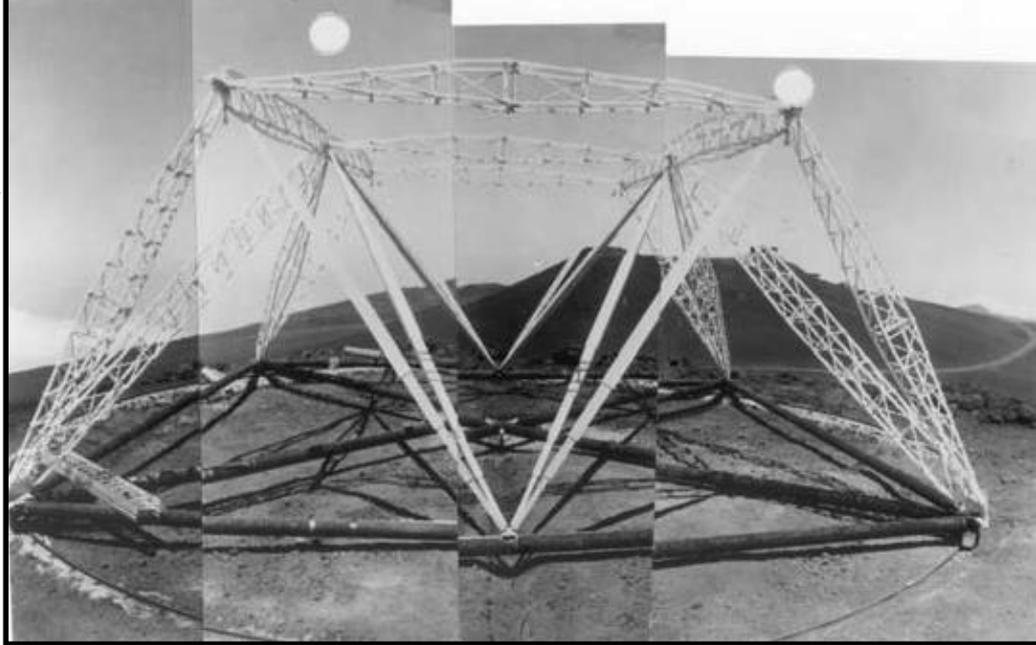
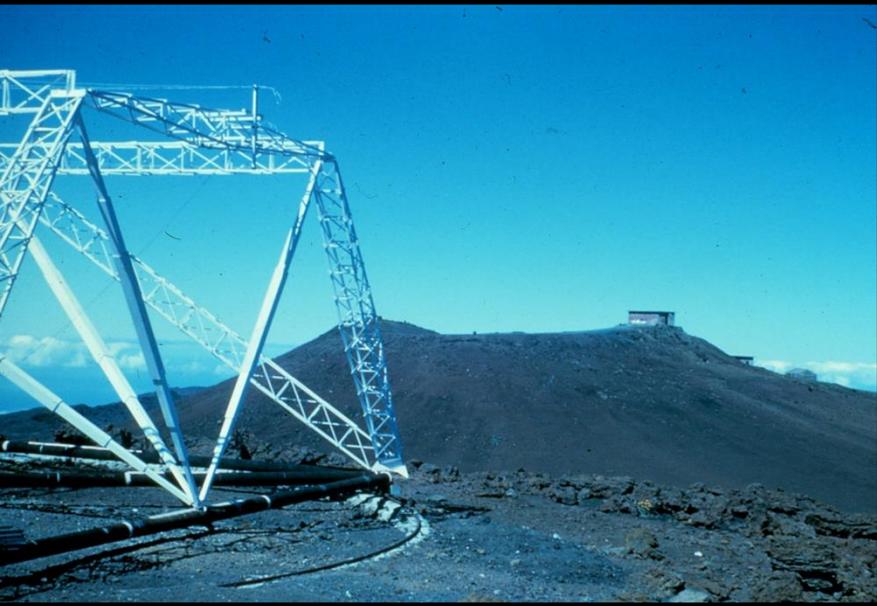


The antenna after being destroyed by an ice storm in February 1957. Reber had left for Tasmania before then.

Haleakala Pictures

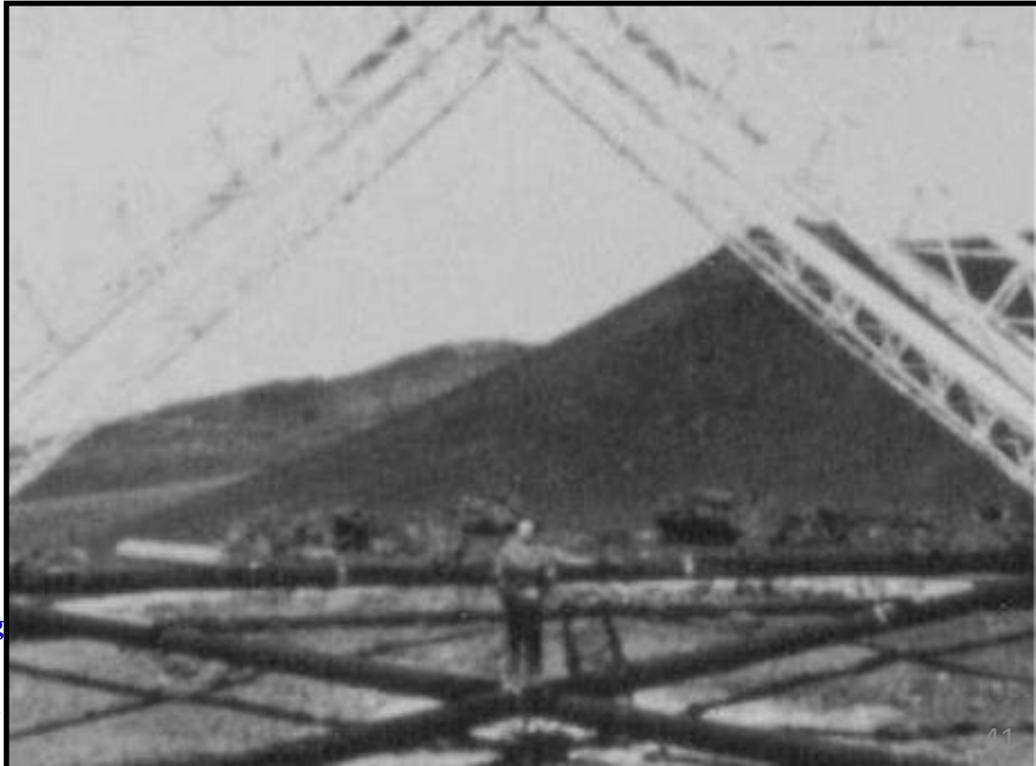
Mosaic picture of Reber's antenna in 1952 →

The antenna in 1954 after Reber had left Hawaii, but before the 1957 ice storm.



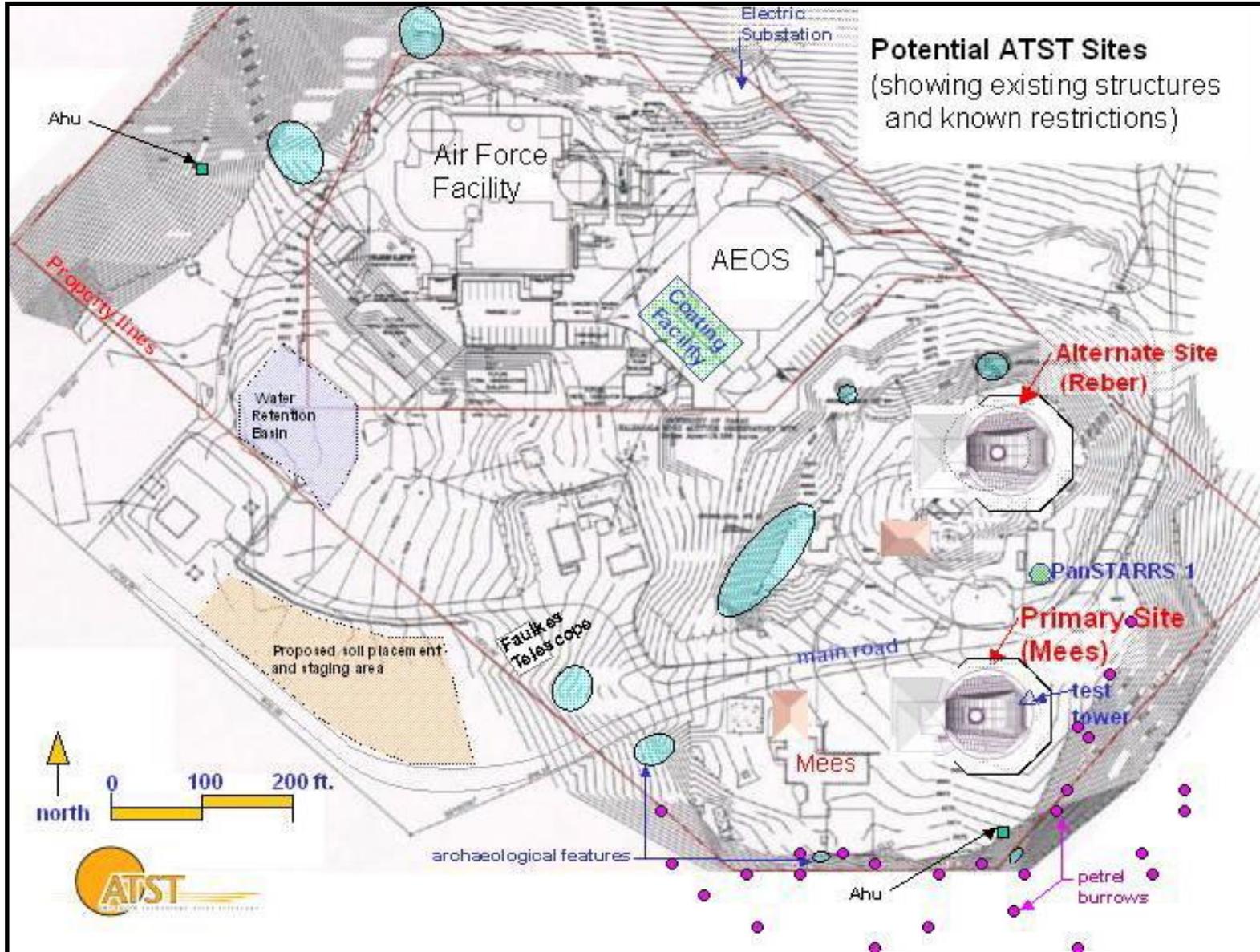
Reber in the middle of his antenna →

“The results were not commensurate with the effort.”



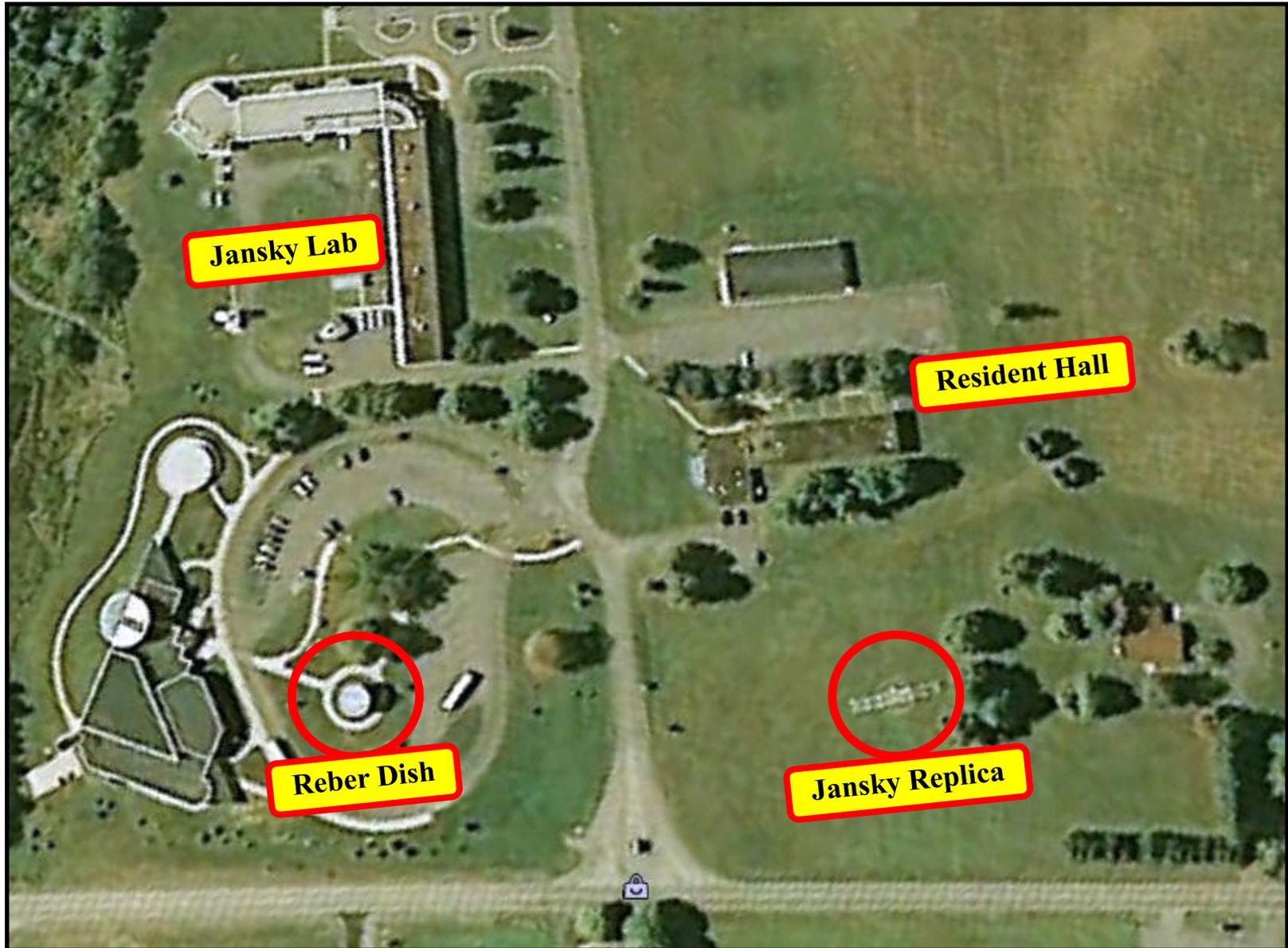
http://jump.cv.nrao.edu/dbtw-wpd/Textbase/Imagefiles/Reber_1st_Radio_Telescope_Maui_1952.jpg
http://jump.cv.nrao.edu/dbtw-wpd/Textbase/Imagefiles/Haleakala-Reber_Steigerphoto1954.jpg
<http://www.groterebmuseum.org.au/images/gallery/full/photo23%20-%20Photo%20of%20Telescope.jpg>

The "Reber Circle" Today



Considered as a potential site for the *Advanced Technology Solar Telescope (ATST)*

The Historical Antennas at Green Bank



The Jansky Antenna Replica at Green Bank

- The idea to build an accurate replica of Jansky's merry-go-round antenna originated with Grote Reber. He suggested it be located at the entrance to the NRAO in Green Bank, WV, as an historical monument.
- On 1959-60, while Reber was supervising the reconstruction of his 32-ft dish at Green Bank (on the left side of the front entrance), it occurred to him that it would be appropriate to have a full-size reproduction of Jansky's antenna on the right side.
- He contacted George Southworth, a contemporary of Jansky who had worked at Holmdel on the development of microwave systems. Southworth brought the idea to the management at Bell Laboratories, who concurred and the replica project was put in motion.
- All the drawings were still available and, surprisingly, the replica was built by the same carpenter that built the original thirty years earlier.
 - The head of the shop was keen to make the reconstructed antenna better than the original. After some persuasion, he finally agreed to make it the same as the original.
 - The only piece of the original antenna which could be found was its speed-reducing gear box. It is now installed on the replica.
- Jansky's original merry-go-round used the front wheels & axles from Ford Model-T cars. These may have plentiful in junkyards during the 1930s, but by 1960 they were long gone.
 - Reber advertised in the Marlinton, WV. newspaper hoping some axles might still be lying around in farm barnyards. Much to his surprise, they were.
 - What to do about tires and tubes was an other matter. The original used hard rubber tires. These had gone out of style many years earlier. The reconstructed merry-go-round consequently uses pneumatic tires, a slight departure from authenticity.
- The replica was completed in September of 1964.

The Jansky Antenna Replica at Green Bank

BELL
LABORATORIES
RECORD

October 1963

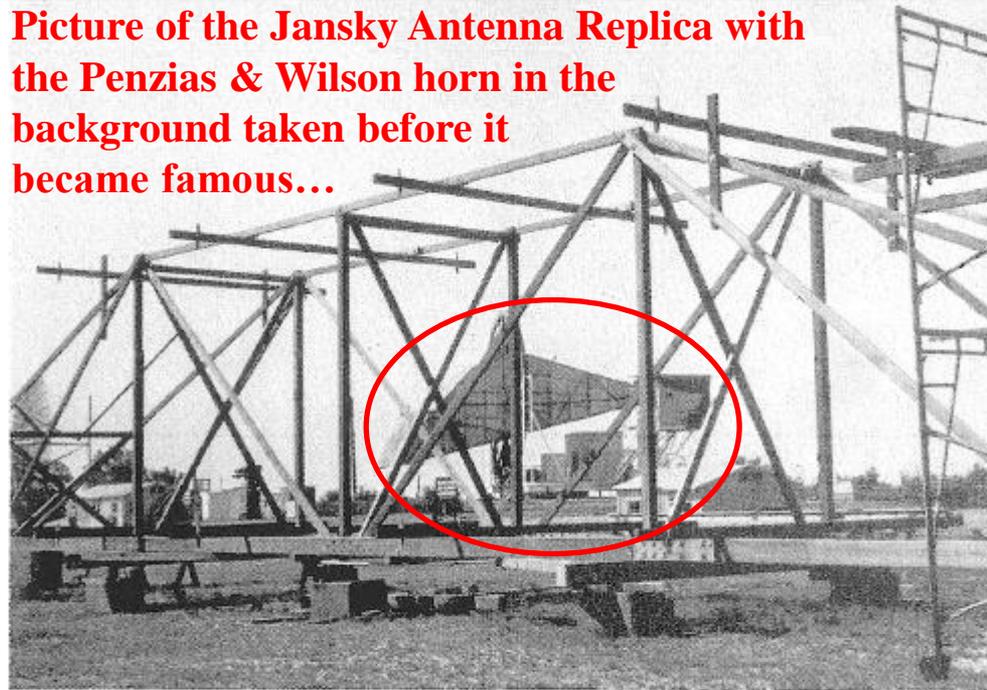
Full Sized Replica Of Jansky Antenna Completed

Construction of a full-sized replica of the original Jansky Antenna has been completed at Holmdel and will be erected at the National Radio Astronomy Observatory in Green Bank, West Virginia, later this year.

A. C. Beck, a member of the Guided Wave Medium Research Department and a contemporary of Jansky when he was at Holmdel, was chiefly responsible for collecting information needed to construct the replica. The replica was built by members of the Crawford Hill Carpenter Shop who worked from some of Jansky's original notebooks, drawings, and monthly progress reports.



Picture of the Jansky Antenna Replica with the Penzias & Wilson horn in the background taken before it became famous...



A full-sized replica of the original Jansky Antenna begins to take shape at the top of Crawford Hill at Holmdel.

<http://www.panoramio.com/photo/2632311>

Full Sized Replica of Jansky Antenna Completed, Bell Laboratories Record, Vol. 41, Oct 1963, p. 351

R&D at Bell Labs vs. the NSF

- Over the years since its creation, *Bell Labs* had been awarded 7 Nobel Prizes and held over 29,000 patents.
- At its peak, *Bell Labs* had 25,000 employees working at 13 locations in New Jersey & 7 others across the country.
- In 1981, the last year before the U.S. government split AT&T up under anti-monopoly restrictions, *Bell Labs* had a budget of \$1.63B.
 - Of this, about \$135M (8.3%) was devoted to *basic research*.
 - Fields of research ranged from telecommunications technology to electronic circuits to material science to neurophysiology.
 - And even radio astronomy.
- In the same year, 1981, the *National Science Foundation* (NSF) had an operating budget of \$1.1B.
- Thus in its final year, the *Bell Labs* basic research budget was typically 10 to 15% of the entire NSF budget.

Adapted from *Three Degrees Above Zero*, J. Bernstein (1984)

http://en.wikipedia.org/wiki/Lucent_Technologies & <http://en.wikipedia.org/wiki/Alcatel-Lucent>

Bell Labs & the Divestiture of AT&T

- Many argue that in the years since, the divestiture of AT&T in 1984 has adversely affected *Bell Labs* (now called *Alcatel-Lucent*) and has significantly diminished the role it was once so famous for with...
 - Its unique mixture of engineering vs. science,
 - Its profitable balance of applied vs. basic science,
 - And its successful demonstration of the benefits of short vs. long term research.
- It is hard to not believe that America has lost one of its greatest hi-tech assets.
 - Many of the labs have been scaled down, or closed entirely.
 - Much of the workforce has been lost due to layoffs.
 - According to *Science* magazine, in 2008 only four scientists remained to carry out basic research in physics.
 - Also in 2008, *Alcatel-Lucent* announced it was pulling out of basic science, material physics, and semiconductor research, and would instead focus on more immediately marketable areas, including networking, high-speed electronics, wireless networks, nanotechnology and software.
- There has been much debate as to whether the break up of *AT&T* totally destroyed the world's best telephone system or whether it spurred what remained of the organization to be more competitive against MCI, Sprint, etc.
- However, there is no doubt that divestiture changed the character of *Bell Labs* and that the U.S. ended up losing an organization which had an unparalleled mix of *applied vs. basic* and *short vs. long* research capability.
- And it is no longer the organization that created & fostered radio astronomy.

Adapted from *Three Degrees Above Zero*, J. Bernstein (1984)

http://en.wikipedia.org/wiki/Lucent_Technologies & <http://en.wikipedia.org/wiki/Alcatel-Lucent>

The



End

Any Questions ?
(from those who are still awake)

