

State of California — The Resources Agency  
 DEPARTMENT OF PARKS AND RECREATION  
**PRIMARY RECORD**

Primary #  
 HRI #  
 Trinomial  
 NRHP Status Code

Other Listings  
 Review Code

Reviewer

Date

Page 1 of 13

\*Resource Name or #: Bracewell Observatory

**P1. Other Identifier:** Stanford Field Site 515. Historic name: Heliopolis.

**\*P2. Location:**  Not for Publication  Unrestricted

\*a. County: Santa Clara

and (P2b and P2c or P2d. Attach a Location Map as necessary.)

\*b. USGS 7.5' Quad: ( See DPR523J Attached)

Date: T ; R ; ¼ of ¼ of Sec ; M.D. B.M.  
 City: Menlo Park Zip: 94028

c. Address: 3185 Alpine Road

d. UTM: Zone: 10S ; 571841 mE/ 4139371 mN (G.P.S.)

e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

Assessor's Parcel Number 14215007

Longitude: 122 deg 11.3 min West, Latitude: 37 deg 23.9 min North

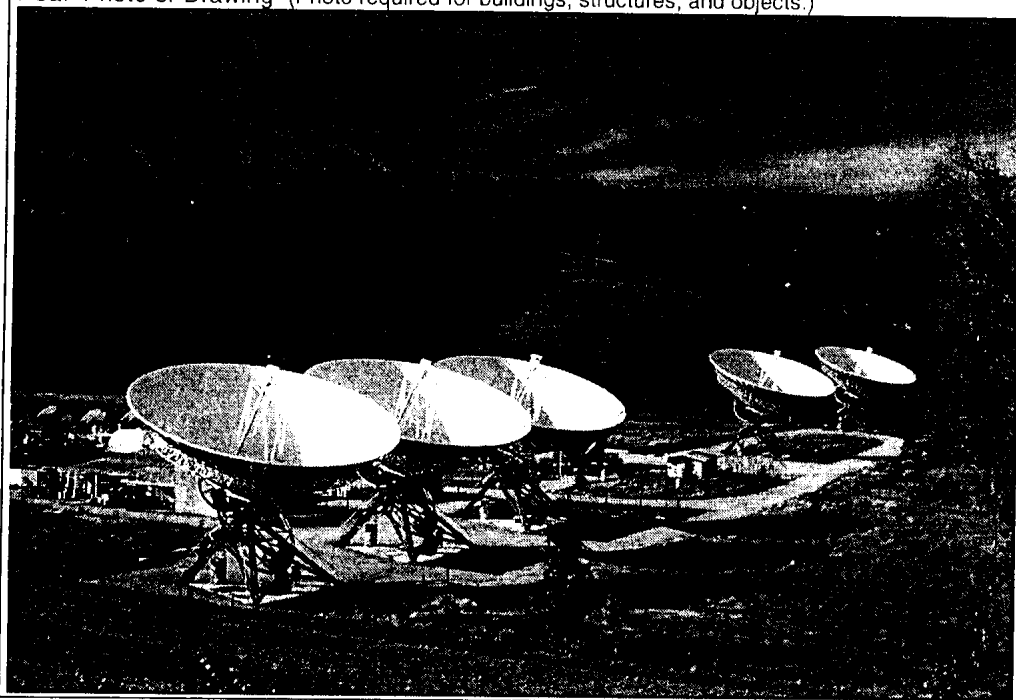
**\*P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

The Bracewell Observatory consists of two major elements. The first element is a radio telescope consisting of 32 10-foot dish antennas, of which the 32 concrete dish mounting piers remain, and the second element is a radio telescope consisting of 5 60-foot dish antennas, 1,500 square foot control room, and 500 square foot antenna signal combiner shed, all of which are currently fully intact at the time of this report. The dishes are of unique design by Radio Astronomy pioneer Professor R.N. Bracewell, and are of aluminum and steel construction. For information regarding the historical significance of these telescopes, please see the attached Building, Structure, and Object Record (DPR523B).

**\*P3b. Resource Attributes:** (List attributes and codes) AH15. Standing Structure; AH10. Machinery

**\*P4. Resources Present:**  Building  Structure  Object  Site  District  Element of District  Other (Isolates, etc.)

**P5a. Photo or Drawing** (Photo required for buildings, structures, and objects.)



**P5b. Description of Photo:** (View, date, accession #)

View looking southwest, 1972

**\*P6. Date Constructed/Age and Sources:**  Historic  
 Prehistoric  Both

**\*P7. Owner and Address:**  
 Stanford University  
 Building 10  
 Stanford, CA 94305-2060

**\*P8. Recorded by:** (Name, affiliation, and address)  
 B. Lash  
 Friends of the Bracewell  
 Observatory Association  
 567 Canyon Road  
 Redwood City, CA 94062

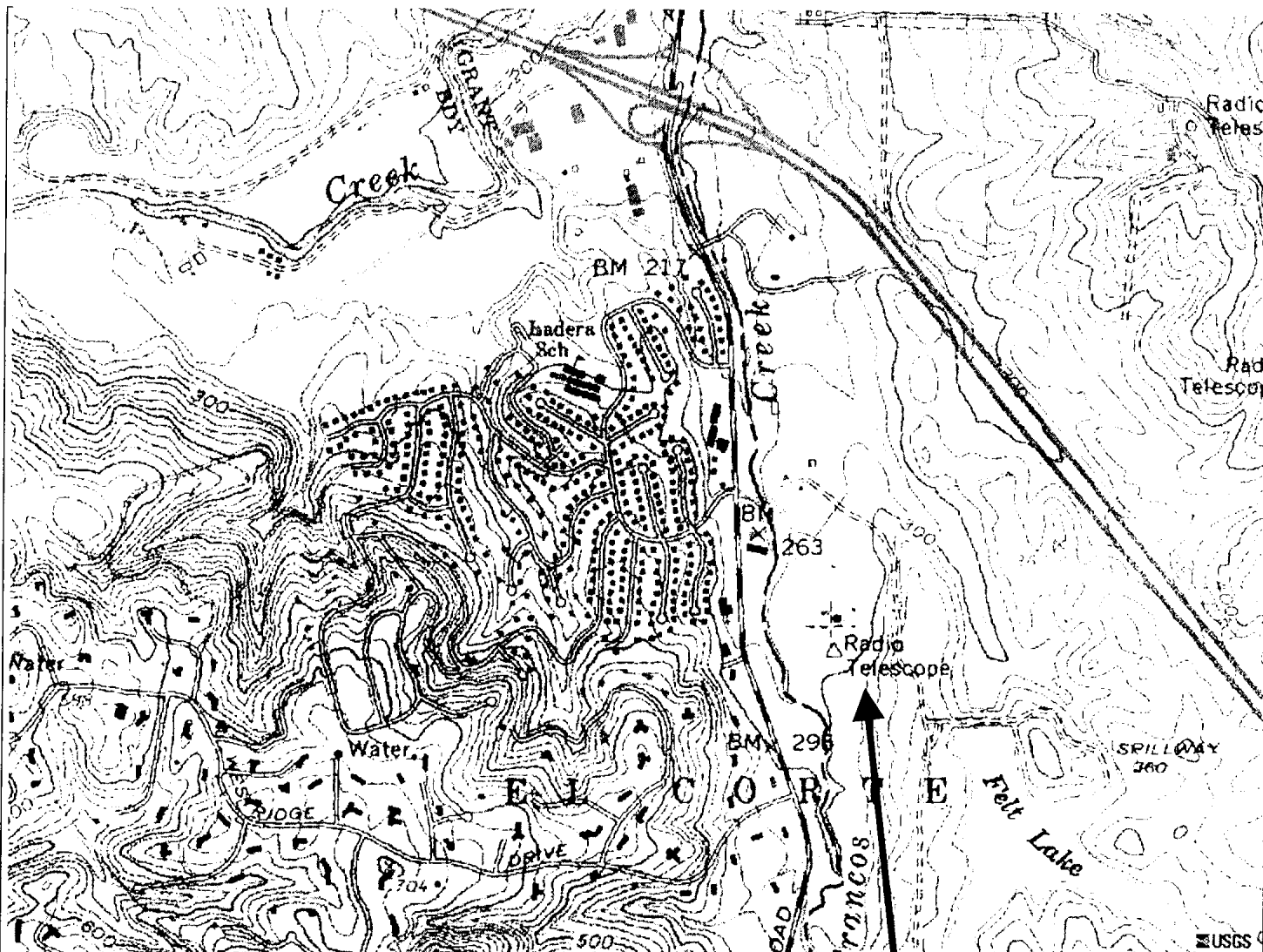
**\*P9. Date Recorded:** 9/25/05

**\*P10. Survey Type:** (Describe):

California Register nomination

**\*P11. Report Citation:** (Cite survey report and other sources, or enter "none.") None

**\*Attachments:**  NONE  Location Map  Sketch Map  Continuation Sheet  Building, Structure, and Object Record  
 Archaeological Record  District Record  Linear Feature Record  Milling Station Record  Rock Art Record  
 Artifact Record  Photograph Record  Other (List):



Site

**BUILDING, STRUCTURE, AND OBJECT RECORD**

\*Resource Name or # (Assigned by recorder) Bracewell Observatory

- B1. Historic Name: Heliopolis
- B2. Common Name: Bracewell Observatory, Stanford Field Site 515
- B3. Original Use: Radio Astronomy Observatory
- B4. Present Use: Radio Astronomy Observatory (currently inactive)
- \*B5. **Architectural Style:** Unique (These five 60 foot radio telescope dishes are of a unique design by R.N. Bracewell)
- \*B6. **Construction History:** (Construction date, alterations, and date of alterations)  
1955 – 1959 Construction of first Bracewell Radio Telescope (32 10-foot dish interferometer)  
1966- 1972 Construction of second Bracewell Radio Telescope (5 60-foot dish interferometer)

\*B7. Moved? No Yes Unknown Date: N/A Original Location: N/A

\*B8. **Related Features:**

Thirty two concrete mounting piers bearing hammer and chisel signatures of 180 distinguished visitors  
Control Room (Butler building, 1500 sq ft., constructed circa 1966)  
Antenna Combiner Shed (500 sq ft., constructed circa 1966)  
Forty species of eucalyptus trees personally planted by R.N. Bracewell

B9a. Architect: Ronald N. Bracewell

b. Builder: Stanford Radio Astronomy Institute (built on-site by staff)

\*B10. **Significance: Theme:** Pioneering Radio Astronomy Observatory **Area:** Unincorporated Santa Clara County  
**Period of Significance:** 1955 – 2005 **Property Type:** Academic **Applicable Criteria:** None  
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

The subject site was constructed by the Stanford Radio Astronomy Institute (SRAI), which was founded in 1955 by Professor Ronald N. Bracewell, the Lewis M. Terman Professor of Electrical Engineering, Emeritus at Stanford, who served as its first director. SRAI is known today as Stanford's Space, Telecommunications, and Radioscience Laboratory (STAR Lab).

In 1955 Professor Bracewell co-authored the first book on Radio Astronomy (R.N. Bracewell and J.L. Pawsey, Oxford, 1955), and today he **recognized worldwide as a leading historical figure in the history of Radio Astronomy and the history of Medical Imaging** (see Sullivan, W.T., The Early Years of Radio Astronomy: Reflections fifty years after Jansky's Discovery, Cambridge Press).  
(Continued on next page, DPR523L)

B11. Additional Resource Attributes: (List attributes and codes)  
(AH15) - Standing Structure; (AH10) - Machinery

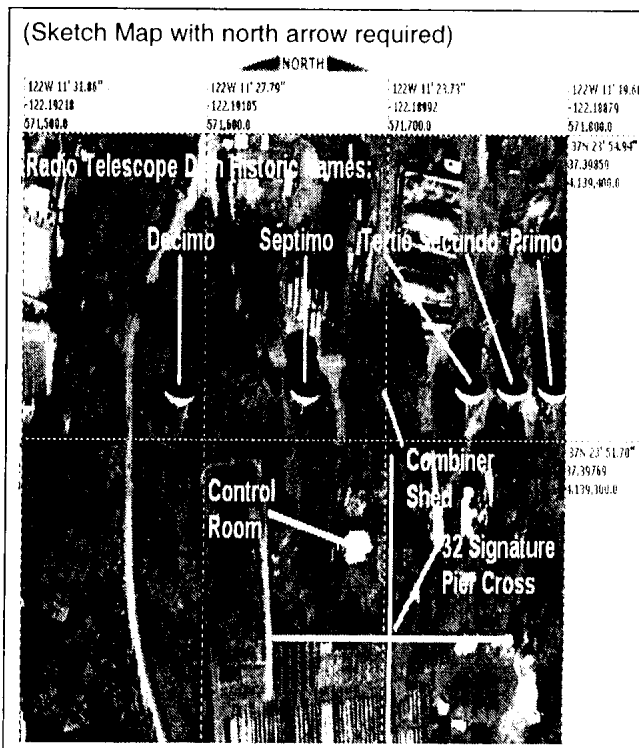
\*B12. **References:**  
(See page 12, DRP523L)

B13. Remarks:  
Stanford University has applied for a demolition permit for this historic resource, which is currently undergoing historic review.

\*B14. **Evaluator:** Bob Lash, President, Friends of the Bracewell Observatory Association

\*Date of Evaluation: 9/25/05

(This space reserved for official comments.)



\*Recorded by: B. Lash

\*Date: 9/25/05

Continuation  Update



*Professor Ronald N. Bracewell*

Born in Sydney, Australia in 1921, Professor Bracewell graduated from the University of Sydney in 1941 with the B.Sc. degree in mathematics and physics, later receiving the degrees of B.E. (1943), and M.E. (1948) with first class honors. During World War II he designed and developed microwave radar equipment in the Radiophysics Laboratory of the Commonwealth Scientific and Industrial Research Organization, Sydney under the direction of J.L. Pawsey and E.G. Bowen and from 1946 to 1949 was a research student at Sidney Sussex College, Cambridge, engaged in ionospheric research in the Cavendish Laboratory, where he received his Ph.D. degree in physics under J.A. Ratcliffe.

For experimental contributions to the study of the ionosphere by means of very low frequency waves, Dr. Bracewell received the Duddell Premium of the Institution of Electrical Engineers, London in 1952.

In 1992 he was elected to foreign associate membership of the Institute of Medicine of the U.S. National Academy of Sciences (1992), the first Australian to achieve that distinction, **for fundamental contributions to medical imaging.**

He was one of Sydney University's three honorees when alumni awards were instituted in 1992, with a **citation for brain scanning.**

Then, in 1994, he was the recipient of the Institute of Electrical and Electronic Engineers' Heinrich Hertz gold medal for pioneering work in antenna aperture synthesis and image reconstruction as applied **to radio astronomy and to computer-assisted tomography (CT scanning).**

In 1998 Dr. Bracewell was named **Officer of the Order of Australia (AO)** for "distinguished service of a high degree to... humanity at large" for his service to science in the fields of **radio astronomy and medical image reconstruction.**

\*Recorded by: B. Lash

\*Date: 9/25/05

Continuation     Update



*Officer of the Order of Australia for  
"distinguished service of a high degree to... humanity at large"*

### **Heliopolis (Stanford Field Site 515): The Birthplace of CT Scan Medical Imaging**

In 1954, while an Assistant Professor of Astronomy at Berkeley, Professor Bracewell proposed the construction of what was to become a world-famous radio telescope at Stanford, and carried out its initial design. He then came to Stanford to fulfill his vision.



*The Stanford 32-Element Cross Interferometer at Heliopolis (Site 515)*

In 1955 construction began of this 9.1 cm microwave spectroheliograph consisting of 32 ten-foot dish antennas, mounted on concrete piers, in a cross-shaped array to create high resolution maps of the face of the sun in the microwave spectrum. The site became known as "**Heliopolis**" because of this solar imaging research. Construction was carried out from 1955 to 1959.

\*Recorded by: B. Lash

\*Date: 9/25/05

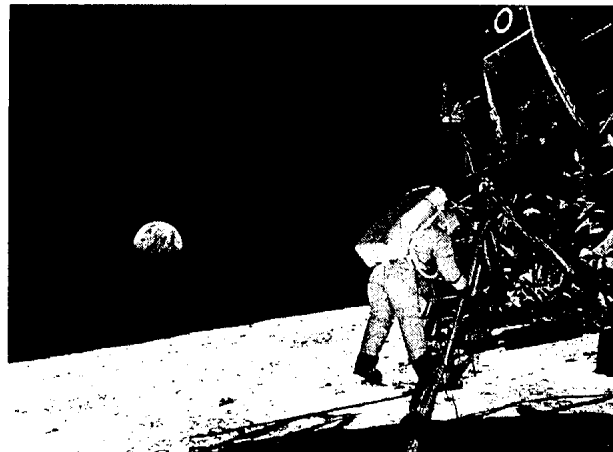
Continuation  Update



*Construction of the 32-dish array, 1955-1959*

Funded by the Air Force Office of Scientific Research, the array produced 11 years of detailed daily maps of the face of the sun in a virtually unbroken sequence from 1962 to 1973, completing one full solar cycle, and was the first radio telescope to achieve the resolution of the human eye.

The National Oceanic and Atmospheric Administration (NOAA) widely disseminated these solar map observations in their Solar Geophysical Data Bulletins. NASA relied on these daily reports during the Apollo lunar missions for solar flare predictions to help the astronauts avoid potentially lethal radiation exposure.



*Daily reports were transmitted from Heliopolis to NASA to protect Apollo astronauts from exposure to deadly solar flare radiation during lunar missions.*

\*Recorded by: B. Lash

\*Date: 9/25/05

Continuation     Update

In addition, this timely warning information about major solar flares was used worldwide, as such events disrupt global communications.

Although the 32 dishes were dismantled after 1973, their historical concrete mounting piers remain, bearing the signatures of many famous radio astronomers carved with hammer and chisel. For a complete list of signers, and their biographical information, please read Attachment E: "Famous Visitors to Heliopolis and their Hammer and Chisel Signatures."

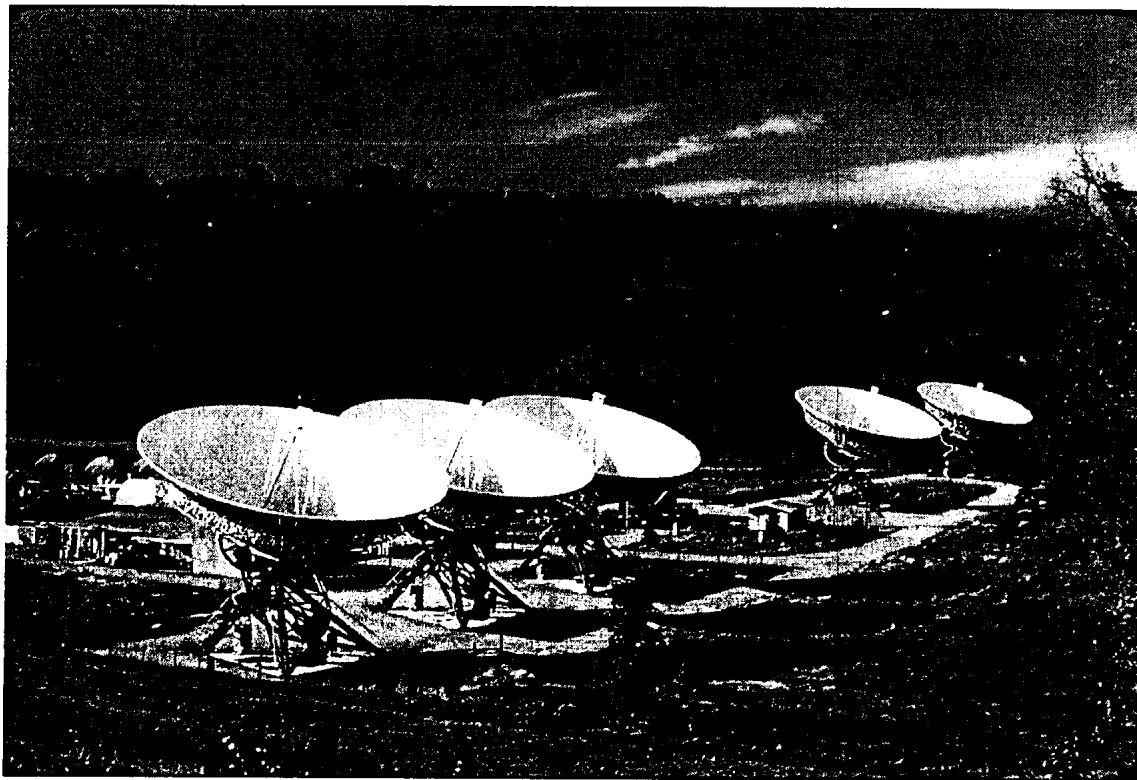


*Many of the remaining dish support piers bear the chiseled signatures of famous radio astronomers, including J.G. Bolton, who discovered the first four radio stars. A total of 189 historical autographs were carved by distinguished visitors during the past 50 years.*

\*Recorded by: B. Lash

\*Date: 9/25/05

Continuation  Update



*The Stanford Five Element Array, consisting of five 60-foot dishes, combiner building, and control room. Construction began in 1966.*

By 1966 Professor Bracewell had begun the construction of a much larger and more powerful imaging radio telescope, capable of studying the structure, movement, and polarization of extragalactic sources at high resolution, as well as the sun, known as the Stanford Five Element Array. The system consists of five 60-foot diameter dish antennas arranged in a minimum-redundancy array, and uses the principle of fast earth rotation synthesis to create high resolution image maps of the sky at a wavelength of 2.8 cm (10.7 GHz).

The array was designed and built from 1966 through 1972, by the Stanford Radio Astronomy Institute at a cost of \$2 million dollars (\$10.5 million in 2005 dollars), and was funded by the Air Force Office of Scientific Research and the National Science Foundation.

One of the most important discoveries made by this telescope was establishing the direction of motion of our solar system relative to the cosmic background.

In addition, the angular diameters, temperatures, and polarizations of numerous cosmic sources were studied, including radio galaxies, supernova remnants, planetary nebula, and H II hydrogen cloud regions.

\*Recorded by: B. Lash

\*Date: 9/25/05

Continuation  Update

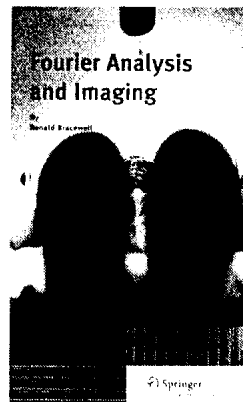
This second major radio telescope employed advanced concepts to achieve an angular resolution of 18 seconds of arc, and was applied to both solar and galactic studies. The calibration techniques for this leading-edge resolution passed into general use in radio interferometry via the medium of Stanford alumni.

The following major astronomical discoveries were made by the 5-Element Array:

- **A remarkable observational limit of 1.7 millikelvins, with considerable theoretical significance for cosmology, was set on the anisotropy in collaboration with Ph. D. student E.K. Conklin (1967).**
- **The correct theory of a relativistic observer in a blackbody enclosure (1968)**
- **Nulling interferometry - an antenna technique for suppressing the radiation from a star while accepting the radiation from a planet resembling the Earth which might a candidate for intelligent life.**
- **the absolute motion of the Sun at 308 km/s through the cosmic background radiation was measured by Conklin (1969), some years before independent confirmation.**

Both extragalactic and solar activity observations were conducted until 1979, when the National Science Foundation decided to cut off funding to individual university observatories, and concentrated all federal funds into a few "big science" national centers (the National Radio Astronomy Observatory in Greenbank, the Very Large Array in Socorro, and the Arecibo radio telescope in Puerto Rico).

The development of the 32-dish and 5-dish telescope arrays at **Heliopolis advanced the state of the art in medical diagnosis**. The image reconstruction mathematical methods developed by Professor Bracewell for these arrays were universally adopted into the algorithms of CAT Scanners.



*Above: An authoritative text book on CT scan imaging written by Professor Bracewell, entitled "Fourier Analysis and Imaging" (Springer Press)*

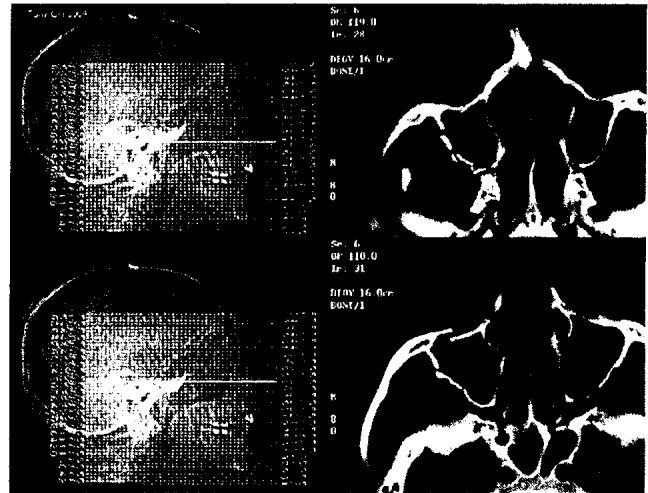
\*Recorded by: B. Lash

\*Date: 9/25/05

Continuation  Update

**In 1967, Professor Bracewell published in the *Astrophysical Journal* (Vol. 150, No. 2) the numerical algorithm for tomographic image reconstruction which had its roots in both the 32-dish and 5-dish arrays.**

Godfrey Newbold Hounsfield at Electrical and Musical Industries (EMI), UK learned of Professor Bracewell's image reconstruction algorithm and decided to build hardware to implement it into a commercial product. EMI was the company that developed the antennas for public TV broadcasting in England before WWII and where Joe Pawsey gained the antenna know how that he imparted to Professor Bracewell in the 40s. These machines were first sold by EMI at a million dollars each to hospitals in the US.



*The CT Scan Medical Imaging System can create detailed 3D views inside of the human body, directly incorporating the reconstruction method originated and refined for the dish arrays of Heliopolis*

Millions of lives have been saved around the world as a direct result of these dishes at 3185 Alpine Road. These structures, personally designed by a significant historical figure, are not merely rare, they are one-of-a-kind.

Stanford University itself has a permanent historical exhibit about the Bracewell Observatory on display in the lobby of its David Packard Building. The exhibit features photos of the dishes, as well as photos of CT Brain Scan images, and describes how the field of Computed Tomography Medical Imaging originated from these dishes.

In April of 2005, The International Astronomical Union's (IAU) Inter-Union Commission for the History of Astronomy (ICHA), which was tasked with identifying and listing "historically significant radio telescopes", has designated Stanford's 60-foot dishes as "historically significant" and published information about them in their bulletin. A copy of the IAU / ICHA Newsletter (No. 7, April 2005, pp. 8-9) is attached as Attachment F. The IAU is an international body consisting of 63 member nations, including the United States.

\*Recorded by: B. Lash

\*Date: 9/25/05

Continuation  Update

International Astronomical Union International Union of the History  
and Philosophy of Science



THE ICHA NEWSLETTER  
NEWSLETTER OF THE INTER-UNION COMMISSION FOR  
HISTORY OF ASTRONOMY

No. 7 - April 2005

SUMMARY

A The IAU Historic Radio Astronomy Working Group. 2. Progress Report 2

*The International Astronomical Union's Inter-Union Commission for the History of Astronomy  
has designated the 60-foot dishes at Heliopolis "historically significant."*

The Friends of the Bracewell Observatory Association (FBOA), a non-profit 501(c)(3) organization, was founded to preserve and present the history of the scientific contributions made at this site, and to fund the restoration and maintenance of the observatory for the benefit of Stanford faculty and students.

FBOA has 65 volunteers who have begun scanning and archiving hundreds of historical documents and photos, and has developed a restoration and maintenance plan. In addition to funding the maintenance of the artifacts, grounds, and facilities, we will provide docents to lead historical pier walks, observatory tours, and provide educational materials to Stanford visitors. In addition, a documentary film is being prepared which will be made available to schools as well as the public at large.

In a recent letter to Stanford Ombudsman David Rasch, science historian William Glen writes:

To: [rasch@stanford.edu](mailto:rasch@stanford.edu)  
From: William Glen <[bglen@usgs.gov](mailto:bglen@usgs.gov)>  
Sent: Thursday, August 18, 2005 16:11:39 -0700  
Subject: Saving Heliopolis

Dear Dr. Rasch:

My feelings, after reading of the history of Heliopolis, is one of amazement. It is a total enigma as to how a Stanford dean could continue to call for the destruction of this absolutely unique and historically significant artifact and landmark.

You don't have to be a historian of science (which I am) to join the effort to stop demolition. I hope that you can play a role in preventing what is tantamount to the burning of a chapter in the book of Stanford's history.

William Glen, PhD  
Visiting historian of science  
U.S. Geological Survey  
345 Middlefield Road, MS901  
Menlo Park, CA 94025

\*Recorded by: B. Lash

\*Date: 9/25/05

Continuation  Update

In-depth historical information about the Bracewell Observatory at Heliopolis is provided in the following attachments:

<u>Attachment</u>	<u>Description</u>
A	Biography of Ronald N. Bracewell
B	Photos and technical descriptions of the 32-dish and 5-dish arrays of Heliopolis
C	The Early Years of Radio Astronomy: Reflections Fifty Years After Jansky's Discovery
D	Radio Astronomy at Stanford from the Journal of Astronomical History and Heritage
E	Famous Visitors to Heliopolis and their Hammer and Chisel Signatures
F	The IAU / ICHA Newsletter, No 7., 4/05 on historically significant radio telescopes
G	Digital Picture Processing, Vol. 1., 1982 on origins of image reconstruction
H	Radiology, Vol. 117, No.3, 1975, "Image reconstruction... [was] solved by Bracewell"
I	Phys. Med. Biol., Vol. 21, 1976 "[CT imaging] ...method was first derived by Bracewell"
J	Stanford Daily, May 20 1992, "Bracewell... elected to the Institute of Medicine [for CT]"
K	Campus Report, May 20, 1992 "Bracewell Recognized by Institute of Medicine [for CT]"
L	Image Restoration and Reconstruction, 1986 "Originally put forward... by Bracewell"
M	1996 SEGUNA Award: "A universally acclaimed giant among all scientists."
N	Cancer Related Astronomy, 1994, remarks for the Heinrich Hertz Medal Award
O	Ronald N. Bracewell Awards and Citations
P	Certificate of Election to the Institute of Medicine, National Academy of Sciences, 1992
Q	Inspection Report Summary for Site 515 Antenna Array, Control Room, and Shelter
R	Observatory Reports of the Stanford Radio Astronomy Institute, 1961 – 1980
S	The Stanford Five Element Radio Telescope, Proc. IE 35775
T	Five Element X-Band Array Design Factors, GLINT No. 153, 1966
U	Inventory of Historical Document and Photo Cartons for Site 515 as of December, 2004
V	Petition to save the dishes, with comments from the public regarding historical significance
W	List of Publications by R.N. Bracewell

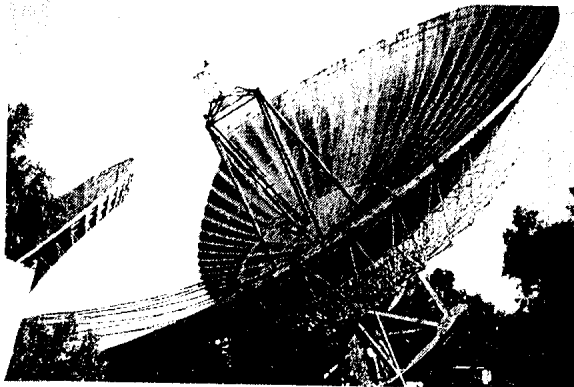
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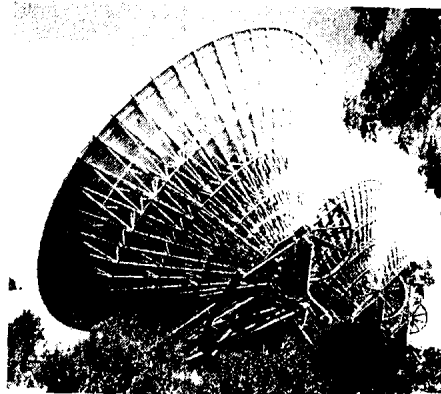
Continuation

Update

Current condition and integrity:



*View looking west 2005, dishes 4 & 5  
(Septimo, Decimo)*



*View looking east 2005, dishes 1, 2, & 3  
(Primo, Secundo, Tertio)*

Radio Telescope Dishes (Historic names: Primo, Secundo, Tertio, Septimo, Decimo)

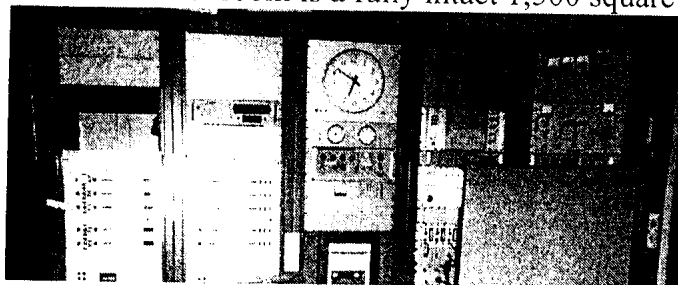
Dish panel surfaces are intact. Mounts are structurally sound, and all key parts are still there. Surface rust is superficial, and can be removed and re-painted. System electronics are intact. Surface grime easily washes away, revealing intact white enameled aluminum panel surfaces. Hour Angle (east-west movement) and Declination (north-south movement) drive components are intact.

Control Room (Butler building)



*View looking south, 9/2004*

The control room is a fully intact 1,500 square foot pre-fabricated Butler building, with metal roof.



*Interior of control room building.  
Telescope systems are fully intact.*



*View looking west, 9/2004  
Antenna Combiner Shed, 500 sq. ft.  
Fully intact, but roof needs repair.*