Interoffice

National Radio Astronomy Observatory

Charlottesville, Virginia

September 1, 1982

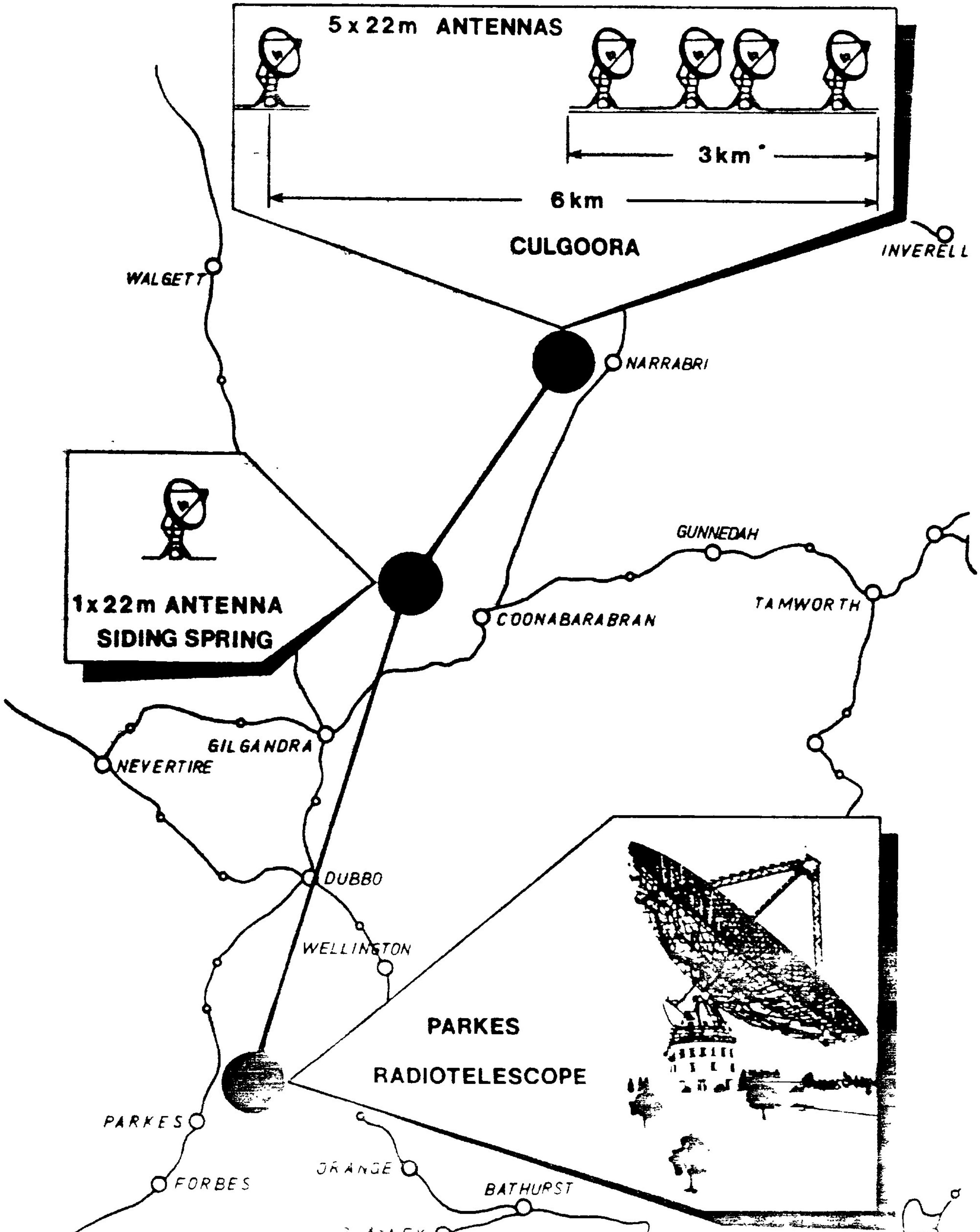
To: VLBA Proposal Group

VLB ARRAY MEMO No. 122

From: H. Hvatum

Subject: Australian Telescope

Here is a copy of a condensed version of the Australian VLBA proposal. I thought it would be of interest to us because of possible coordination with the Australian project. For example, would it be desirable to use the same frequencies?



THE AUSTRALIA TELESCOPE

EXPANDING THE FRONTIERS OF KNOWLEDGE

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Australia will have the most versatile radio telescope array in the world provided the Australia Telescope proposal now before the Commonwealth Government is approved in the 1982 Federal budget. If construction can start in 1982, the Australia Telescope will come into operation in 1988 to give the nation a flying scientific start into its third century.

For further information contact the CSIRO Division of Radiophysics, P.O. Box 76, Epping, N.S.W. 2121.

AUSTRALIAN SCIENTIFIC ACHIEVEMENTS

The two fields of scientific endeavour in which Australia is internationally renowned are: immunology - the study of the immunity from disease and the conditions governing it; and radio astronomy - the exploration of the Universe by means of radio telescopes.

The construction of innovative radio telescopes and their role in unravelling the secrets of the Universe were pioneered by Australian scientists following their wartime effort in the development of radar. The outstanding achievements of the scientists have brought great prestige to Australia and have led to the construction of several fine radiotelescopes financed largely by USA funds: the Parkes 64 metre telescope, completed in 1961; the 1.6 kilometre Molonglo Cross array, completed in 1965 and recently upgraded; the Culgoora radioheliograph for studying emissions from the Sun, completed in 1967; and the Fleurs synthesis telescope, commissioned in 1973.

Even 20 years after its commissioning the Parkes radio telescope is still making major new discoveries. But the Parkes telescope is beginning to show its age and is losing its standing as a competitive telescope in comparison with important new installations in Europe, the USA, USSR and Japan. By 1990 the types of observations needed in radio astronomy will be beyond the capabilities of the Parkes telescope and also those of the Molonglo and Fleurs synthesis telescopes. The radioheliograph at Culgoora is already scheduled to cease operations in 1984.

AUSTRALIA'S FUTURE IN RADIO ASTRONOMY

Since 1975 a national steering committee has been working on proposals for a modern radio telescope to enable Australia to continue its scientific endeavour in radio astronomy into the 21st century. The proposal now before the Commonwealth Government is a new and technologically advanced design known as the Australia Telescope. With it we will be able to turn Australia into a giant radio telescope, one that will be capable of probing the innermost secrets of the Universe.

Provided funding is approved in 1982, the Australia Telescope will come into operation in 1988. Accordingly, the proposal has been put forward for consideration as a bicentennial project. This most significant and lasting project will pay tribute to our past accomplishments in science and ensure the continuation of this fine tradition by a new generation of Australian scientists.

THE CONCEPT OF THE AUSTRALIA TELESCOPE

The Australia Telescope will consist of three main elements. One would be a linear array of five 22 metre dishes at Culgoora near Narrabri in New South Wales. Another 22 metre dish would be located at Siding Spring near Coonabarabran, the site of Australian and British optical telescopes, while the third element would be the existing 64 metre dish at Parkes.

A photograph of the model of one of the proposed 22 metre dishes is shown on the back cover of this booklet.

The array at Culgoora alone will simulate a telescope 6 kilometres in diameter; this array will allow mapping of the broader features of radio sources and investigations of the spectral line emissions from giant molecular clouds in our galaxy. By linking the Culgoora array to the Parkes and Siding Spring dishes, the proposed telescope would form an array equivalent to a single dish 300 kilometres across. As such it will be the most versatile synthesis telescope in the world and it will have the potential to make major discoveries well into the 21st century.

But the possibilities for the Australia Telescope do not end with the proposed array itself. The Australia Telescope array, which would be the first of its type in the Southern Hemisphere, could be linked, via satellite, to span the entire 3000 kilometres of the Australian continent. It would link radio telescopes in Culgoora, Siding Spring, Parkes, Fleurs near Sydney, Tidbinbilla, Hobart, Alice Springs and Carnarvon, as shown in Figure 1.

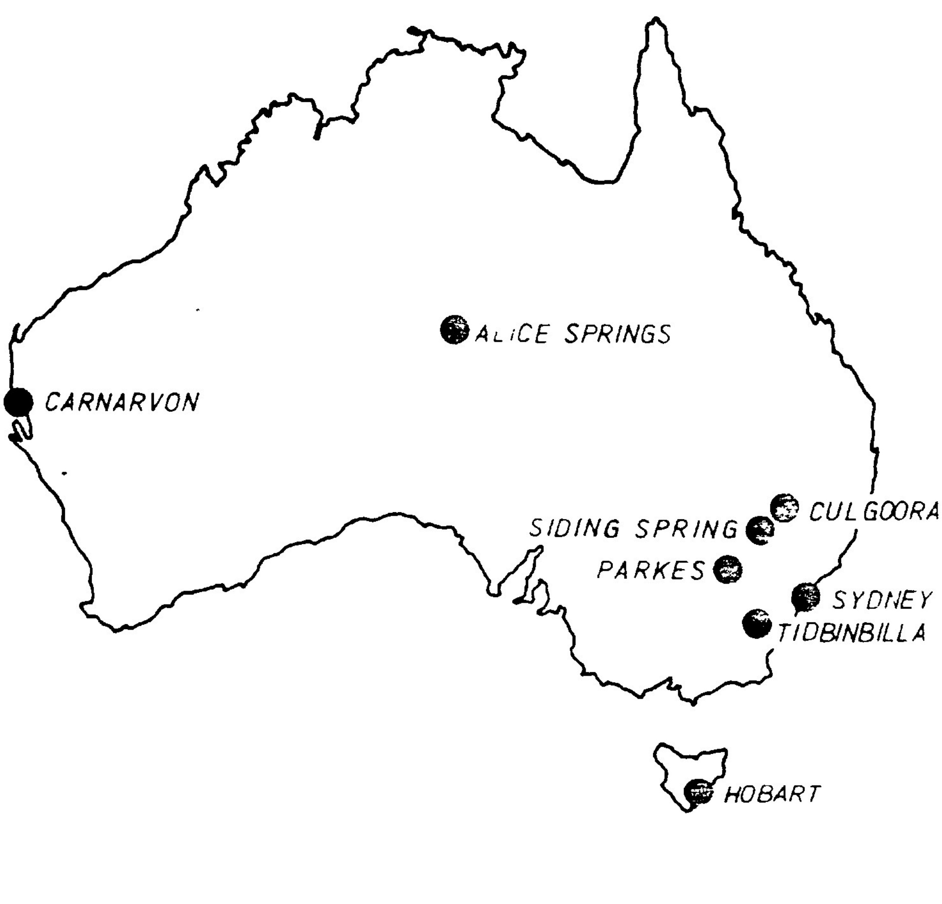


Figure 1

With this enlarged array, Australia would have the highest sensitivity, high resolution telescope in the world, an array which will recognise details 1000 times smaller than even the most powerful single telescopes can detect.

WHAT MAKES THE AUSTRALIA TELESCOPE UNIQUE?

By linking radio antennas across the country via satellite and ground links, the Australia Telescope will be able to see finer details than any optical telescope, either ground-based or space-borne. A unique and fundamental feature of the telescope will be its ability to "see" the radio sky on all angular scales, that is, to have an effective zoom ratio of 10,000 to 1.

By itself, the 6 kilometre array at Culgoora will be able to form radio images with detail matching the 1 second of arc image size of the Anglo-Australian optical telescope at Siding Spring. With the array stretching from Culgoora to Parkes, we will be able to complement the 0.1 second of arc images of the US/European Space Telescope due for launching in 1986. Higher resolutions still, to one thousandth of a second of arc, are available at radio wavelengths by linking radio dishes across the continent; this level of resolution is not obtainable at optical, X-ray or other wavelengths.

In everyday terms, such high resolution is equivalent to a person being able to see a ten cent coin in Sydney whilst stationed in Melbourne.

But there are other aspects which make the Australia Telescope unique. It will be the only instrument designed specifically for spectral line observations.

It will be the only large array in the southern hemisphere. Other existing and proposed arrays of radio telescopes are all in the northern hemisphere. They reveal very fine details of radio sources visible from the northern latitudes. However many of the most interesting radio sources lie too far south in the skies for these telescopes. The Australia Telescope array in the southern hemisphere is ideally located to explore these sources.

The Australia Telescope will also have some very down-to-earth applications as well. The proposal opens up a whole new range of possibilities for the geophysics and geodetic communities. It will allow the operation of a high sensitivity, very long baseline interferometry (VLBI) array in Australia. Using a small portable antenna and the VLBI technique it will be possible to survey to an accuracy of millimetres over the whole of the continent. Such measurements will enable scientists to see how far and in what direction the plates of the Earth's crust are moving. The movement of these plates is believed to be a crucial factor in the causing of earthquakes. Knowledge of fault lines associated with the movement of plates is useful also for mineral and petroleum exploration because deposits often occur along fault lines in the Earth's crust.

AUSTRALIAN INVOLVEMENT

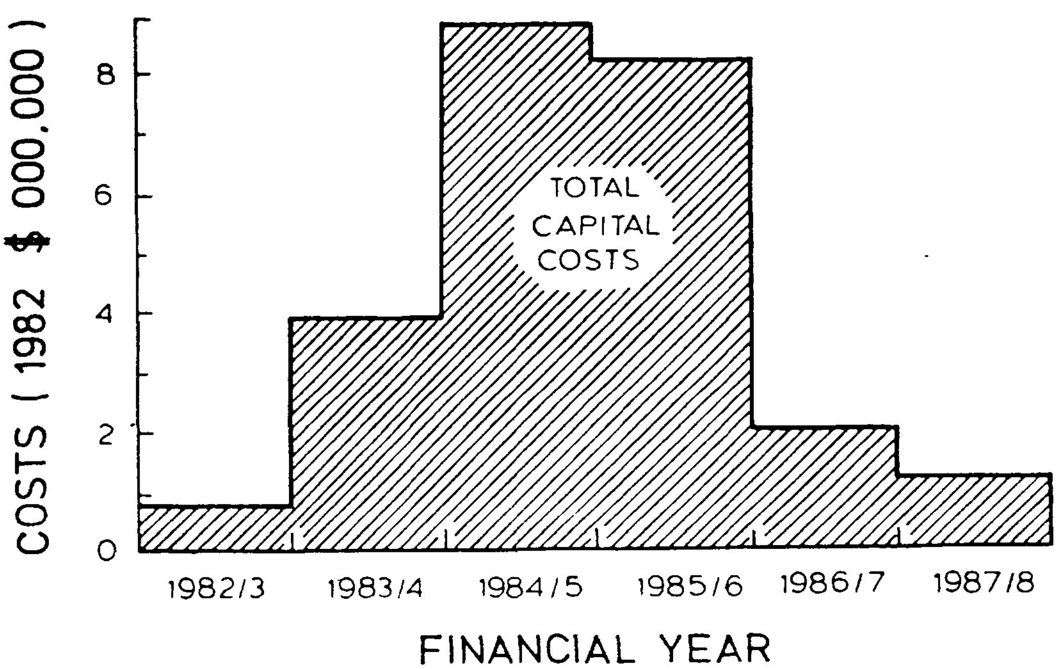
The Australia Telescope is a totally Australian project with an Australian content in excess of 80%. It draws on Australian astronomy expertise which is acknowledged world-wide as being at the forefront in all relevant areas. This is the same sort of expertise that attracted, in different circumstances, substantial overseas funding for previous major telescopes in Australia.

The Australia Telescope is to be operated as a National Facility available to all Australian scientists. Hence, it will provide stimulus and opportunities for continuing development work in a range of Australian institutions. It will provide the basis for sophisticated higher degree work at universities in both astronomy and technical areas.

COST ESTIMATES

The rate of expenditure for the six year construction period of the Australia Telescope is shown in Figure 2. Antenna costs, based on the design study by the Sydney consulting engineers Macdonald, Wagner and Priddle, account for almost half the total cost of $25 million.

In the 1982/83 financial year only 820 thousand dollars is required to commence the project.



AUSTRALIA TELESCOPE PROJECT

Figure 2

TECHNOLOGICAL INNOVATION IN THE AUSTRALIA TELESCOPE

The Australia Telescope project is one of great scientific merit and technological innovation. As with past advances in radio astronomy, major technological spin-offs relevant to Australian industry will result. Much of the skill and expertise developed will be directly applicable to the design and construction of domestic satellite reception and transmission facilities.

Such skills will give local industry a stake in the very important telecommunications market.

CSIRO designs have already provided substantial benefits to the Overseas Telecommunications Commission (OTC) for its ground stations at Moree and Carnarvon.

Work on the image processing capabilities of the Australia Telescope will be of direct relevance to biomedical and industrial applications.

The major design studies which form the basis of the proposal are:

Antennae - Very high performance-to-cost ratio has been achieved in the antenna design by Macdonald, Wagner and Priddle in association with Ir B.G. Hooghoudt, and new ways of achieving precision dish surfaces at low cost have been devised. The expertise will allow efficient ground stations for satellite communication to be designed and built in Australia.

Antenna Feeds - The antenna feeds for the Australia Telescope will be ultra-wideband and will allow simultaneous multi-frequency observations. The "polarization purity" of such feeds, achieved by engineers of the CSIRO Division of Radiophysics, has been crucial for developments in satellite communication. New ideas in feed design for the Australia Telescope have been used to build new feeds for the OTC dish at Moree, so saving OTC some $4 million.

Cryogenic Receivers - CSIRO has a major centre of expertise in low-noise receiver and cryogenic technology thus assuring high sensitivity for the Australia Telescope.

Satellite Distribution of Time and Frequency - The Australia Telescope will pioneer the use of satellites for the distribution of precision time and frequency references for local oscillator synchronization.

Data Transmission using Optical Fibres - The Australia Telescope will employ high-speed digital techniques to transmit information from the antennae to the central control area. Optical fibres and higher-speed links than those used in current practice will be required.

Very Large-Scale Integrated Circuits - Specific new VLSI circuits have been designed for the correlation system and for the signal processing and display systems for the Australia Telescope.

Image Processing - The Australia Telescope will use unique image processors and display systems of Australian invention to provide better facilities and faster turn-around in processing of images.

EXPLORING THE UNIVERSE WITH THE AUSTRALIA TELESCOPE

Important exploratory astrophysical projects await the Australia Telescope at the end of this decade. Many of these projects arise because of our privileged position in the southern sky.

Some of the most interesting radio galaxies will be within the field of view of the Australia Telescope. At present astronomers have only a limited ability to probe the critical central regions of the southern radio galaxy Centaurus A. This galaxy is closer than any other radio galaxy and offers unparalleled opportunities for studying the energy source in such luminous objects. With the Australia Telescope such galaxies will be studied in detail.

The centre of our own galaxy passes almost overhead in northern New South Wales and thus this area is ideally situated as a base for detailed studies of the Galaxy. The Australia Telescope will have unrivalled power to investigate the spectral-line emission from giant molecular clouds in our galaxy. The richest of these clouds, which are the birthplace of stars, lie in the Southern Hemisphere.

The Telescope will permit detailed studies of the structure and dynamics of distant galaxies. The nearest galaxies - the Magellanic Clouds - are only visible from the Southern Hemisphere and provide unique opportunities for research.

Another very important research area in astronomy is that related to the major discrepancy between the apparent birthrate of supernova remnants and pulsars - the two products of a supernova explosion. Such objects can best be studied in the Southern Hemisphere. Scientists from the CSIRO Division of Radiophysics and the University of Tasmania have recently discovered pulsars in the Magellanic Clouds. The Einstein orbiting X-ray observatory has discovered 80 possible new supernova remnants in the Clouds. Initial radio observations of these sources being made with the Molonglo telescope will lay the basis for a major program with the Australia Telescope.

The Australia Telescope is an essential tool in the study of the following:

- Active galactic nuclei and quasars;
- Faster-than-light motions;
- Extragalactic astrometry;
- The nucleus of our own galaxy;
- Violent galactic stars - possible black holes;
- Interstellar chemistry;
- Maser sources - stars in the making;
- Proper motions within our galaxy for radio stars and pulsars;
- Compact ionized hydrogen regions.

1982 - THE YEAR OF DECISION

The Australia Telescope has been conceived as part of Australia's continuing vital role in 20th century scientific endeavour in the field of radio astronomy - a field pioneered by Australian scientists in the postwar years.

The Australia Telescope proposal provides Australia with an opportunity to build, at modest cost, the most versatile radio telescope in the world. With it, Australian astronomers can look forward to solving some of the most perplexing problems in astronomy today; without it, one of Australia's most eminent fields of science will die.

1982 is the year of decision for radio astronomy in Australia. If the Australia Telescope is not funded, we are clearly left in a situation where the present radio telescopes will run down over five to seven years. A decision not to fund the Australia Telescope will be seen by the Australian and the world scientific community as a policy decision to discontinue radio astronomy in Australia.

Alternatively, if a start on the Australia Telescope can be made in 1982, the Telescope will come into operation in 1988, Australia's Bicentennial Year. It would be a scientifically and technologically demanding project which would symbolize our past achievements in science and, more importantly, ensure the continuation of this outstanding tradition by a new generation of Australians.

THE AUSTRALIA TELESCOPE

TECHNICAL SPECIFICATIONS

(as at 1 May 1982)

Antennas: 5 of 22m diameter at Culgoora
1 of 22m diameter at Siding Spring
1 of 64m diameter at Parkes

Antenna types: All antennas alt-azimuth mounting
Culgoora antennas movable on rail-track
22m antennas, Cassegrain optics
64m, prime focus optics

Antenna pointing accuracy:
22m : 15" rms
64m : 10" rms

Antenna frequency limits:
1 GHz to 45 GHz

Antenna spacings:

Culgoora array : 40m to 3120m (20m increments)
40m to 6000m (40m increments)

Long baseline array:	Culgoora - Siding Spring	115km
	Culgoora - Parkes	321km
	(Culgoora-Tidbinbilla	568km)

Antenna links:

Culgoora array : Optical fibres/coaxial cable
Long baseline array : Radio

Receiver frequency bands and types:

1.35 - 1.75 GHz (min.)	Cooled FET	T_{sys}	$\lesssim$ 30K
4.5 - 6.1 GHz (min.)	Cooled FET	T_{sys}	$\lesssim$ 35K
8.4 - 10.7 GHz (min.)	cooled FET	T_{sys}	$\lesssim$ 40K
22 - 25 GHz (min.)	Maser	T_{sys}	$\lesssim$ 50K
40 - 45 GHz (min.)	Maser	T_{sys}	$\lesssim$ 65K

Feed type:

On axis, dual frequency, dual polarization

Receiver polarization:

All Stokes parameters available

Correlator system:

Number of complex correlators : 48

Number of frequency channels per correlator : 128

Bandwidths available : 100 kHz - 50 MHz

Maximum field sizes:

Culgoora array	:	1°.5 x 1°.5 at 1.4 GHz
		3' x 3' at 45 GHz
Long baseline array:		2' x 2' at 1.4 GHz
		4" x 4" at 45 GHz

Maximum map resolution:

1024 points x 1024 points

Resolution:

Culgoora array	:	6" at 1.4 GHz (max.)
		0".2 45 GHz (max.)
Long baseline array:		0".12 at 1.4 GHz
		0".004 at 45 GHz

Observation time per map:

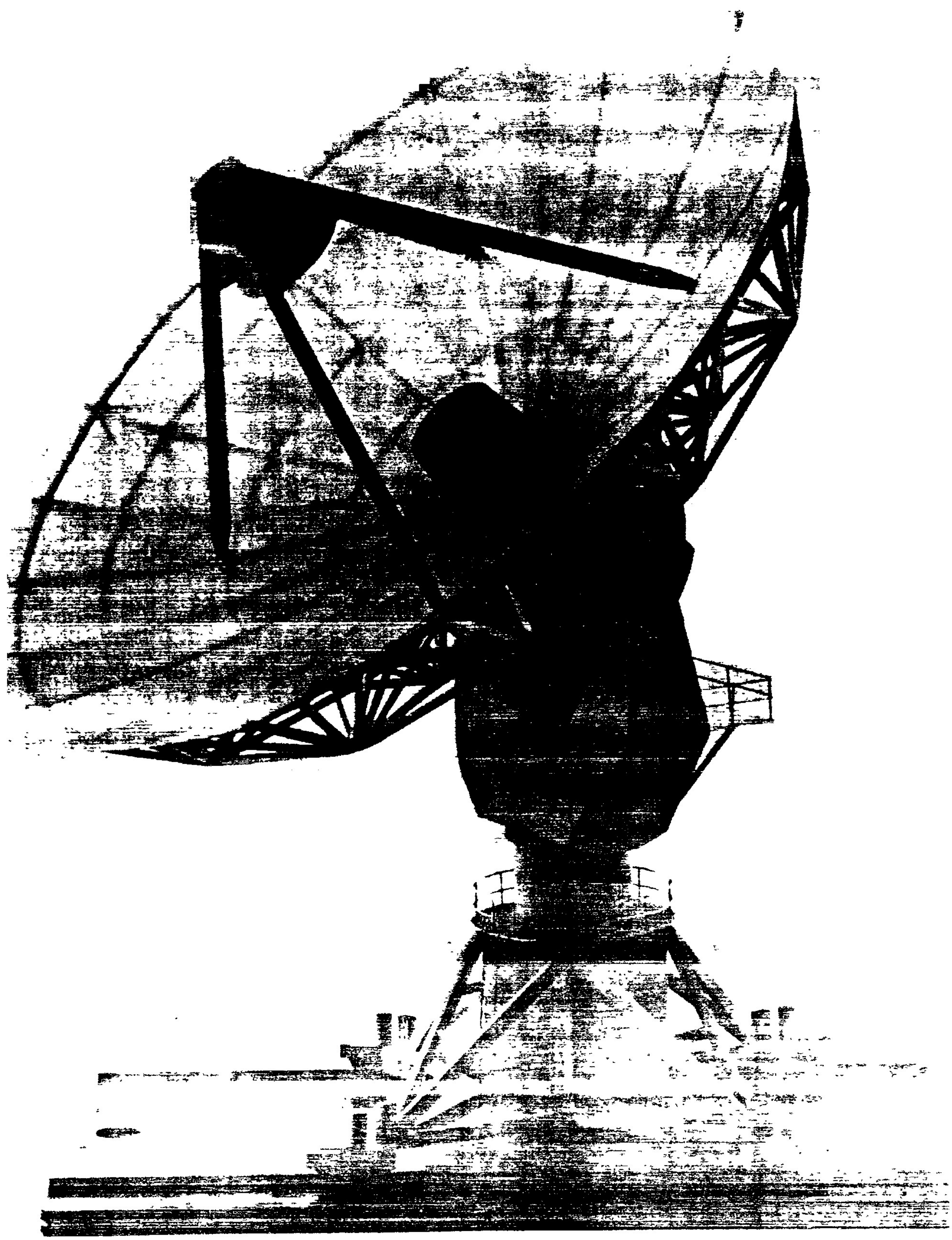
Culgoora array	:	12^h to 18 x 12^h
Long baseline array:		12^h

Sensitivity:

(i) 10 x 12^h, 10 GHz continuum, 6km baseline:
Field 12' x 12', Resolution 0".8, Sensitivity 28 μJy rms

(ii) 8 x 12^h, 1.4 GHz spectral line, 1.6km baseline, 20 kHz spectral resolution:
Field 1°.5 x 1°.5, Resolution 20", Sensitivity 0.5K rms

(iii) 1 x 12^h, 5 GHz continuum, long baseline array:
Field 35" x 35", Resolution 0".03, Sensitivity 100 μJy rms



AUSTRALIA TELESCOPE