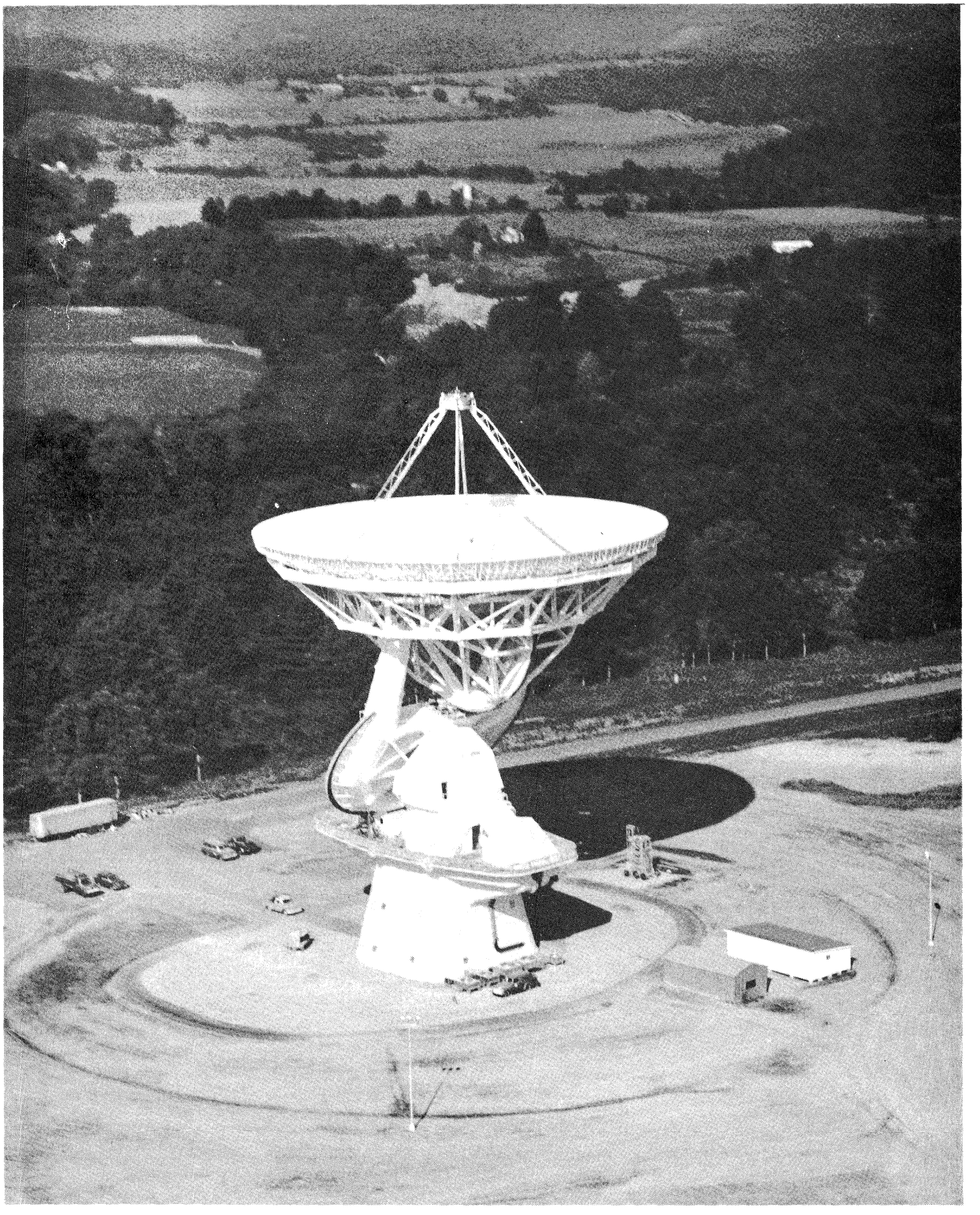
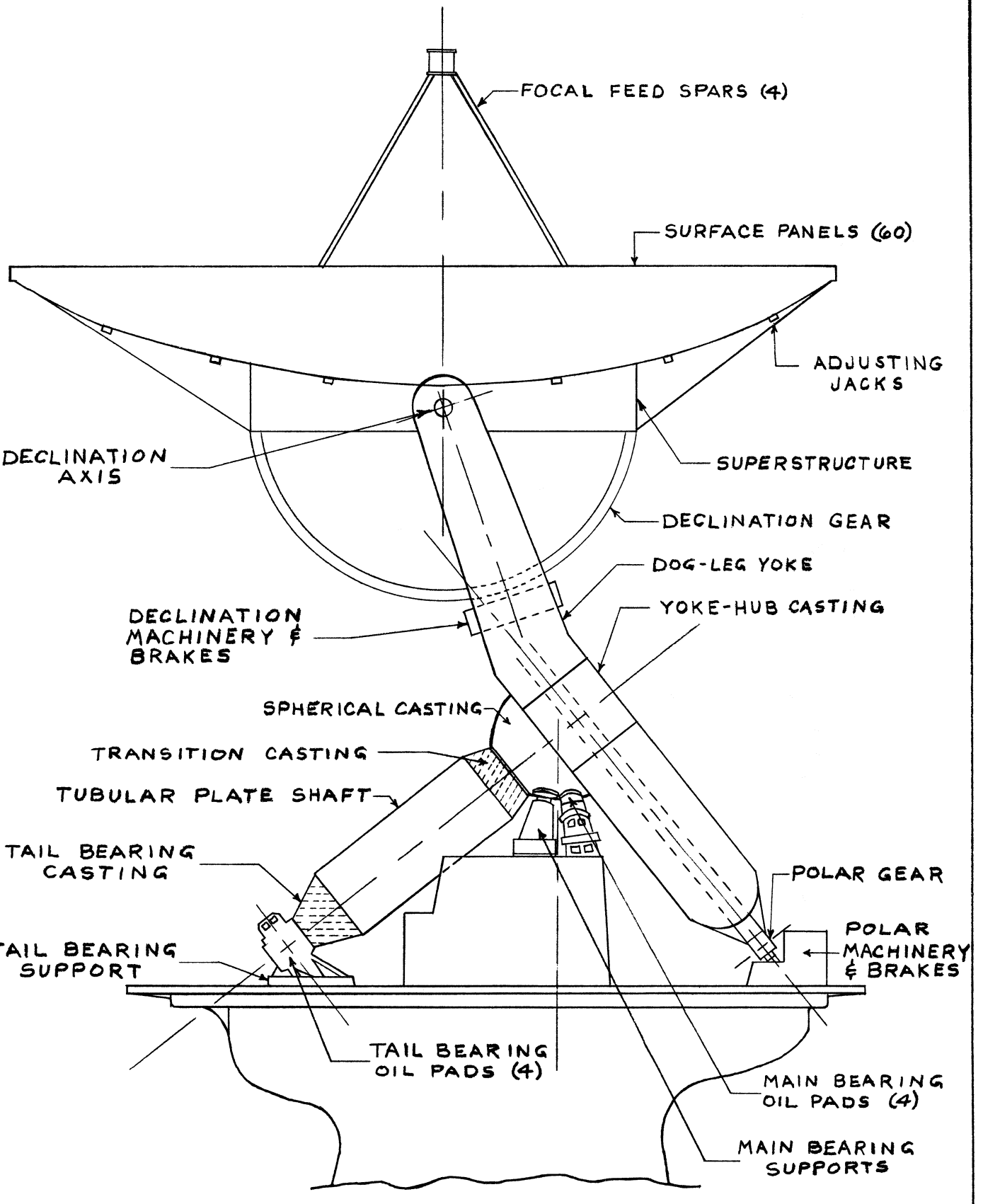


140' RADIO TELESCOPE
NATIONAL RADIO ASTRONOMY OBSERVATORY
GREEN BANK, WEST VIRGINIA.



N.R.A.O.

140 FOOT RADIO TELESCOPE ON EQUATORIAL MOUNT

NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

PHYSICAL VALUES OF 140-FOOT TELESCOPE

Location:

Green Bank, West Virginia;
Latitude — 38° 26' 17" North;
Longitude — 79° 50' West.

Base:

Elevation of observation deck — 2,722.5 feet above sea level;

Height to observation deck — 41' 6" above ground.

Reinforced concrete on rock 30 feet below ground. Contains 5,700 tons of 5,000 psi concrete with 140 tons of steel;

Walls are three feet thick;

Contains control room, hydraulic and electric equipment, transformer vault, electronics shop.

Mount:

Equatorial — two mutually perpendicular axes;

Tail bearing contains friction-less oil pads, adjustable to provide true alignment of the polar shaft parallel with the earth's axis;

Main bearings are four friction-less oil pads, supporting a total static weight of about 2,450 tons.

Main bearing oil pressure — over 4,000 psi at start-up;

Main bearing oil pressure — about 3,800 psi under worst wind load;

Main bearing oil pressure — over 1,500 psi static load only.

Polar Axis:

Will rotate 220° - 110° East of meridian and 110° West;

Is defined by a steel shaft 67 feet long, floated on an oil film .005" thick;

It is made of:

A nickel steel tail bearing casting weighing 40 tons, welded to

A tubular A-201 plate section weighing 90 tons, welded to

A nickel steel conical transition casting weighing 85 tons, bolted to

A nickel steel spherical casting weighing 150 tons, machined to a tolerance of .003" in sphericity and concentricity, with a 15-micro-inch finish, bolted to

A nickel steel casting and A-201 plate hub fabrication weighing 190 tons.

Total assembled weight of shaft ----------	555 tons
Total weight of 250 lb. density concrete in shaft ----------	170 tons
Additional weight supported by shaft ---------	1725 tons
Diameter of tubular plate section ----------	12 feet
Diameter of spherical journal ----------	17' 6"

Yoke:

Serves to support the declination shaft and to rotate the antenna east and west about the polar axis by means of the polar gear;

Yoke (continued): Is an A-201 steel fabrication of plates from 2" to 6" thick, welded to the hub section of the shaft;

Contains 250 pound density concrete counterweighting for East/West rotation weighing 675 tons;

Is fine-balanced by the addition of 35 tons of portable ballast blocks;

Supports two pinion declination drive and three hydraulic stow brakes;

Is rotated by a steel gear consisting of 28 segments aligned to a total indicator runout of .030" and a tooth-to-tooth tolerance of .003";

Dimension from polar axis to declination axis — 49 feet;

Pitch radius of polar gear — 42 feet.

Declination Axis: Will rotate 145° - 53° North of zenith and 92° South;

Is defined by a composite aluminum and steel shaft running in two spherical roller bearings, adjusted on the yoke arms to put the declination axis in a plane perpendicular to the polar axis;

Shaft length overall is 67 1/2 feet;

Shaft length between bearings is 57 feet;

Supports a total assembled weight of 350 tons.

Superstructure: Supports the reflector surface, the focal feed and is supported by the declination shaft;

Is a rigid 5456 structural aluminum weldment, bolted to the declination shaft, with such adjustments that the focal axis, the declination axis, and the reflector surface are held in alignment;

Superstructure (continued):	Is rotated north and south by a bronze gear with pitch radius of 35 1/2 feet.
Reflector	A solid surface parabola of revolution, 140 feet in diameter with a 60 foot focal length;
	Has a design surface tolerance, without wind and sun, of .030" rms in zenith, and .125" rms facing the horizon;
	All material is 6061 aluminum;
	Is built of 60 panels, each with its own back-up structure, welded to 1/8" surface sheets and each attached to the superstructure by four adjustable jack screws.
Feed Support:	Consists of four aluminum legs and housing which will support 1,000 pounds of equipment at the paraboloid focus with a maximum deflection of 1/4";
	System shades 734 square feet — a loss of 4 3/4% in reflector surface;
	Is 200 feet above the ground at zenith but is only 48 feet above the ground in service position, facing the horizon.
Drives:	Each is an electric motor driving two hydraulic pumps driving two wobble-plate hydraulic motors through two double reduction gear trains to two pinions on each main gear rack;
	In slew it is possible to drive the telescope about both axes simultaneously or independently at speeds up to 50 degrees per minute in wind speeds up to 30 mph. In wind speeds above 30 mph the telescope will be driven at a maximum speed of 12 1/2 degrees per minute. It will be possible to move the telescope to the stow position in winds up to 70 mph;

Drives (continued):

To track, the telescope may be moved about the polar axis at a rate of 15'/minute with no deviation in position greater than ± 5"/10 minutes, or greater than ± 20"/hour in winds up to 15 mph;

For scanning, the telescope is provided with eight fixed scan rates from 10 min arc/min to 4° arc/min. Any scan rate can be selected for use on either or both axes simultaneously with an accuracy of 5" arc/hour in winds up to 15 knots. Provision is also made for continuous adjustment of the scan rates from 0.5 to 2.0 times the fixed rate;

The declination axis hydraulic drive is driven by a 60 hp electric motor, and the polar axis hydraulic drive is driven by a 100 hp electric motor. Both motors are supplied power from the 440 V, 3 phase, 60 cycle distribution system;

Design is to the following criteria:

	Polar	Declination
Mass moment of inertia (slug ft.^{2})--	131 x 10^6	19 x 10^6
Pinion pitch diameter (in.) ------	24.5	24.5
Pinion and gear face (in.) --------	12	9
Pinion shaft (in.)--	12	12
Tooth load in 30 knot wind (lbs.) ---	37,800	24,300
Tooth load in 70 knot wind (lbs.) ---	124,900	78,150
Brake torque in 120 knot wind (ft.-lbs.) --------	24.1 x 10^6	13.4 x 10^6
Natural vibration frequency (cps) ---	2.56	2.40

Indication:	Is by inductosyn readout which will indicate the positions of declination and polar shafts to an accuracy of ± 5 seconds of arc when the telescope is tracking or scanning at rates up to 4°/minute; The readability of the fine indicator dials is ±3 seconds of arc.
Survival:	The telescope is designed to withstand wind gusts up to 140 mph when held by the brakes in the best stowing position; It can be moved into that position in wind gusts up to 85 mph.
Completed:	Spring 1965
Cost:	Thirteen million ($ 13,000,000)

Built by Associated Universities, Inc., under
Contract NSF-C50 with the National Science Foundation

at

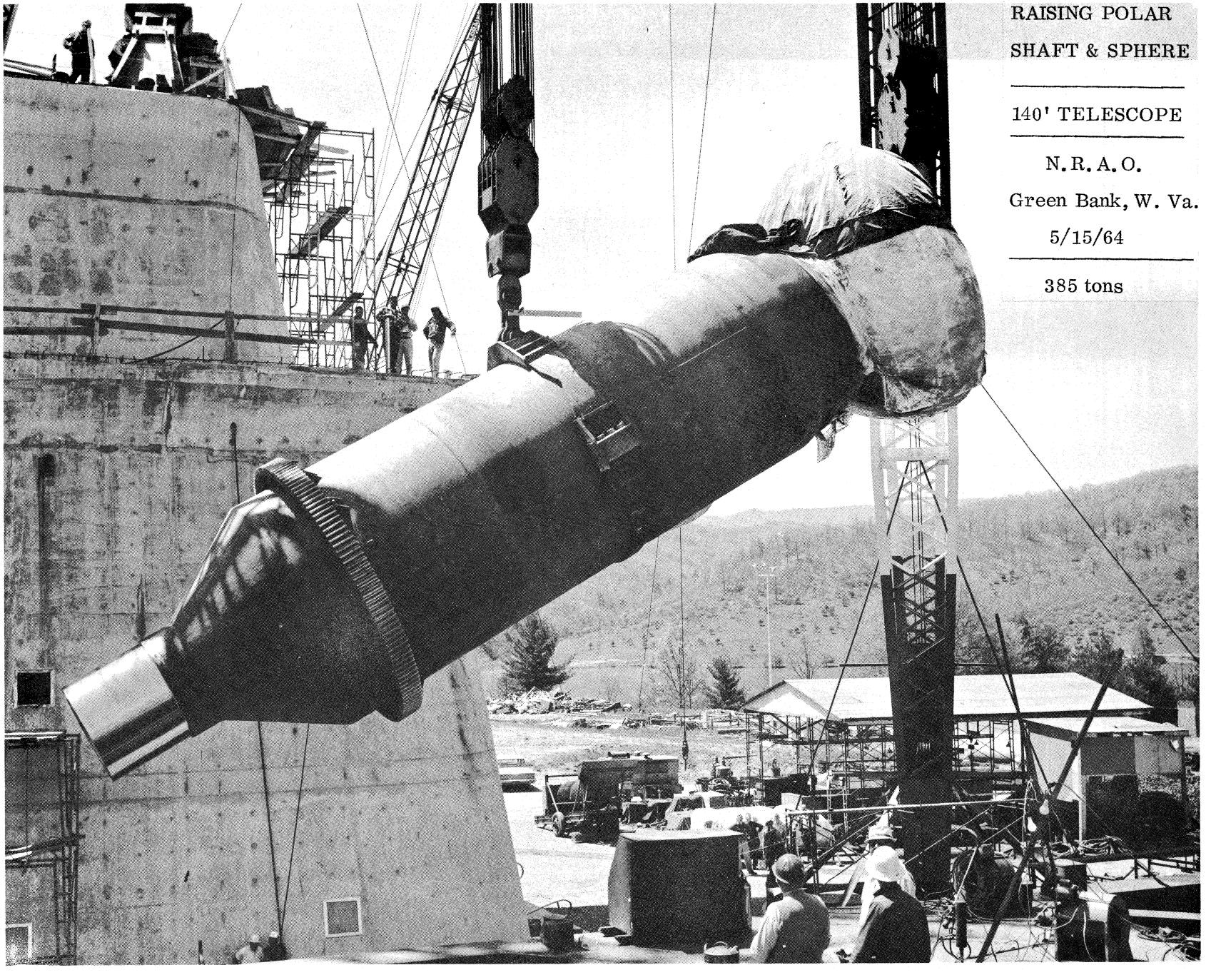
National Radio Astronomy Observatory

D. S. Heeschen, Director

NRAO Project Staff:

Maxwell M. Small	—	Project Manager
Spencer S. Greenwood	—	Construction Superintendent
John N. Ralston	—	Civil Engineer
William G. Horne	—	Structural Engineer
Richard E. Grabe	—	Office Manager
Leslie H. Lambert	—	Senior Clerk
Howard W. Brown	—	Technical Specialist
Eugene L. Marcum	—	Technical Specialist

Conceptual Design:	Ned L. Ashton, Consulting Engineer
Detailed Design:	Stone & Webster Engineering Corporation E. W. Bliss Company Irving Bowman and Associates
Construction:	Darin & Armstrong, Inc. Pacific Crane & Rigging Co. Davis H. Elliott Company, Inc. — Electrical Intrusion Prepakt, Inc. — Heavy concrete
Fabrication:	
Shaft & Hydropads	Westinghouse Electric Corporation
Yoke	Sun Shipbuilding & Dry Dock Co.
Superstructure	E. W. Bliss Company
Declination Gear	E. W. Bliss Company
Surface Panels	Electronic Specialty Co., Kennedy Antenna Division
Drives & Controls	Electric Boat Division, General Dynamics Corporation
Reducers & Polar Gear	Philadelphia Gear Corporation
Brakes	The Goodyear Tire & Rubber Company
Fifth Pad & Tail Bearing	Bethlehem Steel Company



RAISING POLAR
SHAFT & SPHERE

140' TELESCOPE

N. R. A. O.
Green Bank, W. Va.
5/15/64

385 tons

RAISING YOKE/HUB ASSEMBLY

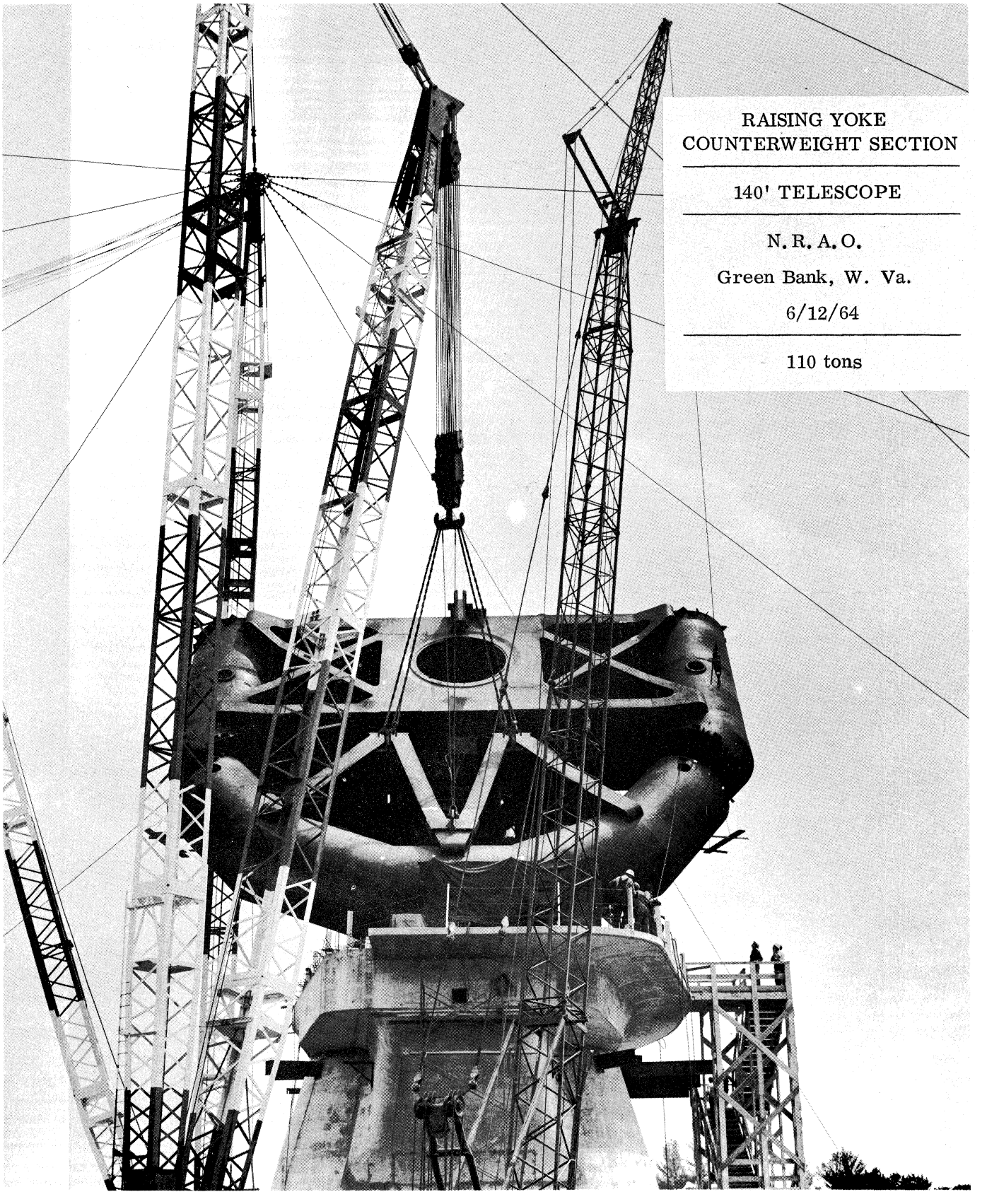
140' TELESCOPE

N. R. A. O.

Green Bank, W. Va.

6/5/64

479 tons



RAISING YOKE
COUNTERWEIGHT SECTION

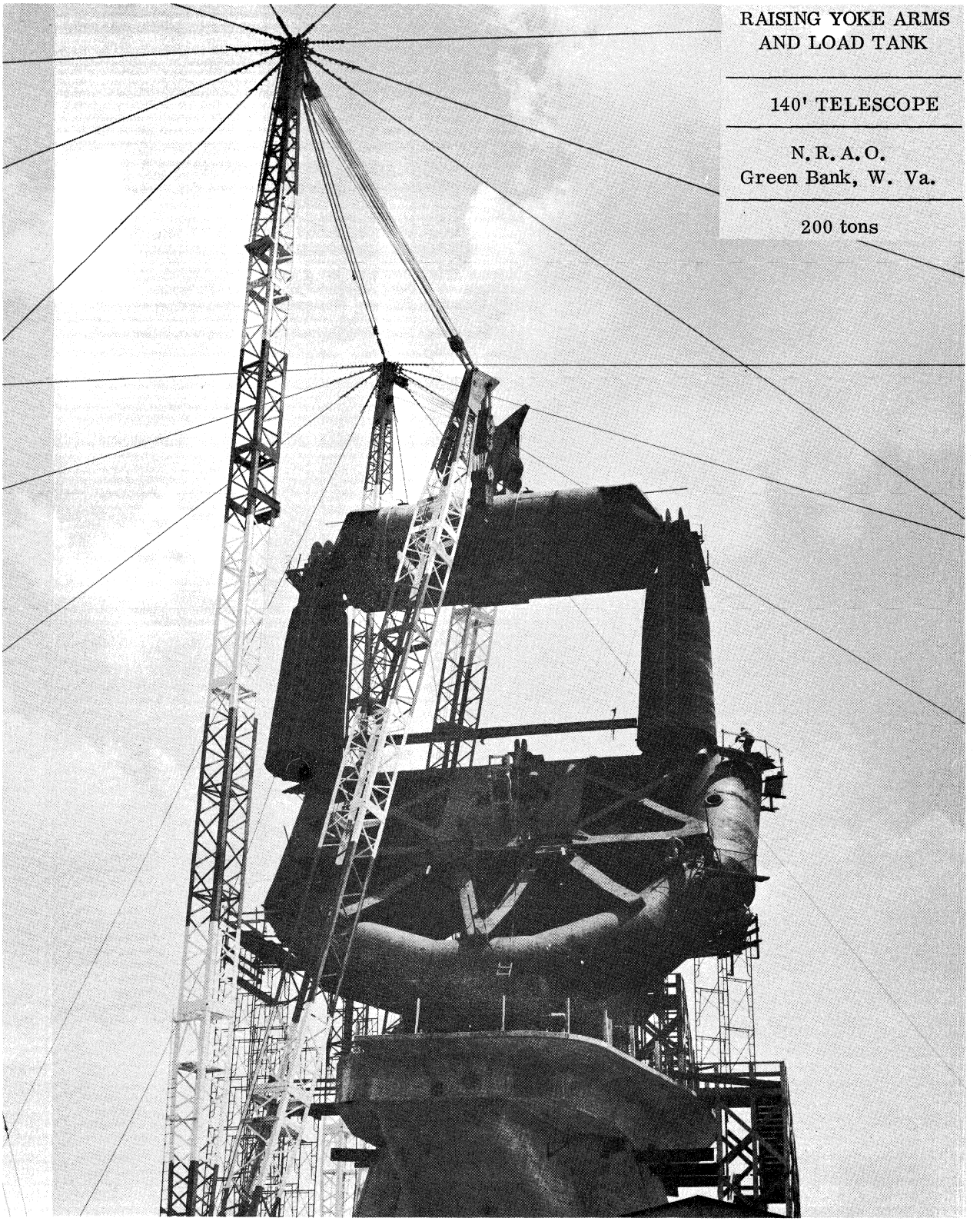
140' TELESCOPE

N. R. A. O.

Green Bank, W. Va.

6/12/64

110 tons



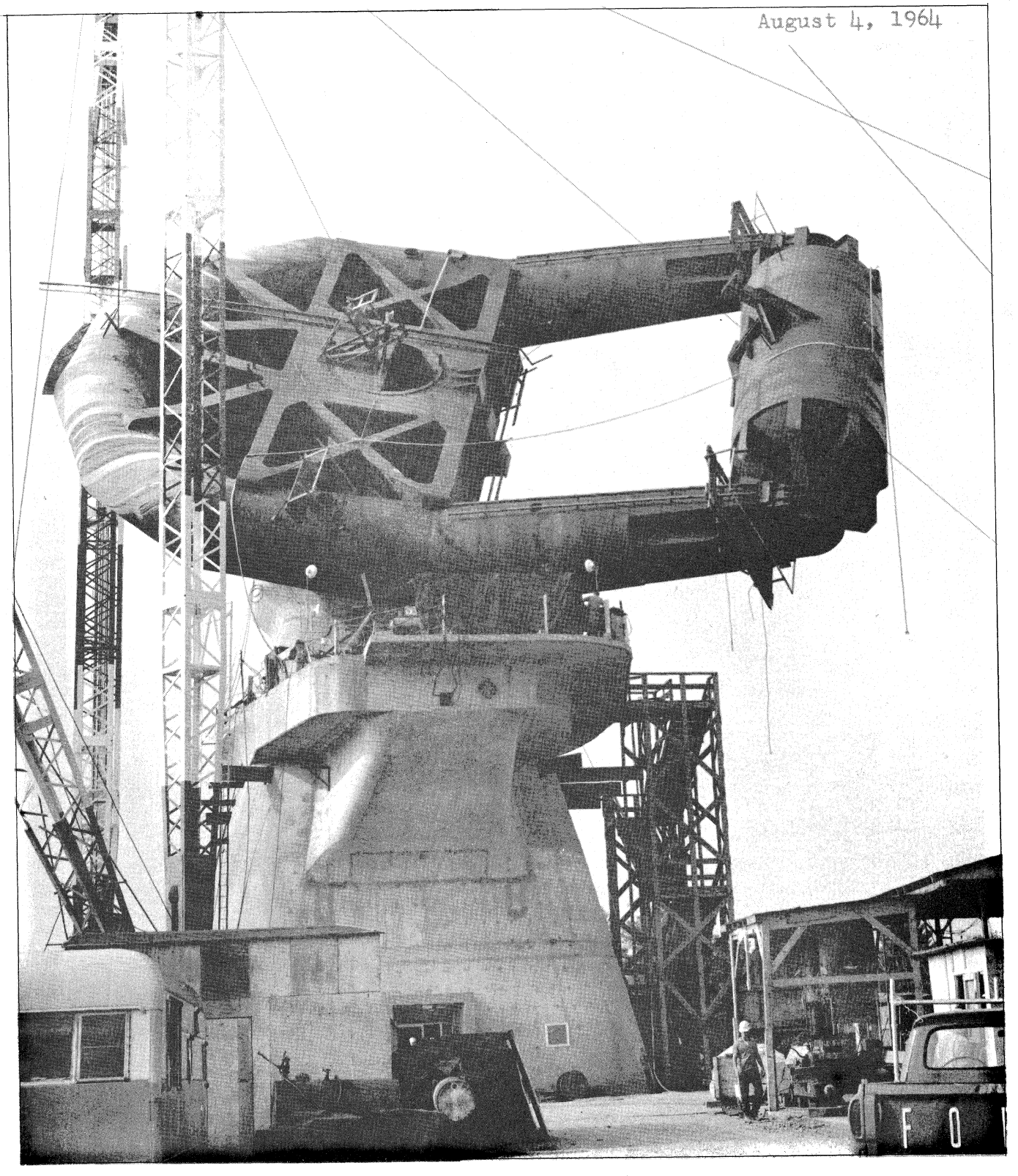
RAISING YOKE ARMS
AND LOAD TANK

140' TELESCOPE

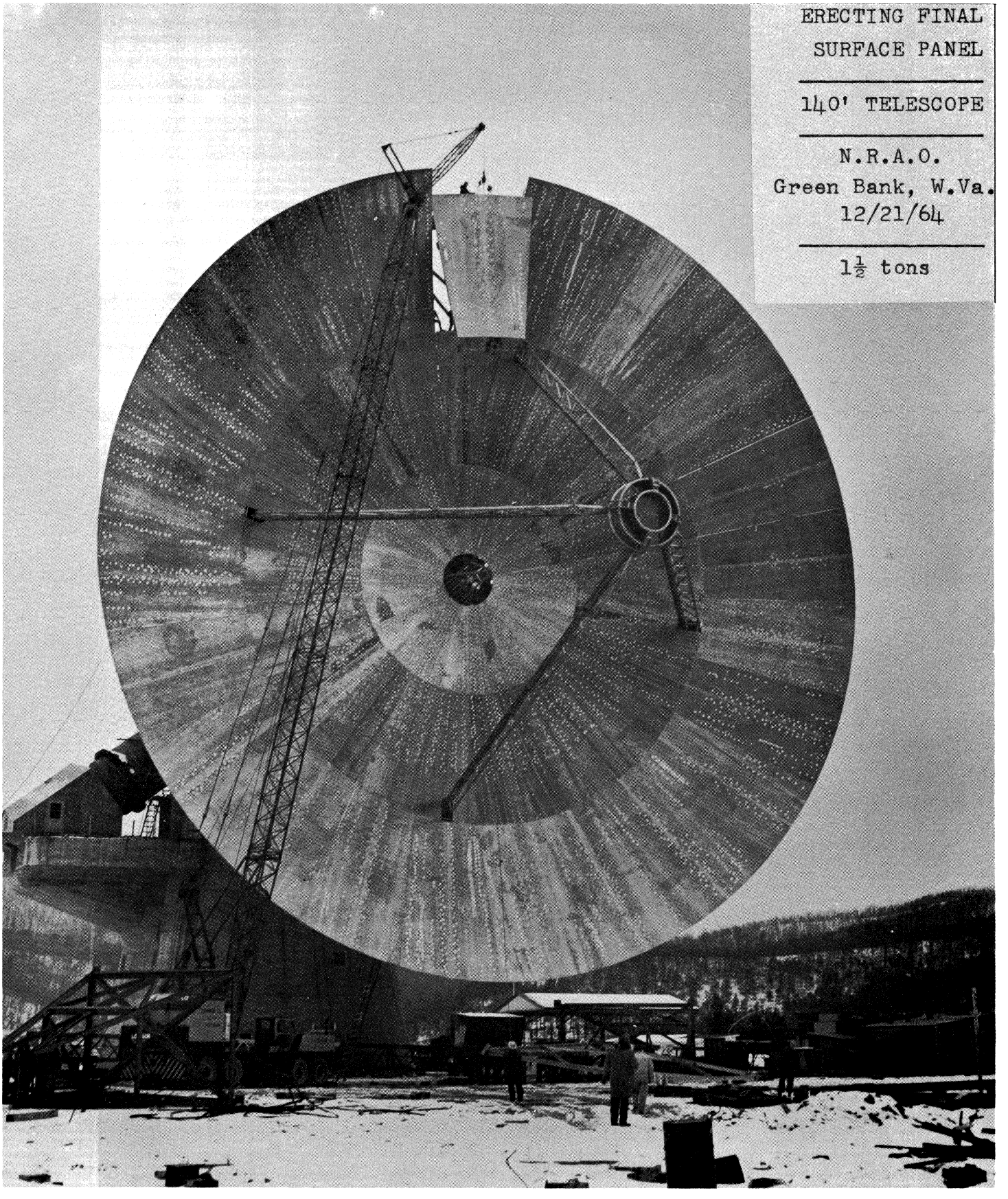
N. R. A. O.
Green Bank, W. Va.

200 tons

August 4, 1964




RAISING
SUPERSTRUCTURE
140' TELESCOPE
N.R.A.O.
Green Bank, W.Va.
11/10/64
266 tons

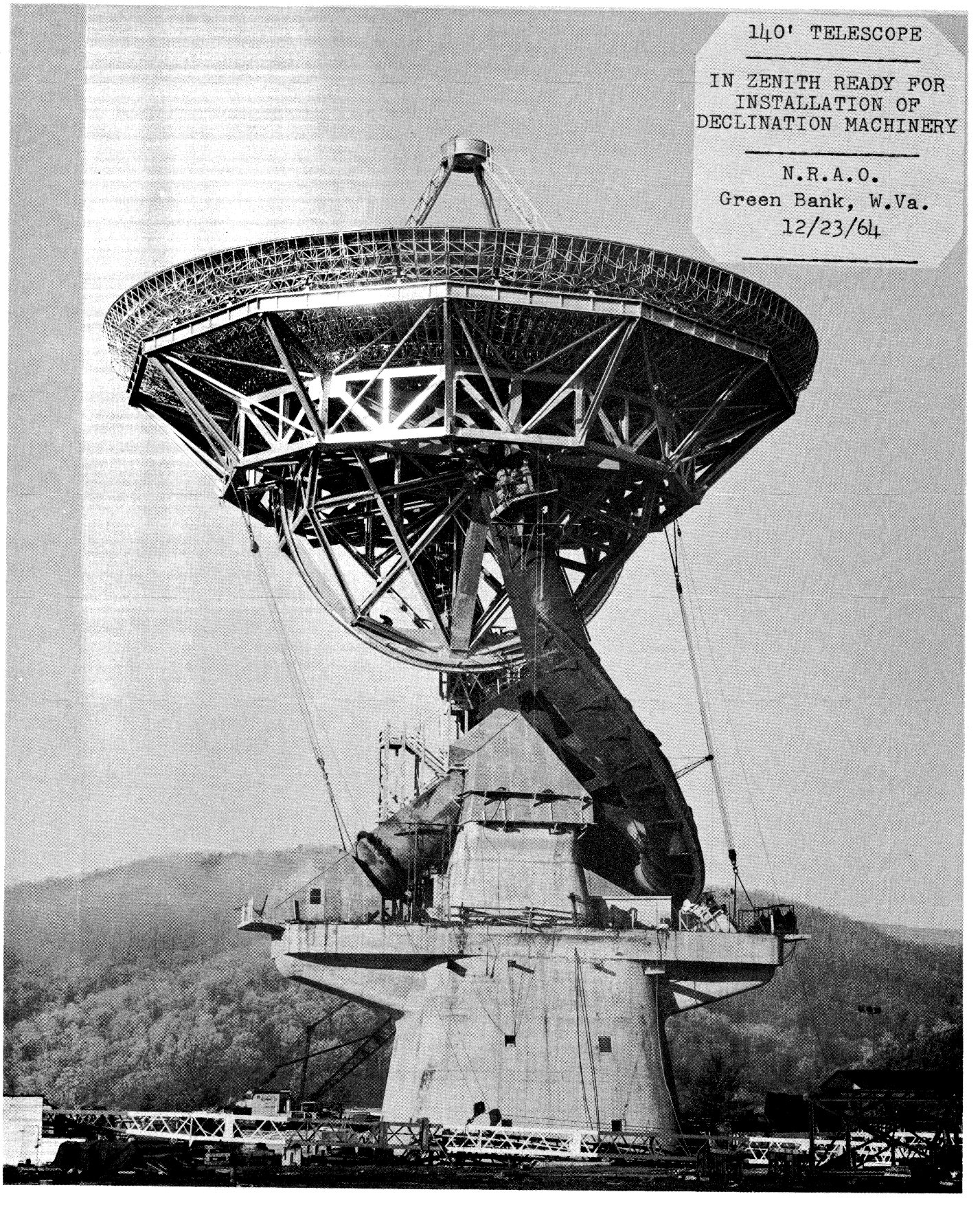


ERECTING FINAL
SURFACE PANEL

140' TELESCOPE

N.R.A.O.
Green Bank, W.Va.
12/21/64

1½ tons



140' TELESCOPE

IN ZENITH READY FOR INSTALLATION OF DECLINATION MACHINERY

N.R.A.O.
Green Bank, W.Va.
12/23/64