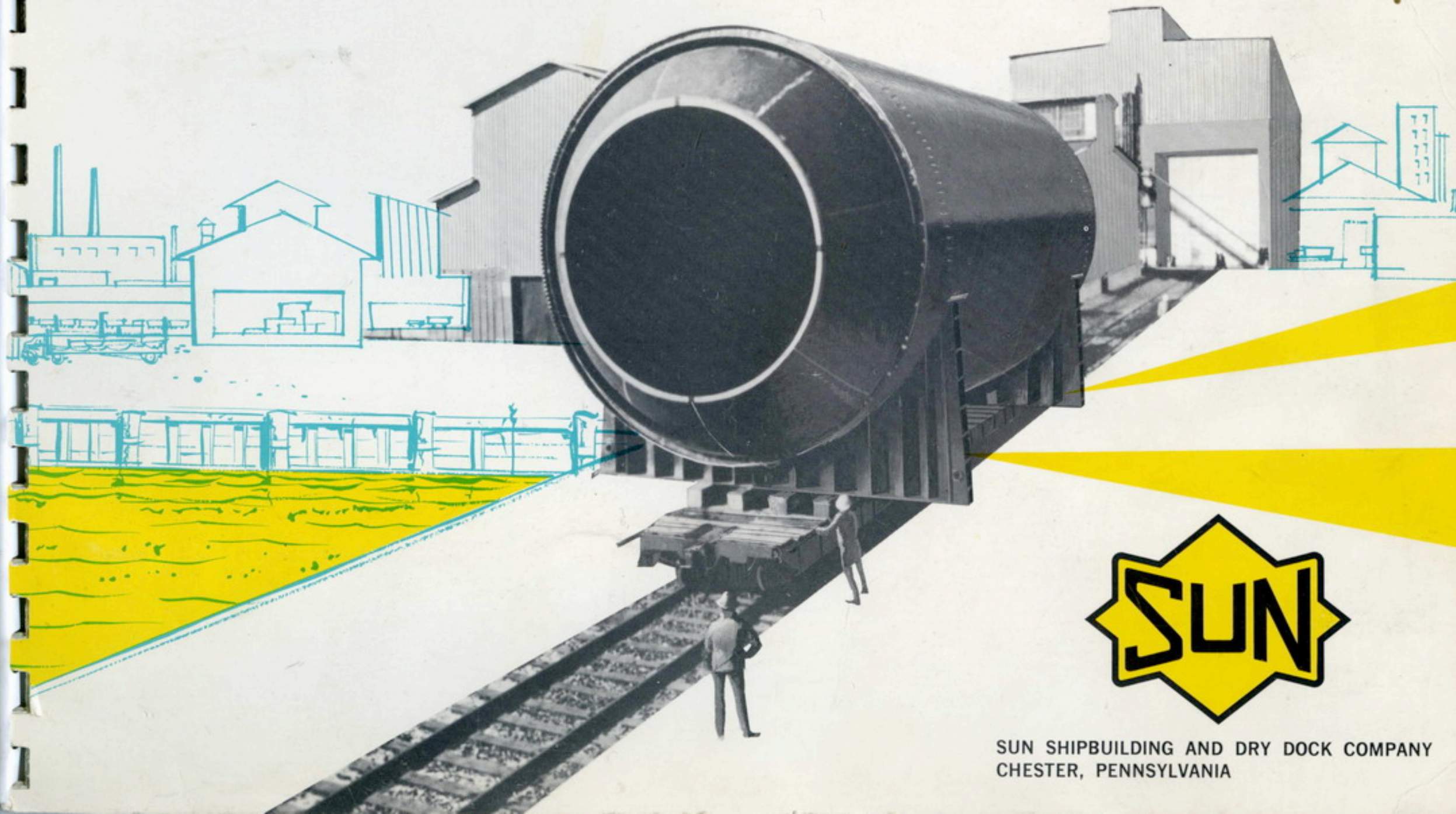
A NEW MEMBER OF THE **Aerospace** TEAM



SUN

SUN SHIPBUILDING AND DRY DOCK COMPANY
CHESTER, PENNSYLVANIA

CHALLENGE

Meeting the requirements of the Aerospace Age and its demand for larger, more powerful booster rockets calls for the development of advanced technologies in fabrication techniques, utilizing new high strength materials, and meeting exacting quality standards.

Sun Shipbuilding inaugurated an engineering, fabrication, and quality control development program to study the anticipated problem areas in material and fabrication and to develop solutions.

Sun Shipbuilding's successful performance in completing this recent program of motor case fabrication is indicative of advanced techniques, abreast of or advancing the state of the art, in the metal working industry.

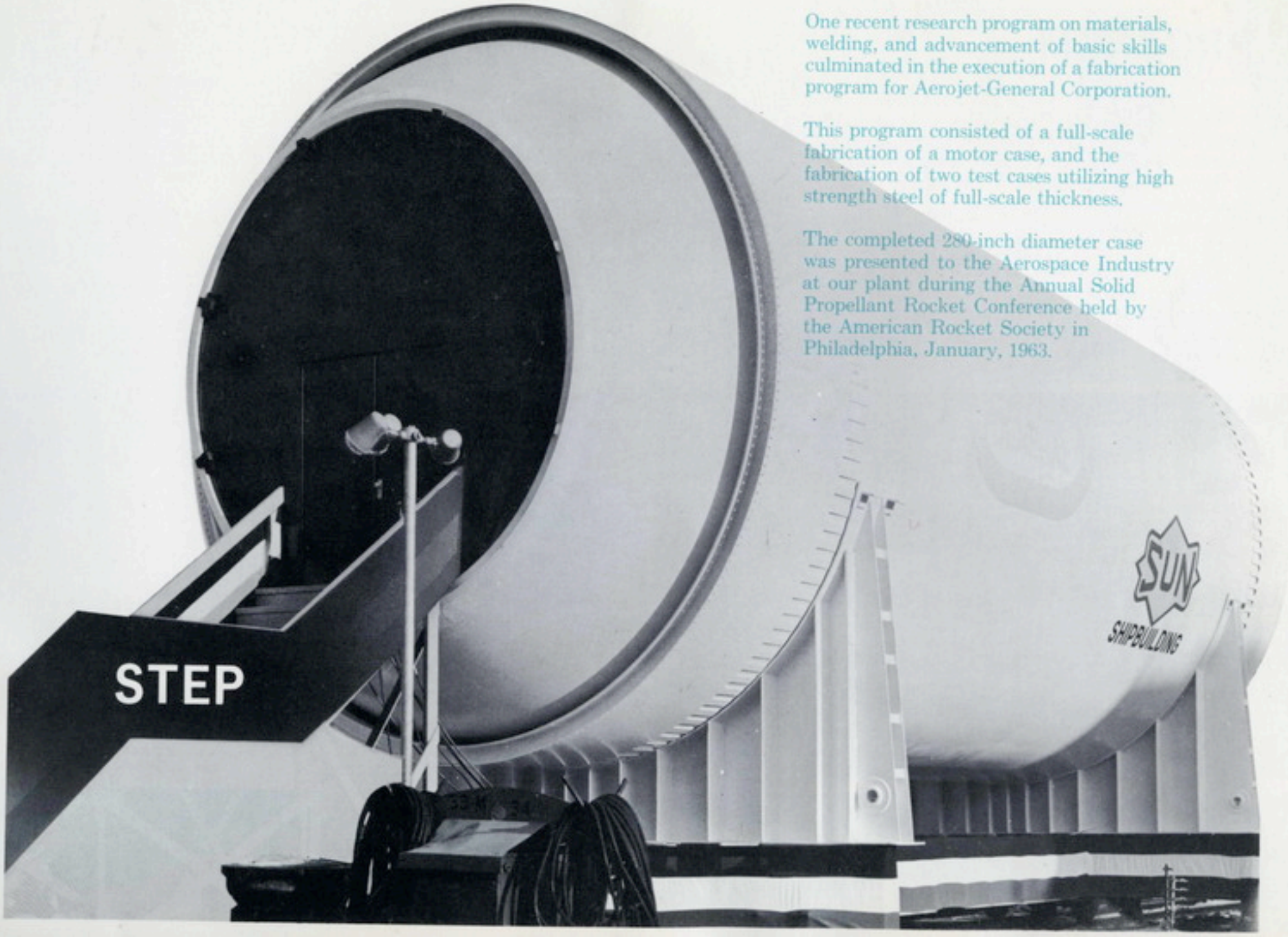
. . . TAKE A

GIANT

One recent research program on materials, welding, and advancement of basic skills culminated in the execution of a fabrication program for Aerojet-General Corporation.

This program consisted of a full-scale fabrication of a motor case, and the fabrication of two test cases utilizing high strength steel of full-scale thickness.

The completed 280-inch diameter case was presented to the Aerospace Industry at our plant during the Annual Solid Propellant Rocket Conference held by the American Rocket Society in Philadelphia, January, 1963.



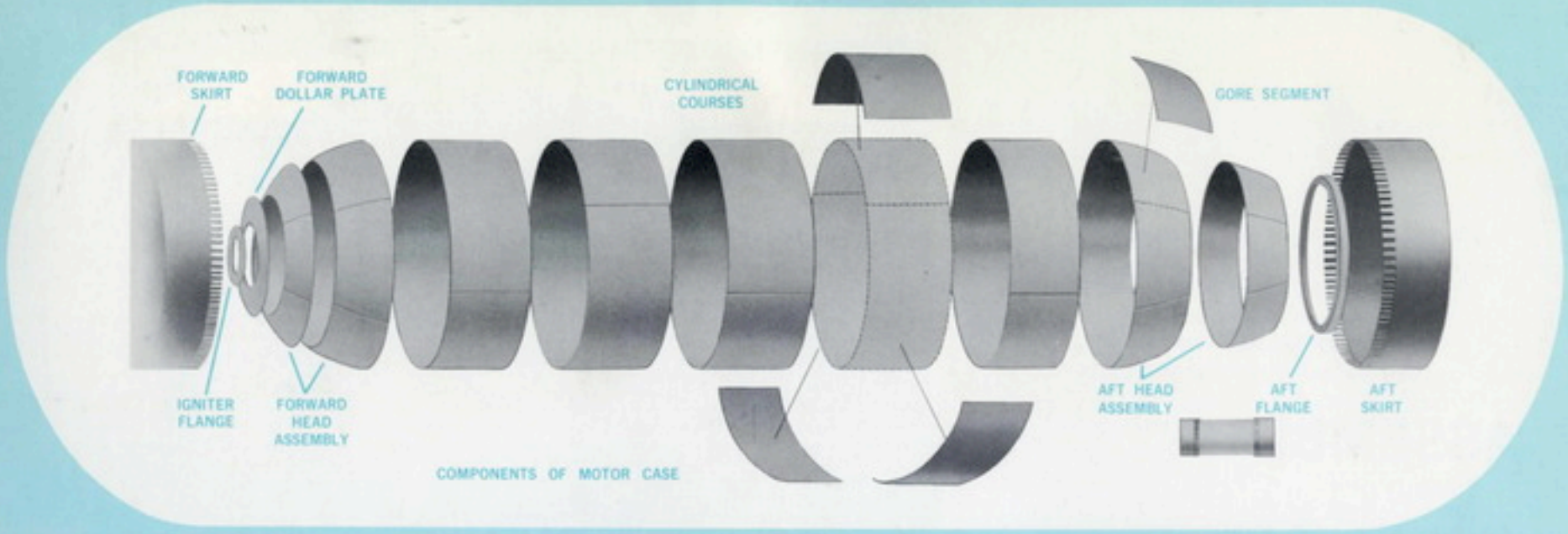
PROGRAM

The fabrication of the 280-inch motor case was designed as a study in control of the tolerances demanded by the Aerospace Industry to conform to reliability standards for manned space exploration.

The two 36-inch diameter motor cases were constructed of 18% nickel maraging steel for the development of fabrication and welding techniques. This program and the final hydroburst tests will contribute greatly to industry's knowledge of this material in its fabricated state.

Additional maraging steel studies on the forming of plate to large diameters with control of spring-back by application of progressive forming operations; research on plate weldments; and preparation of maraging steel test specimens were conducted concurrently with the fabrication phases of the program.

Vertical rolling of one of the three plates that make up each of the five cylindrical sections of the 280-inch motor case.



CHARACTERISTICS

Large Motor Case	
Diameter	280 inches
Length	59 feet—6 inches
Thickness	⅝ inch
Material	Low Carbon Steel
Weight	94 tons
Test Motor Cases	
Diameter	36 inches
Length	96 inches
Thickness	⅝ inch
Material	18% Nickel Maraging Steel, 200/250 KSI

Forming of segments for the hemispherical heads of the large motor cases in the 2,000 ton hydraulic press.

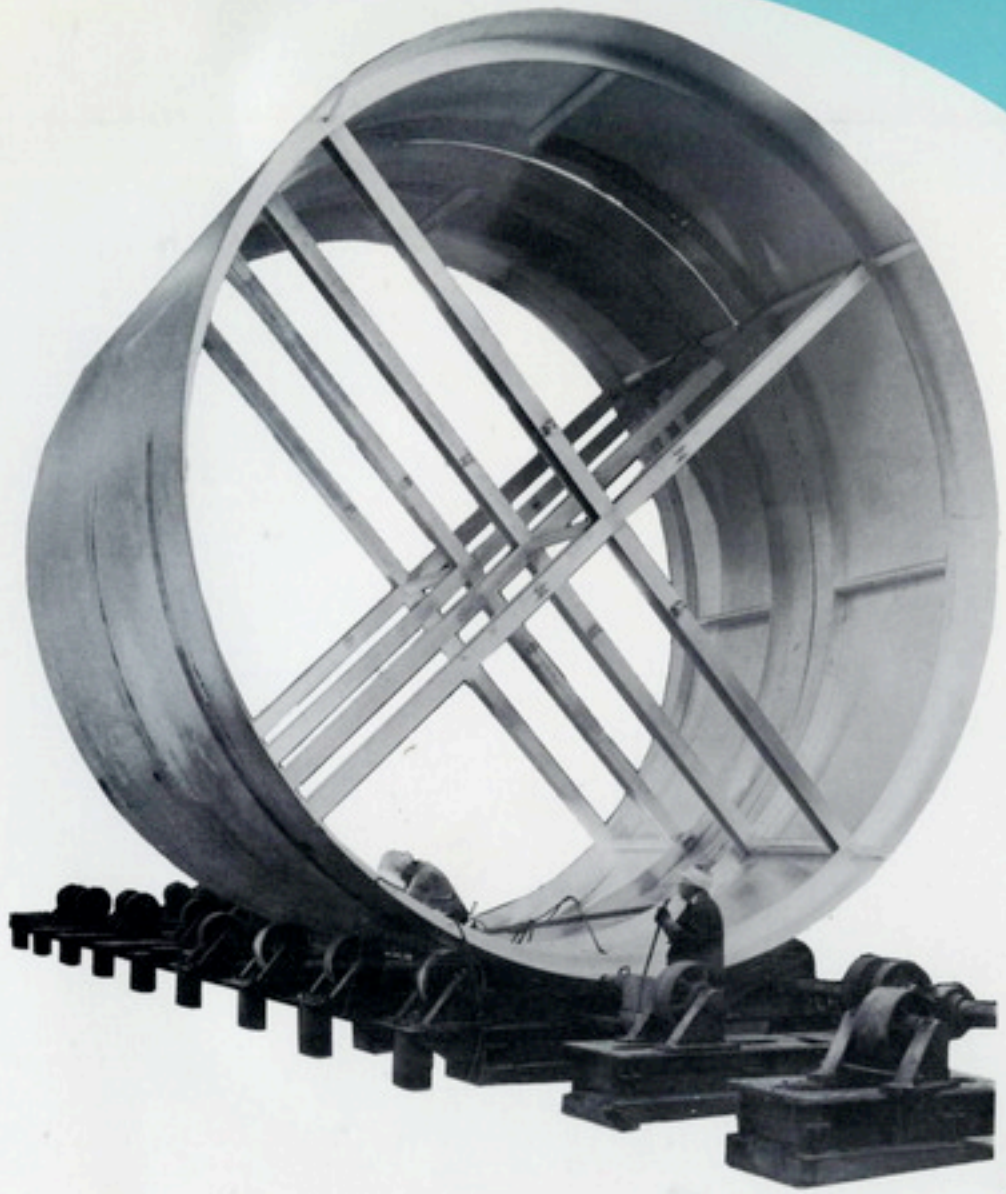
ROLLING

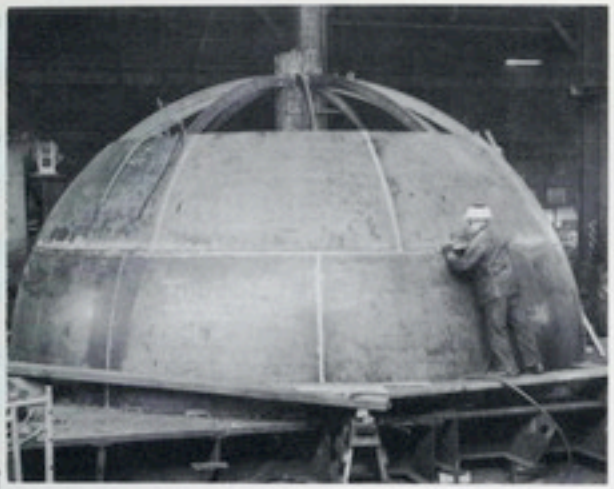
FORMING

ASSEMBLY

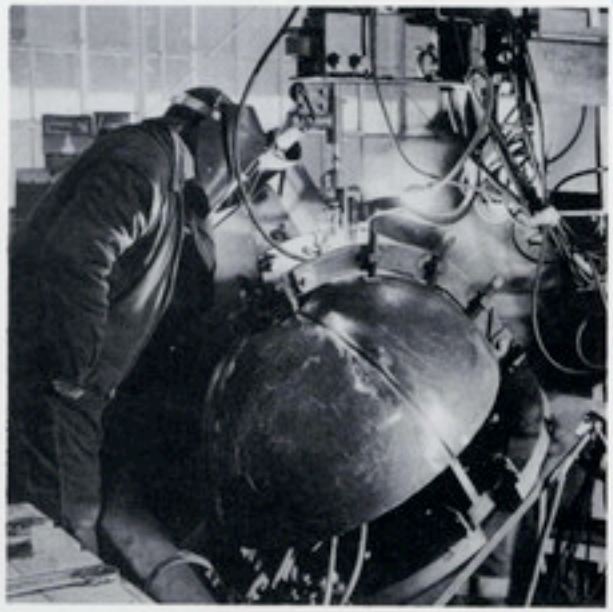
Two completed cylindrical sections on the positioning rolls with the internal "spiders" in place to control alignment and circularity of the sections during assembly.

The "spiders" were retained during final assembly of the motor case and removed after completion of optical inspection.

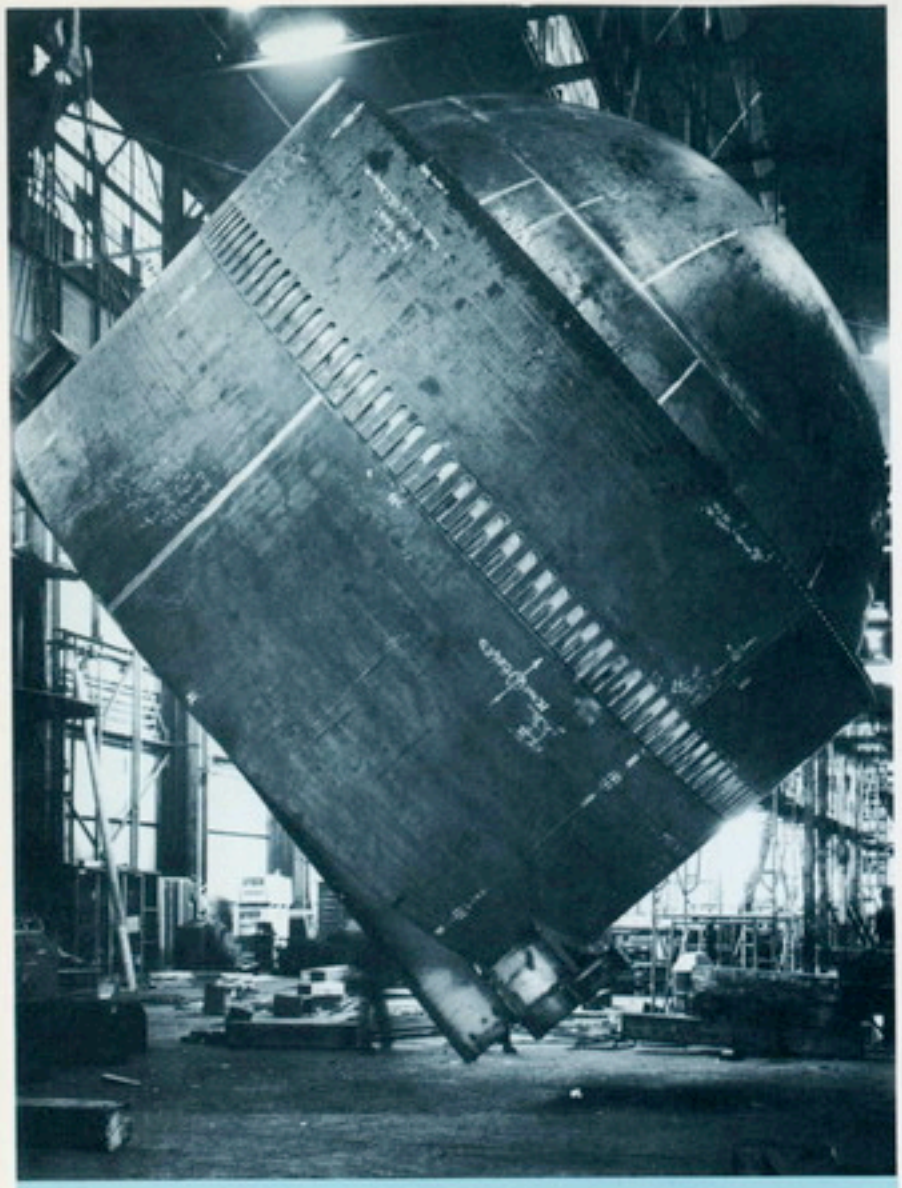




Fabrication of the segmented fore and aft heads of the large motor case was completed on a "soft-tooling type" jig prior to assembly to the adjacent cylindrical sections. All fitting and welding was accomplished on pressure-type jigs requiring no welding of fixtures to the surface of the motor case.



Special tooling for the maraging steel test motor cases was designed to perform the machining and fabrication operations. The illustrations show weld-edge machining of a formed gore segment and the automatic welding of the four segments of the hemispherical head.

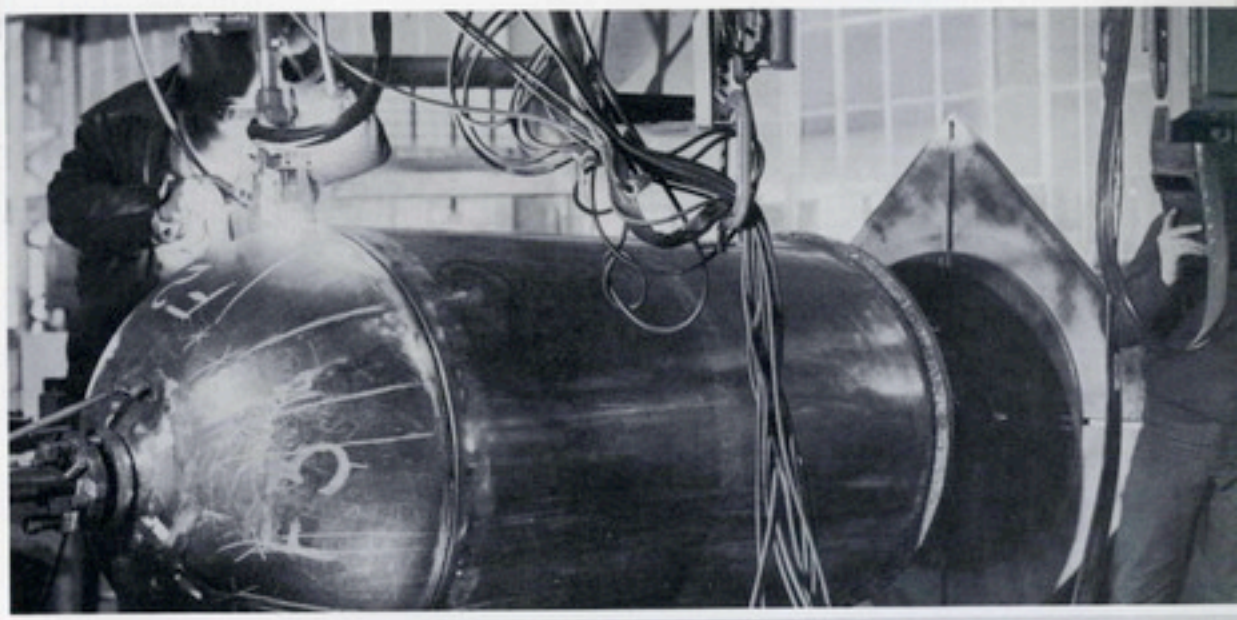


Head, cylinder and skirt sub-assembly after completion on the handling jig ready for final assembly with the cylindrical sections.

WELDING

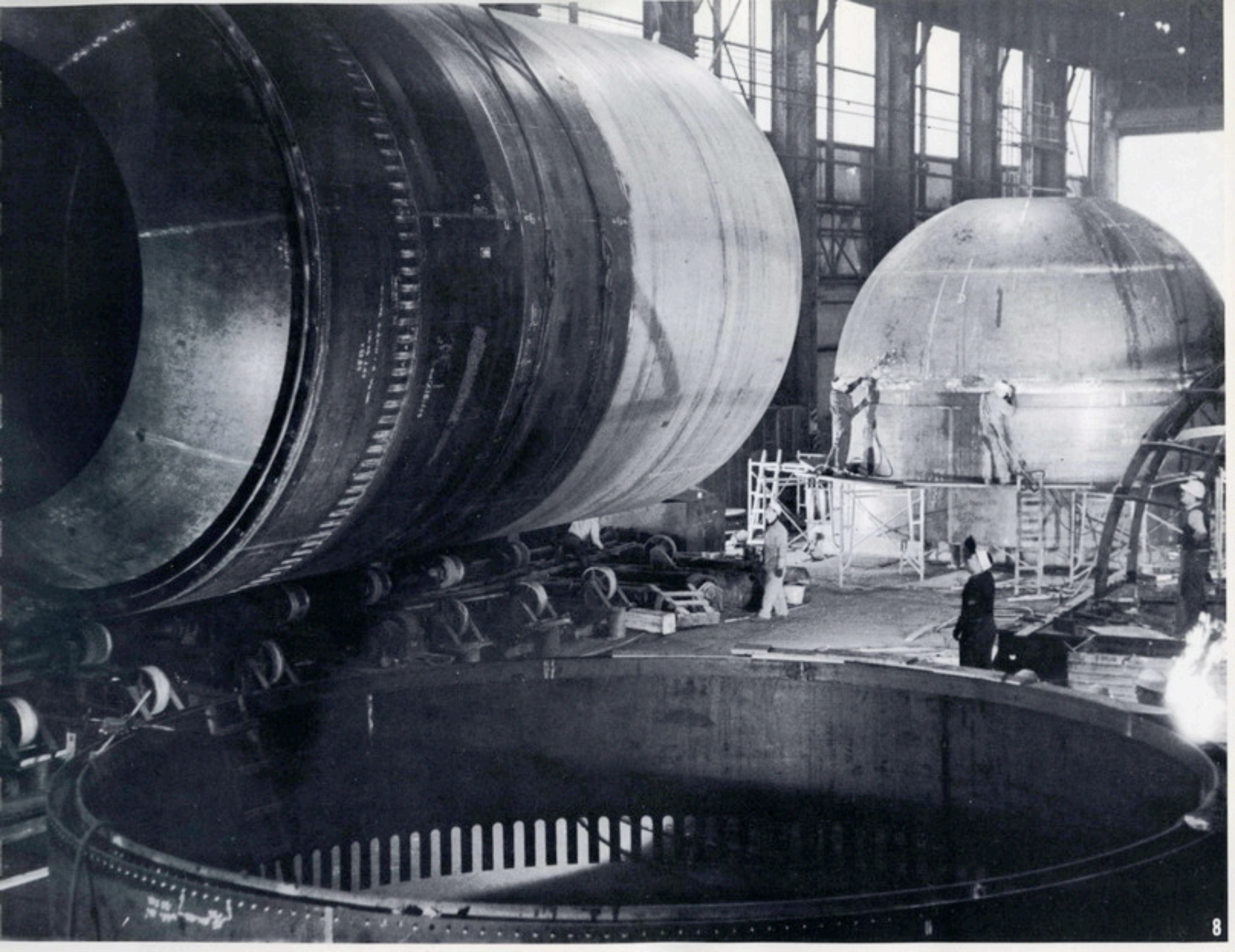
The welding development study included the evaluation of several techniques—tungsten inert gas, metallic inert gas, submerged arc and metallic inert gas short arc.

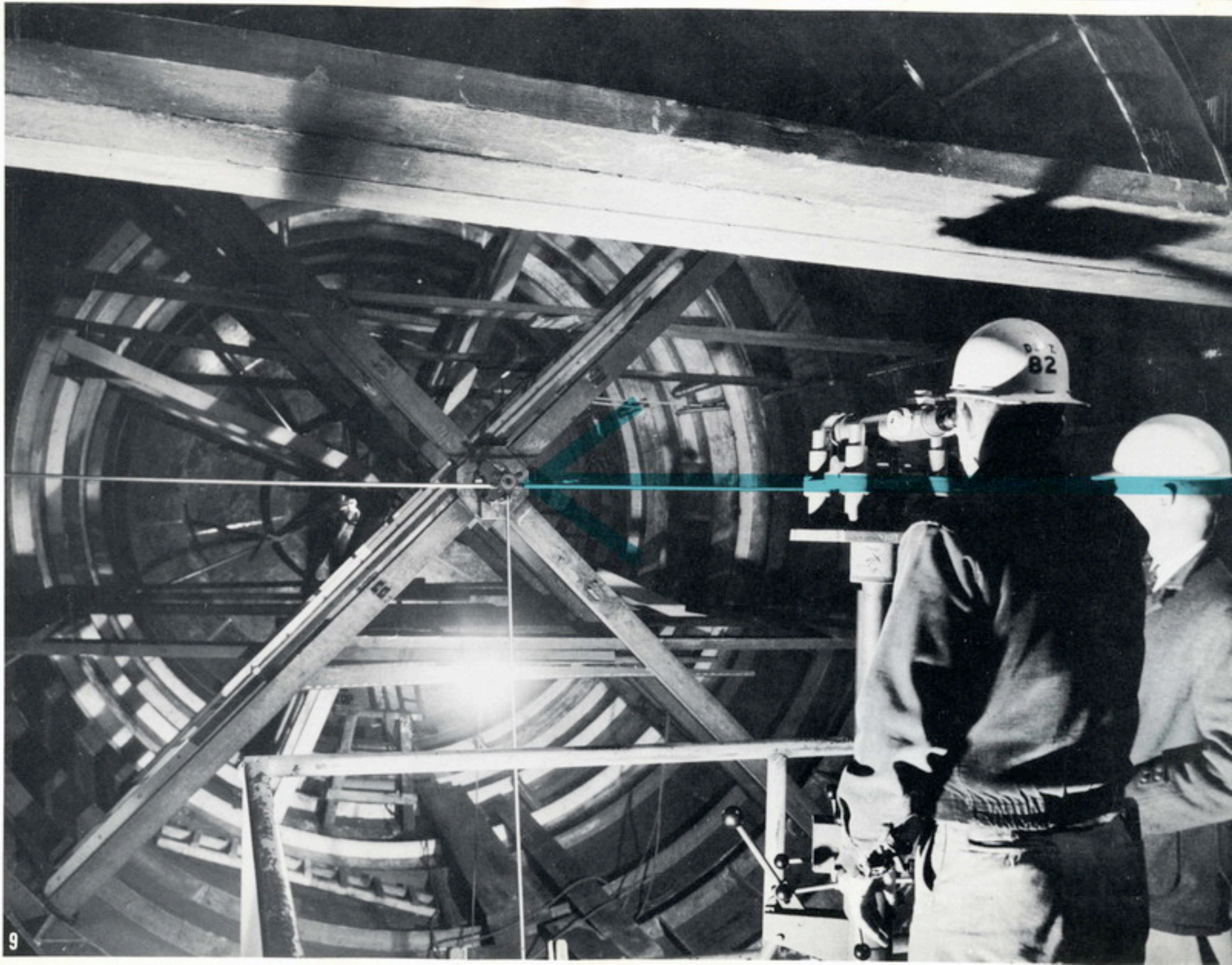
Automatic welding of the completed segmented head to the one-piece cylinder of the maraging steel test motor case.



INSPECTION

Non-destructive testing techniques utilized in both phases of the fabrication programs included x-ray, gamma-ray, magnetic particle inspection, dye penetrant and ultrasonics.

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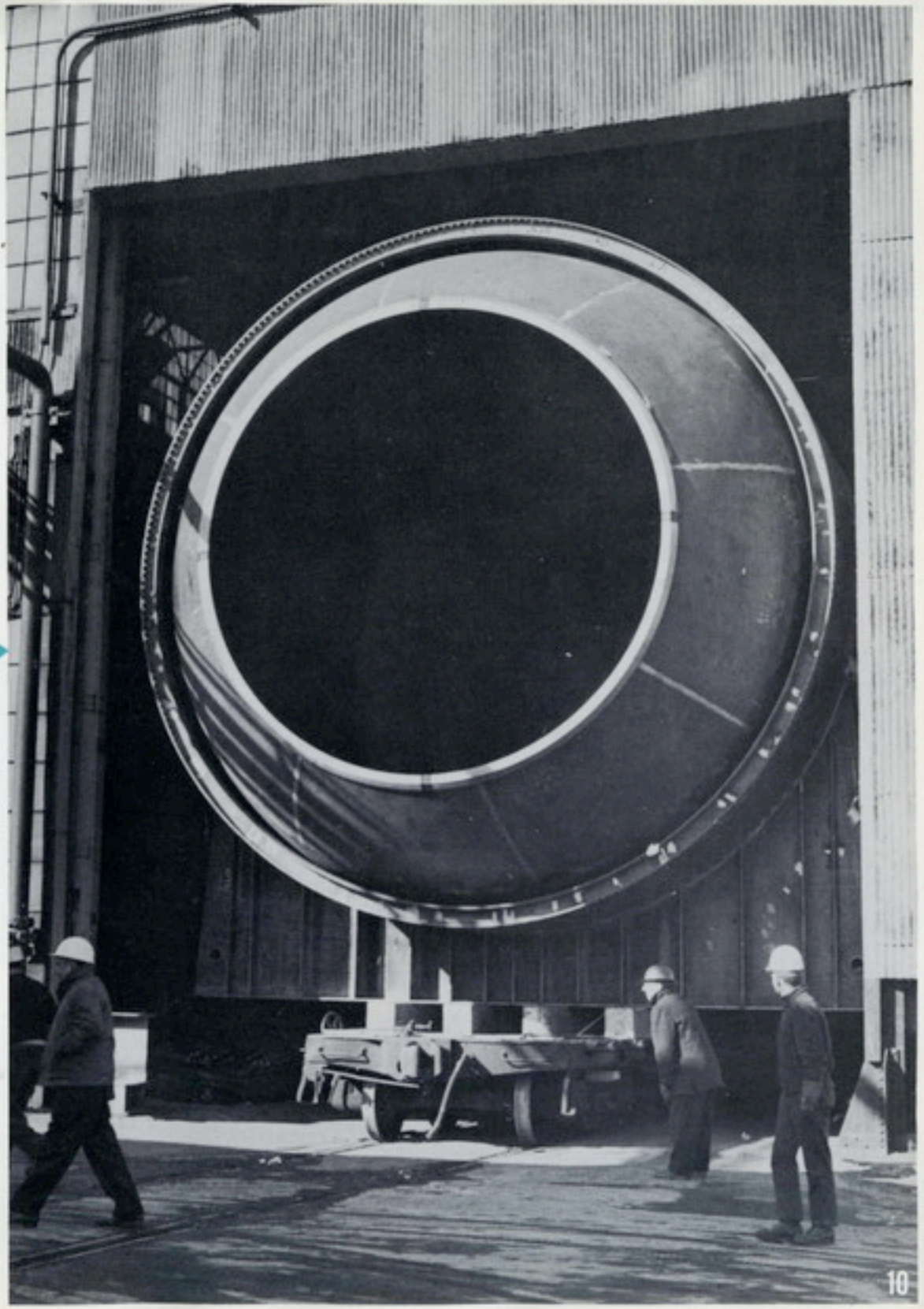
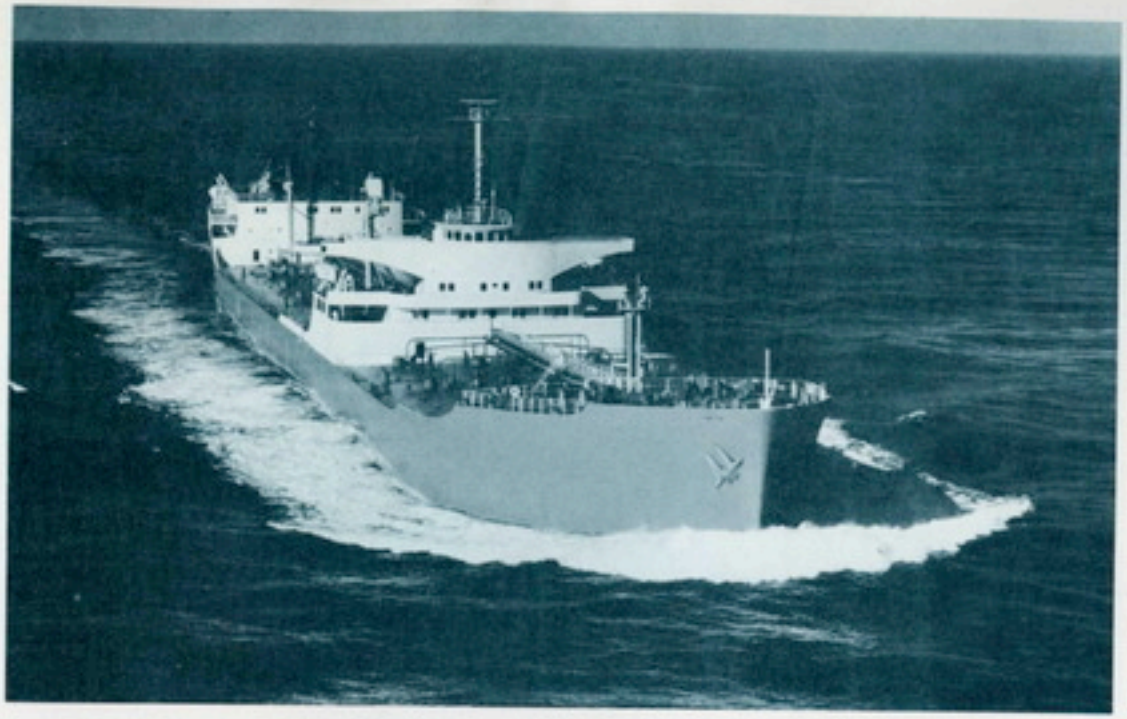
TOLERANCES

An optical alignment scope used with target holders; a radius arm with dial indicators and other optical equipment was used to establish the optical centerline of the completed 280-inch diameter motor case. Circularity tolerances of ±¼-inch maximum on the radius were maintained throughout the cylindrical portion of the motor case.

Dimensions accurate within $\frac{1}{16}$ of an inch were held in the circumference of over 73 feet. Mismatch between cylindrical sections was maintained at an average of .008 inches.

Sun Shipbuilding's experience and techniques for achieving exacting tolerance requirements, prior to and during the fabrication of the large motor case contributed to and further developed the quality control concepts necessary for future aerospace fabrication programs.





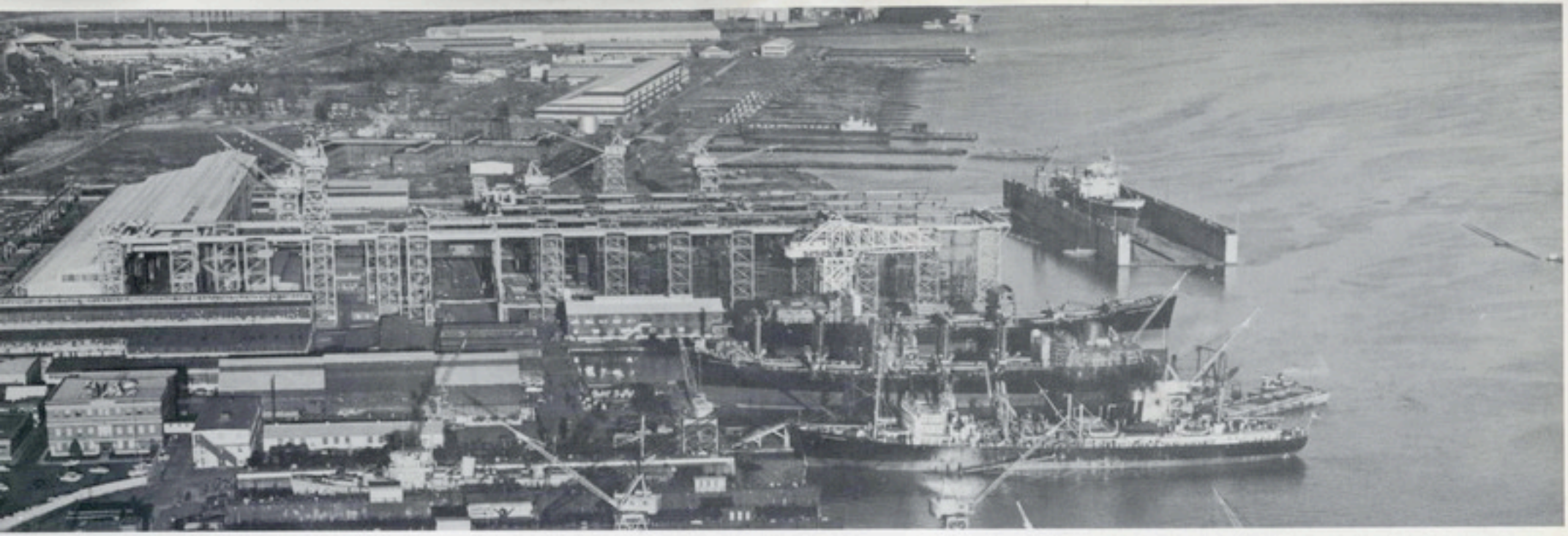
ABOUT SUN . . .

Located in Chester, Pennsylvania, Sun Shipbuilding and Dry Dock Company is a complete manufacturing complex encompassing over 200 acres and employing more than 3,000 people. Full utilization is made of metallurgical research and other scientific skills of Sun Oil Company, the parent organization located in the immediate area. Sun Oil's testing laboratories and computer service are applied to in-plant design and scheduling programs.

Since its founding 46 years ago, Sun Shipbuilding has been a leader in building merchant ships and specialty vessels. Among the 500 vessels launched from the shipways was the first all-welded ship constructed in 1931 that revolutionized established shipbuilding practice.

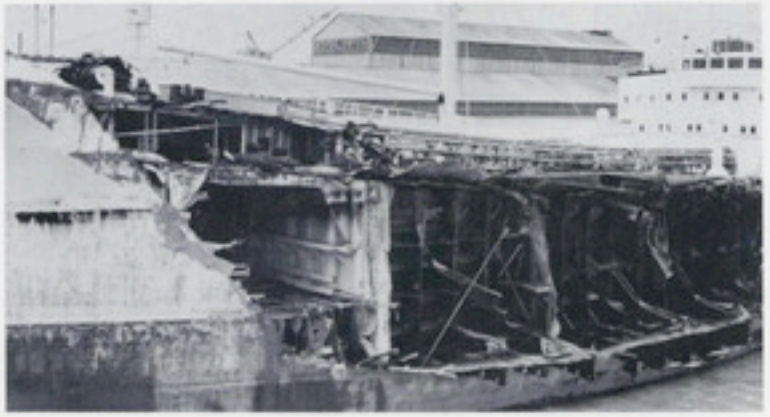
Along with new construction capability, a complete ship repair service is available for all classes of vessels. A new addition, the 38,000-ton floating dry dock is the largest in the United States and was designed and constructed by Sun Shipbuilding.

Industrial products range from pressure vessels and large machining work to fabrication of Titan missile silo girders and the yoke and counter weight for a large radio telescope.



SHIPBUILDING

SHIP REPAIR



INDUSTRIAL PRODUCTS

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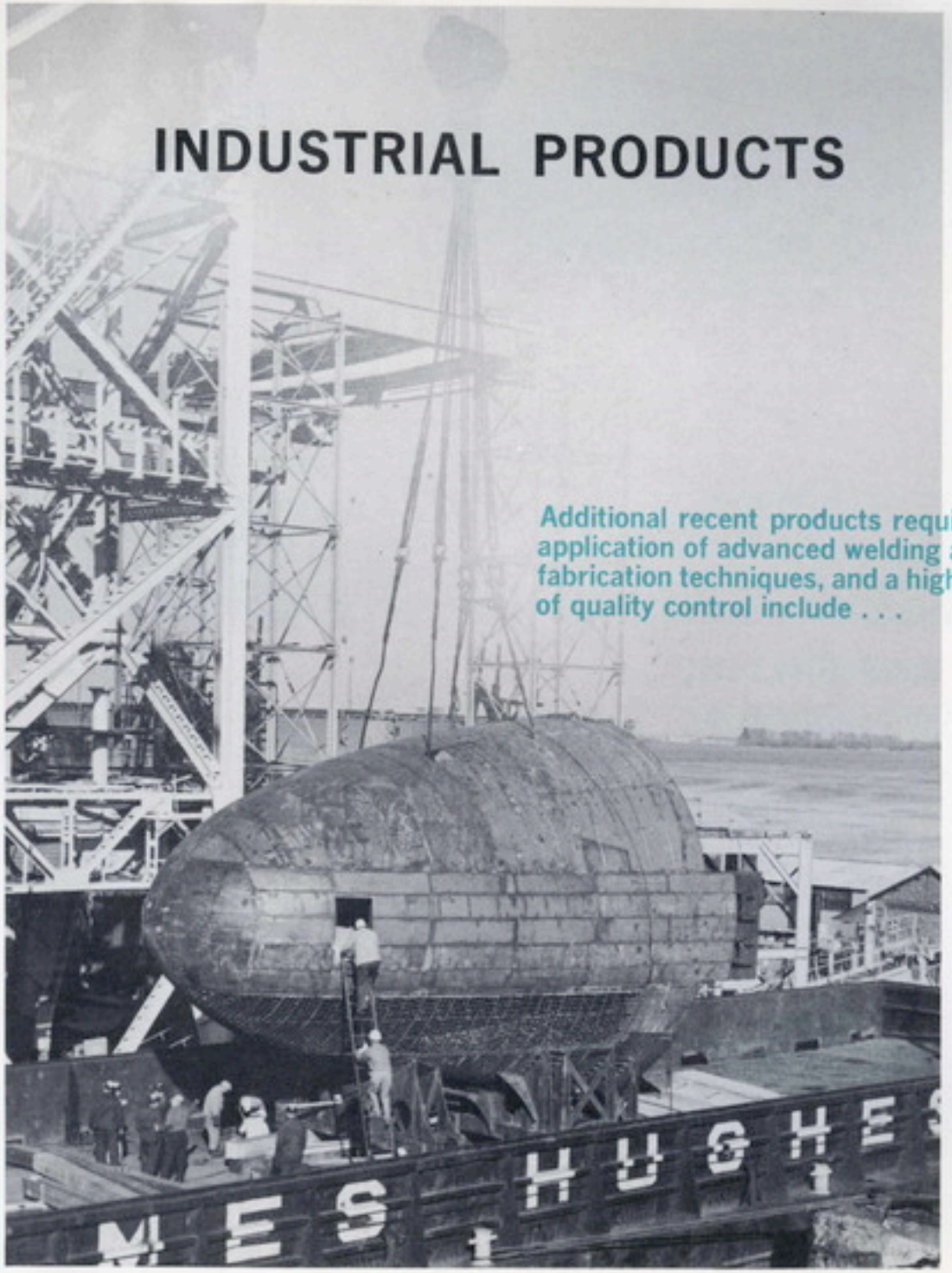
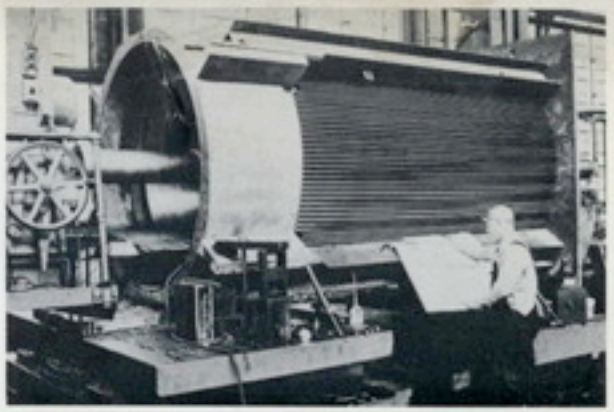
Additional recent products requiring application of advanced welding and fabrication techniques, and a high degree of quality control include . . .

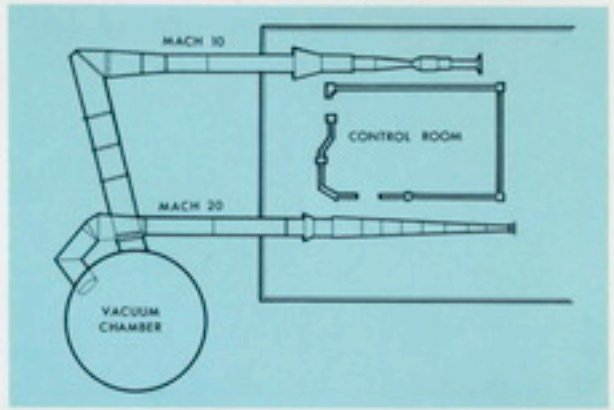


. . . Five pressure hull sections of a Polaris Submarine for Portsmouth Naval Shipyard. These sections were 1½-inch thick HY-80 steel, 22 feet in diameter. The bow section, shown, includes the outer hull and weighs over 115 tons.

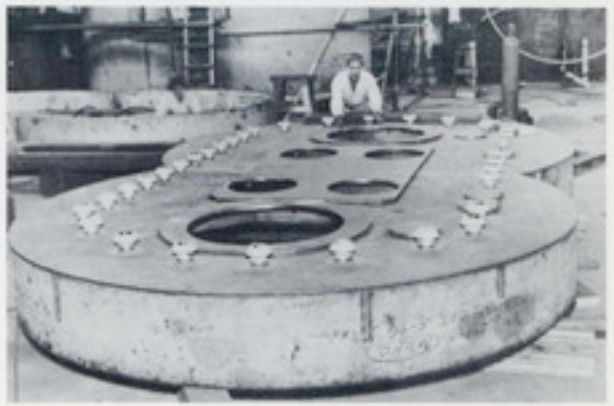
• • • Thirteen nuclear spent fuel containers were fabricated and machined to exacting quality standards. The internal stainless steel overlay required development by Sun Shipbuilding of an improved series arc, two-electrode welding machine to prevent contamination by the carbon steel base.



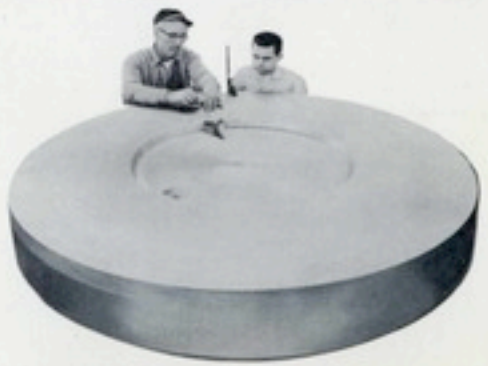
• • • Mach 10 and 20 helium-blowdown-jet wind tunnels for the National Aeronautics and Space Administration for installation at Langley Air Force Base. The close tolerance steel nozzles and jets and the high strength steel entrance pipe and approach chamber encounter extremely high operating pressures and temperatures.



• • • Seven bi-cylindrical tanks for the Savannah River Project manufactured of stainless steel with internal coils of the same material requiring 14,000 welded joints. The 33 nozzles on the 17-foot diameter heads demanded precision alignment for simultaneous engagement by a remotely operated mechanism.



• • • Twenty-two precision weights for the U. S. Bureau of Standards for use in a new 300,000-pound dead-weight testing machine. Load cells for thrust measurement of high performance rockets will be calibrated on this high capacity machine at the Bureau's new facility at Gaithersburg, Maryland.



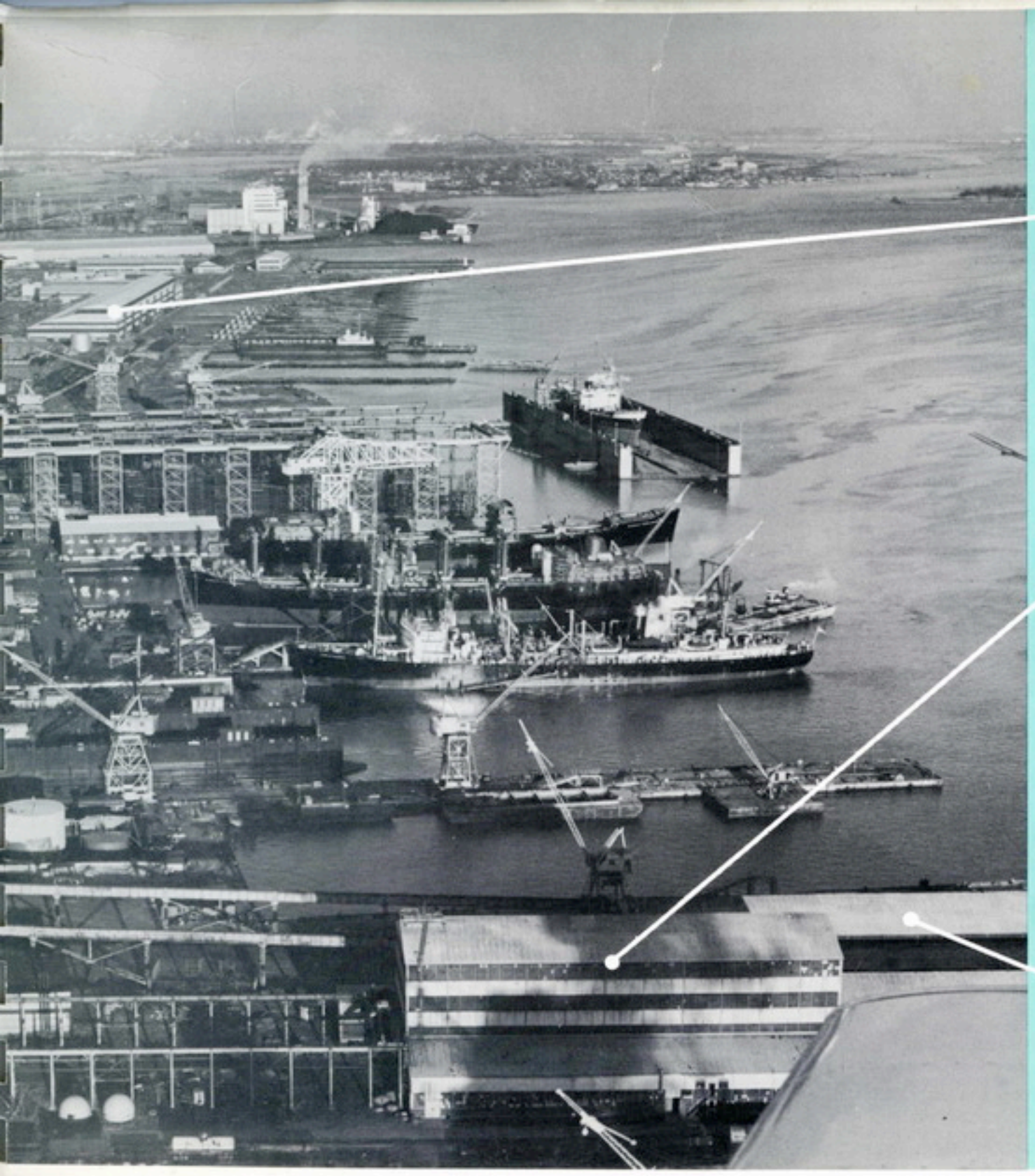
FACILITIES

Manufacturing operations on all phases of the recently completed rocket motor case fabrication program utilized existing plant facilities. Existing facilities are available for additional projects of this type and the buildings are adequate for high level production. The Delaware River location provides direct inland waterway access for barge shipment of large motor cases.

The Alloy Steel Shop is used for fabrication and welding of specialty products requiring a high degree of cleanliness. The two 18% nickel maraging steel cases were assembled in this location.

The adjacent South Yard Shop is isolated from other manufacturing operations and suitable for performance of large rocket motor case feasibility studies. Its 54,000 square feet of floor space and 60-foot high bay clearance provide adequate room for all assembly operations. Open space for heat treatment and hydro-testing is available directly in front of the building.

The North Yard Shop features 200,000 square feet of manufacturing space with a 1,000-foot long, 80-foot wide high bay for final assembly of full length rocket motor cases. This location is isolated from shipbuilding operations and has separate receiving facilities with frontage on the river for barge shipments. The available land and the size of the building allow complete centralization of all manufacturing operations in this location at production levels.



North Yard Fabricating Shop

South Yard Fabricating Shop

Alloy Steel Fabricating Shop

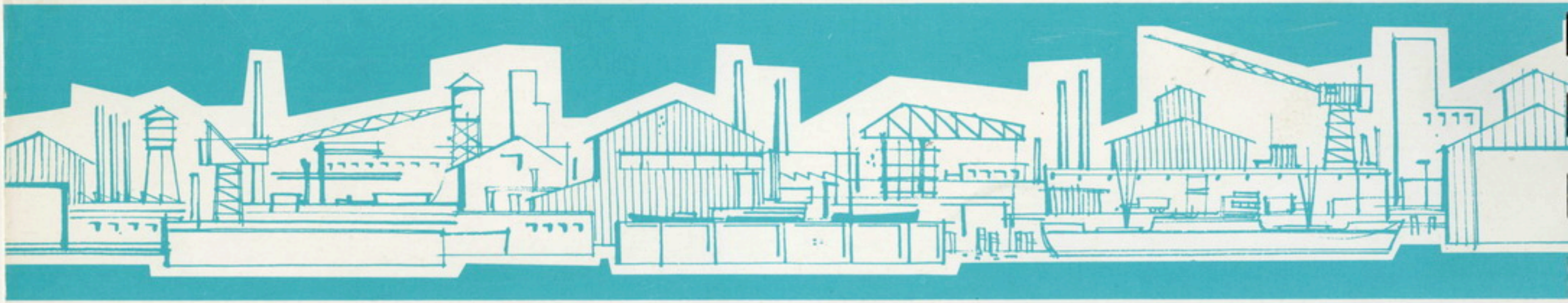
Paul E. Atkinson
President

Charles Zeien
Vice President Engineering

Robert Galloway
Vice President Sales

Arthur A. Holzbaur
Vice President Operations

John G. Pew, Jr.
Vice President



SUN SHIPBUILDING AND DRY DOCK COMPANY, CHESTER, PENNSYLVANIA

A Subsidiary of Sun Oil Company