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TEST EQUIPMENT ENGINEERING CAPABILITY

Nuclear Systems Programs • Space Division • Aerospace Group • GENERAL ELECTRIC

NSP NUCLEAR SYSTEMS PROGRAMS

TEST EQUIPMENT ENGINEERING CAPABILITY

Nuclear Systems Programs
Space Systems
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Aerospace Group
GENERAL ELECTRIC
Cincinnati, Ohio 45215

INDEX

INTRODUCTION

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This brochure lists some of the capabilities and experience of the Test Equipment Engineering group of Nuclear Systems Programs. This group has the responsibility of specifying, designing, and checking out all equipment related to the testing of space power systems, components, and related equipment of the department. The group is staffed with all the engineering talent required and is supported by service organizations such as drafting and analysis laboratories.

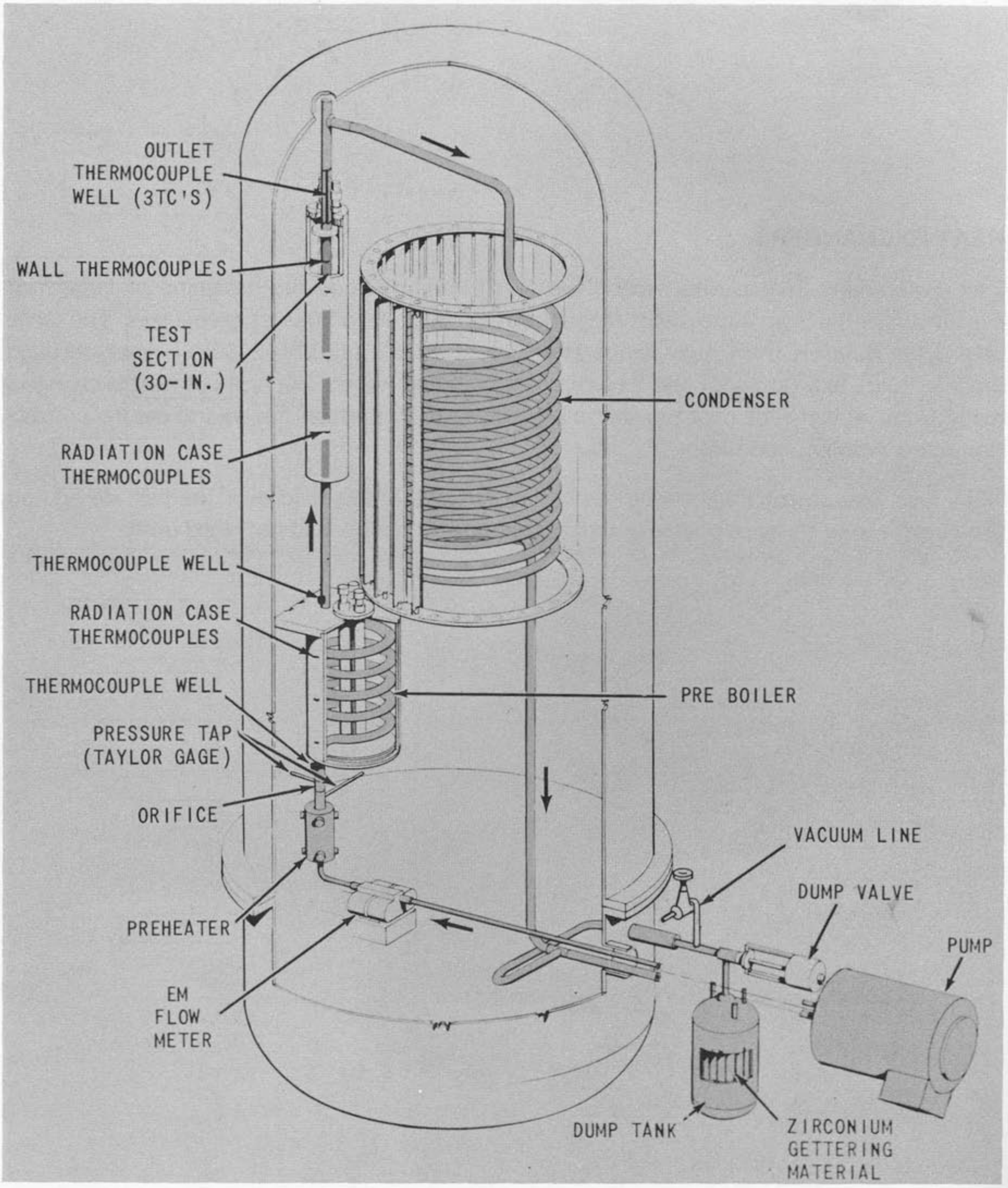
The experience of the Test Equipment Engineering group over the past 15 years covers the design of equipment not only for space systems but also for jet engine testing. Experience has been gained in the design of test facilities both for in-house applications and for various Government agencies. In addition, this group has made a number of studies for NASA and for the Air Force on specialized facilities. NSP Test Equipment Engineering studies consist of conceptual designs, problem area identification, and preparation of preliminary cost information, and encompass a wide field including either the rework and updating of existing facilities or design of new and different facilities pushing the state-of-the-art both in space and alkali metal field application.

The NSP Test Equipment Engineering group has special competence in component and specialized equipment design, complete turnkey facilities, and related studies.

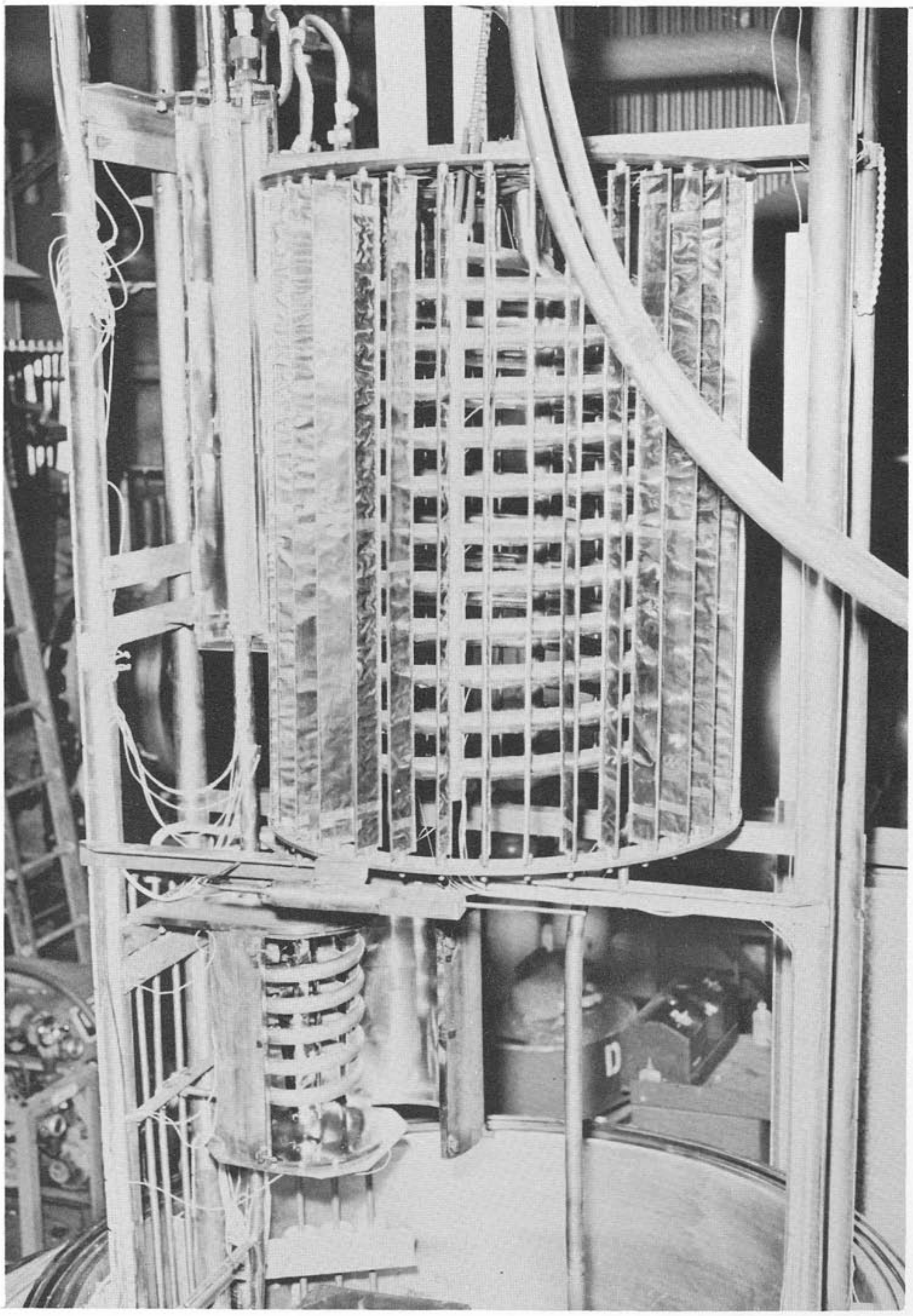
HEAT EXCHANGERS

Test Equipment Engineering capabilities in this area include the designing of large heat exchangers in the 3- to 4-megawatt range down to small 40 to 50 watt exchangers. The range in process fluids is from high temperature liquid metals (1200°–2100°F) down through organic fluids like Coolanol and Dowtherm, to oils and water. The types of heat exchangers range from radiant-type heat transfer in vacuum systems through forced and natural convection under ambient conditions.

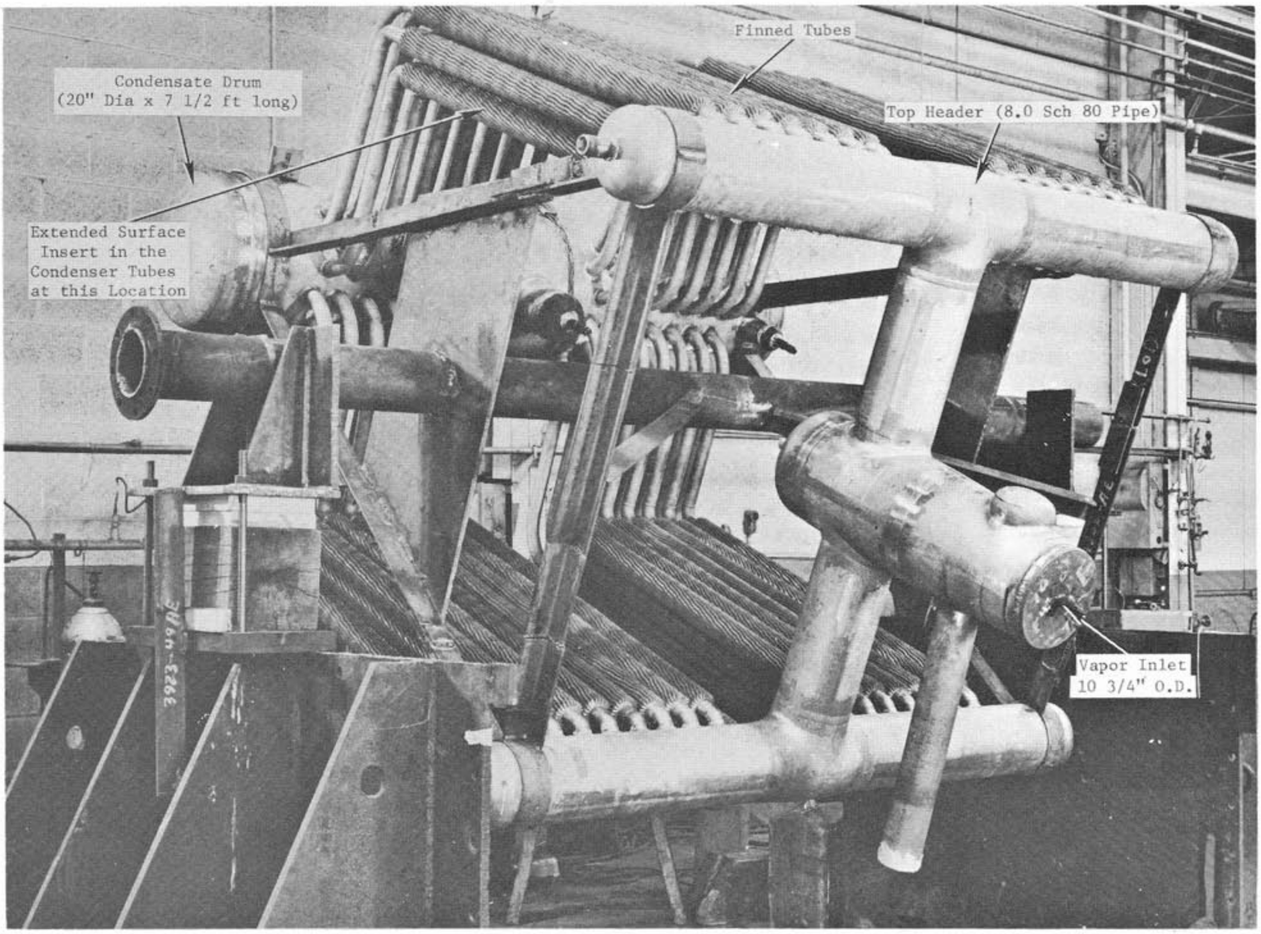
NSP–Test Equipment Engineering has had experience in the field over the past decade on programs related to space power systems, component cooling, and packaged units.



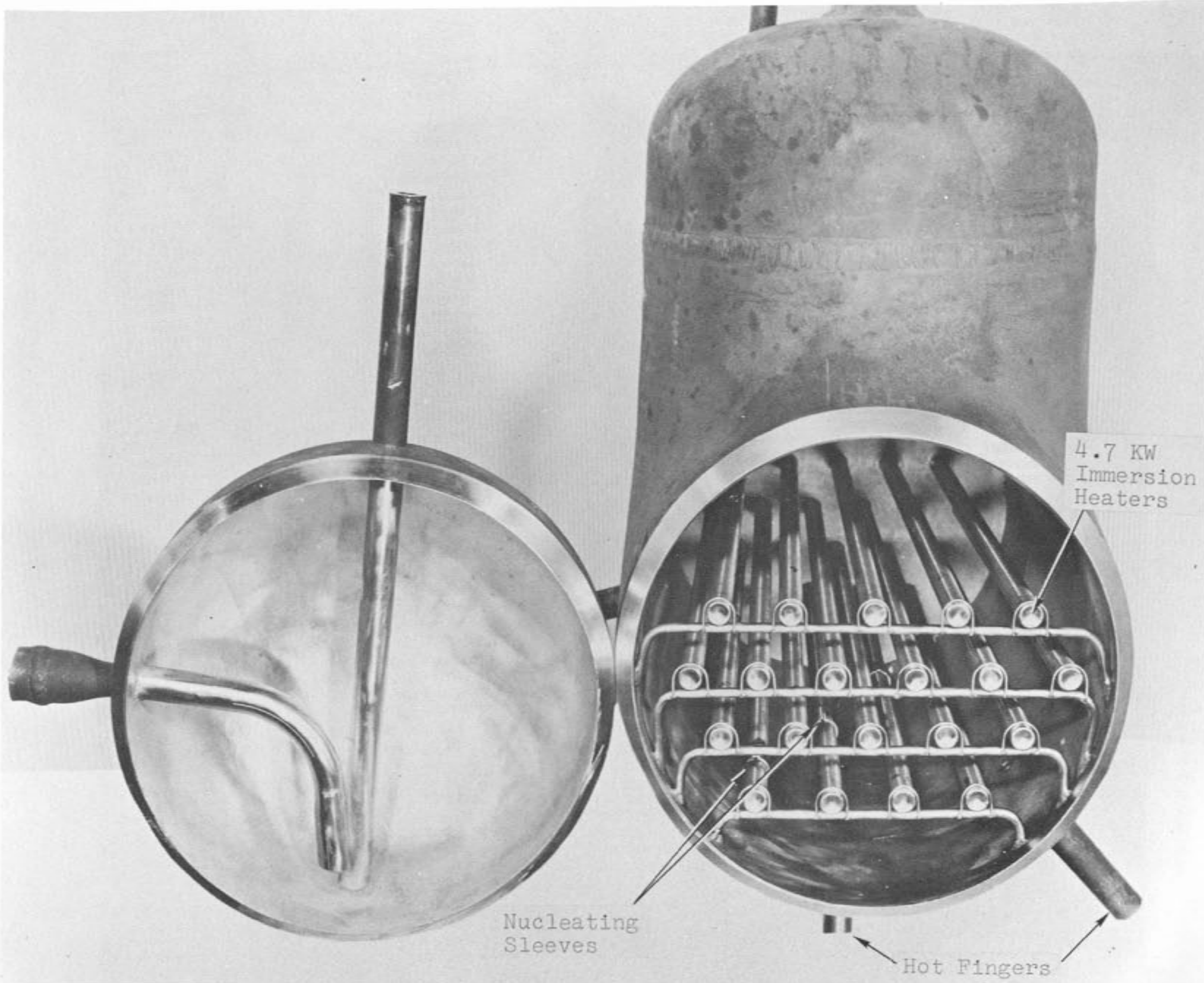
An artist's concept of a 100 KW heat transfer facility. The boiler and condenser shown in the photo are installed in a high vacuum environment.



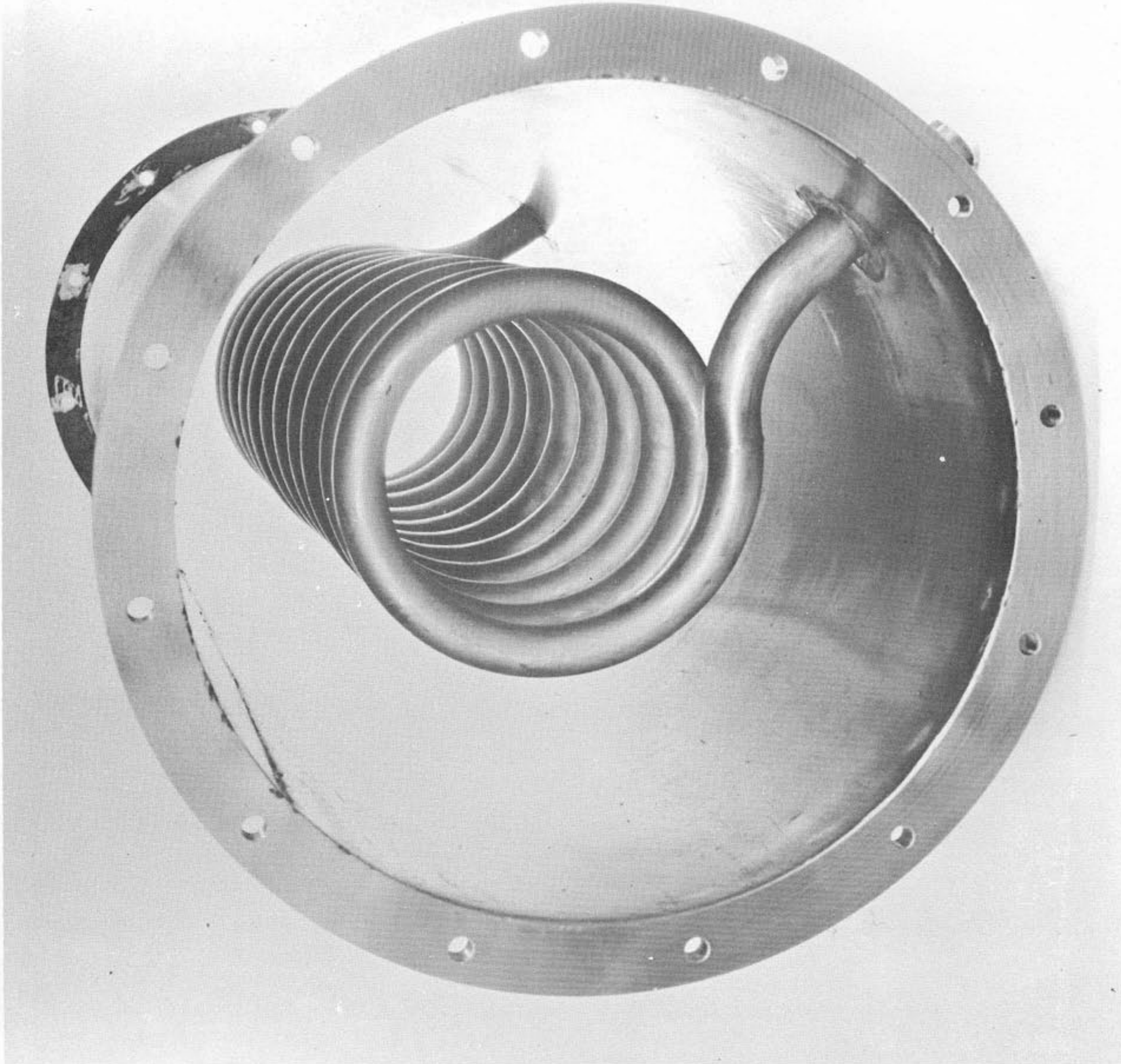
A radiant type heat transfer coil used to dissipate heat in a vacuum system. The movable shutters are used to control the amount of heat loss from the coil.



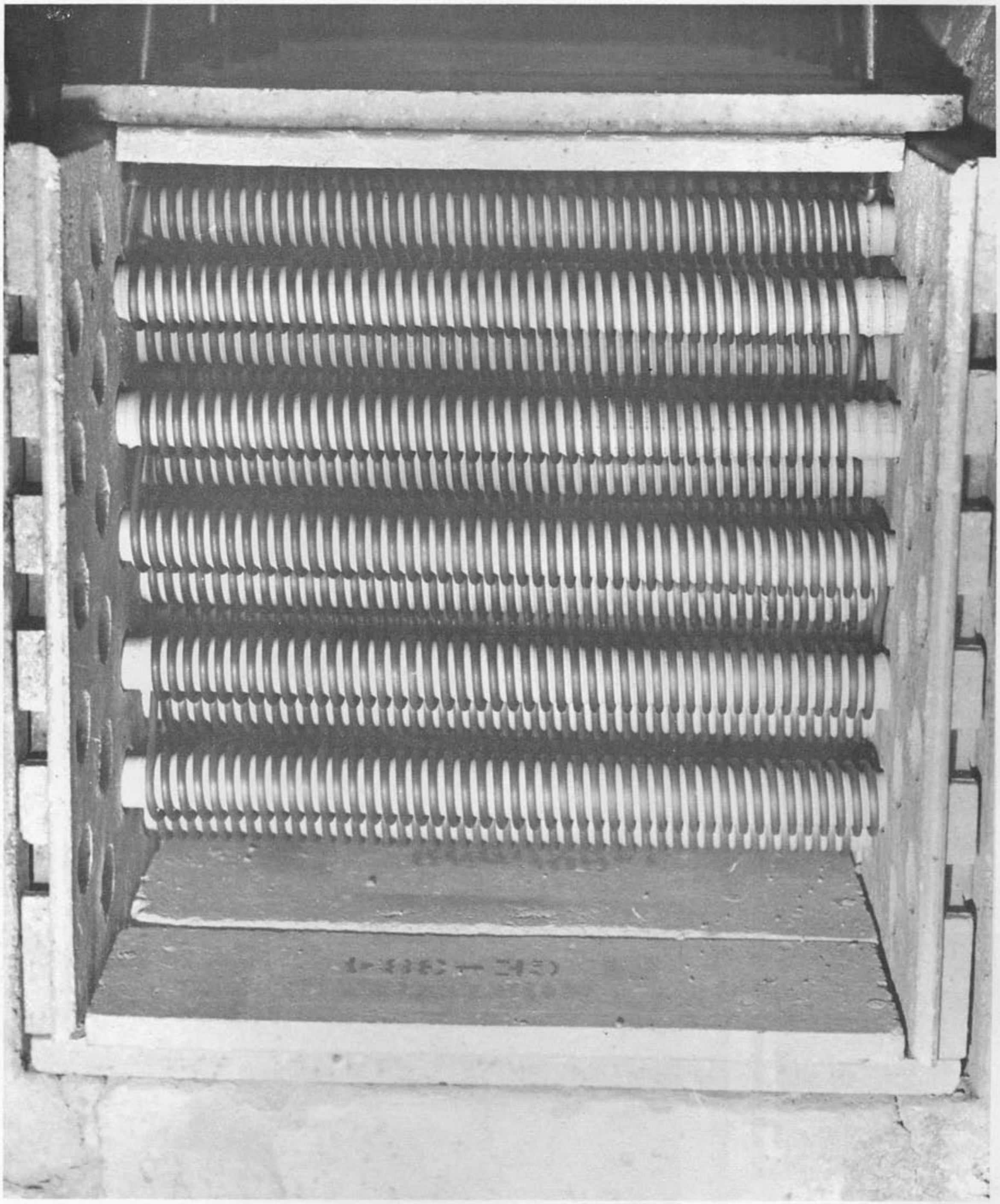
A 3000 KW thin condenser made of stainless steel and capable of operating at a maximum of $1500^{\circ}F$.



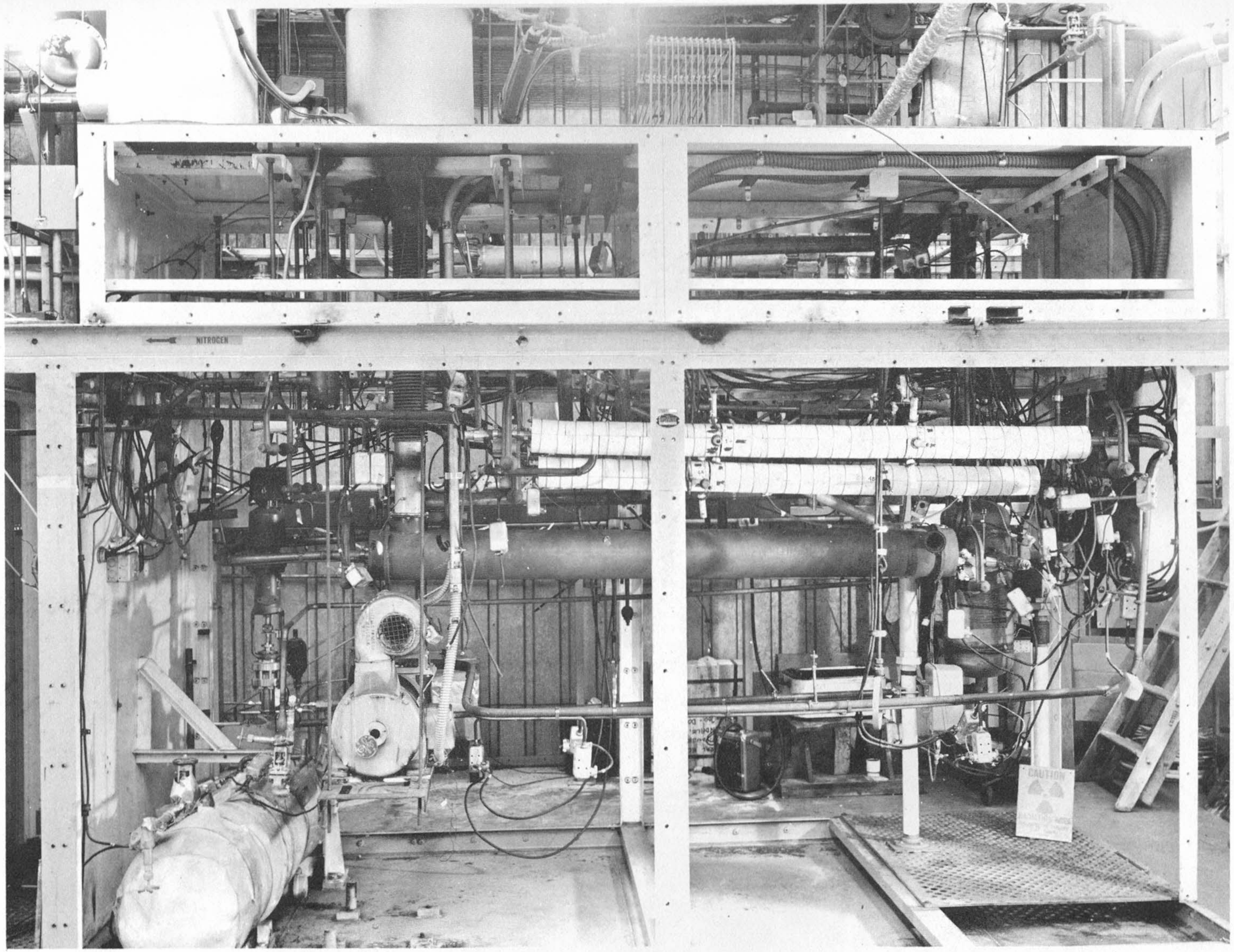
A 50 KW imersion heater for operating at 1200^{o}F. The heater is an all welded assembly and is mass-spectrometer leak tight but the individual imersion heaters are readily removable.



An air-to-oil heat exchanger design.



The design of a typical I^2R heating element for a 2000^{o}F air heater

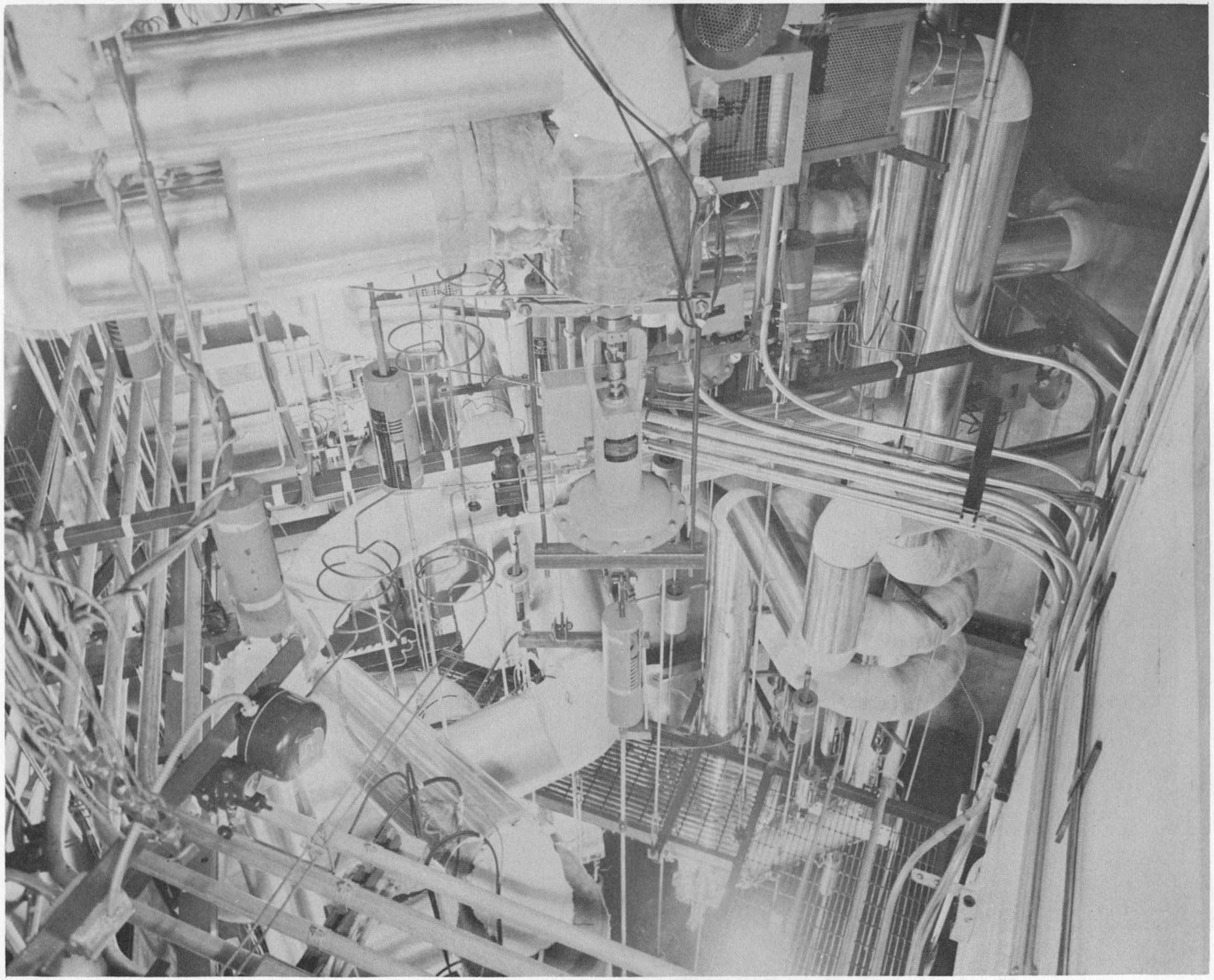


High temperature alkali metal facility. Facility is capable of supplying hot alkali metal to a variety of components, such as bearings and seals. Insulated heat exchangers are capable of heating the alkali metal from room temperature to 1400°F. An air-cooled heat exchanger is capable of returning the hot alkali metal to 2000°F.

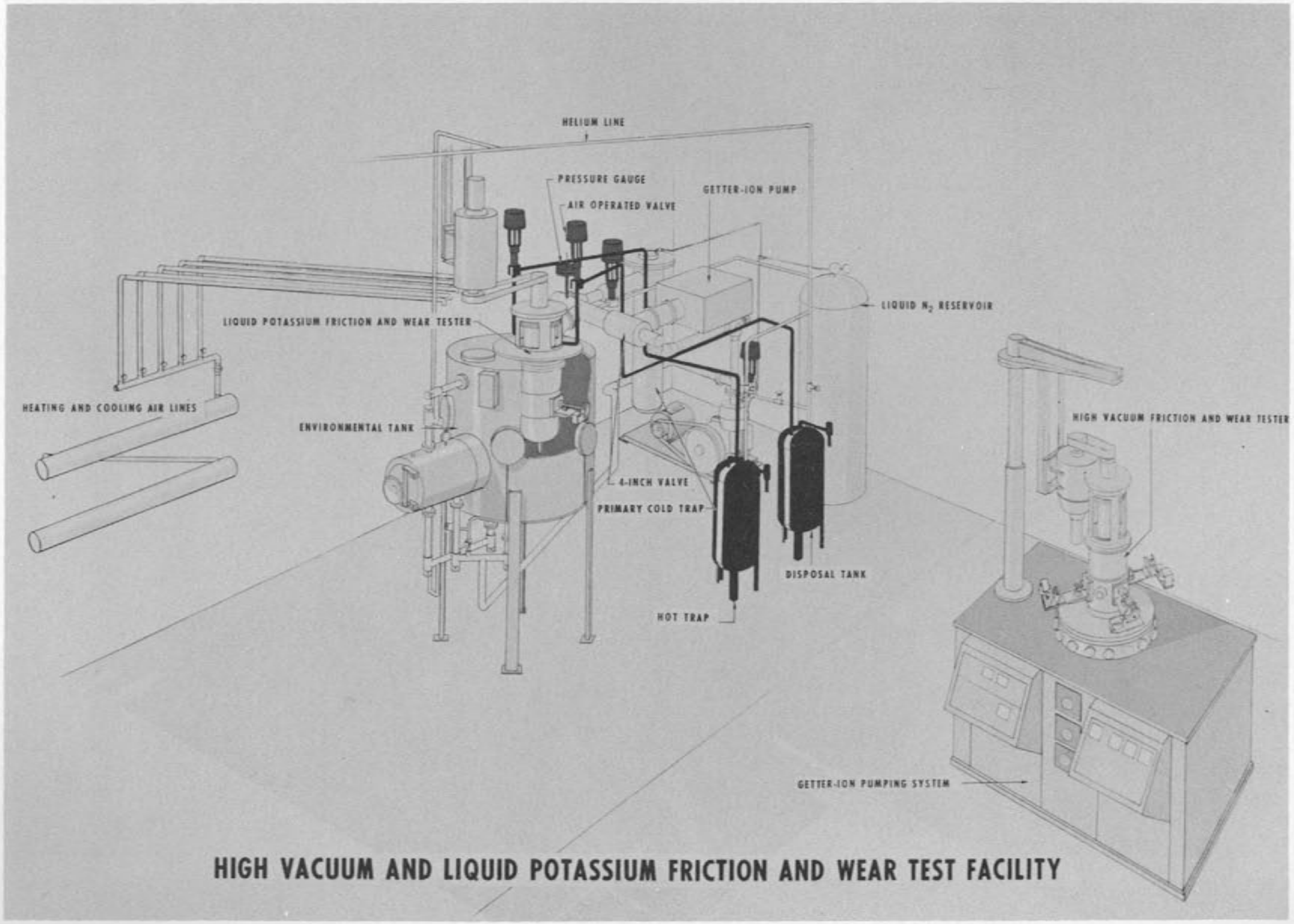
PIPING SYSTEMS

NSP experience in piping systems is mainly based on systems in the range of 1200^{o} to $1550^{o}F$ using stainless steels and up to $2100^{o}F$ using refractory metal alloys. These systems are designed and supported in a manner to minimize stresses in the piping because of the low allowable stress of the materials at these temperatures. Due to the hazardous nature of the process fluids, the systems must be completely leak-free and remotely operated; and due to the high temperature, they must be insulated to prevent damage to wiring and other surrounding structural parts.

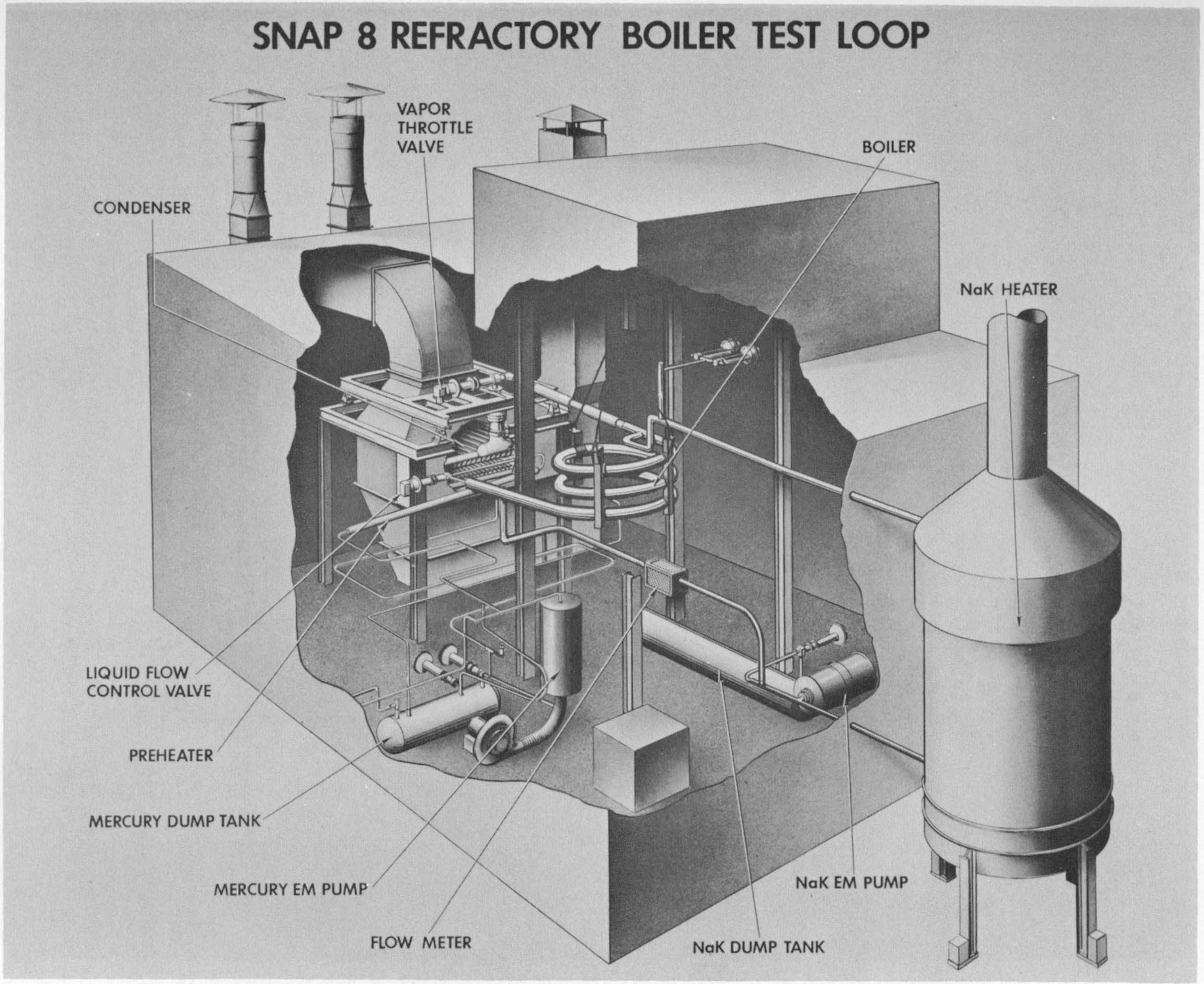
NSP has the necessary experience to design, analyze and install piping systems for alkali metal and other high temperature and high pressure process fluids. Considerable experience over the past 8 to 10 years has been gained in the design and fabrication of complex piping systems.



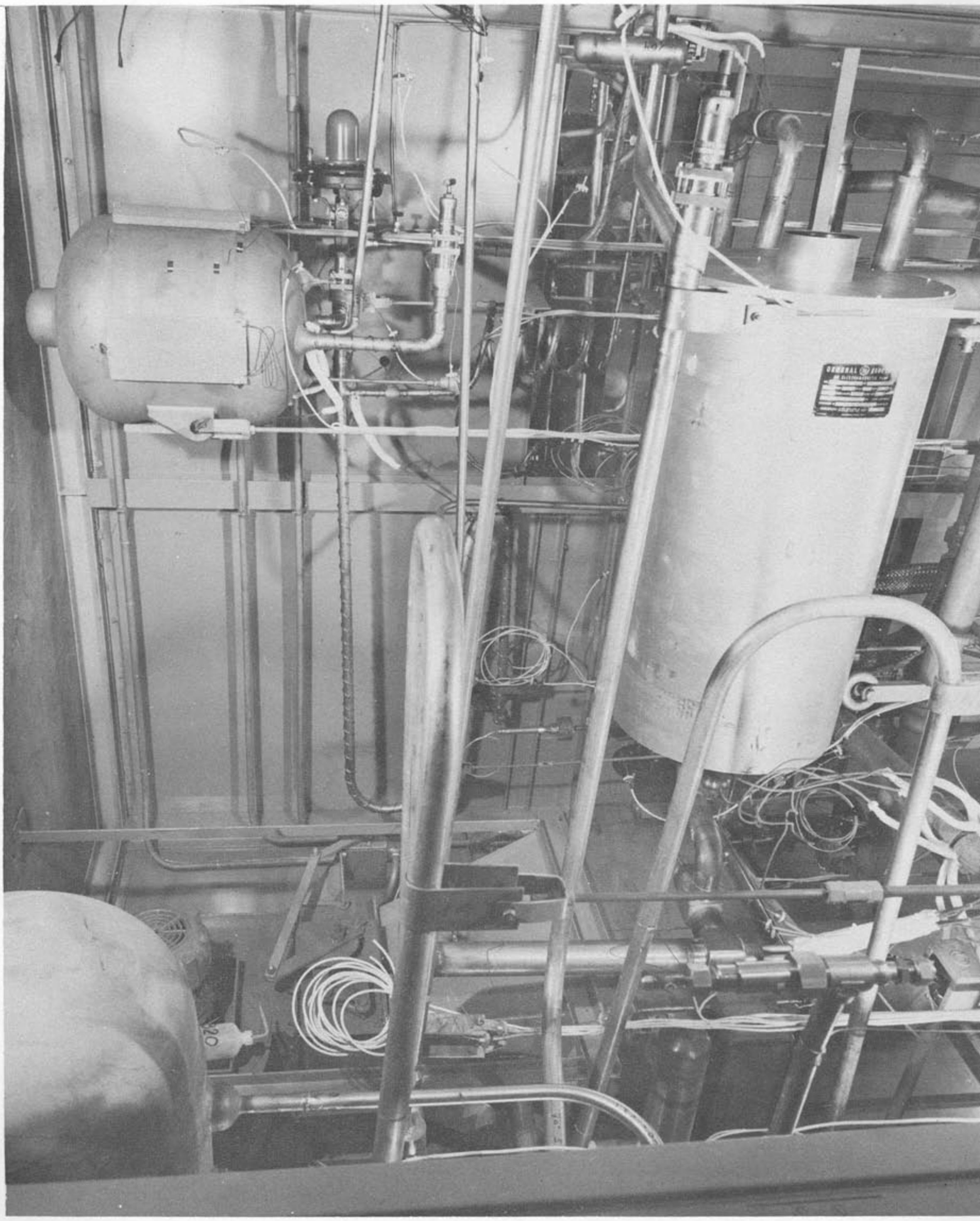
This view looks upward at a complex alkali metal piping system furnished as a turn key job to Wright Patterson Air Force Base. The piping operates at 1200^{o}F, is hung in a manner to be practically stress free at temperature, and is insulated with 4 inches of insulation to prevent heat loss to the cell.



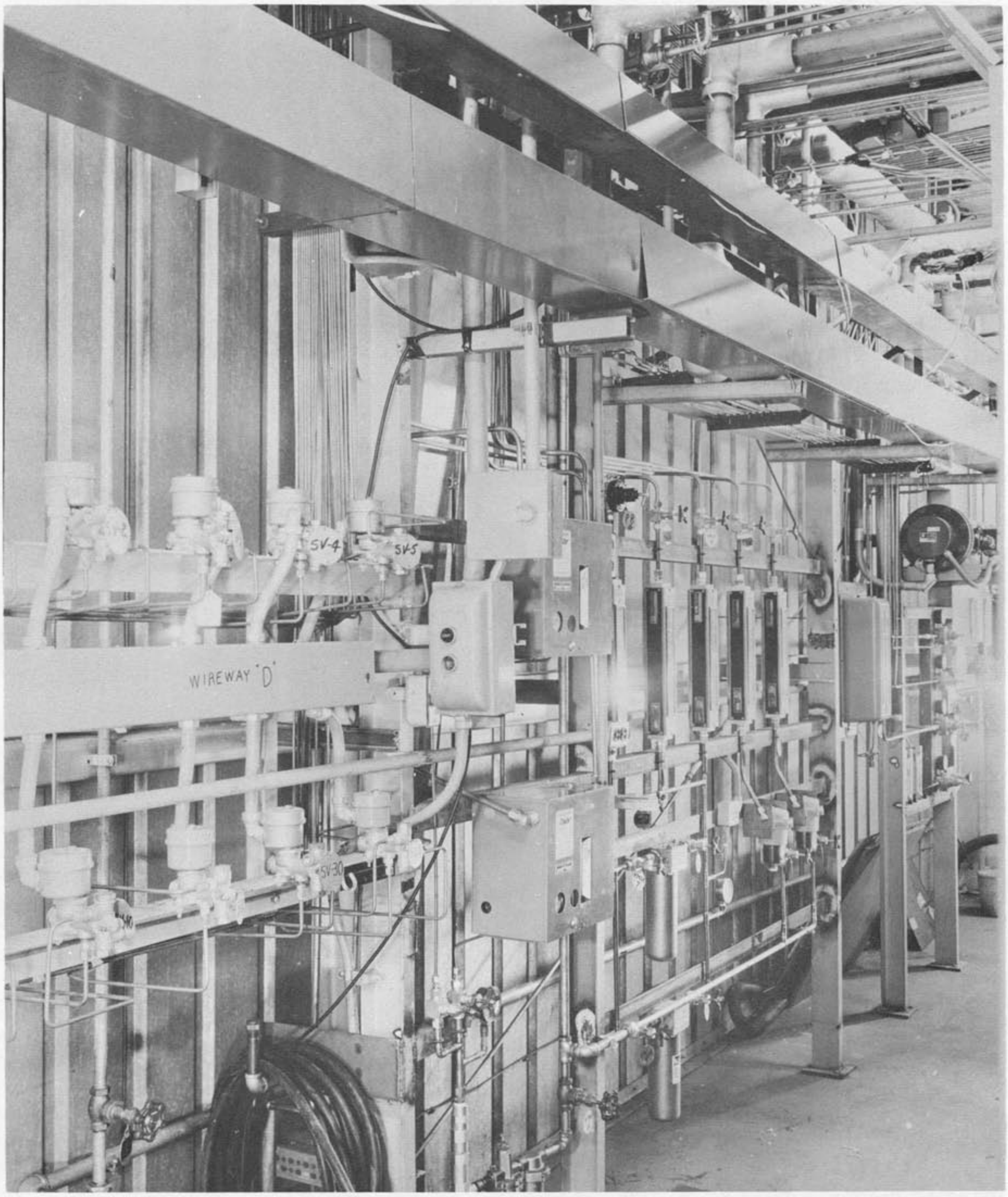
An artist's concept drawing of a high vacuum and liquid potassium friction and wear facility. It shows the friction and wear tester and the associated equipment and piping required to conduct the test.



An artist's concept of a mercury boiler test loop. The facility components, test hardware and associated piping were positioned and hung in one of the NSP test facility buildings. The facility has been operated for over 8000 hours at up to 1200°F temperatures without shutdown.



A high temperature piping system capable of handling process fluid to 1200^{O}F. The loop was designed and supported to prevent high stresses in the stainless steel piping at temperature. The photo was taken prior to adding 4 inches of thermal insulation to the pipe.

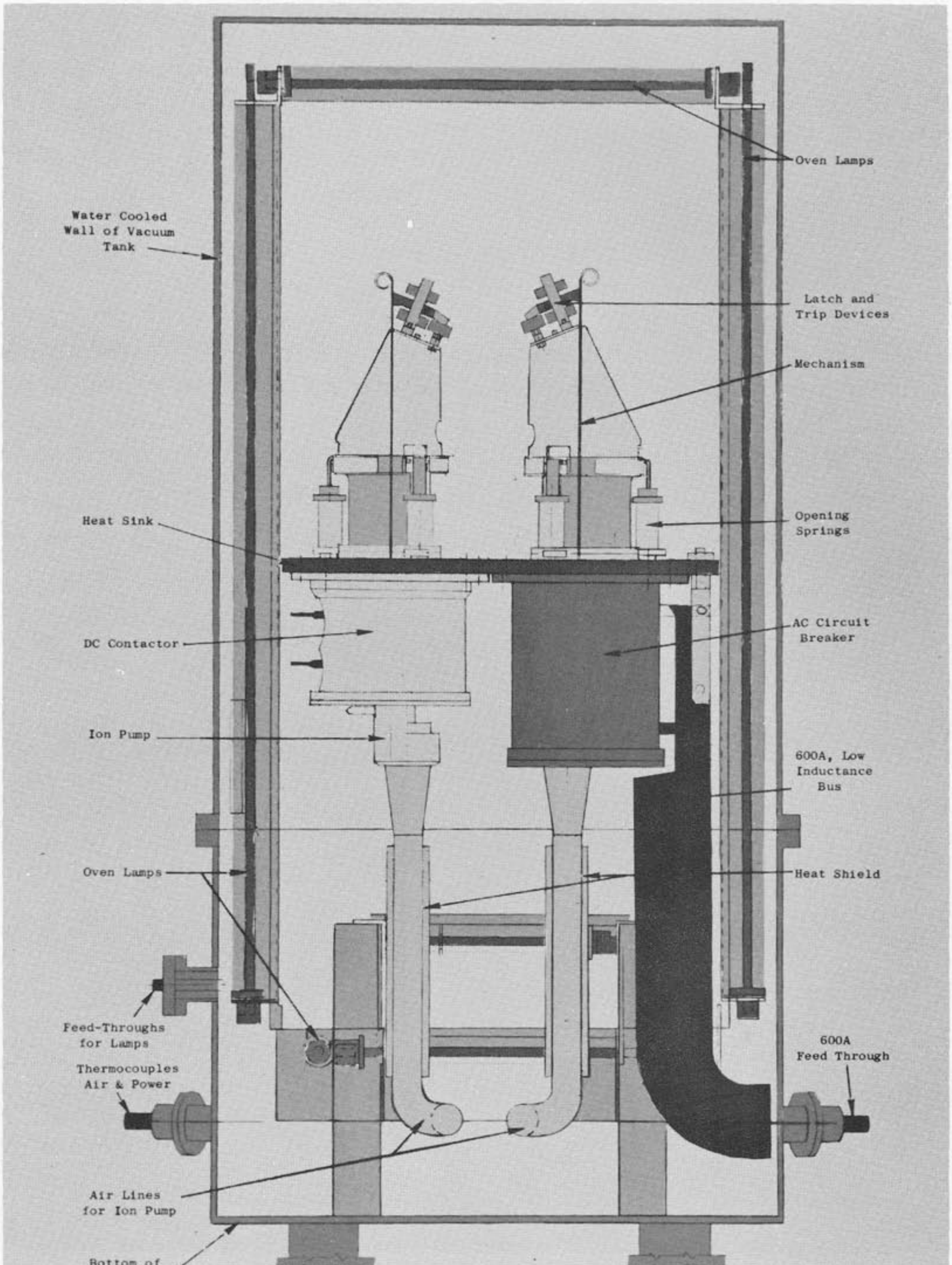


An argon gas distribution system. Five separate argon supplies are controlled and measured.

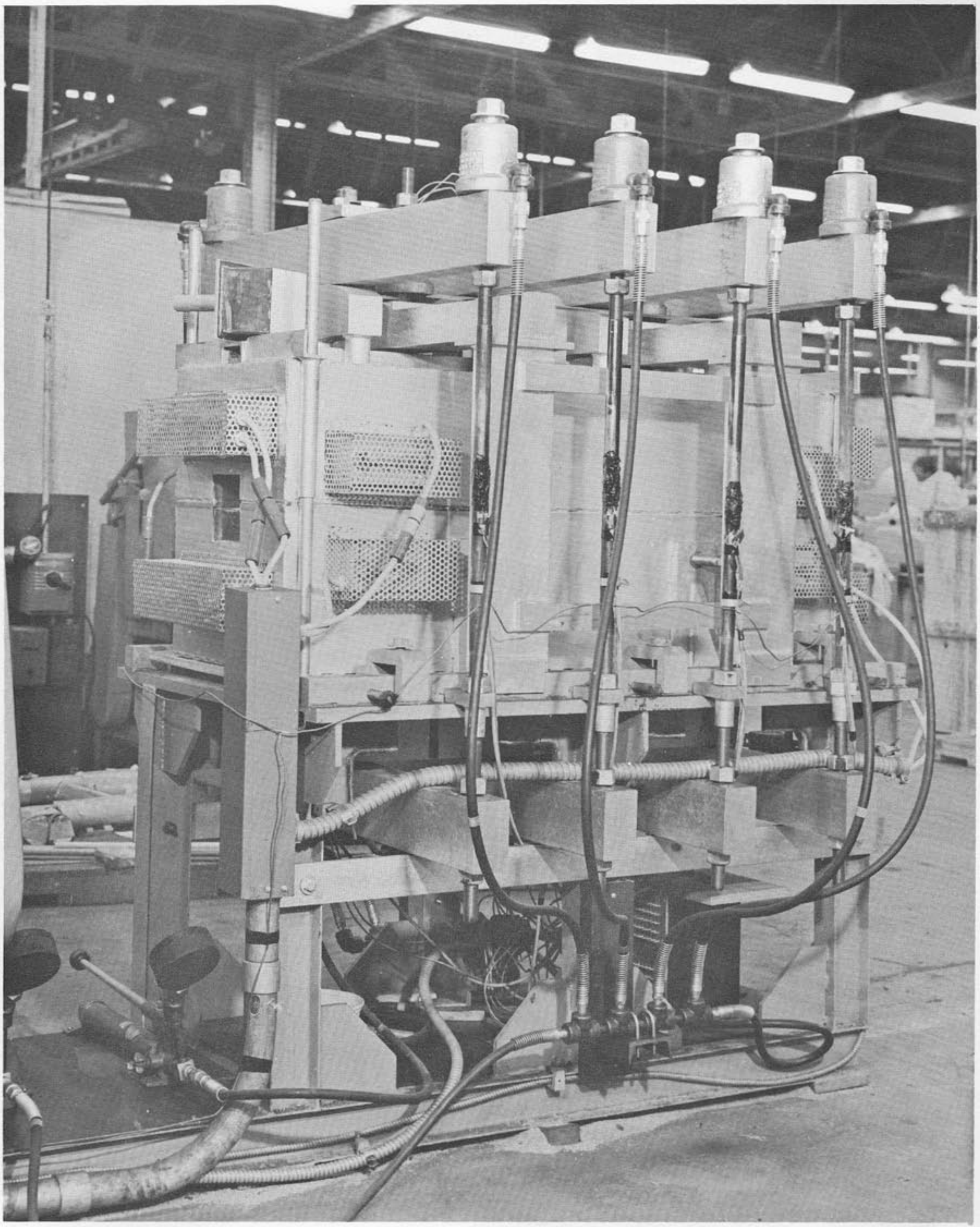
FURNACES

NSP experience in furnace design has been mainly in the specialty field. The Test Equipment Engineering group has designed furnaces to simulate space conditions in vacuum systems; designed high temperature inert gas furnaces for processing refractory alloys; and designed special high temperature furnaces—3000^{o} to $4000^{o}F$—using tungsten/tantalum as the heating elements.

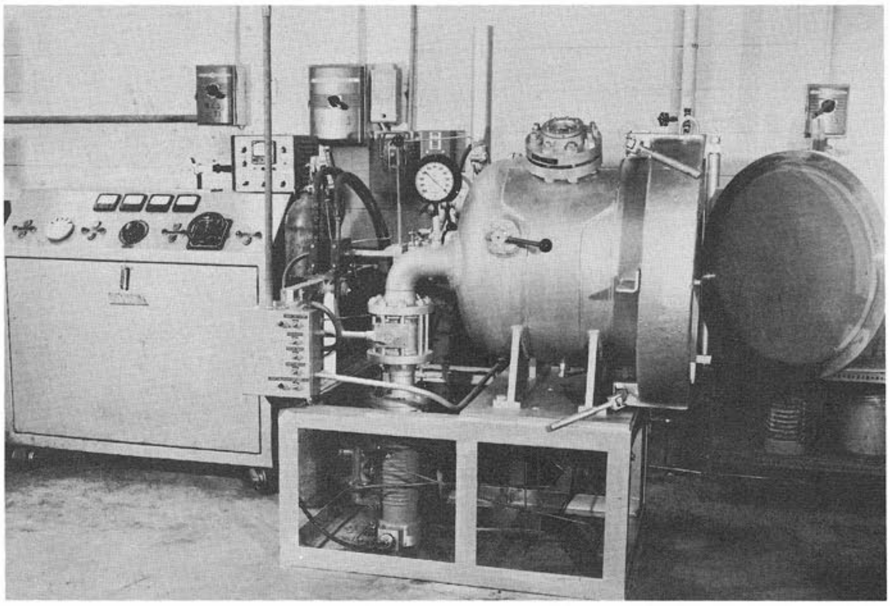
The NSP Test Equipment Engineering group has experience in this field for the past 17 years in association with high temperature materials programs and space efforts.

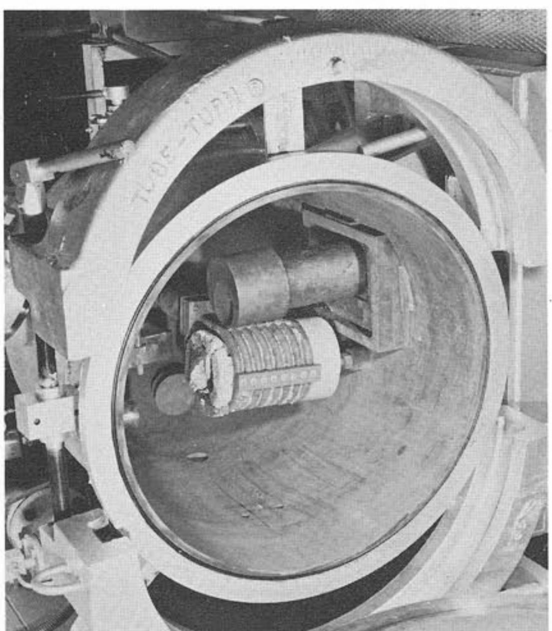


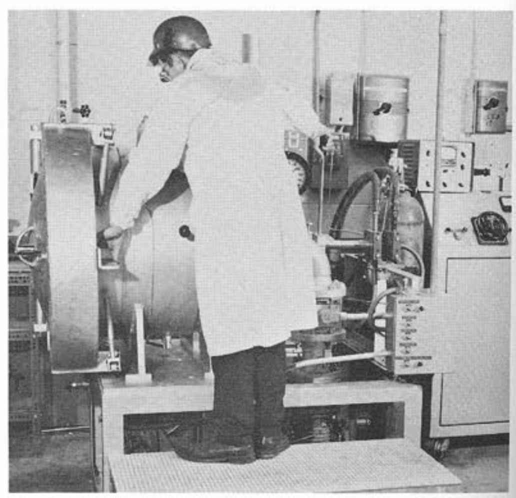
An artist's concept of a switchgear test in an oven and vacuum tank. The quartz oven lamps, the ceramic insulators, and the oven support structure were designed and furnished for an NSP test facility.



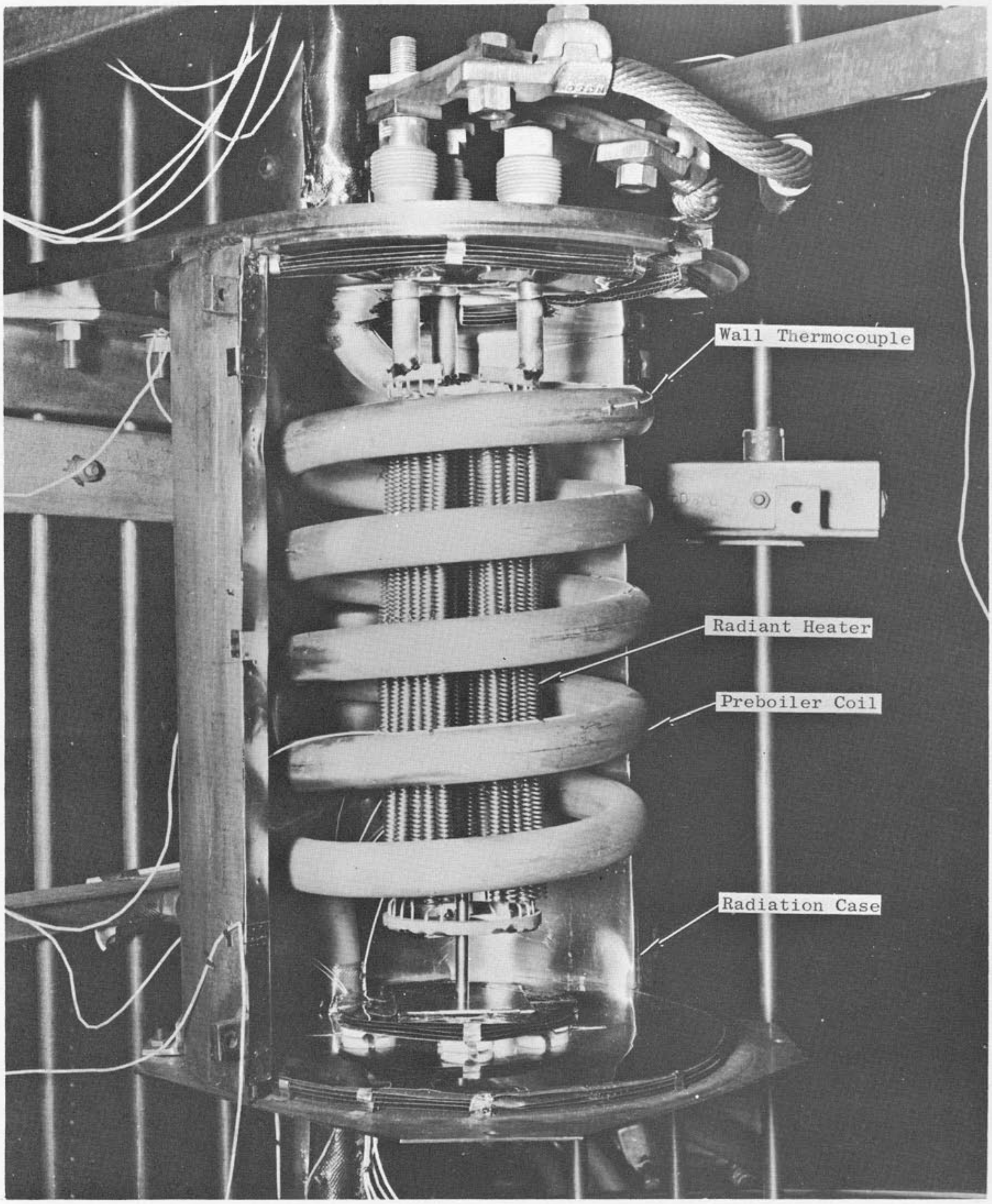
A high temperature swaging furnace for bonding dissimilar metals at high temperature and pressure. Hex shaped zirconium was clad with a milti-layer of molybdenum and stainless steel sheet material.







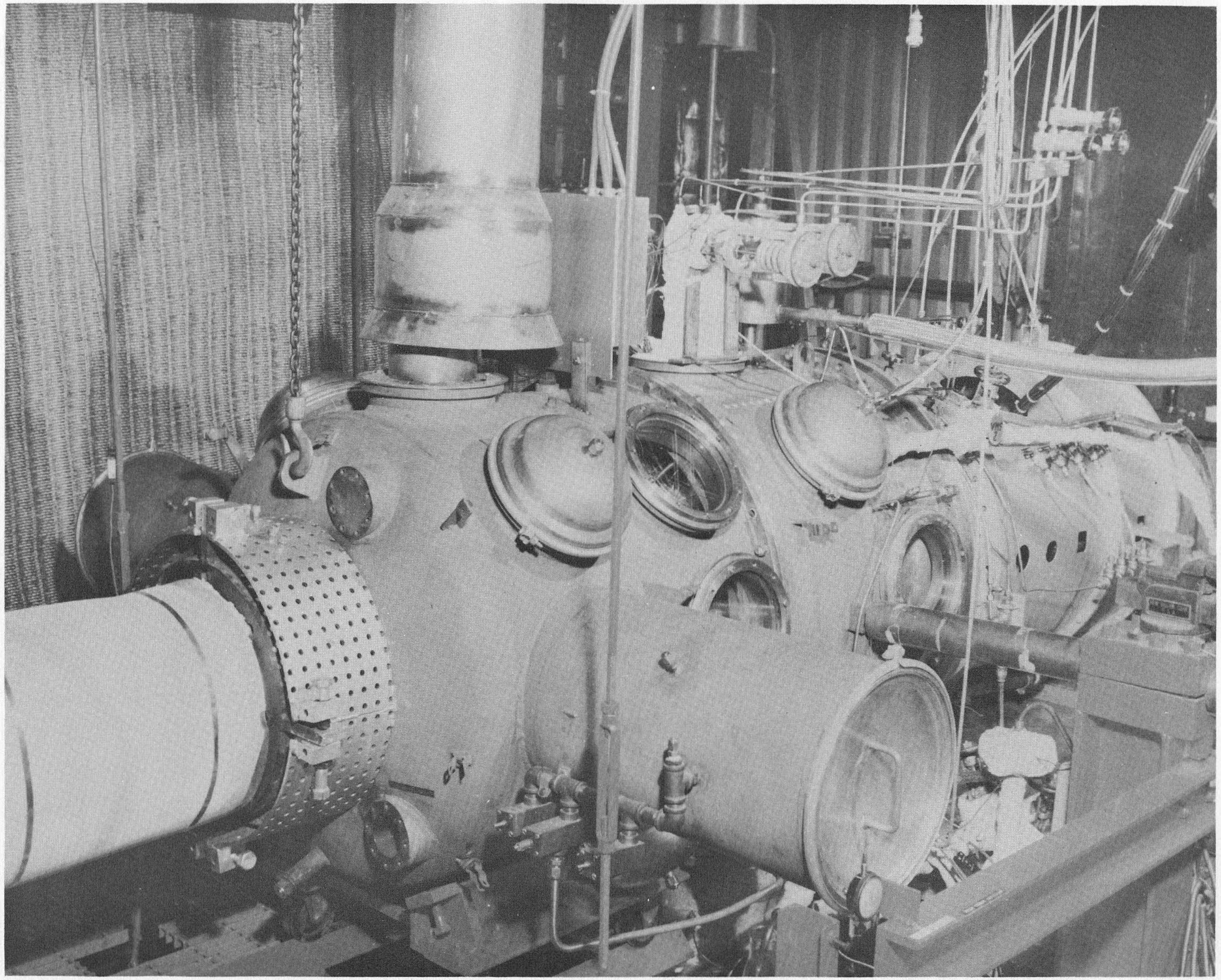
High pressure induction melter used in the purification of chrome and molybdenum base alloys. It has a capacity of 12 lbs of melt and a maximum temperature of $4000^{\circ}F$, a maximum pressure of 750 psi, and a vacuum capability of 10^{-6} torr.



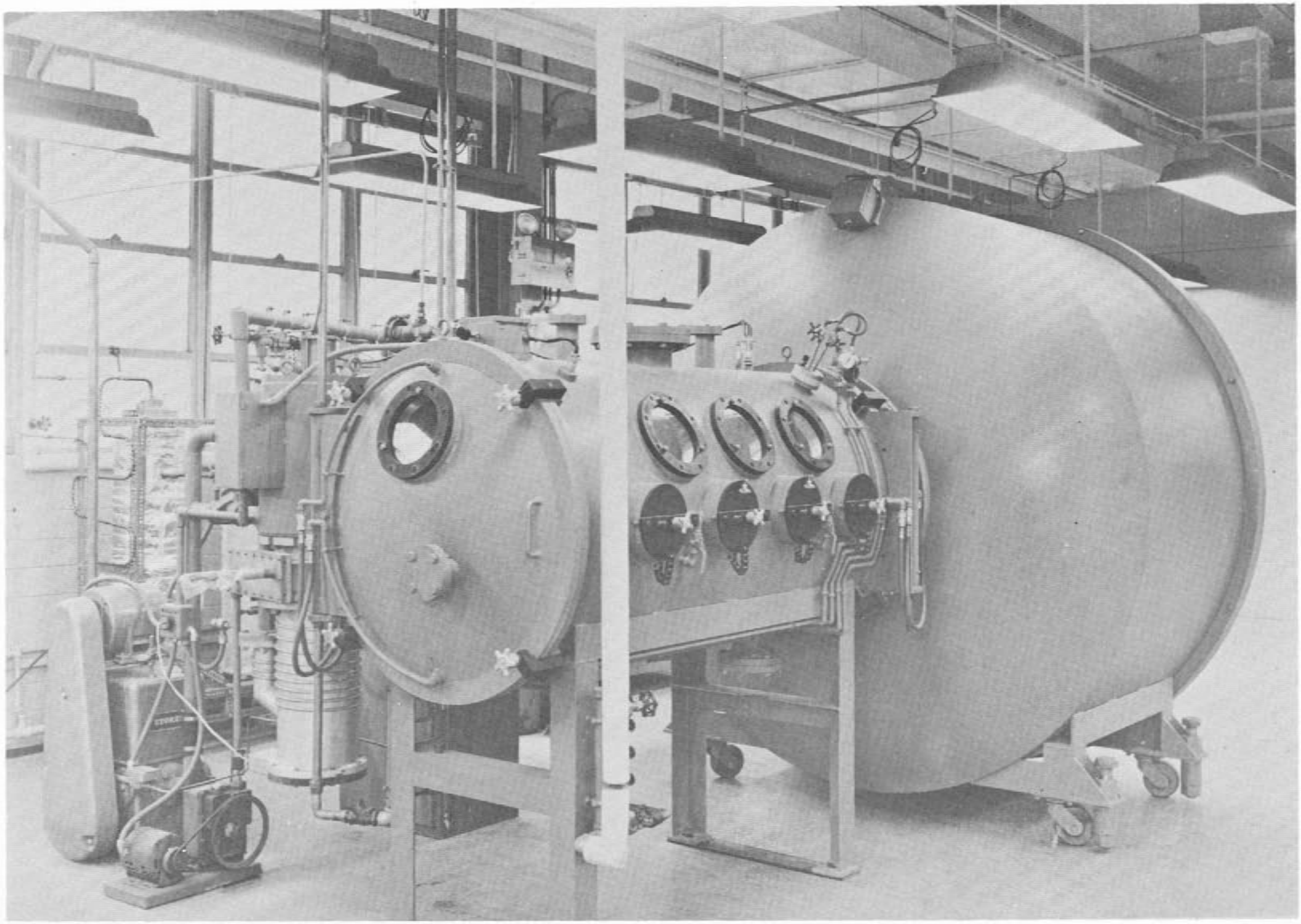
Design of a tungsten radiant heater for use in a vacuum furnace.

ENVIRONMENT CHAMBERS

The NSP Test Equipment Engineering group has had a great deal of experience in designing environment chambers because of the nature of the materials required by the programs of this department. There are frequent requirements for welding or testing in an inert atmosphere or in a vacuum. These requirements have necessitated the design of ultra pure inert gas chambers with sight glasses, glove ports, and with and without remote manipulators and automatic welding equipment.



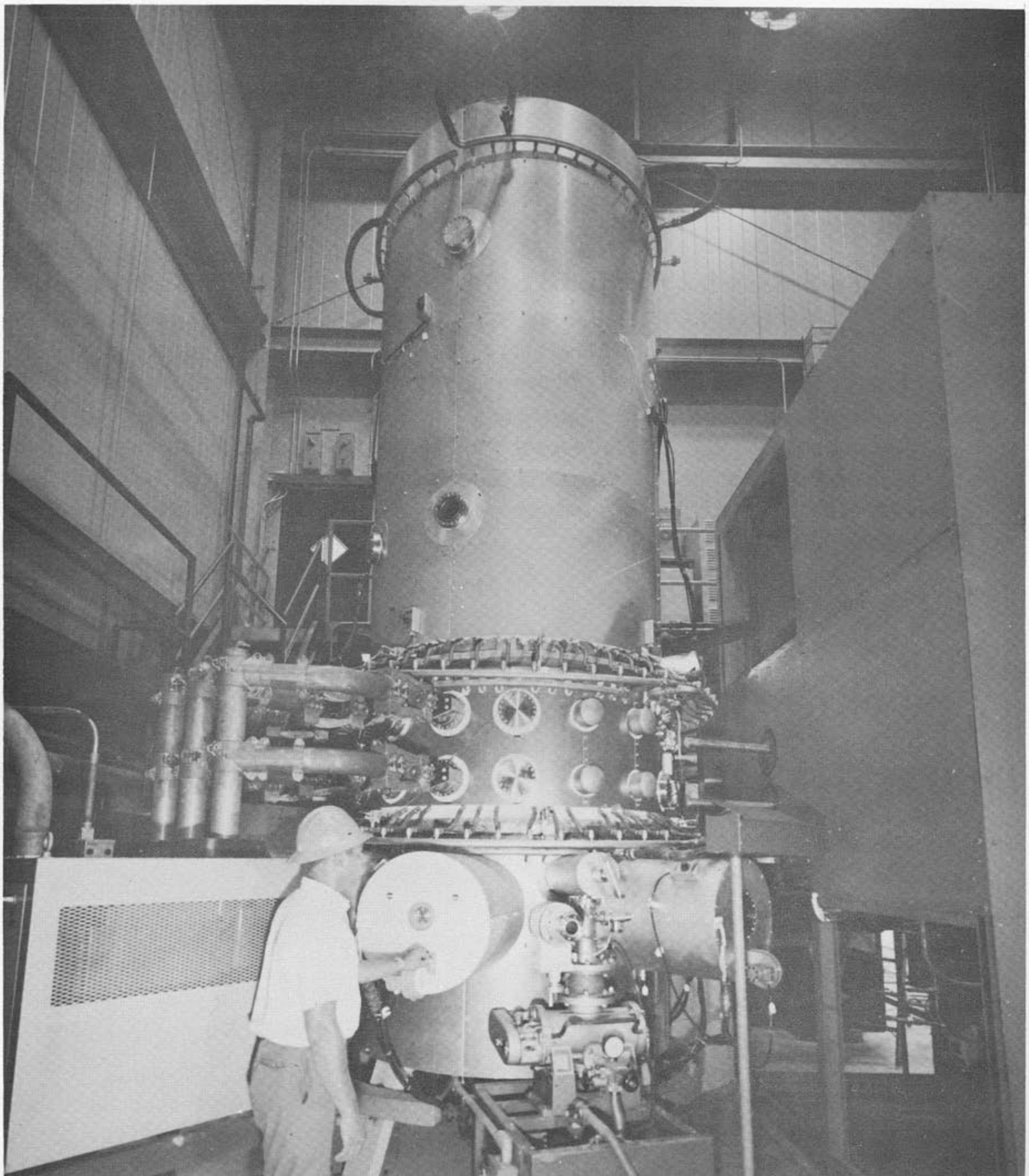
Design of an environment chamber used in testing a high speed turbine. An argon atmosphere can be maintained in the chamber.



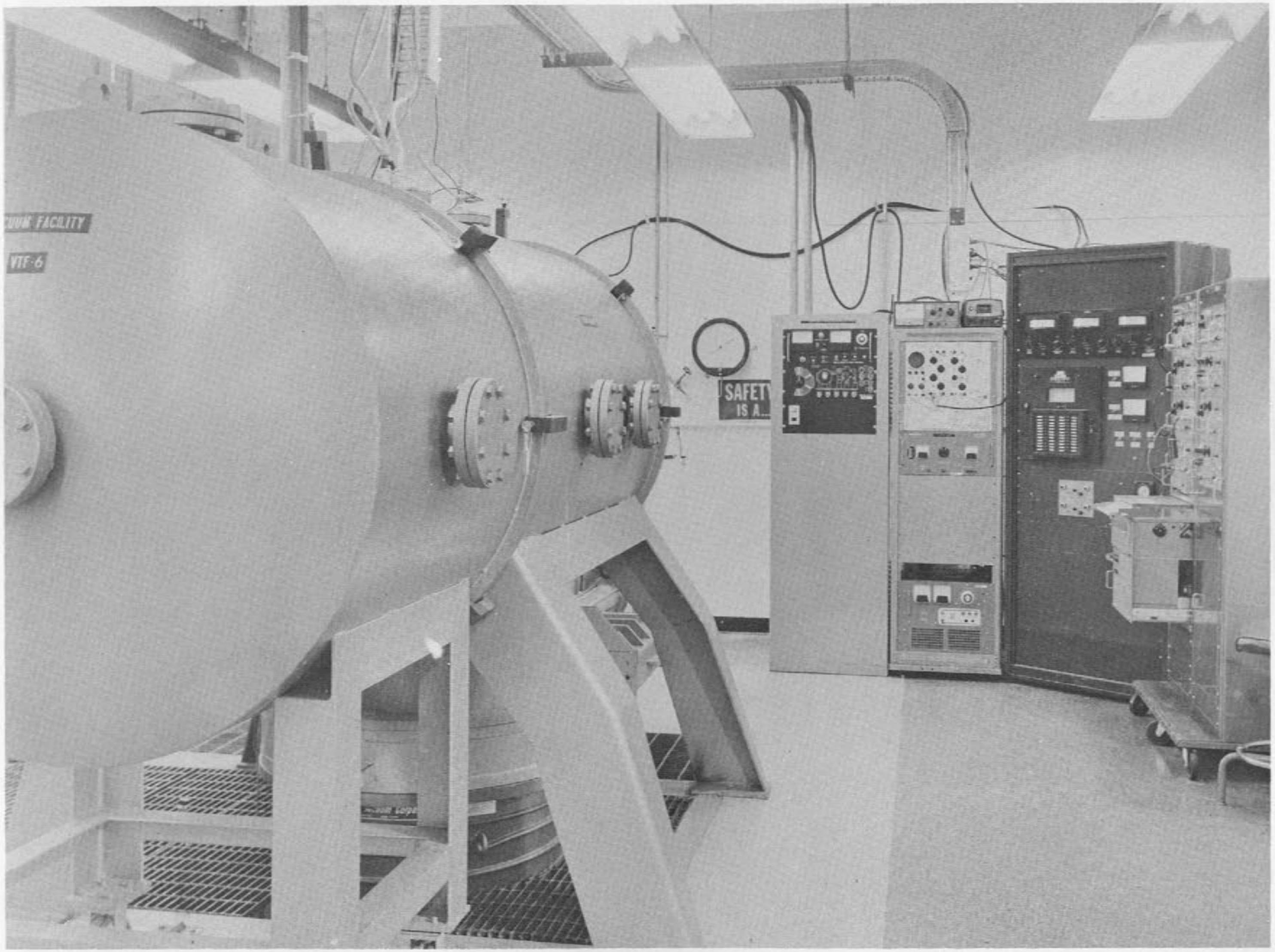
A controlled atmosphere welding chamber and associated pumping equipment. This chamber was conceived, specified, purchased and installed to support NSP programs. The chamber is 3 feet in diameter x 6 feet long, equipped with a 10-inch diameter oil diffusion pump capable of attaining a pumping speed of 4100 l/sec at a pressure of 1×10^{-5} torr. An extension to the chamber, 8 feet in diameter x 6 feet long, is shown in place.

VACUUM SYSTEMS

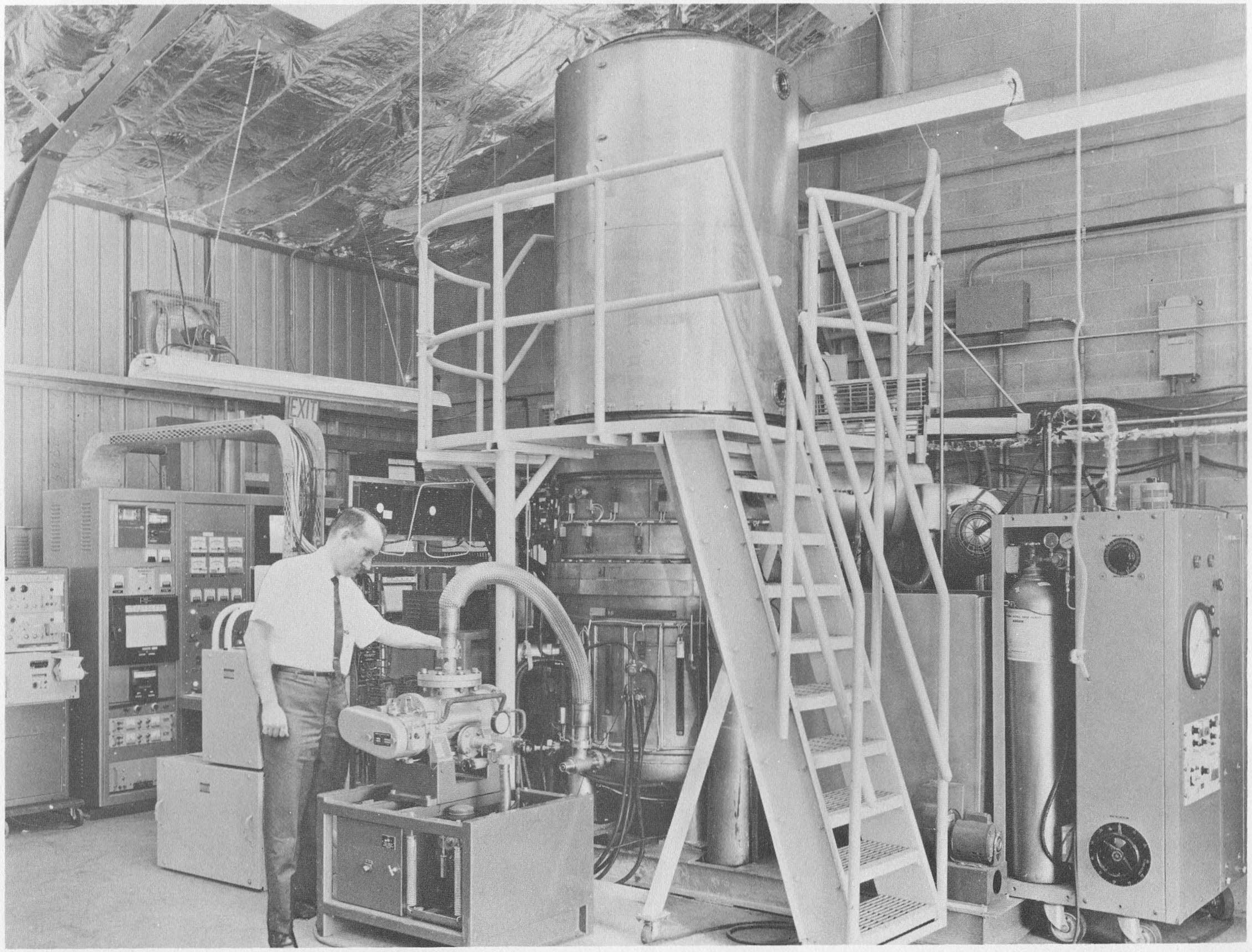
A great deal of experience has been gained by NSP over the past 7 or 8 years in the design, specification, installation and checkout of all types of vacuum systems. The Test Equipment Engineering group has designed vacuum systems that are used for testing various propulsion systems in space. These are principally high vacuum systems with a large "throughput" to handle the effluent from the propulsion system. Vacuum systems have also been designed to serve as environment chambers for refractory alloy testing; these require ultrahigh vacuum, using both diffusion and solid state pumping. The chambers are baked to 500^{o}F and have water cooling capabilities to remove hundreds of kilowatts of heat that is liberated from the test equipment within the chamber.



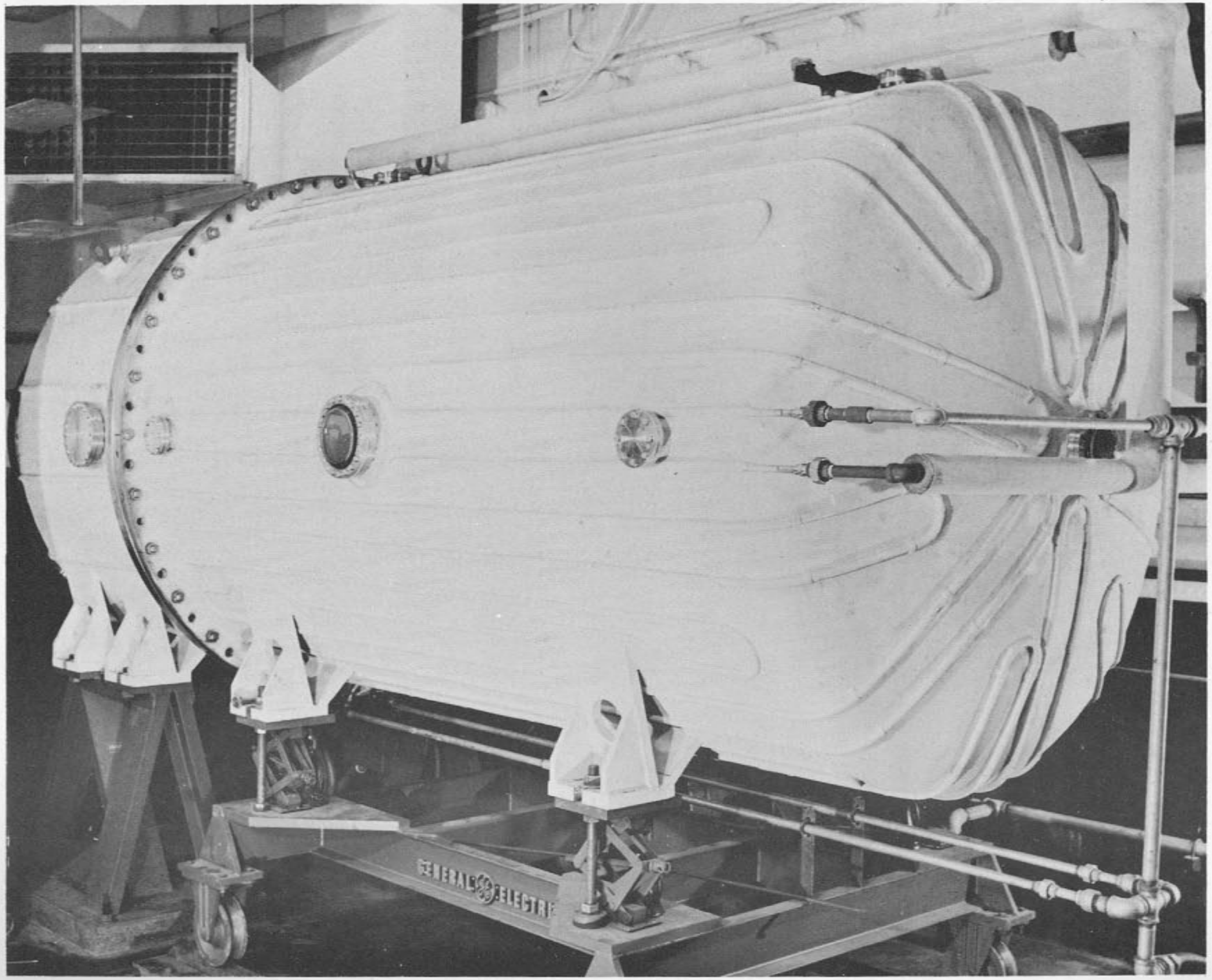
An ultra-high vacuum system designed and specified for NSP boiler development programs. The chamber is 6 feet in diameter, 21 feet high, is solid state pumped and has an ultimate pressure 1 x 10^{-10} torr.



A 4-foot-diameter vacuum chamber with associated controls. This facility has a pumping speed of 50,000 liters per second.



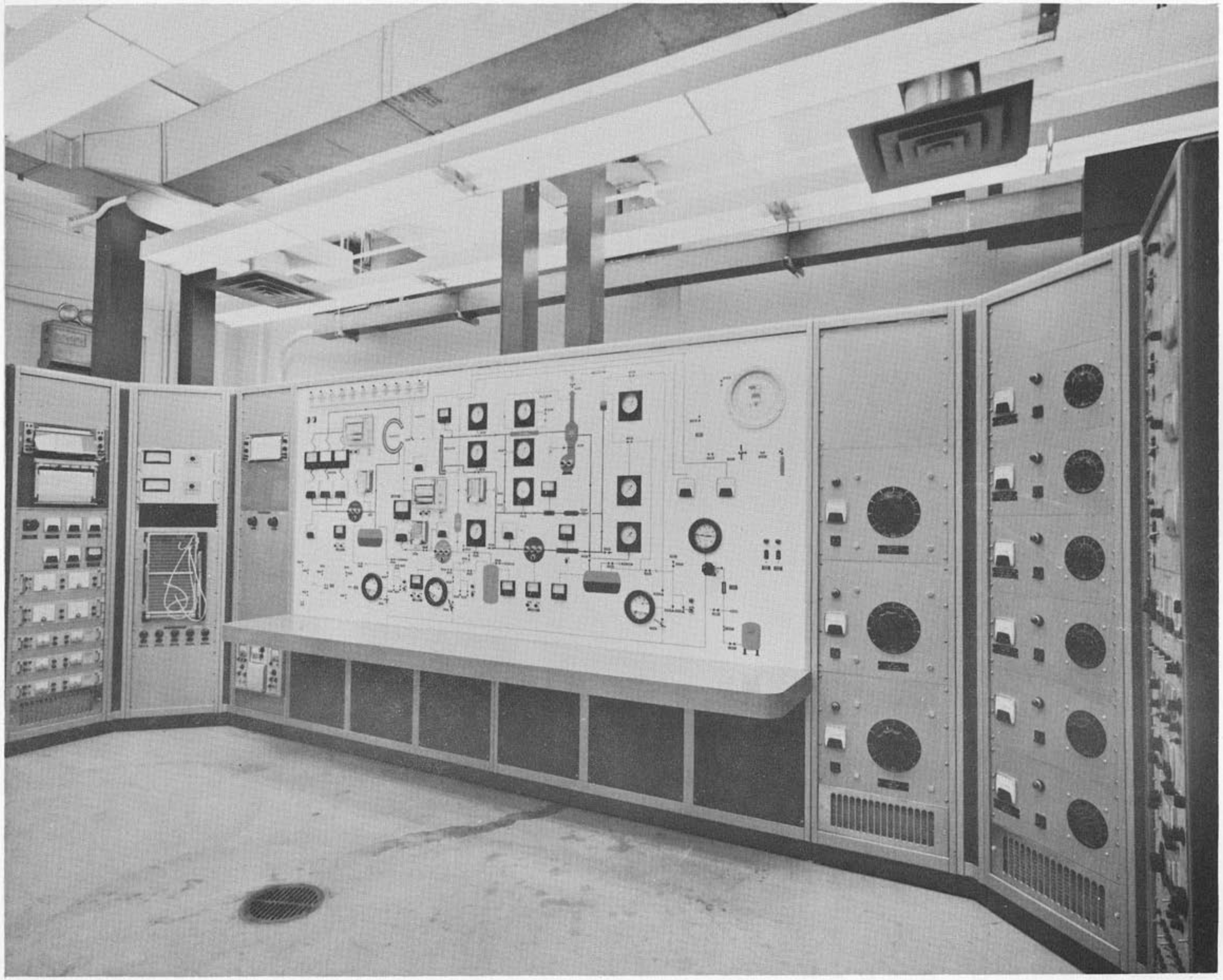
A 4-foot-diameter ion pumped, vacuum system and its associated controls.
The tank can be heated to 500°F or water cooled to near room temperature.



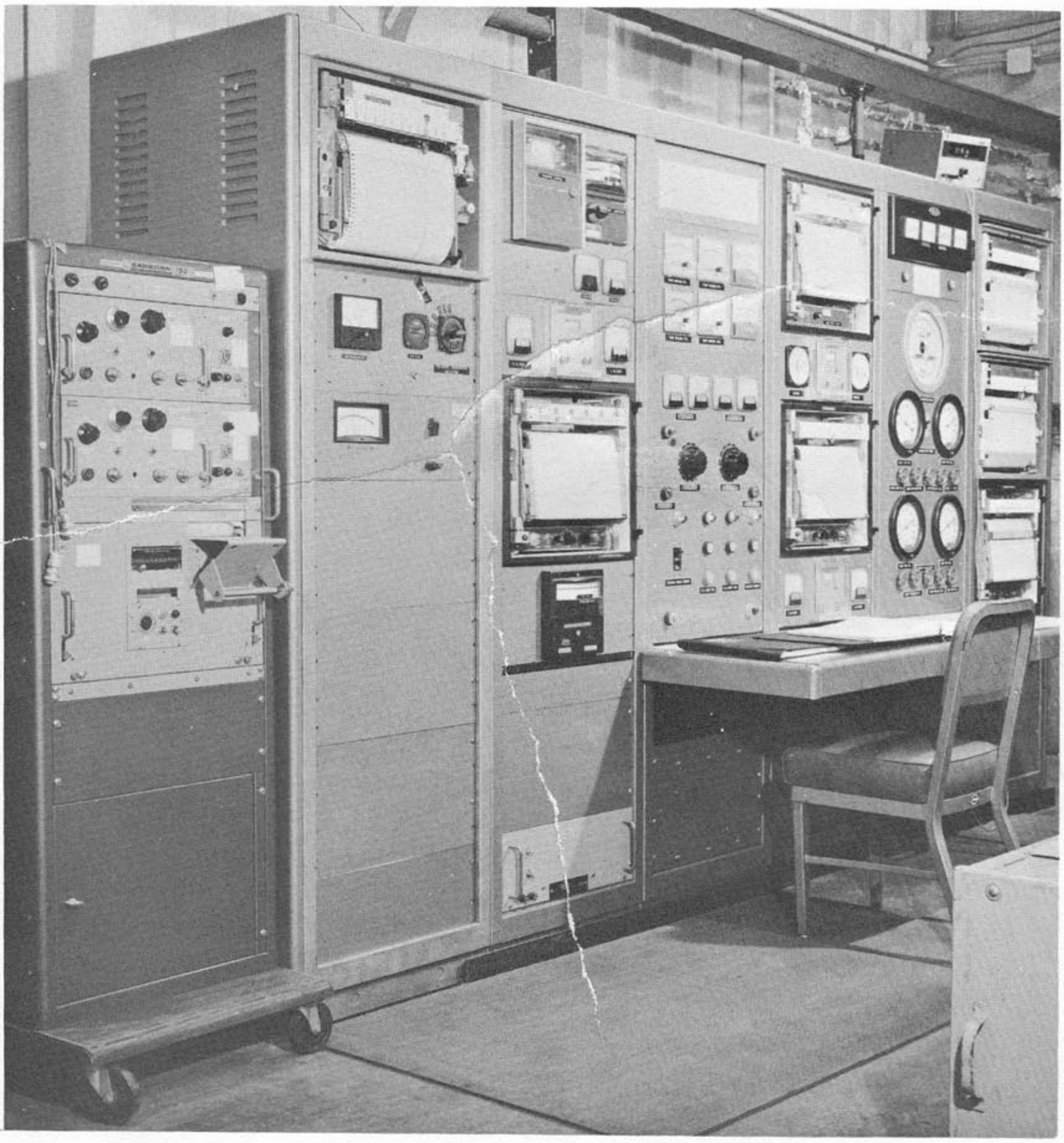
A 5-foot-diameter by 12-foot-long horizontal ultra-high vacuum tank. The tank, vacuum pumps, and associated heating and cooling equipment were designed, specified, installed and checked out within a tight schedule.

CONTROL CONSOLES

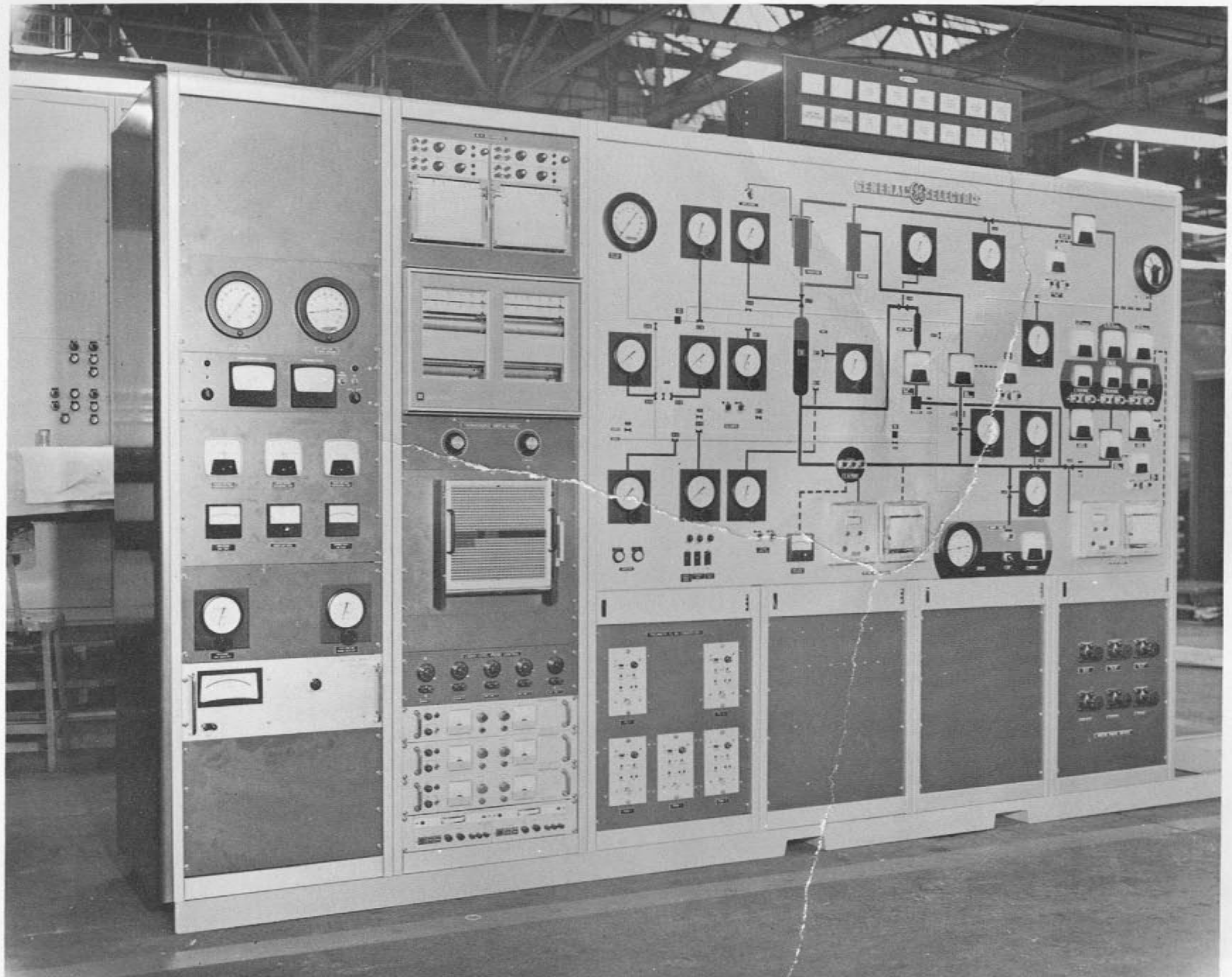
The nature of NSP programs is such that most of the facilities must be remotely controlled and are extremely complicated. This in turn has required the design of complex control systems and associated graphic displays. Experience gained in support of in-house programs has been applied to meet other customer needs such as jet engine test facilities and turnkey alkali metal facilities for the Air Force.



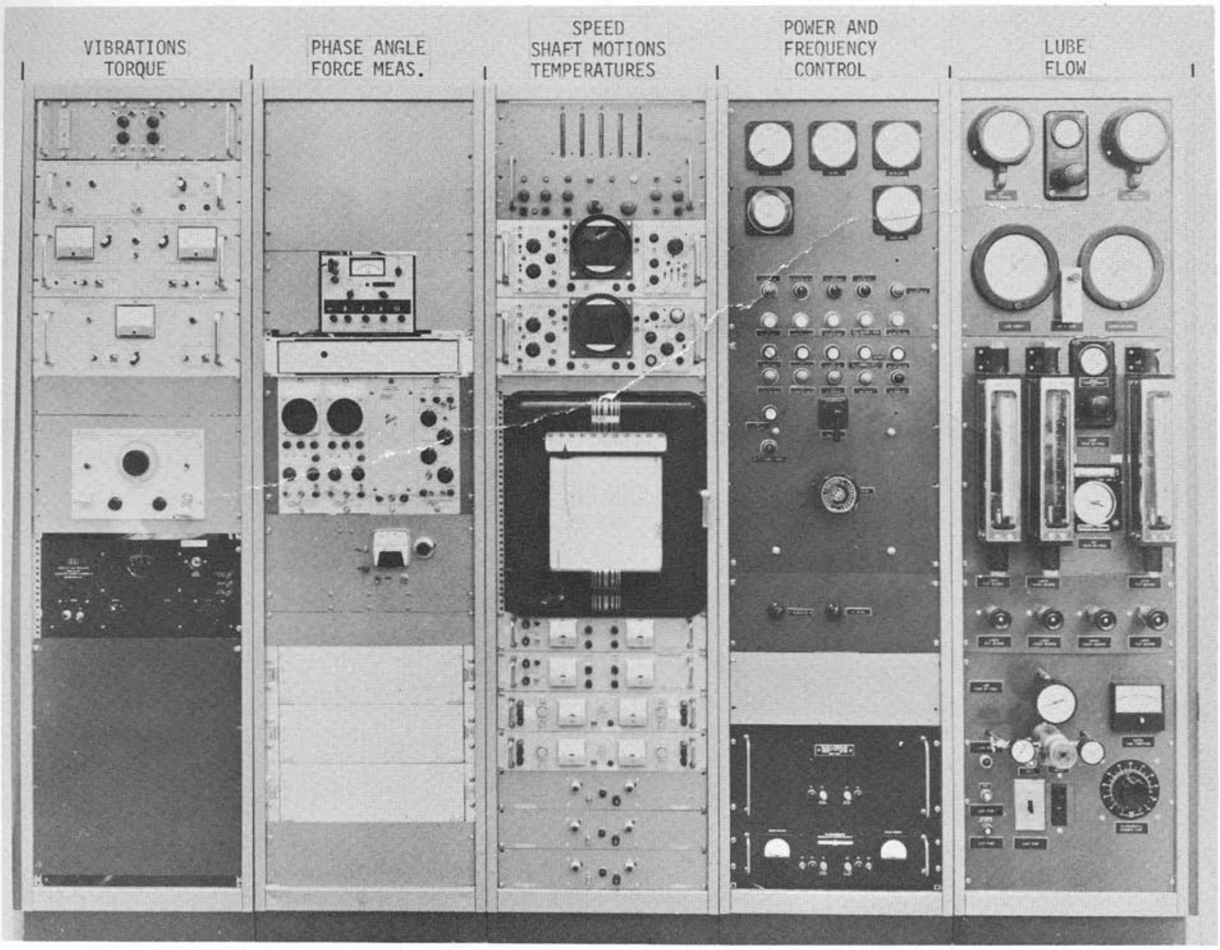
Control console for a multi-loop high-temperature alkali metal facility.



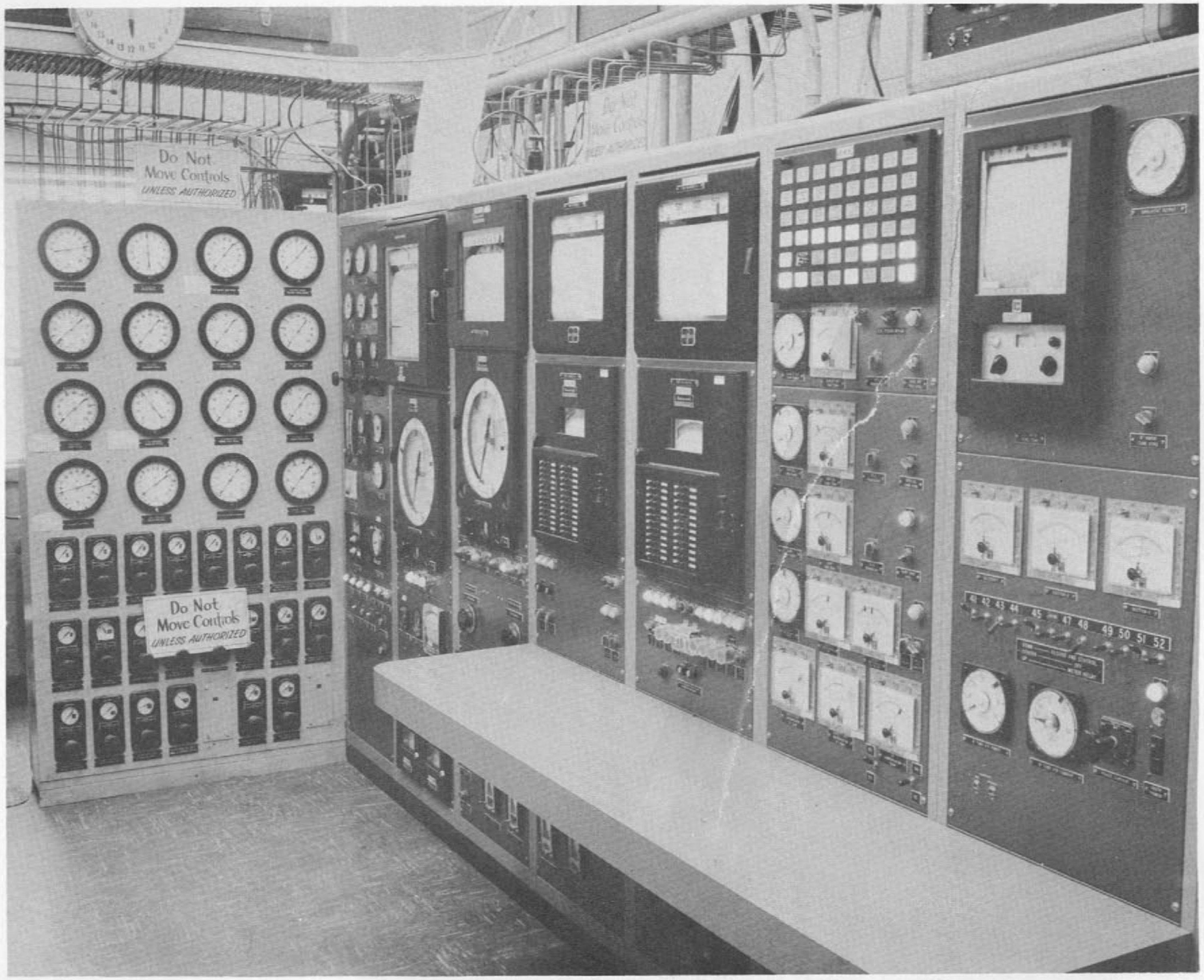
Control console for a seal and bearing test facility.



Control console for a turn key facility delivered to Wright Patterson Air Force Base.



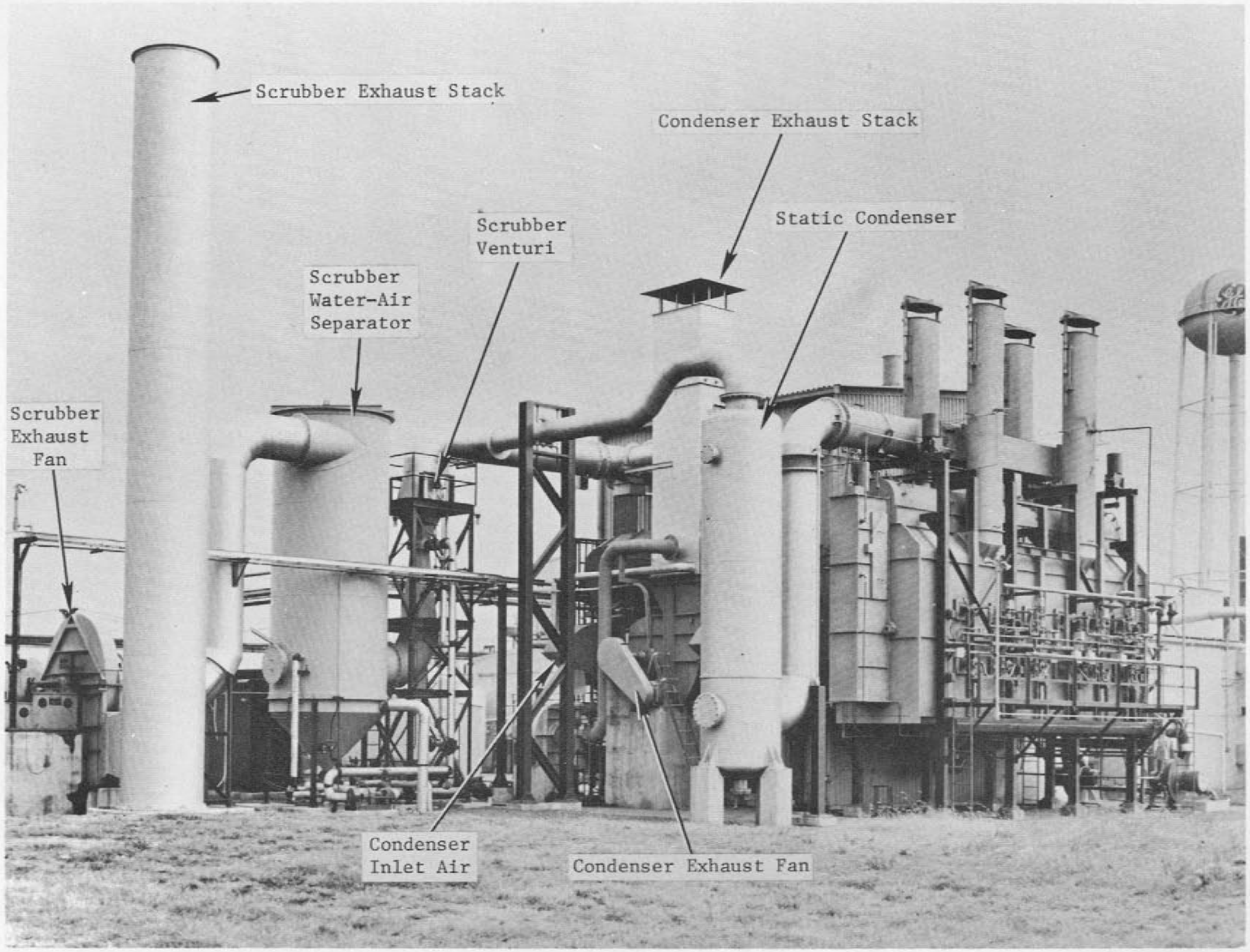
Instrument panel for a high-speed bearing-stability test rig.



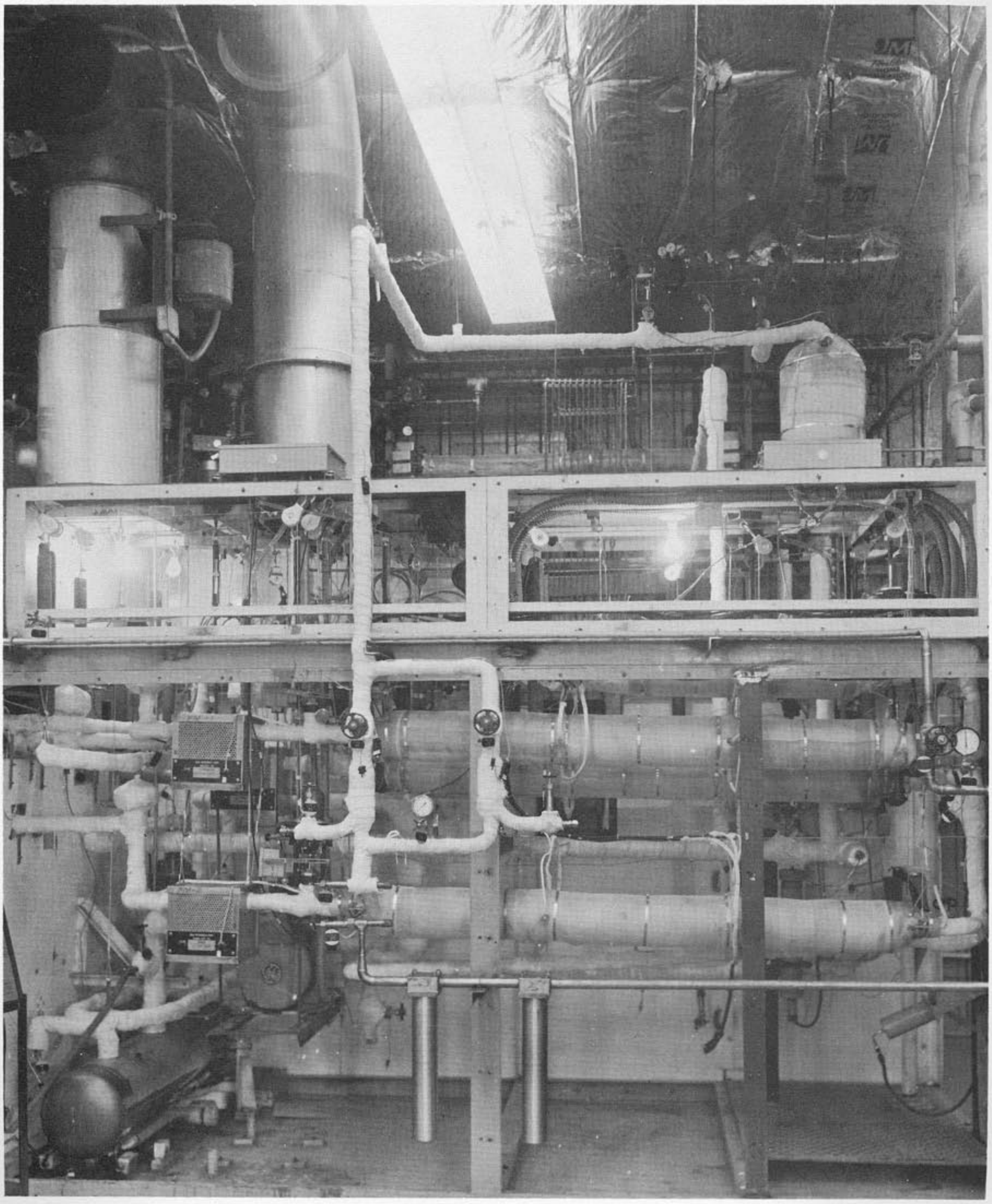
Control console for a potassium-vapor-turbine test facility.

LIQUID METAL SYSTEMS

Because for the past ten years it has been the primary job of the Test Equipment Engineering group to design equipment in support of space power systems, it is in this field that this group's greatest capability lies. NSP space power facility capability consists of systems from a 3-megawatt alkali metal system down to 10 kilowatt systems for cooling bearings and seals. The process fluids include sodium, potassium, lithium, mercury and NaK. The Test Equipment Engineering group has experience in the design of associated systems connected with the alkali metal facilities, such as: air handling, inert gas distribution, safety monitoring, and the handling of toxic effluent.



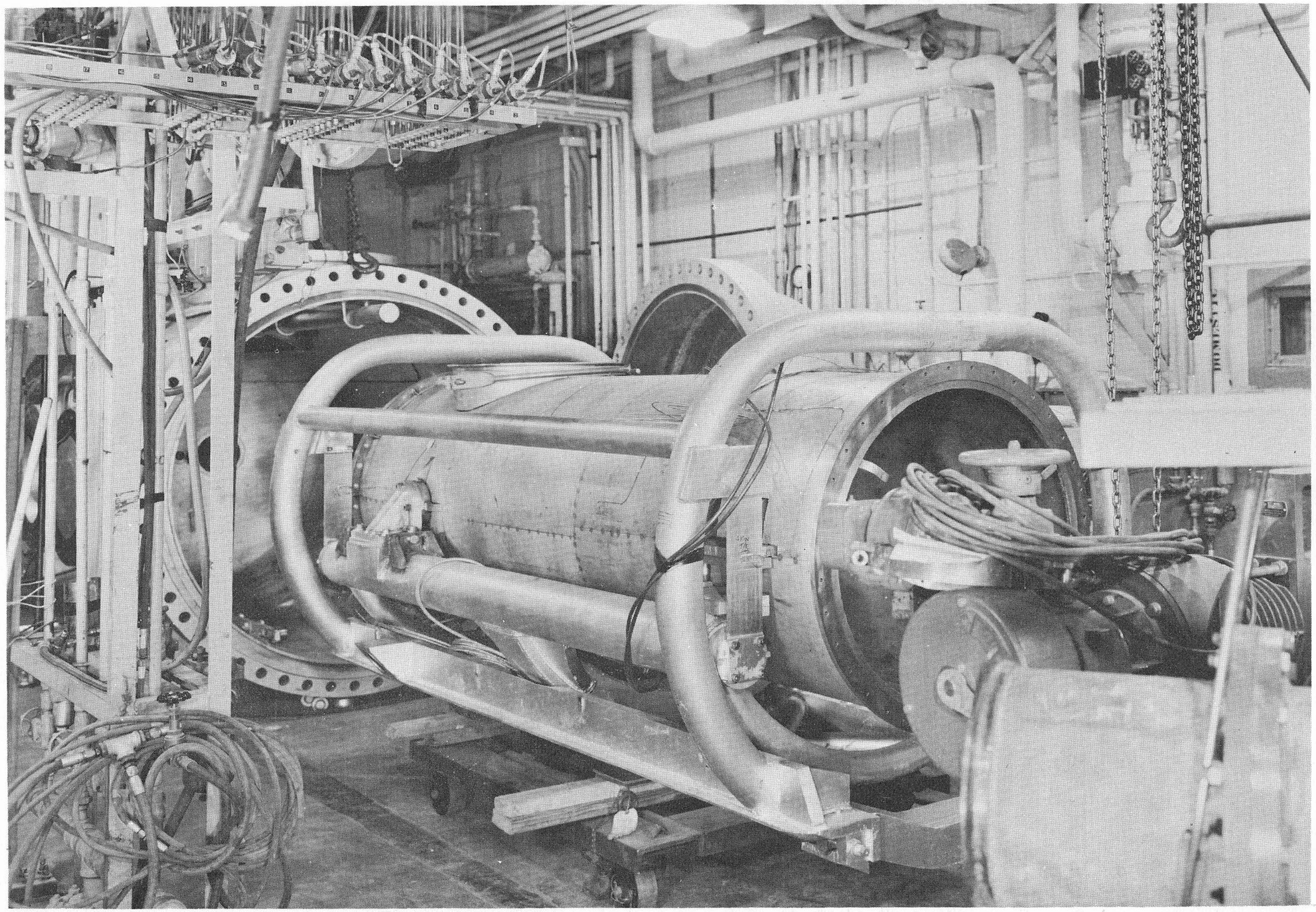
This is an exterior photograph of the 3000 KW turbine test facility, showing a gas fired boiler, condenser air ducting, and alkali metal fume scrubber.



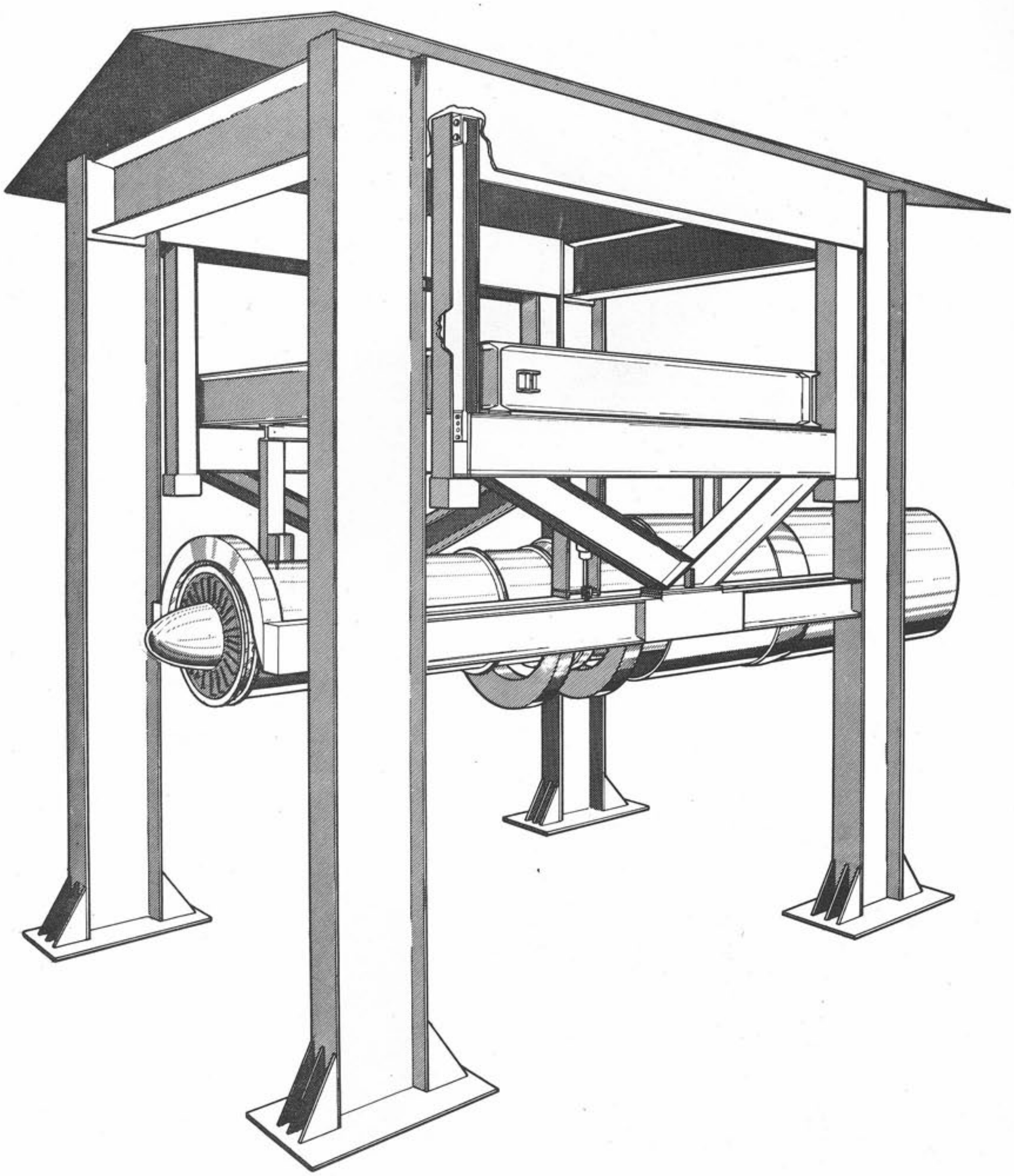
Installation of a potassium bearing and seal facility. This facility handles potassium liquid to a temperature of 1200°F.

MEASURING SYSTEMS

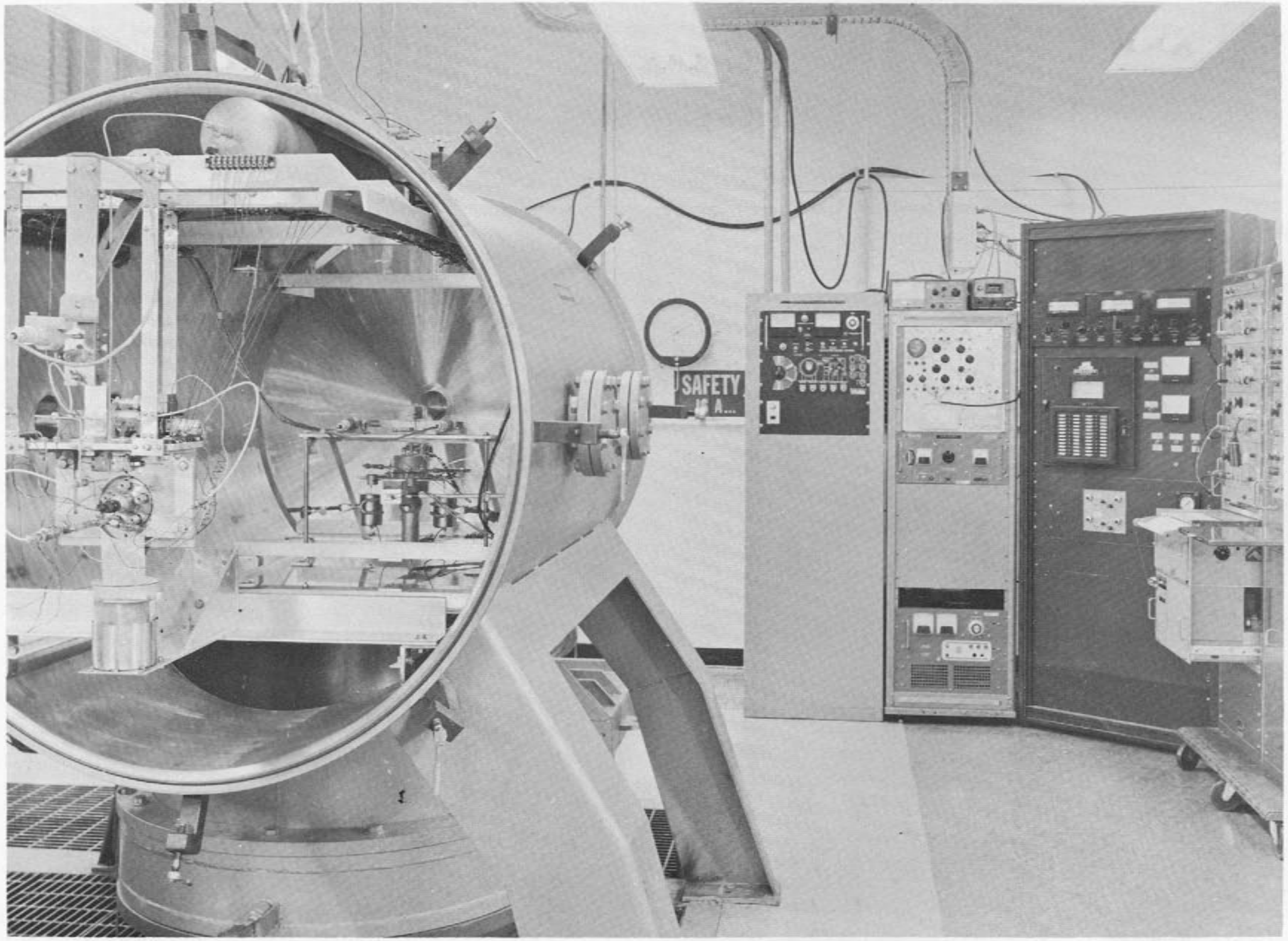
The Test Equipment Engineering group of NSP has had considerable experience in measuring thrusts, temperatures, and pressures not only in the field of jet engine testing, but also for space power systems. Thrust measurement has necessitated the design of thrust systems capable of upwards to 30,000 pounds of thrust for jet engines down to millipounds of thrust for attitude control thrusters. Much of the low thrust measurement has been done on toxic gases or with hazardous fuels which required the design of enclosed systems or systems using special environments. GE-NSP Test Equipment Engineering, with 15 years of experience in this field, has the proven ability to design high temperature thrust measuring systems for both laboratory use and field application.



Target type thrust measuring system used to measure the thrust of hot toxic exhaust gases. Thrusts from 2 to 2000 pounds.



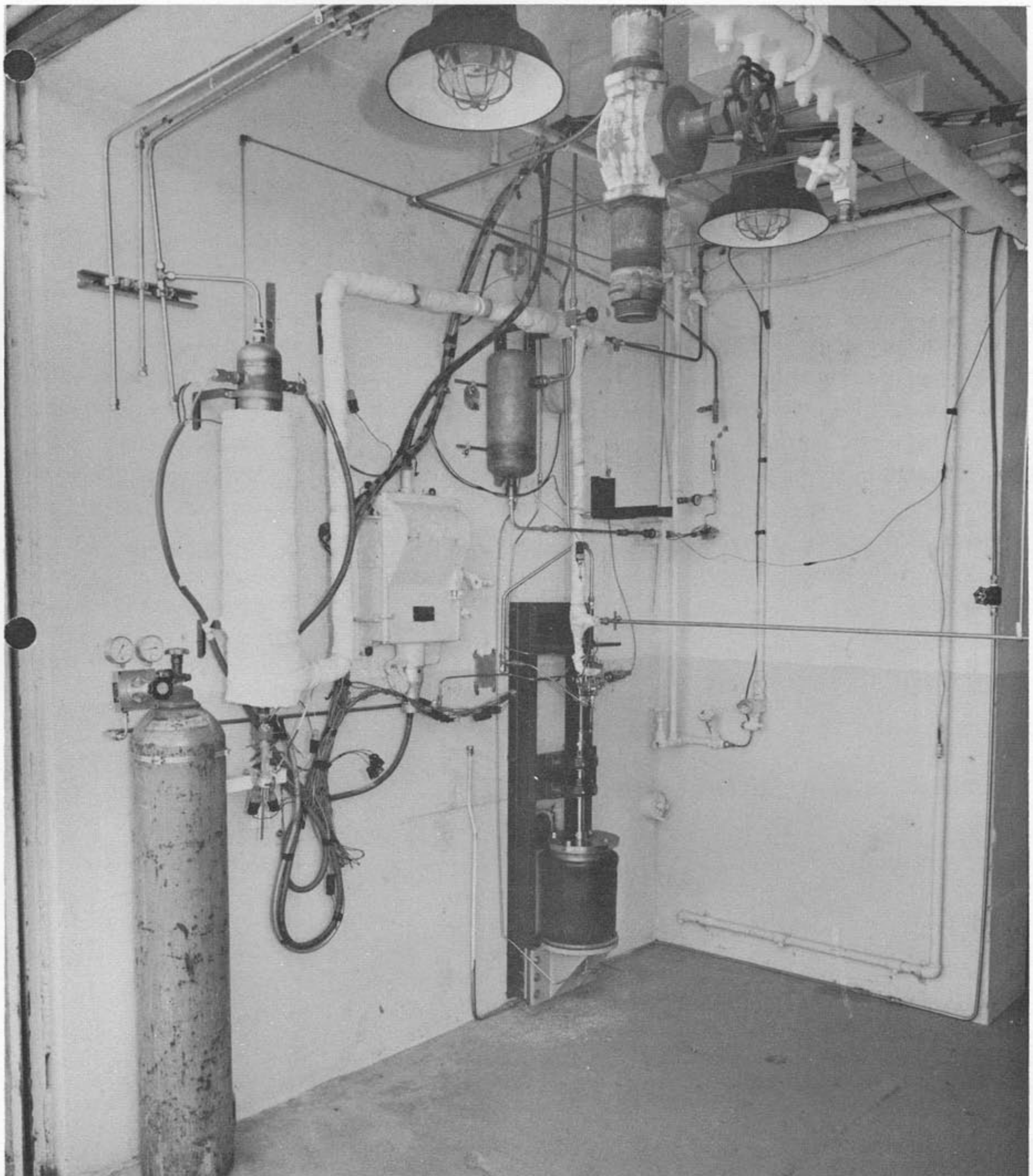
An artist's concept of an outdoor jet-engine-thrust-rig capable of measuring thrust to 30,000 pounds.



Microthruster vacuum test facility. A millipound thrust rig capable of measuring thrust while operating in a 4-foot-diameter high vacuum system. Thrust levels lower than one millipound were measured accurately. Vacuum levels of 10^{-6} and 10^{-7} torr with pumping speeds of 50,000 liters per second are available.

HAZARDOUS FUELS

NSP has had considerable experience in the design of facilities for handling hazardous or toxic fuels. The Test Equipment Engineering group has designed fuel handling equipment and test cells for burning hydrogen fuel, high energy boron fuels, and hydrazine. Activities over the past 12 years in the area of these hazardous fuels has given NSP the experience to handle them routinely. Due to the fact that NSP testing on hazardous fuels has been free of major incidents, NSP is able to use these fuels within the Evendale complex.



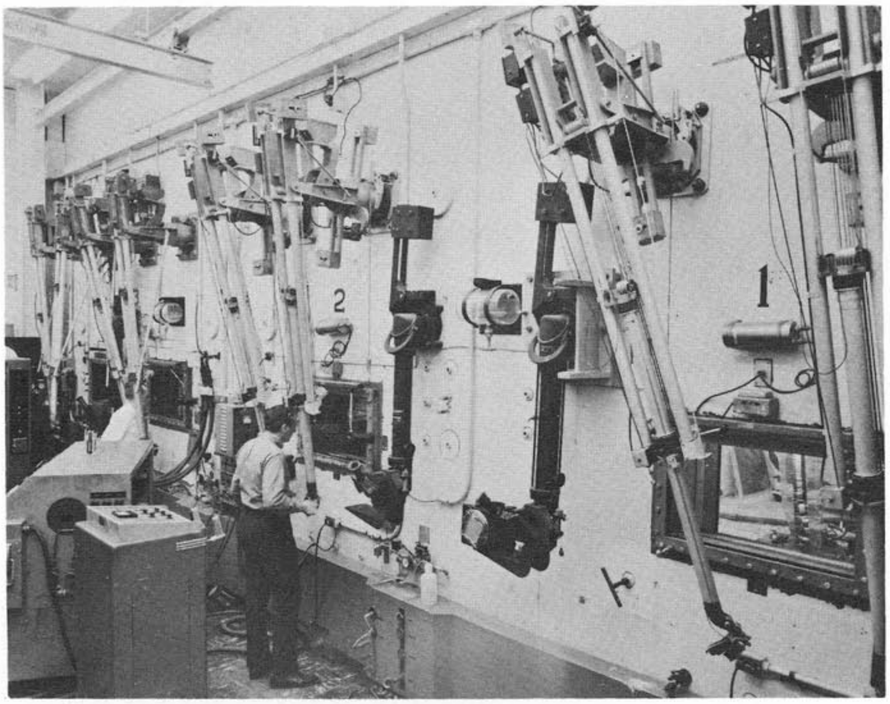
Piping system and valving for testing a high temperature nitrogen and hydrazine valve assembly. The facility was capable of introducing 1200^{o}F nitrogen or 1500^{o}F decomposed hydrazine into a valve assembly and dummy load.

Block house and handling capability for testing combustion systems using hydrogen or other hazardous liquids as the fuel.

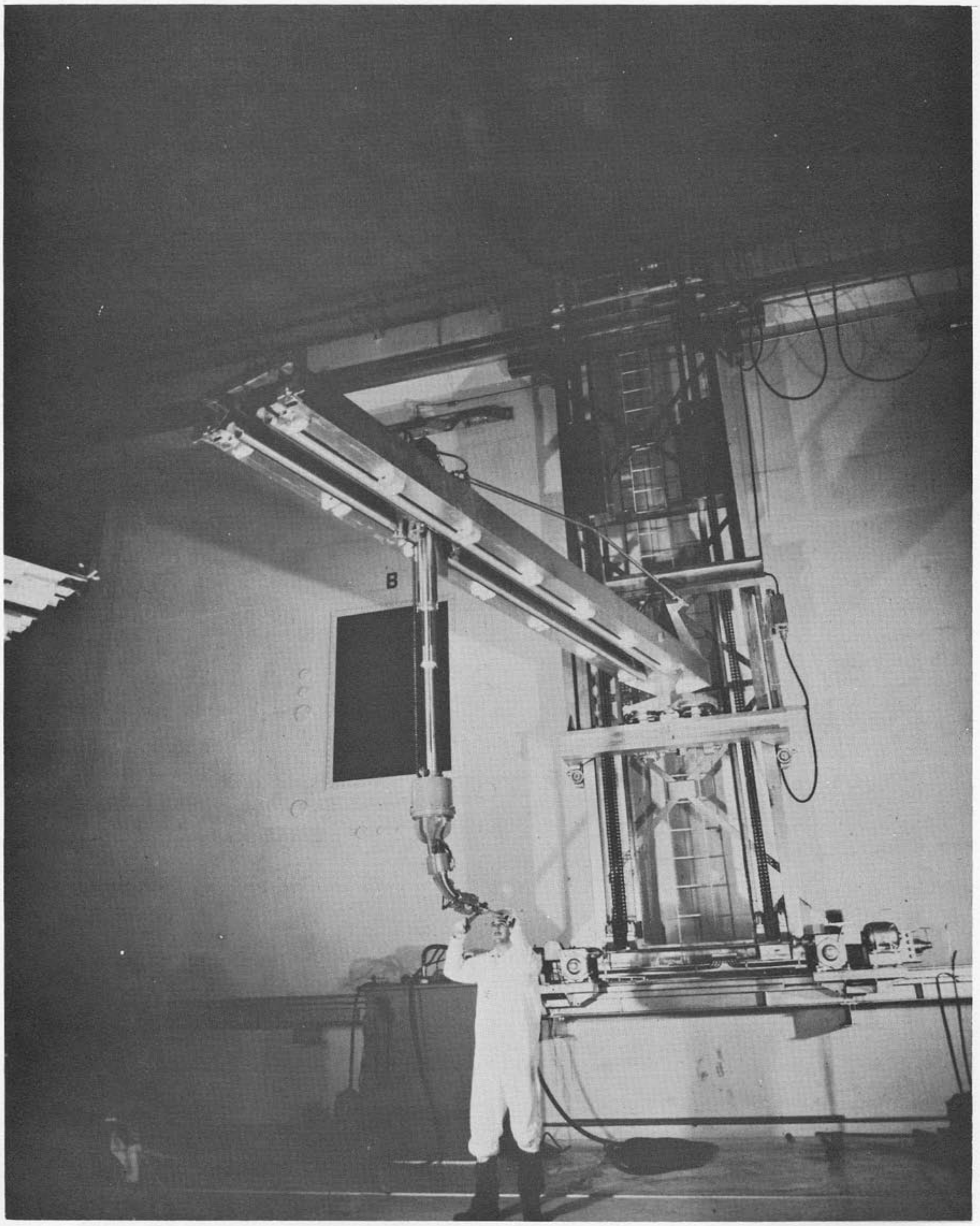
A concrete block building and associated bunker used for testing high energy fuels such as hydrazine and hydrogen. Special tests can be designed to meet the customer requirements.

REMOTE HANDLING

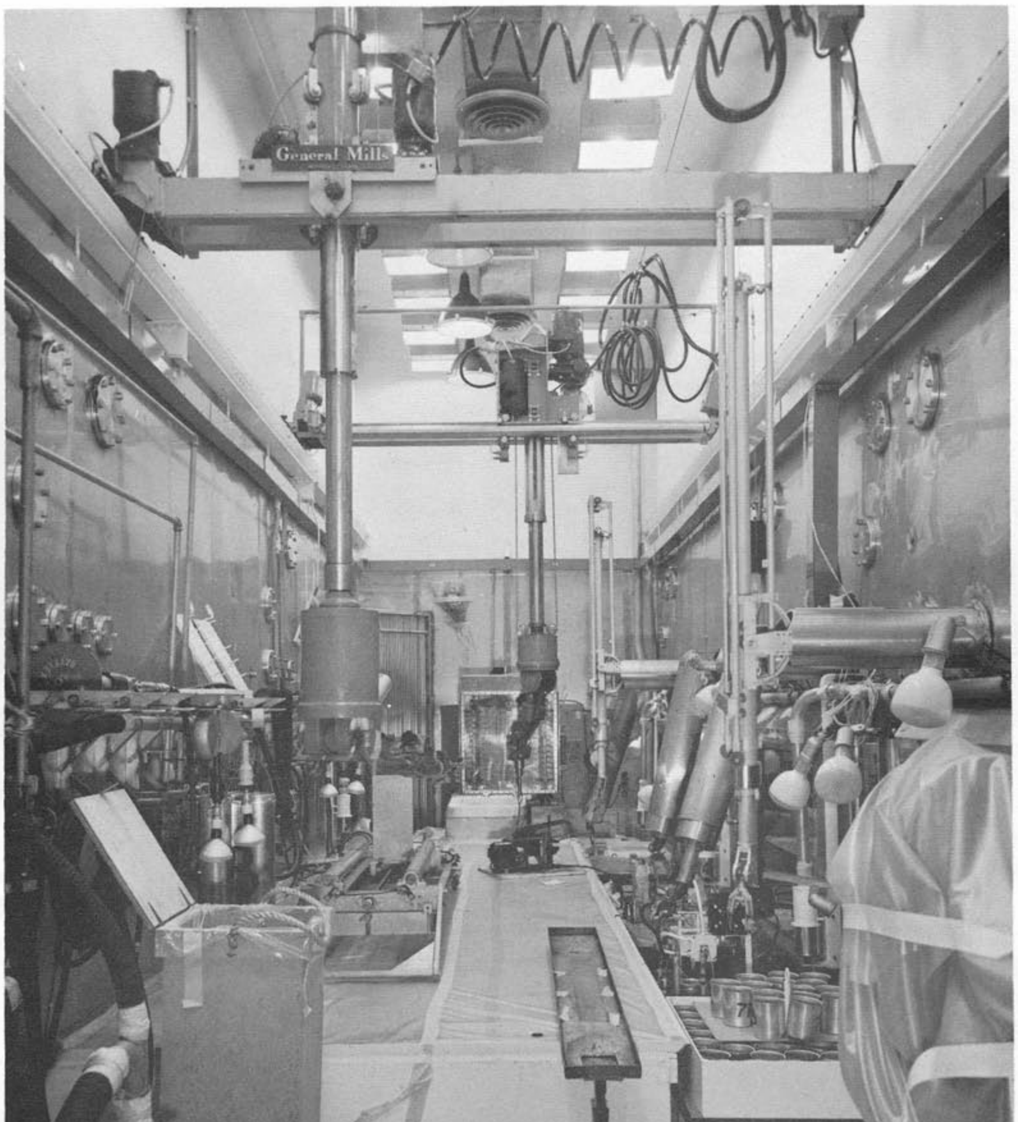
NSP has had considerable experience in designing, specification preparation, and checkout of remote handling equipment both for the radioactive cells in the NSP plant in Evendale, Ohio, and for remote site activities at Idaho Falls, Idaho. This remote handling equipment is capable of handling jet engine reactors.



Remote handling equipment in one of the cells at NSP



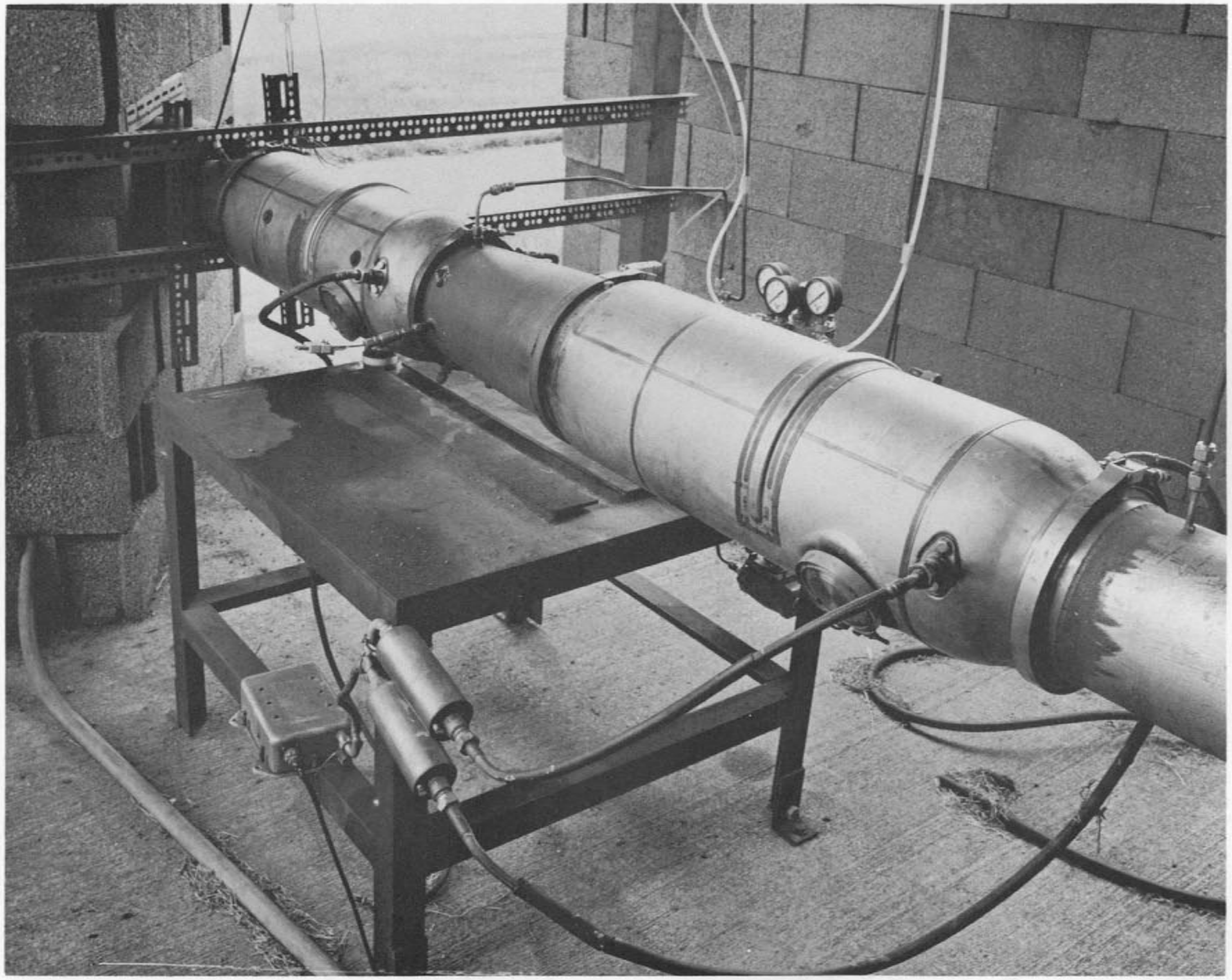
Remote handling equipment designed, built and installed at NSP for handling radioactive material.



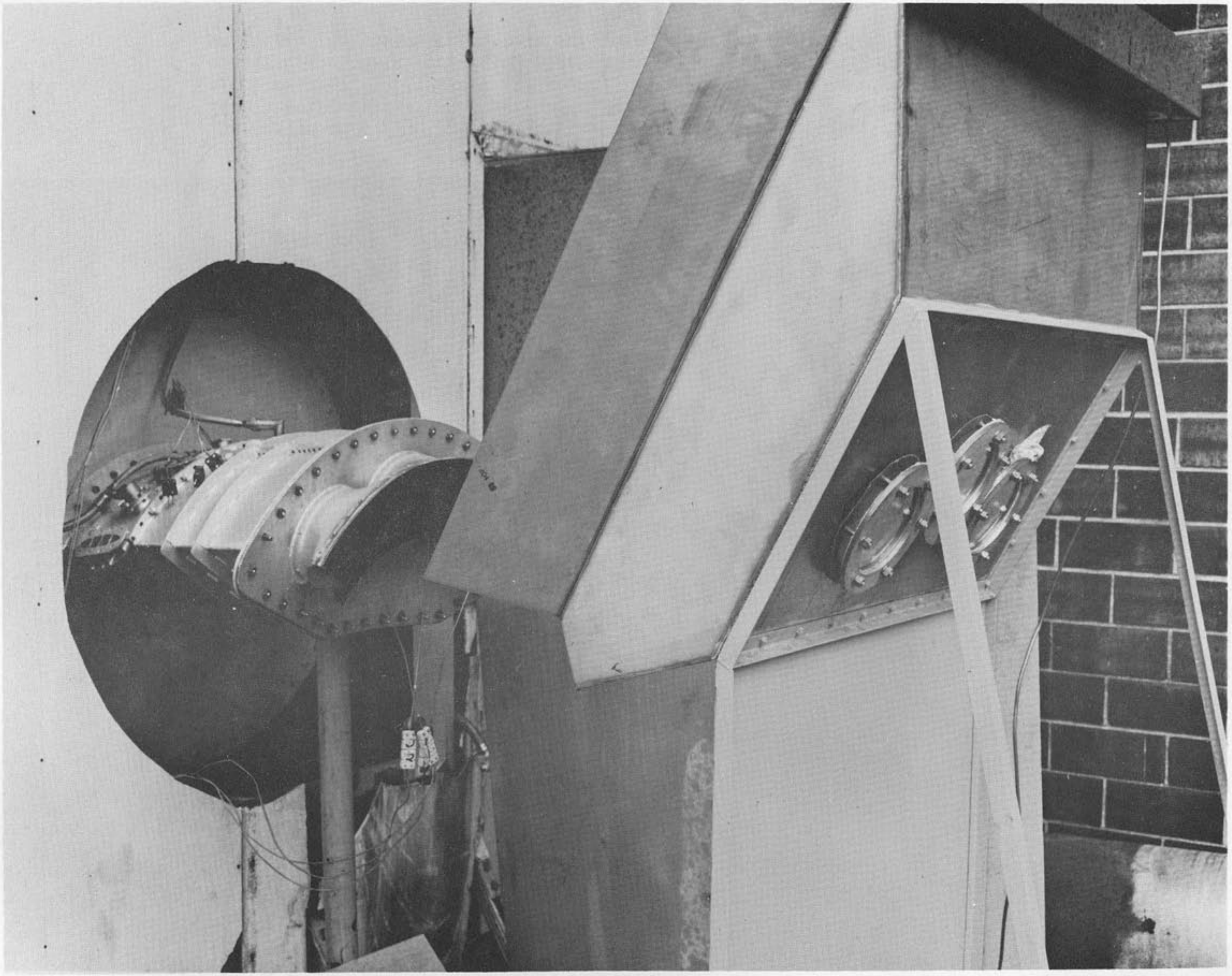
Remote handling equipment designed at NSP for installation in the remote site at Idaho Falls, Idaho, during the nuclear reactor program.

HOT GAS TEST EQUIPMENT

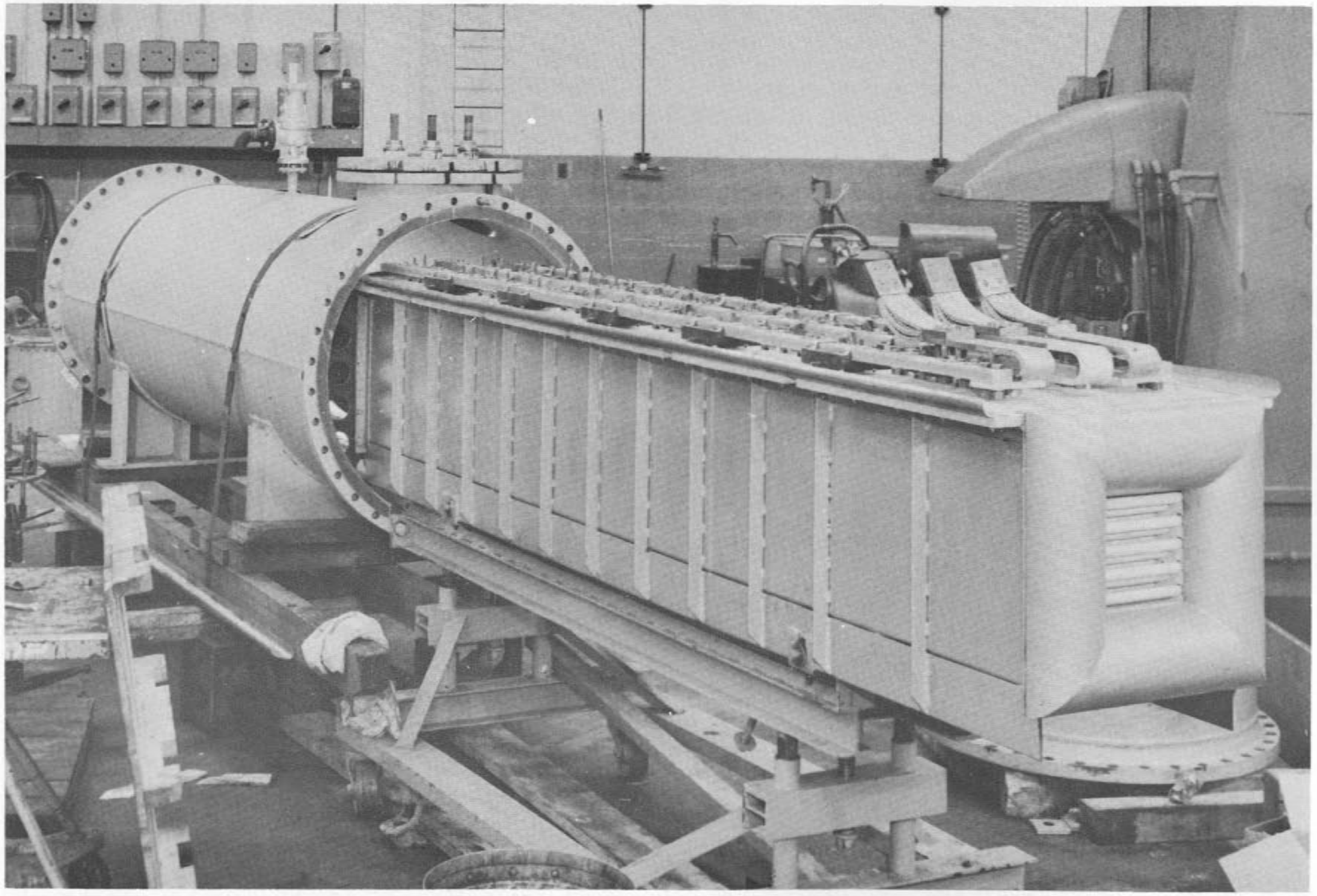
Through GE-NSP's association with the Aircraft Engine Group, a great deal of experience has been gained in the design of hot gas simulators and combustion systems for testing of associated jet engine components. Hot gas test equipment has been designed for temperatures to 3000°F using both cooled and uncooled walls, annular and conular configurations, and using vitiated and non-vitiated air. This experience has enabled the Test Equipment Engineering group of NSP to generate and handle hot gases and other process fluids routinely at temperatures up to 3000°F.



Hot gas simulation for special component testing. Photo shows jet engine combustion cans in series for maximum exit temperature.



Sector test of an annular combustion system for a jet engine.



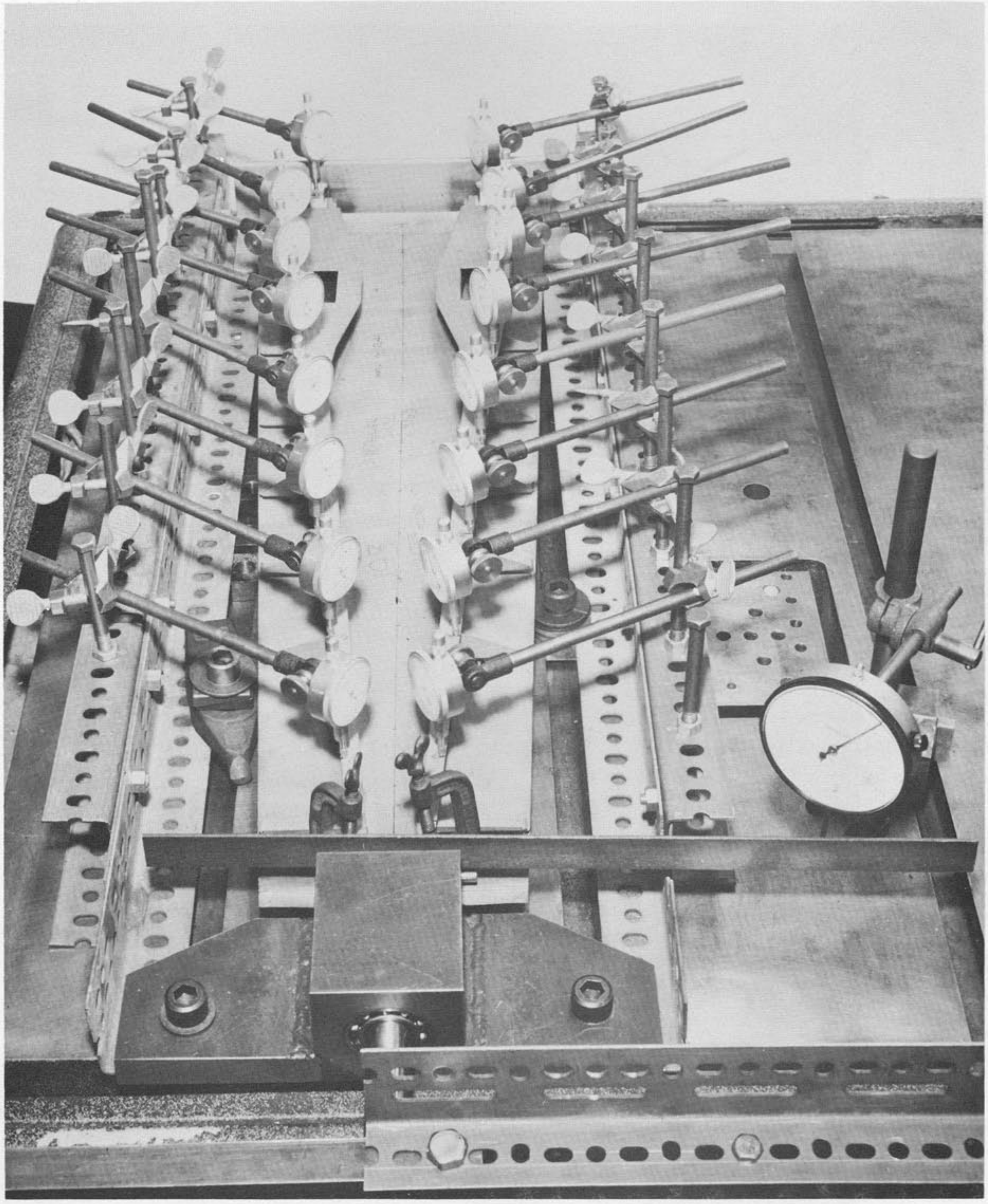
The design of a 2000°F air heater assembly includes 2 lbs/sec rated flowrate; 2000°F rated exit air temperature; 2200°F maximum exit air temperature; 150 psig air pressure; 99+% overall efficiency and < 10,000 hours service life. Compact electric air heater providing clean high temperature air without combustion products. All pressure containment operates at less than 500°F.

TOOLING

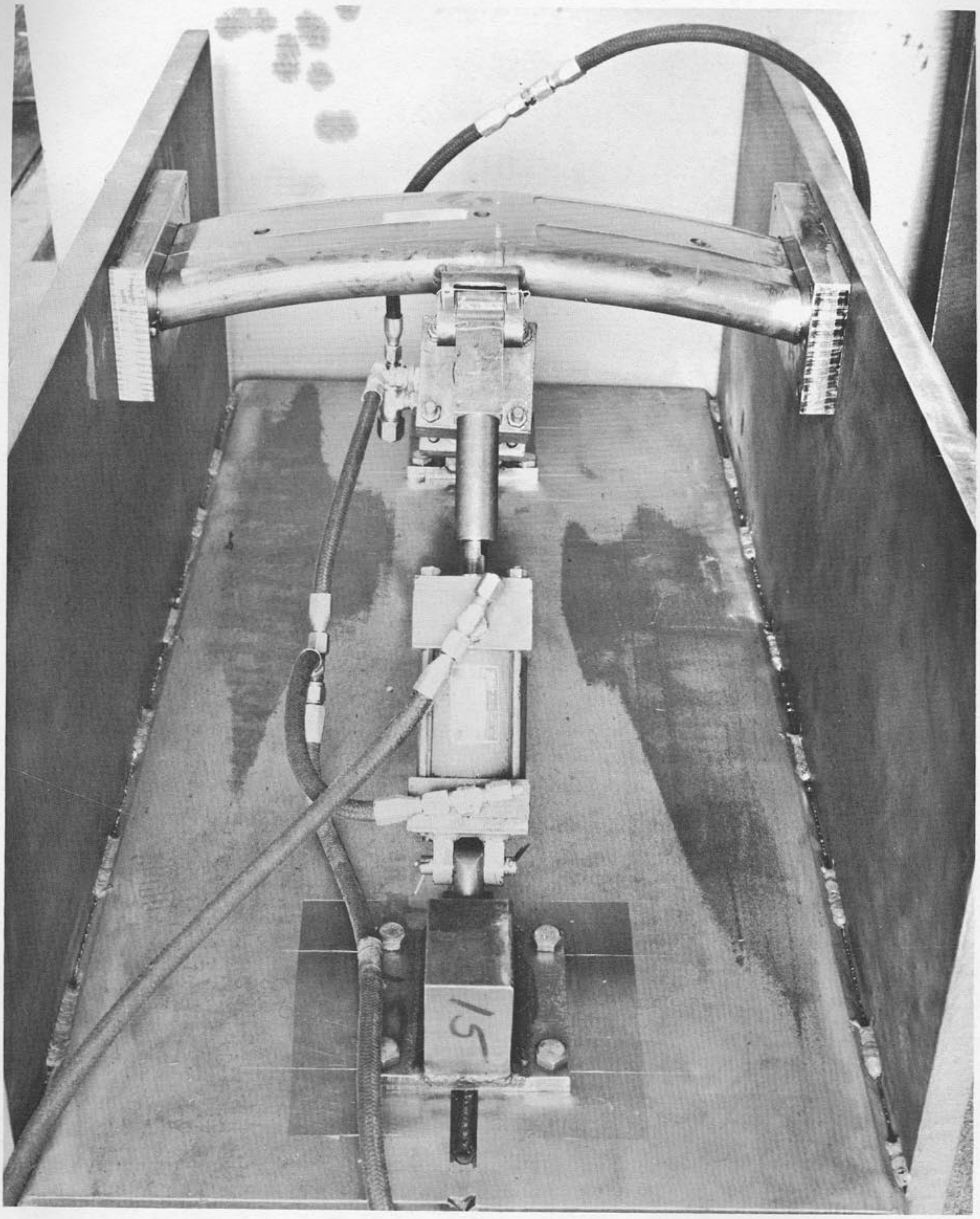
Because of the NSP capability for testing jet engine parts and space components, the Test Equipment Engineering group has been required to design special tools and fixtures to assist in the fabrication and testing of these components. Many times the tooling or fixture must be designed for flight conditions because of the nature of the loads applied to the jet engine or space parts. This has given NSP a great deal of experience in the design of flight type high stress and high temperature fixtures and tooling for steady state and vibrating conditions.

Due to the toxic nature of some of the fuels and process fluids that NSP handles, Test Equipment Engineering has been required to design remote handling tools and specialized tooling for cutting and welding parts used in NSP facilities. Test Equipment Engineering has had to design complex tooling for high speed seal and bearing deflection measurements and safety tooling to prevent catastrophic failure during testing.

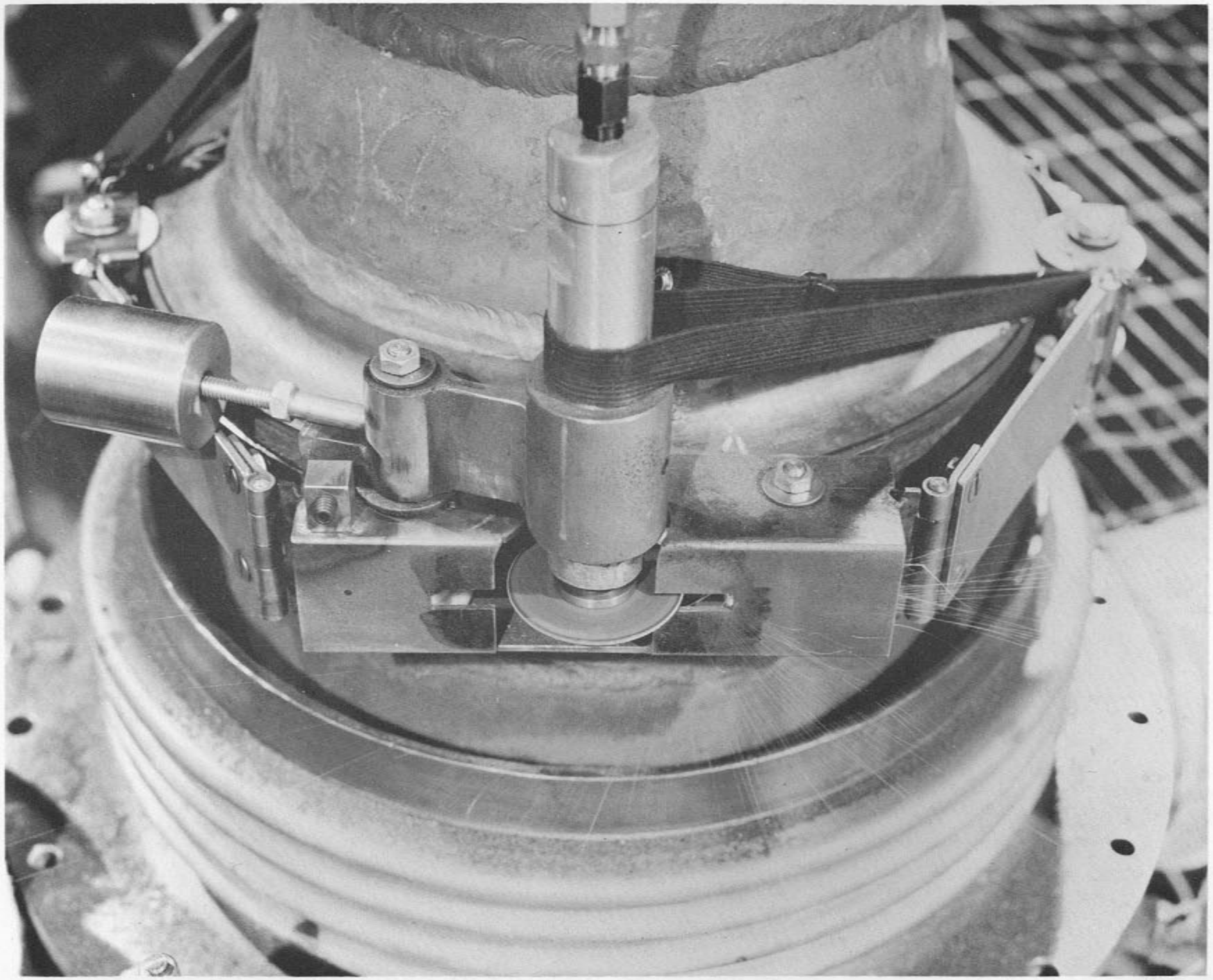
NSP programs require remote handling and inert environment chamber welding, so Test Equipment Engineering has been called upon to design special handling and positioning fixtures for these applications.



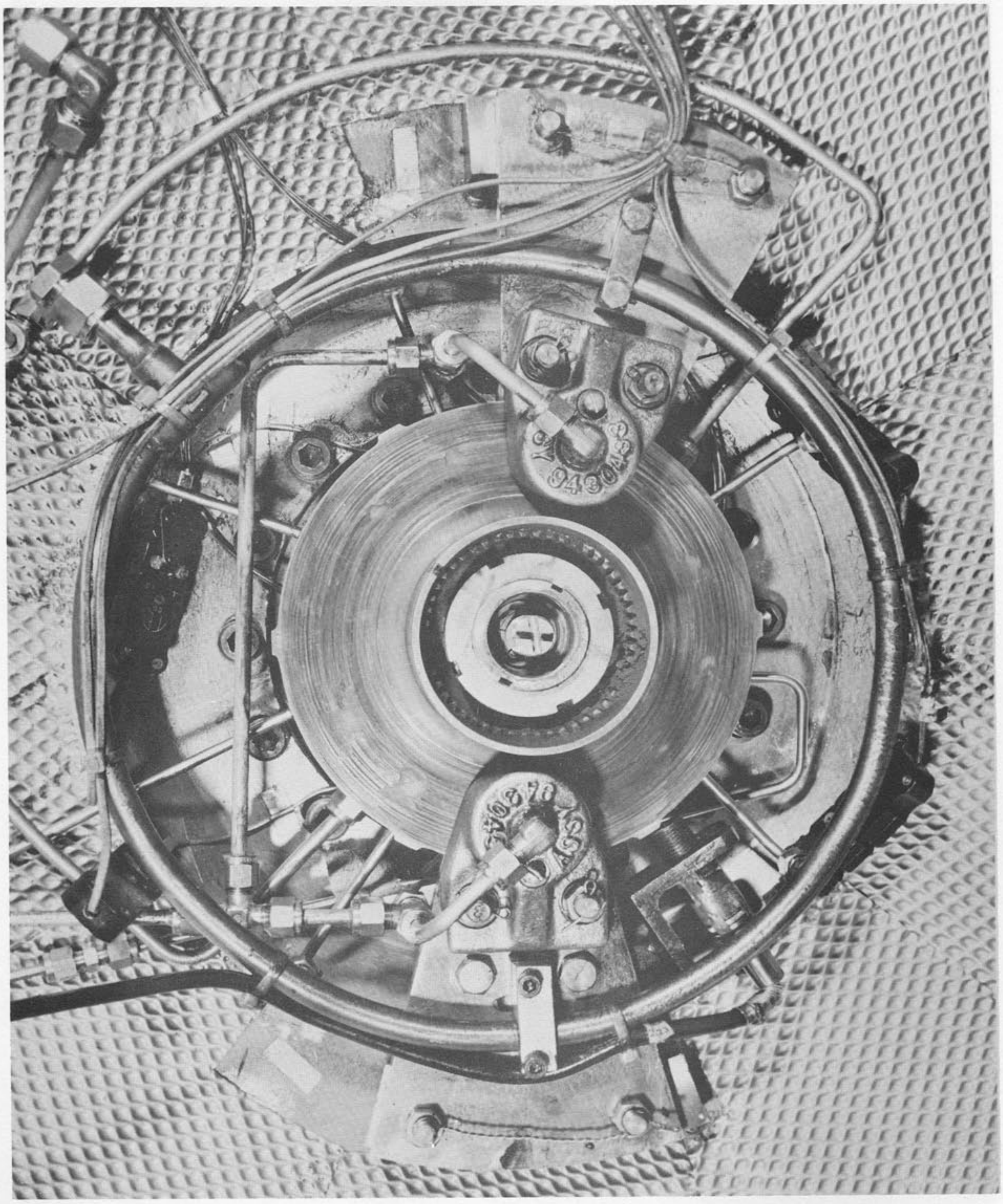
Tooling and fixtures designed to load and measure deflection of parts both large and small.



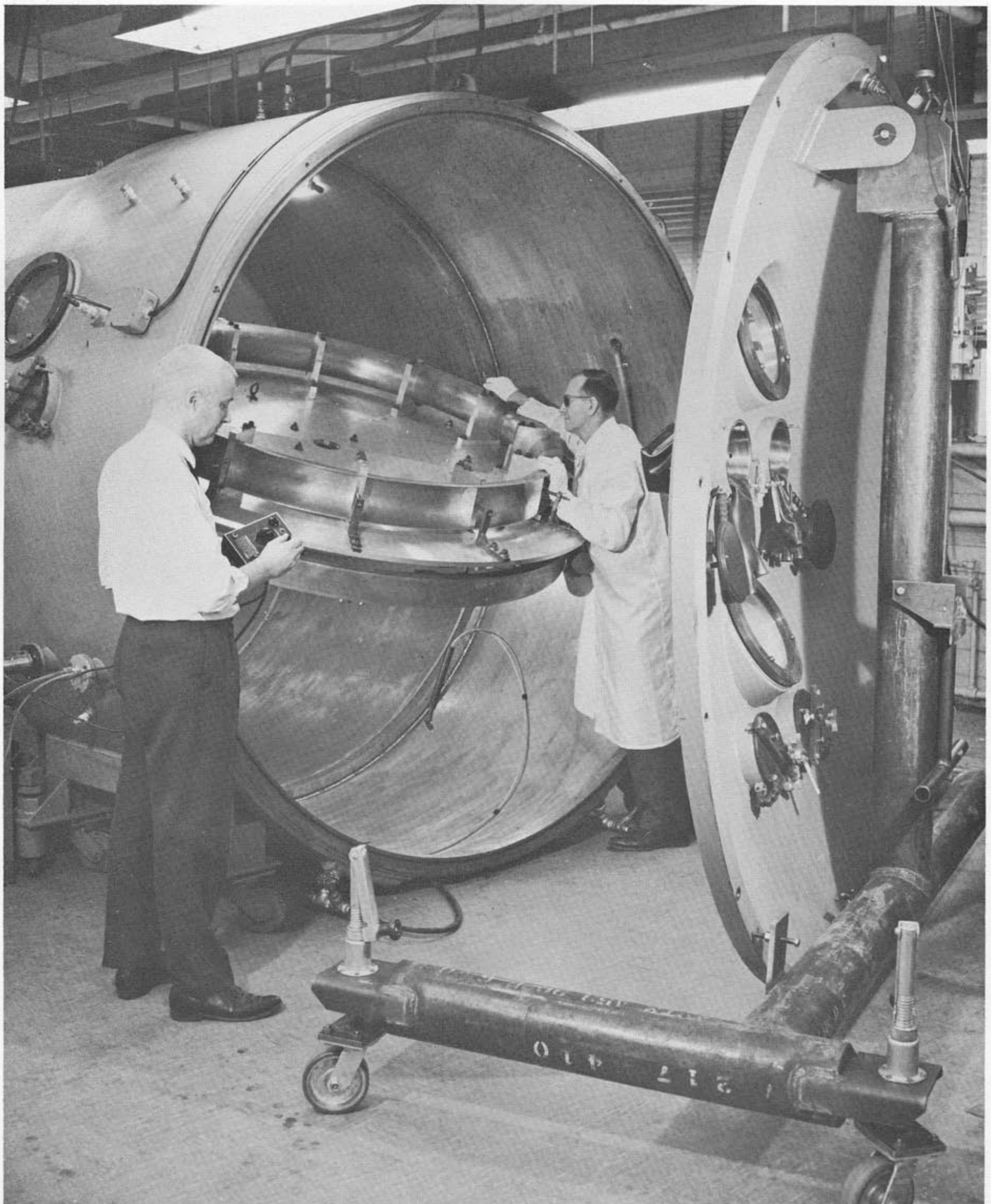
Jigs and fixtures capable of simulating loads on jet engine parts or customer components.



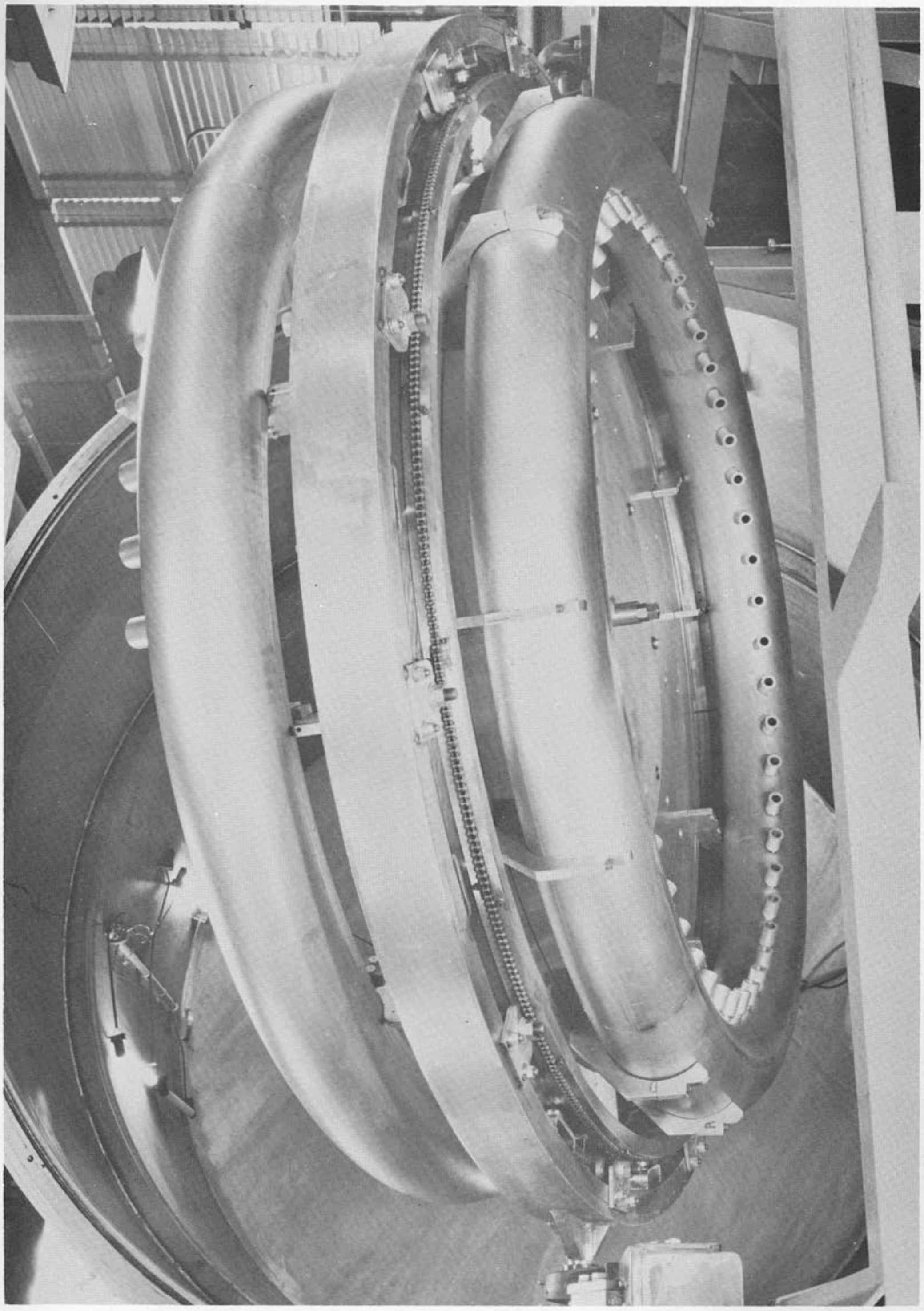
Installation and operation of a special test fixture for cutting the weld from a 10-inch stainless steel pipe while allowing the pipe to remain in place.



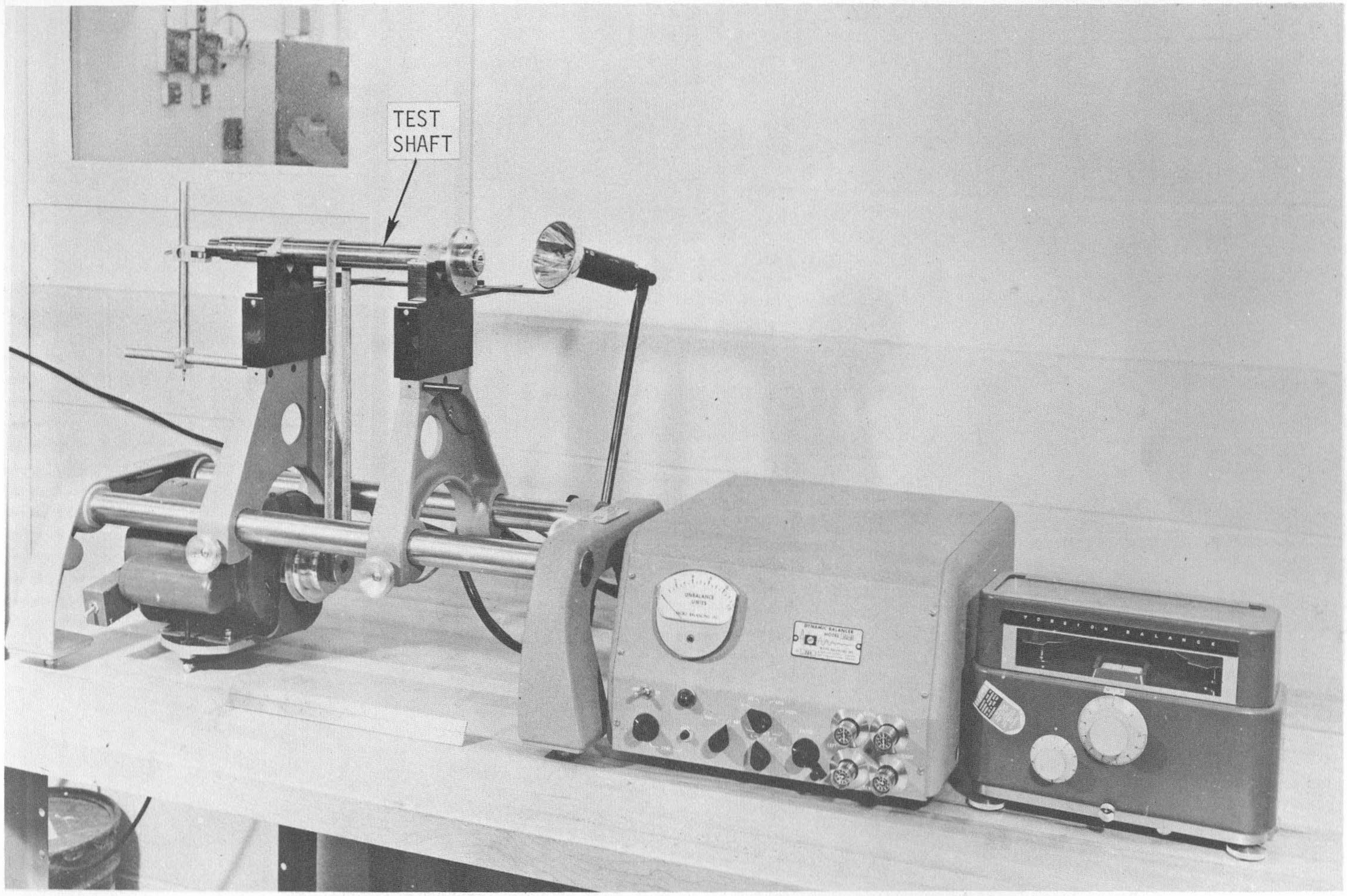
Installation of a set of disc brakes to stop a high speed turbine during an emergency. The photo was taken after a successful braking of the turbine.



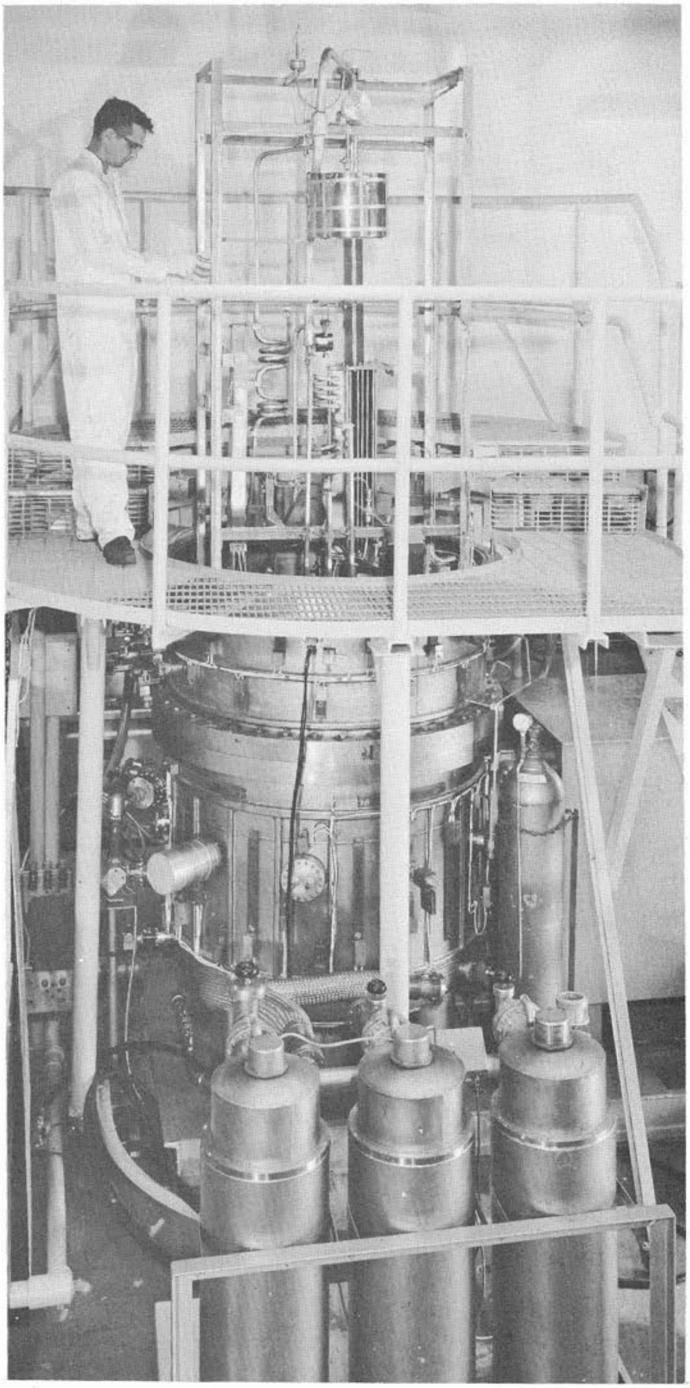
Fixture for positioning a torus inside a welding chamber prior to welding. It also shows the design of a dolly for handling an 8-foot-diameter weld chamber door.



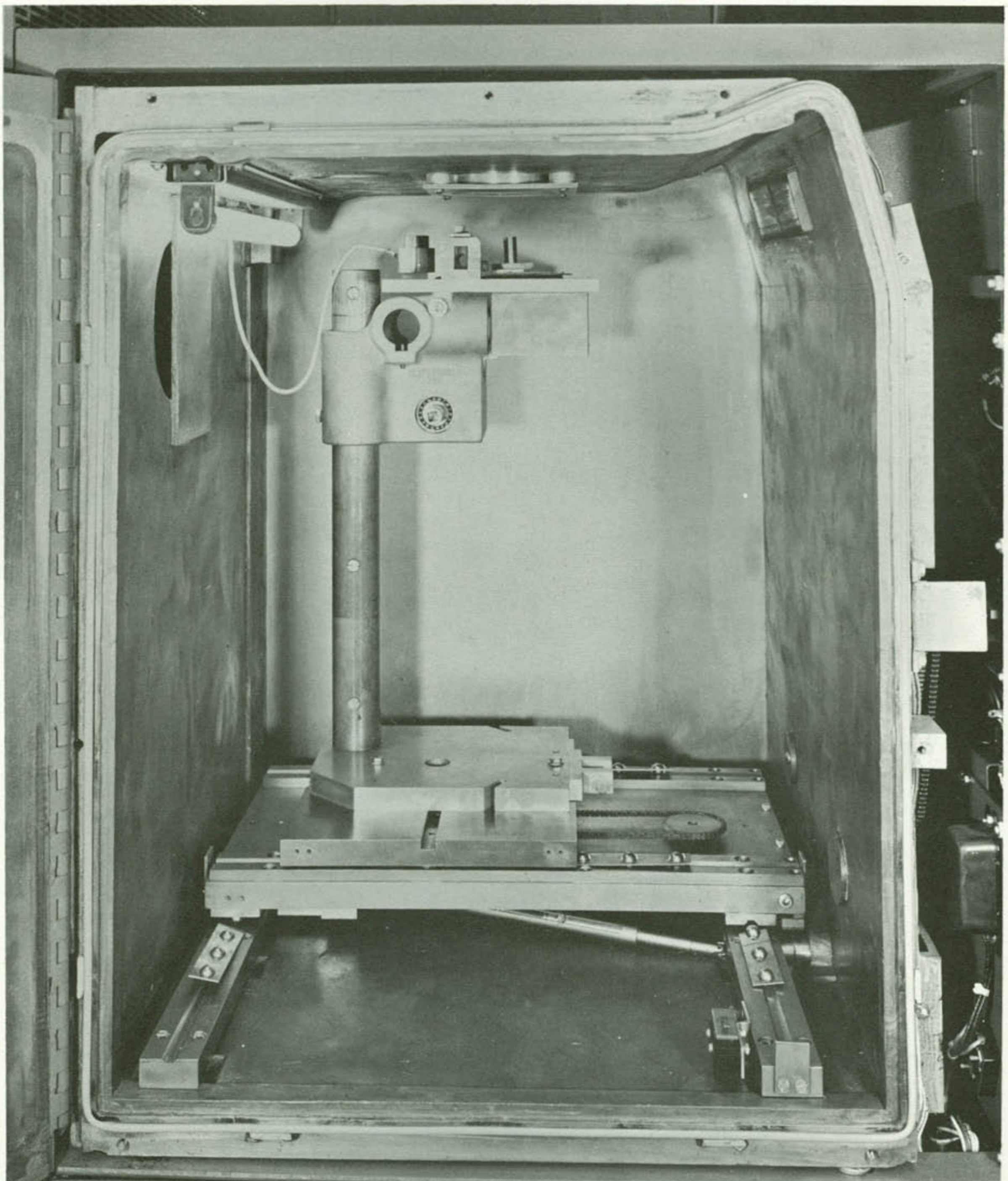
Design of a positioning fixture for a torus prior to being placed in a weld chamber.



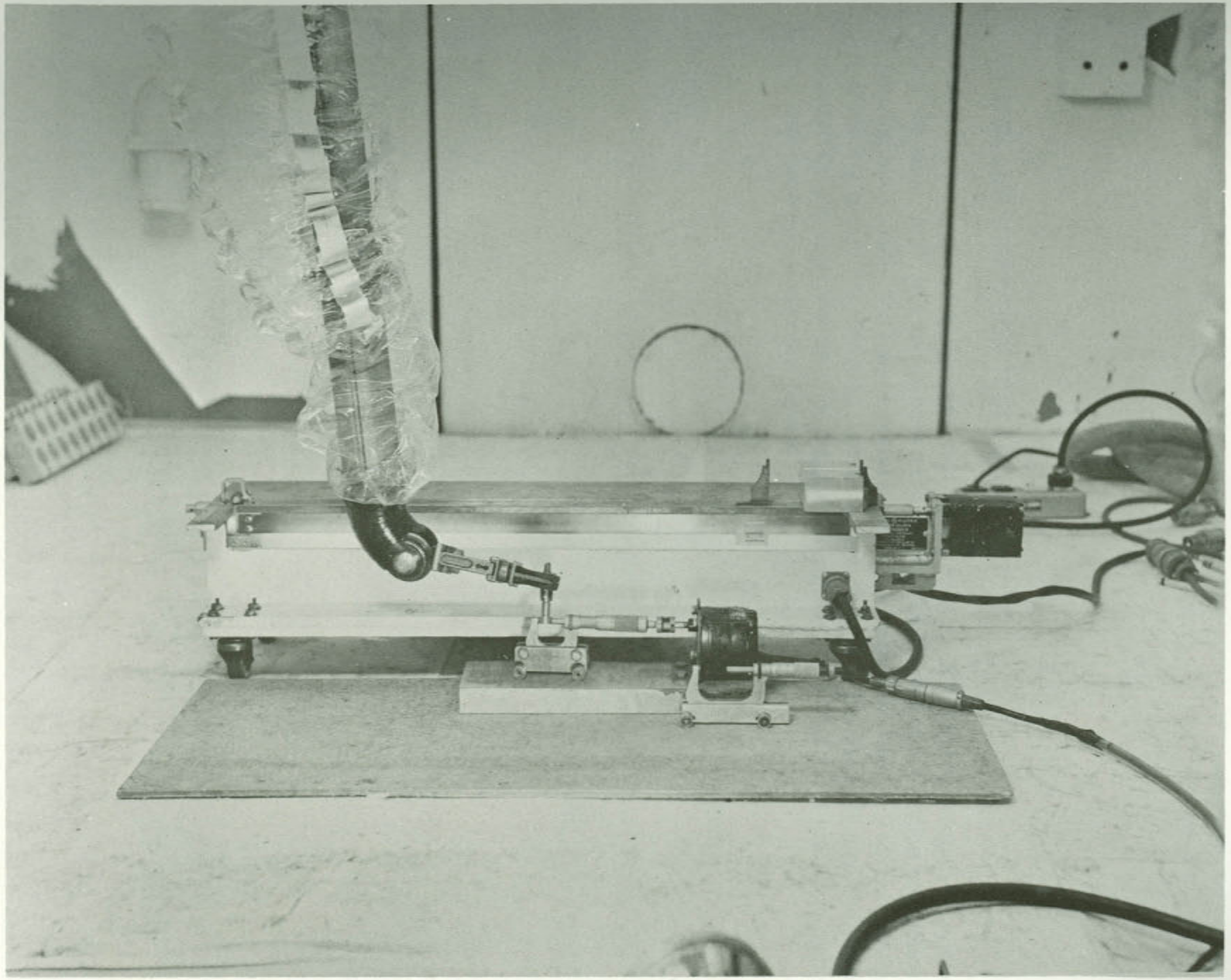
Test shaft being balanced on a dynamic balancer. Tooling can be designed to balance shafts and other components as required.



A 4-foot-diameter vacuum system. Of prime concern is the platform and fixturing used in conjunction with the piping within the chamber. This auxiliary equipment was designed to exacting specification.



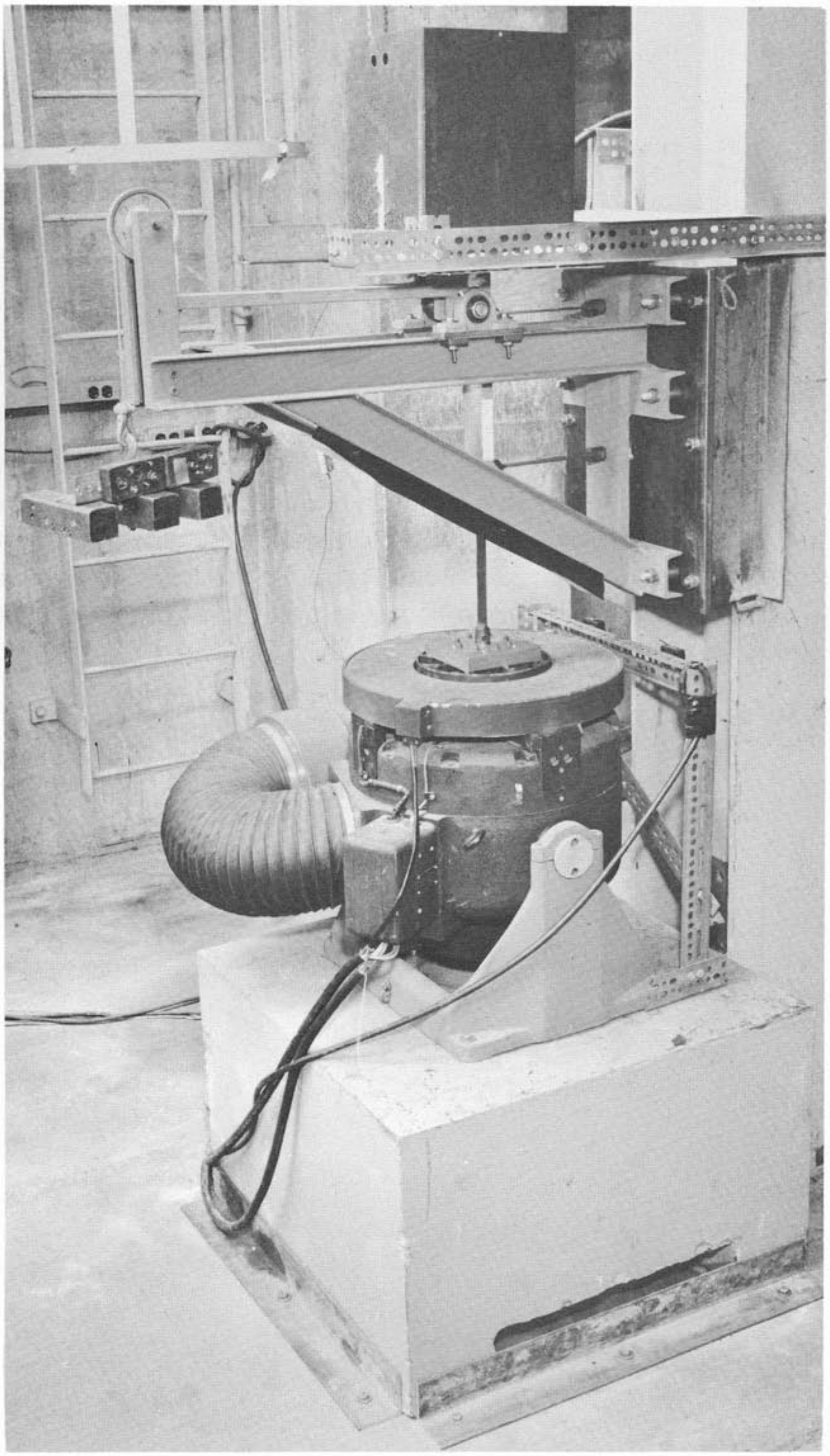
Chamber and associated fixturing and supports for ion-beam welding.



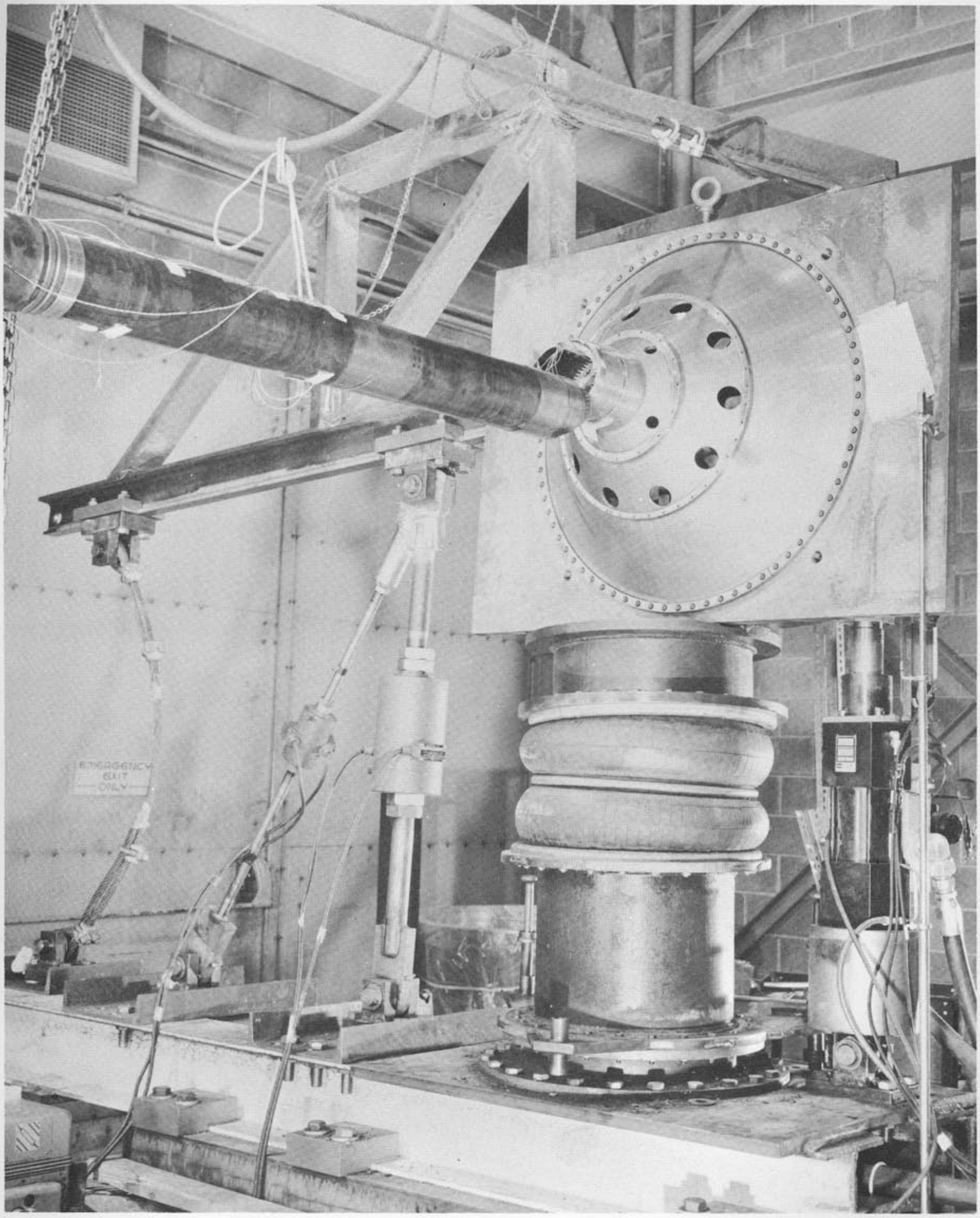
Portion of remote handling equipment that is used on one of the three cells in NSP's Radioactive Materials Laboratory. This remote actuator is used to position with delicate care the equipment within the cell.

STRESS AND VIBRATION TEST EQUIPMENT

NSP has the capability of designing and testing all types of equipment associated with stress and vibration. NSP has had considerable experience in testing jet engine components by applying both steady state and vibratory stresses to these components. The Test Equipment Engineering group has designed special setups to apply the loads at any and all points required by the customer and has designed equipment to test at both low cycle high stress and high cycle low stress conditions.



Shake table and tooling designed to vibrate or stress test components or individual parts.



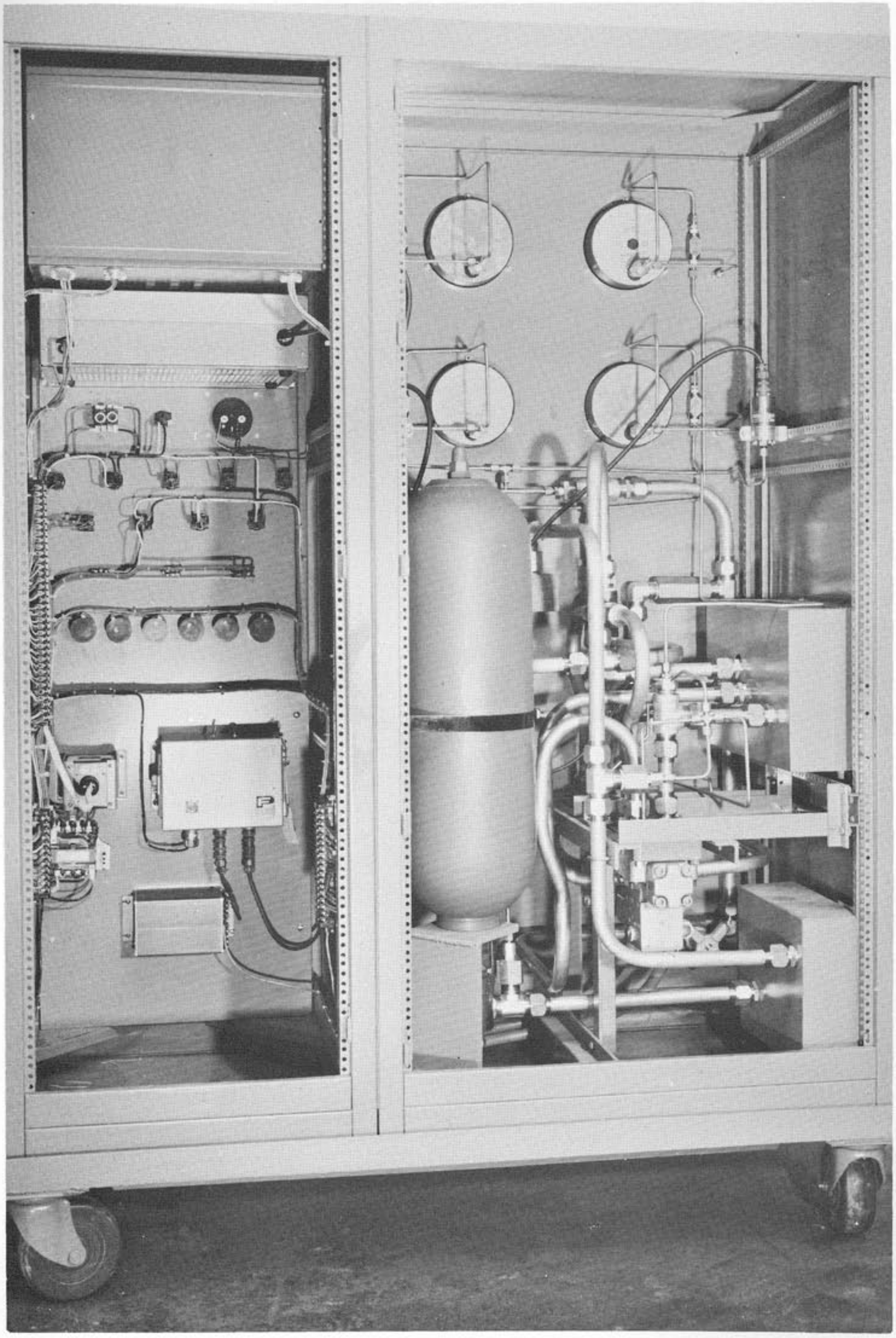
A special fixture for cyclic testing of a main jet engine shaft and the results of the test.

GROUND SUPPORT EQUIPMENT

NSP experience in the field of Ground Support Equipment consists of designing lube carts, special dollys, handling equipment, and auxiliary gas and oil power stations. This experience has been gained over the past 15 years in designing ground support equipment for jet engines and space satellites.

The Test Equipment Engineering group at NSP is capable of designing equipment to simulate almost any conditions that might be encountered by jet engines or space systems in the field.

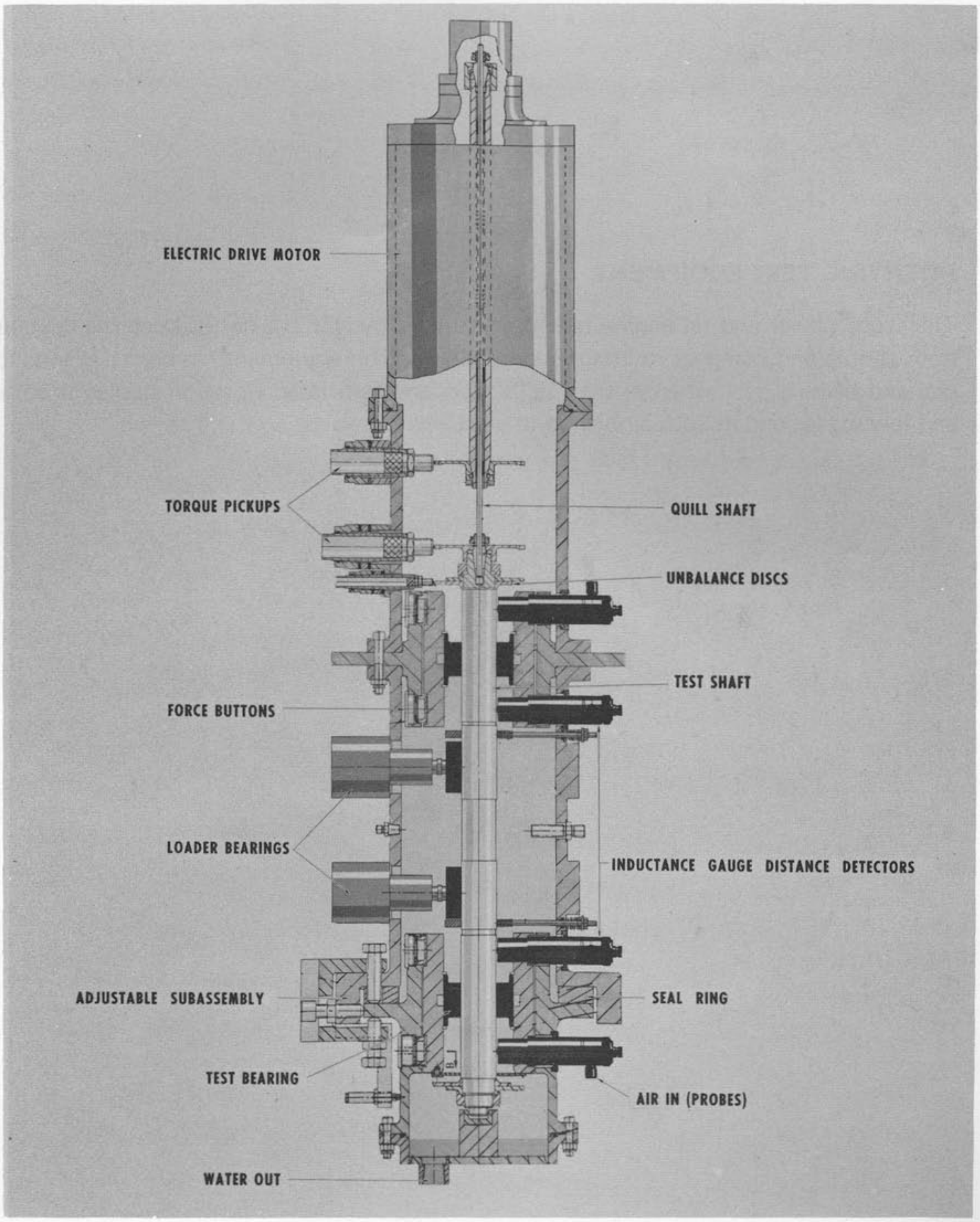
Temperature controlled lubricant supply facility.



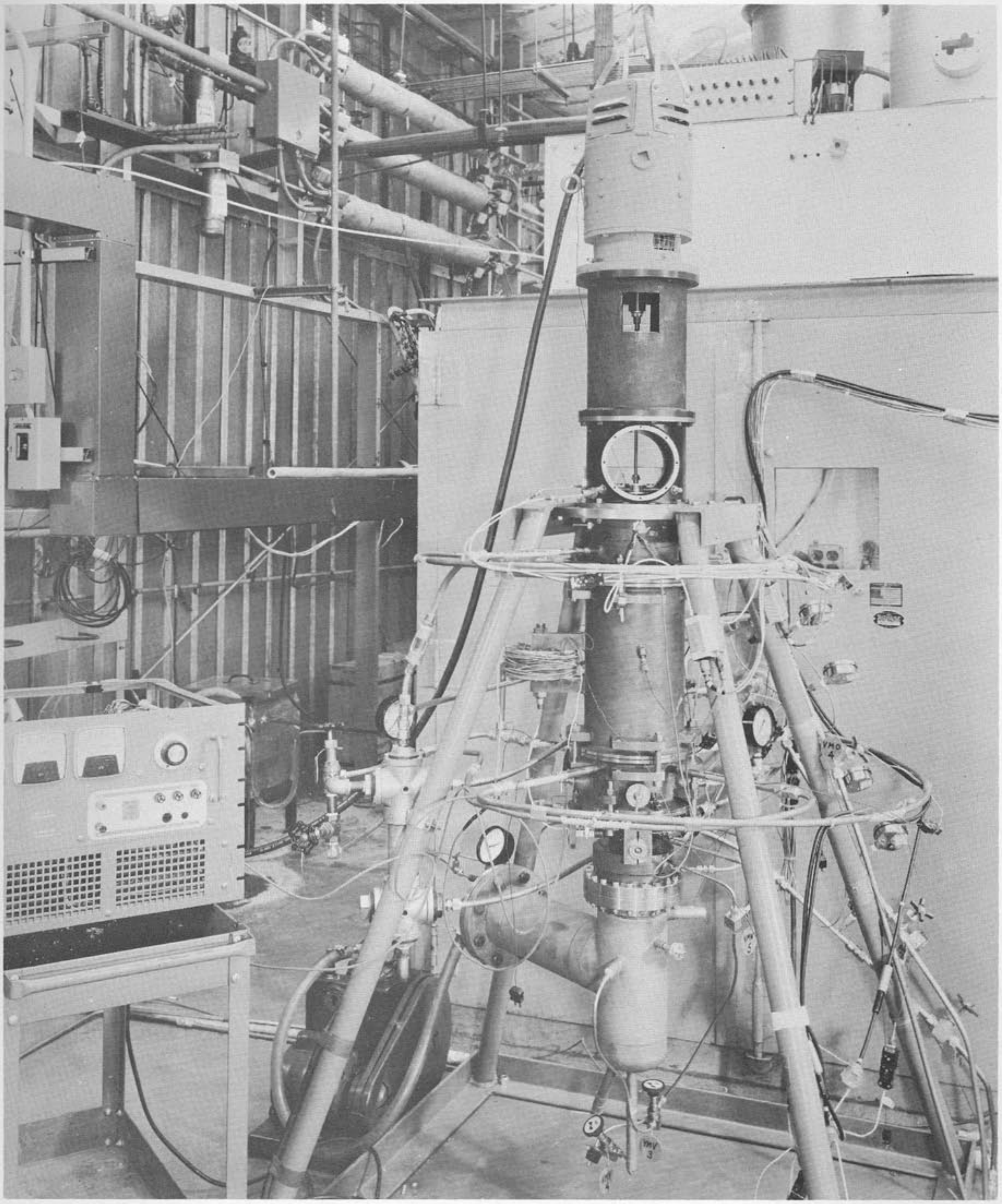
Portable lube cart capable of producing, measuring and recording oil pressures and flows to perform a variety of functions.

ROTATING TEST EQUIPMENT

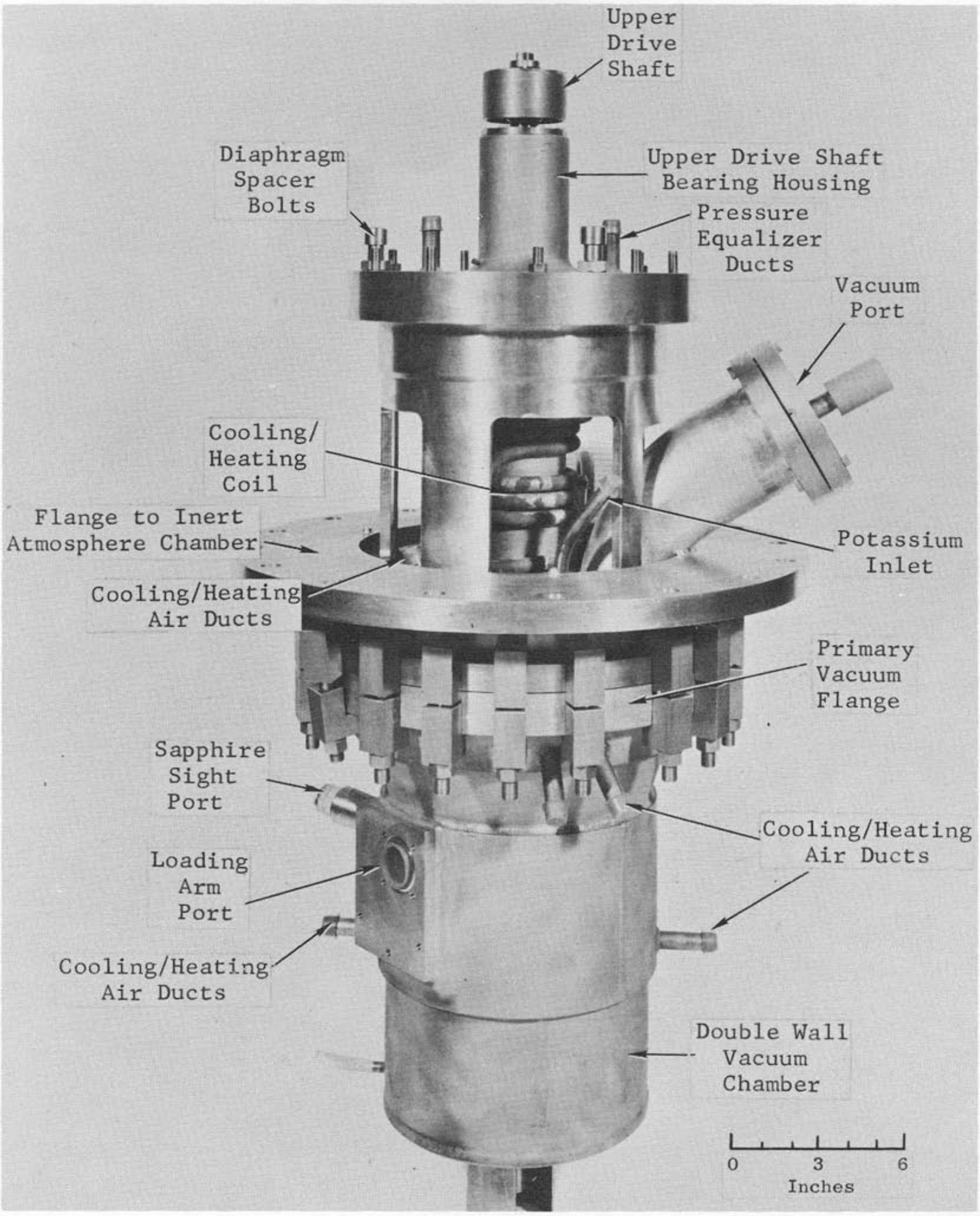
The space power and jet engine testing performed by NSP has necessitated the designing of both simple and complex rotating test equipment. This equipment has been designed to test seal and bearing performance; shaft deflection; and associated vibration studies at both high and low speeds and in both ambient and inert environments.



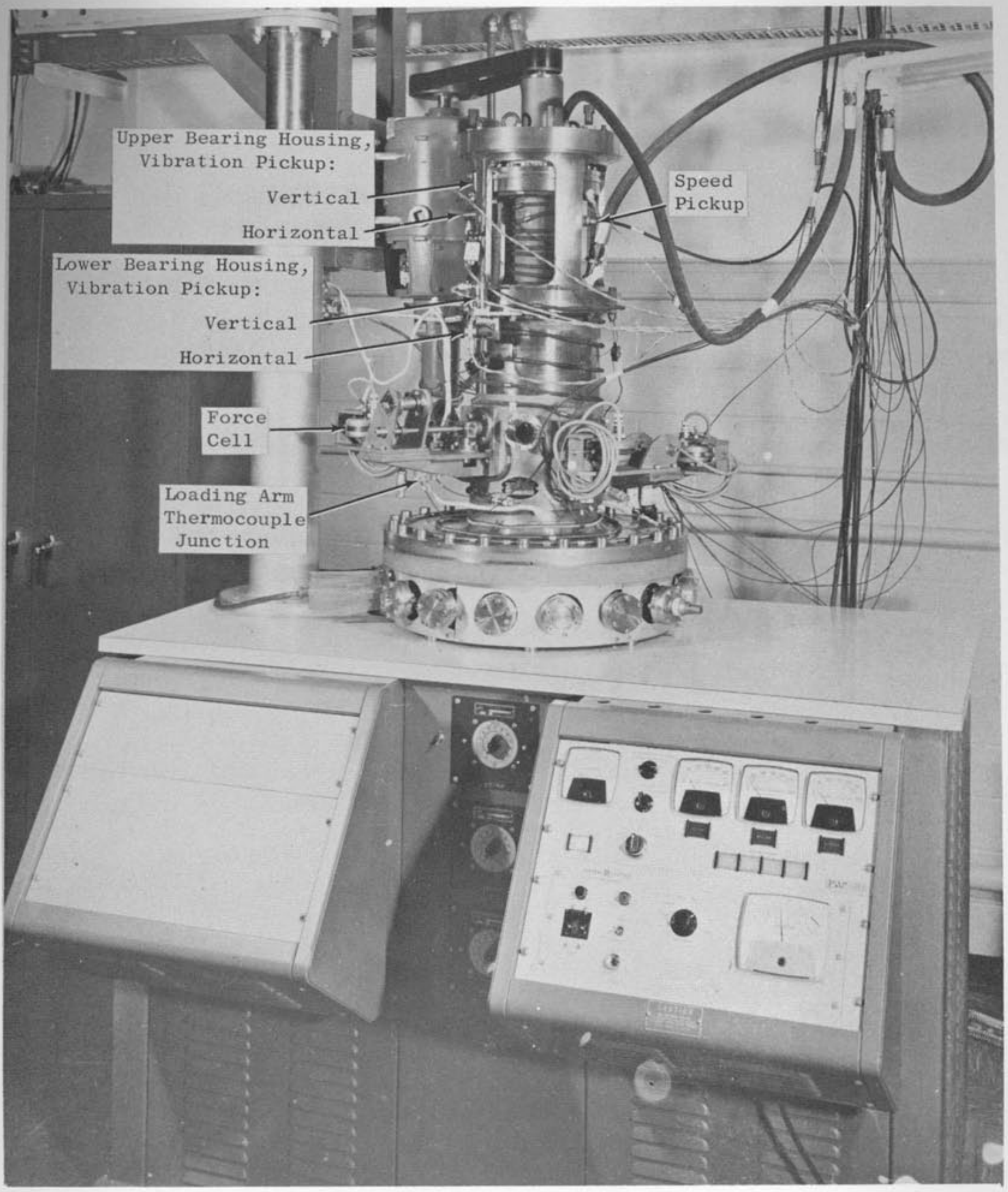
An artist's concept of a bearing stability test rig. This rig was designed and built to test bearing performance under adverse conditions.



Installation of a bearing test rig. This rig is capable of rotating and checking the alignment of a series of bearings.



The design of an alkali-metal friction and wear test rig. The hardware performs tests for friction coefficients of various materials at high temperature and in an alkali-metal environment.



A friction and wear tester along with bearing performance test equipment. This equipment can be used in a vacuum chamber or at ambient pressures in conjunction with Materials Compatibility Programs.