THE ROLE OF THE NASA-MSFC MANUFACTURING ENGINEERING LABORATORY IN THE DEVELOPMENT OF SPACE PROJECTS

by

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for

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Marshall Space Flight Center
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Gentlemen:

First, let me thank you for your invitation to participate in your meeting. Aerospace manufacturing engineering is playing an important role in our national space program, and that role will increase with the advancement of space travel.

In order to explain to you the role of NASA's Manufacturing Engineering Laboratory, let us look at the Organizational Chart of Marshall Space Flight Center in Huntsville. (SLIDE #1) The R&D Operation of MSFC consists of eight laboratories. They are engaged in three areas of space flight.

a. Research and Technology.

b. Development of Space Vehicles.

c. Support of Prime Contractors.

The next slide shows the organizational arrangement within the Manufacturing Engineering Laboratory. (SLIDE #2) You see there the three major Divisions: the Manufacturing Research and Technology Division, the Manufacturing Development Division, and the Planning and Tool Engineering Division. The total Civil Service strength of the Laboratory is about 850 people. I will show to you later an example of how many people are involved in the productive fabrication effort of MSFC's "in-house fabrication" of Saturn Stages. But in order to help you better understand what our manufacturing relationship is to the big hardware taking shape in Huntsville, let me show you the complete picture of the Manufacturing Engineering Laboratory functions.

(SLIDE #3) There are three basic functions: the first one covering the general or largely "non-program" oriented R&D activity. The second one concerns the program oriented development of prototype vehicles, where MSFC acts as the prime contractor and participates with in-house hardware operations. The third function concerns support of NASA's and the Prime Contractor's management in the area of manufacturing on a monitoring and consulting basis.

Let me explain now in more detail what we actually do under each of these functions:

Function I is based on the fact that the small scale technology development does not yield the required confidence level for full scale space vehicle application. A space vehicle is a one shot item of extremely high cost. The approval of a launch vehicle project, for instance, is a National decision, and successful launches must be accomplished within a relatively short time after the go-ahead is given. Because of that, only proven technology can be utilized in a conservative manner whenever it is possible. There are still enough areas where the state-of-the-art must be exceeded in order to achieve the minimum mission requirements. Therefore, manufacturing methods research and development for critical elements and demonstration of manufacturing feasibility represent an important support for the programs.

There is another essential portion of Function I which is reflected in the "building of experimental structures." Here, the development of space vehicle elements and space vehicle configurations on large or full scale takes place in advance of the need. Experimental projects are established in close coordination with the Future Projects Office and Advanced Design elements of the Center, but reflect in first place the manufacturing feasibility aspect and provide a realistic test bed for a large number of technology advancements, proven previously only on small sample laboratory work.

Experimental projects are developed, for instance, in order to cover areas where present solutions are marginal in being scaled up for next generation vehicles. (SLIDE #4) For example, with increasing diameters of stages, there is the question of increasing gages to be welded. Looking at the presently most efficient high strength aluminum alloy 2014, it is not only an affair of scaling up, but also the natural laws change, and the material looses weldability when exceeding 1/2 inch of material thickness. Furthermore, the size of the plates and sheets becomes smaller with increasing thickness, because of the given limitation in ingot weight. Capacities of the biggest machines and facilities in the country, like stretch form presses, boring mills, heat treat furnaces and buildings, are becoming too small. Transportation requirements start exceeding the inland waterway clearance profile, which is limited to about 90 feet in width by the locks and 50 feet in height by the bridges.

Questions whether to turn to novel materials, double or triple the ingot weight capacity of the aluminum industry, promote a national forming center, and widen the Panama Canal locks and raise over-passes and bridges, <u>or</u> find new ways for launch vehicle configurations and structural elements must be studied and evaluated to the required level of confidence. This is the reason why we have an experimental tank development program underway like the <u>multicell tank</u> (SLIDES #5 & #6), <u>a toroidal tank</u> (SLIDE #7), <u>a semi-toroidal tank</u> (SLIDE #8), and others. The vehicle element development is represented by the <u>big electron beam station</u> (SLIDE #9) for "Y"-shaped ring welding, <u>local tooling</u> (SLIDES #10, #11, #12, & #13) development including electric field applications for forming, <u>flaring</u> (SLIDE #14), <u>magnetic hammer</u> (SLIDE #15), etc., skin stiffener build-up development by high frequency welding instead of milling out of the full plate, ultra light-weight beam projects, <u>super insulation</u> (SLIDES #16 & #17), and many more.

The far reaching consequences just caused by the simple fact of increase in size of vehicles are given here as an example and do not cover the wide spectrum of development activities caused by the changing mission requirements and environment in orbit, lunar, and planetary space vehicles like the <u>Mobile Lunar Laboratory</u>. (SLIDE #18)

ME Laboratory's role in manufacturing research and development is also in letting and supervising contracts to other research institutes and to industries' manufacturing research departments. Only portions of the projects are done in-house, where special experience, equipment and facilities are not available in industry, or where the close cooperation with other Center elements and a time factor require it. In many cases, the ME Laboratory activity is restricted only to the "pre-contractual phase" in order to clarify the validity and feasibility of the project goals and must be done on the Government side in order to establish and justify budget requests and enable the project supervisor to write a realistic scope of work for the contract.

That covers the first function.

The second function, as I already have mentioned, is the participation in the manufacture of prototype launch vehicles. I think the best explanation of how we handle the first phase of even a very large prototype development project is given in the next slide. This shows the portion of the productive fabrication effort (SLIDE #19), which took place since July 1960 within ME Laboratory versus the portion furnished by industry. The manpower effort concerns the portions of the Saturn Programs which were handled directly by ME Laboratory before Chrysler became prime contractor of the Saturn I first stage, and Boeing for the Saturn V first stage. In the Saturn I Program, three ground stages and eight flight stages were assembled in Huntsville; and in the Saturn V Program, two ground stages and two flight stages will be assembled in Huntsville. You can see how small the ME Laboratory fabrication effort is; presently about 10%, which is contributed by the Government operation. After the completion of these first small prototype phases, the manufacturing continues entirely at the prime contractor's plants and his sub-contractors. A logical question, then would be: What are these 10% Government fabrication during the starting phase of a launch vehicle good for? The answer lies in the following statements:

1. It is an essential factor in originating a realistic program by NASA.

2. It provides early backup for justification of large program commitments to industry.

3. It speeds up the early development phase.

4. It provides up-to-date knowledge for determining the program requirements in critical areas where further Government support must be provided.

5. It provides the basic knowledge and experience for Function III, the monitoring and support of prime contractor manufacturing activities.

This is the <u>full scale mockup area</u> (SLIDES #20, #21, & #22) where the major interfaces of the Saturn V Launch Vehicle are kept at Marshall.

Here the assembly welding station (SLIDE #23) for the big 33-foot diameter bulkheads is shown.

This is the C-Frame, a 50-ton universal transportation and handling fixture for the big Saturn sub-assemblies. (SLIDE #24)

This is another universal transportation and handling tool, the Travel Lift A-Frame. (SLIDE #25)

Here the Vertical Assembly Tower (SLIDE #26) is shown with a Saturn LOX Tank in final assembly.

Now to the last function, the monitoring and support of prime contractor. One main activity is to provide visibility in the areas of manufacturing and facility requirements to the Project Managers and Headquarters. Based on the in-house experience from Functions I and II, ME Laboratory has developed a superior competence in the following areas:

a. Early identification of possible manufacturing problem areas.

b. Capable assessment and judgments of needed knowledges on the side of the prime contractors for successful accomplishment of the task.

c. Consultation resting on the in-house experience, support of industry manufacturing research by planning and budgeting this area for NASA, and coordinating and seeking sources where the required new learning is currently being generated.

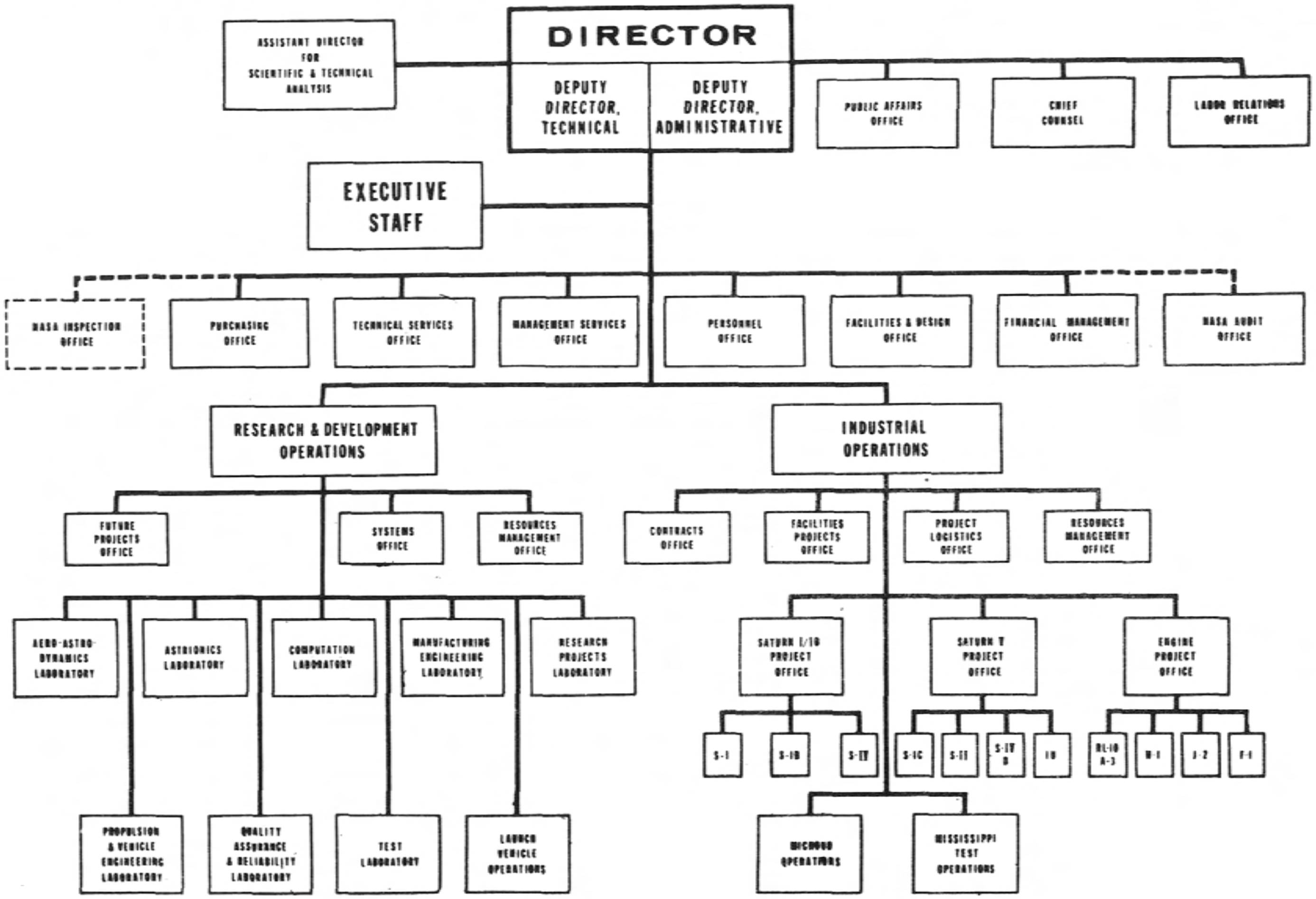
I hope that the explanations of the three basic functions of Marshall's ME Laboratory gave you a good picture about its role in the development of space projects, its capability and its relationship to industry.

In the Apollo Program, we are rapidly approaching the phase where getting hardware on the launch pad which works might be the most critical phase of the whole Lunar Program. We are already beyond the phases of developing the mission feasibility and the design feasibility. The manufacturing feasibility is presently a leading item in the program. The selection of the most reliable manufacturing mode, in order to build the quality in, is the task of manufacturing engineering. In ME Laboratory, you find your partner on the Government side helping you to cope with the many problems in space vehicle manufacturing. The problems seem only to get bigger in the future, because a realistic program of orbital, lunar and planetary missions requires a realistic demonstration of manufacturing feasibility before such large new commitments will be made. The planning of properly sized and effective development programs, concerning the hardware feasibility aspect in advance of the need, is therefore an important role of our Laboratory, and I want to take the chance to call on your recommendations and proposals.

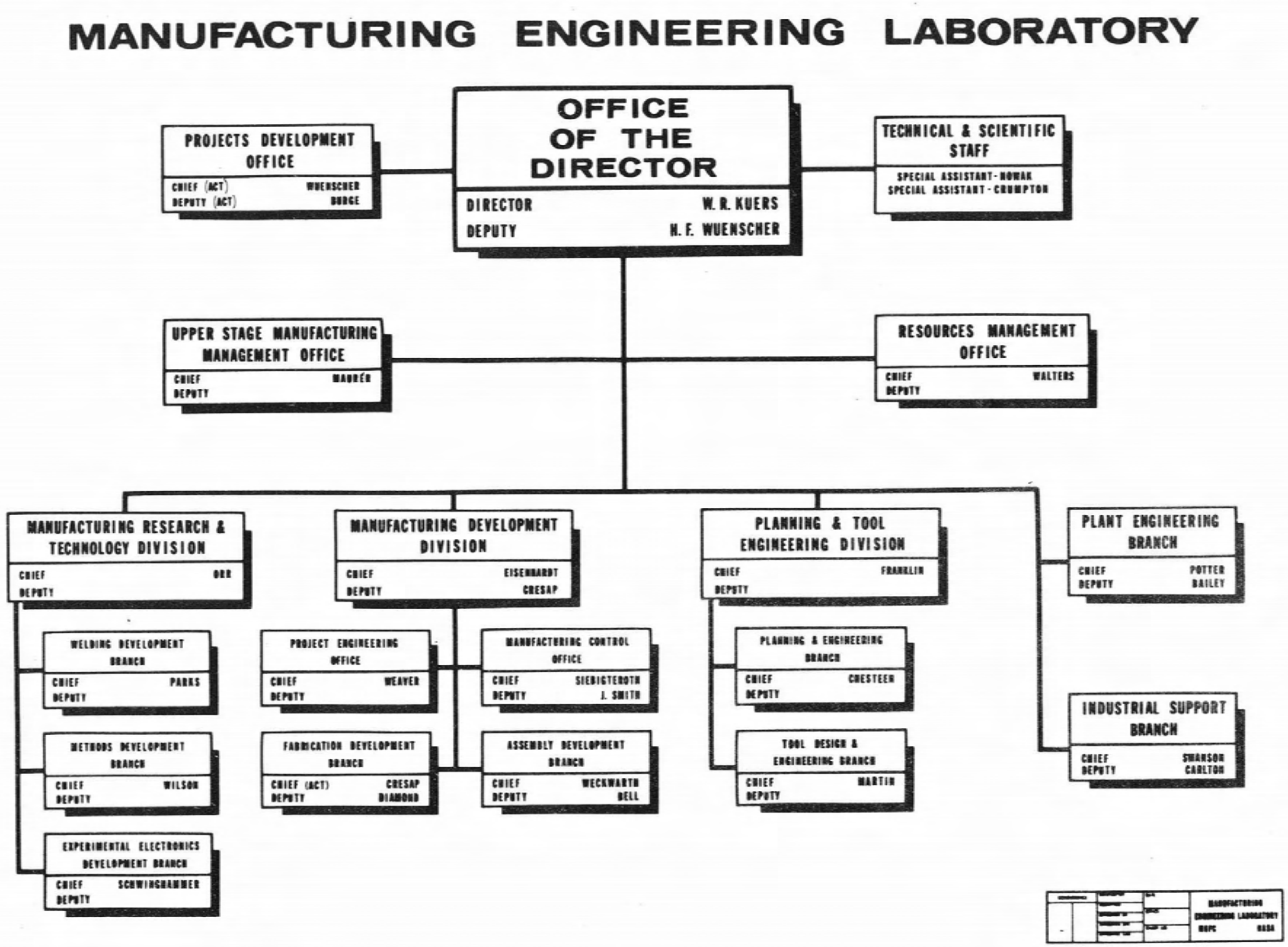
Any questions?

LIST OF SLIDES

GEORGE C. MARSHALL SPACE FLIGHT CENTER



SLIDE #1. ORGANIZATION CHART - MSFC



SLIDE #2. ORGANIZATION CHART - MANUFACTURING ENGINEERING LABORATORY

CHARTER-MANUFACTURING ENGINEERING LABORATORY

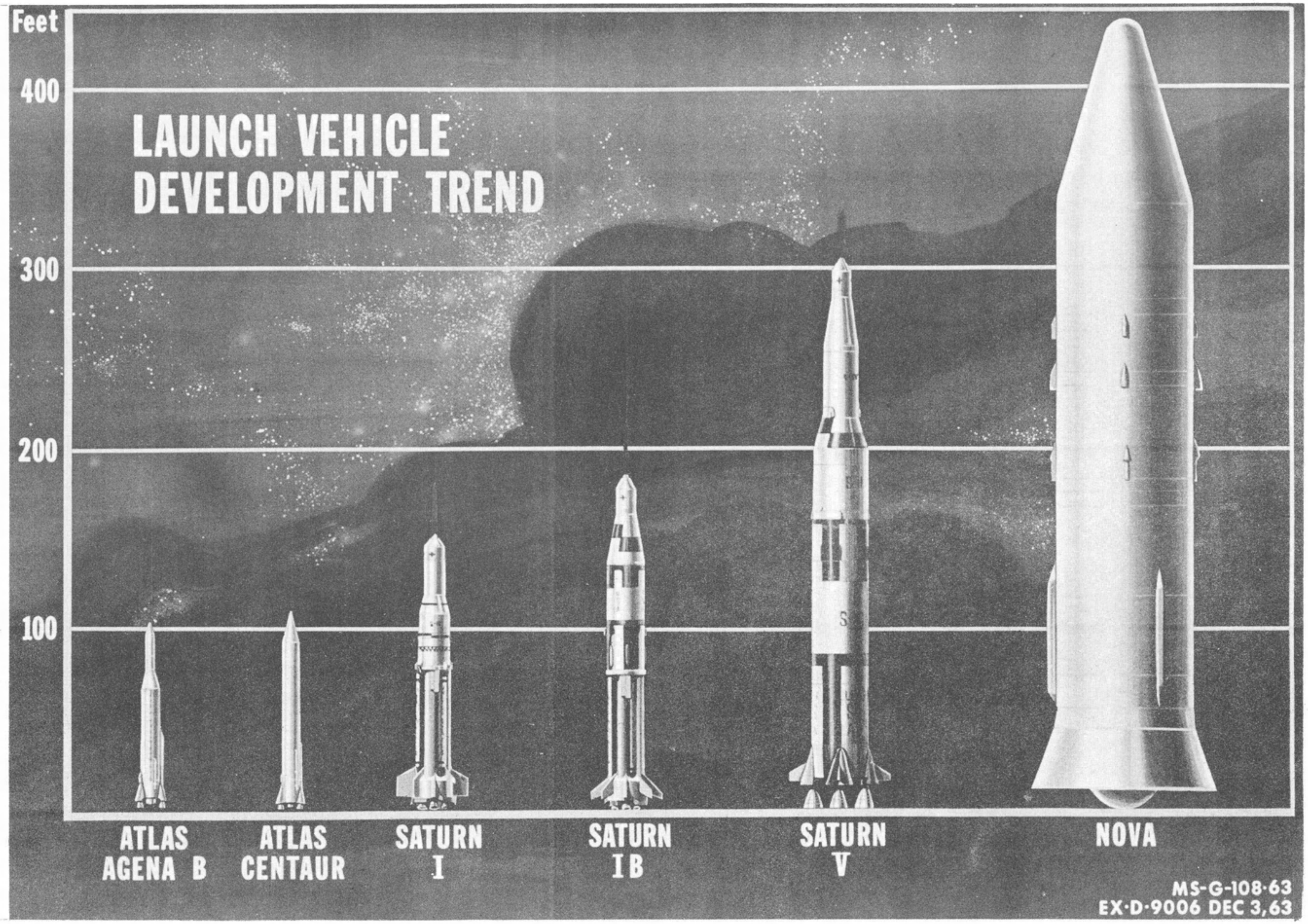
FUNCTIONS

1. TO CONDUCT BASIC AND APPLIED MANUFACTURING METHODS RESEARCH AND DEVELOPMENT AND MAKE APPLICATION TO EXPERIMENTAL STRUCTURES; EVALUATE NEW MANUFACTURING TECHNOLOGY, EQUIPMENT AND FACILITIES; CONDUCT FEASIBILITY STUDIES OF PROPOSED DESIGNS; AND BUILD EXPERIMENTAL STRUCTURES.

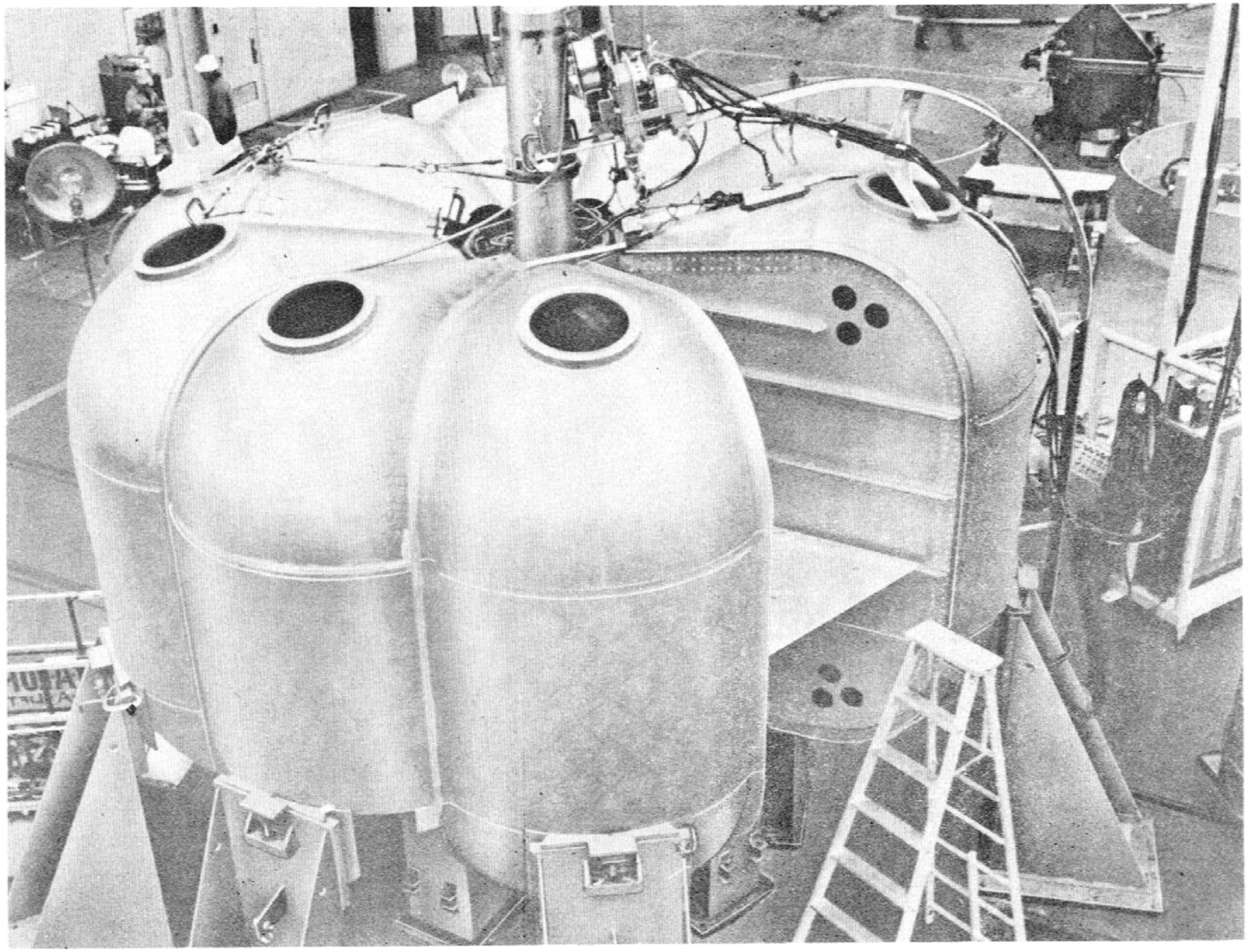
2. TO PROGRAM, PLAN, DIRECT, COORDINATE AND DOCUMENT THE METHODS, PROCESSES, SEQUENCE OF OPERATIONS, TOOLING, FACILITIES AND EQUIPMENT FOR AND MANUFACTURE OF PROTOTYPE LAUNCH VEHICLES.

3. TO UTILIZE AND DISSEMINATE ACCUMULATED KNOWLEDGE AND EXPERIENCE IN MONITORING MANUFACTURING PLANS AND ACTIVITIES OF UPPER STAGE PRIME CONTRACTORS.

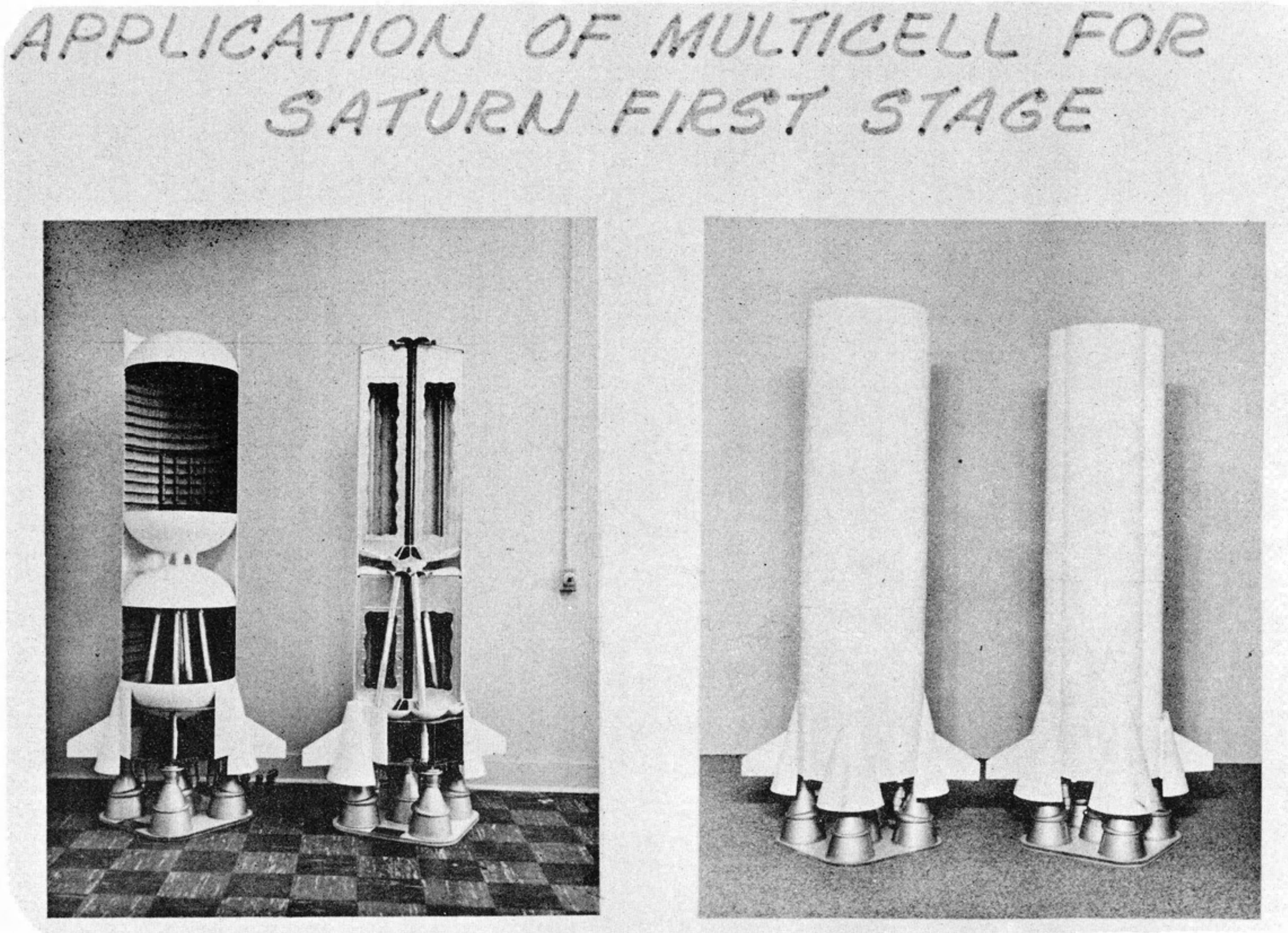
SLIDE #3. CHARTER - MANUFACTURING ENGINEERING LABORATORY FUNCTIONS



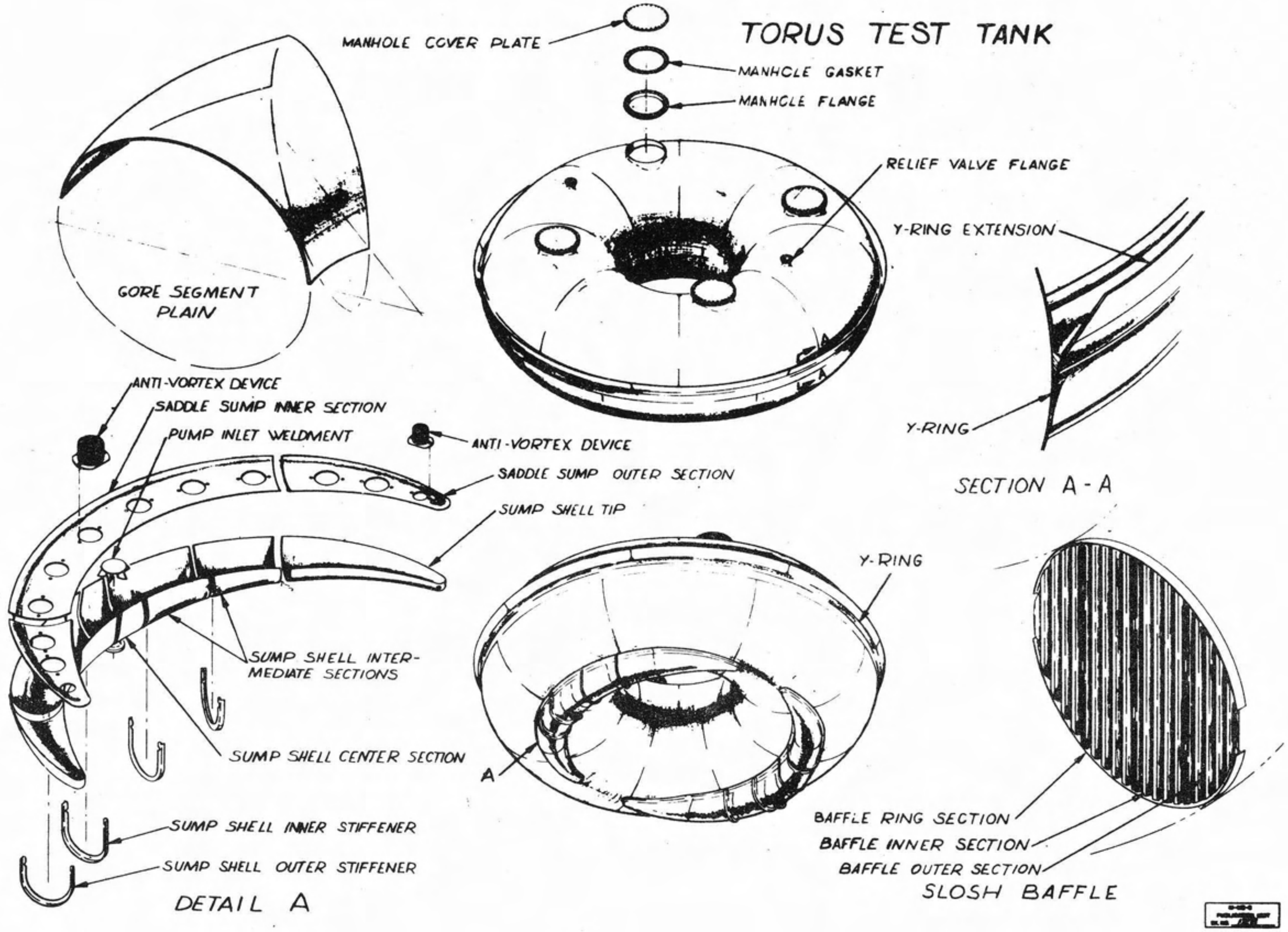
SLIDE #4. LAUNCH VEHICLE DEVELOPMENT TREND



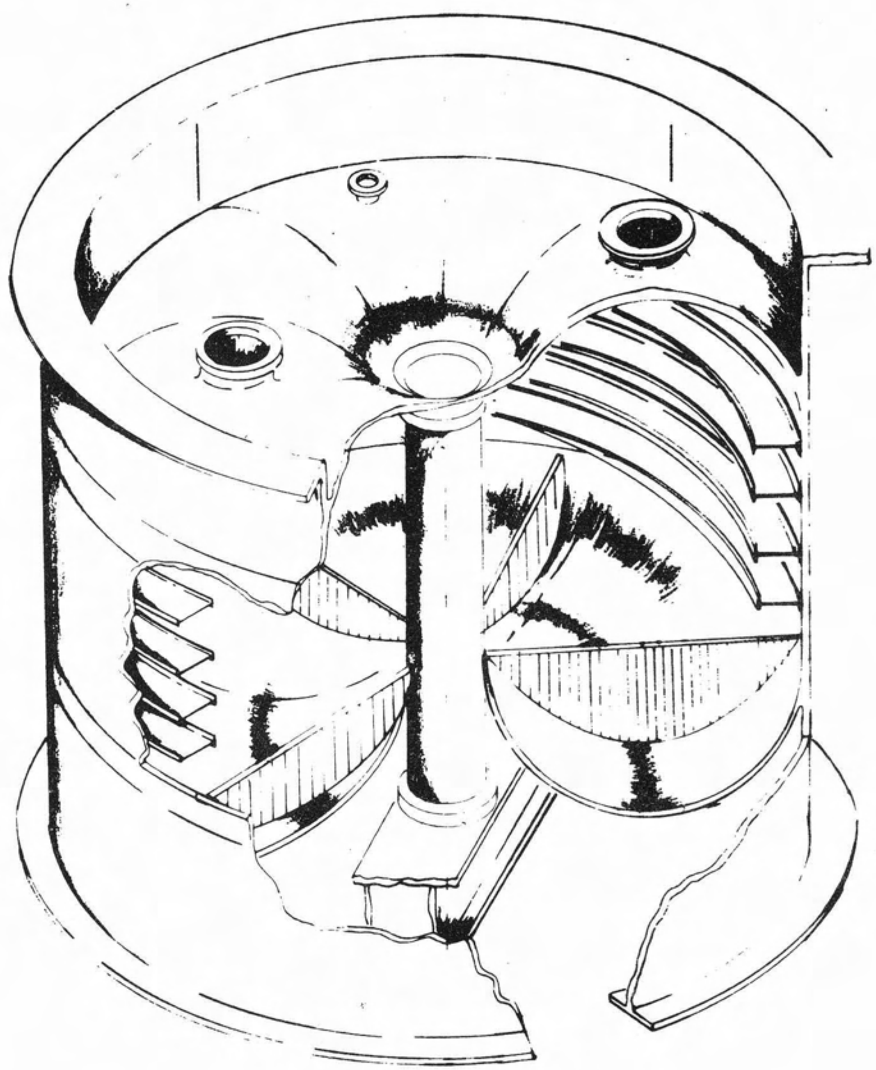
SLIDE #5. MULTICELL TANK



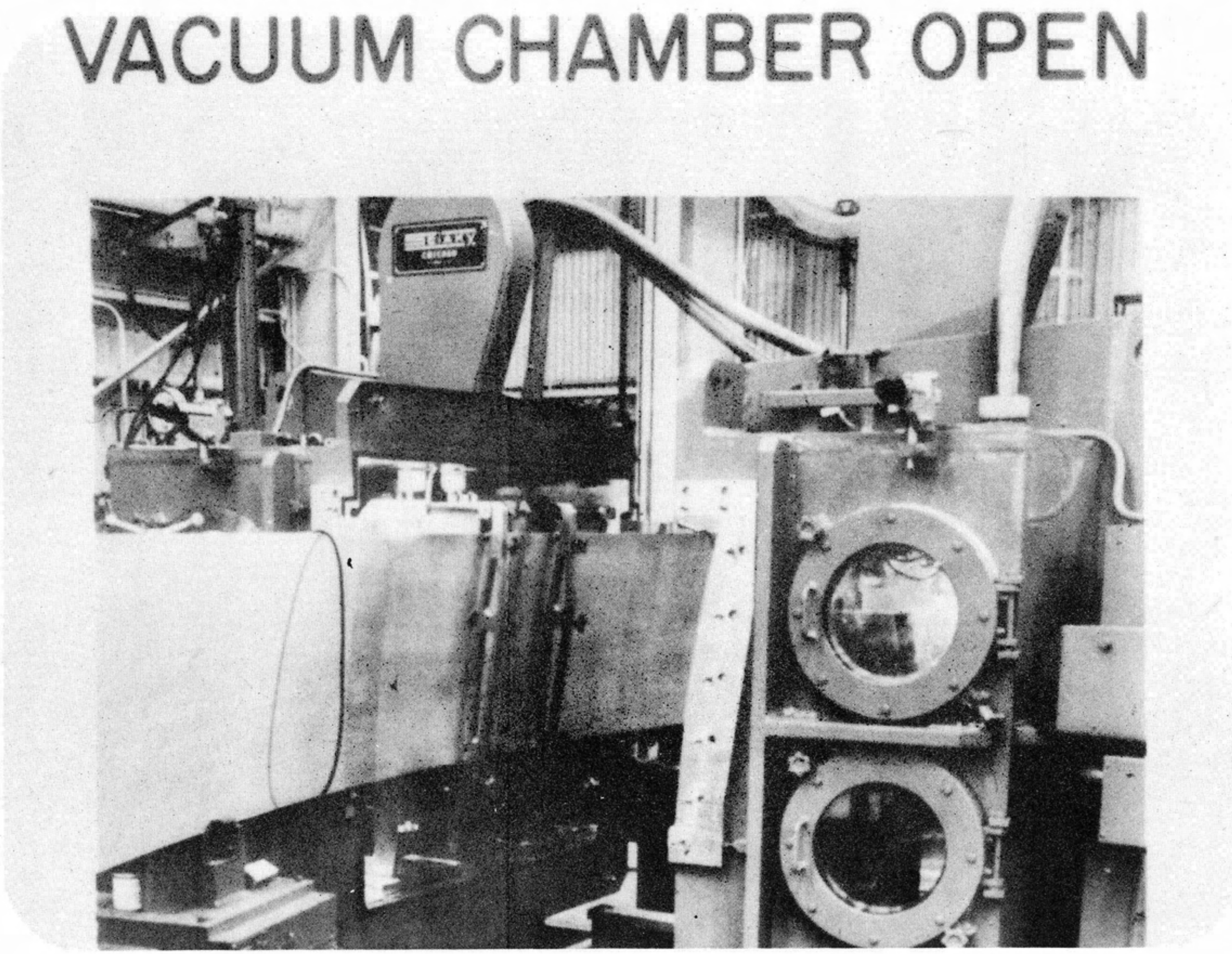
SLIDE #6. APPLICATION OF MULTICELL FOR SATURN FIRST STAGE



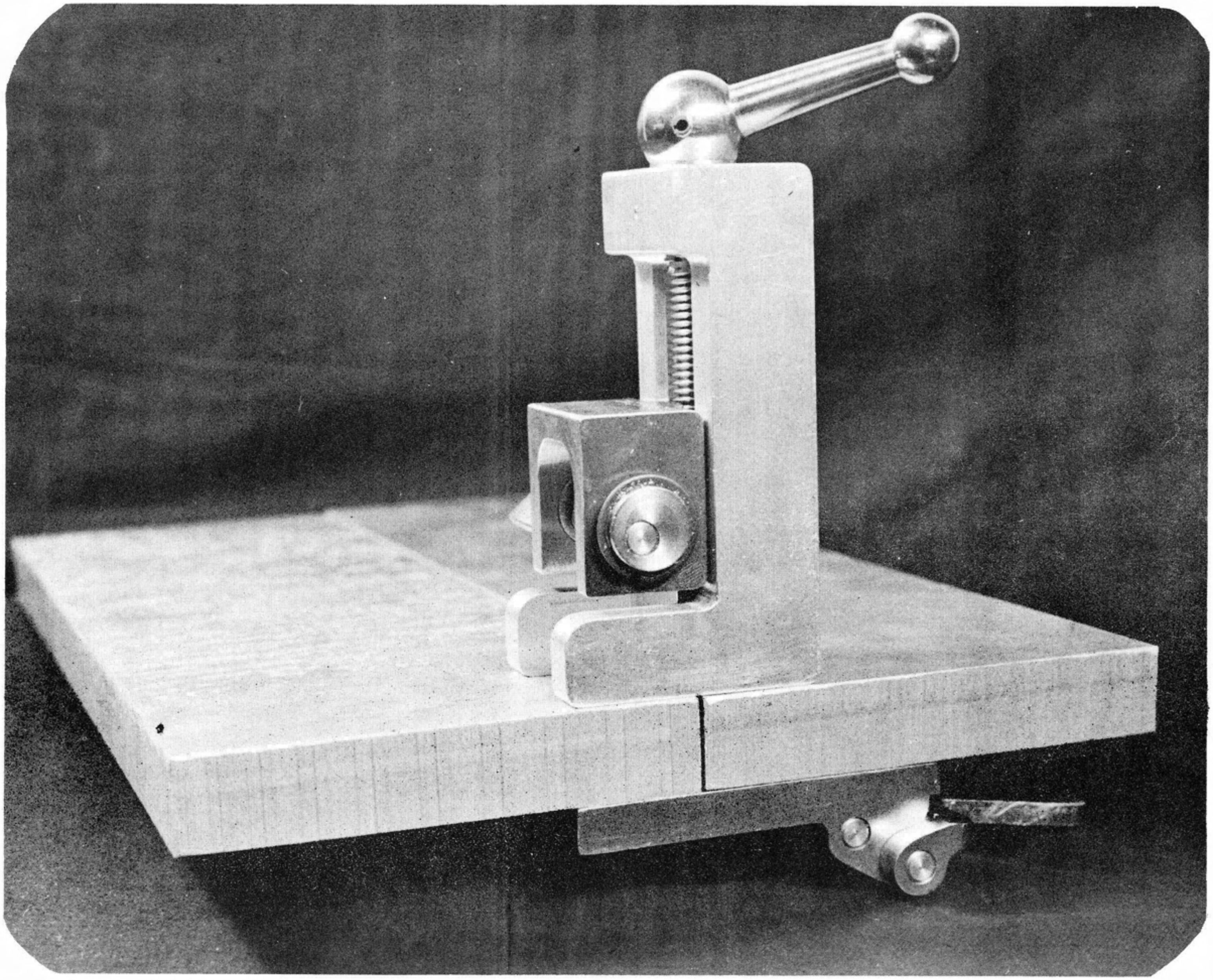
SLIDE #7. TOROIDAL TANK



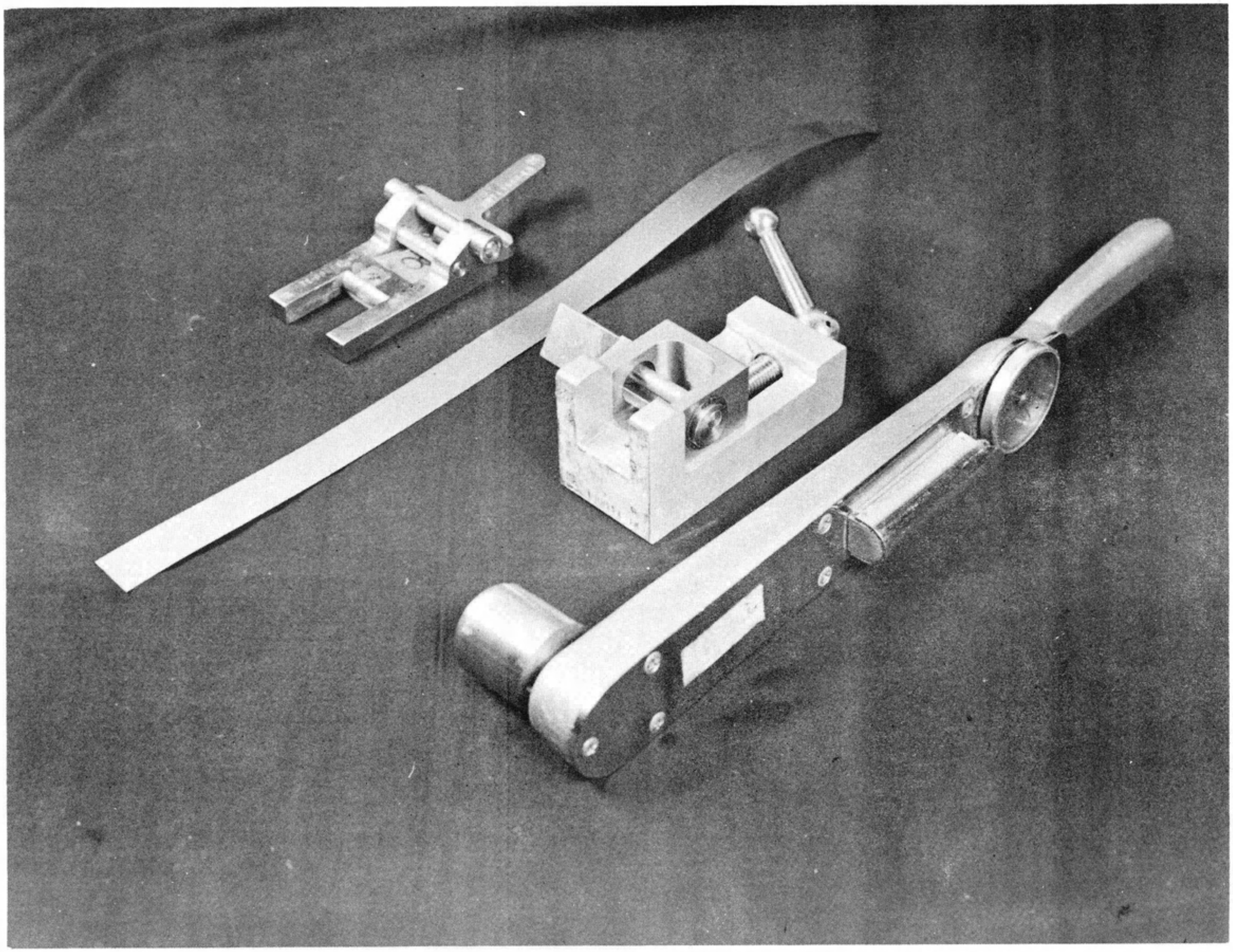
SLIDE #8. 200 INCH SEMI-TOROIDAL TANK



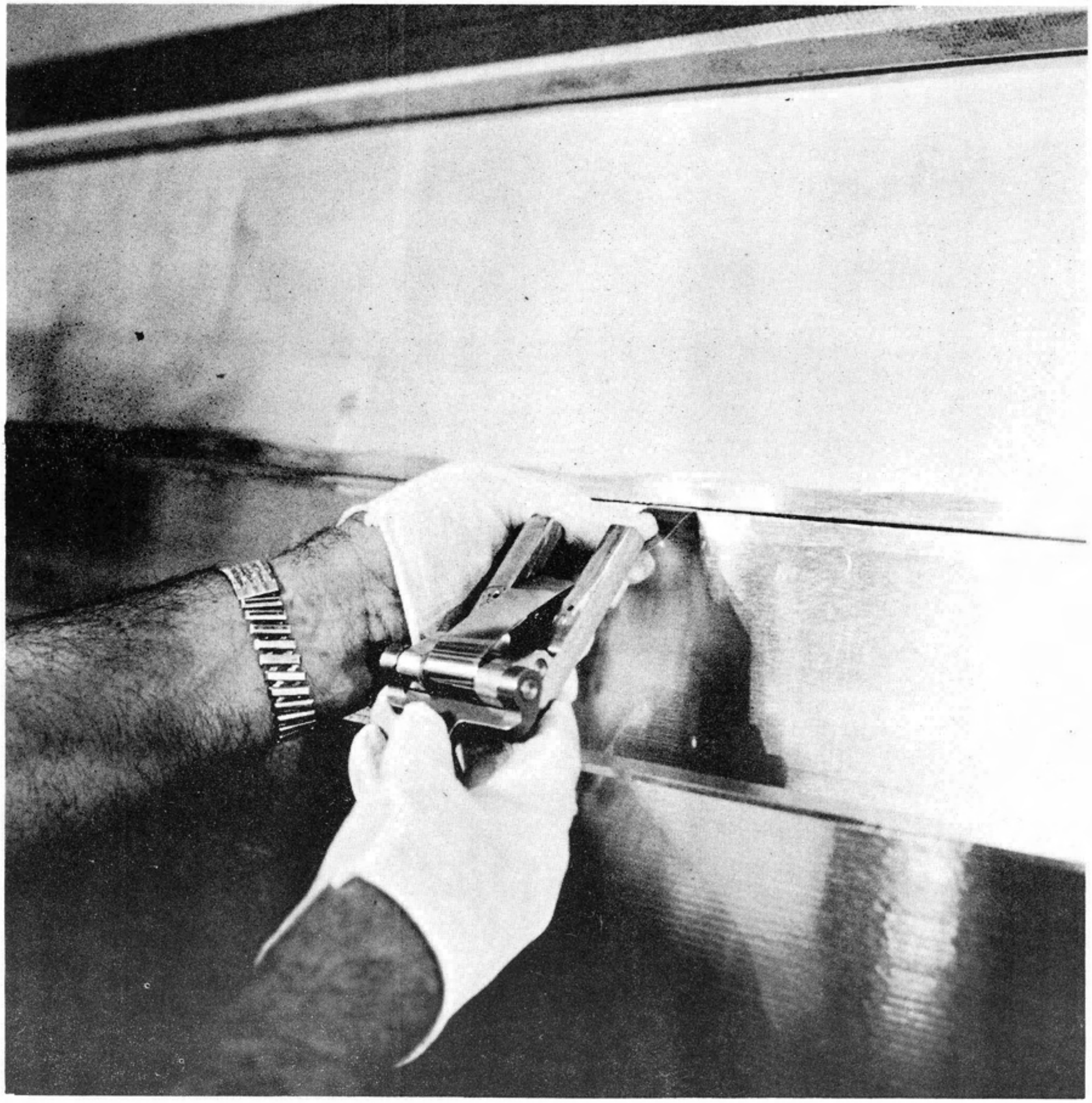
SLIDE #9. ELECTRON BEAM WELDING STATION



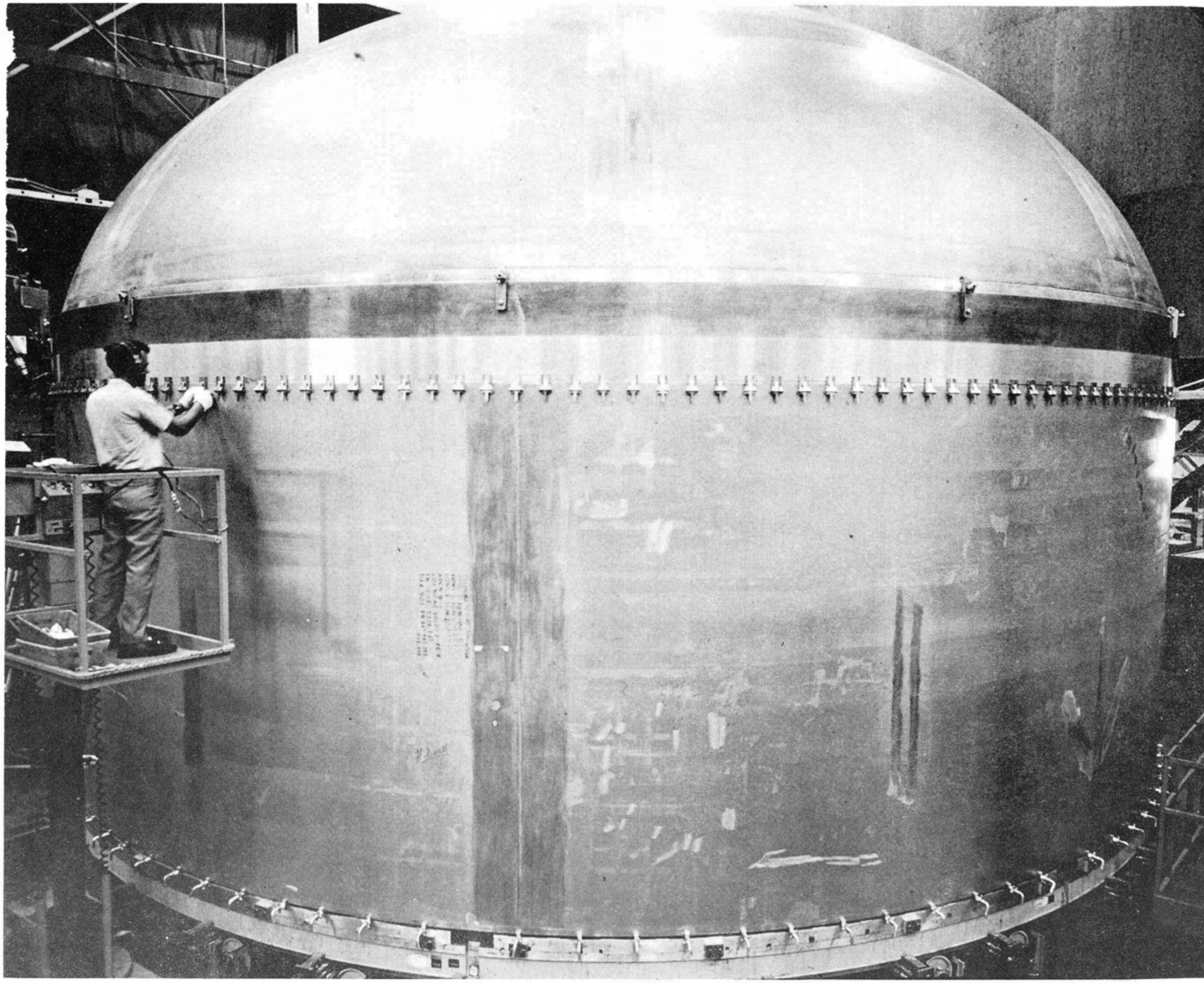
SLIDE #10. STRAP CLAMPS



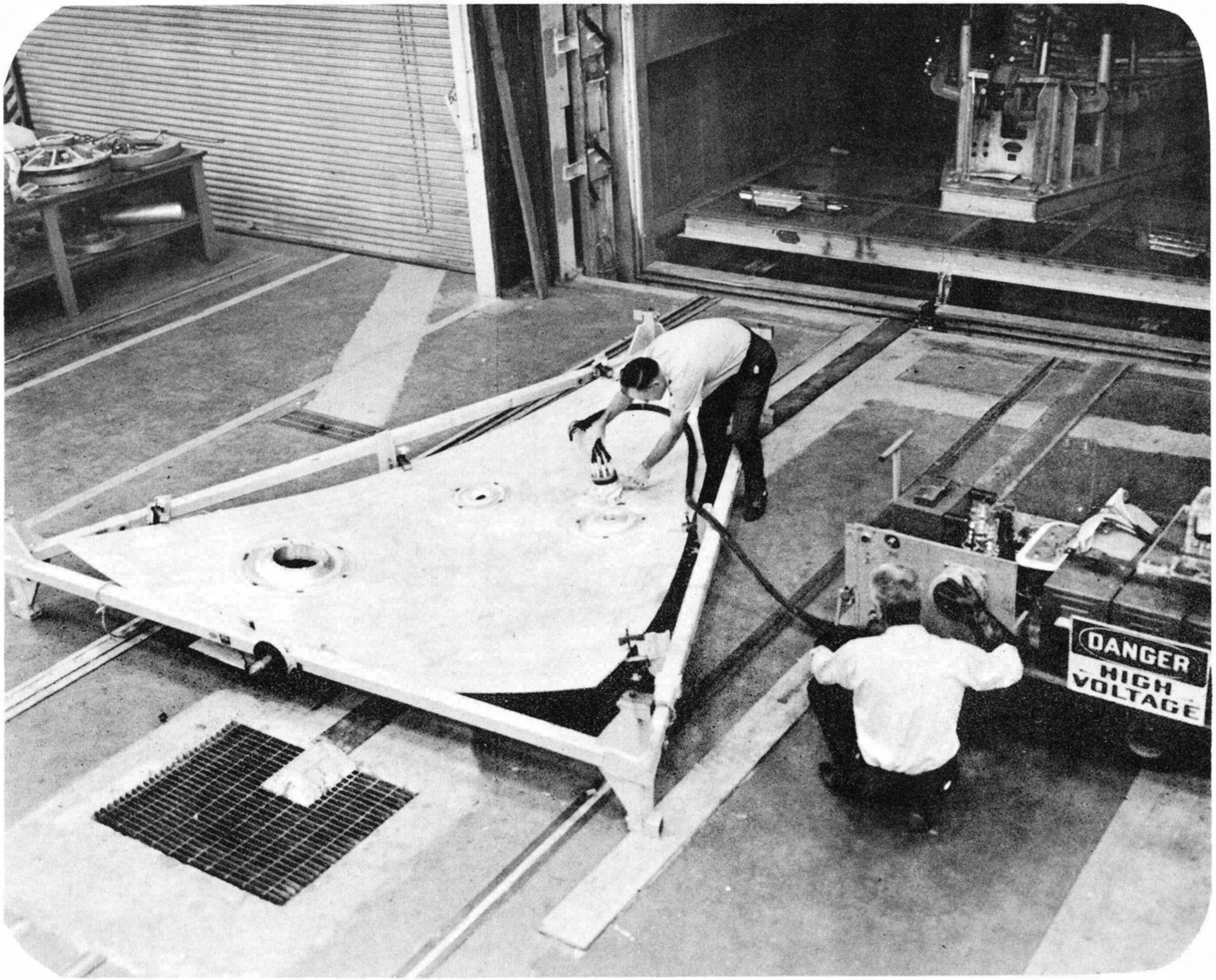
SLIDE #11. STRAP CLAMPS



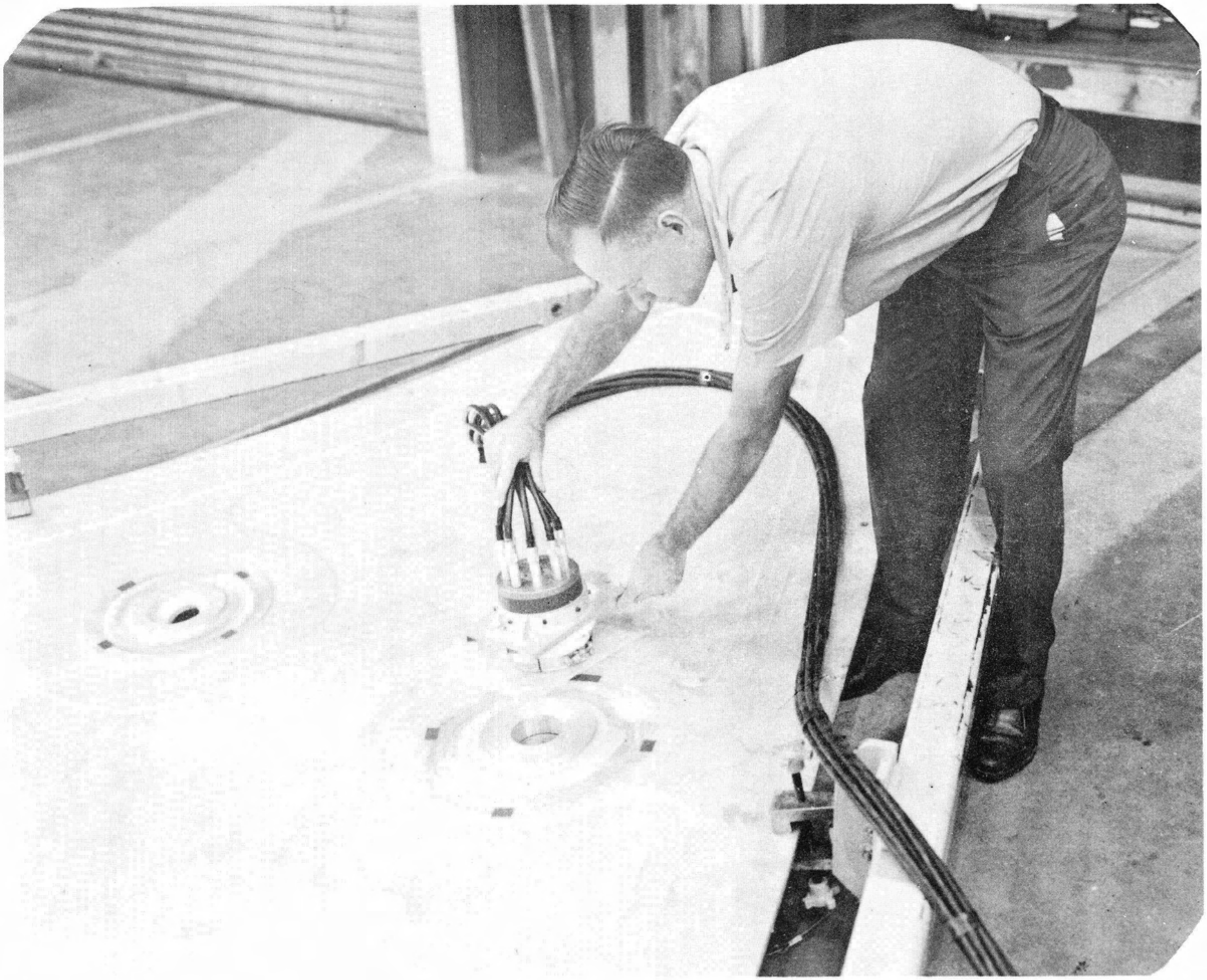
SLIDE #12. STRAP CLAMPS



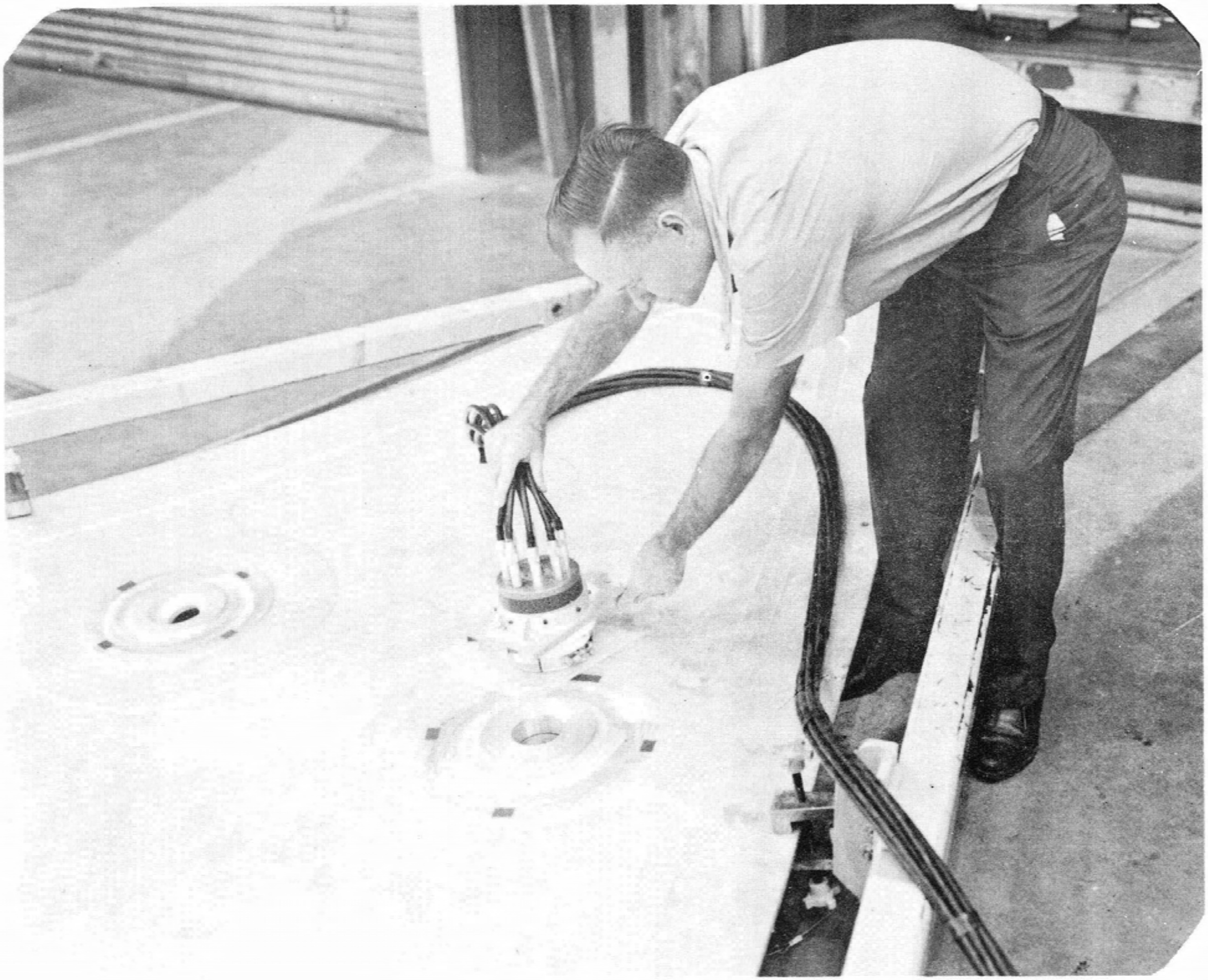
SLIDE #13. STRAP CLAMPS



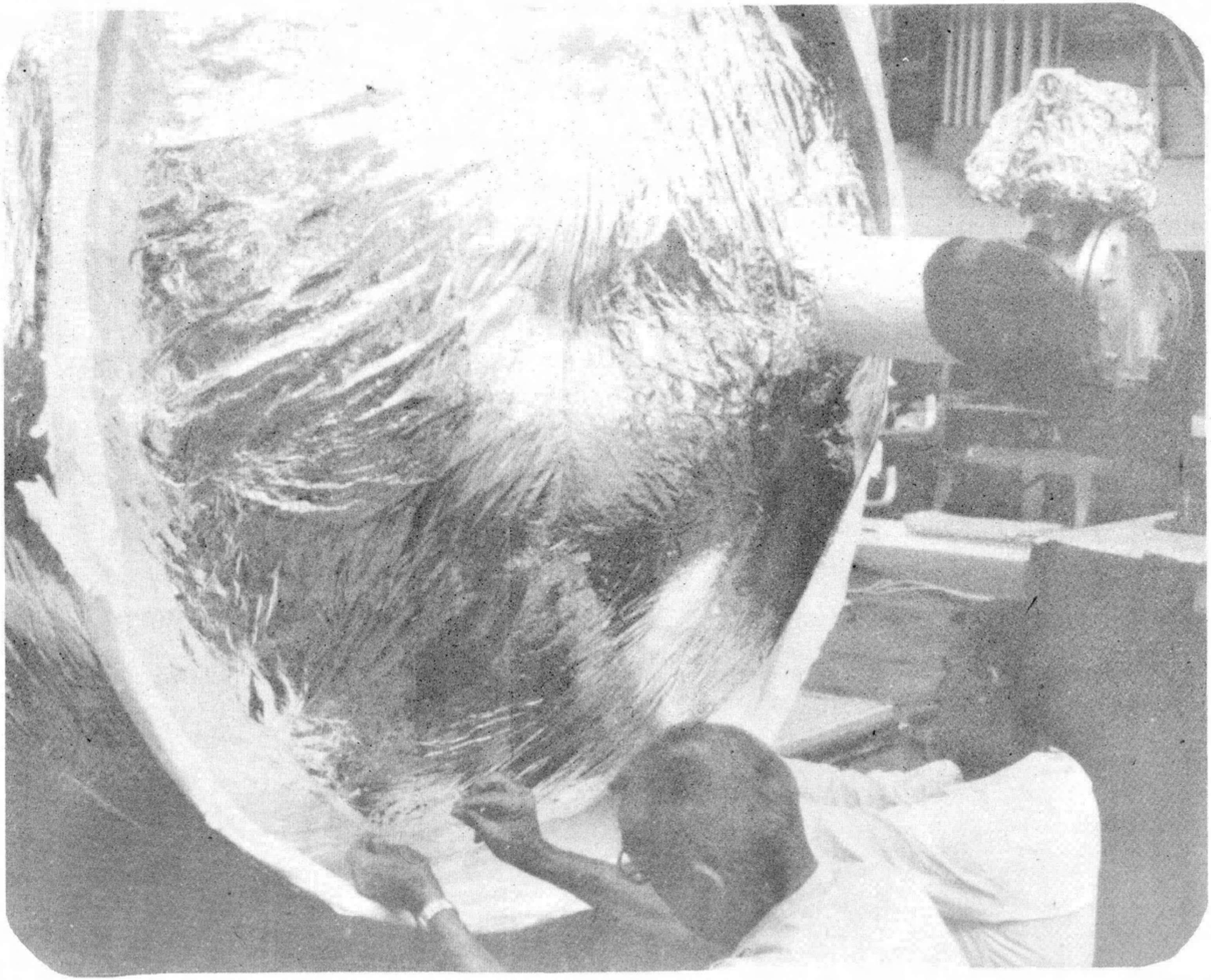
SLIDE #14. FLARING SETUP



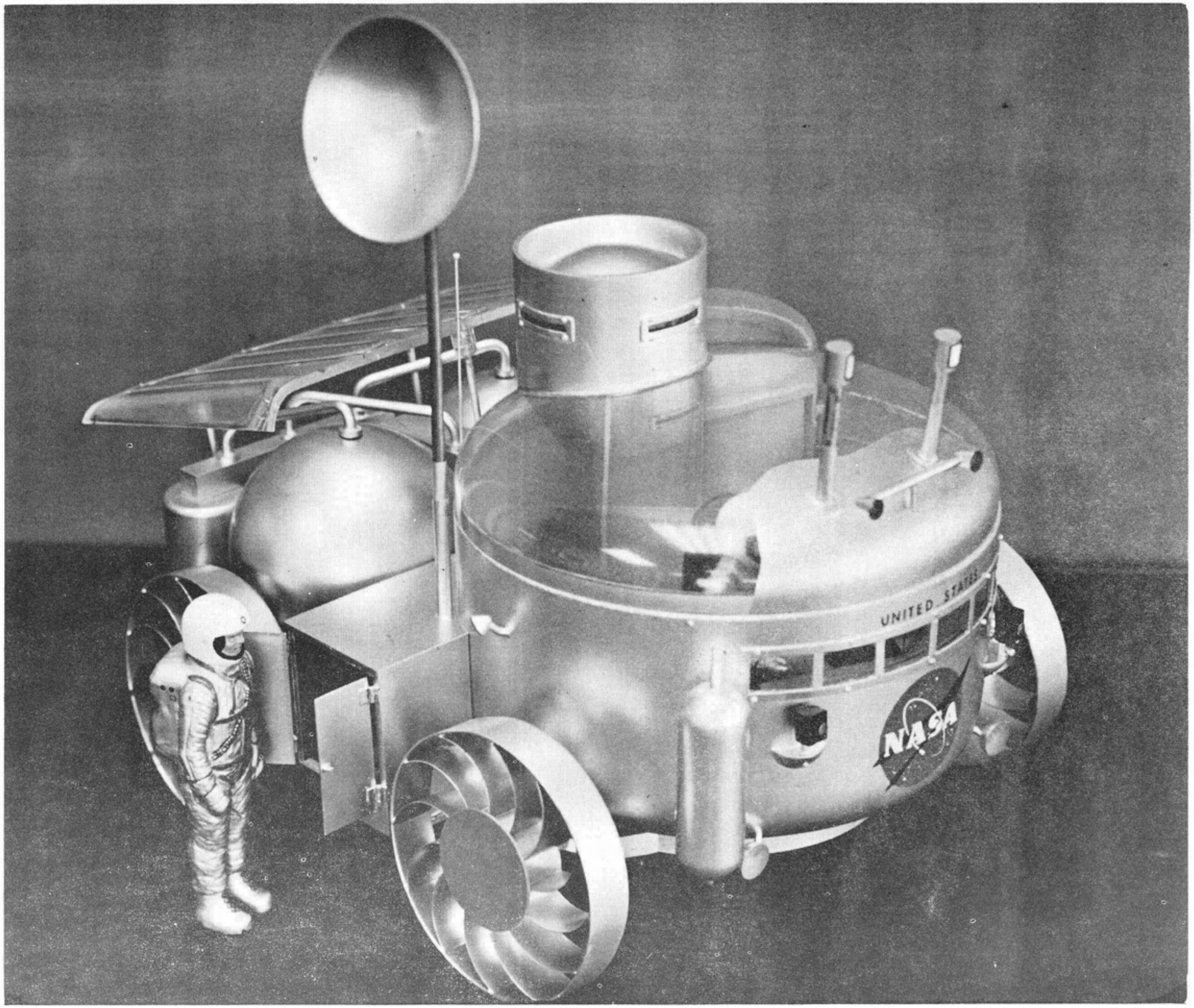
SLIDE #15. MAGNETIC HAMMER



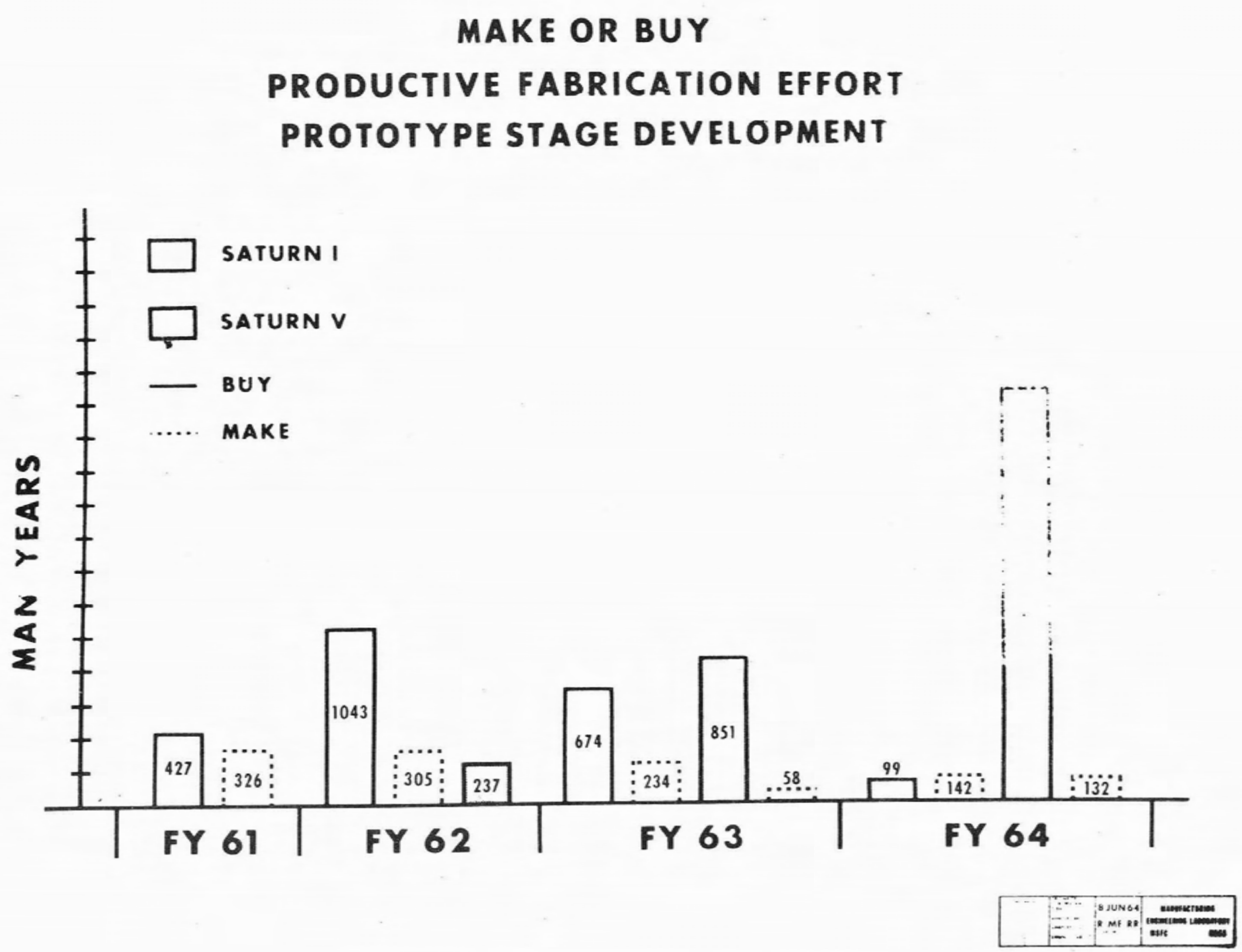
SLIDE #15. MAGNETIC HAMMER



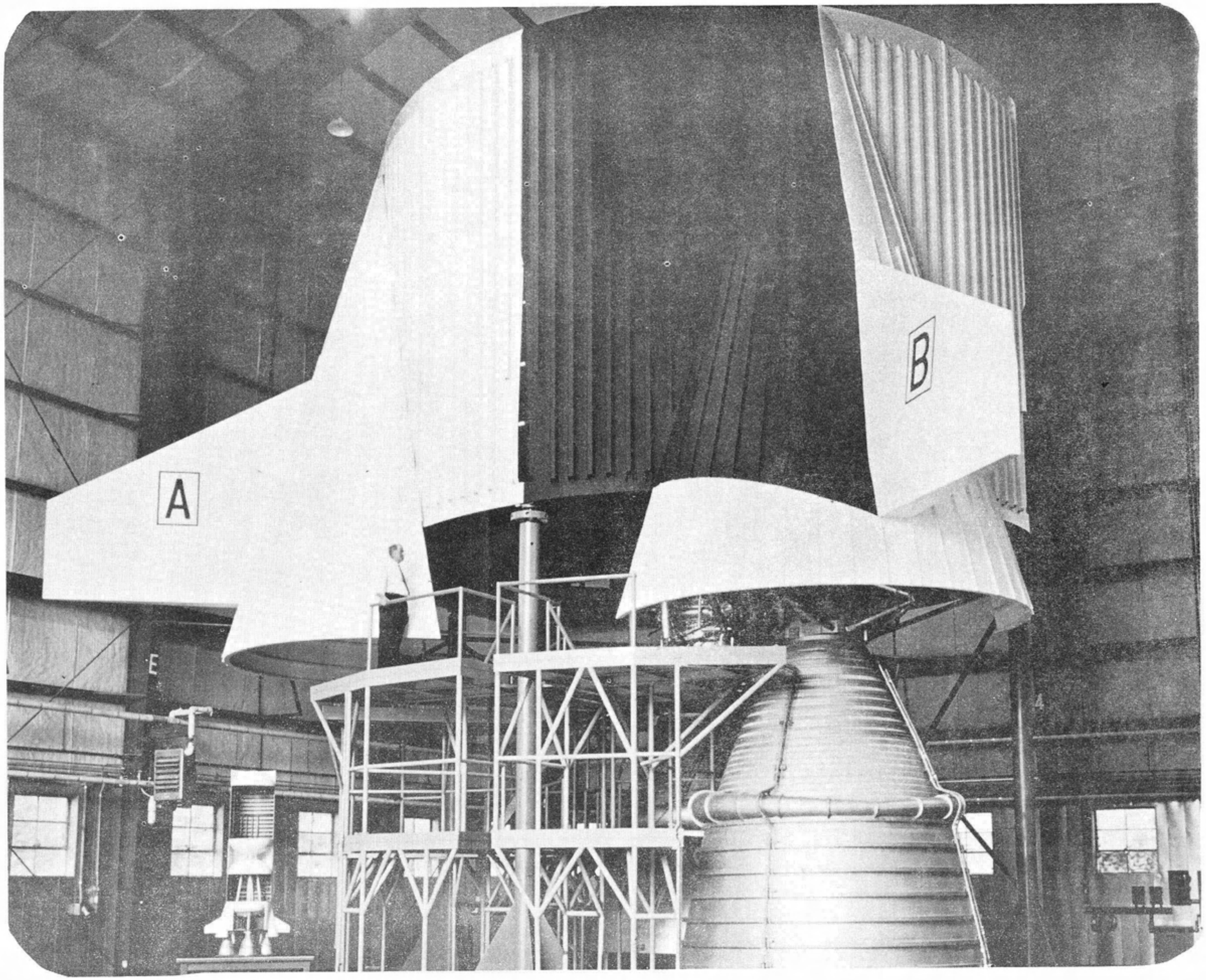
SLIDE #17. SUPER INSULATION



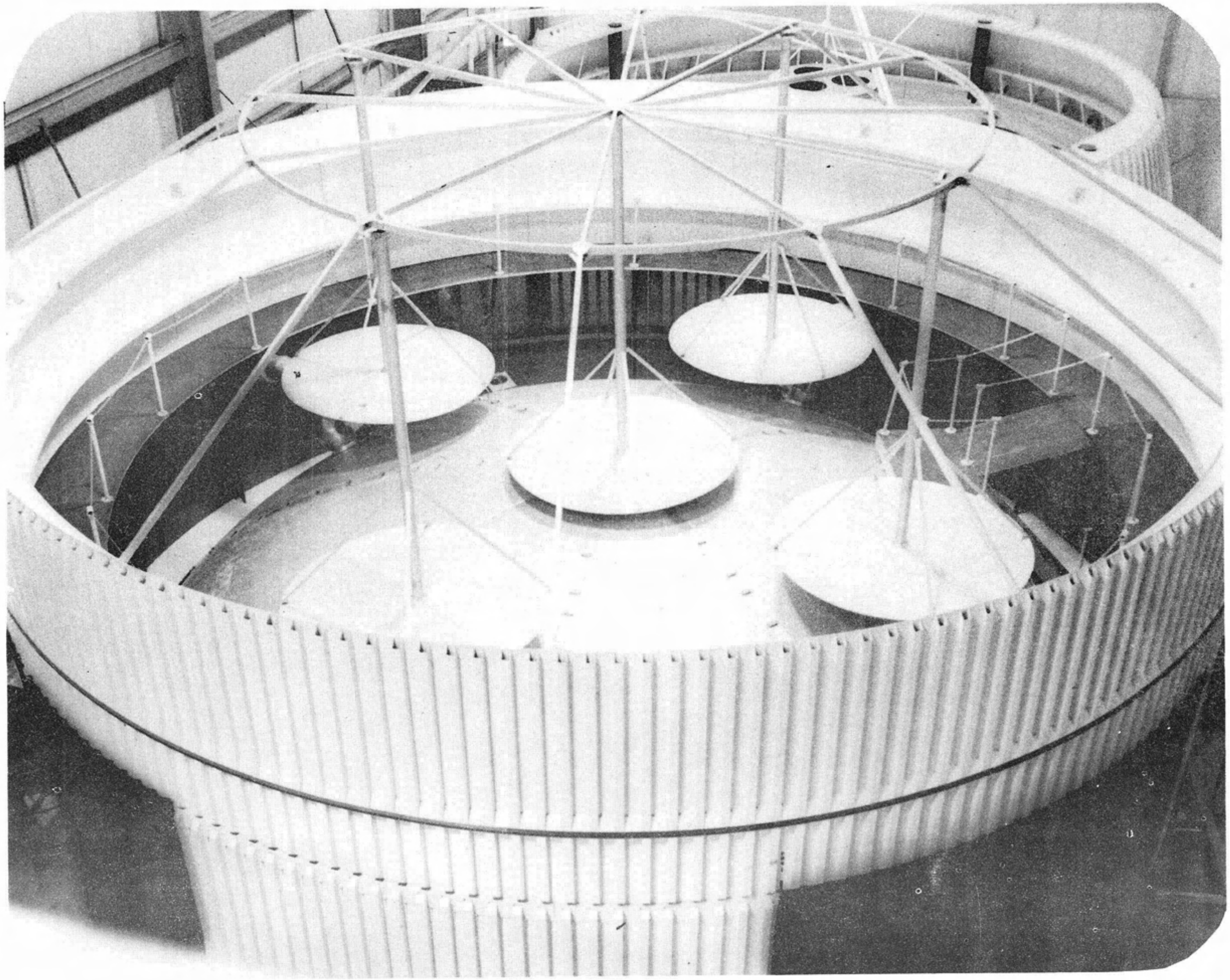
SLIDE #18. MOLAB R.F. VIEW



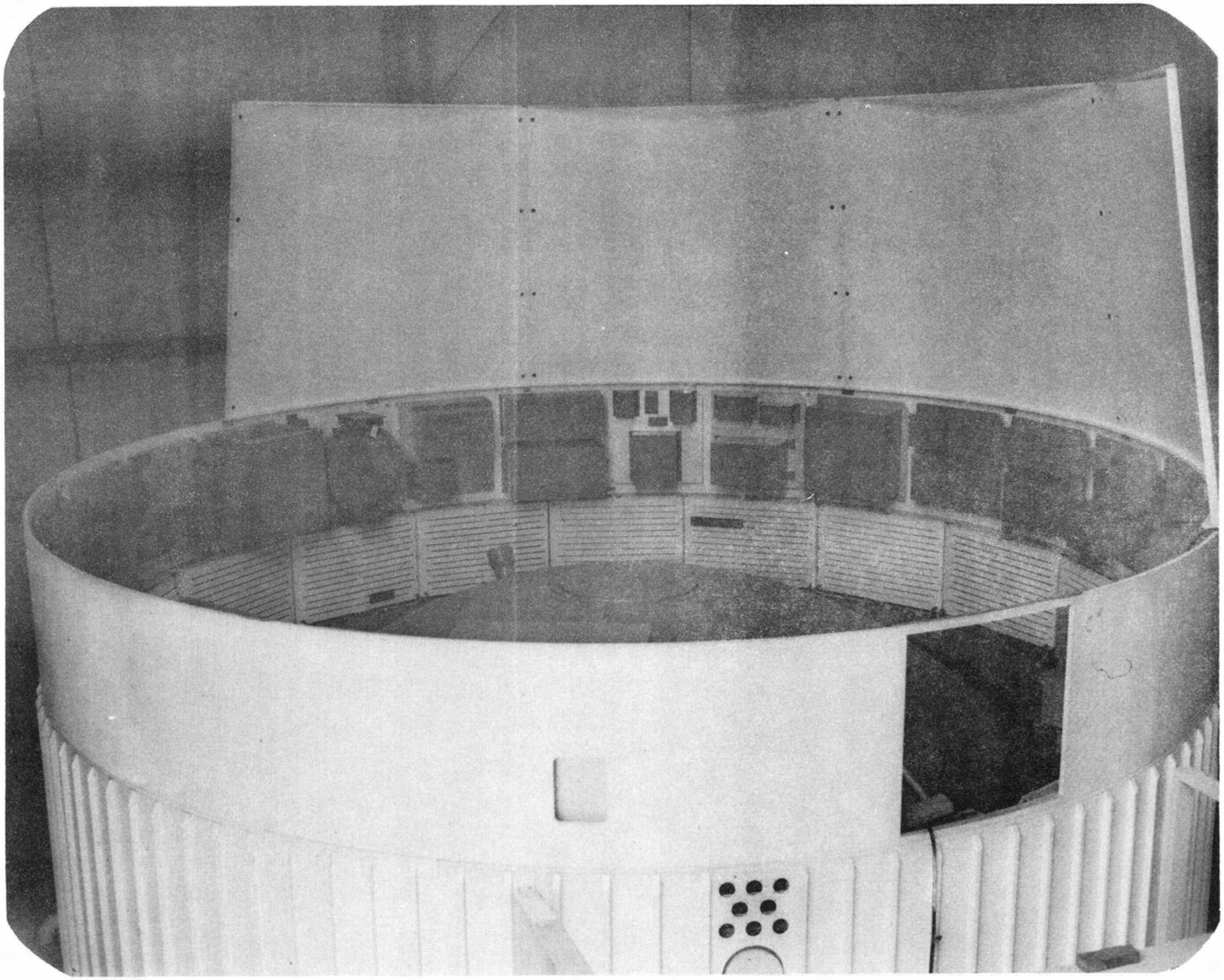
SLIDE #19. MAKE OR BUY BAR CHART



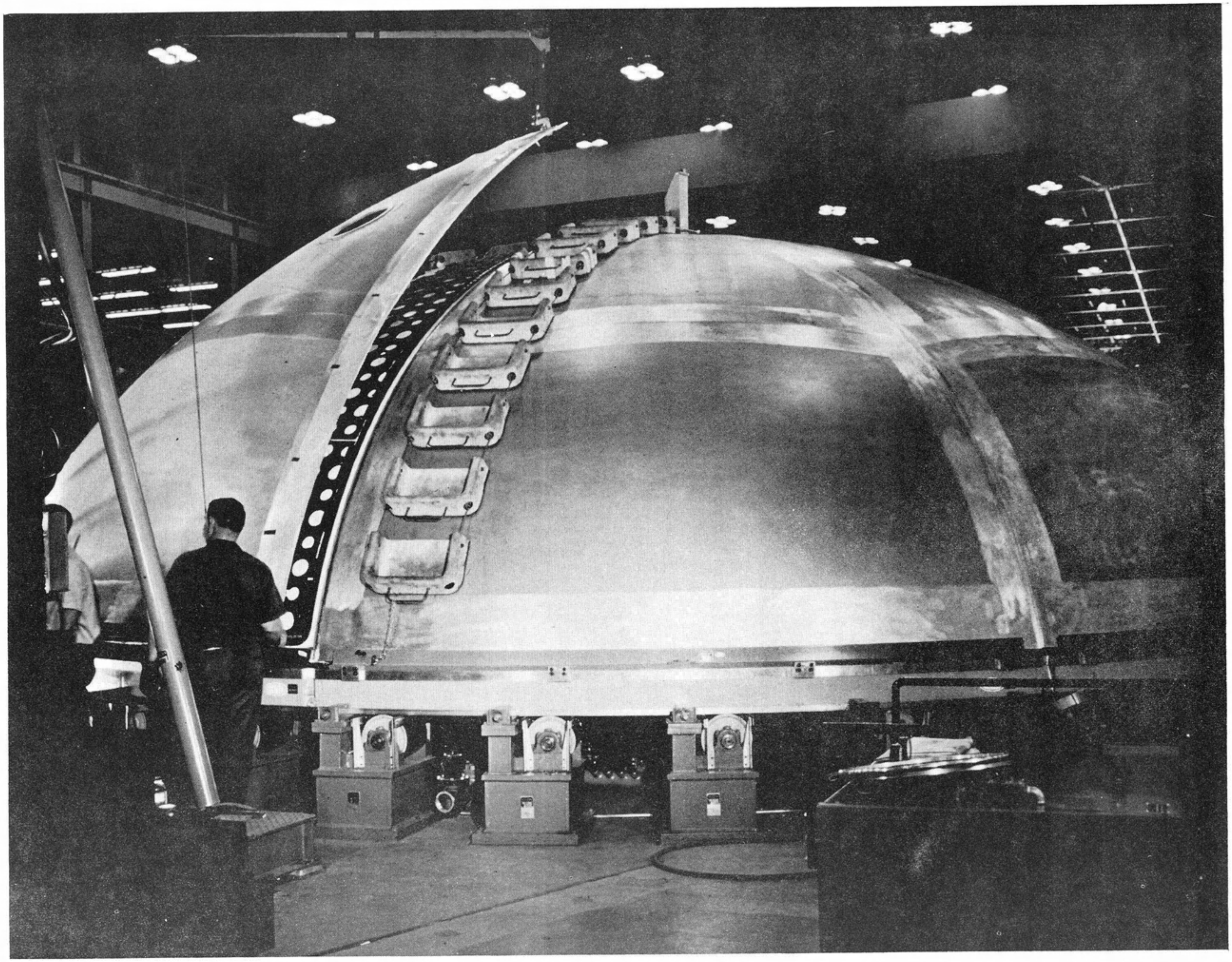
SLIDE #20. SATURN V FULL SCALE MOCKUP AREA



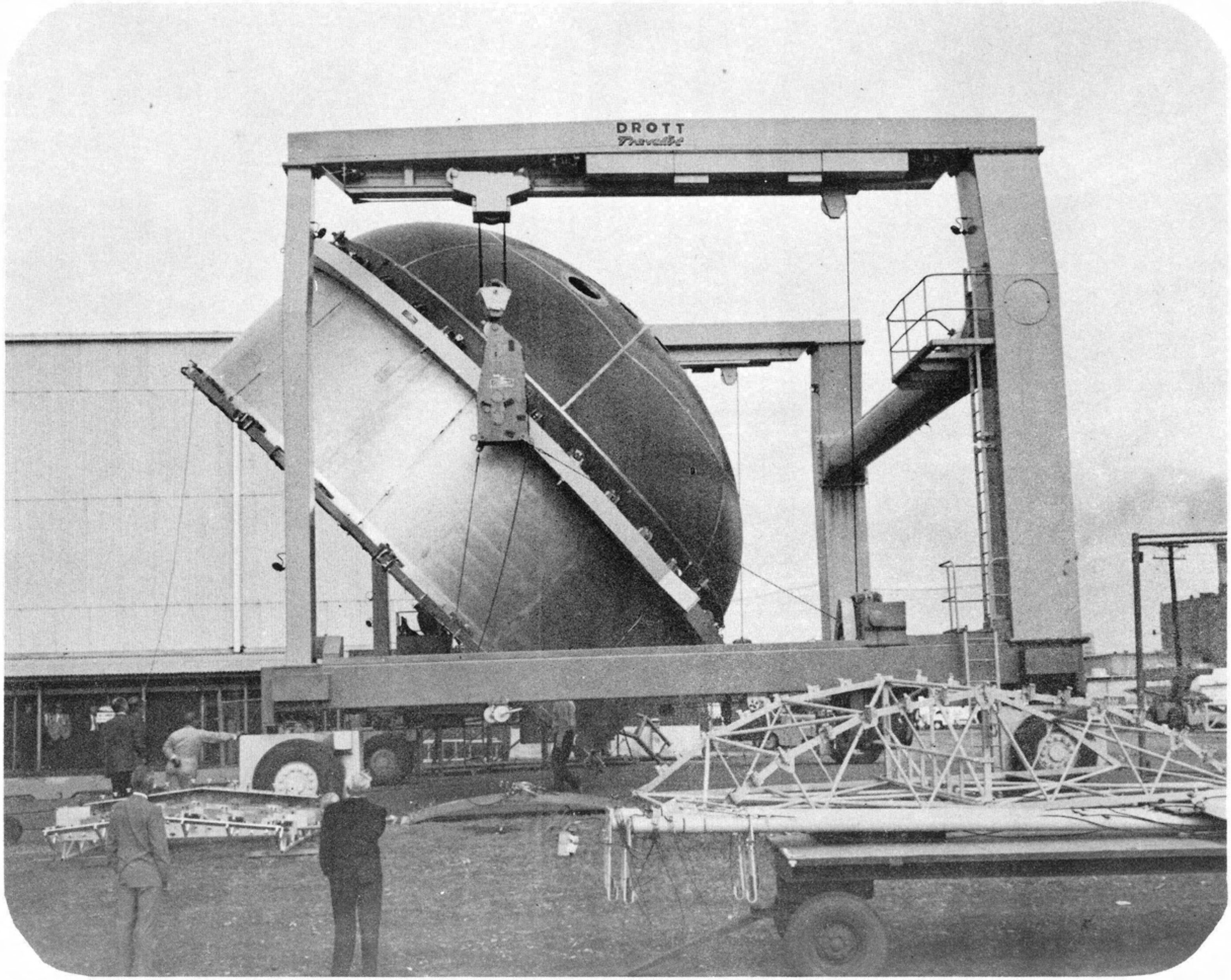
SLIDE #21. SATURN V FULL SCALE MOCKUP AREA



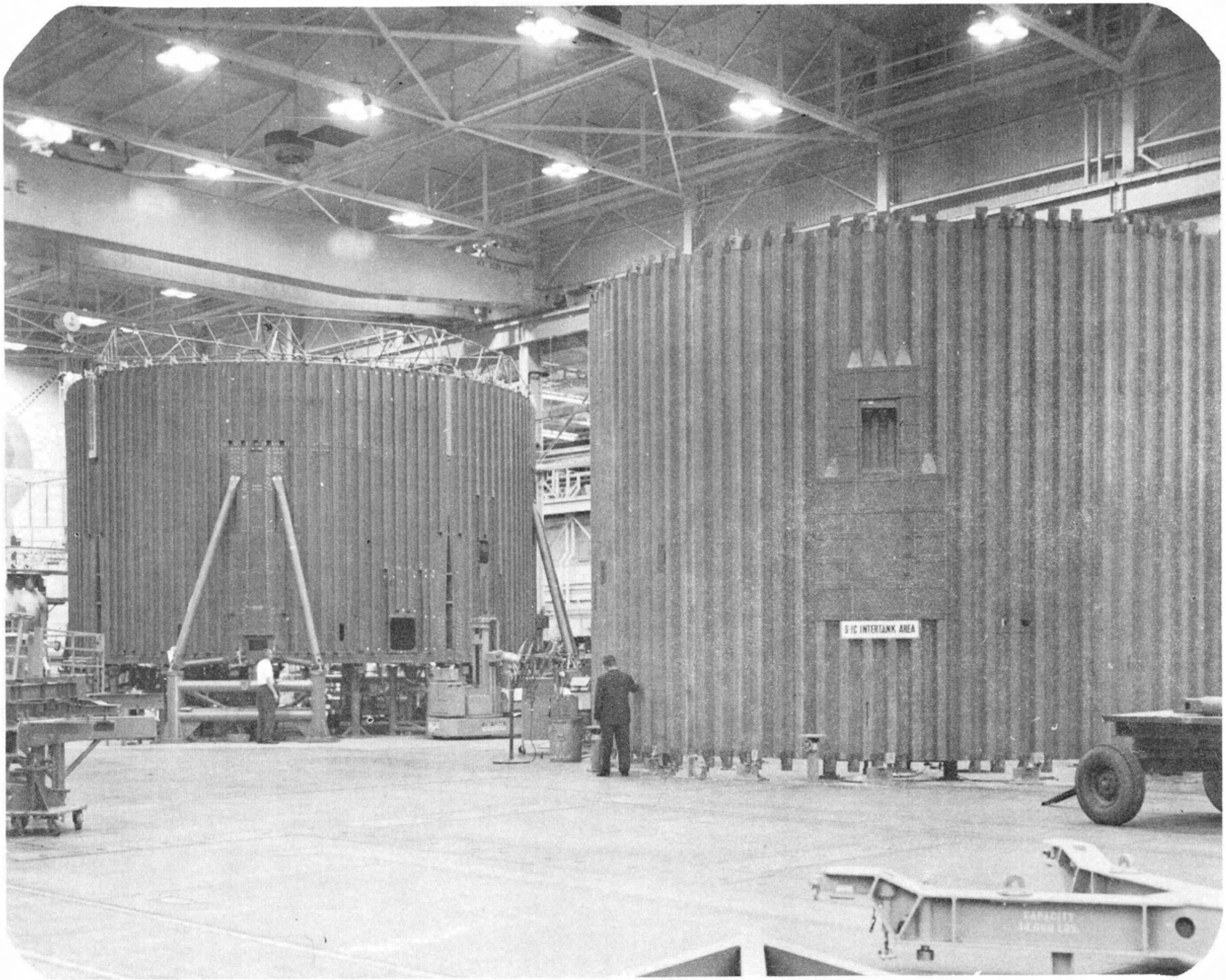
SLIDE #22. SATURN V FULL SCALE MOCKUP AREA



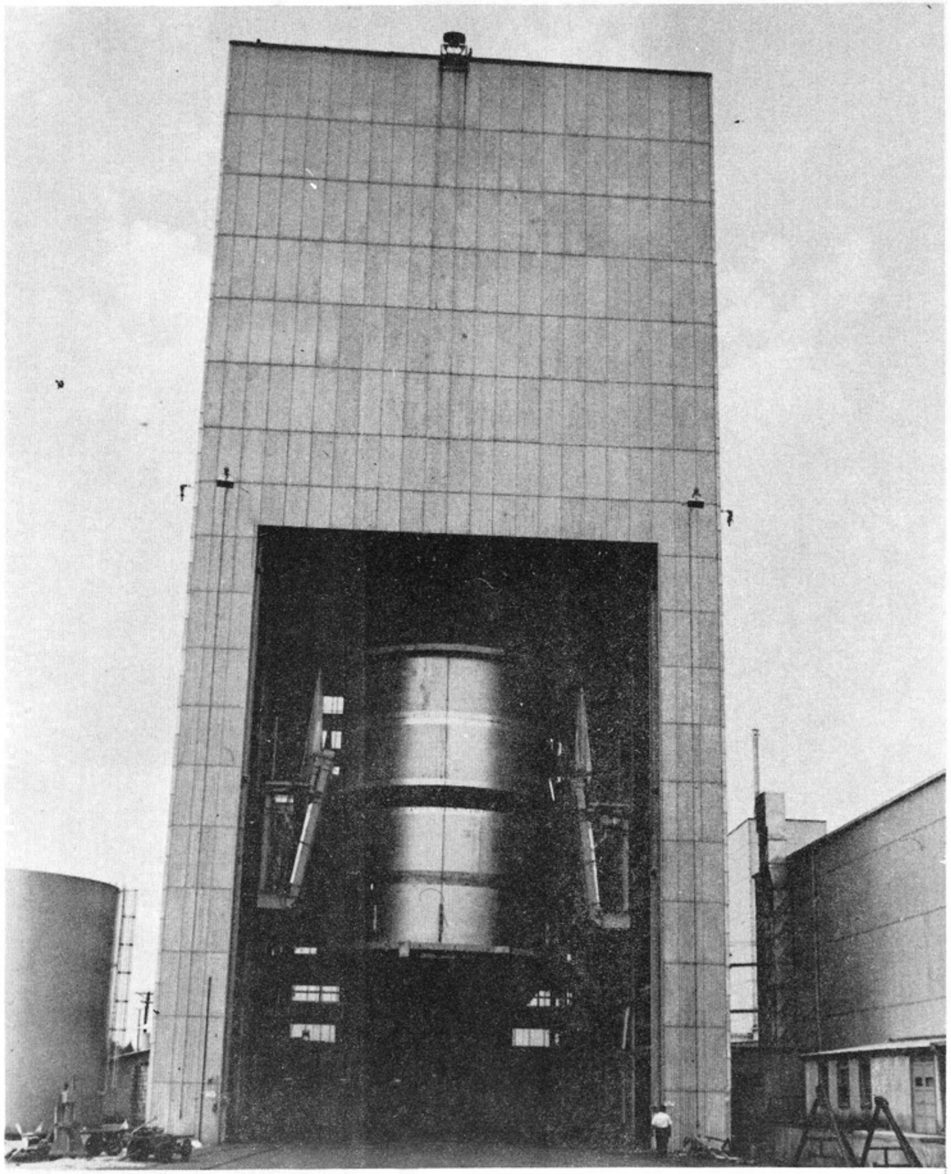
SLIDE #23. BULKHEAD ASSEMBLY STATION



SLIDE #24. C-FRAME



SLIDE #25. A-FRAME



SLIDE #26. VERTICAL ASSEMBLY TOWER WITH LOX TANK