DOCUMENTATION OF THE

300-MILE PER HOUR 7- BY 10-FOOT WIND TUNNEL

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INTRODUCTION

The origin of the 300-Mile Per Hour (300-MPH) 7- by 10-Foot Wind Tunnel of the National Aeronautics and Space Administration (NASA) may be traced to a 1928-29 investigation in the original National Advisory Committee for Aeronautics (NACA) 5-foot Atmospheric Wind Tunnel (ref. 1). This investigation is documented in reference 2 which reports the results of an experimental investigation to determine the jet-boundary corrections for a wind tunnel with a ratio of height to width of approximately 7 by 10 (1 to $\sqrt{2}$). Figures 1 and 2, taken from reference 2, show the scope and test setup used in the investigation.

The need for a facility that could accommodate models of sufficient size to represent airplane configurations fairly had been evident for some time. The concept was that such a facility would provide early determination of the stability and control characteristics of configurations and that defects could be corrected before finalization of the design. In addition, if an existing airplane was in difficulty, then corrective changes could be expeditiously determined from tests of a model. In such a facility, systematic investigations could be conducted of control devices for longitudinal, directional, and lateral controls to eliminate the undesirable arrangements. These investigations would also provide the information for the most desirable arrangements for further investigation at higher Reynolds numbers and in flight. In other systematic investigations, various high-lift devices such as leading-edge slots, plain-, split-, and slotted flaps could be developed.

The 7- by 10-Foot Wind Tunnel which was the predecessor to the 300-MPH 7- by 10-Foot Wind Tunnel was completed in 1930 and was equipped with the first independently reading six-component balance (fig. 3) which measured the moments about the center of gravity of the model. For systematic investigation, the results were read directly in coefficient form by utilizing a standard size model and running the test at a standard dynamic pressure. It is of interest that the contract price for the basic six-component balance was only $5,000. The wind tunnel (fig. 4) and balance are fully described in reference 3.

One of the first systematic investigations in this facility was of lateral-control devices with the view of increasing control at large angles of attack.

This research is reported in reference 4, and a summary of this and other related lateral-control work is reported in reference 5.

Another systematic investigation, both three and two dimensional of various types of high-lift systems, was conducted in the facility. The most promising arrangements were investigated also at flight Reynolds numbers. An interesting development in this connection was the adoption by a number of aircraft companies of a 25.66-percent-chord slotted flap. The particular chord length of the flap was an accident. By definition, at that time, the flap chord was defined as the distance from the flap-hinge axis to the trailing edge of the airfoil. The systematic two-dimensional investigation of flaps was started with a 20-percent-chord plain flap. A slotted flap used in the investigation was obtained by adapting the nose section of the Clark "Y" airfoil to the leading-edge portion of the 20-percent-chord plain flap. When measured, it was found that the overall flap chord from the flap leading edge to trailing edge was 25.66 percent of the wing chord (see ref. 6). In addition to the systematic investigation, specific high-lift arrangements such as the Zap, Hall, and Fowler flaps were investigated. Of those investigated, the Fowler and other variations of extensible slotted flaps were, and still, are used.

By actual count, over 50 specific models of airplanes for the Army, Navy, and industry were investigated and developed from the standpoint of stability and control. Among those that became well known were the Navy F-4B's, PBM's, SO3C, F2A F4F, TBF, SB2C, XBTC, F6F, and F-8F, and the Army Air Corps' P-36, P-47, P-60, B-28, and B-33. Many of these airplanes played an important role in World War II.

The justification of semi-span testing was illustrated in connection with the correction of the stick force characteristics of the Navy TBF-1 airplane. The results of the investigation are reported in reference 7. Importance of trailing-edge angle on the hinge moment of control surfaces was vividly illustrated in this investigation.

THE 300-MPH 7- BY 10-FOOT WIND TUNNEL

It was a result of the many contributions to the services and industry by the original 7- by 10-Foot Tunnel that Capt. Walter Diehl, Navy Bureau of Aeronautics, at my suggestion, prepared a letter requesting the NACA to proceed with the procurement of a modern 7- by 10-foot wind tunnel to replace the original 7- by 10-foot wind tunnel. The final approval was for two 7- by 10-foot wind tunnels - one with a top speed of approximately 300-miles per hour and the other with a top speed of approximately 500-miles per hour.

The basic concepts of the 300-MPH 7- by 10-Foot Wind Tunnel were as follows:

(a) Easy accessibility to the test section.

(b) Simple model installation facilitating quick interchangeability of models.

(c) Special model assembly carts to be rolled from the shop level floor into the test section through a large door.

(d) Three-dimensional, two-dimensional, and half- or partial-span model installations.

(e) The tunnel was equipped with a six-component, independently indicating and recording force and moment balance with moments taken about the model center of gravity. In addition, a q-balance was also included. Readings from all balances could be recorded simultaneously or could be read directly. It was, therefore, possible for a single operator to conduct tests in the tunnel.

(f) Consideration was also given to the use of young ladies in the operation of the tunnel.

On-site construction of the tunnel was started in the early winter of 1943-44 at the west end of the Langley Laboratory boundary. A view during the early construction is shown in figure 5. A view of the completed wind-tunnel structure with the unfinished laboratory building is shown in figure 6. Figure 7 is an aerial view of the laboratory before landscaping. The 300-MPH 7- by 10-Foot Wind Tunnel is in the right foreground. Figure 8 is a front view of the 7- by 10-Foot Tunnel's Laboratory after completion. The air exchange tower of the wind tunnel may be seen to the left over the second story auditorium and shop.

Some of the balance linkage system below the tunnel test section is shown in figure 9. The control console and balance arrangement in the test section are shown in figure 10.

The operating crew during a test is shown in figure 11. The operating crew are Mrs. Hazel S. Redding and Mrs. Billie J. Walker.

A skeleton crew is shown during a Christmas holiday in figure 12. The original staff of the 7- by 10-Foot Wind-Tunnel Laboratory is shown in figure 13.

The 300-MPH 7- by 10-Foot Wind Tunnel was put into operation in the month of February 1945. The initial test program to establish satisfactory flow conditions is summarized in figure 14. The loading system used in the balance calibration is shown in figure 15. The calibration of the tunnel is completely described in reference 8, and the tunnel is described in reference 9.

Before looking in detail at the research and development during the 25 years of the tunnel's operation, let us see what Mr. John G. Lowry has to say. Mr. Lowry was project engineer for the 300-MPH 7- by 10-Foot Wind Tunnel and associated equipment. I quote from Mr. Lowry as follows:

> "Looking back over the years, I guess the thing that impresses me the most was the versatility of the 300-MPH 7- by 10-Foot Tunnel. In thinking back over the jobs that were done in the tunnel, the range is very large - calibration of unmanned weather stations, Mercury escape and tower stabilities, flying boat hull drag studies, escape capsules for fighters, bomb and missile separation from military aircraft, stability and control tests of very low-speed airplanes to supersonic configurations, tests of flexible airplanes and parachutes, two-dimensional tests of propeller, simulated jet, and actual rocket-powered airplanes, just to name a few.
>
> The simplicity of the tunnel model supports and scale systems resulted in a tunnel in which accurate data could be obtained with minimum crew training. The ease and simplicity of getting models into and out of the tunnel provided for very efficient operation of the facility.
>
> Trying to single out specific jobs that were done in the tunnel that were potentially significant to the overall low-speed aerodynamics field is hard to do. I think that many of the 'bootlegged' tests that were run has as much significance as many of the well planned programs. For example: The time a spoiler was attached to a swept wing and indicated for the first time that spoilers would work if located correctly on the wings. Prior to this,all tests of spoilers on swept wings had showed very little, if any, roll effectiveness.
>
> The initial work on jet flaps may well prove to be very valuable work if the air transport industry turns to jet-powered STOL aircraft with augmented flaps and controls.
>
> I guess the early work on swept wings might deserve a mention including the work done on variable sweep.

When you really sit back and try and decide why this particular tunnel was so successful, I feel that one must turn to the staff of engineers, technicians, and mechanics that ran it over its 25 years of service. It was their desire to do a good job, their inventiveness, their adaptability to the many different problems and disciplines encountered etc., that gives the Langley 300-MPH 7- by 10-Foot Tunnel a glorious history."

DEVELOPMENT OF RESEARCH TOOLS

The 7- by 10-Foot 300-MPH Tunnel had been in operation less than a year when it was decided to utilize the pressure difference in the test section and the outside atmospheric pressure to power a small induction tunnel. This tunnel had a test section about 10- by 14-inches with both the inlet and exit shaped like the 7- by 10-foot tunnel. A photograph of a portion of this tunnel is shown in figure 16. The tunnel was used to develop the throat for the High-Speed 7- by 10-Foot Wind Tunnel which increased the speed from about Mach 0.75 to choke. Later the transonic bump used in the High-Speed 7- by 10-Foot Tunnel was developed in this facility. This work is described in reference 10.

The work done in this facility on oscillating flow for the study of unsteady aerodynamic predates the technique later developed for the Transonic Dynamics Tunnel.

As the work on VTOL and STOL configurations intensified, the need for a facility suitable for routine study of the transition from hovering to normal cruising was needed. In order to satisfy partially this requirement, a 17-foot test section was installed just ahead of the 7- by 10-foot test section. (See fig. 17.) The shapes of the entrance cone and test section for this facility were developed in the induction tunnel. To the best of my knowledge, this series of working sections in a wind tunnel was never achieved before. Since the installation of the 17-foot test section in October 1956, it was continually used until the operation of the 300-MPH 7- by 10-Foot Tunnel was discontinued in May 1970. In fact, over the last 10 or 12 years of operation, it was used more extensively than the 7- by 10-foot test section. It is very interesting to read the tunnel log and note that models were in both test sections simultaneously. While one was being tested on the day shift, the other was being tested on the night shift.

From the early thirties, and all through the subsequent years, ground effect has been determined in a wind tunnel by use of a flat plate that could be located in proximity to a model. While this technique had proved very useful, it still was not entirely satisfactory because of the build up of boundary layer on the plate. This was especially true when the model was very close to the ground board. To overcome this deficiency, a moving-belt ground-plane simulation was developed for the 17-foot test section (ref. 11).

SPECIFIC HIGH-SPEED MILITARY AIRPLANES

It was appropriate that the first complete powered model tested in the tunnel was the Fleetwing XBTK-1 for the Navy (May 1945). A photograph of this model in the landing configuration is shown in figure 18. Figure 19 shows what happened when the propeller of a model failed during operations. In spite of the accidents that do occur in the operation of a wind tunnel, no serious damage to the faiIiity had occurred during the 25 years of operation. Soon after this, tests were made on a free-to-roll setup of the CTC Johns Hopkins missle for the military. The purpose of this investigation was to provide information for automatic roll stabilization. Following these investigations, other models such as the XP84, L-39 (fig.20), F-84, F-86 (fig. 21), F-10F, F-100, F-103, F-104, F-105, F-3H, F-4D, and F-8U were investigated. In the early fifties, the investigation of the low-speed characteristics of fighter-type models was transferred to the High-Speed 7- by 10-Foot Wind Tunnel. As near as I can determine, one of the last of the fighter models tested in the 300-MPH 7- by 10-Foot Wind Tunnel was the Republic F-103, shown mounted over the ground board in figure 22.

Other types of tests in support of the military were quite varied. Development of the bomb-bay configurations is shown by simulated bomb drops with original bomb bay (fig. 23),and modified bomb bay (fig. 24)

The trajectory of rockets, when fired from wing-mounted positions on aircraft, are influenced by the flow disturbance from the wing. A study of this problem is illustrated in figure 25 where model scale rockets are shown being fired from a fighter model.

Among the methods considered for escape from high-speed fighter aircraft was by ejection of the pilot compartment which had to be stabliized. A simulation of such a system is illustrated in figure 26.

From about the middle of 1952 until about the middle of 1955, considerable work was done in support of the Army helicopter development. A typical installation of a helicopter model in the tunnel is shown in figure 27.

RESEARCH AIRPLANE DEVELOPMENT

An important role in the development of the low-speed and launching characteristics of the research airplane was determined in the tunnel. The first of these was the X-1 shown in figures 28 and 29. This development program covered the Navy-NACA cooperative programs on the D-558 Phase I and II. In addition, in cooperation with the Air Force, the X-2, X-3, and X-5 were all developed in conjunction with high-speed tests in other facilities. The X-2 was the first of these with a swept wing; the X-3 was an application of low-aspect-ratio for supersonic speed. The X-5 was the application of variable sweep to obtain good low-speed characteristics with small angles of sweep. The last research airplane model development in the tunnel was the X-15. This investigation dealt primarily with the separation and launch characteristics as the model was released from the mother airplane, the B-52. Figure 30 shows the model of the X-15 mounted below the wing of the model of the B-52 in the launch configuration, and figure 31 is a multiple exposure photograph showing the location of the X-15 at equal time intervals after being released from the B-52.

GENERAL RESEARCH

Beginning in the late forties and on into the mid fifties, considerable effort was directed to the development of seaplane hulls. This work covered a wide range of length-beam ratio well beyond what was considered practical. A typical arrangement is shown in figure 32. For this investigation, the hull models were mounted on a two-dimensional wing setup in the tunnel.

Work on the control devices for roll control was continued primarily to determine systems that would be satisfactory for swept wings with and without high-lift devices. Typical setups for development of lateral-control devices are shown in figures 33 and 34. Previous research had indicated that spoilers were not very effective on swept wings. It was found, however, that when they were placed perpendicular to the relative wind rather than along a constant chord position that they were very effective.

It had been determined early in the investigation of swept wings that there was a correlation between wing aspect ratio and sweep on the pitching-moment characteristics. It was also found that the vertical location of the tail with respect to the wing chord plane had a profound effect on the pitching-moment characteristics of a complete model. Some of the wing and tail effects were discussed during the 1946 Annual Inspection (see fig. 35). Much effort was devoted to the determination of satisfactory configurations. The results of this research have been used throughout the industry in both this country and foreign countries to determine satisfactory arrangements.

Other approaches to cure the adverse effect on the longitudinal stability characteristics of swept wings were by use of fences, leading-edge notches, and tip extensions. These devices interrupted the lateral flow along the wing and thus delayed tip stall, which was responsible for the instability at large angles of attack of swept wings. Another approach to curing the unsatisfactory longitudinal characteristics of swept wings was the possible use of M- or W-planforms. Two installations of these types of wings in the tunnel are illustrated in figures 36 and 37. Swept forward wings inherently have a tendency toward structural divergence with increasing angle of attack. A W-planform wing used in the investigation of this phenomenon is shown in figure 38. This wing is constructed of segments joined together elastically, this providing a very flexible wing for the study of the divergent characteristics.

In the late fifties and early sixties, considerable effort was underway at Langley looking toward a supersonic transport. In order to determine the low-speed characteristics of proposed configurations, low-speed models were constructed and investigated in the 300-MPH 7- by 10-Foot Wind Tunnel. An example of one such model is shown mounted on the single strut support in the wind tunnel (fig. 39).

The George C. Marshall Space Flight Center, through contract and otherwise, had an extensive program on the transport of Saturn boosters from the manufacturer to the launch site. Langley Research Center supported this program. An example of one concept is illustrated in figure 40 which shows the second stage of a Saturn booster model mounted on a model of the C-133 in the tunnel.

The Langley Research Center has over the years carried out both an experimental and analytical research program in spinning directed at both prevention and recovery. With the increase in speed and wing loading of aircraft, it became necessary to rely to a greater extent on analytical techniques. To supply inputs to support this program, an extensive research program was initiated in the tunnel on the two-dimensional characteristics of cylinders of various cross-sectional shape covering the probable fuselage cross-sections of airplanes. One of the models used in this investigation is shown mounted in the tunnel (fig. 41).

MISCELLANEOUS INVESTIGATIONS

Because of its ease of operation and many mounting arrangements, specific investigations of a wide variety of projects were investigated in the tunnel. A selected few are illustrated in figures 42 to 48, inclusive and cover the time period from the late forties until the Tunnel was deactivated in 1970. The titles of these figures are generally self-explanatory. The models shown in figures 42 to 45 were tested in the 7- by 10-foot test section. The models shown in figures 46 and 47 were tested in the 17-foot test section utilizing the moving-belt ground board. It might be mentioned that the air-cushion landing gear (fig. 47) was a concept for landing in unprepared areas. The rooftop type of STOLport with wind screens on the side develops eddy flow over the surface. The investigation illustrated in figure 48 was to study the flow fields with the wind from the various directions.

A study of jet-tail interference is illustrated in figure 49. The streamers indicate the flow of the jet exhaust with respect to the tail. This investigation utilized the moving-belt ground board in the 17-foot test section.

SHORT TAKEOFF AND LANDING (STOL)

The utilization of power effects to augment the aerodynamic lift of various aircraft configurations received considerable attention in the 17-foot test section of the 300-MPH 7- by 10-Foot Wind Tunnel. One concept used the propeller slipstream to augment lift over the flapped wing (fig. 50). One application of this research is the OV-10A currently in operational use by the Marine and Air Force. The flow field around a wing with a jet-augmented flap is illustrated in figure 51. A model of a Boeing 707 airplane, modified to incorporate a jet-augmented flap, is shown in figure 52. The airplane, equipped in like manner, illustrated the capabilities of the system. A different approach to the application of a jet-augmented flap to a jet airplane is illustrated by the externally blown flap configuration in figure 53. In this case, the exhaust from a fan-jet engine is directed over the slotted flap. This is analogous to utilizing the slipstream over the wing and flap of a propeller-driven airplane. Another externally blown flap configuration utilizing an early version of the supercritical airfoil is illustrated in figure 54.

Research effort has been continued throughout the years on power effects on propeller-driven airplanes. An example of a half-span counter-rotating propeller model used in this research is shown in figure 55. Another technique used in the study of slipstream effects, utilizing a tuft grid, is illustrated in figure 56.

VERTICAL TAKEOFF AND LANDING (VTOL)

Beginning in the early fifties, it became evident with the increase in powerplant capability that vertical takeoff and landing aircraft (VTOL) were feasible. The research in the development of high-lift systems such as slotted flaps, jet-augmented flaps, and leading-edge devices (such as leading-edge flaps and slats) was intensified and carried to angles of attack well outside of what had previously been considered the operating range. A half-span research model with leading- and trailing-edge high-lift devices completely immersed in the slipstream is shown in figure 57. This work lead to the USAF tilt-wing XC-142 aircraft. A model of this aircraft is illustrated over the moving belt ground plane in figure 58. The limitation of the 7- by 10-foot test section for this type of research became increasingly evident and resulted in the installation of the 17-foot test section previously described. A two-propeller half-span model in the 17-foot test section is shown in figure 59. A different ground-board installation with a six-propeller general research model is shown in figure 60. The shortcomings of the fixed-plane ground board became more evident with these types of models and resulted in the development of the moving-belt ground simulation previously described.

One of the first VTOL airplanes was built by the Fairchild Company, and a model of this airplane is shown mounted in the 17-foot test section (fig. 61). This airplane used a high-lift flap arrangement and a high noseup attitude to hover. It had appeared from general research that a combination incorporating these features appeared most promising.

Another concept considered for VTOL aircraft was the use of ducted fans. A general research model incorporating a ducted fan is shown (fig. 62) mounted in the 17-foot test section. A research airplane incorporating this concept was built by the Doak Airplane Company and successfuly demonstrated. Another model incorporating four ducted fans is shown in figure 63.

A different concept of a ducted fan is a fan-in-wing, illustrated in figure 64, in which the duct had vanes at the top and bottom of the wing which could be adjusted for the various flight conditions. In this arrangement, the exhaust from the jet engine or engines was used to operate the fans for takeoff, landing, and transition. In the cruise condition, the ducts were closed; the thrust from the jet engine was used directly for propulsion.

Considerable research effort was devoted to various concepts of a jet or fan-jet aircraft. Three of these are illustrated in figures 65 to 67. The model shown in figure 65 incorporates different jet engines for takeoff and landing from those used for cruising. The concept illustrated in figure 66 for the United States/Federal Republic of Germany (US/FRG) VTOL fighter configuration utilizes tiltable jets to cover the various phases of flight. In figure 67, fan jets are mounted in both the wing and fuselage with different deflections of the wing propulsive lift to cover the various flight regimes.

AIR-CUSHION VEHICLE RESEARCH

About the middle fifties, a new type of vehicle which incorporated a shield or curtain of high velocity air around the perimeter was conceived. This curtain provided a cushion of high pressure under the vehicle when in close proximity to the ground. Such vehicles have been called ground-effect machines, and for short - GEM. The machines work equally well over ground or water but are confined to very close proximity to the surface. A close-up of a model of such a machine is shown in figure 68. The tufts indicate the direction of airflow. Vehicles utilizing this principle have been built for use over both land and water. A research program in support of the Department of Transportation was undertaken on air-cushion concepts for a proposed Tracked Air-Cushion Research Vehicle (TACRV) as part of a future high-speed ground transportation system (fig. 69).

FLEXIBLE-WING RESEARCH

Soon after World War II, Mr. Francis M. Rogallo, as an extracurricular activity, was experimenting with flexible kites. He extended this work to flexible gliders that could be thrown into the air where they would deploy and glide to a landing. The military became interested in this type of vehicle,and as a consequence, work was initiated at Langley to obtain quantitative information. The recovery of a large flexible-wing model (paraglider) is illustrated in figure 70. These vehicles were constructed with both inflatable and rigid leading edges and keels. Some of the potential applications of the flexible-wing principle are illustrated in figures 71, 72, and 73. An airplane recovery concept is illustrated in figure 71. In figure 72, a model of a flexible-wing aircraft is illustrated. In both of these illustrations, rigid leading edges and keels are used. A completely flexible wing is illustrated in figure 73 which shows a model of the Apollo spacecraft in a possible recovery arrangement. The sequence of pictures in figure 74 illustrates the deployment of a flexible-wing model in the 300-MPH 7- by 10-Foot Wind Tunnel. The opening loads are critical in the deployment of flexible wings. To obtain information on opening loads, a fundamental investigation was initiated in the 300-MPH 7- by 10-Foot Tunnel. In this investigation, inflatable balloons of different porosities were deployed, and time histories of the loads during opening were measured. In figure 75, Mr. John Lowry, the writer, and Mr. F. M. Rogallo are shown examining one of the models. This, incidentally, was the last investigation conducted in the 300-MPH 7- by 10-Foot Tunnel before its deactivation in 1970.

REENTRY RESEARCH

The low-speed characteristics of reentry configurations were investigated in the 7- by 10-Foot Wind Tunnel in collaboration with and support of tests in other facilities. A retractable-wing configuration used in this investigation is shown in figure 76. Figure 77 shows a fixed-geometry configuration which was tested in the tunnel.

VARIABLE-SWEEP RESEARCH

In 1947, because of the interest in variable sweep, intensive research was initiated in the 300-MPH 7- by 10-Foot Wind Tunnel to provide design information. An existing X-1 airplane model, modified to allow for wing-sweep variations, was used (see fig. 78) in the study. The results of this research led to the previously mentioned X-5 variable-research airplane and the Grumman F-10-F, both of which were also tested in this wind tunnel. In the late 1950's, interest in variable sweep was renewed, and a research program directed towards the development of a new wing concept in which the sweep is variable, but no fore and aft translation of the wing is required, was initiated in the High-Speed 7- by 10-Foot Wind Tunnel and augmented by studies in the 300-MPH 7- by 10-Foot Wind Tunnel. A model incorporating the resulting outboard pivot variable-sweep wing concept, which led to the F-111 and F-14 aircraft, was tested in this tunnel in 1959 and is shown mounted on a sting support system in figure 79.

PEOPLE

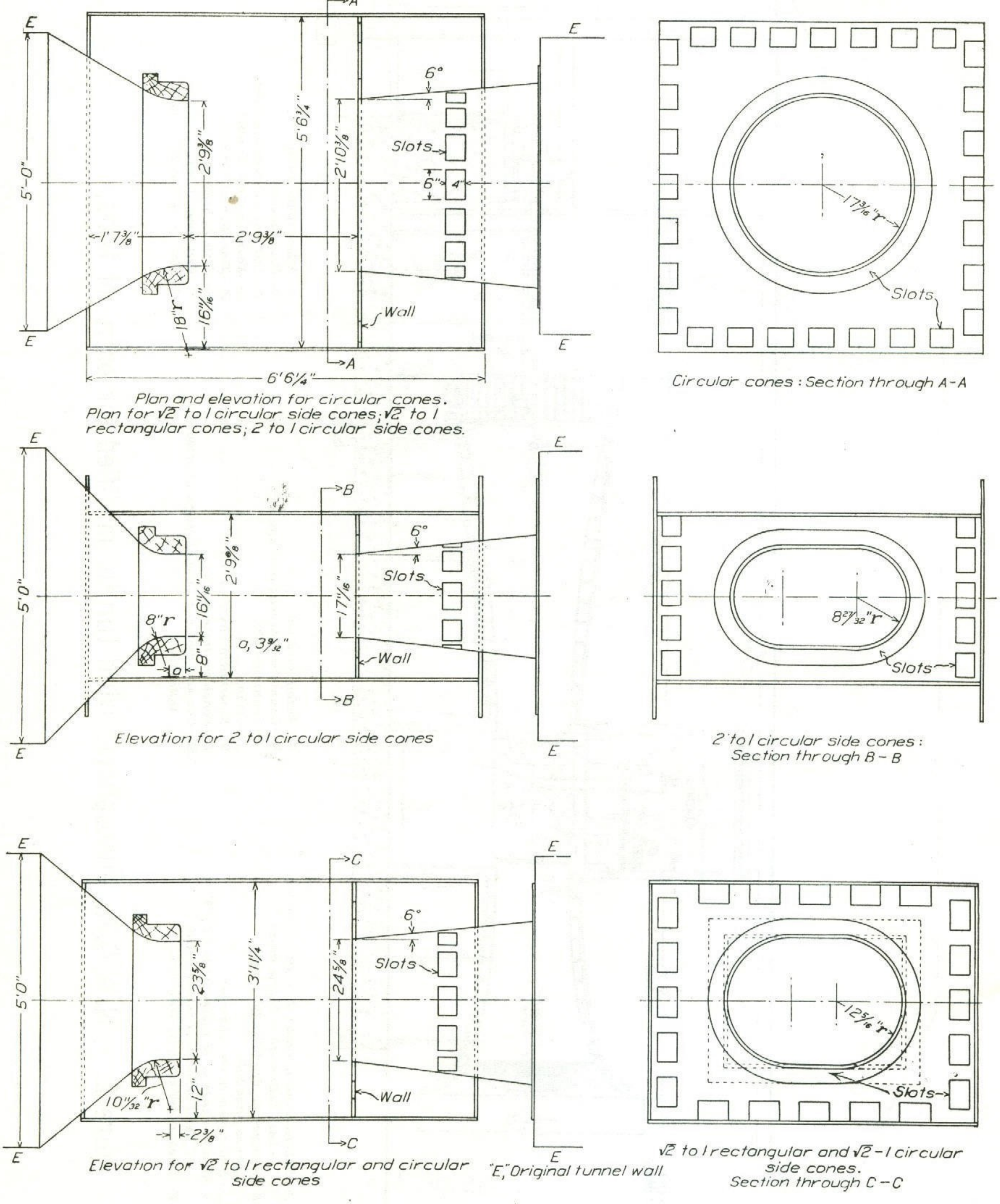
The success of an operation depends entirely on the people responsible; not only the professional staff, but also the supporting staff. It is not possible for me to list the members of the supporting staff, which includes the shop, the tunnel operation, the data reduction, and the figure preparation crews. Suffice it to say that there has always been a high degree of competence, dedication, and cooperation throughout the 25 years of operation of the facility.

The preparation of a bibliography, covering the research carried out in the tunnel, would include hundreds of papers. Instead of a bibliography, the following is a list of some of the names of authors of papers that cover the research associated with the Tunnel:

William J. Alford, Jr.	Delwin R. Croom
Edwin E. Davenport	Albert G. Few
Jack Fischel	Paul G. Fournier
Thomas G. Gainer	Garl L. Gentry, Jr.
Kenneth W. Goodson	Kalman J. Grunwald
Alexander D. Hammond	John R. Hagerman
William C. Hayes, Jr.	William P. Henderson
Jarrett K. Huffman	William B. Kemp, Jr.
Richard E. Kuhn	Vernard E. Lockwood
John G. Lowry	John W. McKee
Linwood W. McKinney	Harry L. Morgan, Jr.
Rodger L. Naeseth	James H. Otis
W. Pelham Phillips	Edward C. Polhamus
Edward J. Ray	John M. Riebe
Francis M. Rogallo	Kenneth P. Spreemann
William C. Sleeman, Jr.	Bernard Spencer, Jr.
Robert T. Taylor	Thomas R. Turner
Raymond D. Vogler	Richard J. Margason
Arthur W. Carter	William G. Johnson, Jr.
Matthew M. Winston	Frank M. Bugg
Joseph Weil	Robert Becht
William C. Hayes	Robert F. Thompson
John W. Draper	Richard G. MacLeod
William Moseley	Joseph E. Fikes
James W. Wiggins	James M. Watson
William Morrison	Harold S. Johnson

Thomas A. Harris

Thomas A. Harris



Plan and elevation for circular cones. Plan for √2 to 1 circular side cones; √2 to 1 rectangular cones; 2 to 1 circular side cones.

Circular cones: Section through A-A

Elevation for 2 to 1 circular side cones

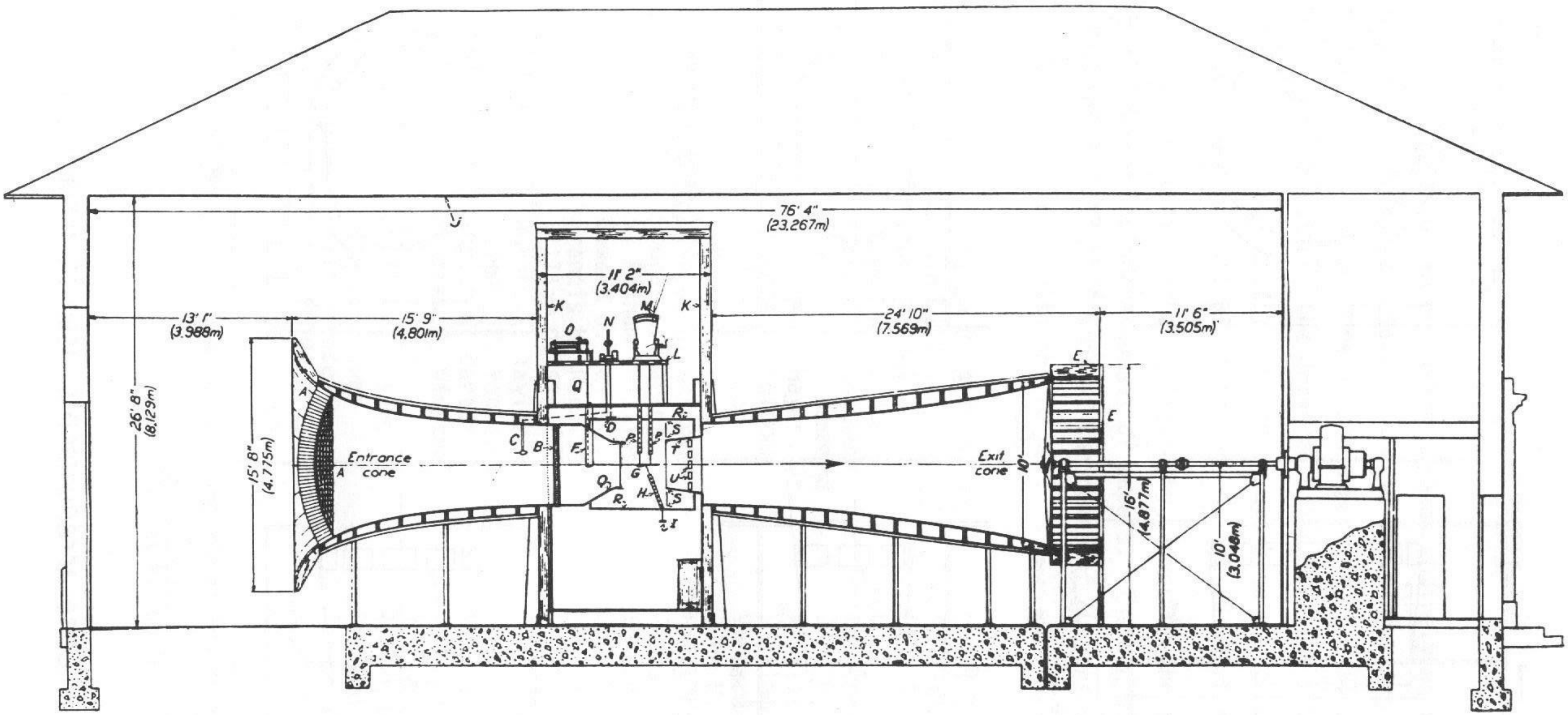
2 to 1 circular side cones: Section through B - B

Elevation for √2 to 1 rectangular and circular side cones

"E," Original tunnel wall

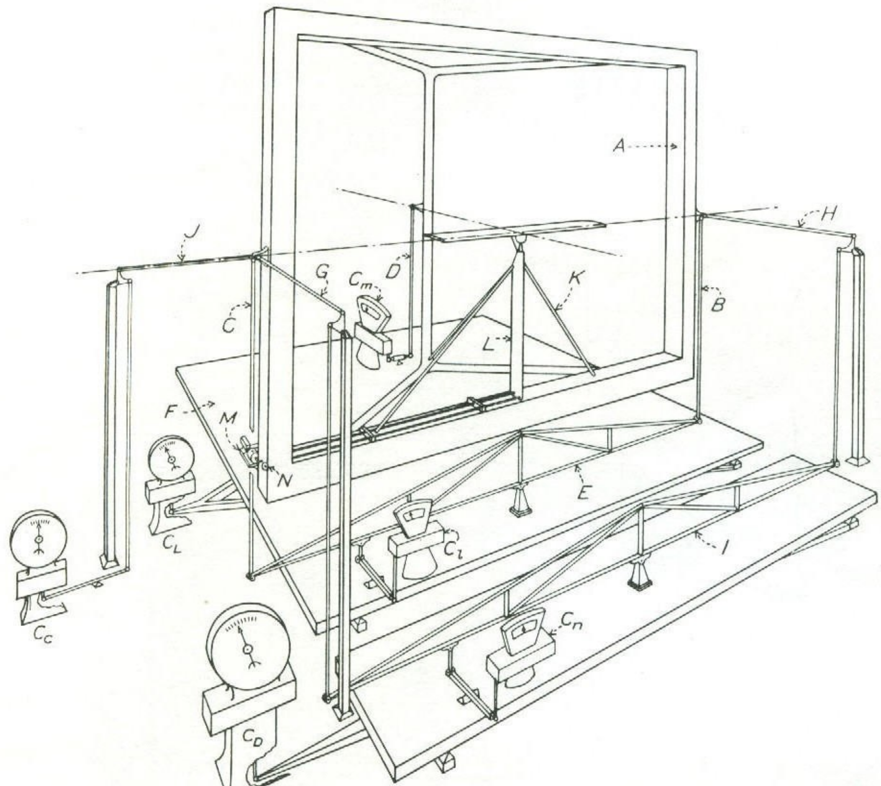
√2 to 1 rectangular and √2 - 1 circular side cones. Section through C - C

Figure 1. - Cone arrangements used in force tests.



A—Spherical honeycomb (12" × 2½" ± conical tubes), bellmouth of beaver board.
B—Honeycomb-fine (3" × ⅜" tubes).
C—Service pitot tube.
D—Static plate in test chamber.
E—Squirrel cage of 48 radial vanes (3' × 9" × ⅛") and deflector of beaver board.
F—Streamlined strut for drag wire.
G—Airfoil, inverted.
H—Counterweight wire boot and wire.
I—Counterweight.
J—Ceiling.
K—Experiment chamber wall.
L—Bench for instruments.
M—Lift and moment balance, angle of attack indicator.
N—Micro-manometer.
O—Drag balance.
P—Lift and moment wire boots.
Q—Entrance cone (model).
R—Test chamber (model).
S—Slots in baffle wall.
T—Exit cone (model).
U—Slots in exit cone (model).

Figure 2. - N.A.C.A. atmospheric wind tunnel modified for open jet tests.



A, Floating framework
B, C, Lift and rolling moment members.
D, Lift and pitching moment member.
E, Lift and rolling moment truss.
F, Lift scale platform.
G, H, Drag and yawing moment members.
I, Drag and yawing moment truss.
J, Side drag member.
K, Tripod for supporting model.

L, Vertical tube to which model is secured.
M, Motor for changing angle of attack.
N, Handwheel for changing angle of yaw.
C_L, Lift scale head.
C_D, Drag scale head.
C_c, Cross wind force scale head.
C_m, Pitching moment scale head.
C_l, Rolling moment scale head.
C_n, Yawing moment scale head.

Figure 3. - Diagram of the 6-component balance.

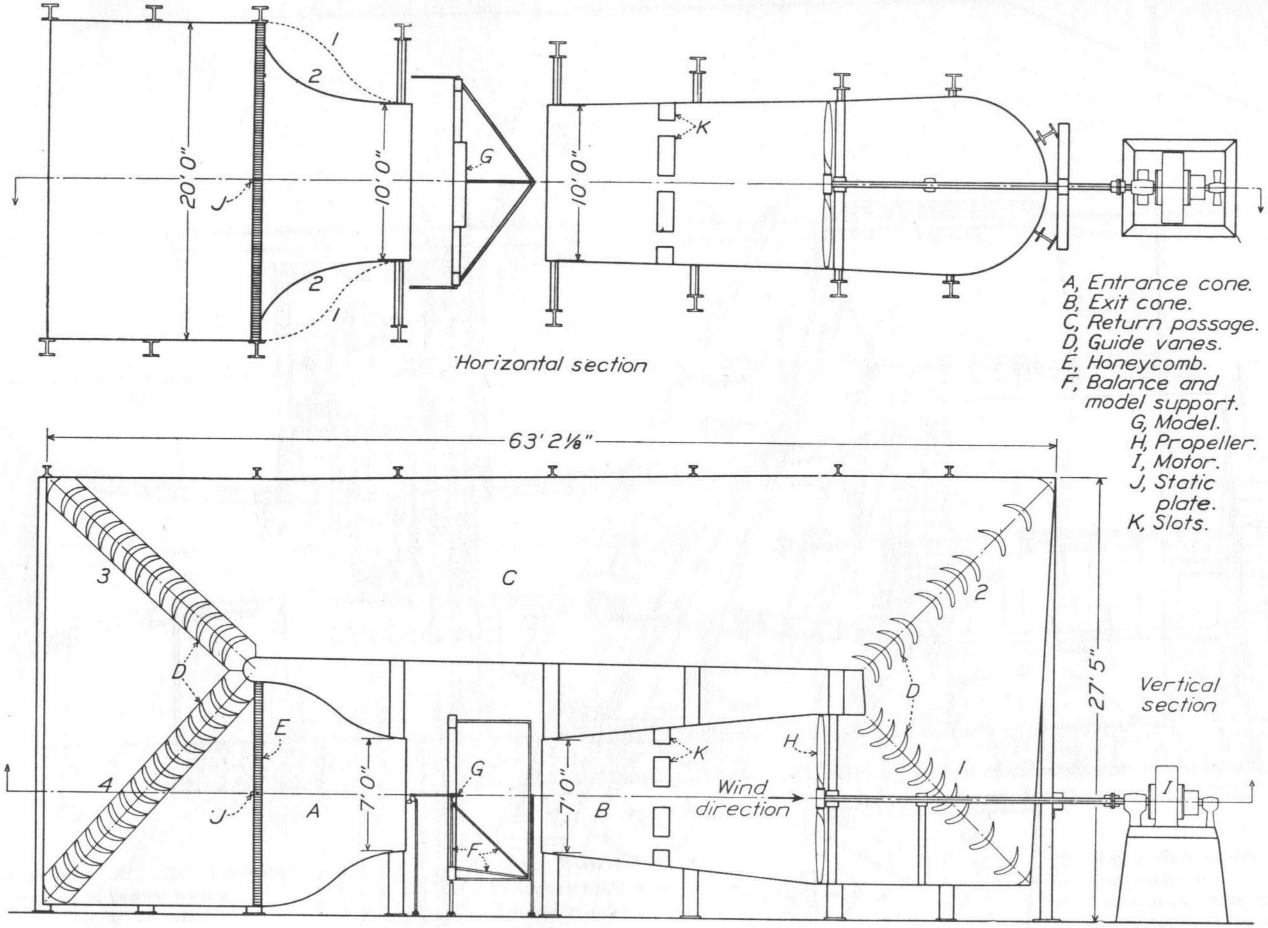


Figure 4. - Diagram of the tunnel.

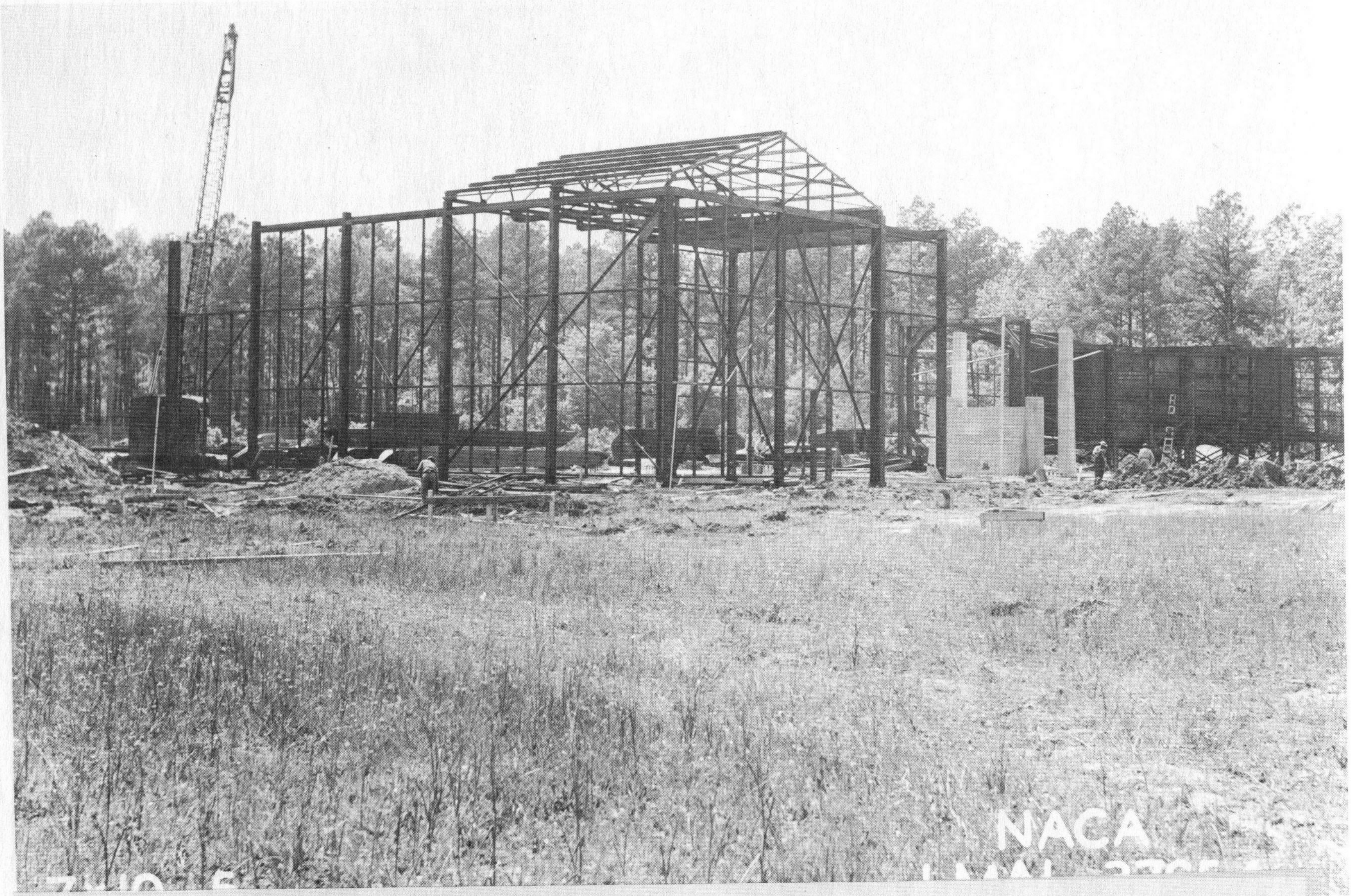


Figure 5. - Construction photograph of 300-MPH 7- By 10-Foot Wind Tunnel.

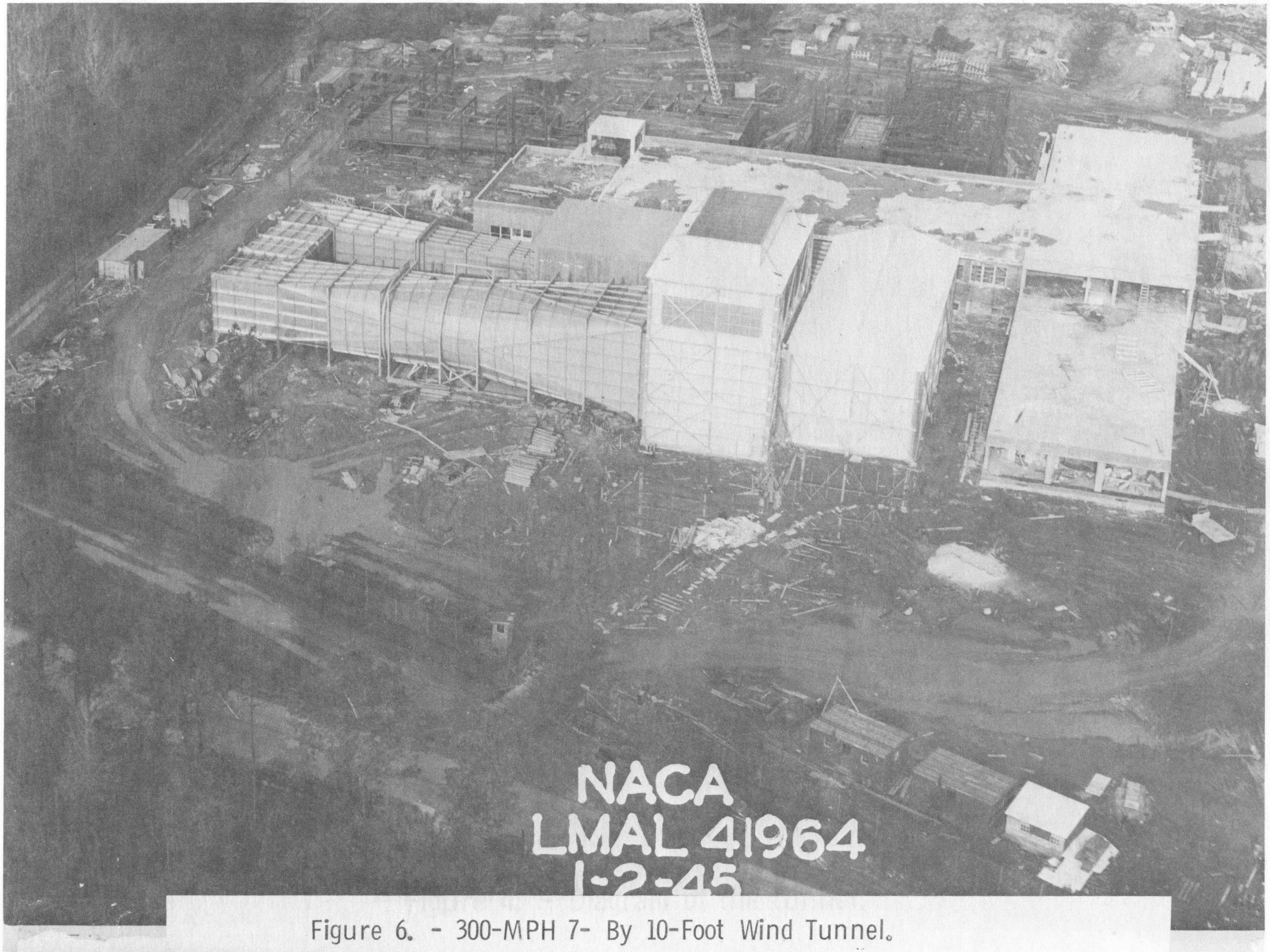


Figure 6. - 300-MPH 7- By 10-Foot Wind Tunnel.

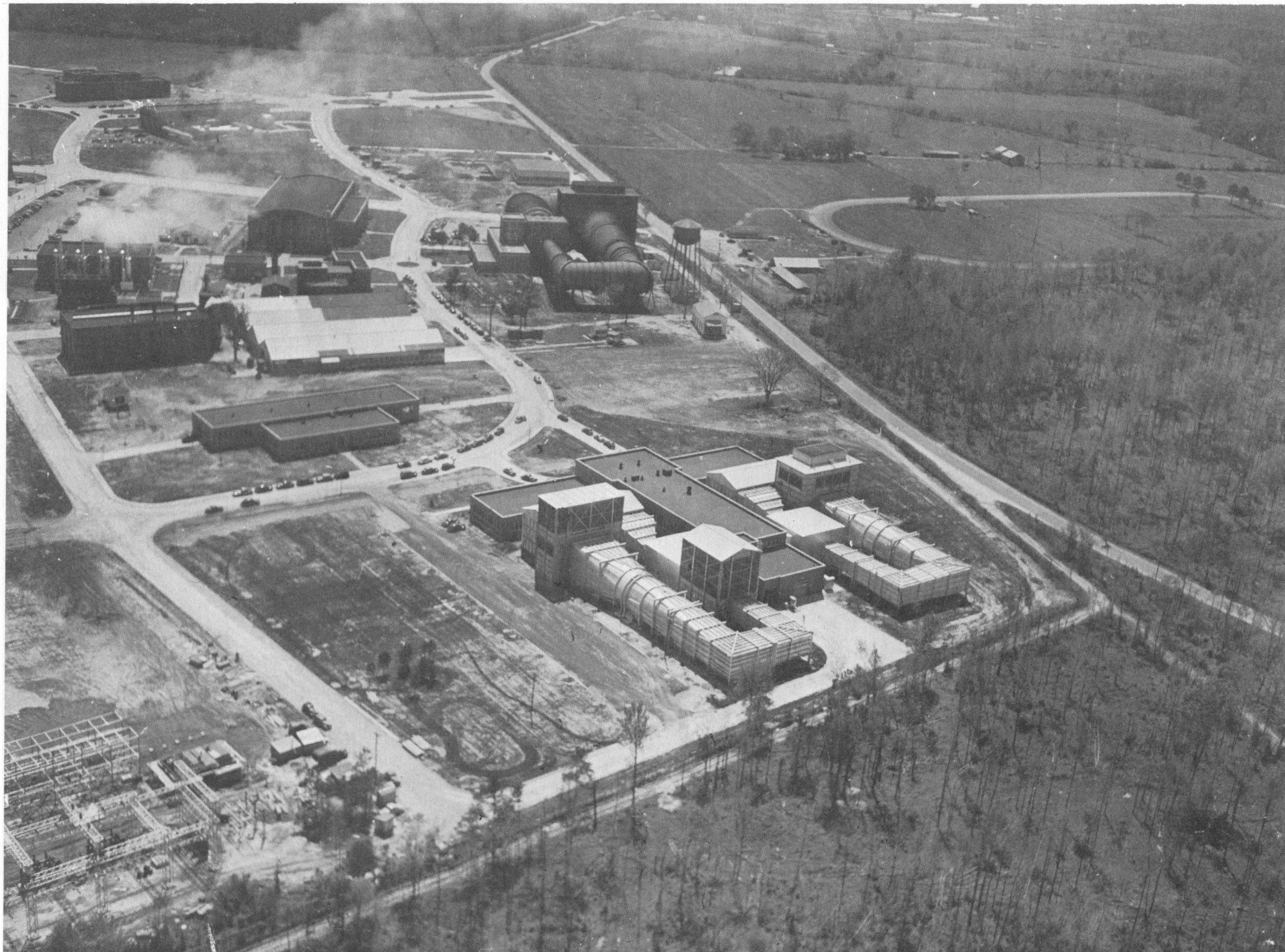


Figure 7. - Aerial view of the finished laboratory.

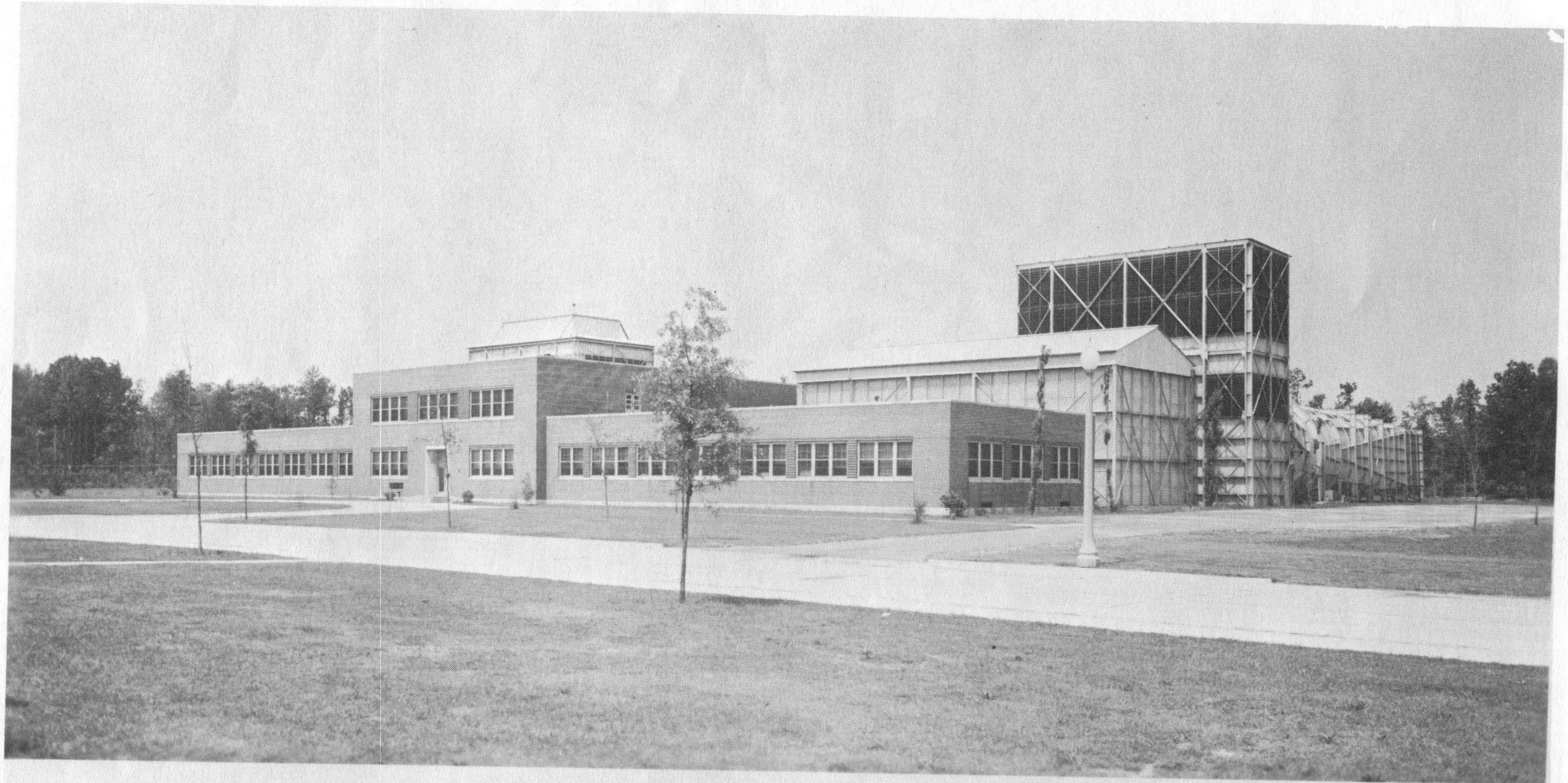


Figure 8. - Front view of finished laboratory.

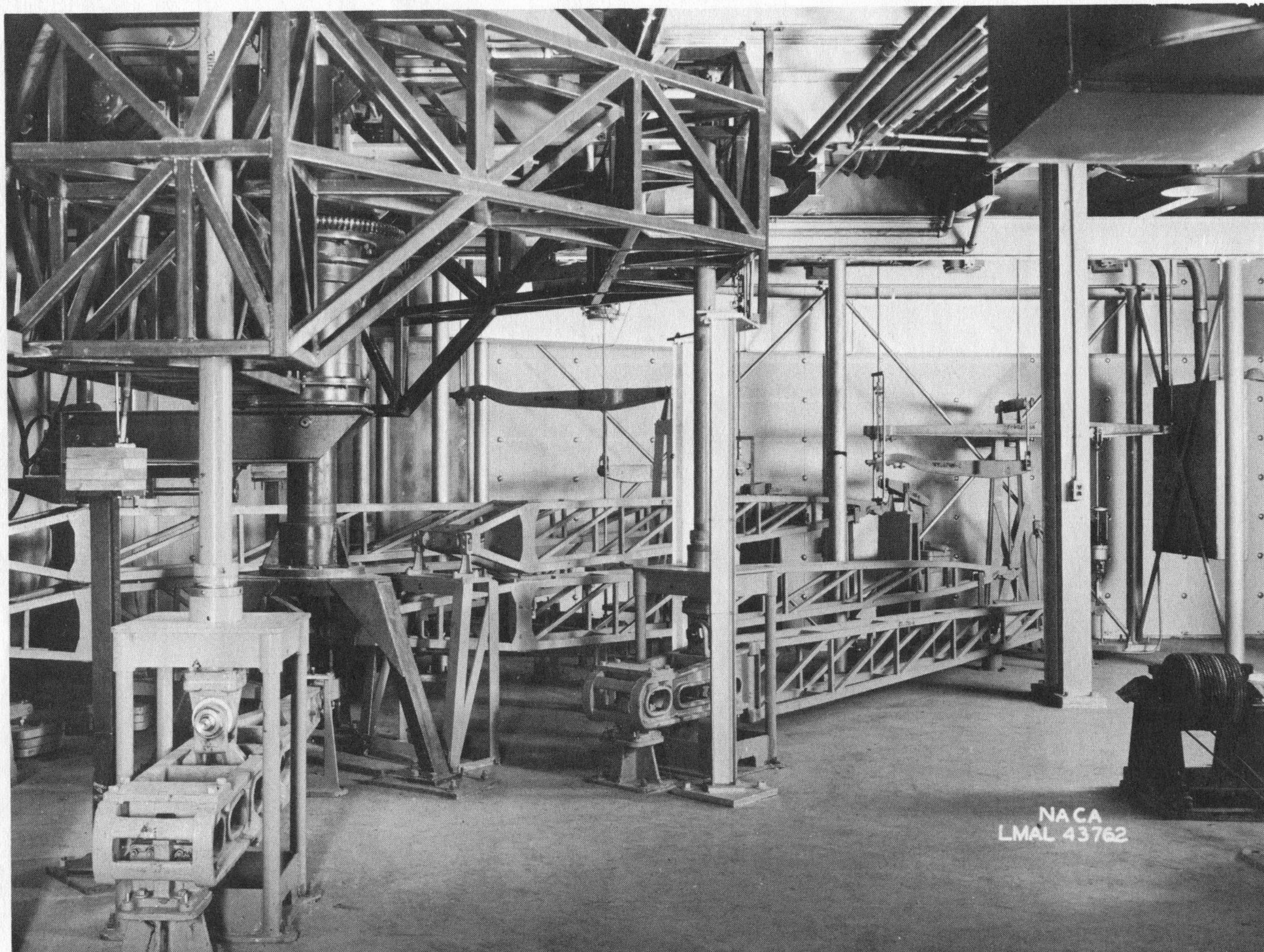


Figure 9. - View of balance linkage.

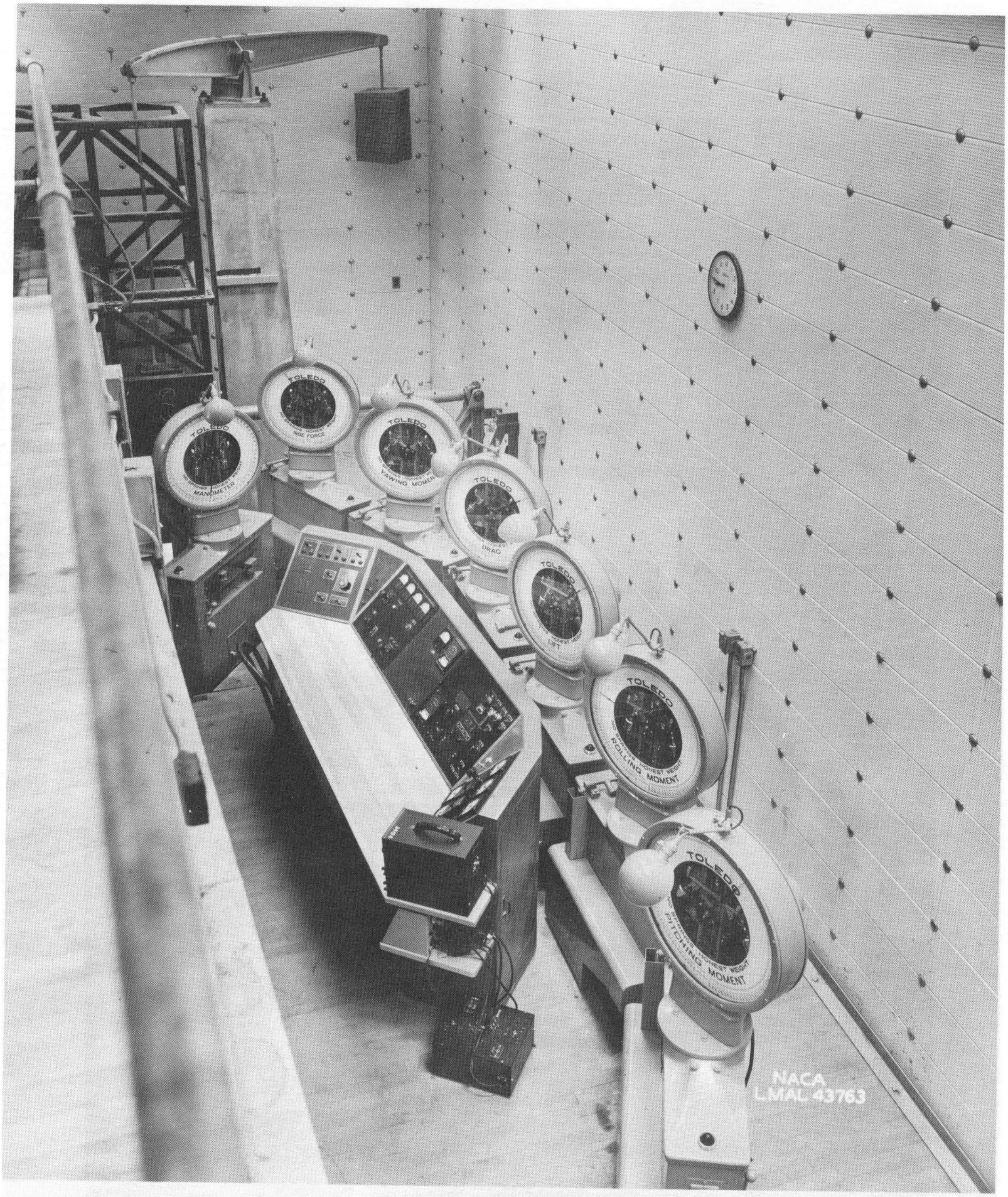


Figure 10. - Control console

Figure 11. - Typical operation.

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Figure 12. - Skeleton crew.

Figure 13. - Staff.

SUMMARY

Preliminary Surveys, 300 mph 7 x 10 W.T.

Power run	Date	Tunnel condition	Propeller condition	Comments
1	2-10-45	Test section clear except for survey apparatus; 4 divergence vanes in original position	Original propeller	
2	2-13-45	Same as 1	Trimmed 1-1/2" at tip; tapered to 0 at 6 feet	
3	2-14-45	Same as 1	Trimmed 2-1/2" at tip	
4	2-14-45	Same as 1 - also with angle iron in test section	Trimmed 3-1/2" at tip	
5	2-15-45 2-16-45	Same as 1 Inside vertical deflector out Outside vertical deflector decreased 3°	Trimmed 3-1/2" at tip and refaired	
6	2-17-45	Inside vertical divergence vane set at 0° with top surface to wall. Outside vertical divergence vane set at 3.6°	Trimmed 3-1/2" at tip	
7	2-22-45	Inside vertical vane removed; outside set at 3.6°, tabs set at 5° ; Vanes removed in 2nd set	Finished	
8	2-26-45	Same as 7 except "A" vane tabs set at 10°		
9	3-1-45	Both vertical divergence vanes removed		
10				
11	3-2-45	Same as 10, except pulsation strut out, survey rig moved up to centerline bal., 3 holes 2" dia. near center of roof		

Figure 14. - Calibration test schedule.

Figure 14. - Calibration test schedule.

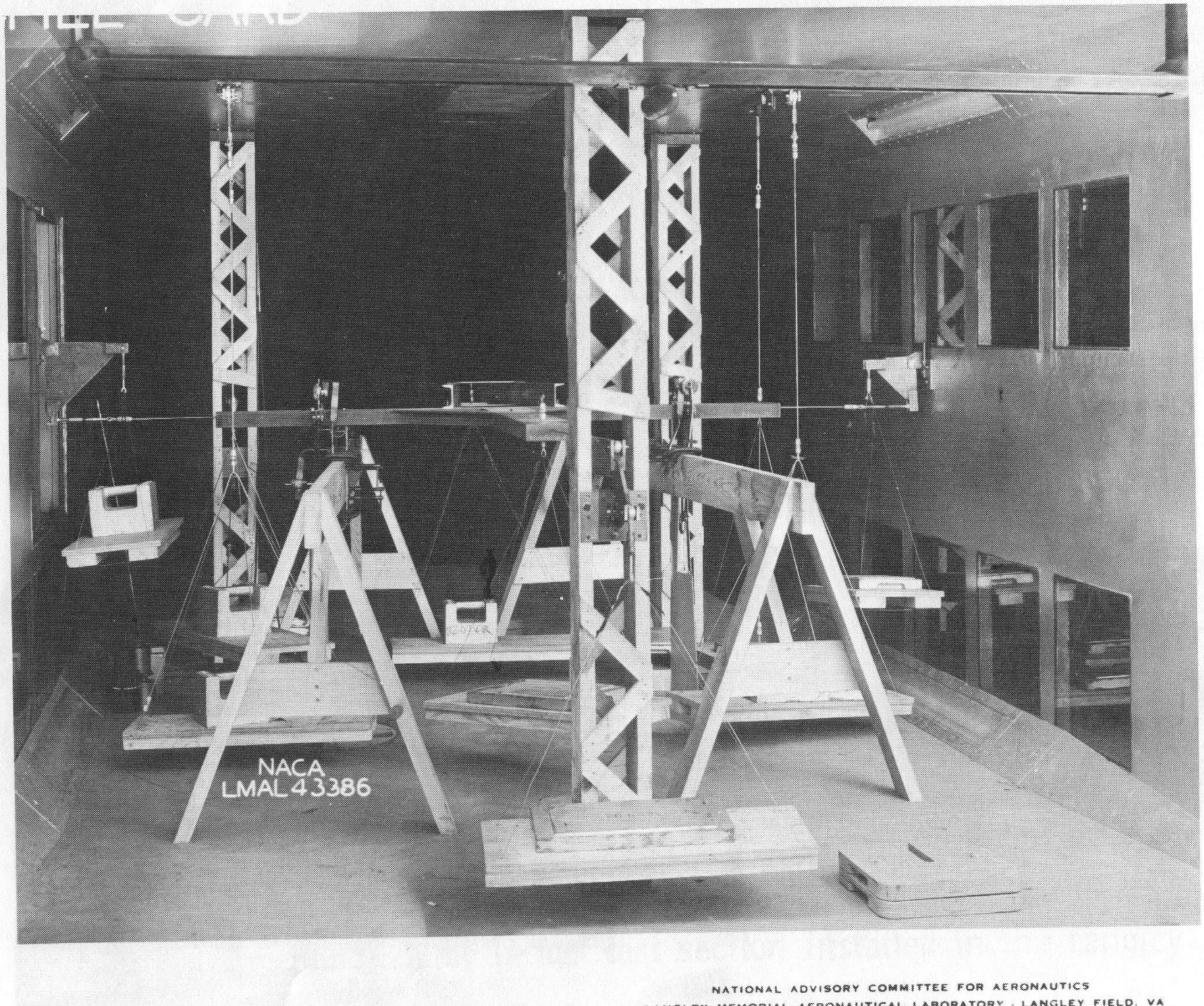

Figure 15. - Balance calibration loading system.

Figure 16. - 10- By 14-Inch Induction Tunnel.

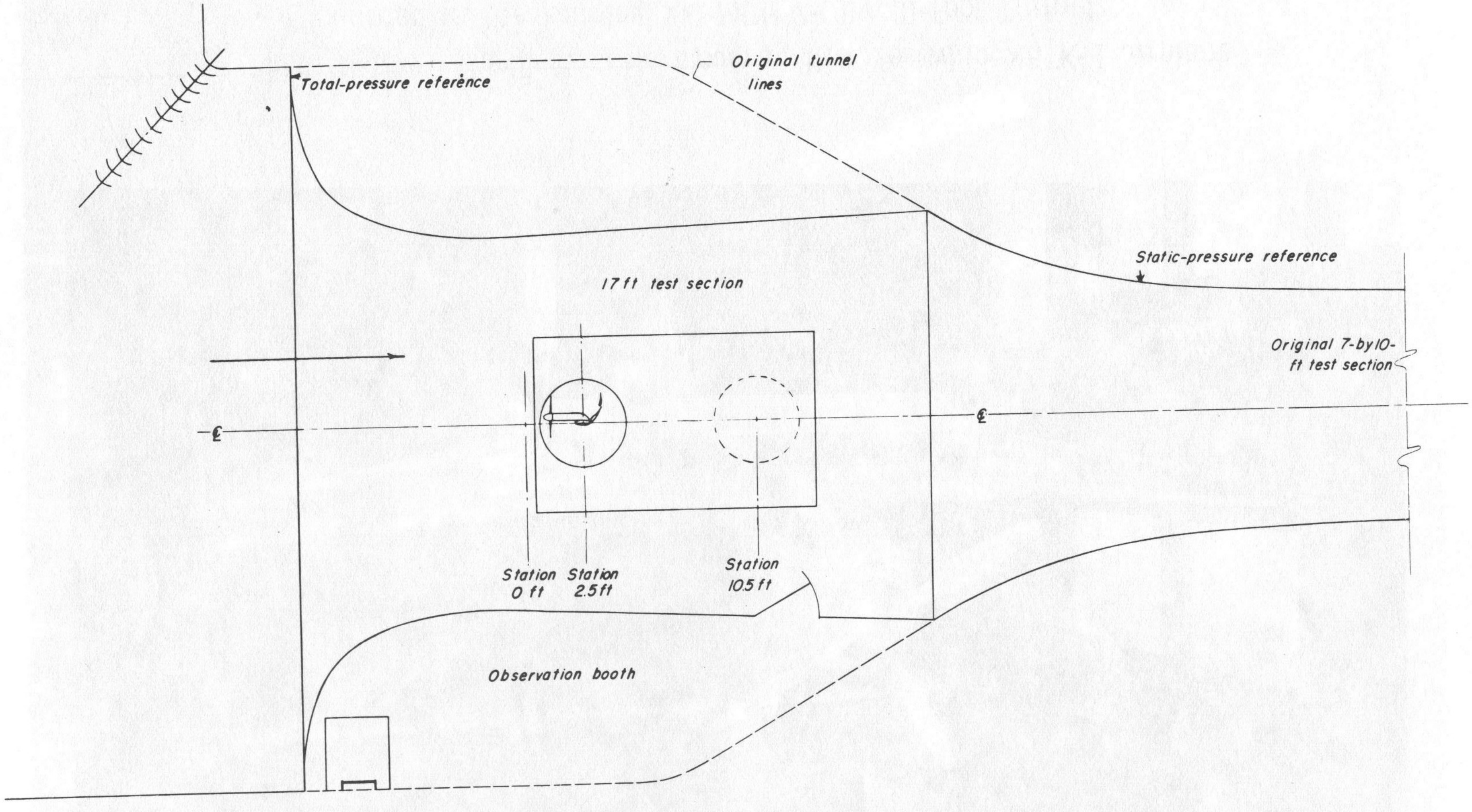

Figure 17. - Planview of 17-foot test section installed in the Langley 300-MPH 7- By 10-Foot Wind Tunnel.

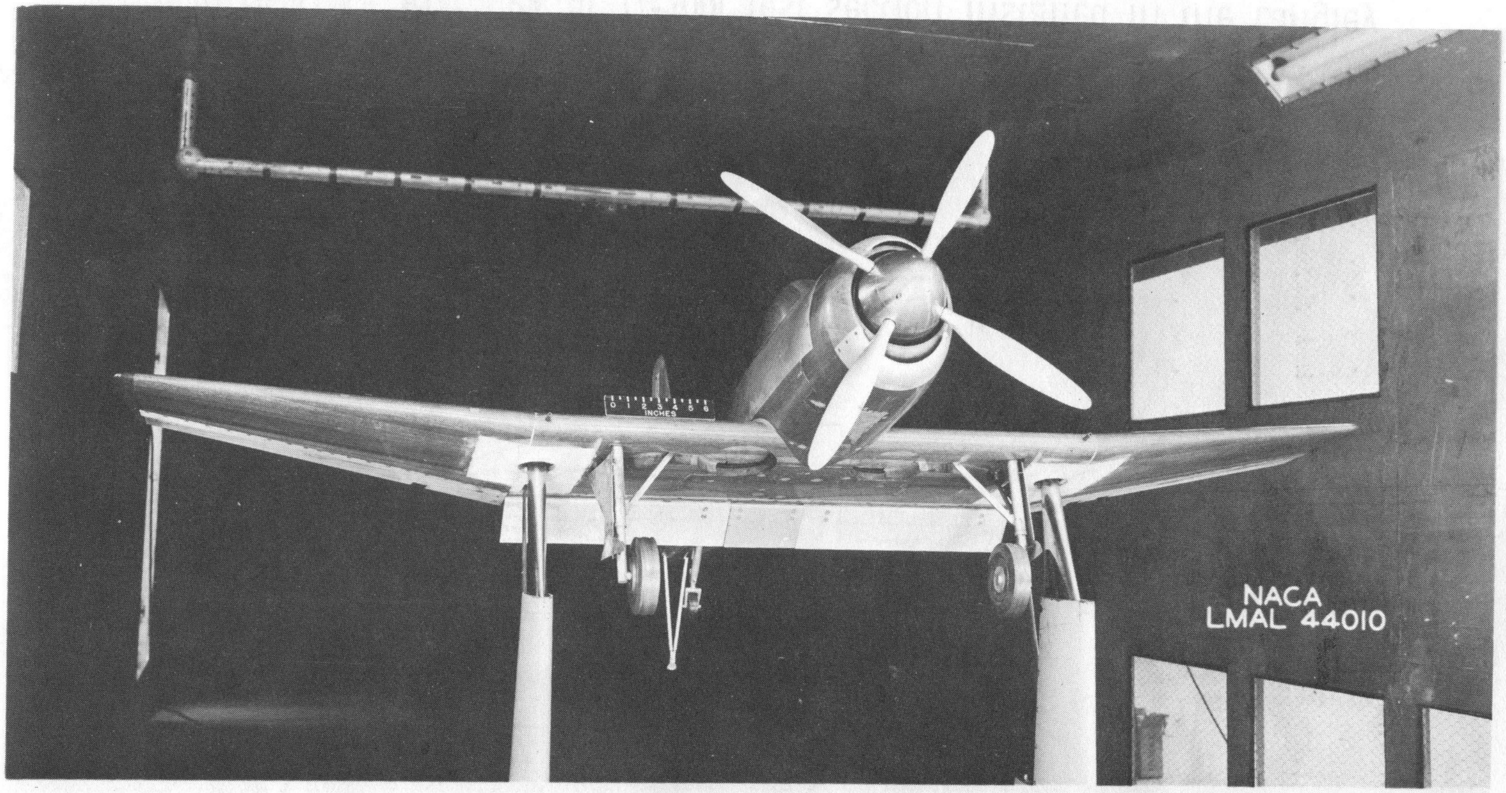

Figure 18. - The 0.15-scale model of the Fleetwing XBTK-1 airplane mounted in the Langley 300-MPH 7- By 10-Foot Tunnel.

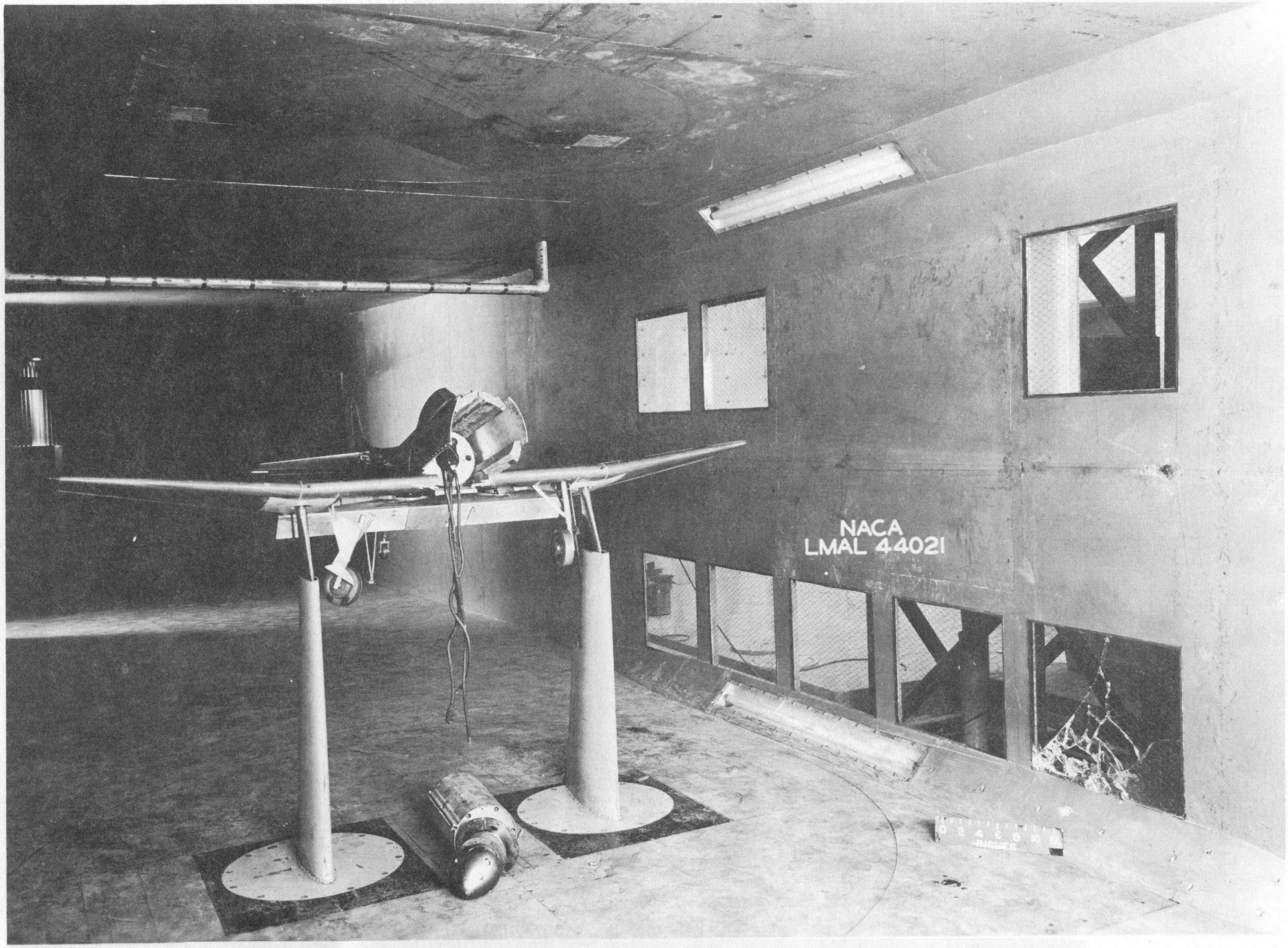

Figure 19. - XBTK-1 model after propeller failure.

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Figure 20. - L-39 mounted behind turbulence screen.

Figure 21. - External stores on F4U model.

Figure 22. - Republic F-103 model over ground board.

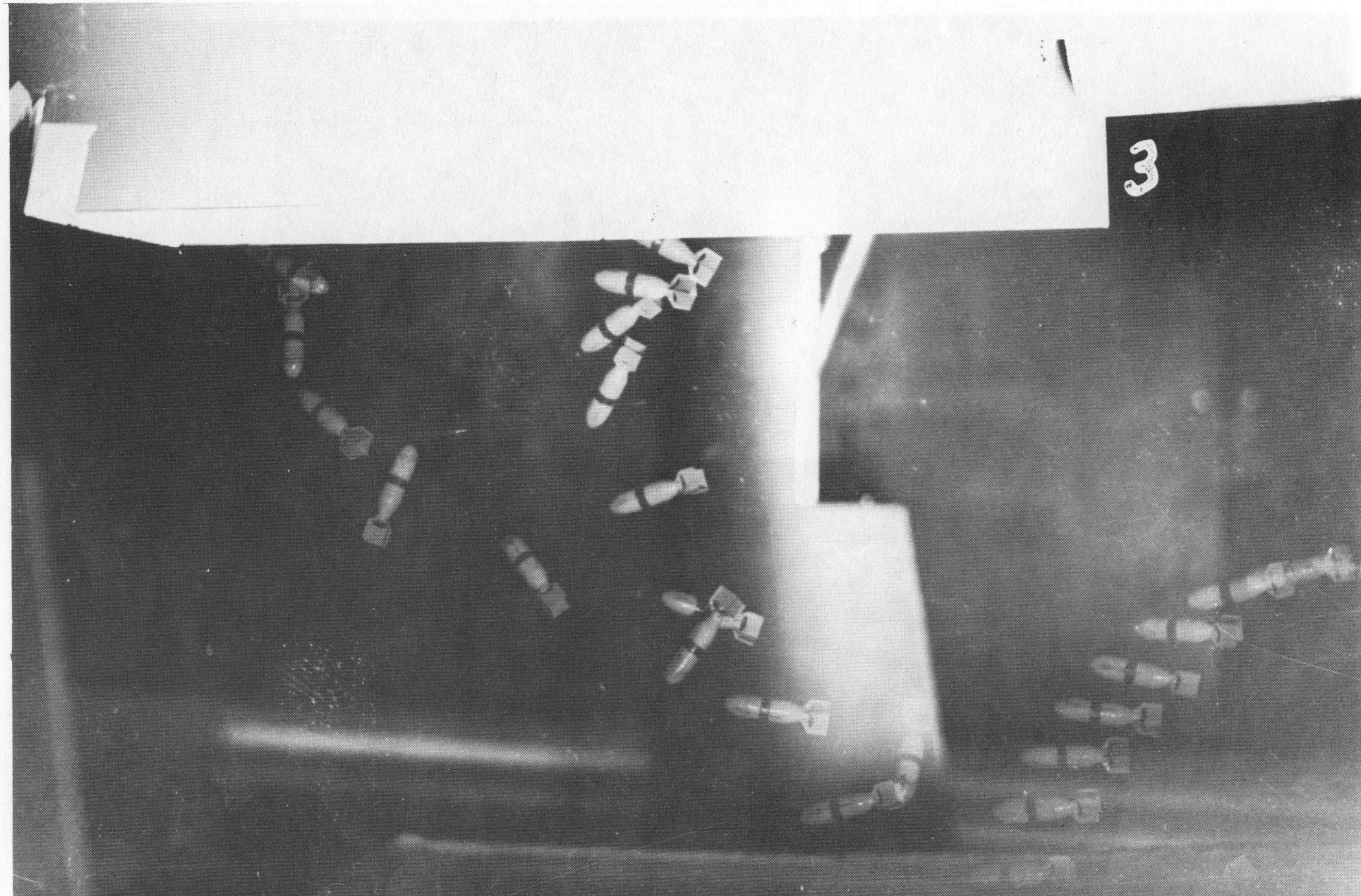


Figure 23. - Simulated bomb drops, original bomb bay.

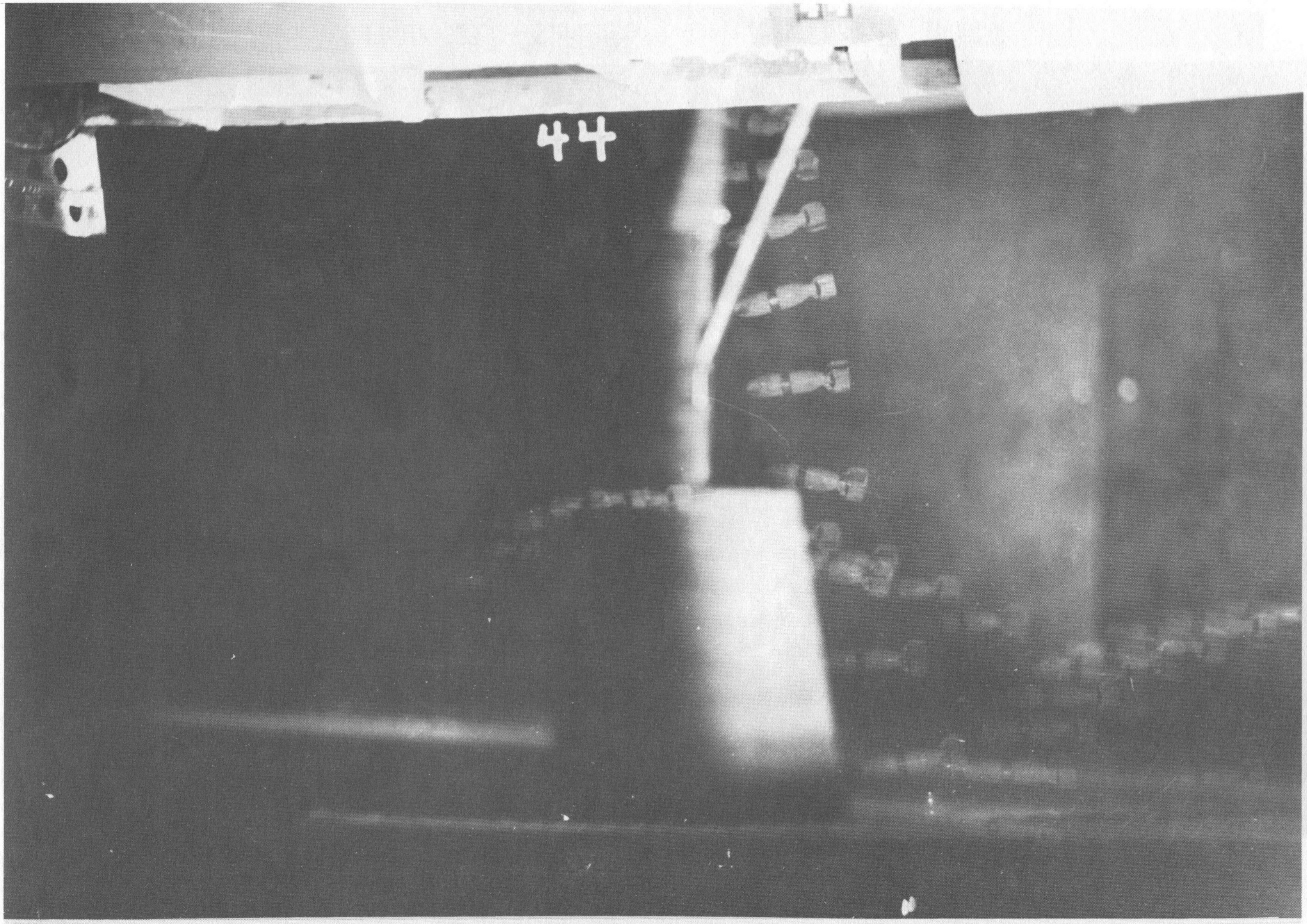
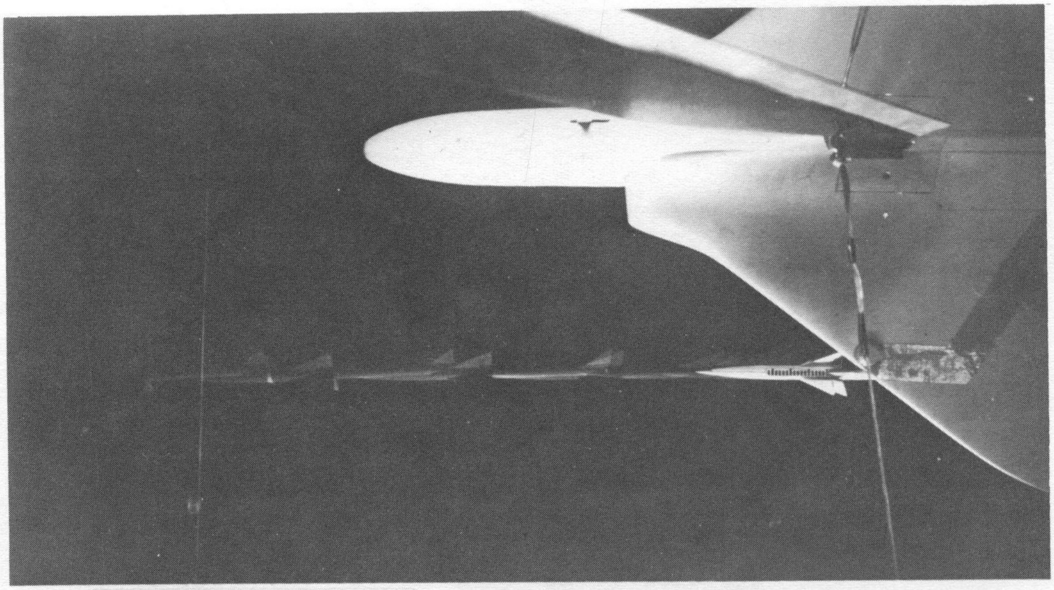
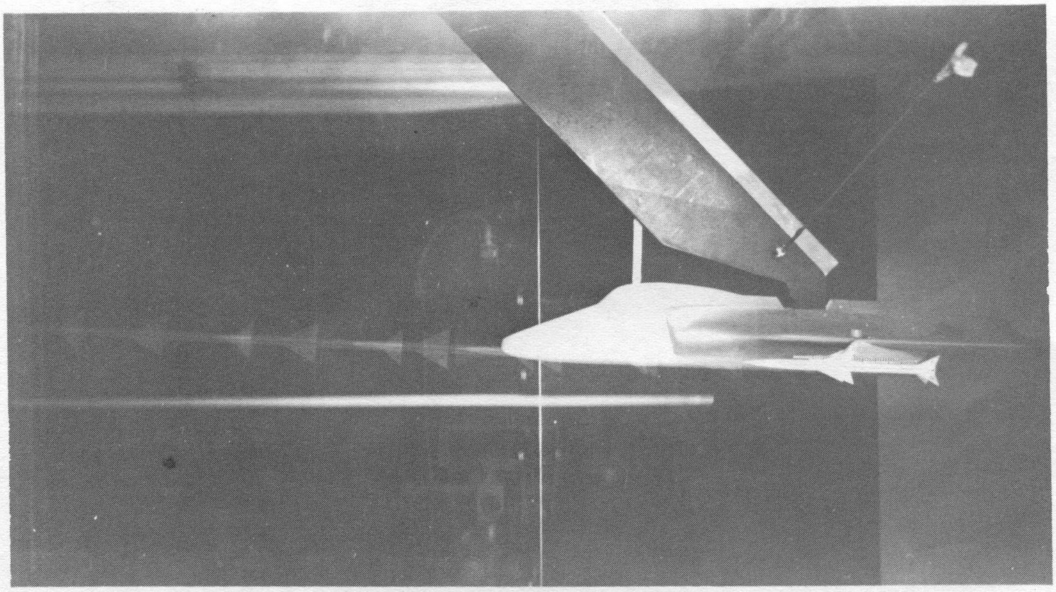


Figure 24. - Simulated bomb drops, modified bomb bay.



(a) Top view



(b) Side view

Figure 25. - Simulated rocket launching.

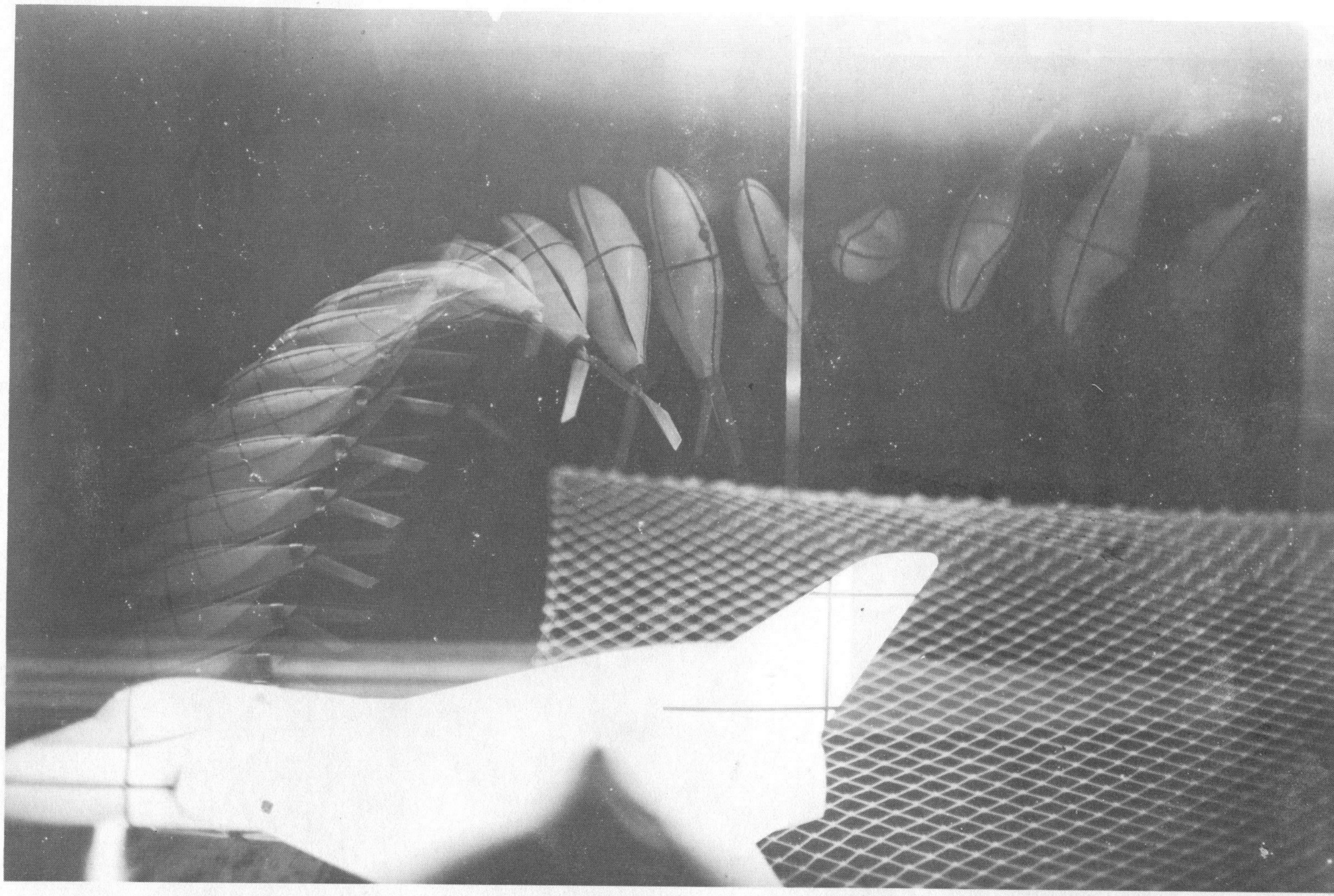
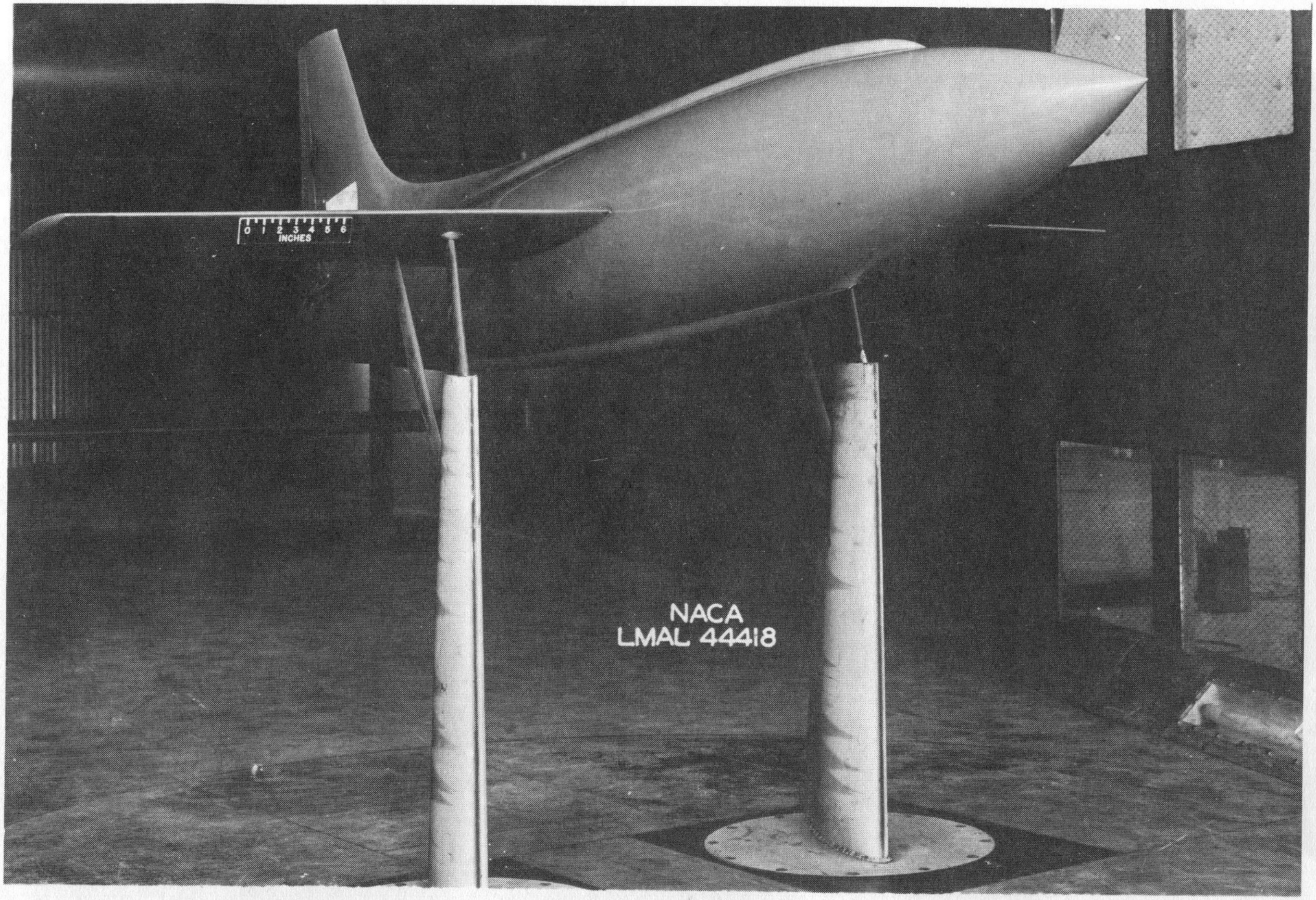


Figure 26. - Simulated cockpit escape system.

Figure 27. - H-21 helicopter model in wind tunnel.



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LANGLEY MEMORIAL AERONAUTICAL LABORATORY - LANGLEY FIELD, VA.

Figure 28. - X-1 research model mounted in tunnel (front).

Figure 29. - X-1 research model mounted in tunnel (rear).

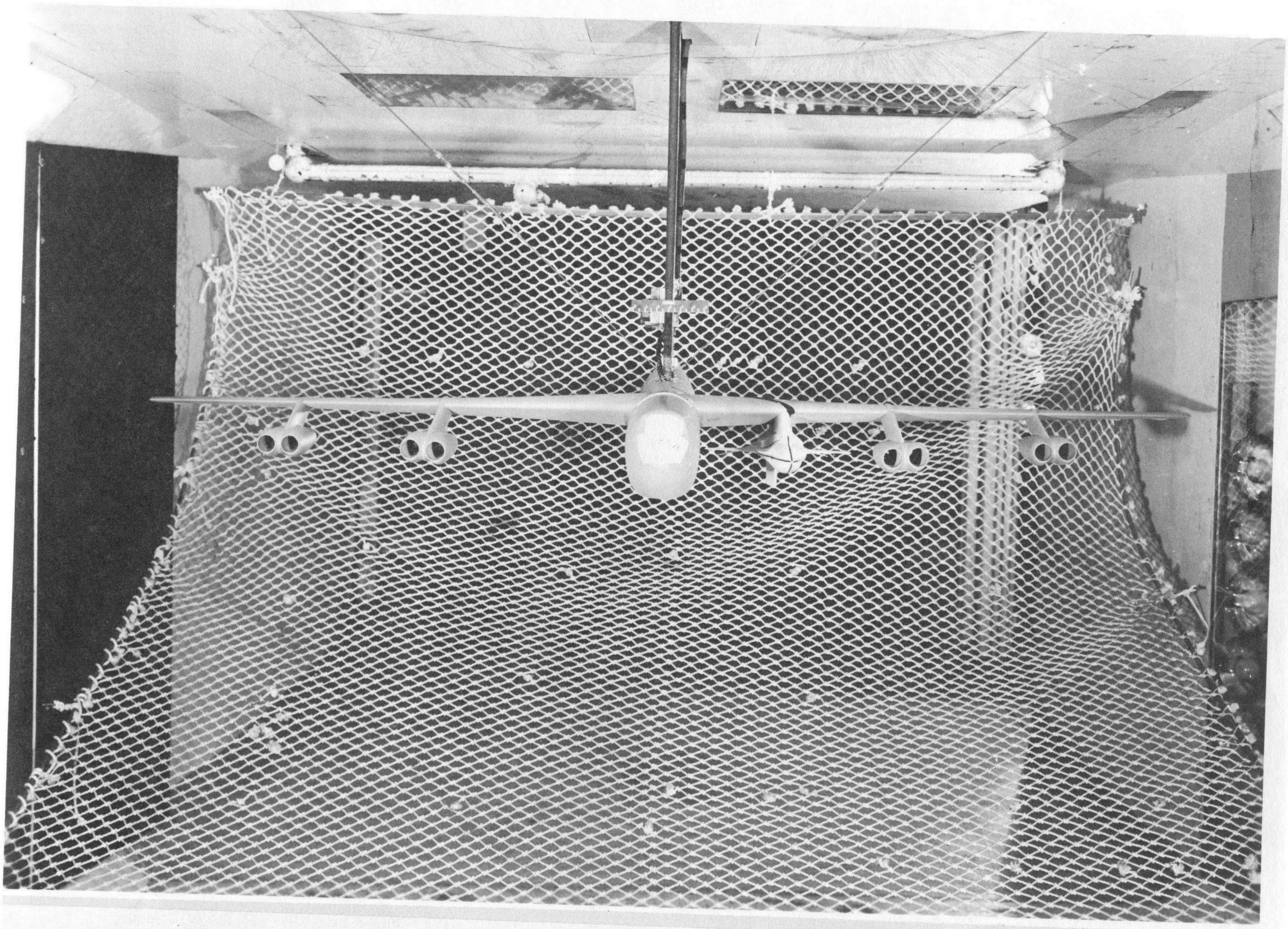

Figure 30. - X-15 model mounted under B-52 model.

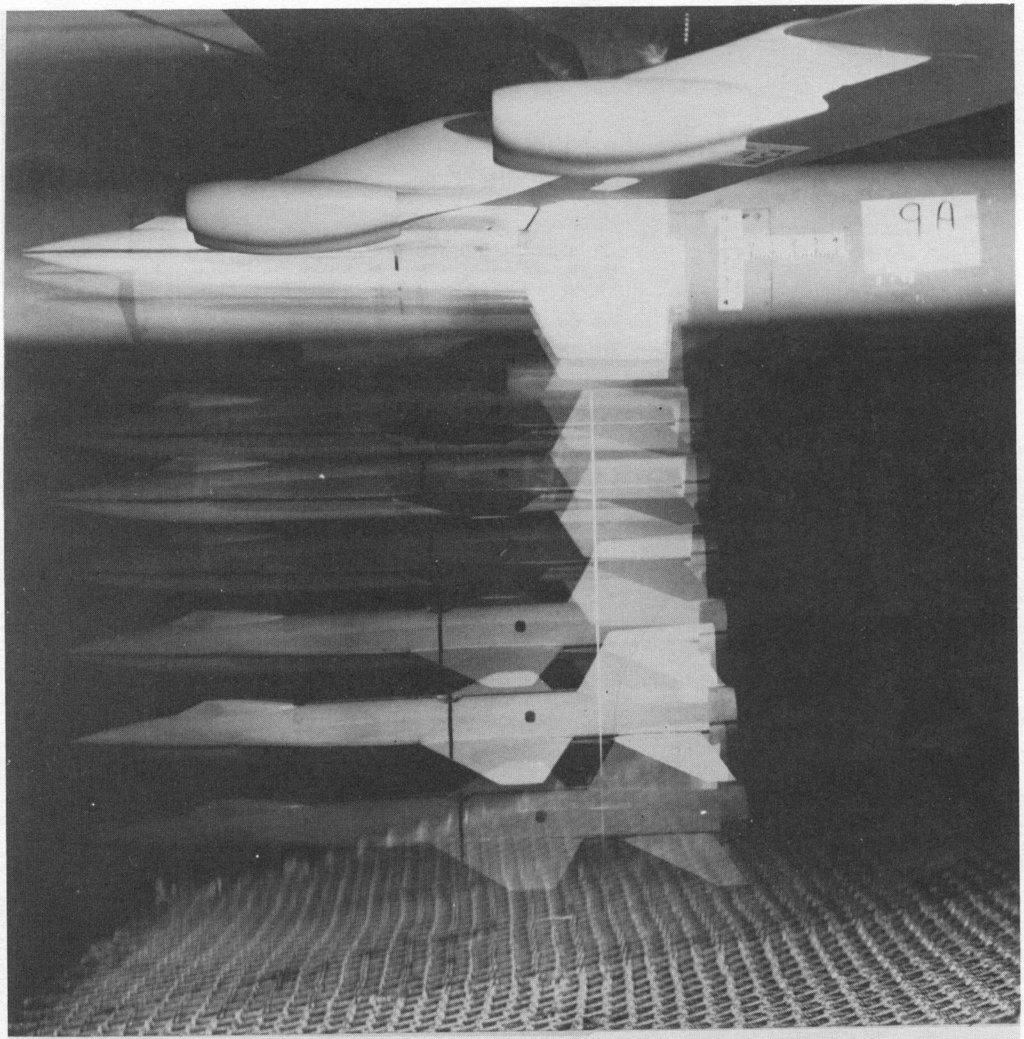

Figure 31. - Simulated launch of X-15 model.

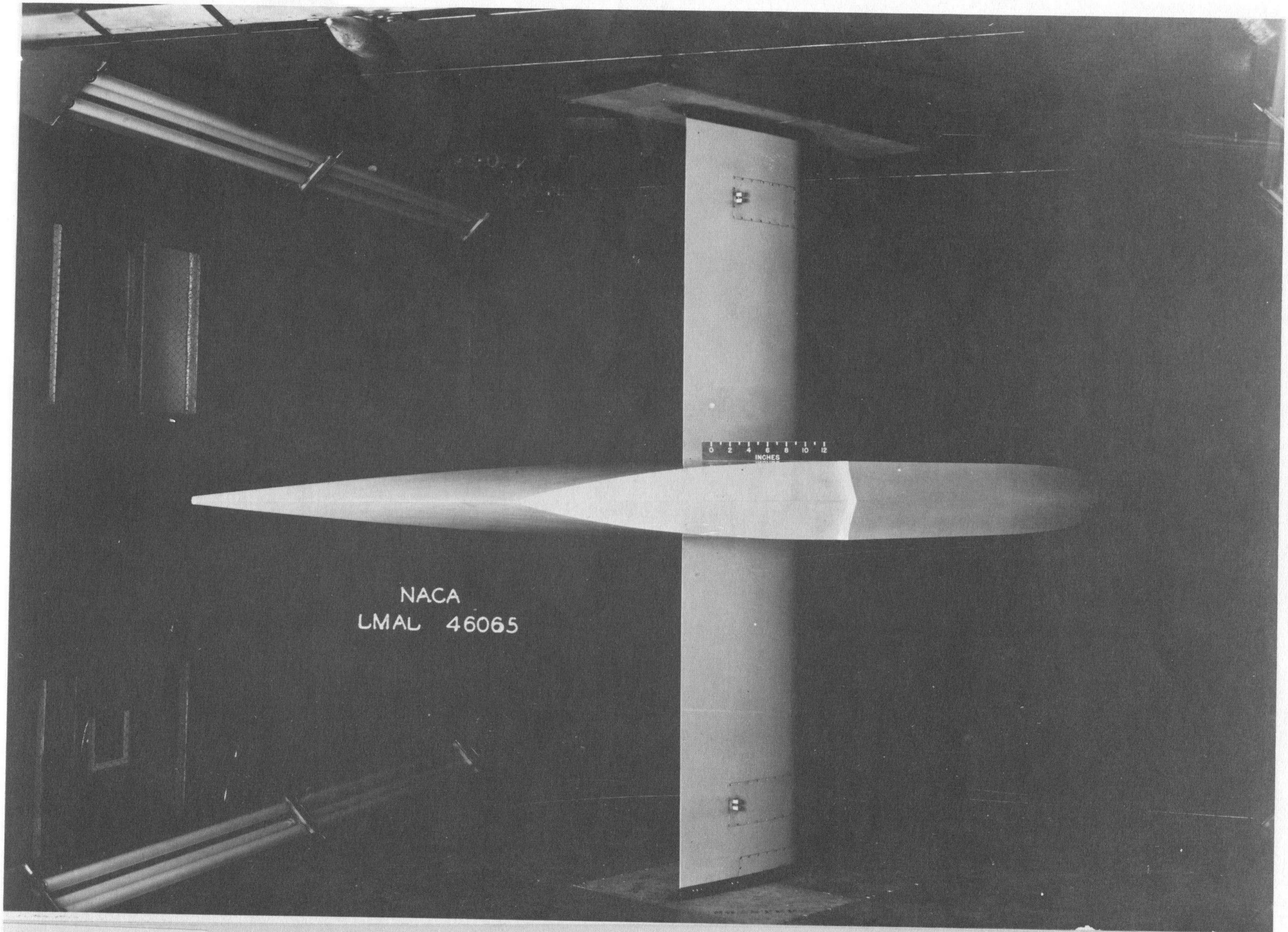

Figure 32. - Seaplane hull mounted in tunnel.

Figure 33. - X-2 model used in spoiler research.

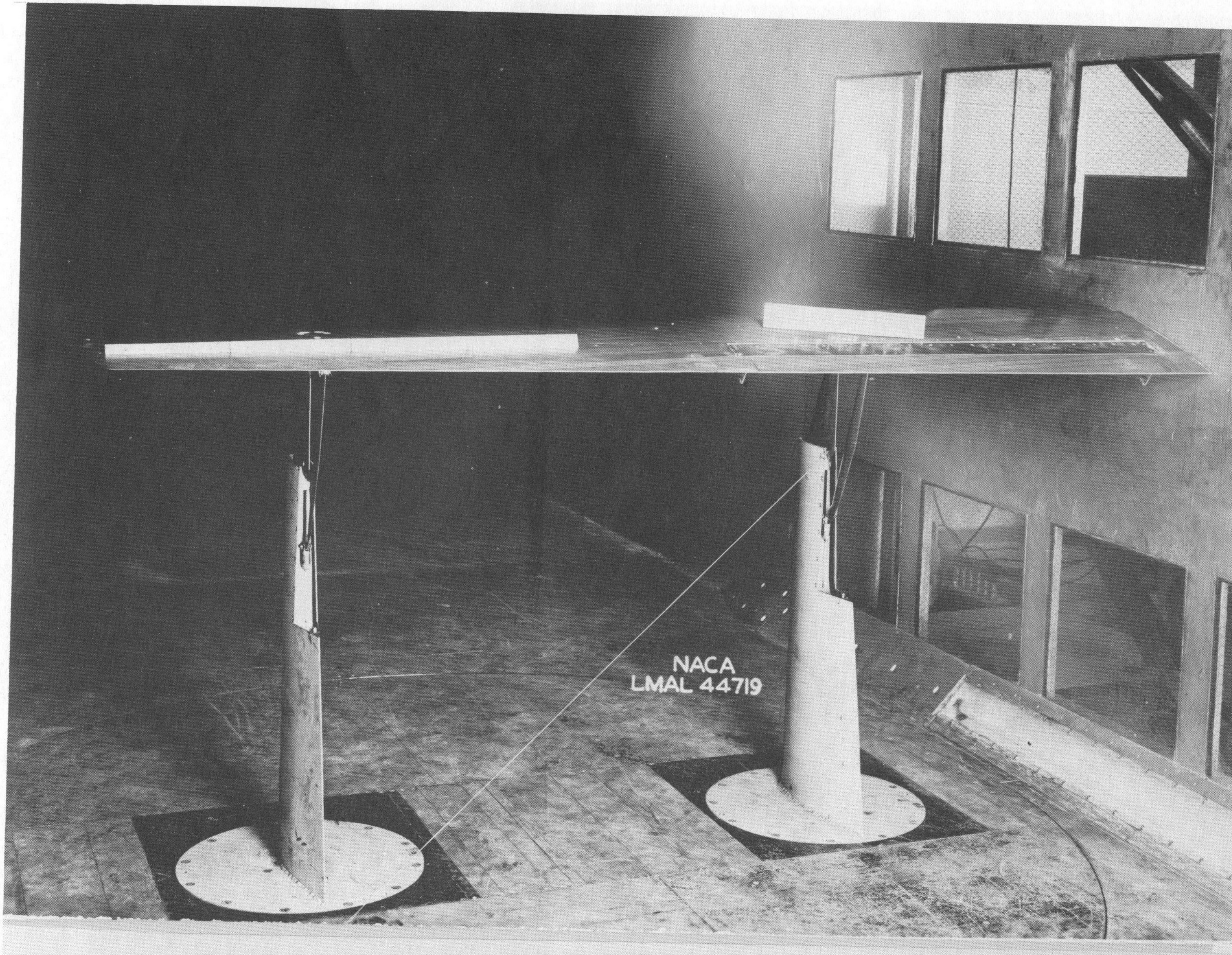

Figure 34. - Wing model used in spoiler research.

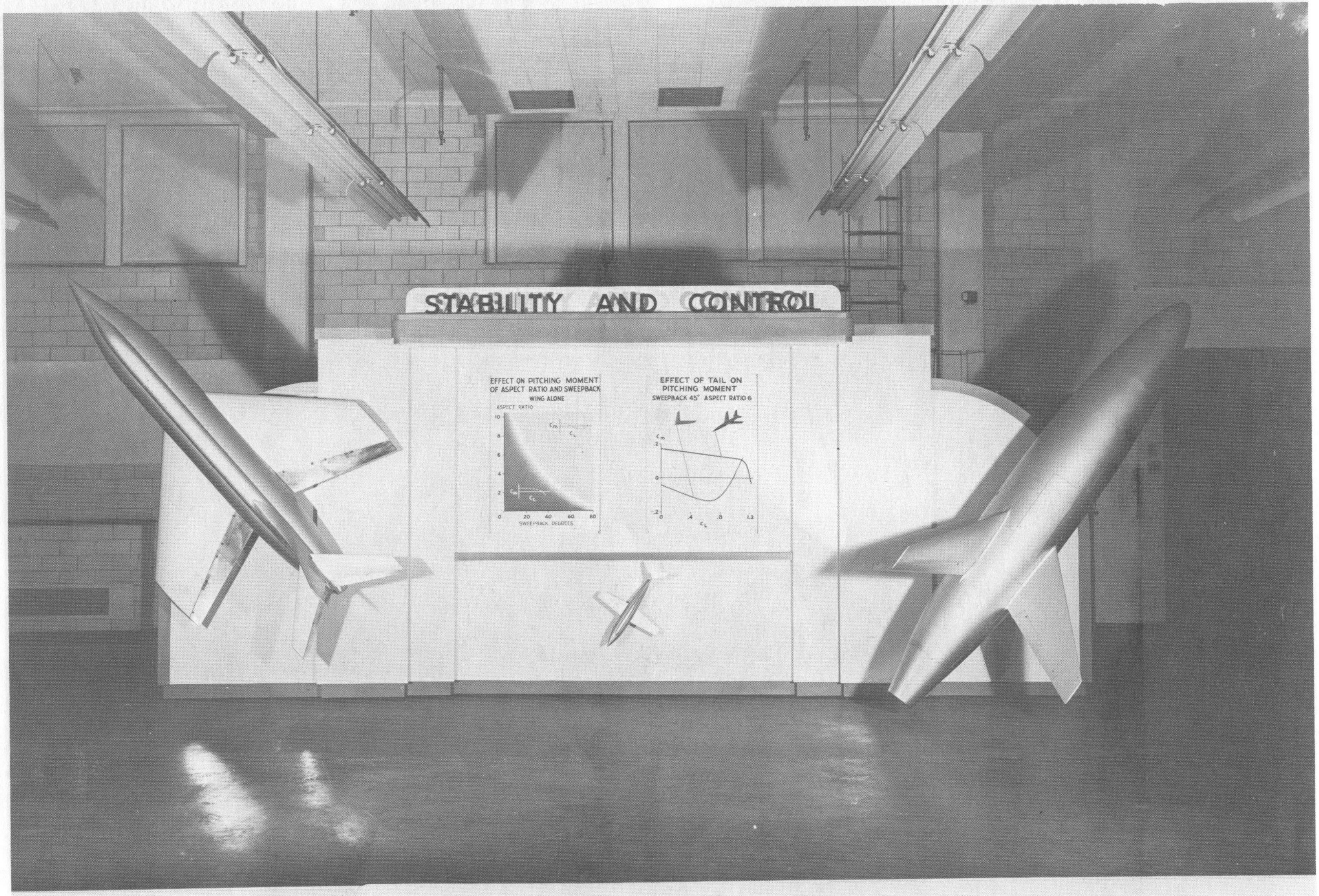

Figure 35. - Display in 7 by 10 Shop at 15th annual inspection (1946).

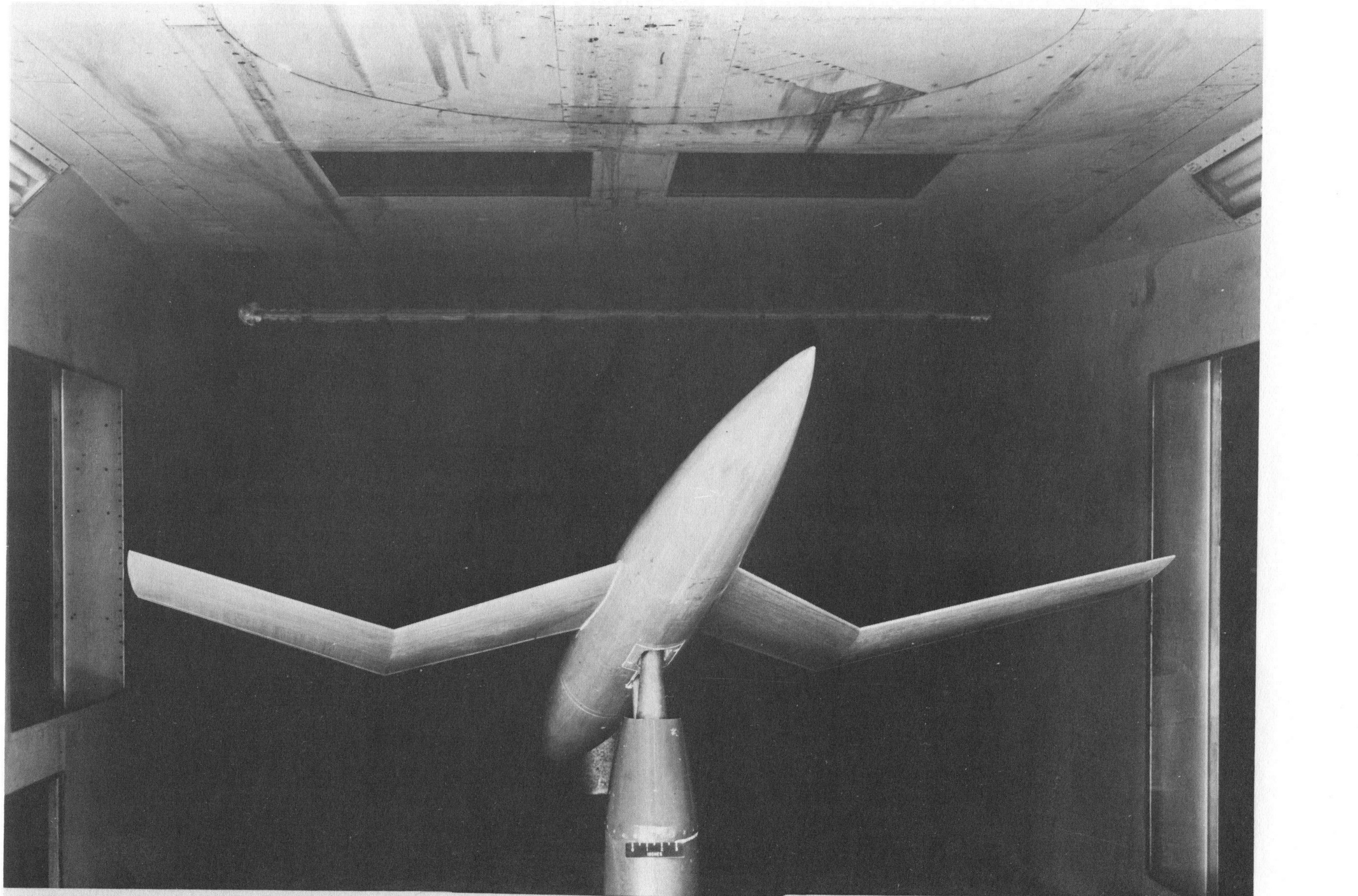

Figure 36. - Complete model, W-planform wing.

Figure 37. - Reflection plane model, W-planform wing.

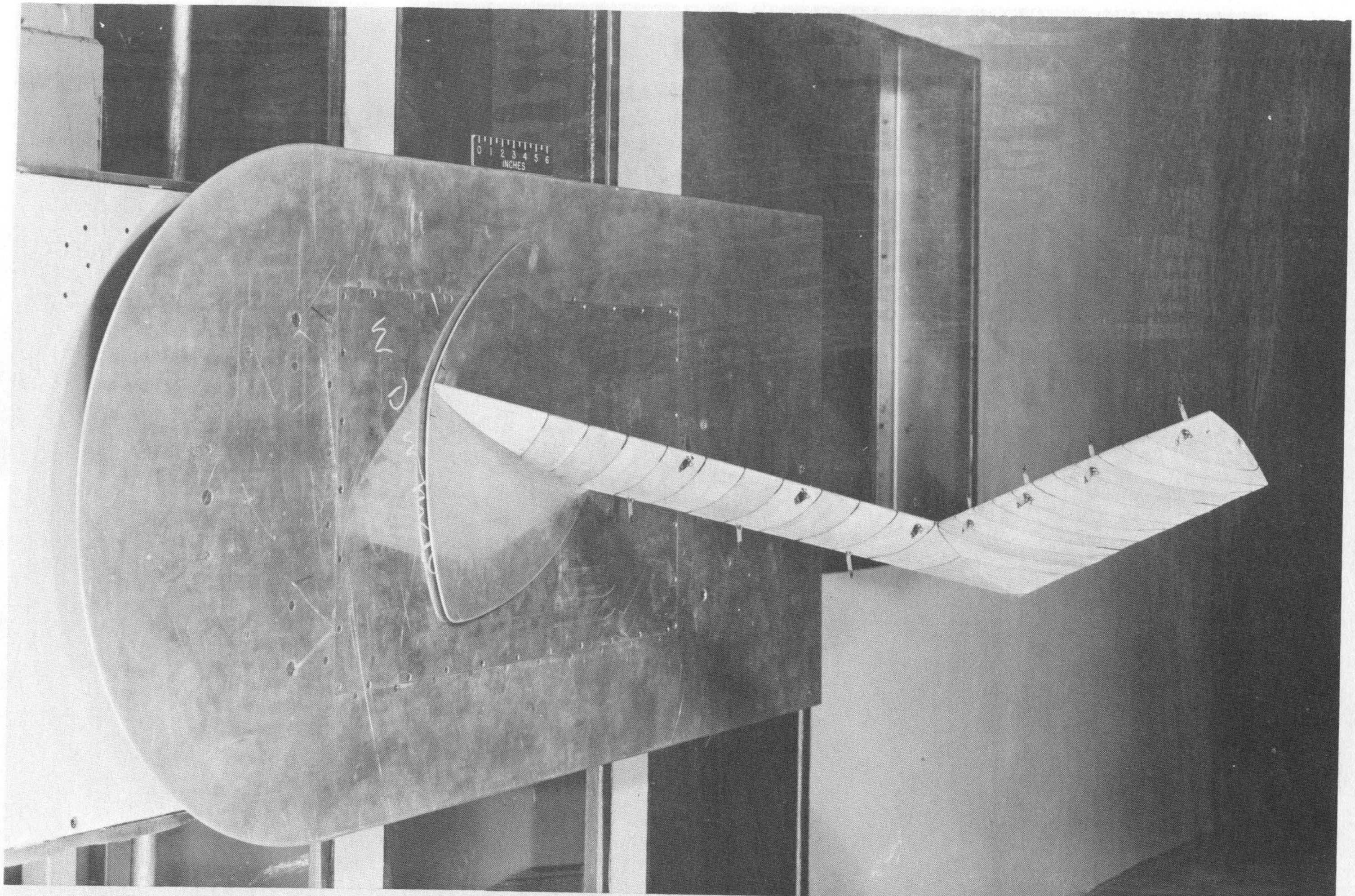

Figure 38. - Flexible W-planform wing.

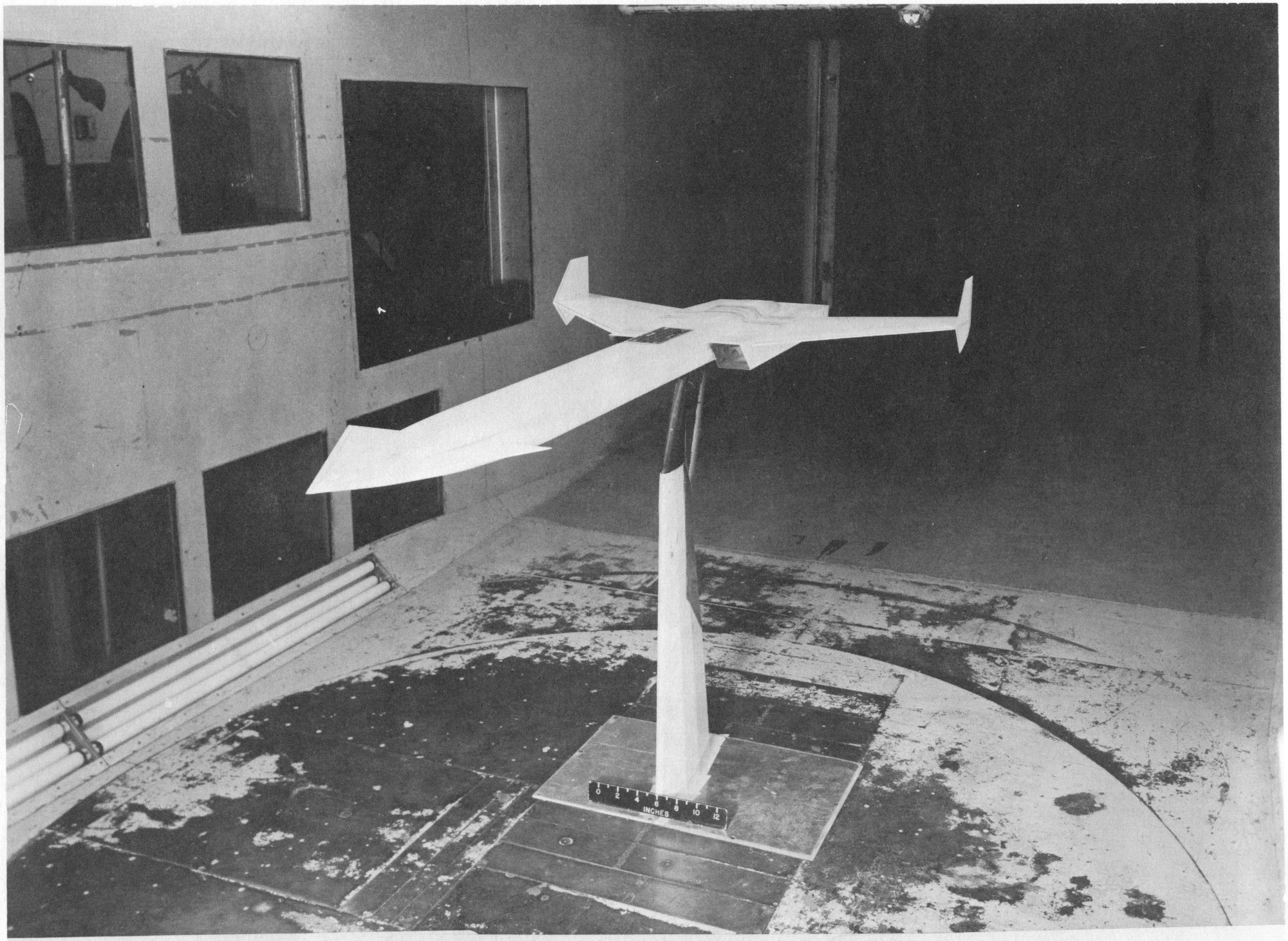

Figure 39. - 1961 supersonic transport concept.

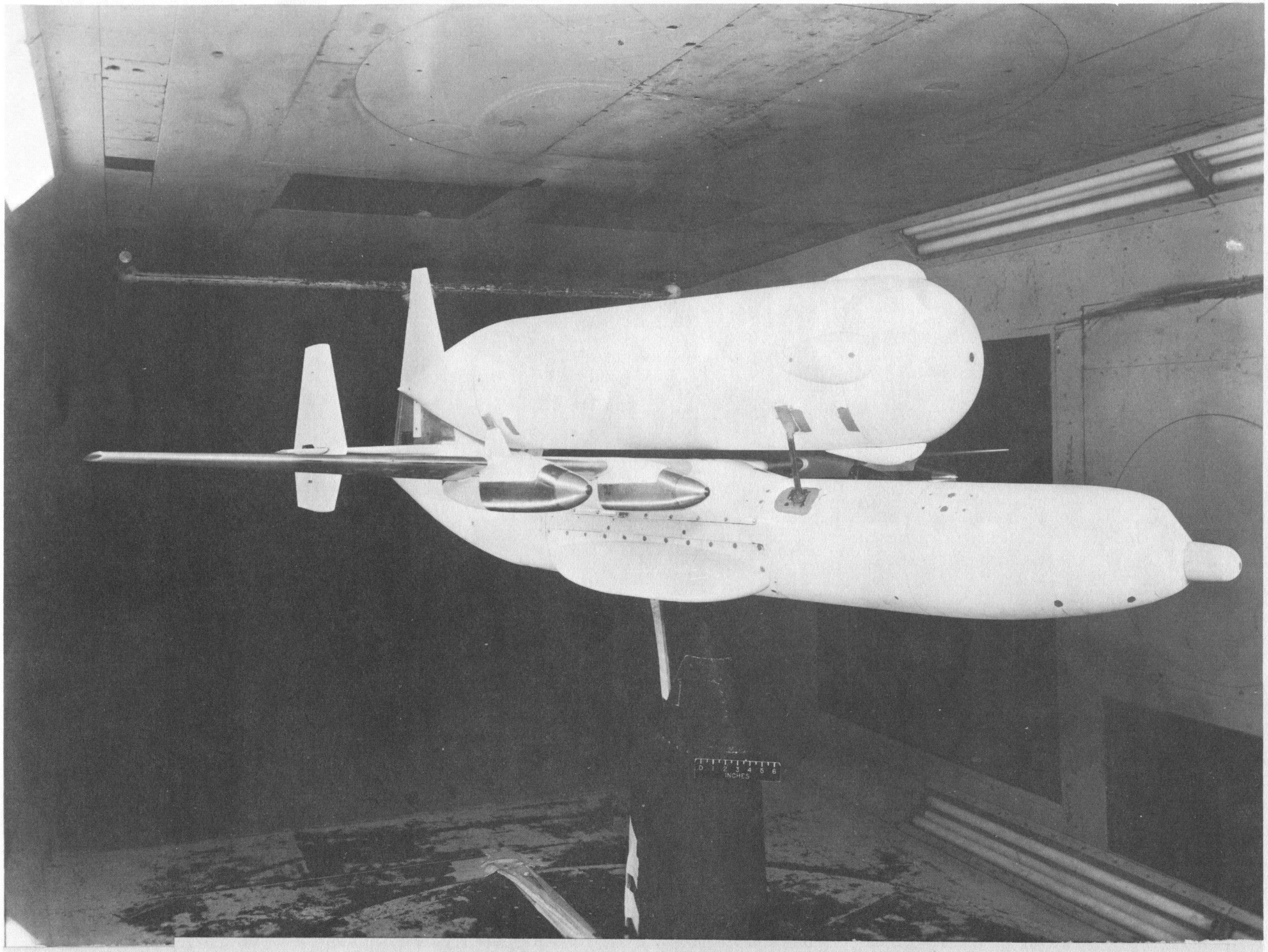

Figure 40. - C-133 model with Saturn booster model.

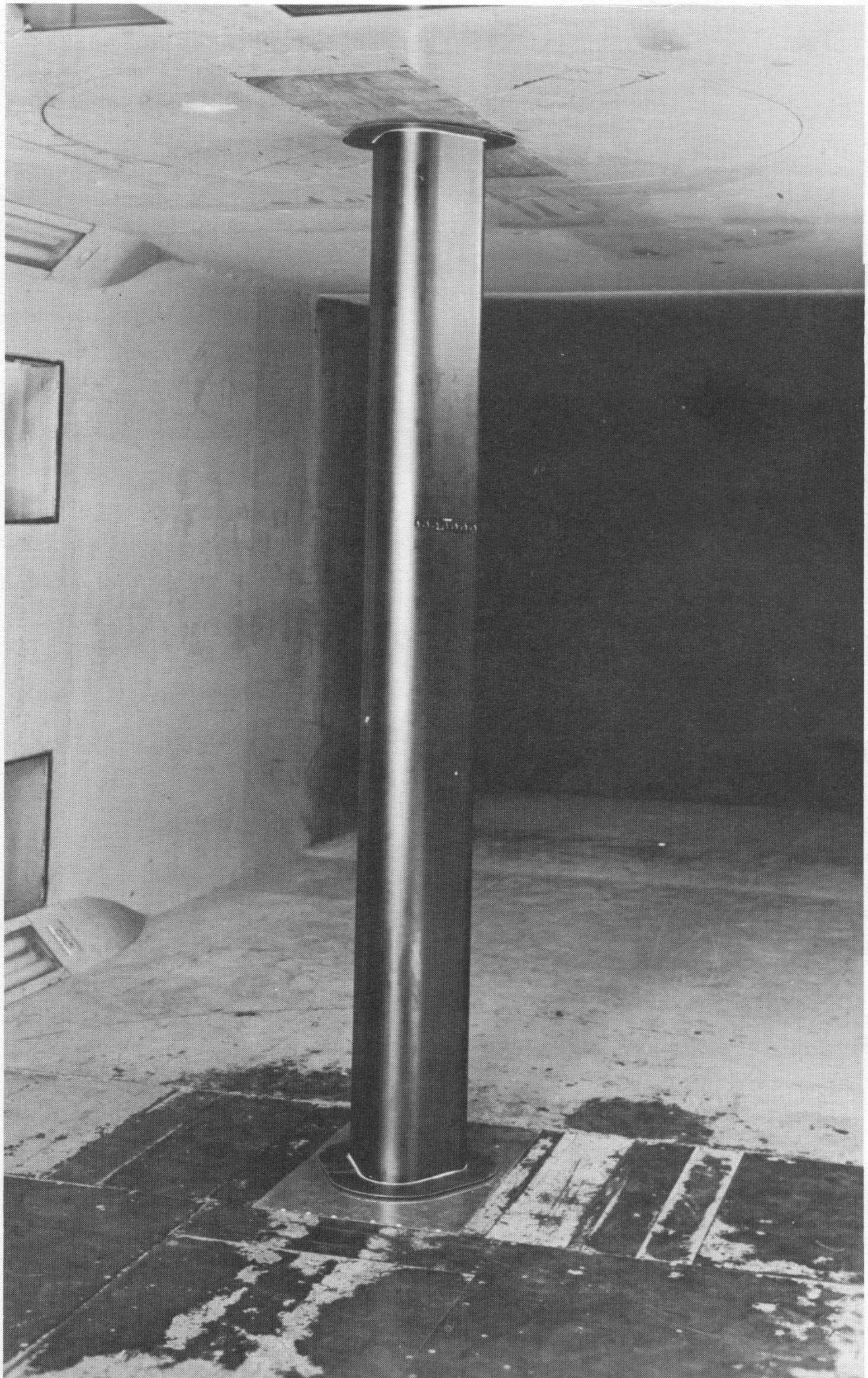

Figure 41. - Two-dimensional cylinder model.

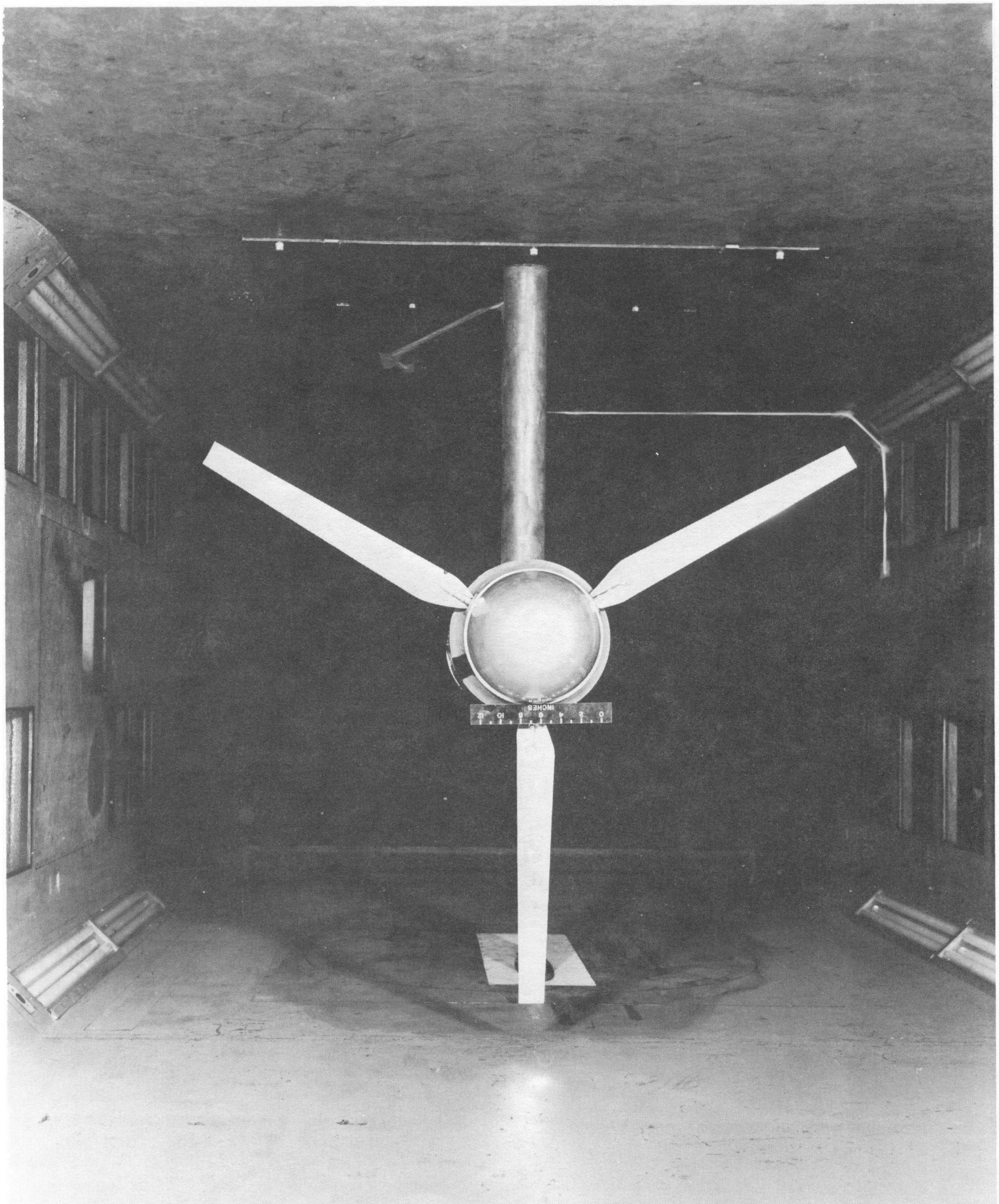

Figure 42. - Wind-driven generator.

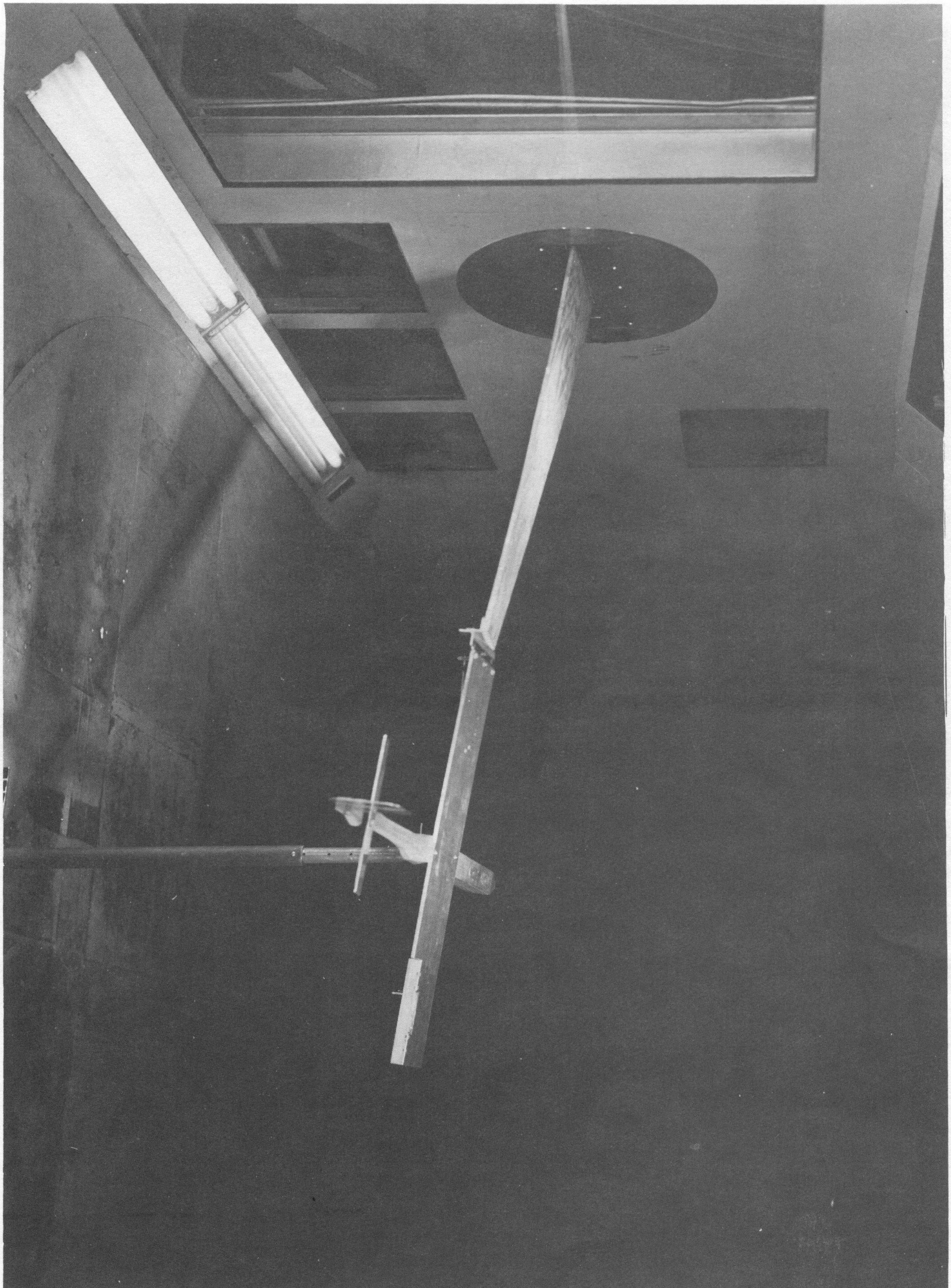

Figure 43. - Tip mounted flutter model.

Figure 44. - Friez anemometer.

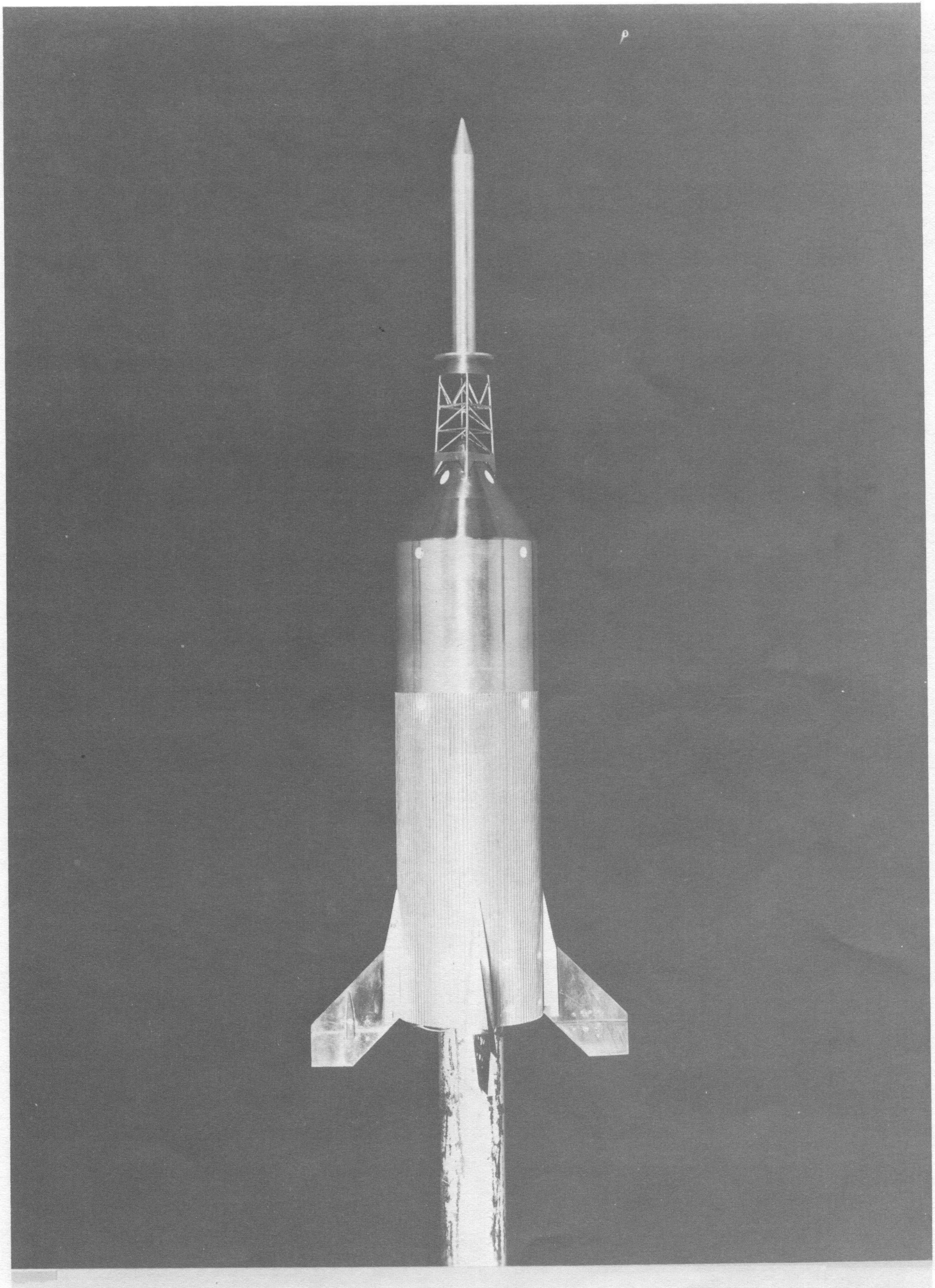

Figure 45. - Little Joe II for Apollo escape.

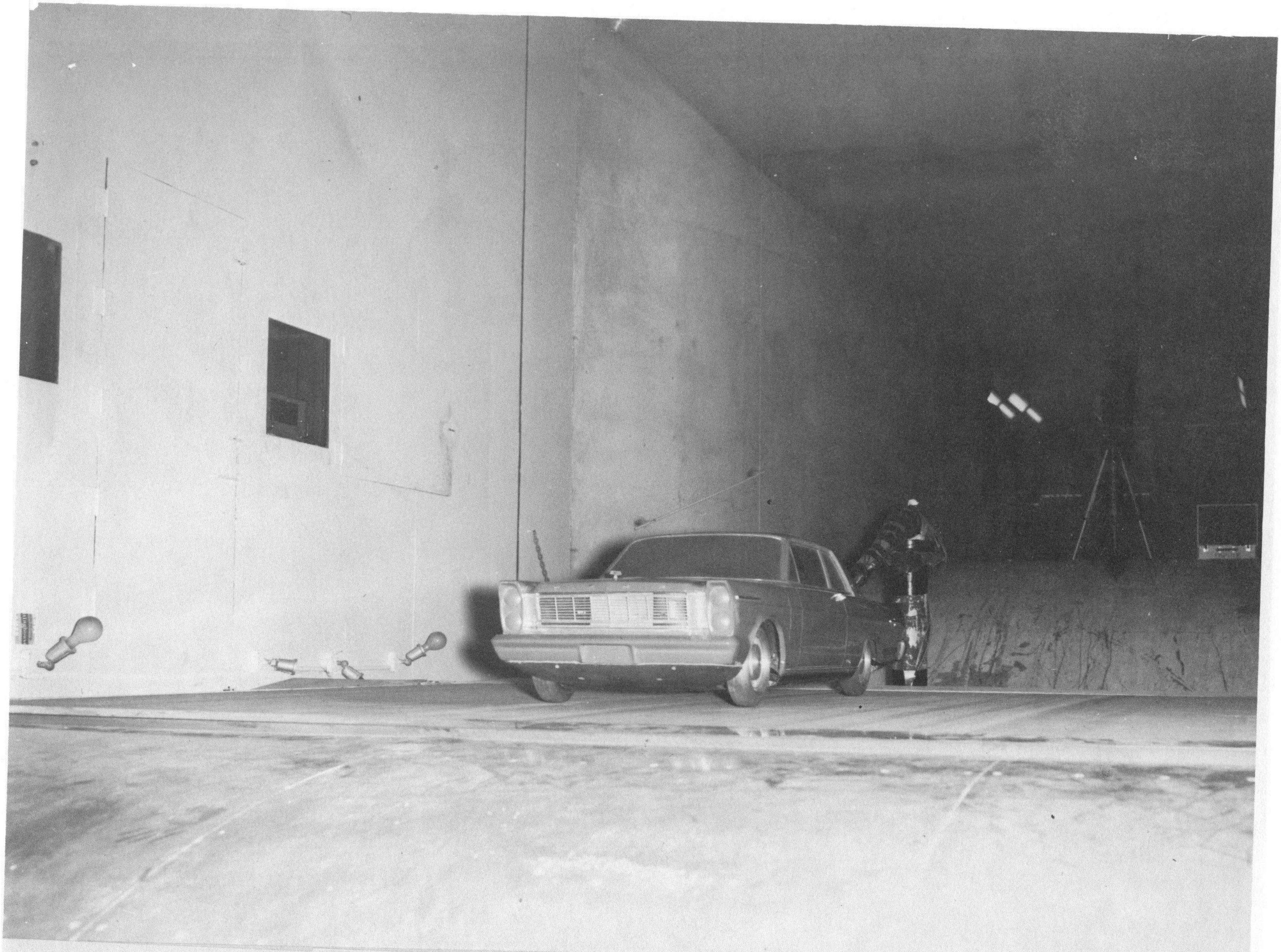

Figure 46. - Automobile model.

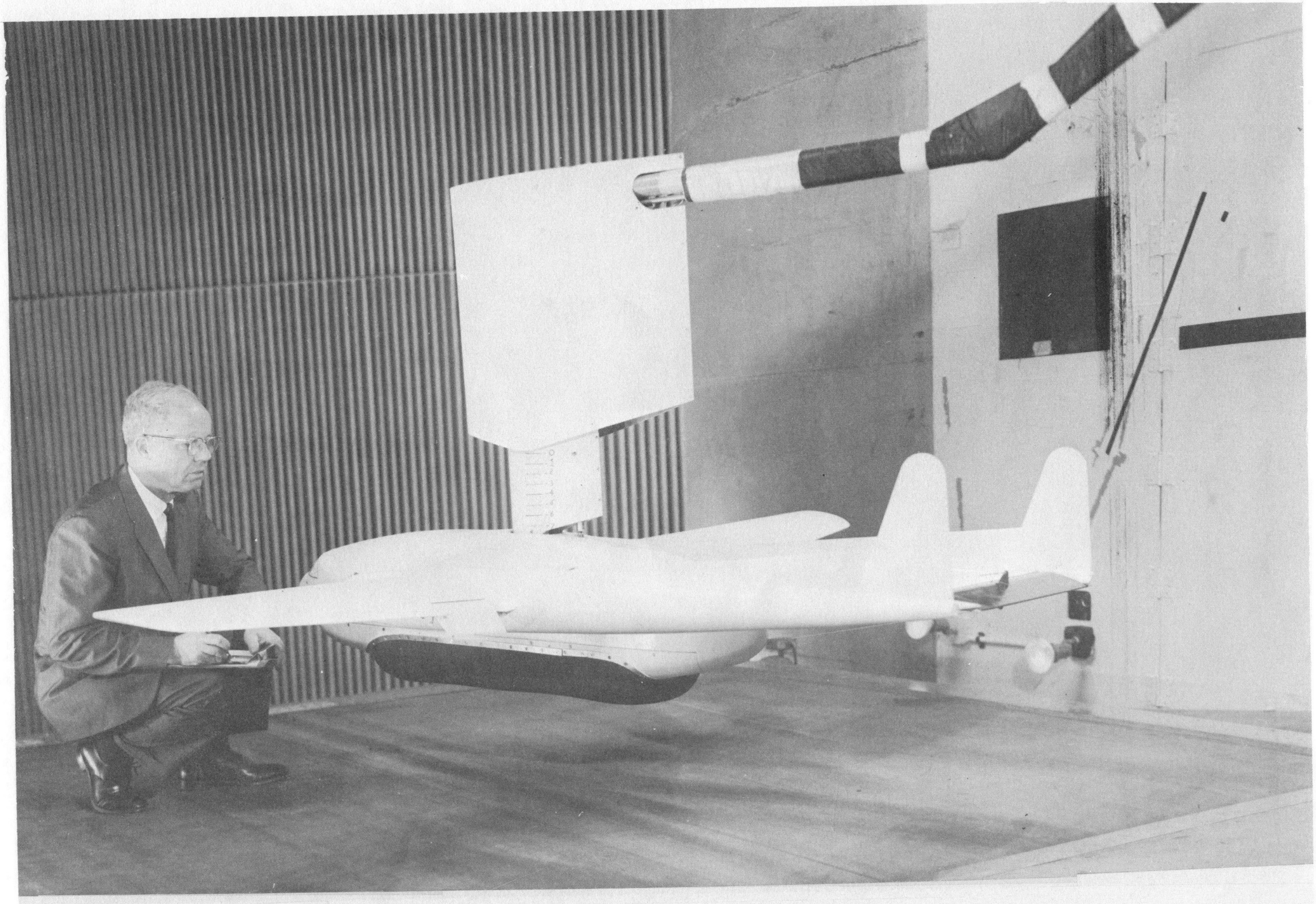

Figure 47. - Air-cushion landing gear model.

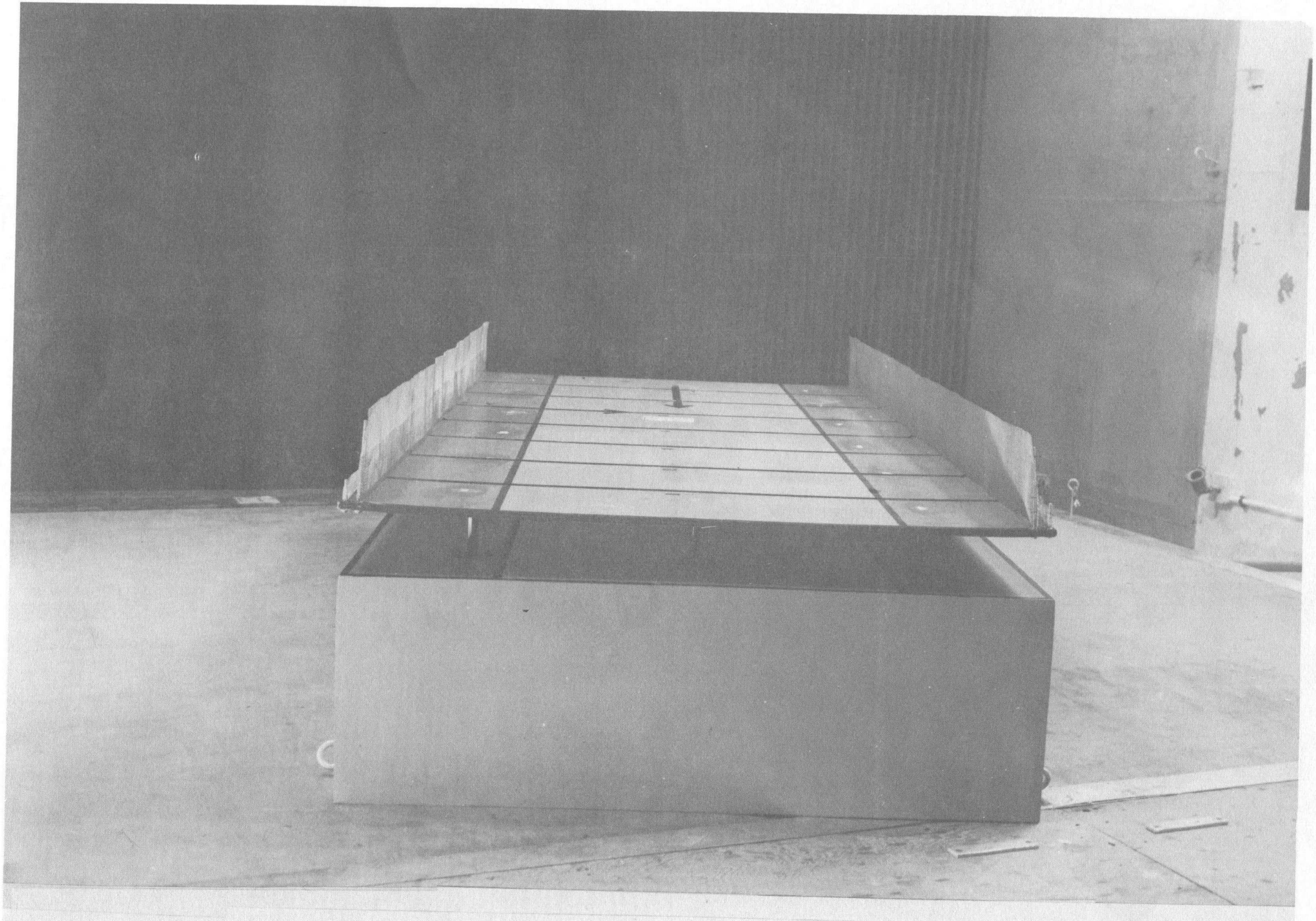

Figure 48. - STOLport model for flow-field studies.

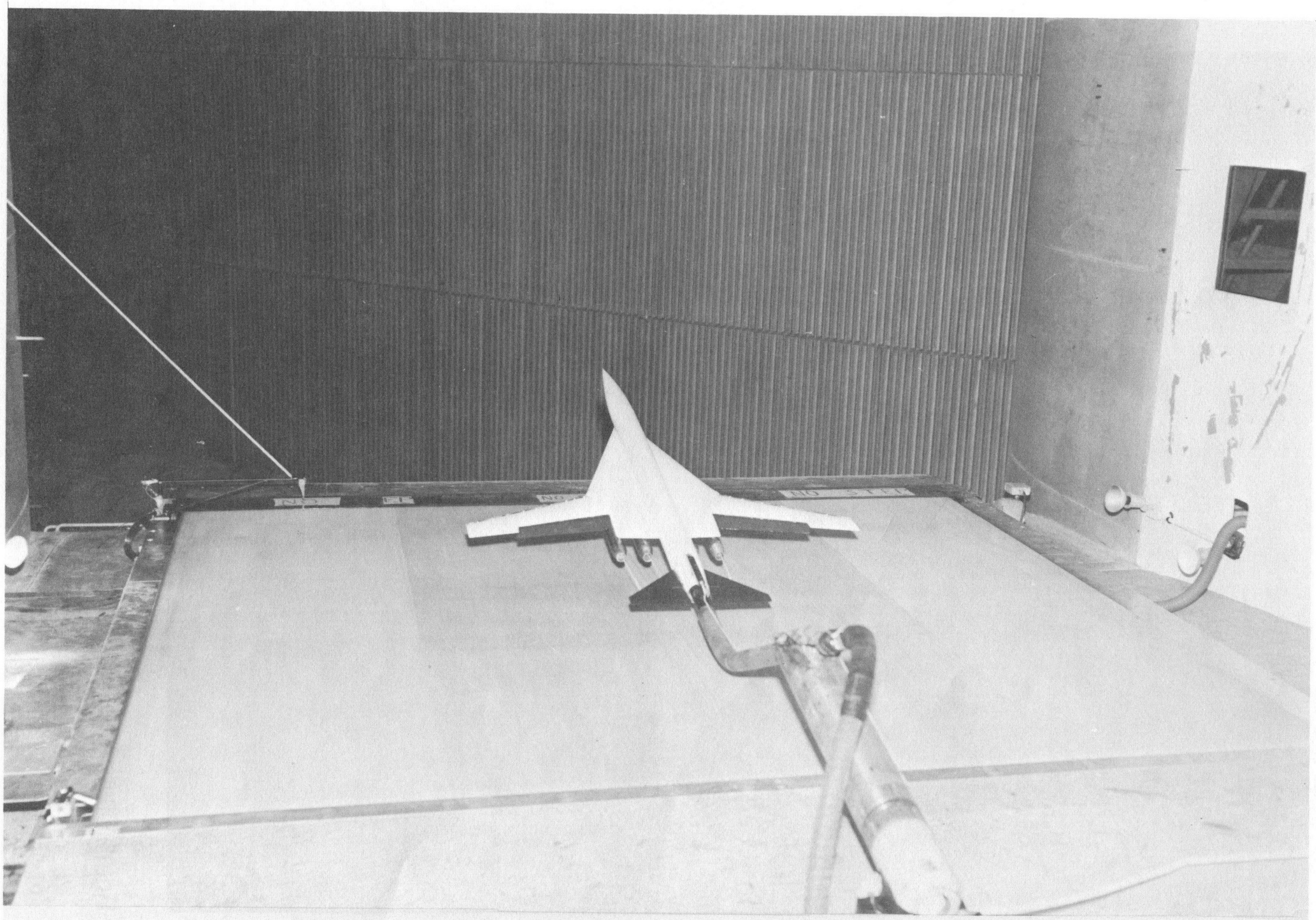

Figure 49. - Jet-tail interaction model.

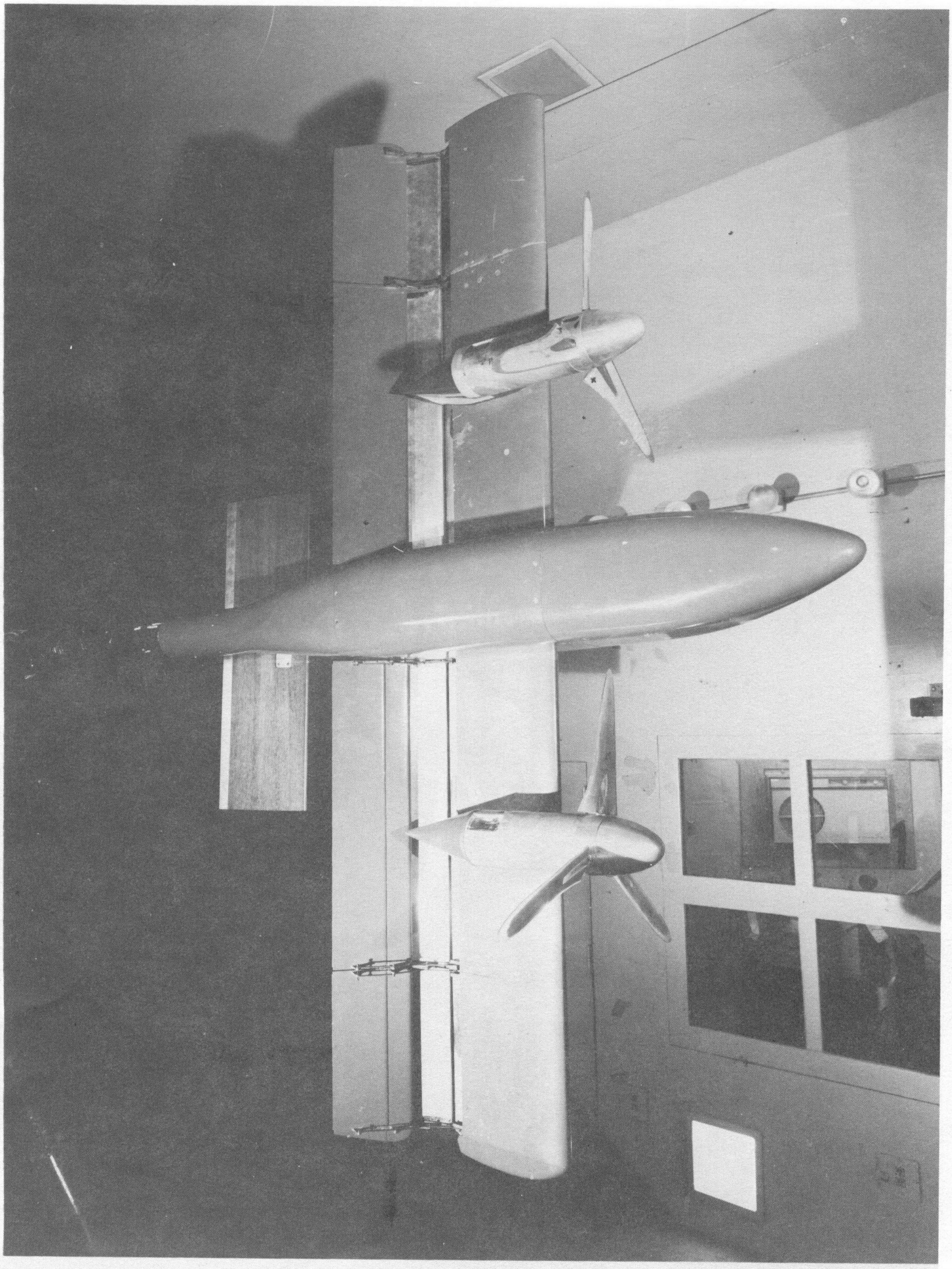

Figure 50. - General research model in support of the Marine/Navy Counter-Insurgency (COIN) aircraft program.

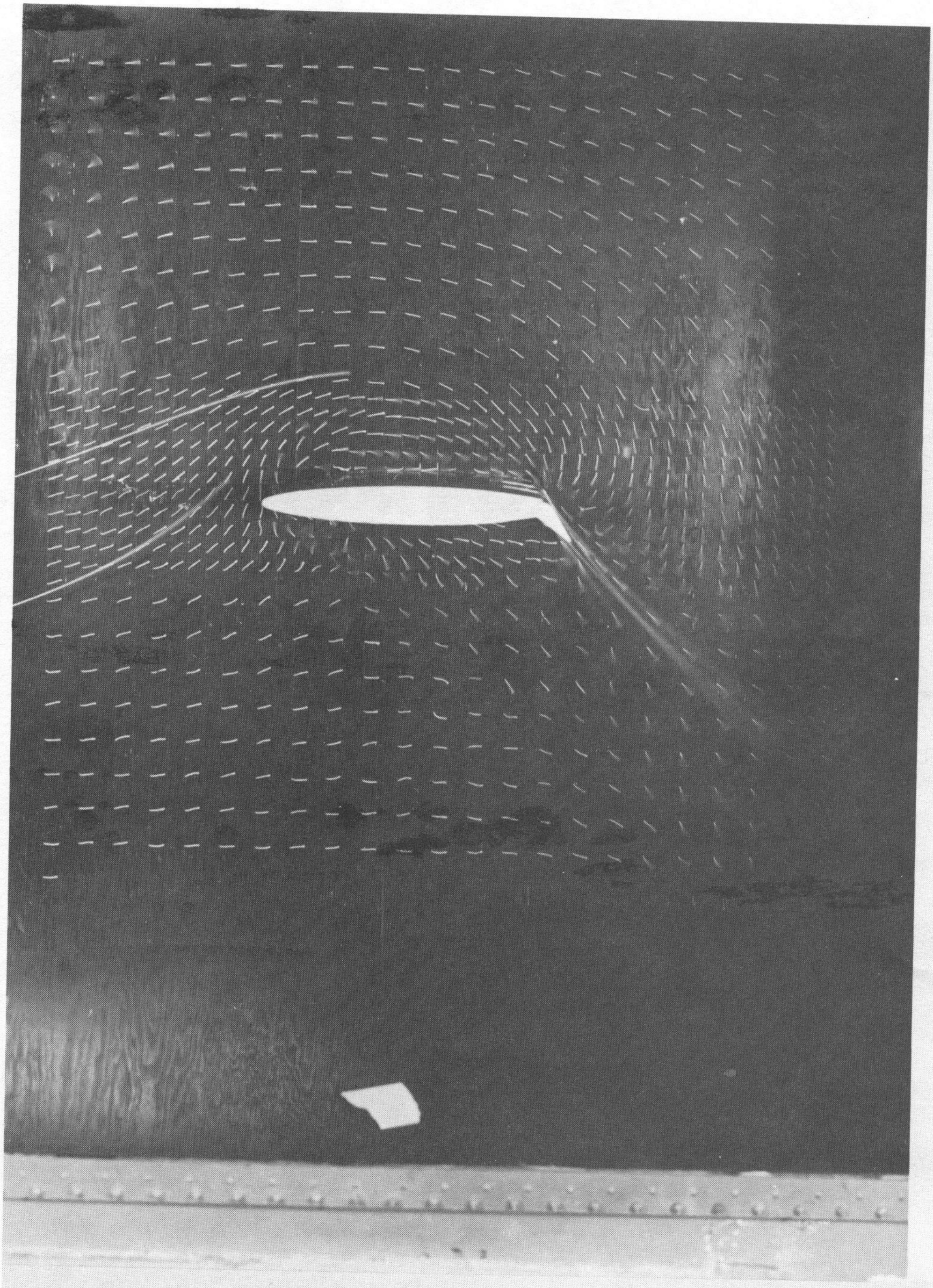

Figure 51. - Flow-field around a wing with a jet-augmented flap.

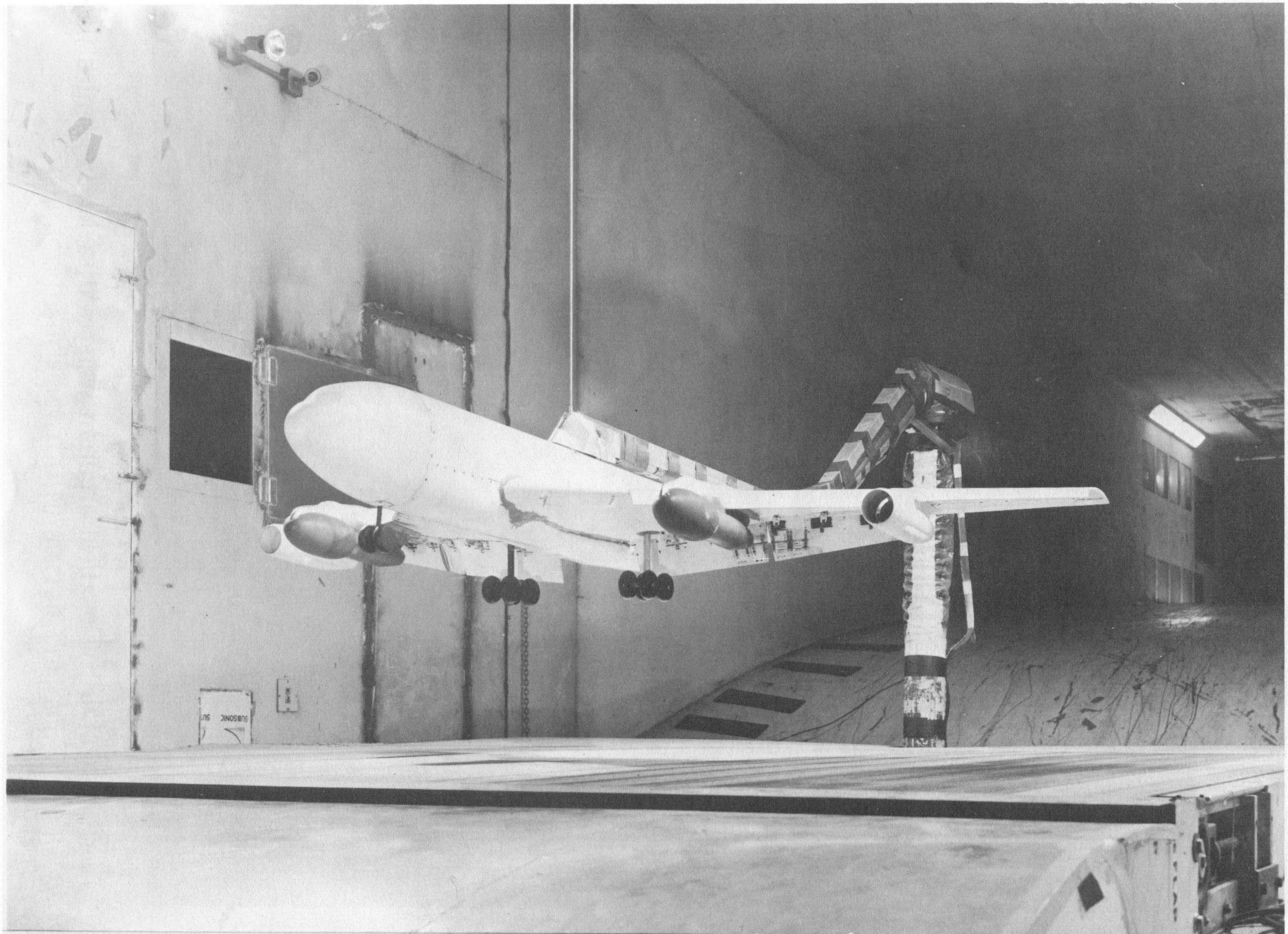

Figure 52. - Model of Boeing 707-80 modified to incorporate a jet-augmented flap.

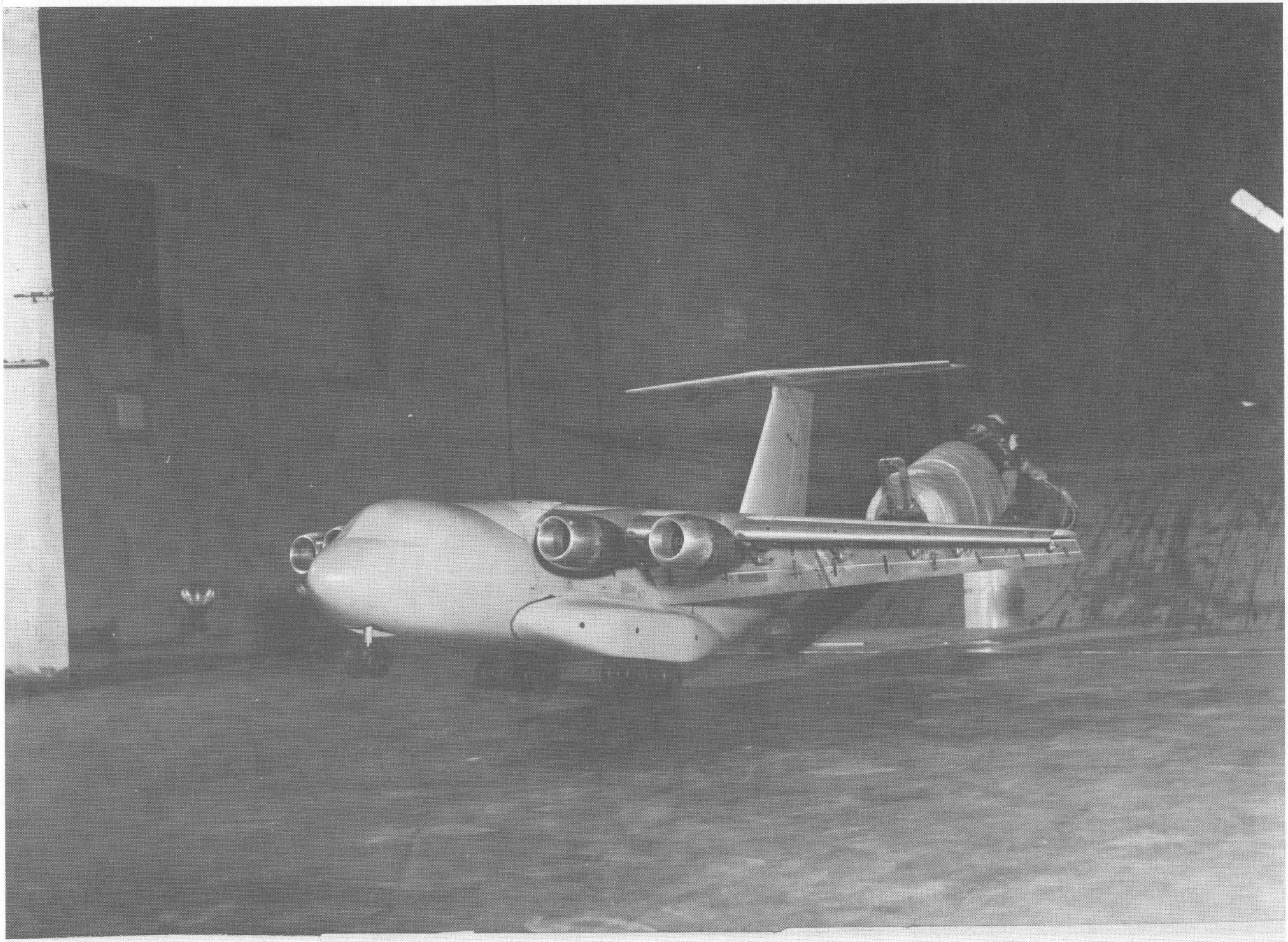

Figure 53. - Externally blown jet-flap model.

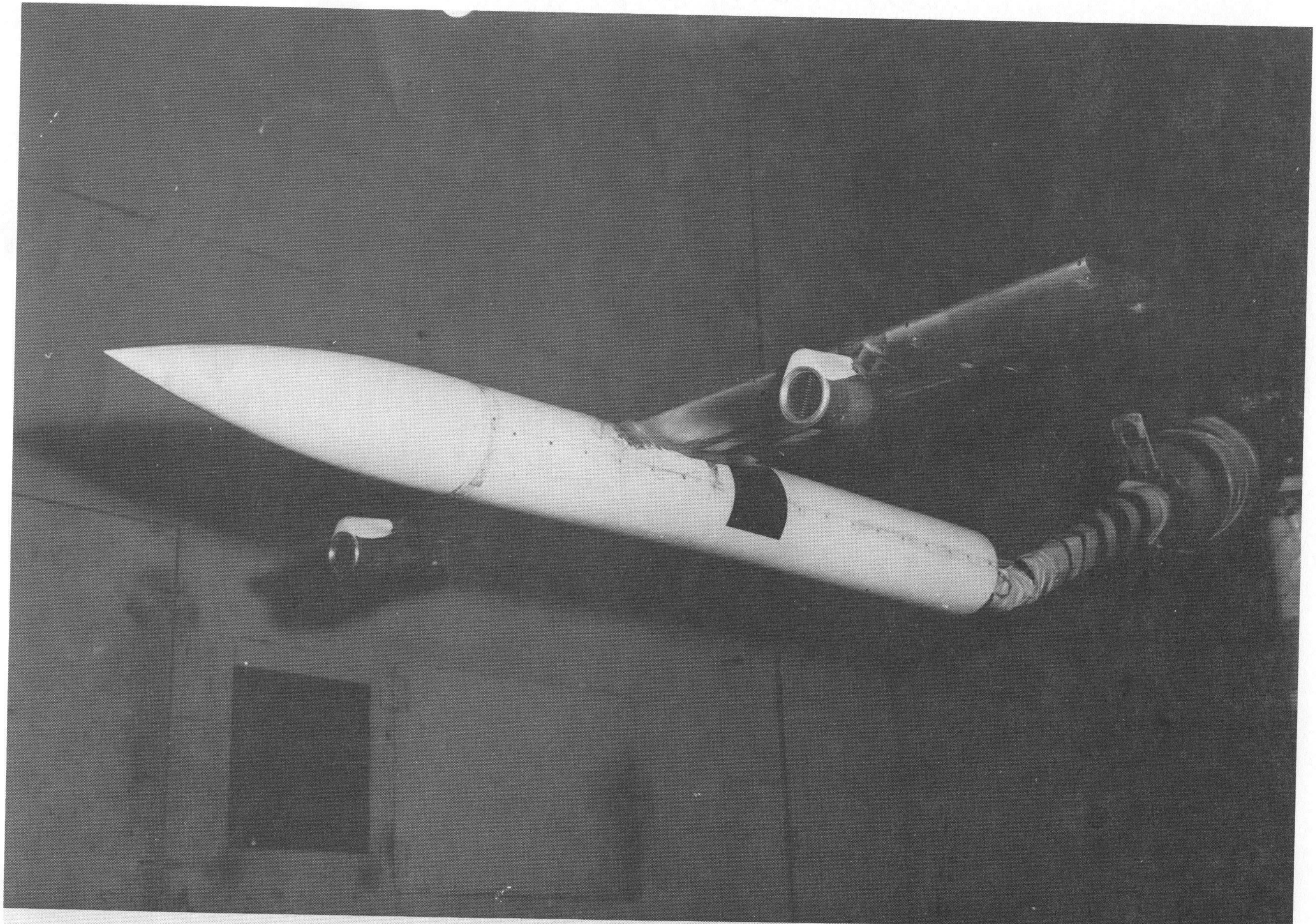

Figure 54. - Externally blown flap research model utilizing an aspect ratio 6 wing with an early version of the supercritical airfoil.

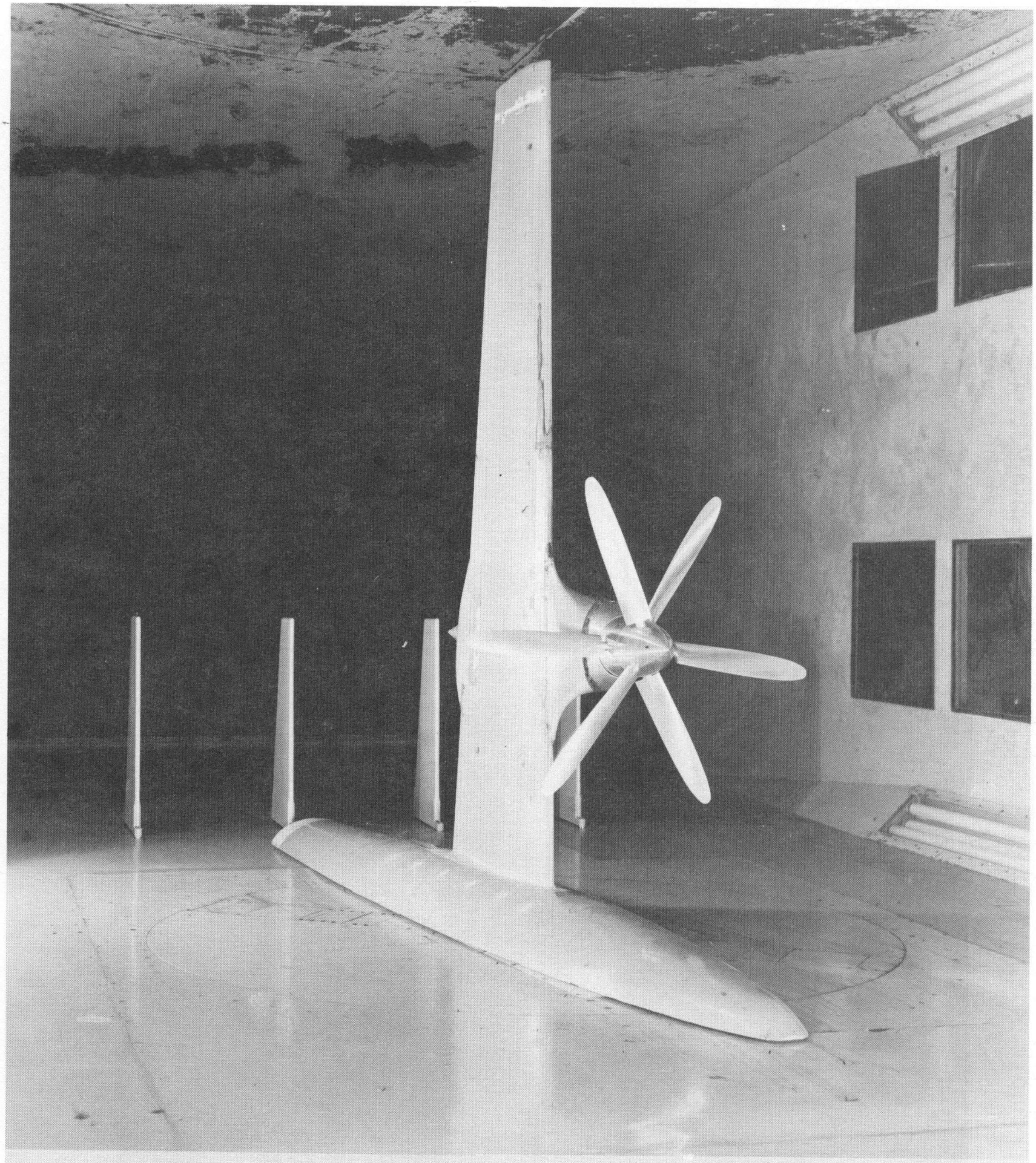

Figure 55. - Half-span counter-rotating propeller power effects model.

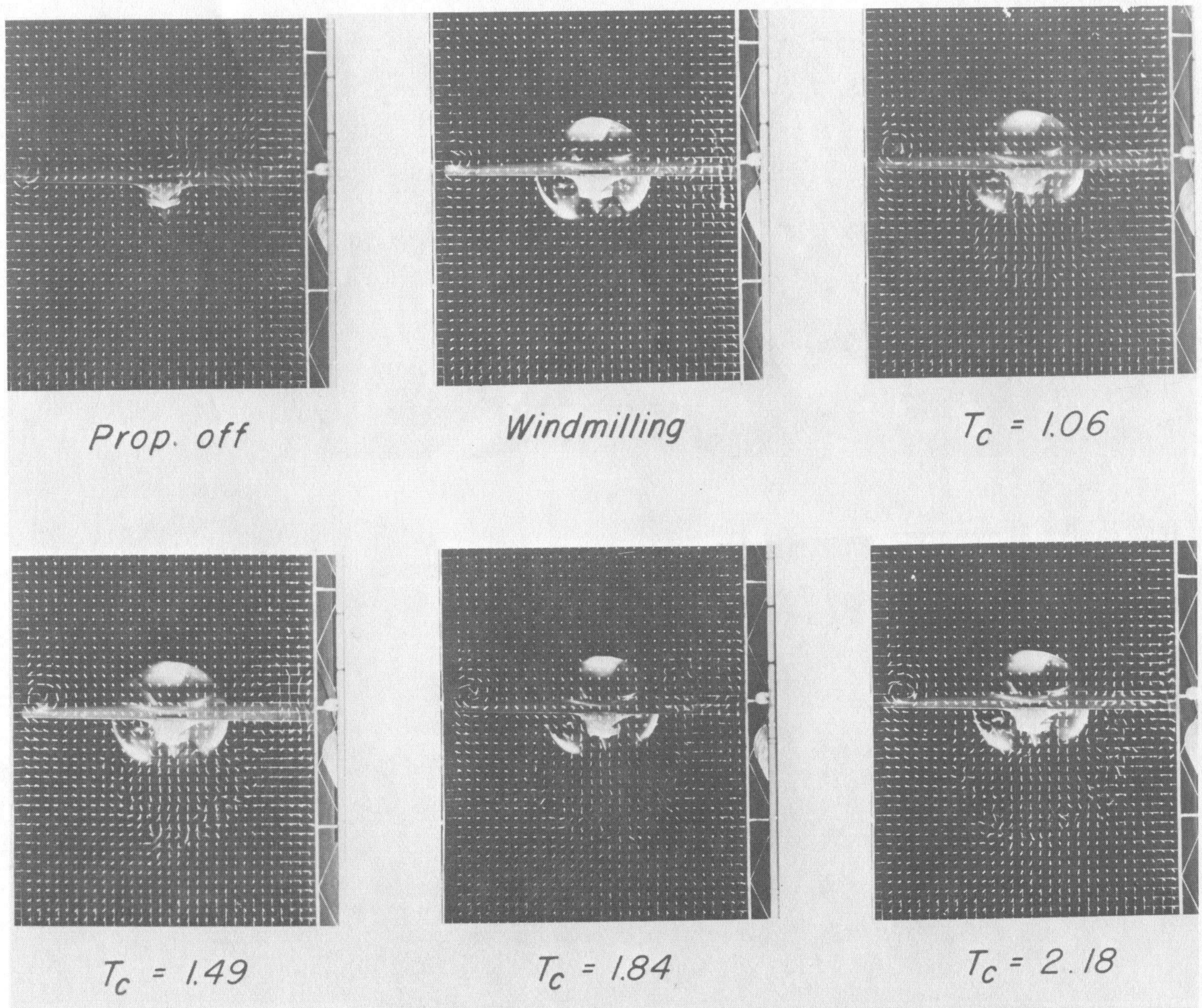

Figure 56. - Tuft grid for flow-field studies.

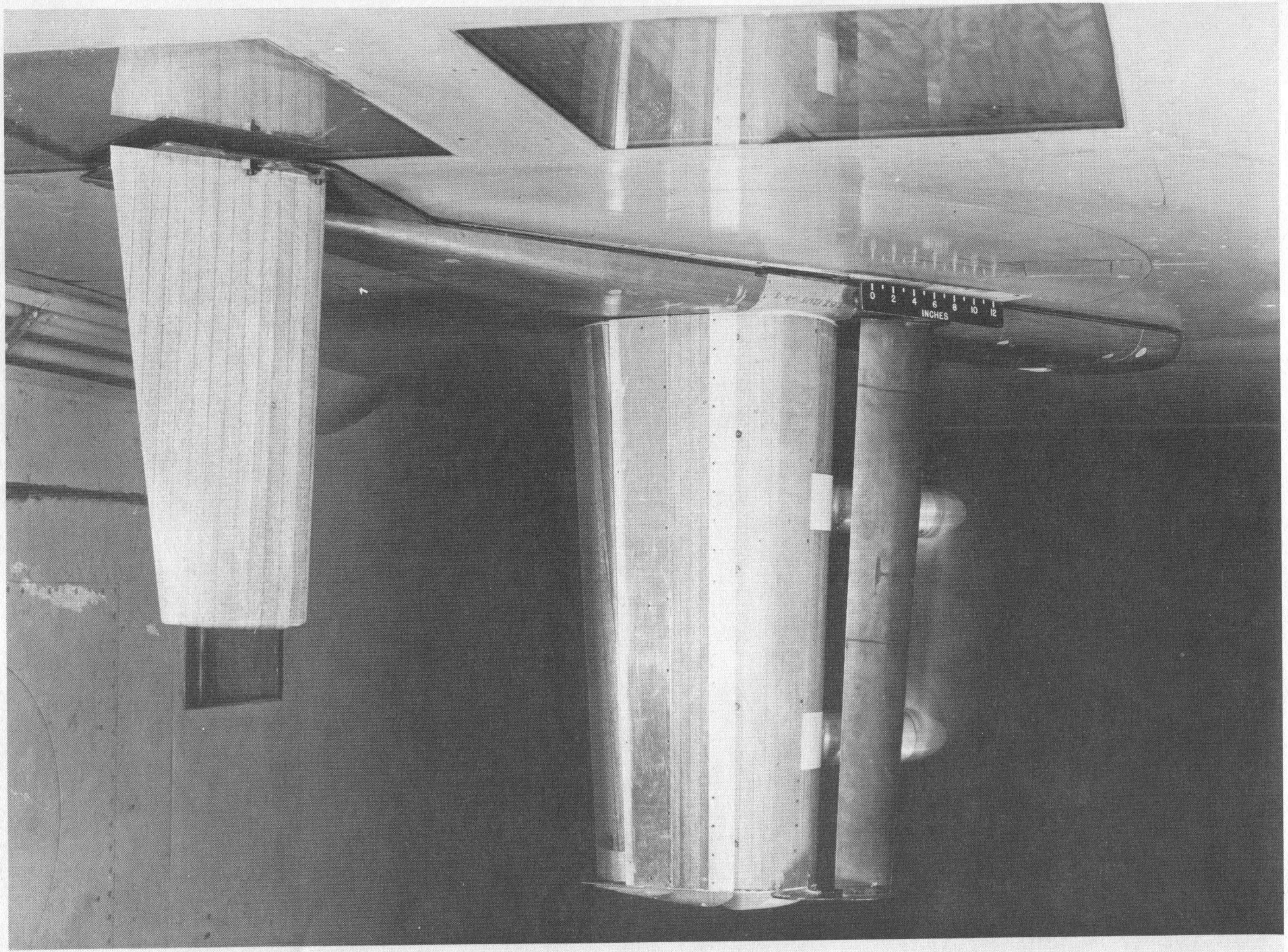

Figure 57. - Half-span research model with leading- and trailing-edge high-lift devices immersed in the slipstream.

Figure 58. - Force-test model of the XC-142 tilt-wing research aircraft.

Figure 59. - First general research VTOL model mounted over the ground board in the 17-foot test section.

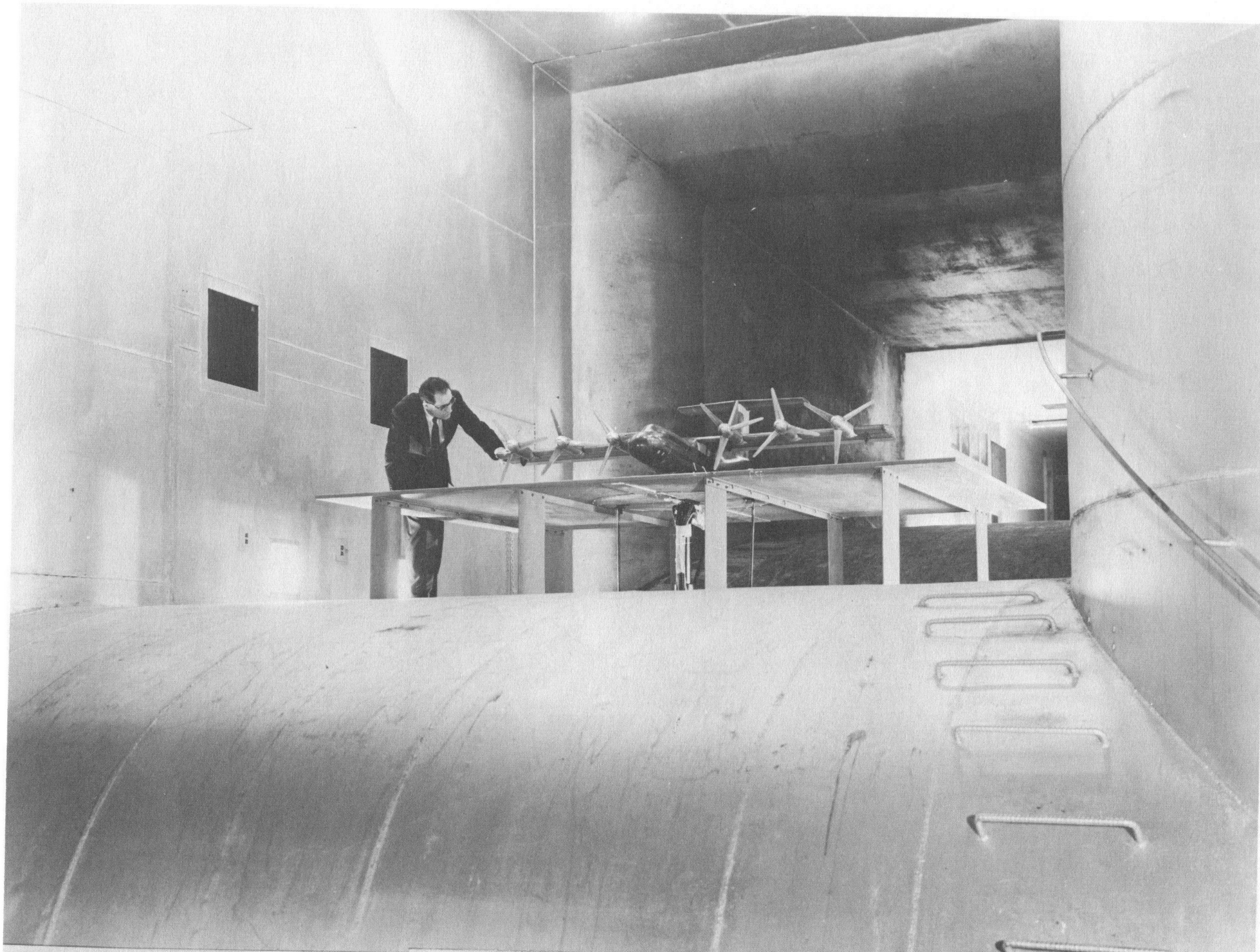

Figure 60. - Six-propeller general research model over ground board.

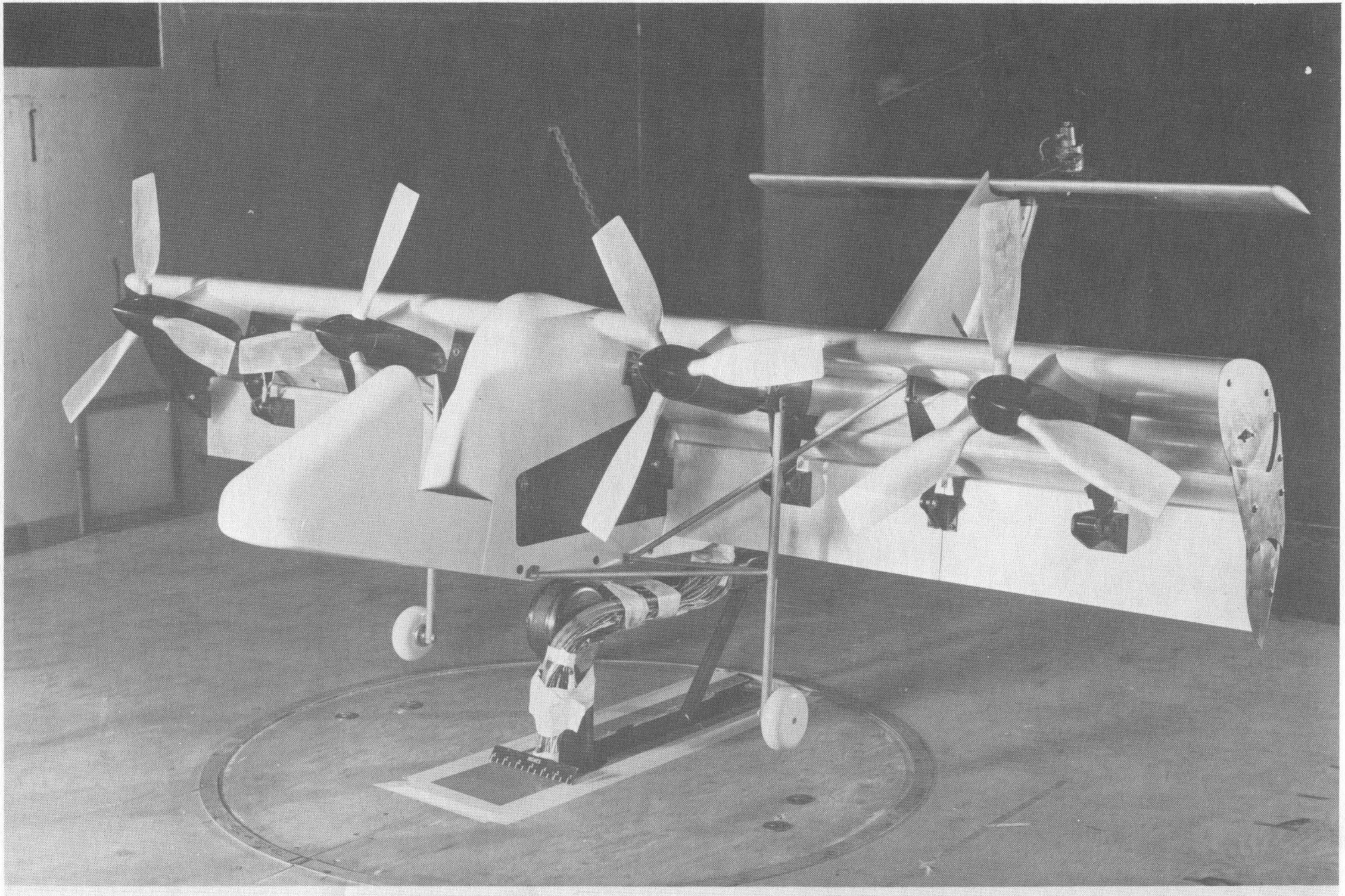

Figure 61. - Fairchild VTOL model.

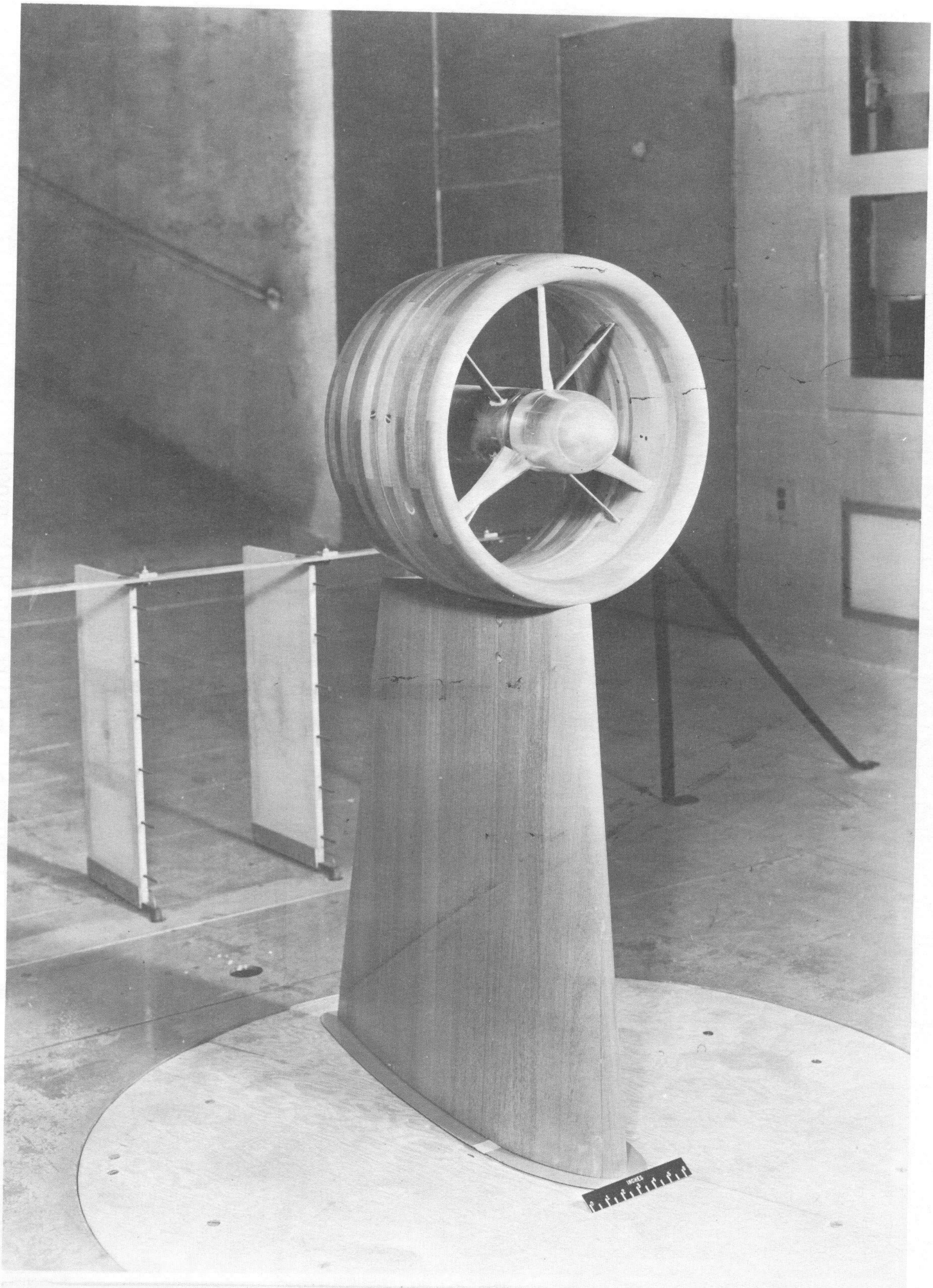

Figure 62. - Doak ducted-fan model.

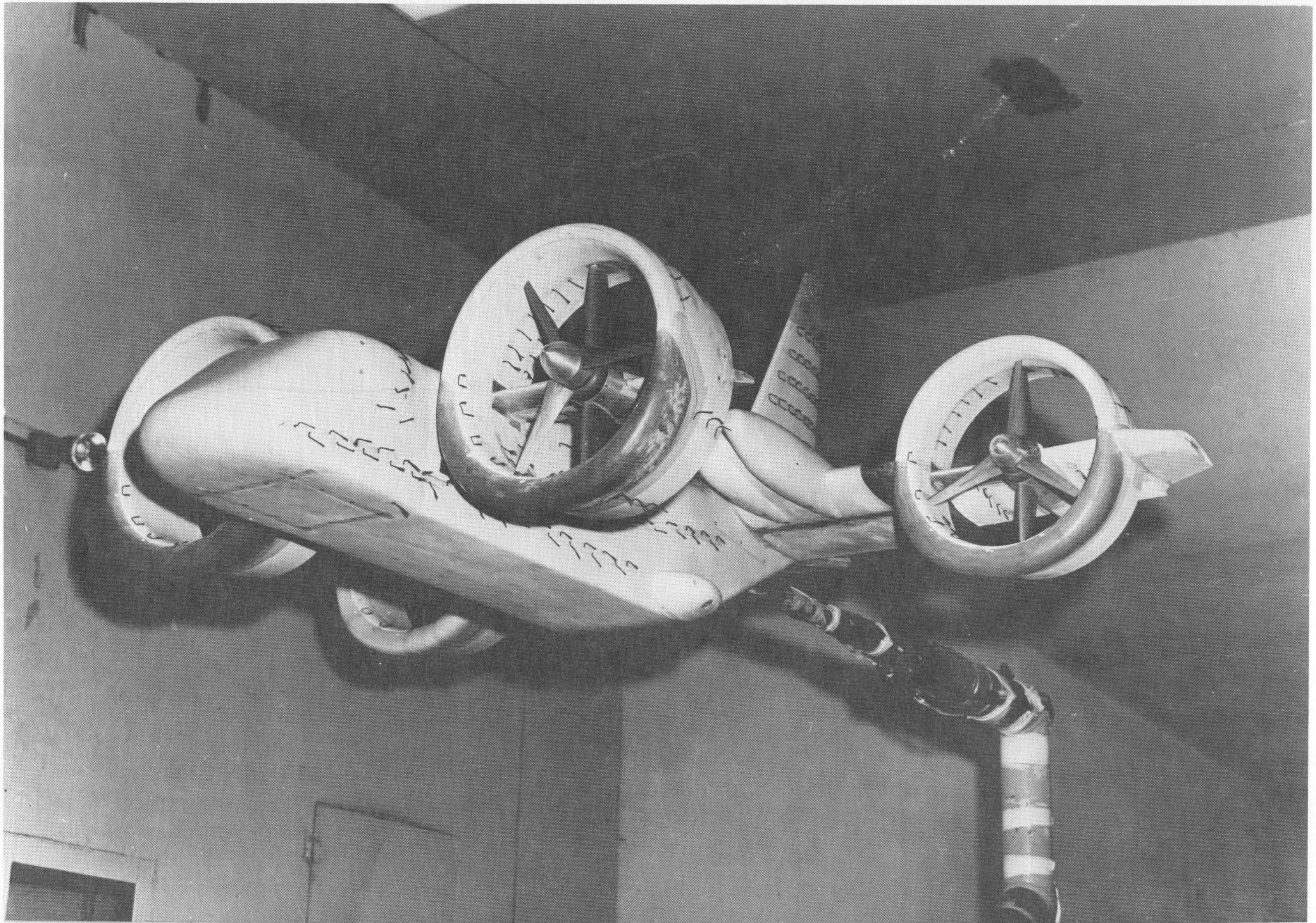

Figure 63. - Four-ducted-fan VTOL model (X-22A).

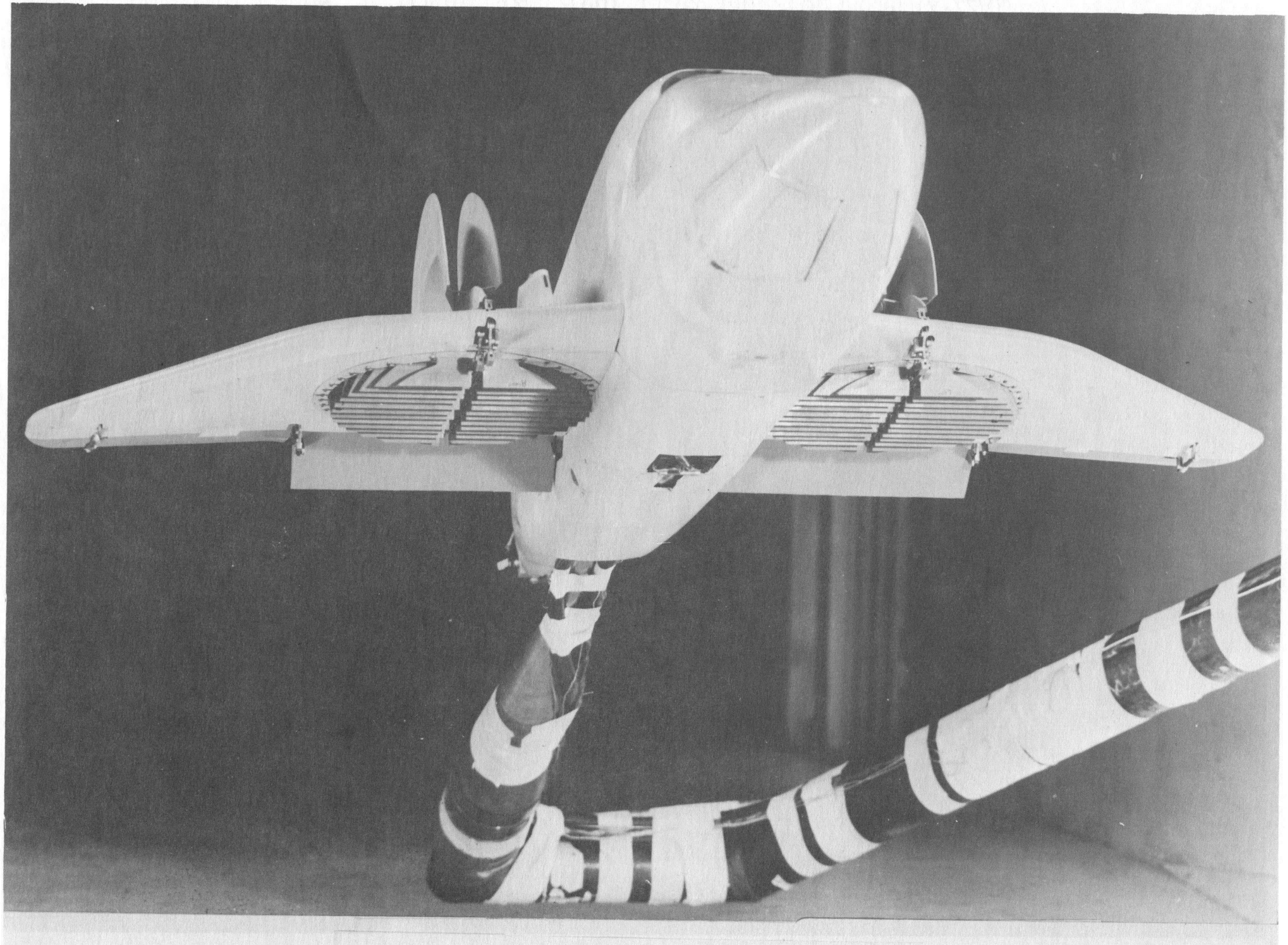

Figure 64. - Fan-in-wing VTOL model (SV-5A).

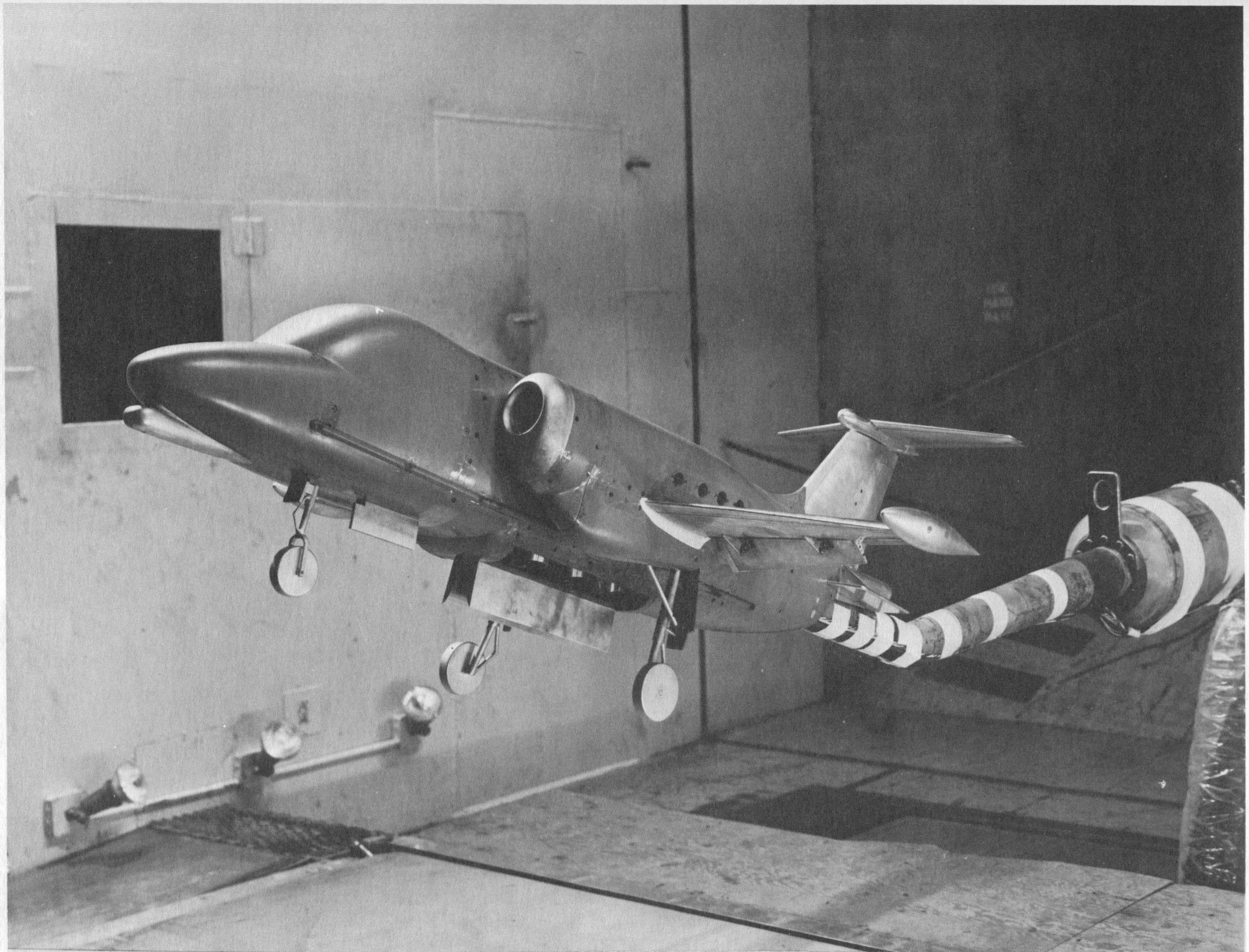

Figure 65. - XV-4B general research VTOL model.

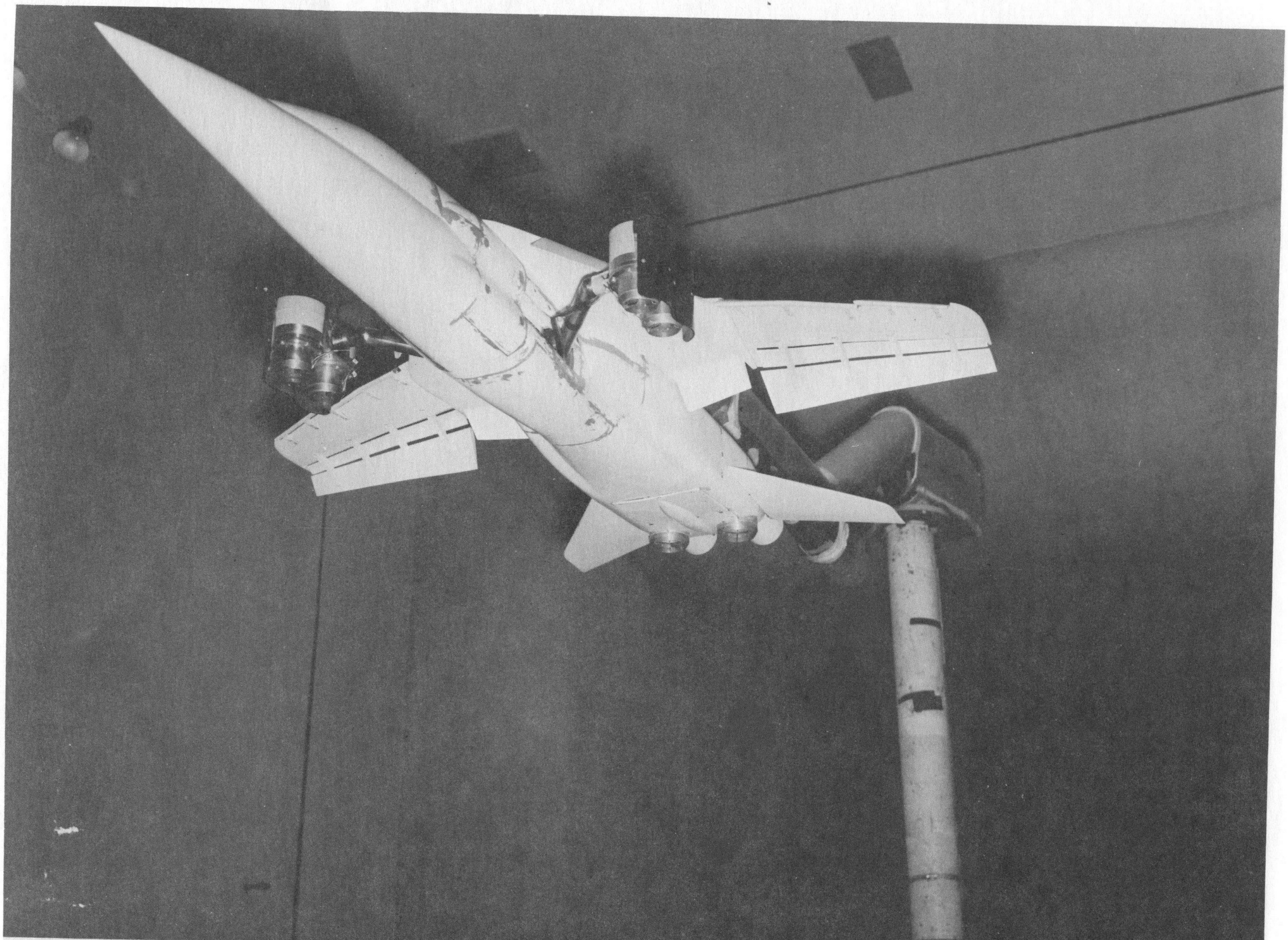

Figure 66. - A model of the US/FRG jet VTOL fighter model.

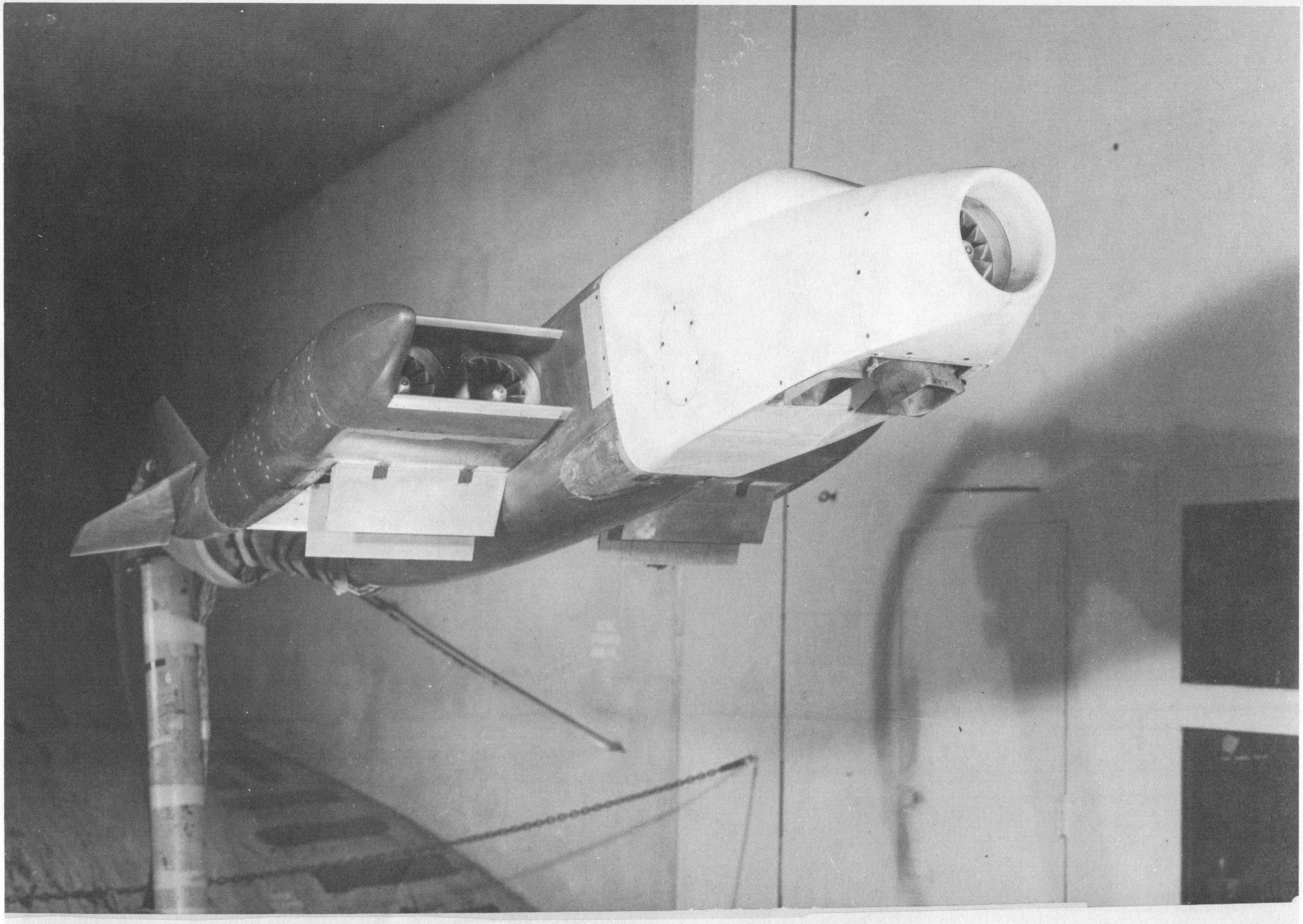

Figure 67. - Propulsive-wing concept (ADAM II).

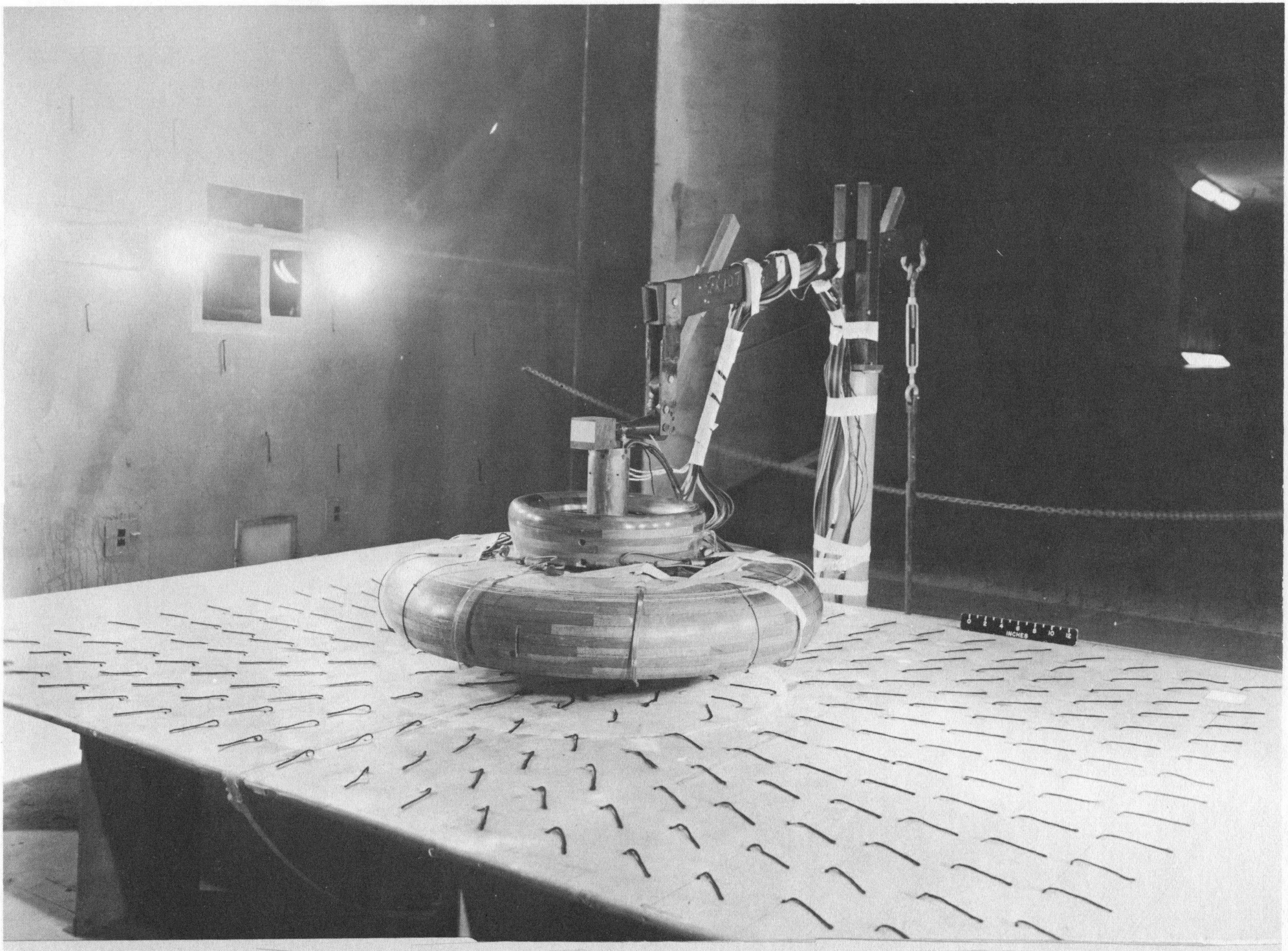

Figure 68. - Ground-effect machine flow-field studies (GEM).

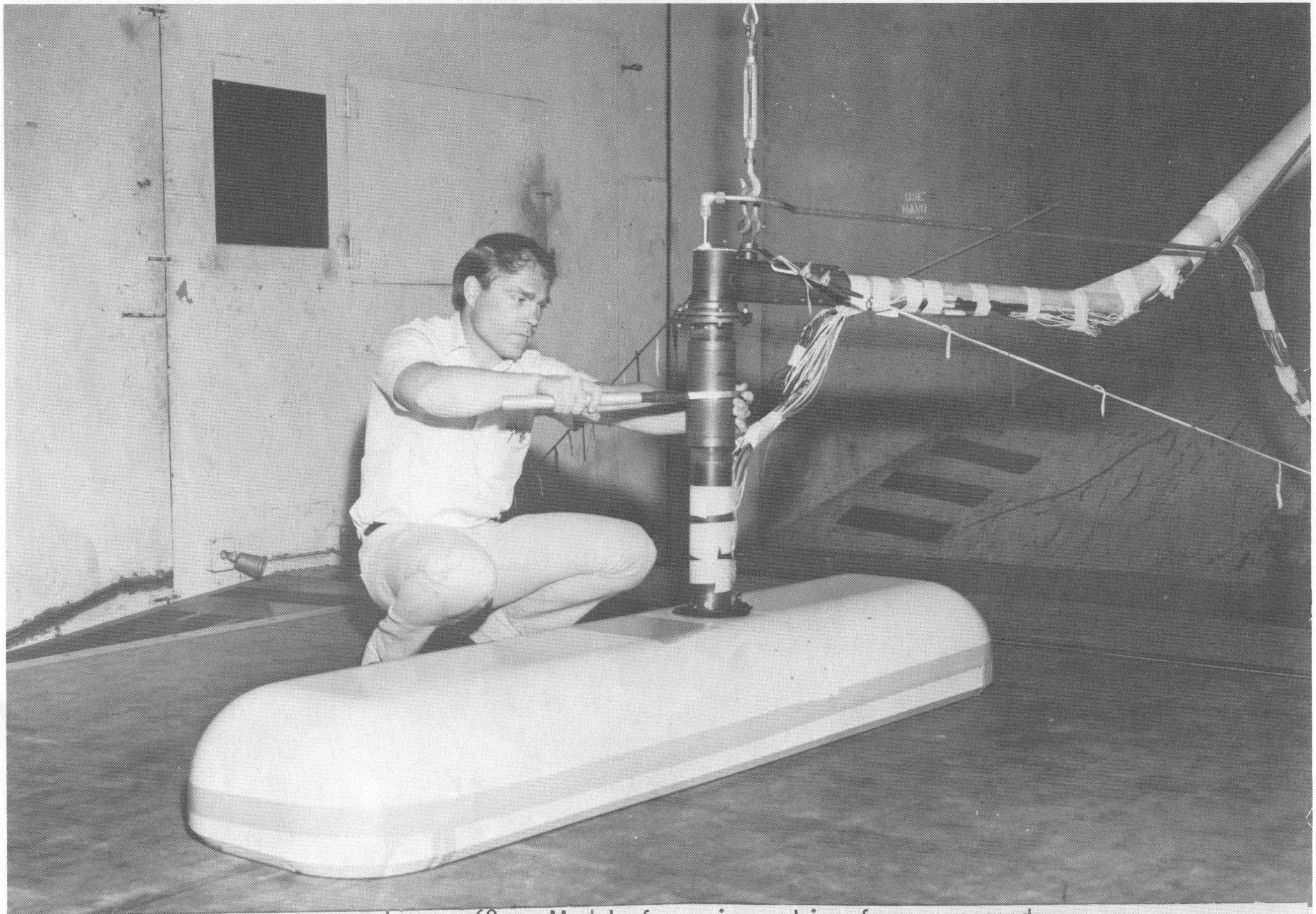

Figure 69. - Model of an air cushion for a proposed Tracked Air-Cushion Vehicle (TACV).

Figure 70. - Parawing recovery.

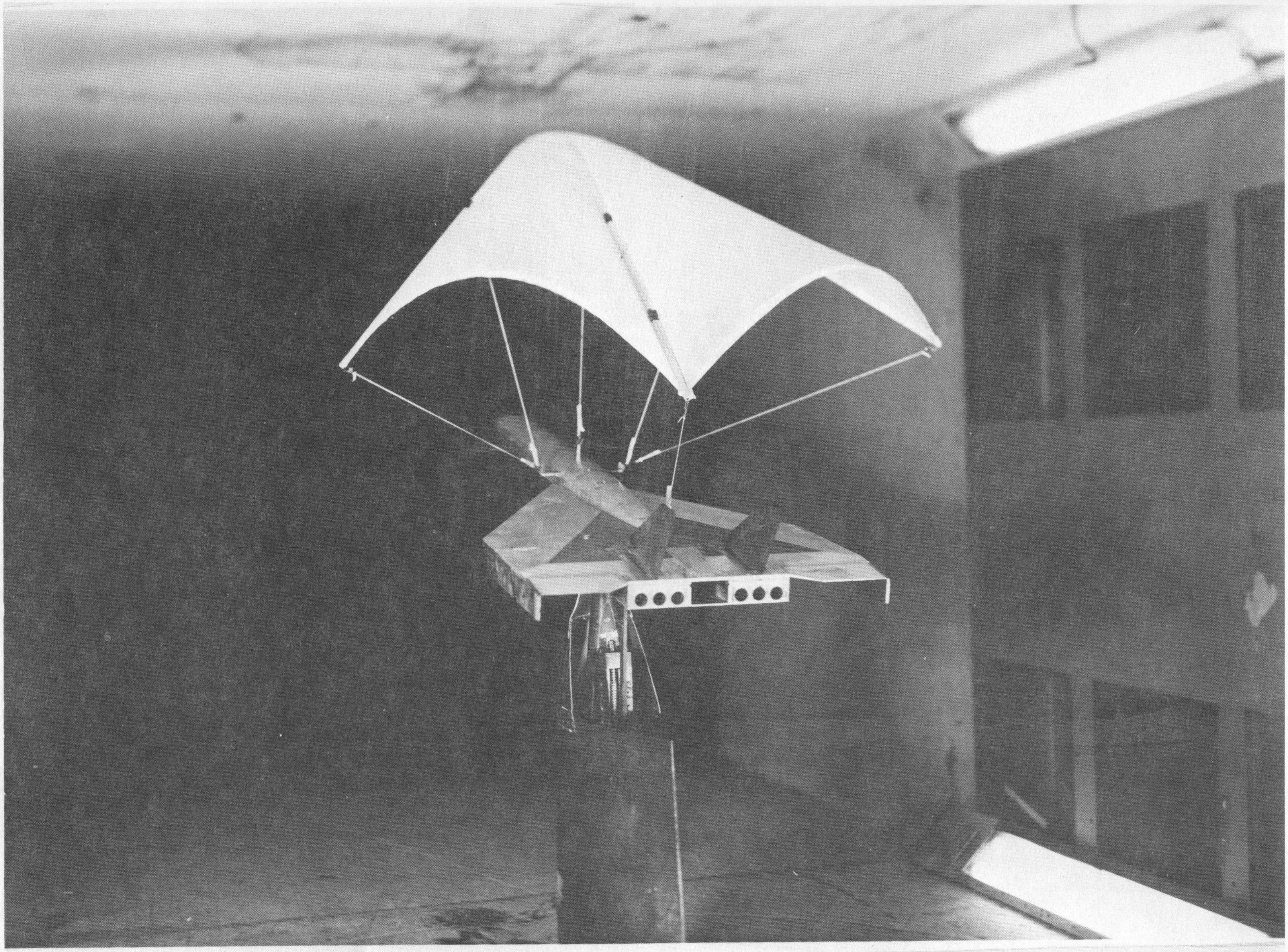

Figure 71. - Paraglider recovery concept for airplane.

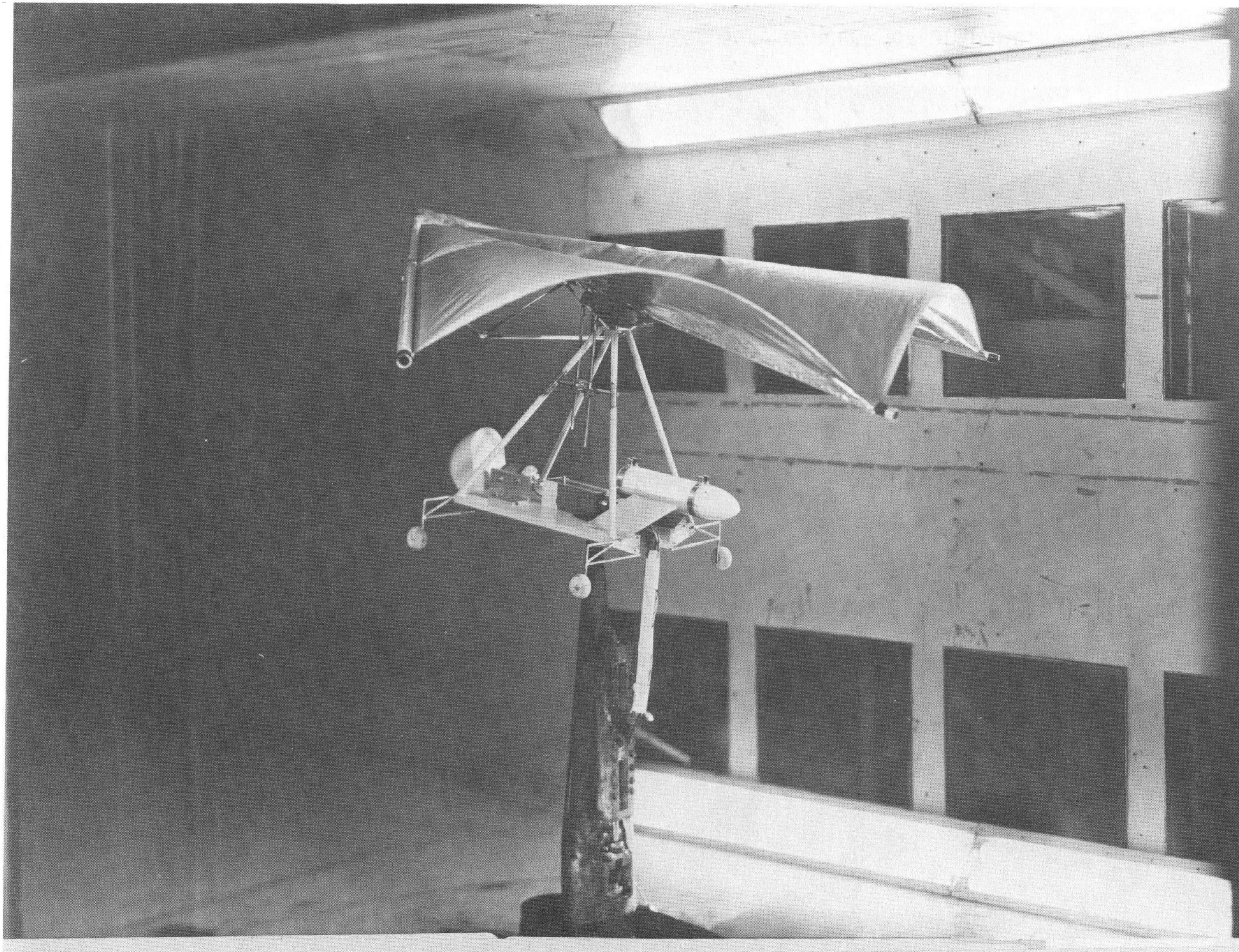

Figure 72. - Ryan paraglider airplane model.

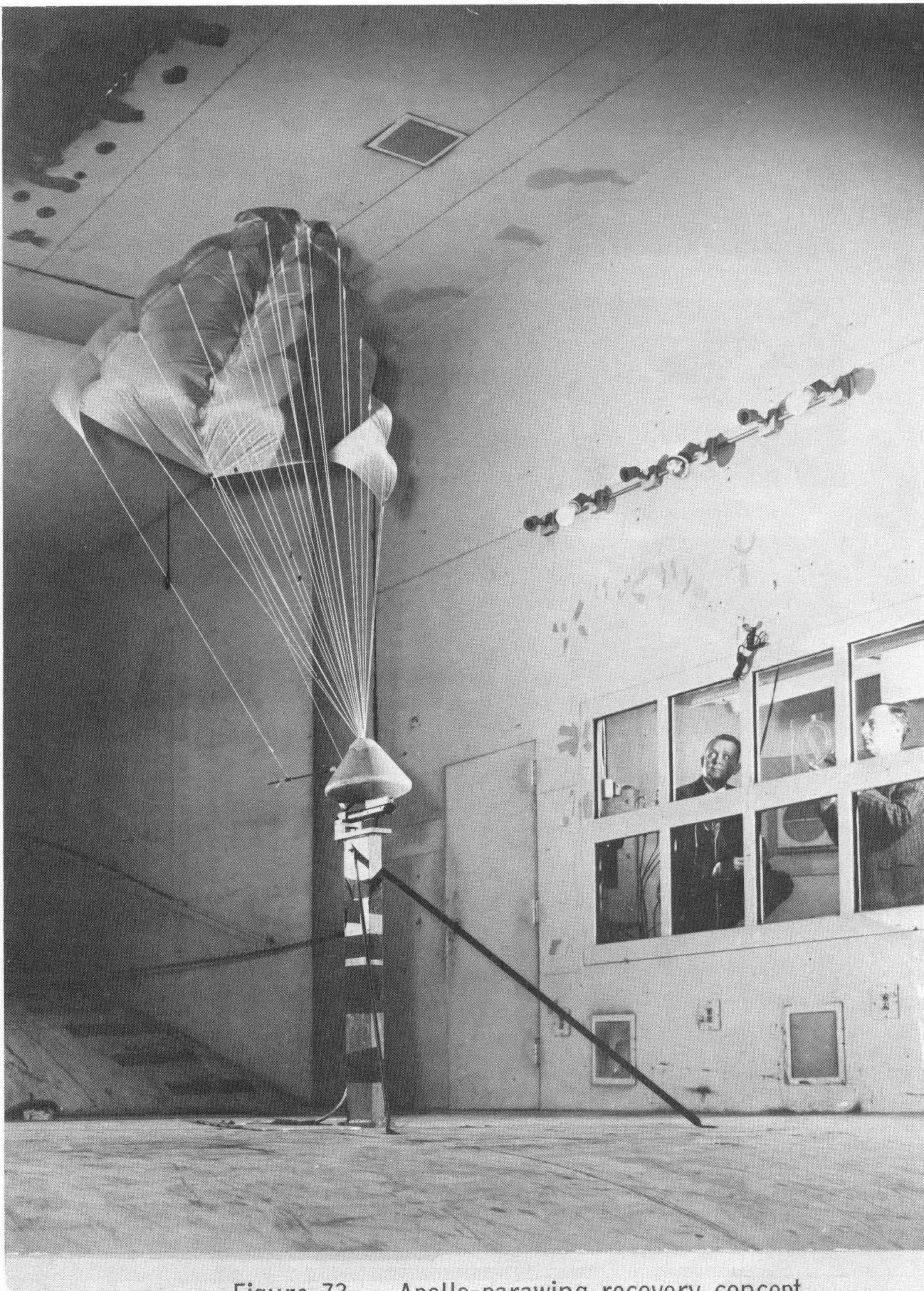

Figure 73. - Apollo-parawing recovery concept.

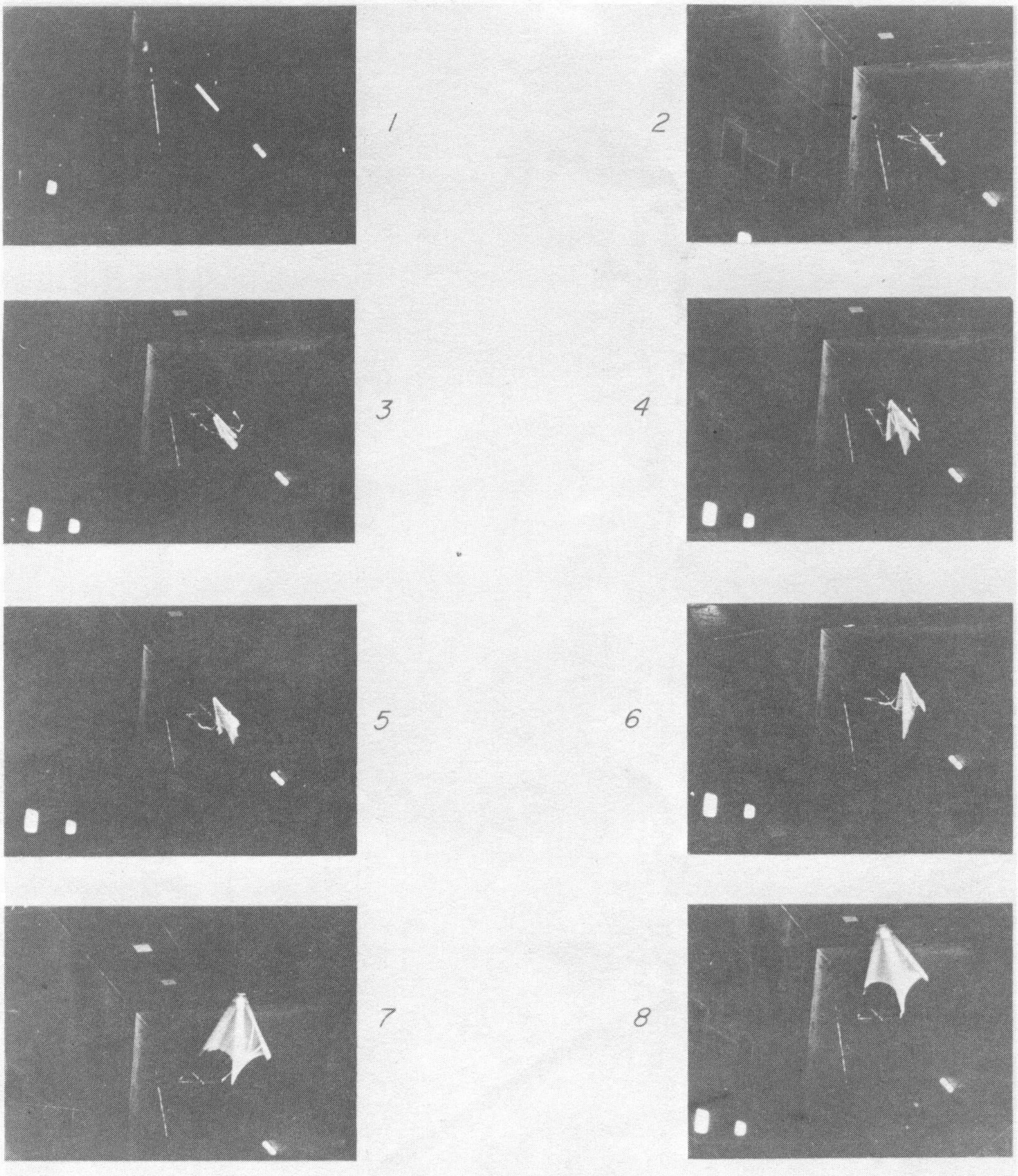

Figure 74. - Paraglider deployment tests.

Figure 75. - Inflatable balloon - shock loads.

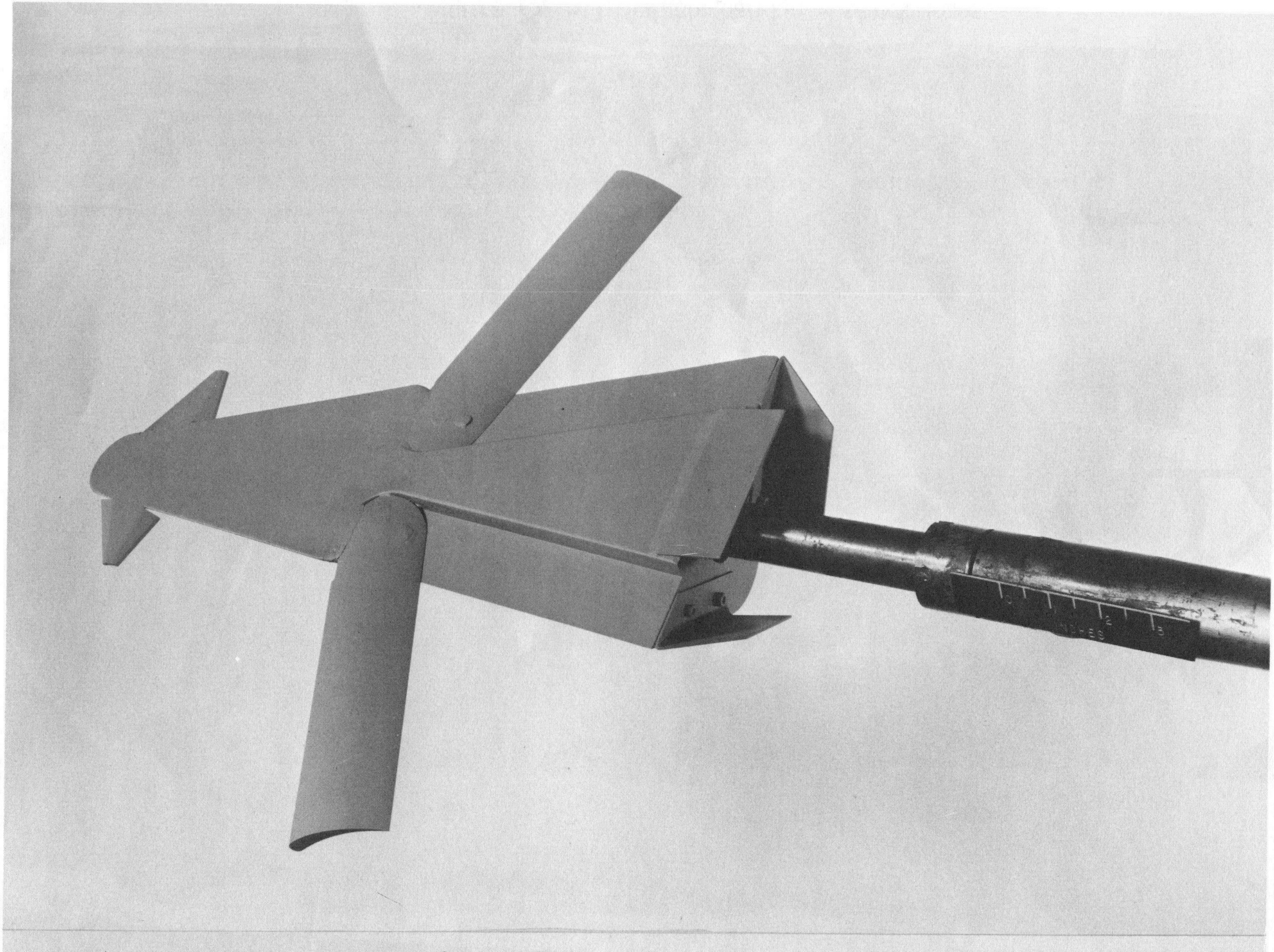

Figure 76. - Retractable-wing reentry concept.

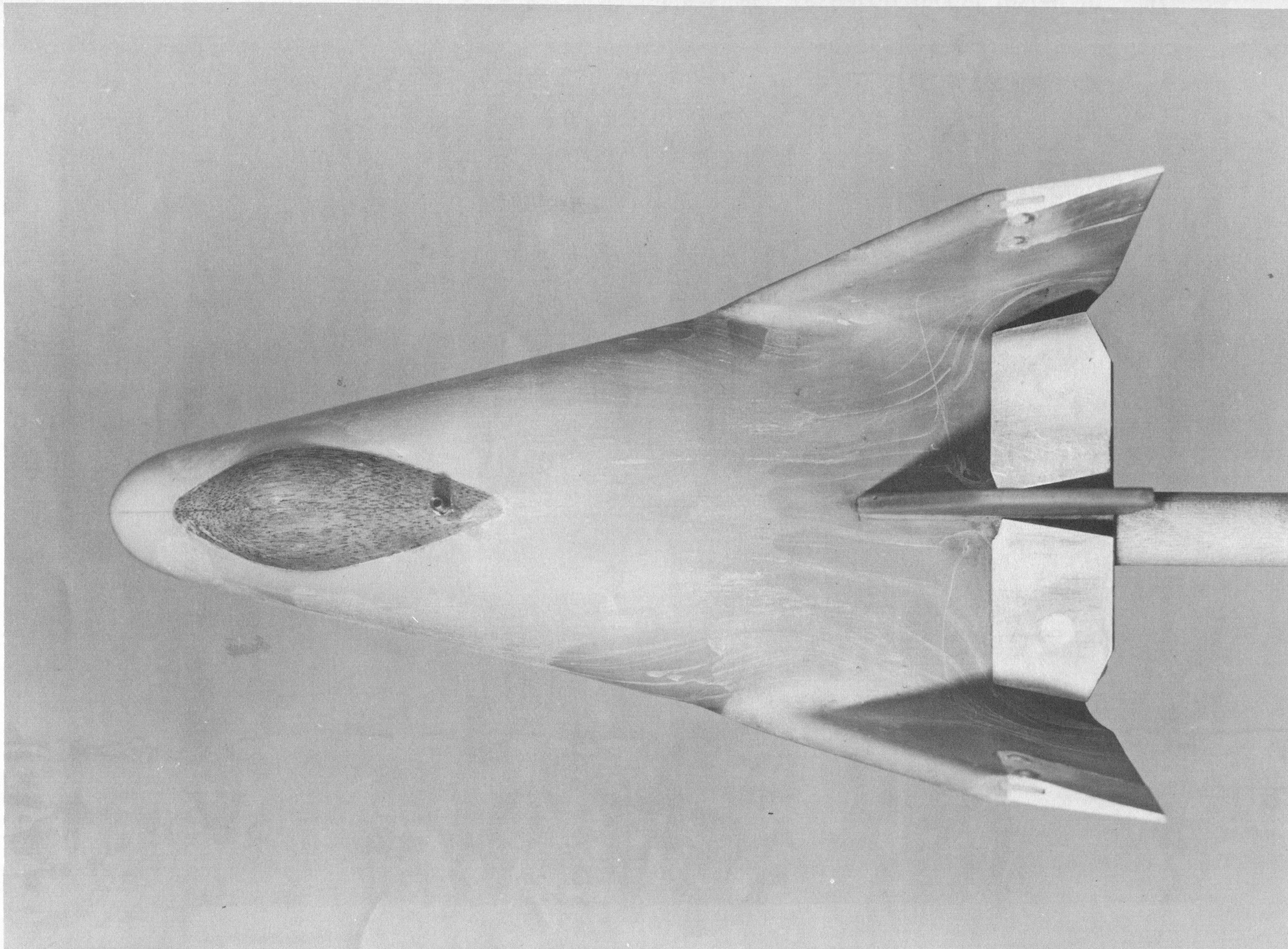

Figure 77. - Fixed-geometry reentry concept.

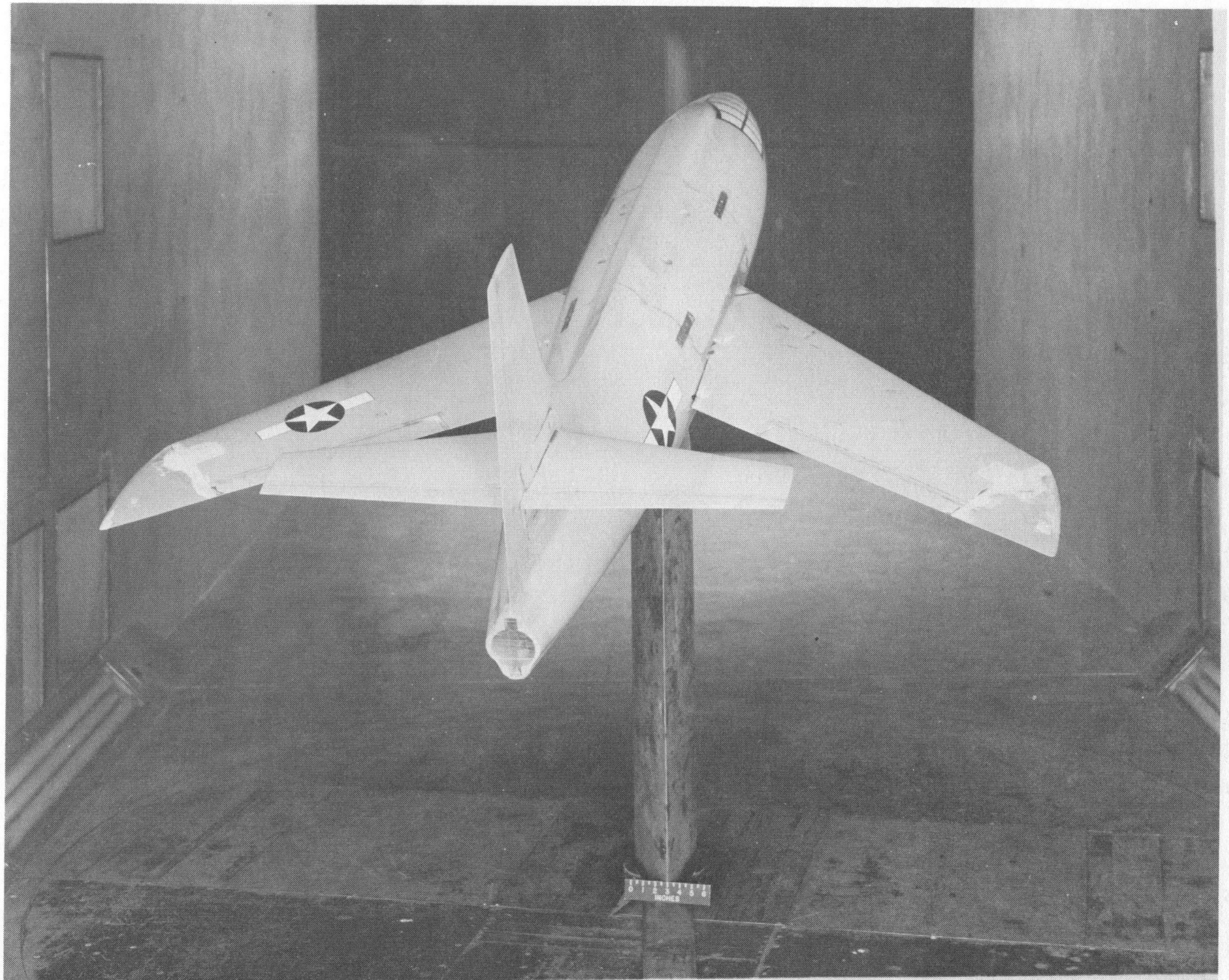

Figure 78. - Early variable-sweep research model tested in 1947.

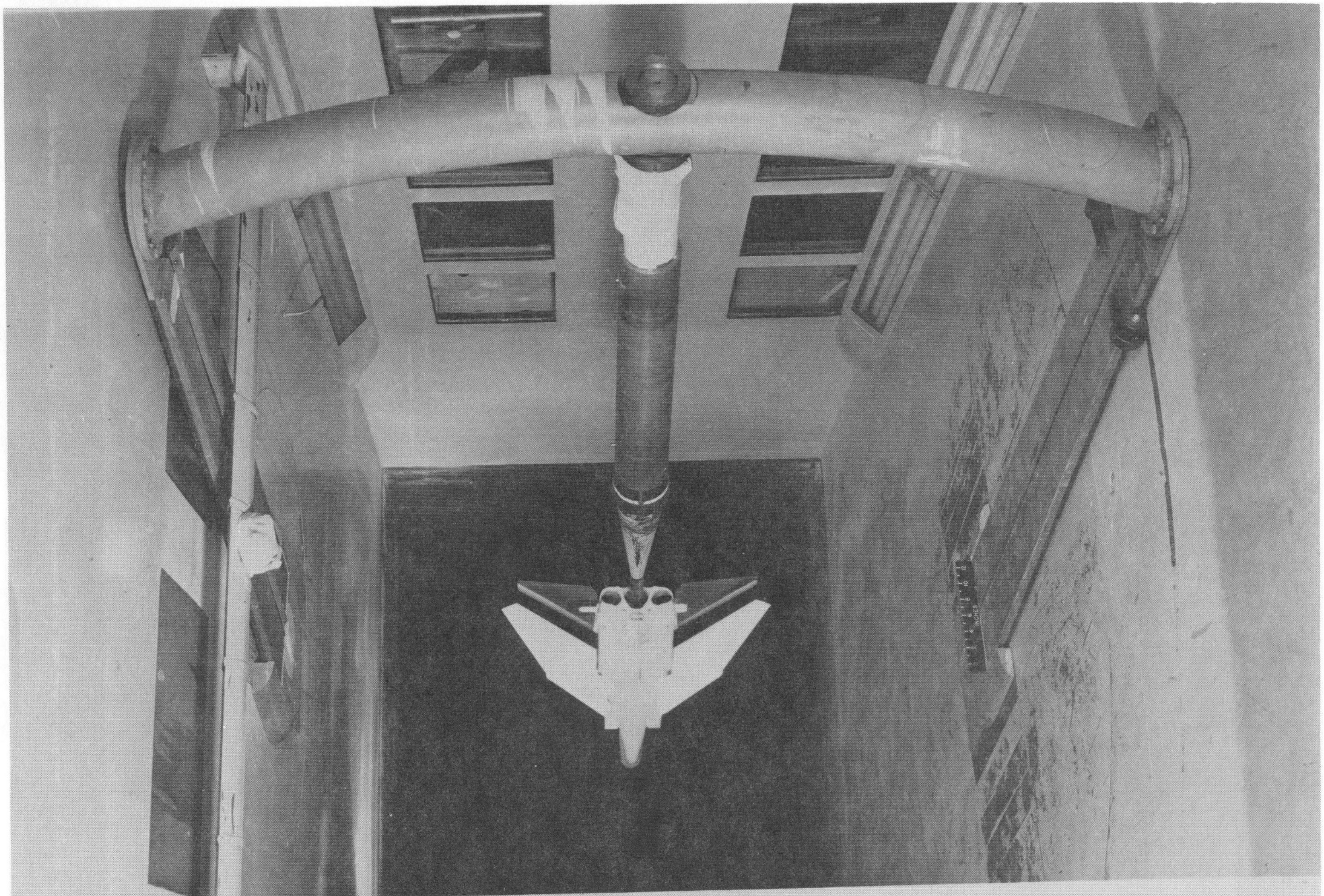

Figure 79. - Outboard pivot variable-sweep model tested in 1959.

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