TEST FACILITIES
AIRCRAFT FIRE PROTECTION PROGRAM

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PURPOSE

The purposes of the aircraft fire protection program making use of these facilities are

A To develop means for protecting aircraft against fire in flight
B To determine design criteria for minimizing the occurrence of fire in flight.
C. To develop simplified test procedures to duplicate the conditions of fire in flight so that more detailed studies can be conducted in the laboratory

METHOD

As the most hazardous source of fire in flight is the powerplant installation, the existing facilities are arranged to test that installation and associated equipment under simulated flight conditions This method is deemed necessary from the standpoint of safety, and provides reasonable control of some of the variables involved which might not be possible under conditions of actual fire tests in flight.

TEST PROGRAM

In order to clarify the use of the test facilities, a knowledge of the work being conducted is essential

The general test program is divided into four major phases to provide fire prevention and fire protection data

(A) Investigations of Ignition Sources

(1) Determination of electrical system and exhaust system ignition sources by release of quantities of fuel and oils throughout the engine installation under various simulated flight conditions
(2) Comparison of ignitability of gasoline and safety fuels on ignition sources determined under (1).
(3) Determinations of ignitability of lubricating oils, hydraulic fluids and non-inflammable hydraulic fluids

(B) Design Criteria

(1) Determination of design criteria to eliminate or reduce ignition source hazards
(2) Investigations of the fire resistance of the materials and equipment used and proposed for use in aircraft
(3) Determinations of the locations and areas requiring the use of fire resistant materials and equipment

(C) Fire Detectors

(1) By test, to encourage the development of new and improved fire detectors
(2) The full scale testing and bench testing of developed aircraft fire detectors
(3) Determination of specific detector locations required in particular engine installations.

(D) Fire Extinguishing Systems

(1) Determinations of the best extinguishing agents for combatting aircraft powerplant fires
(2) Determination of the simplest optimum system for distributing agents to the fires
(3) Compare the effectiveness of power section fire extinguishing systems plus engine shut-down versus engine shut-down alone (no extinguishing agent)
(4) Determination of fire duration assuming stoppage of inflammable fluids with and without propeller feathering
(5) Determination of effect of airspeed on the ease of extinguishing engine fires.
(6) Determination of the best crew procedure to insure fire extinguishment

This general test program is to be accomplished on the powerplant installations of.

(1) Boeing Superfortress (B-29) with the Wright 3350 fuel injection engine
(2) Lockheed Constitution (Model 89) Navy XR-60 with the P & W 4360 engine
(3) Lockheed Constellation (C-69) with the Wright 3350 carburetor engine.
(4) Allison 3420 engine in any installation which becomes available

BUILDING

The first building which is being used for providing fire protection for large piston engine installations is shown in Figure 1. Plan and elevation views of that building are shown in Figure 2.

In the test chamber or center section of the building, a full scale powerplant installation and a section of wing are mounted The engine installation is identical in all respects to that used on actual aircraft The wing section is a frame of structural steel covered with stainless steel sheet identical with the actual wing in dimensions and contour only. See Figures 3 and 4

On both sides of the test chamber are ground and second story observation rooms. The second floor on the south side includes an office space The second floor on the north side includes controls and equipment for handling extinguishing agents for the test fires

The north wing includes observation space, space for fabricating components of test set-ups, a heater room, lavatory, and stock room Additional space is provided for the installation of any necessary special test equipment and controls.

The south wing includes observation space, control equipment space, shop space, and a pump room.

FACILITIES AND EQUIPMENT

A Wind Tunnel

This unit is constructed of steel and is approximately 45 feet long. The inlet diameter is approximately 16 1/2 feet, and the outlet diameter is eight feet The tunnel is driven by a 1500 horse power electric motor which is capable of developing 2250 horse power for the short tests that are necessary. The air flow is regulated by the electric pitch control of a three-bladed steel propeller. The tunnel is used to provide various degrees of air blast over the engine installation being fire tested to simulate the air speed produced by flight. See Figures 1 and 5.

B Electrical System

The electrical system of the fire test facilities includes a substation which connects to the 33 kilovolt high lines and which supplies 2300 volts for operating the wind tunnel motor Appropriate switch gear automatically brings the wind tunnel motor up to its operating speed. Other transformers reduce the 2300 volts to 110 volts and 220 volts to provide power and light for the building services

C. The engine, wind tunnel, and fire controls are all located in the observation space of the south wing. These controls, as well as part of the electrical switch gear, are shown on Figure 6.

D Pyrometers

A bank of 24 recording pyrometers is located in the north wing. Each instrument can be read directly and makes a permanent record of the temperature at a single location on the unit during fire tests Although only 24 recorders are used, they may be easily and rapidly connected to any group of thermocouple pick-ups, a great number of which are located throughout the test installation See Figure 7

E Machine Shop

A small machine shop is located in the north wing See Figure 8 In this shop are built all the structures, components, and parts necessary to the construction and maintenance of fire test equipment. The shop tools include two drill presses, three lathes, two milling machines, a shaper, and a Do-all Saw In addition, the shop includes equipment for gas and arc welding and hand tools

F Build-up Shop

This is a small area in the south wing devoted to the construction and revision of test powerplant installations. See Figure 9 At this location, the necessary changes are made to actual engine installations to enable them to withstand great numbers of severe fires The shop includes a tube bender, shear, brake, and drill press

G Fire Protection System

A large concrete cell adjacent to the north wing of the building houses a four-ton carbon dioxide storage tank and refrigerating unit Carbon dioxide liquid is piped from this tank throughout the fire test building

The locations so protected include the wind tunnel motor, the north and south wings of the building, both ground and second floors, pump room, heater room, lavatory, and test chamber. An additional line leads into the test installation proper in the event a test fire should get out of control, and auxiliary 100 foot hose reels are located on either side of the test installation

Carbon dioxide liquid is piped to the extinguisher control room (north wing, second floor) where the necessary equipment for transferring it to the test containers is located. Thus, this carbon dioxide system is useful in the test program as well as in the protection of all the test facilities

The system can be operated

1. Automatically - by heat detectors located throughout the building.
2. Electrically - by push button stations located immediately outside each hazardous area
3. Manually - by valves located near the liquid storage tank.

H. Bench Test Equipment

A few bench tests can be conducted in the south wing

The first bench test involves the testing of aircraft vacuum systems under abnormal conditions of blockage of the pressure line and failure of the pressure relief valve The original bench test set-up for this investigation is shown on Figure 10

An improved bench test of this equipment is being built as well as a bench testing device for fire detectors.

I. Auxiliary Test Equipment

1. A bank of 24 pyrometers with calibrated leads for checking temperatures between 0 and 1800° F
2. Chronometers and stopwatches
3. Intercommunicating system through which all personnel of the test crew are directed during the conduct of the tests.

J Photographic Equipment

This includes 16 mm motion picture cameras and a speed-graphic still camera. All important tests are photographed and motion pictures taken in color Photographs of typical fires early in the test program are shown in Figures 11 and 12.

FUTURE PLANNING

A. Development of Fire Protection for Jet Engine Installations

General This phase of the work is being undertaken at the request of, and with the assistance and cooperation of the U. S. Army Air Forces and the U S. Navy, Bureau of Aeronautics In order to simulate the ram effect of high speed flight (650 mph), it is necessary to supply air to the installation at a rate of 100 pounds per second (to include tests on installations proposed in the foreseeable future) at a pressure of 7.5 p s i.g It is not believed that the heat of compression will appreciably affect the fire tests, but provisions are being made for the possible need for an intercooler arrangement.

1. Facilities

The proposed facilities for the fire testing of jet engines are shown in Figure 13 The larger building provides a small, ruggedly built test chamber on either side of which are first and second story observation spaces In the observation spaces will be the jet engine controls, fire fuels pumps and controls, extinguishing systems and the measuring and recording equipment necessary for the work In addition, the building includes a stockroom, office, lavatory, and an assembly space for the preparation of both piston engine and jet engine installations for fire test purposes.

The smaller building houses two blowers, each of which is driven by a 1750 horse power electric motor The necessary motor and blower controls, power distribution transformers for both buildings and motor-generator units will be located in this building.

2 Test Program

The general test program for jet engine installations will be similar to the program already outlined for the piston-engine installations

B. Existing Plans for Expanding the Aircraft Fire Protection Studies Include

1 Single story laboratory for developing and conducting bench tests to determine fire characteristics of various aircraft and engine materials, accessories, components, and equipment, which has already been requested.
2 Small test chambers for the development of fire protection for personal aircraft and submerged engine installations (helicopters)

Figure 1. Piston Engine Fire Test Building and Wind Tunnel.

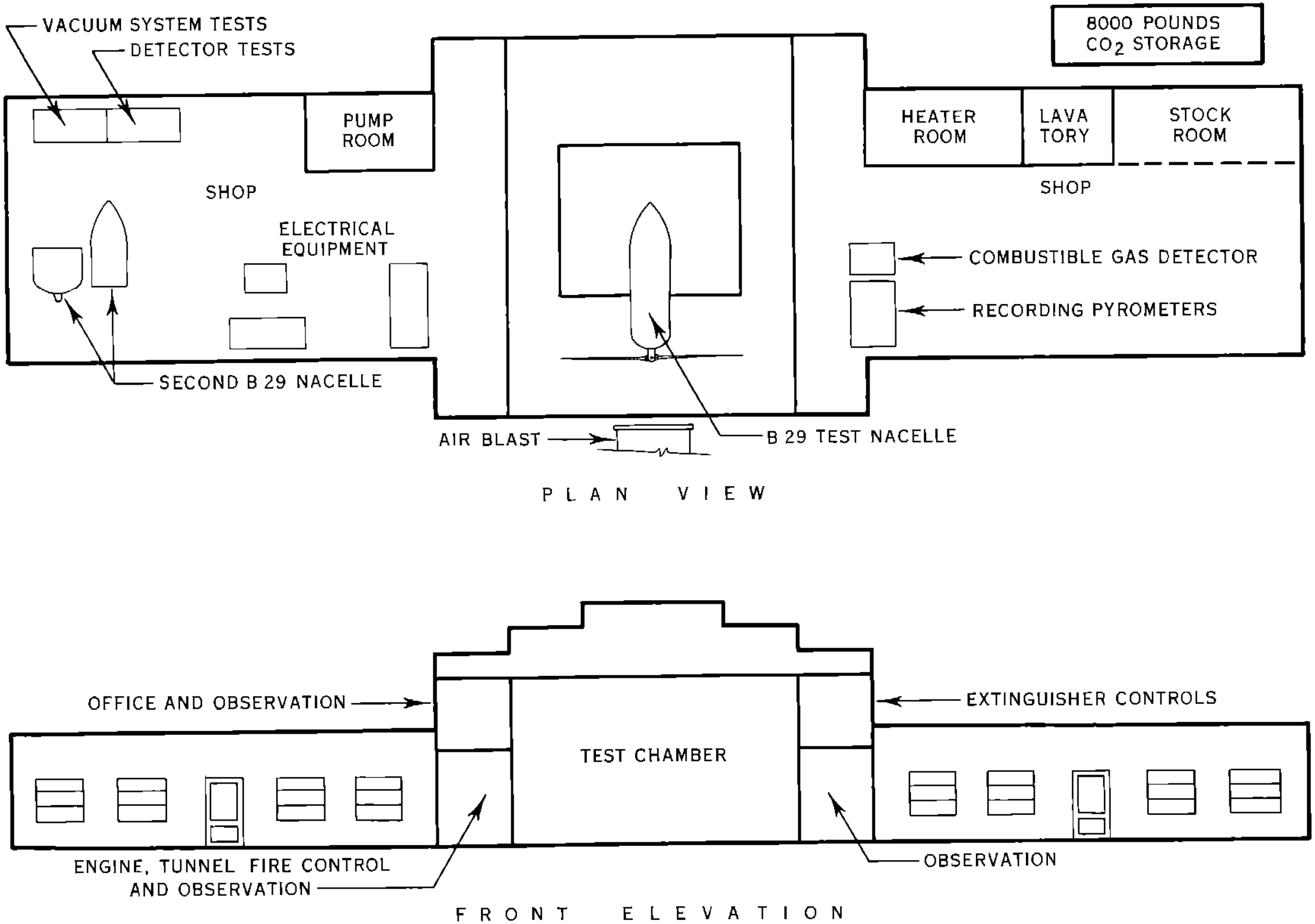

Figure 2 Piston Engine Fire Test Building

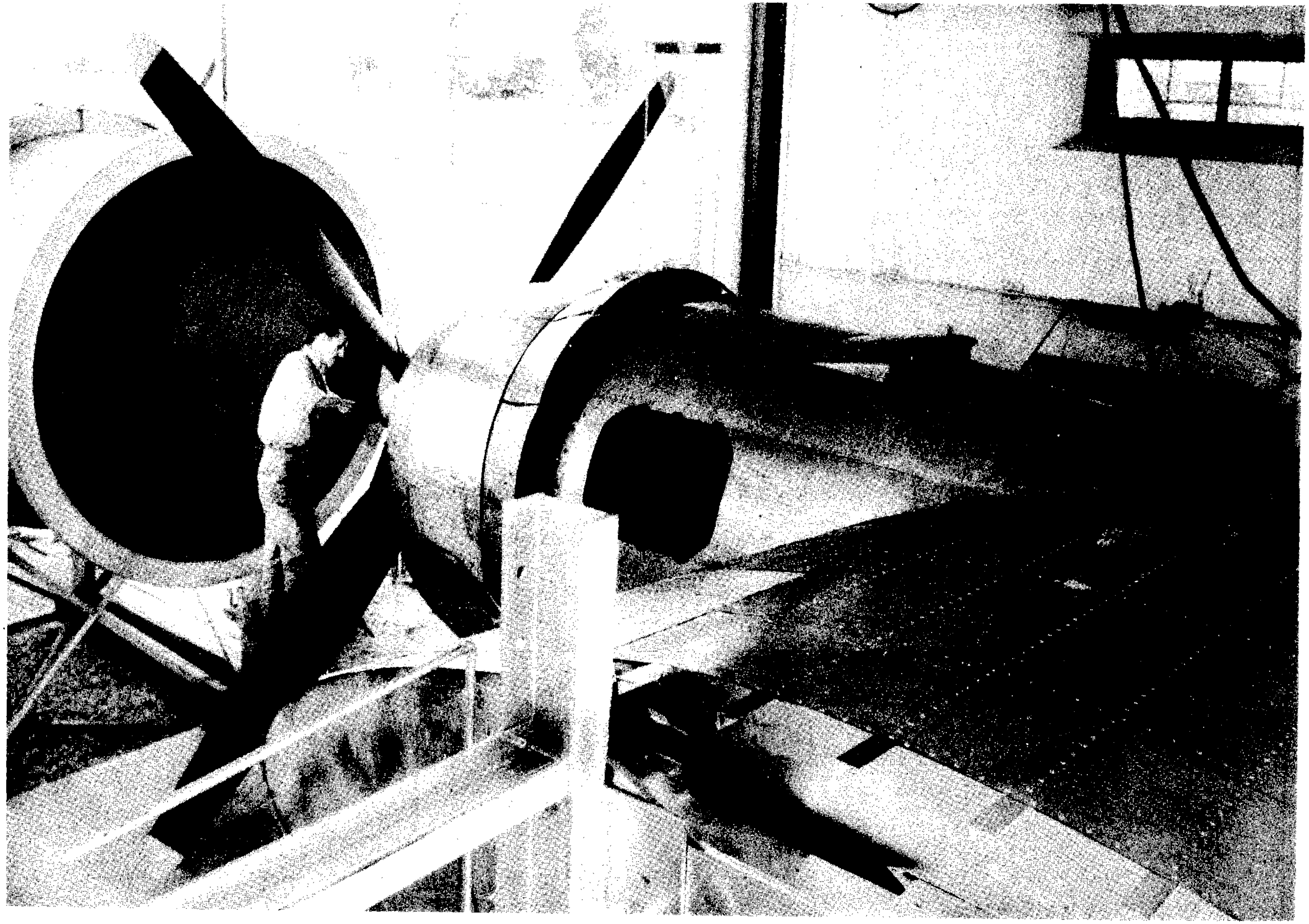

Figure 3. Full Scale Powerplant Installation in Test Chamber.

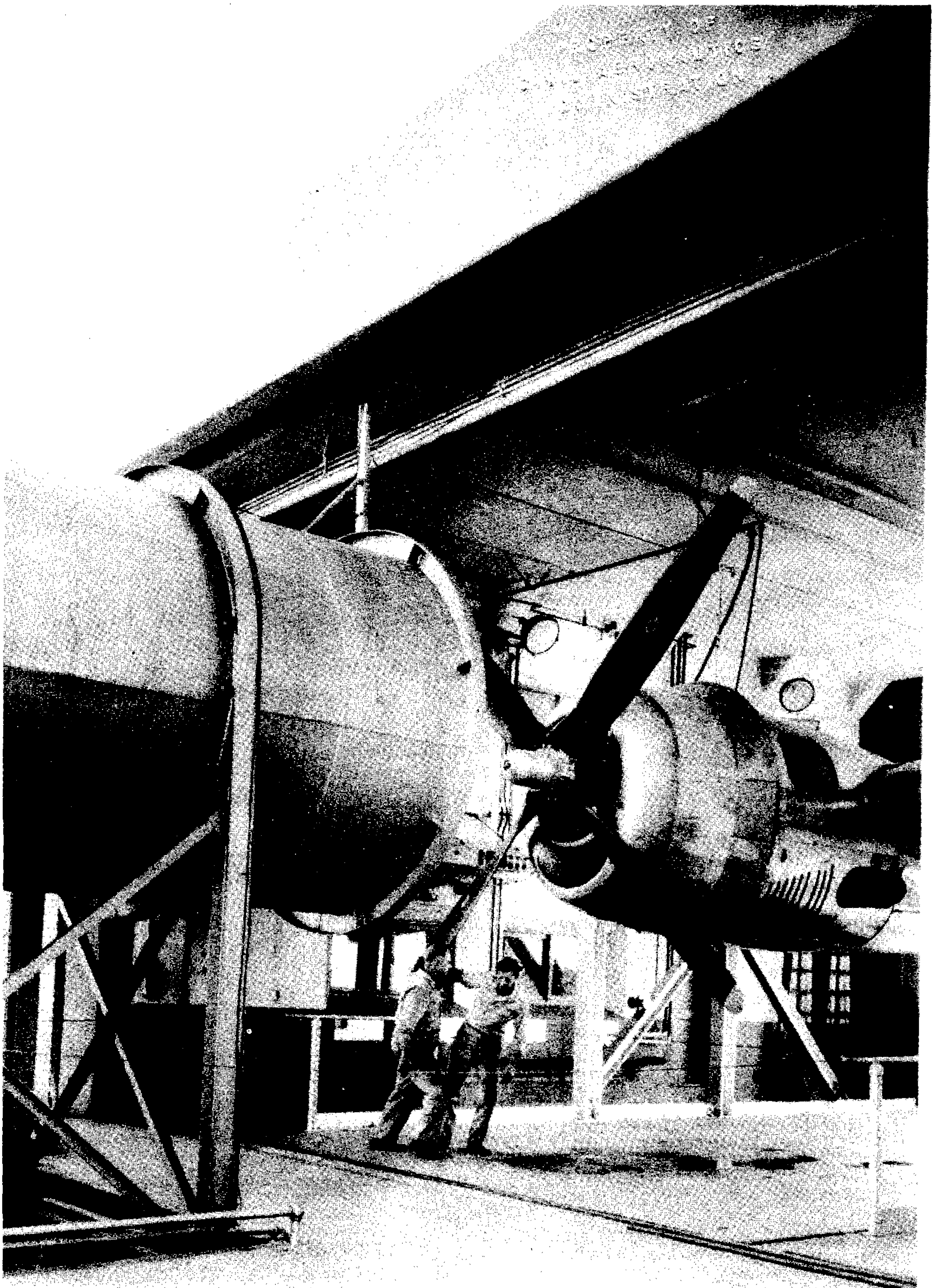

Figure 4. Test Chamber, Tunnel Outlet, and Test Installation.

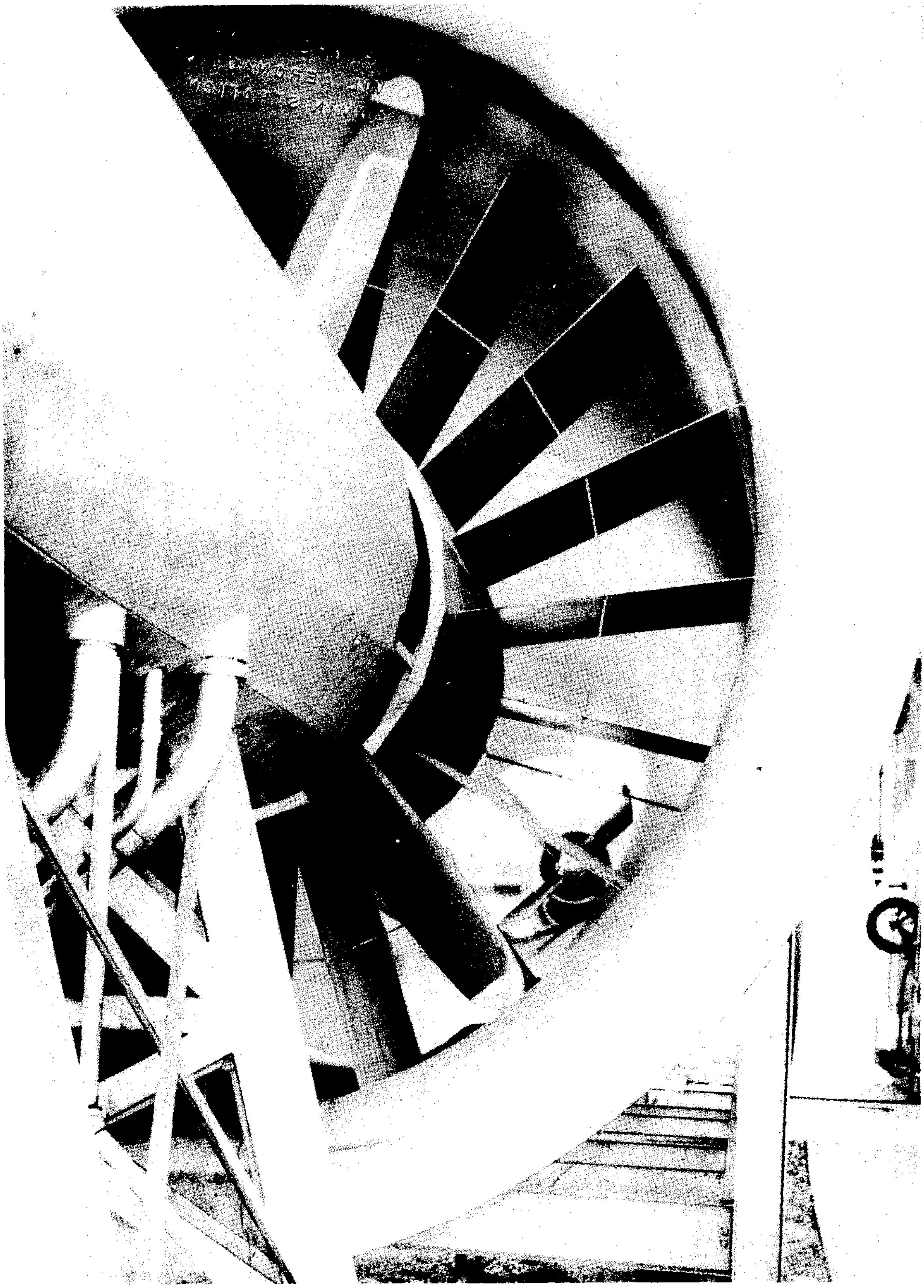

Figure 5. View Through Wind Tunnel and Test Chamber.

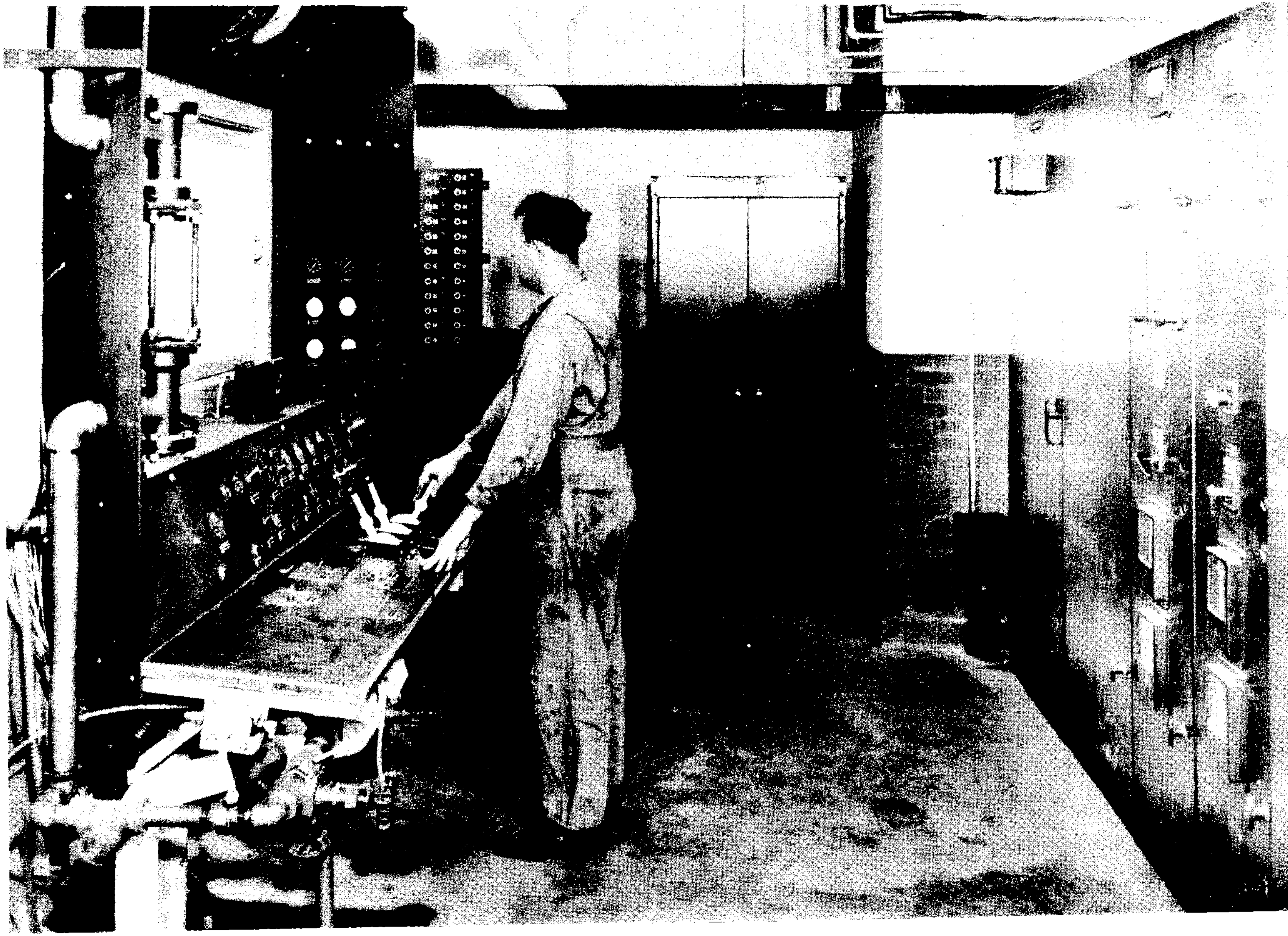

Figure 6. Engine, Wind Tunnel, and Fire Controls.

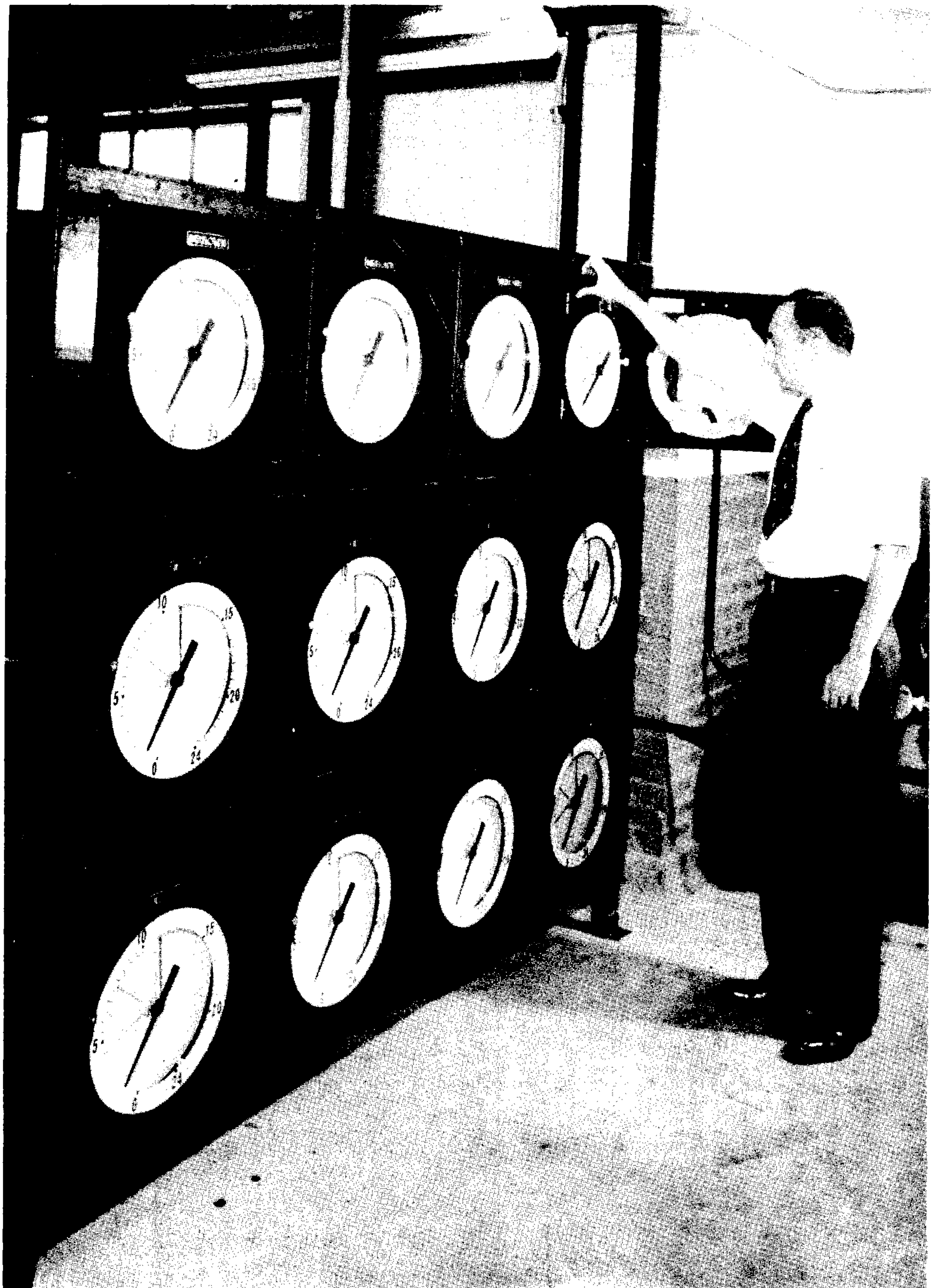

Figure 7. Bank of Single Point Recording Pyrometers.

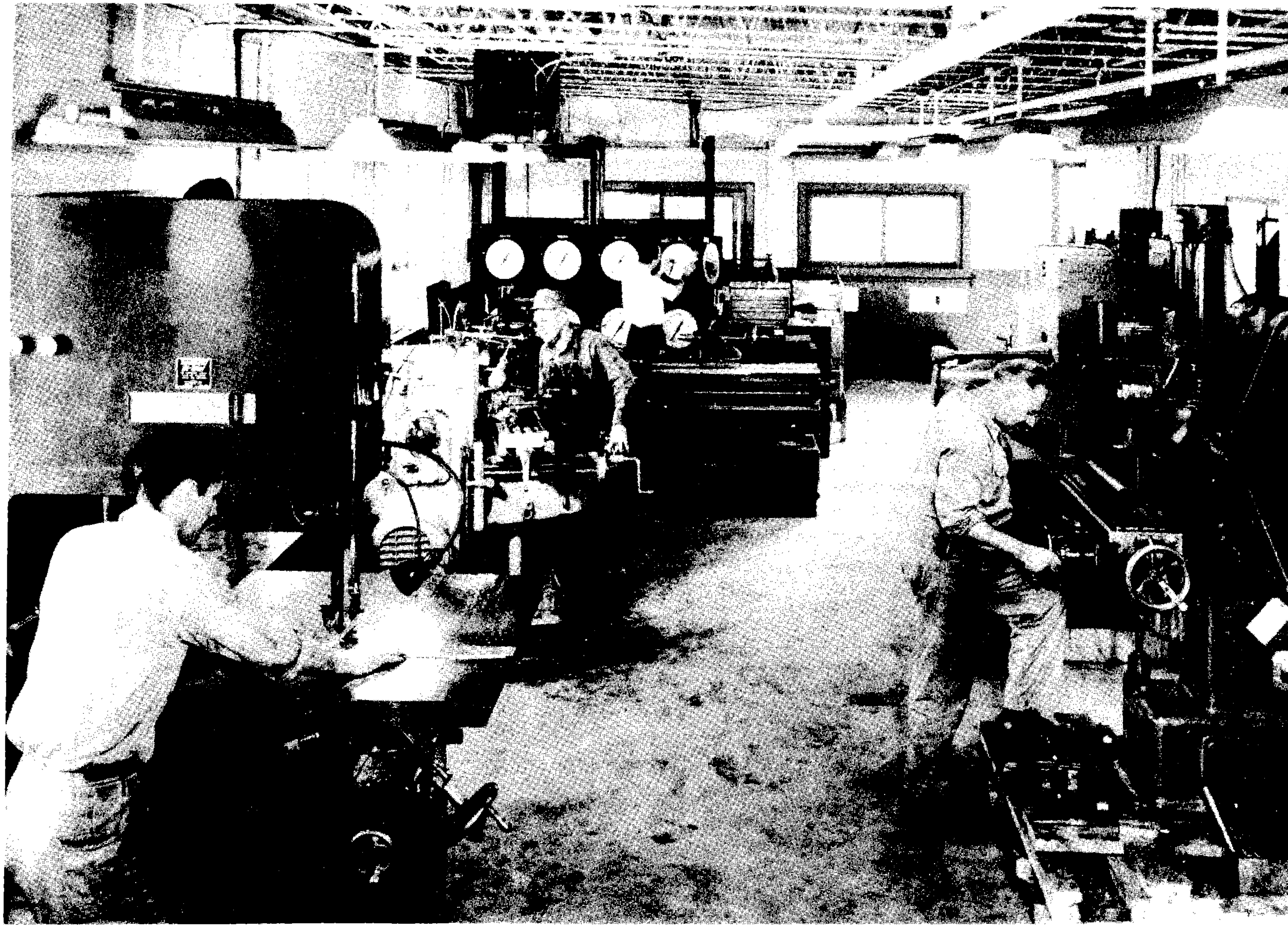

Figure 8. Machine Shop.

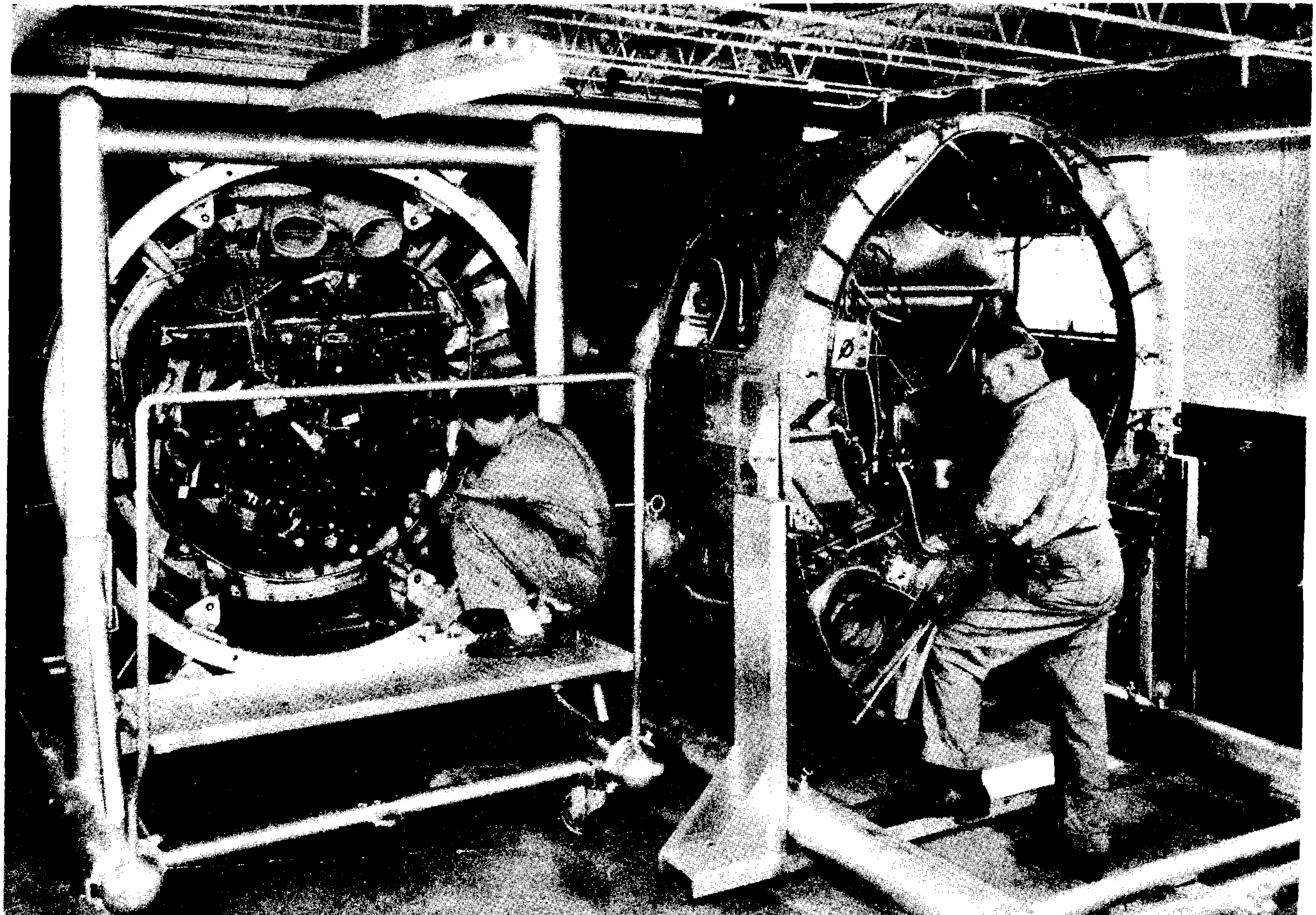

Figure 9. Build-Up Shop.

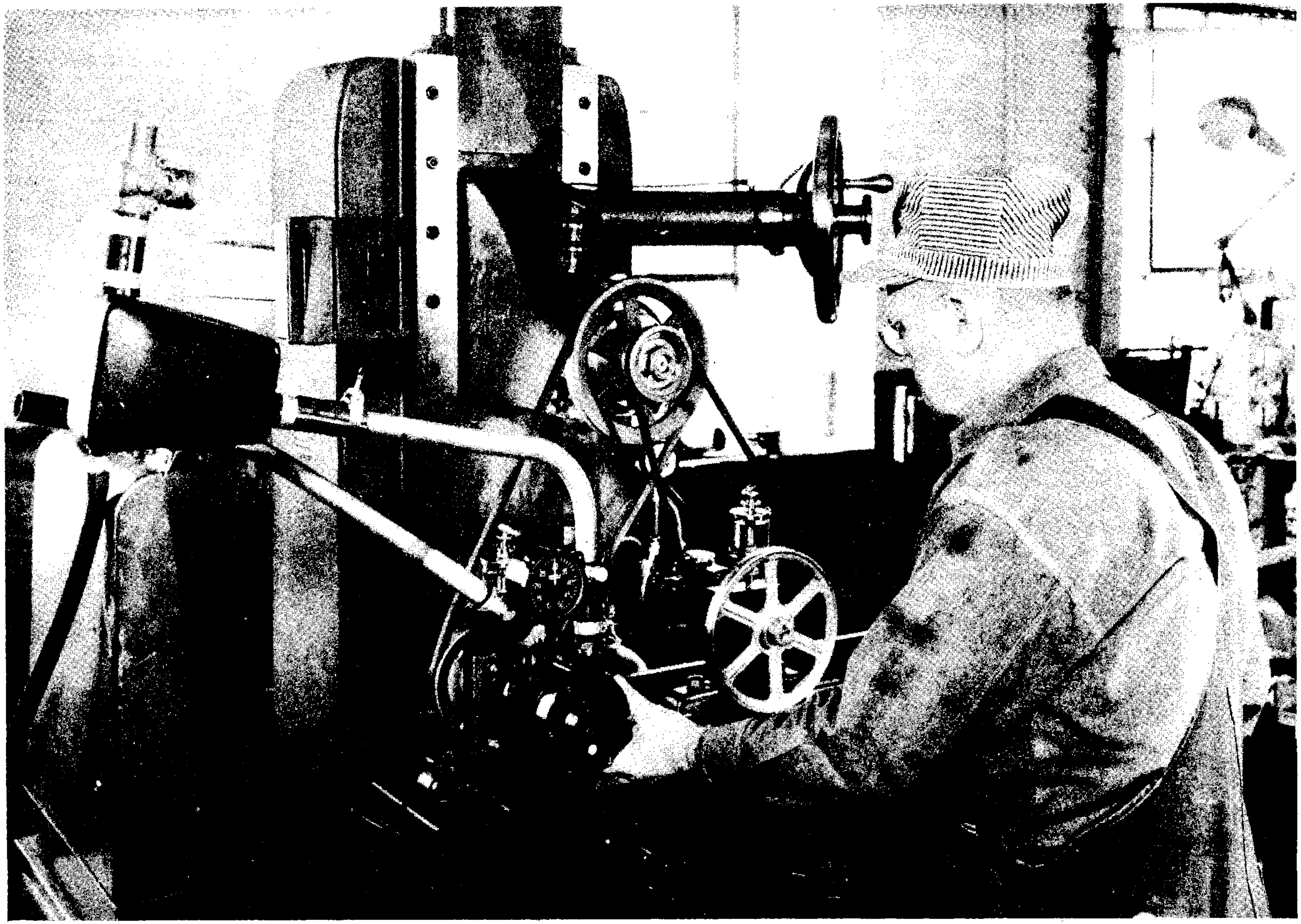

Figure 10. Original Vacuum System Bench Test.

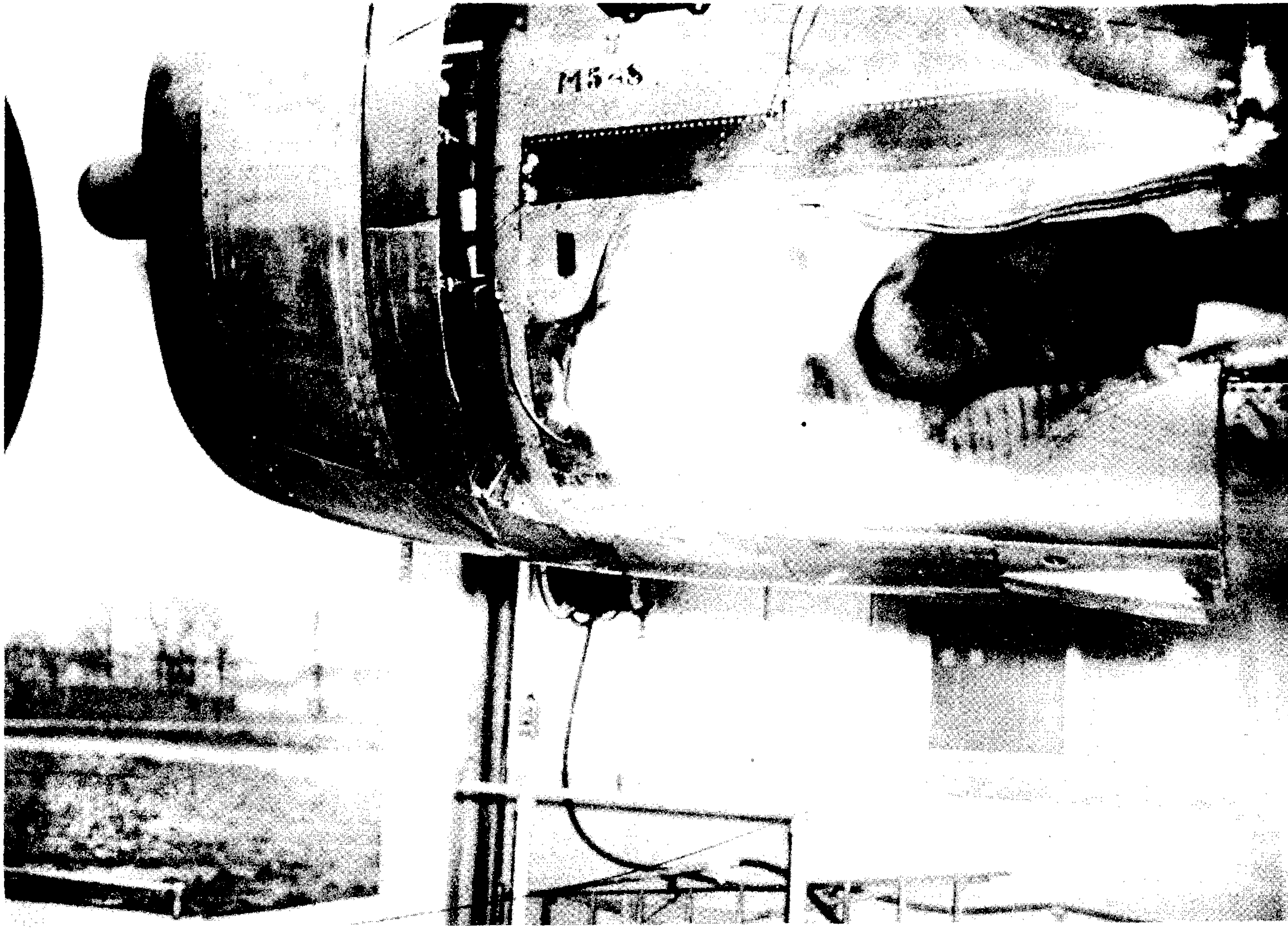

Figure 11. Hydraulic Fluid (AN-VVO-366) Igniting on Exhaust Stack.

Figure 12. Gasoline (100 Octane) Ignited by Exhaust Gas.

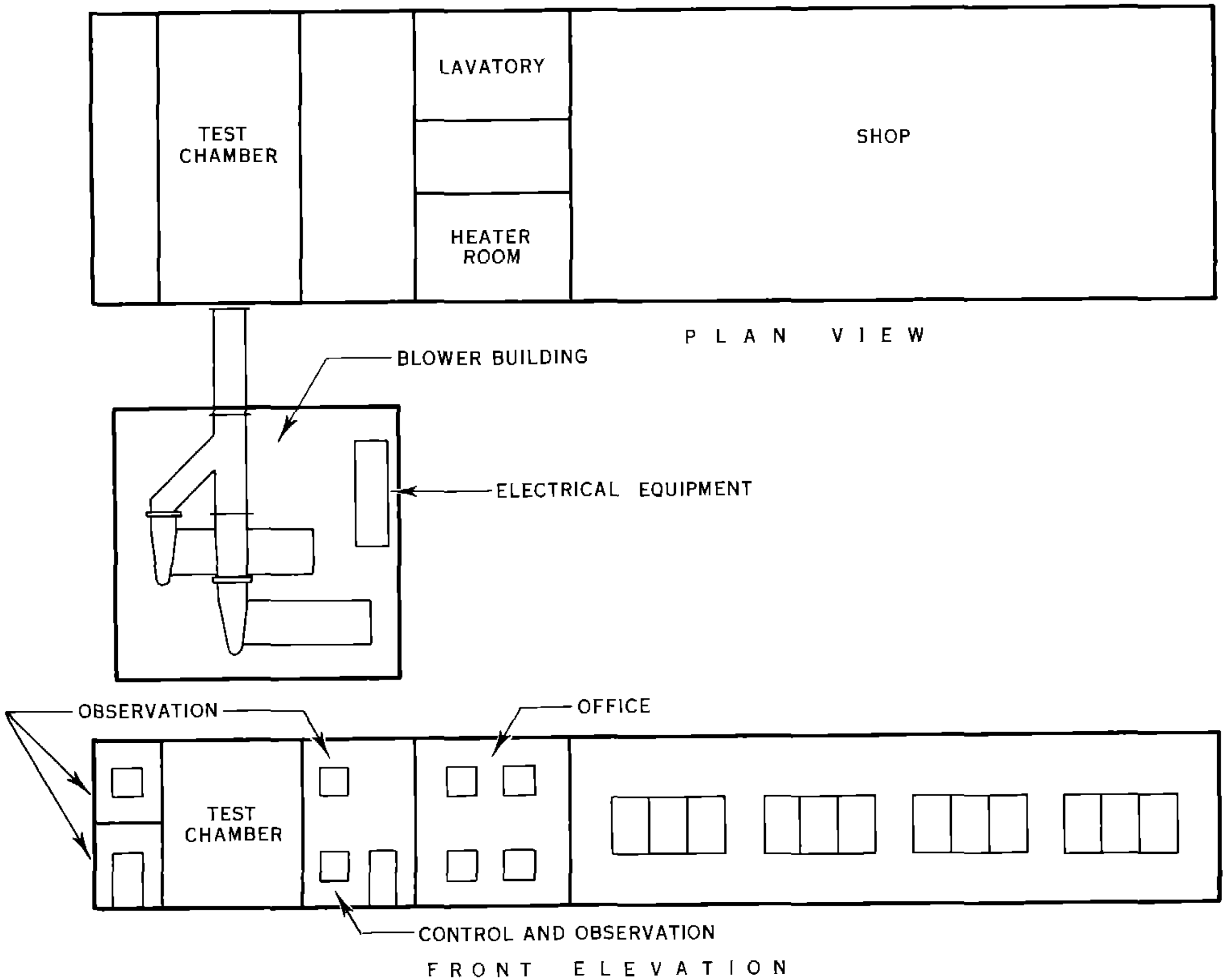

Figure 13 Jet Engine Fire Test Building