June 2, 1954

Lewis Flight Propulsion Laboratory
N A C A
21000 Brookpark Road
Cleveland, Ohio

Expansion of America's aeronautical research effort in the late thirties, spurred by the outbreak of World War II, required that the National Advisory Committee for Aeronautics establish a new research center to concentrate on the problems of flight propulsion. Cleveland was selected as the site for the new laboratory after a nationwide survey. Among reasons for the choice were availability of highly skilled labor and adequate electrical power.

Now known as the Lewis Flight Propulsion Laboratory, the facility began work on urgent engine problems in the spring of 1942. About 2600 scientific and supporting personnel are now employed at the Laboratory. Several hundred research projects are in progress at one time.

Principal Facilities:

In the 8- by 6-foot Supersonic Wind Tunnel, tests can be conducted at air speeds up to approximately 1500 miles per hour in a stainless-steel test chamber which measures 8 by 6 feet. Complete engines or scale models of complete engines as well as engine components (air inlets and exit nozzles for jet engines, etc.) are mounted in the tunnel test chamber. The characteristics of the air flow and shock waves which exist around the models being tested can be observed and also photographed. A special feature of the tunnel is the variable area expansion nozzle which controls the Mach number (air speed at which the tunnel is operated). Three 29,000 horsepower electric motors are required to drive the tunnel's axial flow compressor with 956 blades arranged in seven stages. The rotor weighs 160 tons.

Now under construction at the Lewis Flight Propulsion Laboratory is the Unitary Plan Supersonic Wind Tunnel which will have a 10- by 10-foot test section. Two sets of drive motors will produce test section conditions for model testing at Mach numbers from approximately 2 to 3.5 (air speeds 1500 to 2500 mph). Full sized engines and models of airplane-engines will be studied.

Several smaller supersonic wind tunnels are used in research on small scale models.

Turbo-jet, ram-jet, and turbo-prop engines are tested in the Altitude Wind Tunnel under conditions which simulate the pressures and temperatures at various altitudes up to 50,000 feet. This tunnel has a test section 20 feet in diameter and is driven by an 18,000 horsepower motor at speeds up to

500 mph. Refrigeration equipment requiring 22,000 horsepower cools the air in the tunnel to -48°F.

The Icing Research Wind Tunnel operates over a temperature range of from atmospheric to -40°F. Water vapors and sprays of various droplet sizes are mixed with the tunnel air stream. An electric motor of 4160 horsepower generates speeds of 300 mph.

In the Propulsion Systems Laboratory there are two altitude chambers for testing high speed turbo-jet and ram-jet engines under conditions simulating very high altitudes and low temperatures. Engine thrust, fuel consumption, operating temperatures and other characteristics are measured. These 14 foot diameter, 100 foot long chambers are supplied with air at various pressures, heated, dried, or refrigerated, as required. Exhaust compressors remove the products of combustion from the engines being tested and reduce pressures to those at altitude. A total of 150,000 horsepower is required to drive the air and exhaust moving machinery. Two smaller test chambers for testing turbo-jet and ram-jet engines also simulate altitude and temperature conditions of high speed flight.

In the Engine Research Building are about 100 test stands for investigation of the many components of aircraft propulsion sytems. Using the compressed and refrigerated air and exhaust supplies alternately used by the altitude engine test chambers, studies are conducted on turbo-jet engine air compressors, combustors, and gas turbines.

Materials suitable for use in engines are studied in the Materials and Stresses Laboratory.

Instruments are originated and developed for research on ice-formation, gas-analysis, flow visualization, electronic control of machines, special pressure and temperature probes and special data reduction devices, at the Instrument Research Building.

The High Energy Fuels Laboratory employs high pressure air supply systems and burners and evacuated exhaust systems to investigate special fuels under various conditions of air mixing and burning.

In the Rocket Laboratory, thrust producing devices which carry their own fuel and oxidant and therefore require no external air supply are tested. Various engine configurations, fuel injectors, nozzles, fuel ignition and combustion with a variety of fuels and oxidants are studied and their effects upon the thrust developed by the engine determined.

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio

June 2, 1954
For Immediate Release

NACA Scientists Make Use of Metal Doughnuts In Studying Nuclear Energy Propulsion Problems

Cleveland, June 2 --- A "metal doughnut" is being used by scientists of the NACA's Lewis Flight Propulsion Laboratory at Cleveland to gain new insights into the corrosion problems at the very high temperatures that exist in a nuclear reactor for aircraft engines. Corrosion of the reactor material by the coolant circulated through the reactor is a very serious problem.

Called a toroid by the scientists, the device provides an easy means for studying what happens when a highly corrosive liquid circulates through a metal pipe.

Until the Lewis researchers developed the "doughnut pump," it was very difficult to investigate such problems because pumps and other necessary accessories had to be fabricated from the same material as those under study. Presence of a third material would have influenced any reaction occurring between the pipe and the liquid flowing through it.

The toroid, made in circular tube form, is fabricated from the metal to be studied. It is mounted on a flat plate which is oscillated back and forth by an electric motor. This movement of the plate causes the liquid inside the doughnut to form a "slug" which travels around the tube. Flow speed can be regulated by varying the speed of the oscillation of the plate.

The toroid is wrapped with electric heating coils and one portion is subjected to cooling by an air blast to simulate the temperature distributions that exist in a nuclear-reactor system. In this way the effect of temperature on the corrosion process is studied.

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The power required to propel an airplane at supersonic speeds is very large, as much as five times the amount needed to sustain the same airplane at subsonic speeds. It has become increasingly apparent that if supersonic aircraft are to possess the long-range capabilities required, a way must be found to breach the fundamental limits inherent in engines using chemical fuels.

One obvious way to extend the range of supersonic aircraft would be to utilize nuclear energy for propulsion. Fission of a single pound of uranium will produce as much heat as burning 2,000,000 pounds of gasoline. Stated another way, the total energy which can be obtained from the "burn-up" of a single pound of uranium equals the energy in 3,500,000 pounds of coal, yet the uranium would be a one and one-half inch cube against 32 railroad cars of coal.

There are many ways in which the heat generated in a nuclear reactor can be converted into power or thrust. One of the simplest is to use the reactor to do the air-heating job in a turbojet engine in place of the usual combustion chambers where chemical fuel is burned.

The rate of heat-transfer to air is relatively low, and the amount of power required for supersonic flight forces use of larger and heavier reactors. Shielding problems for a small reactor in an airplane in themselves are serious; they are greatly intensified by the need to utilize a larger reactor.

Shields must be constructed from several materials to protect against the different kinds of radiation. For example, water or paraffin may be used to stop fast neutrons. Cadmium or boron can be used to absorb slow neutrons, and lead can be employed to stop gamma rays. The weight of the resultant shield is presently extremely heavy; in fact, so heavy as to make it most difficult to design a nuclear-powered airplane with the desired performance. Much study on the best combination of shielding materials, as well as the relationship with respect to the reactor and the crew, will be necessary to obtain the necessary weight reductions.

Another approach is to obtain sufficient heat release from a smaller reactor by cooling it with a liquid which then transfers the heat to the air in the engine using a second heat exchanger. Reactor parts such as fuel-element parts and heat exchangers must have high strength at high temperatures, satisfactory corrosion resistance, and ability to withstand the effects of intense radiation.

Any material in a reactor absorbs neutrons; materials with a tendency to absorb neutrons readily are said to have a high capture cross section, and are unsuitable because such high absorption would deplete the neutron supply and interfere with the fission process. Aluminum is low on the capture-cross-section scale but lacks high-temperature strength; iron is higher on the scale but by careful design it is possible to use iron-based alloys which have high-temperature strength.

At the high temperatures involved, some coolants react with and corrode the material over and through which they flow; material dissolved from the reactor heat exchanger may be deposited on the cooler surfaces of the air heat exchanger, weakening the structure and plugging the flow passages.

Because of the high flux of radiation present in the reactor, the characteristics of materials used may be altered. Molecular structure may be broken down; there may be changes in brittleness, hardness, strength, and dimensional stability. The radiation stability of materials considered for nuclear power plant construction is a factor of great importance.

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Both experimental and analytical investigations of the many problems of nuclear aircraft engines are necessary. Often problems are so complex as to require development of novel facilities which can be used to split them into their several parts for piecemeal study and solution.

The performance capabilities to be realized from harnessing nuclear energy for aircraft propulsion would be nonstop supersonic flight to any point on the face of the earth, and return. With so large a gain the goal, industry, the Atomic Energy Commission, the Military Services, and the NACA are participating in vigorous, sustained attacks on the formidable technical problems that must be solved.

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Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio

June 2, 1954
For Immediate Release

Fuel Studies Promise Improved Afterburner Performance

New and special fuels to furnish more "kick" for jet engine afterburners and for high-speed ram jet engines are the subject of vigorous basic chemical research at the NACA's Lewis Flight Propulsion Laboratory.

Special fuels studies are being pushed in an effort to bring about marked improvements in jet engine afterburner performance. Jet engines almost twice as powerful as those in today's operational fighters may result from such fuel investigations.

One such special fuel demonstrated by NACA scientists here today at the Triennial Inspection at Lewis Laboratory is a petroleum derivative named propylene oxide. Its flame speed, an index to a fuel's efficiency, is 2.29 feet per second, better than twice the flame speed of ordinary jet fuel which is about 1.12 feet per second.

Tests in an actual ram jet combustor or burner chamber show that propylene oxide has a much higher performance than ordinary jet fuel and that with it a flame can be maintained at much higher air velocities than with the usual type fuel.

This is importance since afterburners characteristically operate at much higher velocities and much lower pressures than a jet engine's combustion chambers. Such severe high velocity conditions impose special problems which must be overcome to improve afterburner efficiency. Propylene oxide and other special fuels under research attack are showing the way to more efficient afterburner operating conditions.

-- MORE --

The NACA scientists are working on the basic molecular structures of various fuels in an effort to find substances with high flame speeds like that of propylene oxide. From studies showing how various atoms are linked together in a molecule of a special fuel, the NACA researchers are seeking ways of building synthetic fuels even more powerful than those already known. Such synthetic fuels are then tested in an apparatus to measure their flame speeds and the more promising are evaluated further by burning them in jet engine combustors.

Propylene oxide is by no means the most promising of the special fuels already tested and research is continuing to provide fuels having even better performance in ram jets and in turbojet afterburners.

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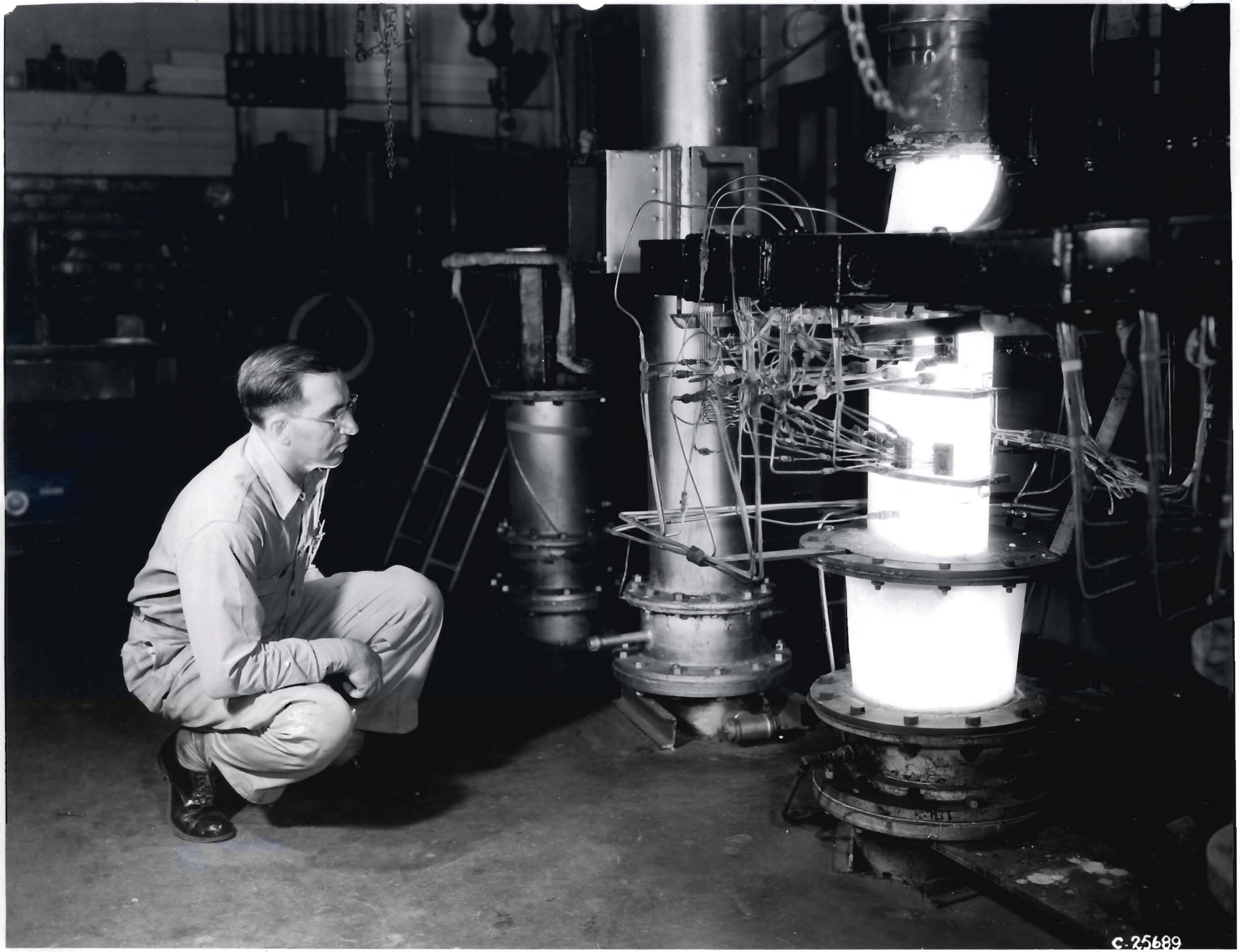
1954 Triennial Inspection
Lewis Flight Propulsion Laboratory

Photographs Used for Publicity Purposes

*C-25689	Experimental jet engine combustor
*C-29008	Ground test of flight ram-jet engine
*C-29145	Ram-jet missile in 8x6 SWT test section
C-31339	Apparatus for detecting surface cracks
*C-31493	Scientist analyzes material by electron diffraction
*C-31574	Instrumented heat exchanger for reactor studies
C-31594	Scientist checks apparatus for studying heat transfer of liquids - CE-11
*C-31938	High temperature corrosion furnace
*C-32802	Setup for studying compressor air flow
C-35470	Scientists inspecting experimental axial-flow compressor prior to testing
*C-35799	Turbojet engine crash fire research
*C-35857	Technician checks compressor for test operation
C-35858	Experimental passenger seat and dummy - after impact
C-35859	Experimental passenger seat and dummy - before impact
C-35867	Thrust reversal device - rear view
C-35868	Thrust reversal device - forward view
LAL-82578	Structures testing machine
*LAL-84111	Radiant heat simulates aerodynamic heating
*A-19306	Stroboscopic camera pictures pulsing shock
*A-19310	Nitrogen afterglow observed at Mach 3

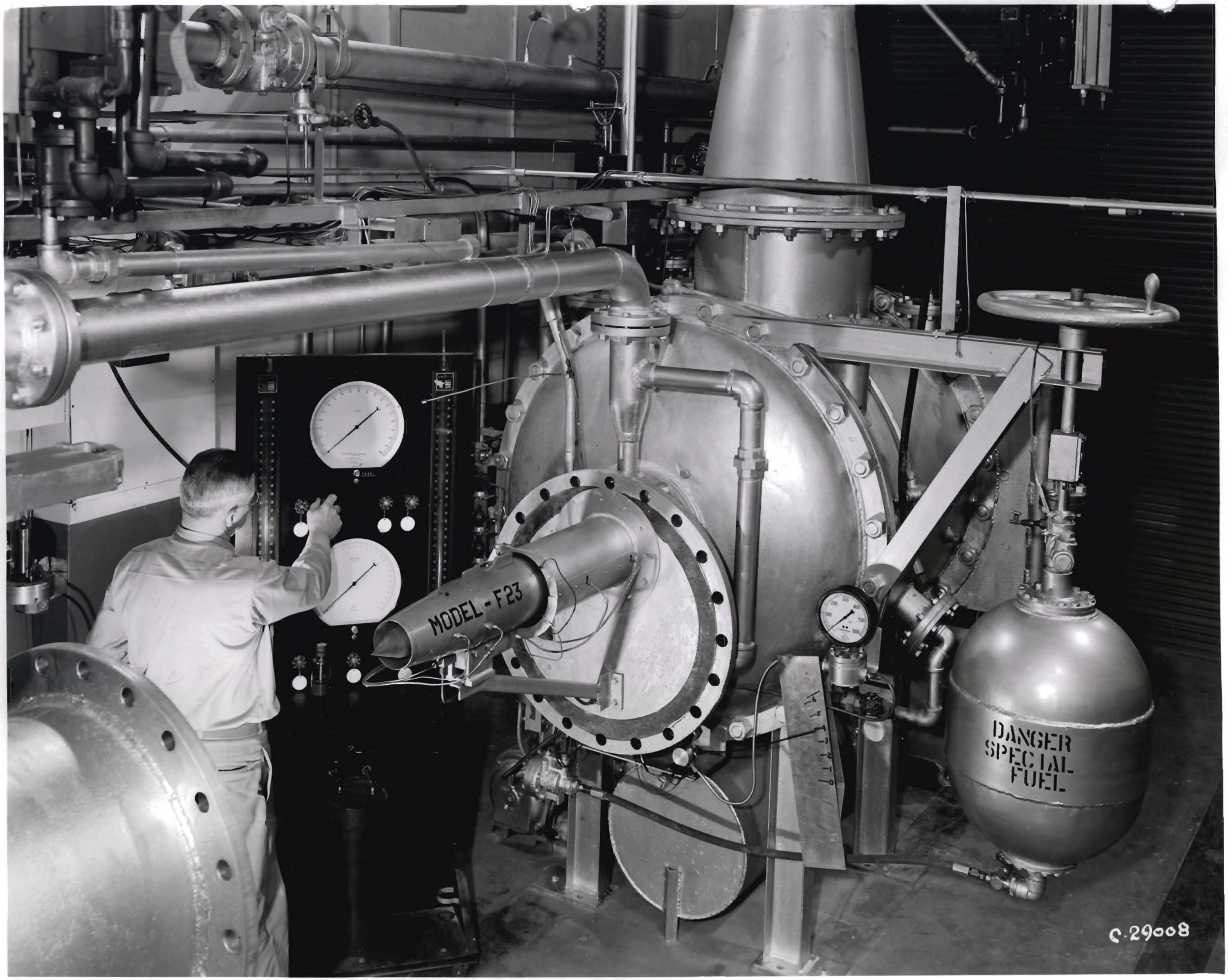
*Used also in brochure


C-25689

One important way of making a turbojet engine deliver more thrust is to increase its operating temperature. The research project seen here in progress at the NACA's Lewis Flight Propulsion Laboratory is exploring such high temperature problems by operating a single combustor and thus isolating the problem for more intensive study. In the glowing hot instrumented exhaust section, which essentially duplicates the turbine entry section of an actual engine, pressure and temperature measuring devices can be seen. At temperatures between 1500° and 1600° F, data are being gathered on ignition, coke deposition, temperatures and combustion efficiency which contribute importantly to improved jet engine design.

C-25689

NACA



The experimental ram jet model seen here is mounted for testing to simulate high altitude conditions in a test cell at NACA's Lewis Flight Propulsion Laboratory. After the technician completes a final check on the instruments which will record its performance, an enclosure will be placed over the model and it will be tested in a blast of air under actual burning conditions. Data from tests of this kind are hastening development of the ram jet unit which may play a major role in sustained supersonic flight.

C-29008

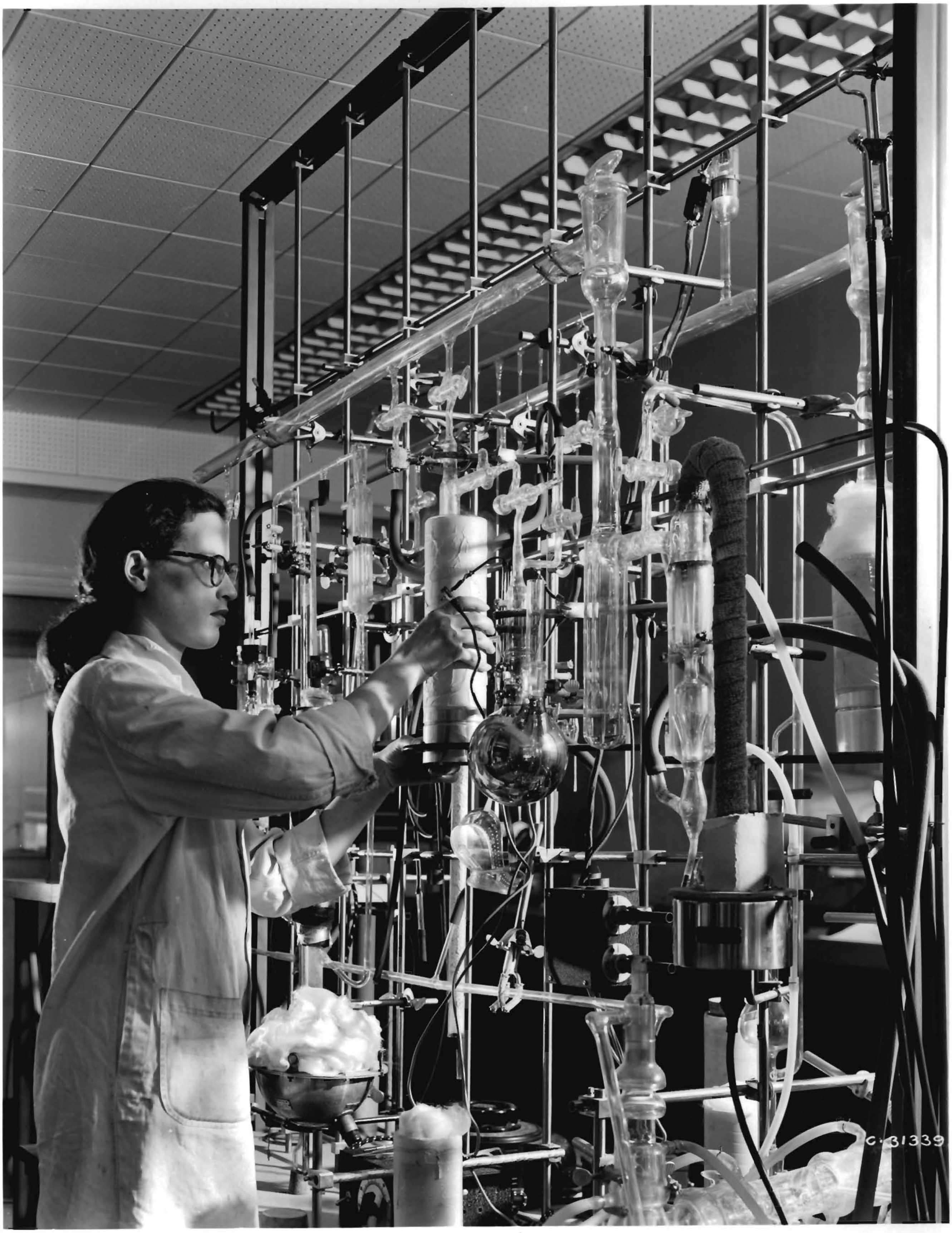
NACA

C-29145

The 1/4-scale ram jet missile model seen mounted in the 8- x 6-Foot Supersonic Wind Tunnel at NACA's Lewis Flight Propulsion Laboratory at Cleveland will soon go through tests simulating flight at 50,000 feet altitude and at speeds up to 1300 miles per hour. This is one of several ram jet configurations being used by the NACA scientists to study the relationship between the airframe and the power plant. This test will uncover any effects which the smaller wings known as a canard bow plane trim control might have on the scoop-shaped air inlet. The study will include measurements of lift, drag, and pitching moments and the model is also fitted to explore boundary layer problems in the inlet.

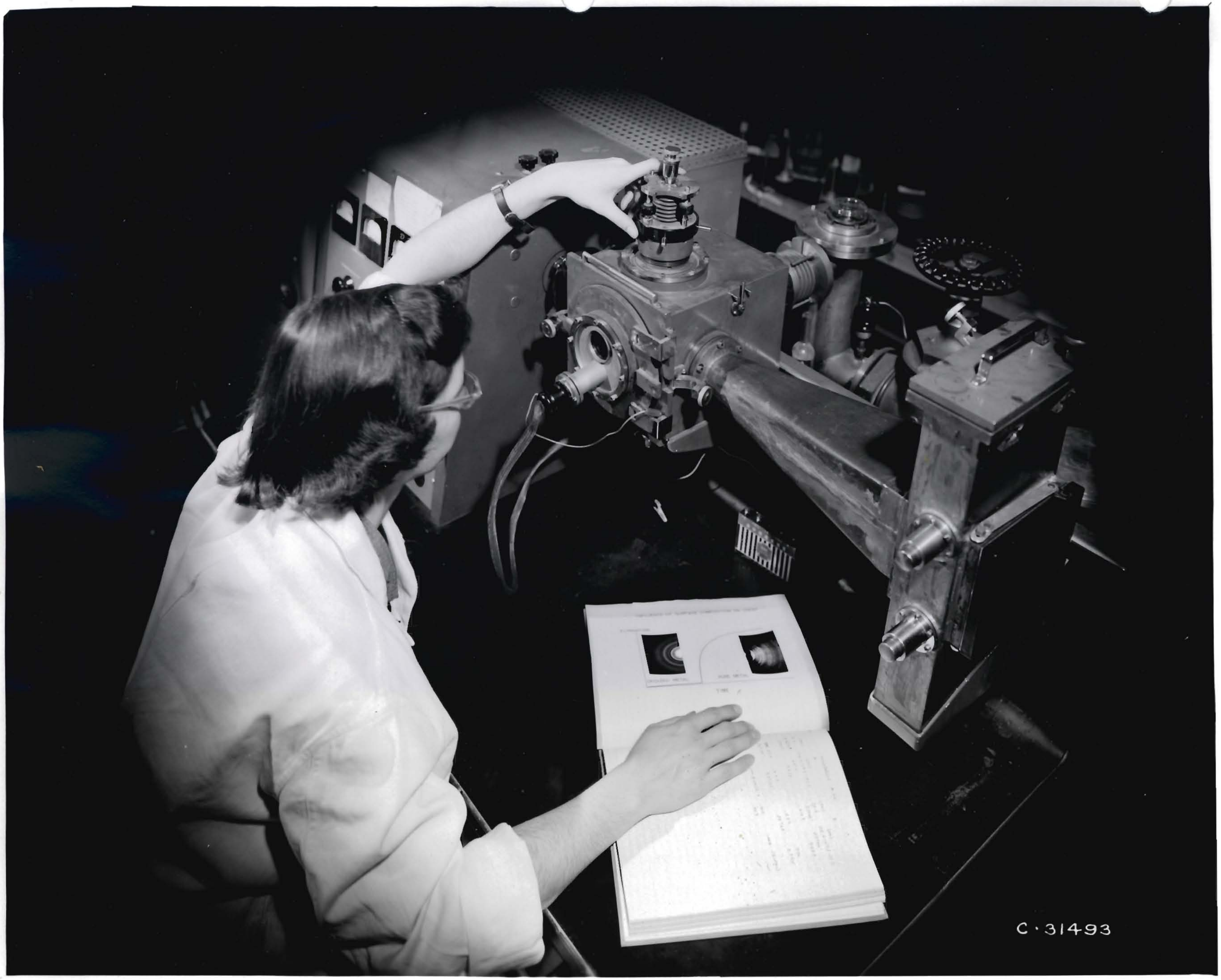
C-29145

NACA



Spurred by the urgent need for stronger materials to withstand the high operating temperatures and pressures in today's jet and rocket engines, NACA scientists are deep in basic physical research to learn why materials are not as strong as theory predicts. One of the reasons for the disagreement between theory and experiment may be explained by submicroscopic cracks found on the surface of most metals. This research chemist at NACA's Lewis Flight Propulsion Laboratory is operating an apparatus which will make such cracks visible by depositing a thin layer of high reflective silver on the surface of a specimen under high vacuum. Such studies in the physics of solids, although difficult and laborious, will ultimately be the key to major improvements in materials.

C-31339



C·31493

Accurate identification of metals and chemical compounds is made possible by this electron diffraction camera used by scientists of the NACA's Lewis Flight Propulsion Laboratory at Cleveland. It permits taking a picture of the characteristic "fingerprint" of the material being studied, thus giving specific information on its structure and composition. In contrast to an X-ray diffraction camera, which will penetrate deep into, if not through a sample, this unit will analyze only a surface layer thinner than a human hair. This is of great importance in studies of the effect of surface film on the strength of materials.

C-31493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C-31574

The multiple sandwich adjusted by this NACA technician is one of the many devices being used to furnish the enormous quantities of basic data required in designing heat exchangers. The electrically heated plates, separated by alternating blocks of conductors and insulators, transfer their heat to an air stream. The many wires attached to the apparatus are thermocouple leads, which report temperatures from various points on the plates. Information obtained from test units like this is useful in designing heat exchangers such as might be used in reactors.

C-31574

NACA

Heat transfer data for water and other materials are needed at very high temperatures and pressures as flight speeds climb the Mach number scale. This NACA scientist, on the staff of the Lewis Flight Propulsion Laboratory at Cleveland, is checking the complicated temperature measuring device fastened to the hollow tube at hig right hand. This apparatus is designed to reach temperatures of 1200° F and pressures of 3000 pounds per square inch. The liquids being studied are pumped thought the tube which is electrically heated. These studies are filling the gap in our knowledge of the properties of water and other materials at temperatures far above their normal use.

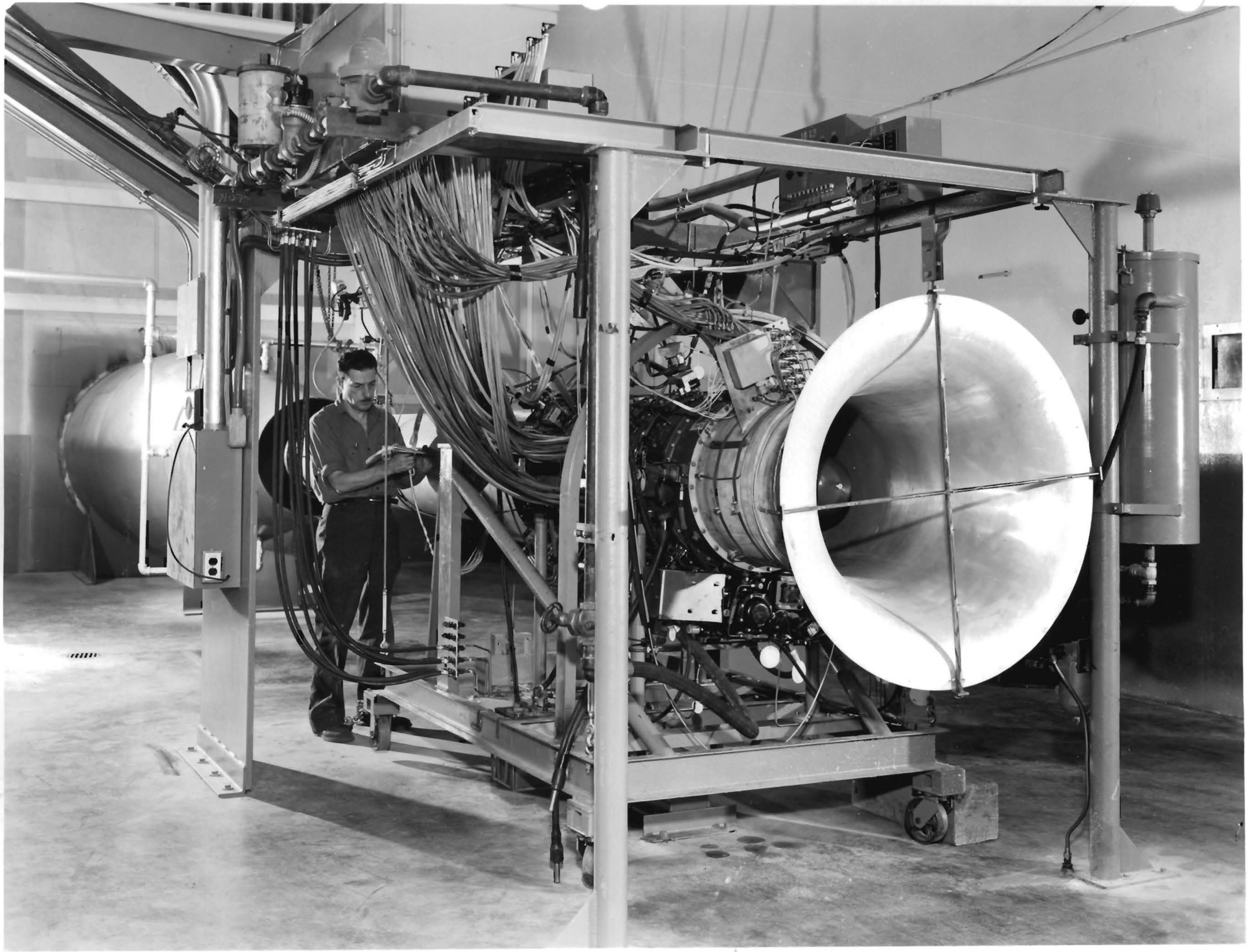
C-31594

NACA
C-31938

Corrosion research is carried out in this experimental toroid furnace at the NACA's Lewis Flight Propulsion Laboratory at Cleveland. The toroid is actually a "metal doughnut" or circle of tubing which is oscillated to circulate a liquid inside. Under certain conditions metallic particles eroded from the tube walls at the hottest part are deposited in cooler sections, a physical phenomenon known as mass transfer. Heating elements and thermocouples furnish high temperatures and means for measuring them, and the study is intended to measure the quantities of metal moved in the process.

C-31938

C-32802



Exhaustive studies of an NACA-designed turbojet engine compressor incorporating much of the most recent thinking in compressor design will be made in this sea level static test stand at the Lewis Flight Propulsion Laboratory at Cleveland. Some 200 internal pressure measuring stations (note the pressure tubing leads above) and 70 temperature recording points will develop a precise sensitive picture of the compressor's characteristics. Rotational speeds around 12,000 rpm will be used. The test stand is equipped for measuring static thrust.

C-32802

NACA

C-35470

Research scientists at the NACA's Lewis Flight Propulsion Laboratory at Cleveland are seen here inspecting an experimental jet engine axial flow compressor prior to a testing run. Careful testing of full scale units such as this helps to confirm theoretical studies and develops large quantities of information needed by designers to continue the steady improvement of jet engines.

C-35470

NACA

C-35799

The experimental crash fire research program conducted by the NACA's Lewis Flight Propulsion Laboratory at Cleveland has been expanded to include jet engine studies. This photograph shows a service-weary C-82 on which the reciprocating engines were replaced by pylon-mounted turbojet units. It was then run down the launching track and into a crash barrier, starting the fire seen above. The NACA studies show that jet engines offer numerous ignition sources which could lead to fire in a crash landing, and work is being pushed to develop ways of rendering these sources less dangerous.

C-35799

NACA
C-35857

Framed in the hedgehog of stator blades inside a jet engine compressor casing, an NACA technician uses a micrometer to check vital internal dimensions. This casing covers the compressor rotor, whose blades whirl between the stator blades at thousands of revolutions per minute. Clearances here are critical, since compressor efficiency depends in part on extremely accurate control of blade dimensions.

C-35857

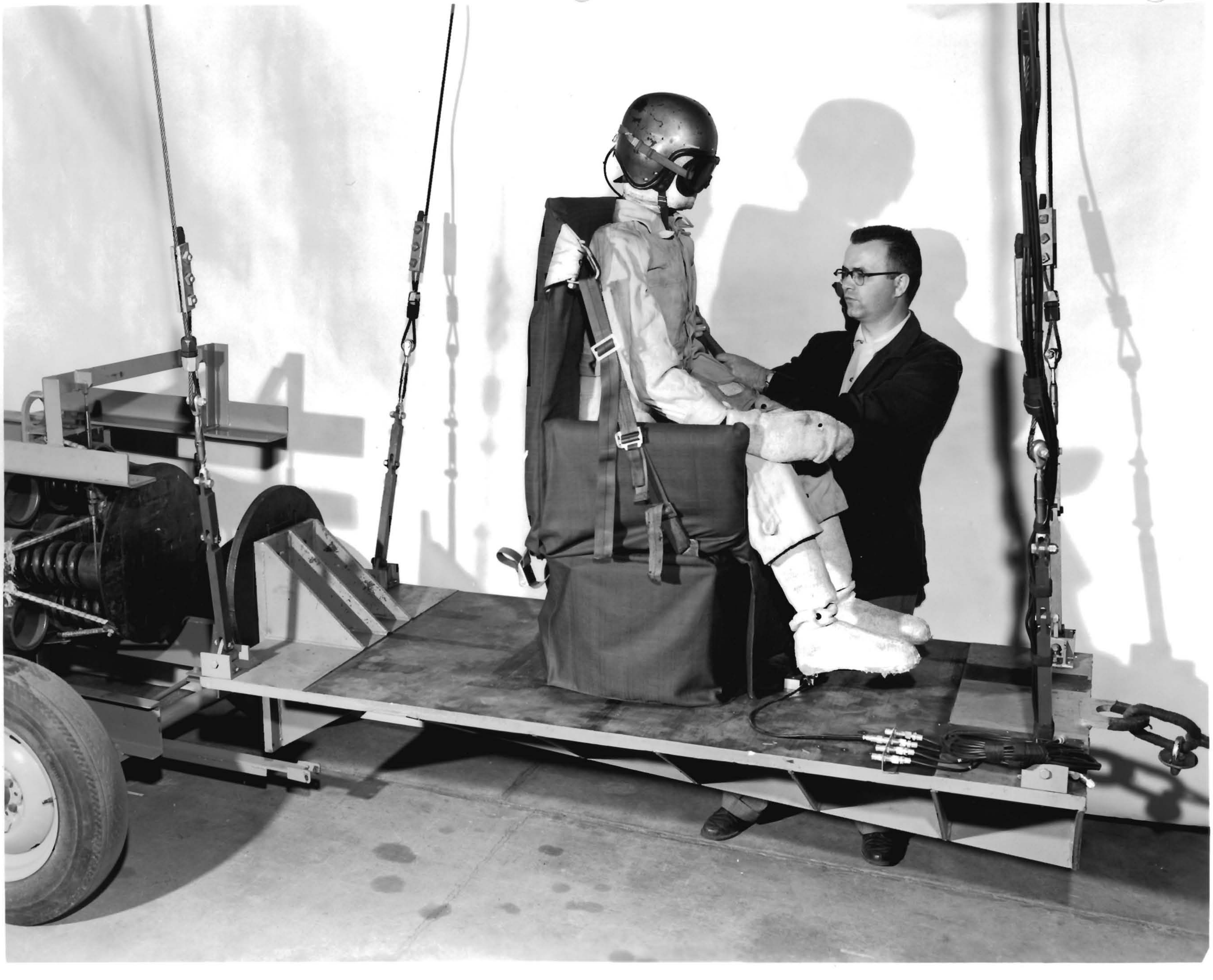
NACA
C-35858

An experimental approach to aircraft passenger seat design is shown here mounted for testing on a pendulum type impacting apparatus at the NACA's Lewis Flight Propulsion Laboratory. In its present form the seat has construction features required for research purposes which make it unsuitable for commercial production. Preliminary tests have been encouraging, and final evaluation is to come as part of the NACA's full-scale crash fire research program. Photo C-35858 shows a dummy in the seat after impact; before the test (see photo C-35859) the dummy is upright. The seat has an inflated back, arms and seat-pan made from rubberized fabric. A body or head striking these parts would be well-cushioned and there are no metal parts to break into sharp puncturing or cutting edges.

C-35858

NACA

C-35859



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C-35859

NACA
C-35867

A new experimental device for reversing the thrust from a jet engine tailpipe to use it to slow an airplane's landing roll is being intensively studied at the NACA's Lewis Flight Propulsion Laboratory at Cleveland. The device, as shown in this photograph, is a set of curved vanes carried inside a jet tailpipe. In use the tailpipe opens into two side sections and the curved vanes move out into the stream of hot gases. This actually turns the jet flow forward and it issues as two separate jets under the airplane's horizontal stabilizer. When the vanes are closed they offer minimum resistance in the tailpipe. A major advantage of the method is its ability to direct the reversed stream away from parts of the airplane which might be damaged. This rear view shows how the exit shape alters when thrust is being reversed.

C-35867

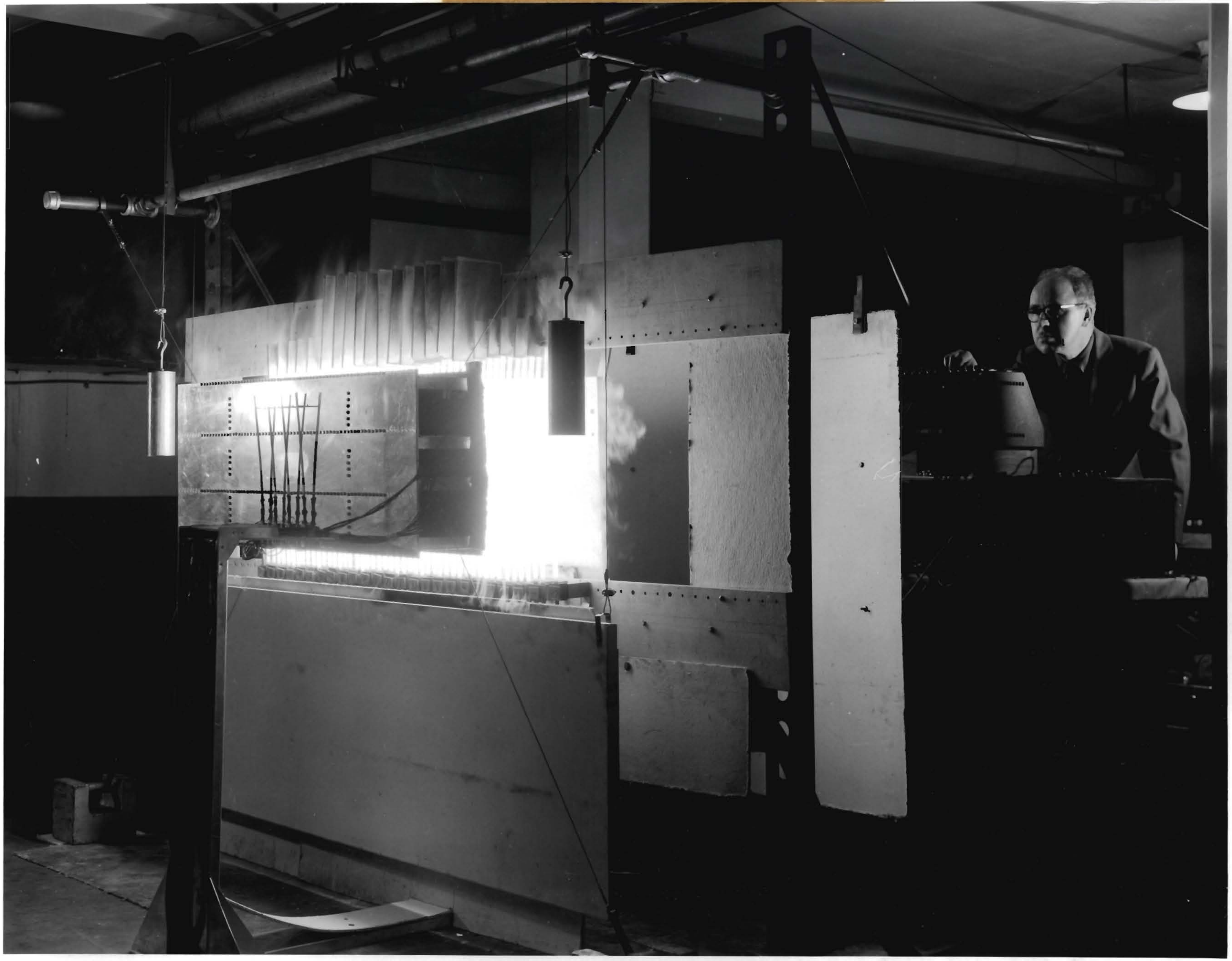
NACA
-35868

A new experimental device for reversing the thrust from a jet engine tailpipe to use it to slow an airplane's landing roll is being intensively studied at the NACA's Lewis Flight Propulsion Laboratory at Cleveland. The device, as shown in this photograph, is a set of curved vanes carried inside a jet tailpipe. In use the tailpipe opens into two side sections and the curved vanes move out into the stream of hot gases. This actually turns the jet flow forward and it issues as two separate jets under the airplane's horizontal stabilizer. When the vanes are closed they offer minimum resistance in the tailpipe. A major advantage of the method is its ability to direct the reversed stream away from parts of the airplane which might be damaged. This forward view shows the vanes open as they appear when producing reversed thrust.

C- 35868

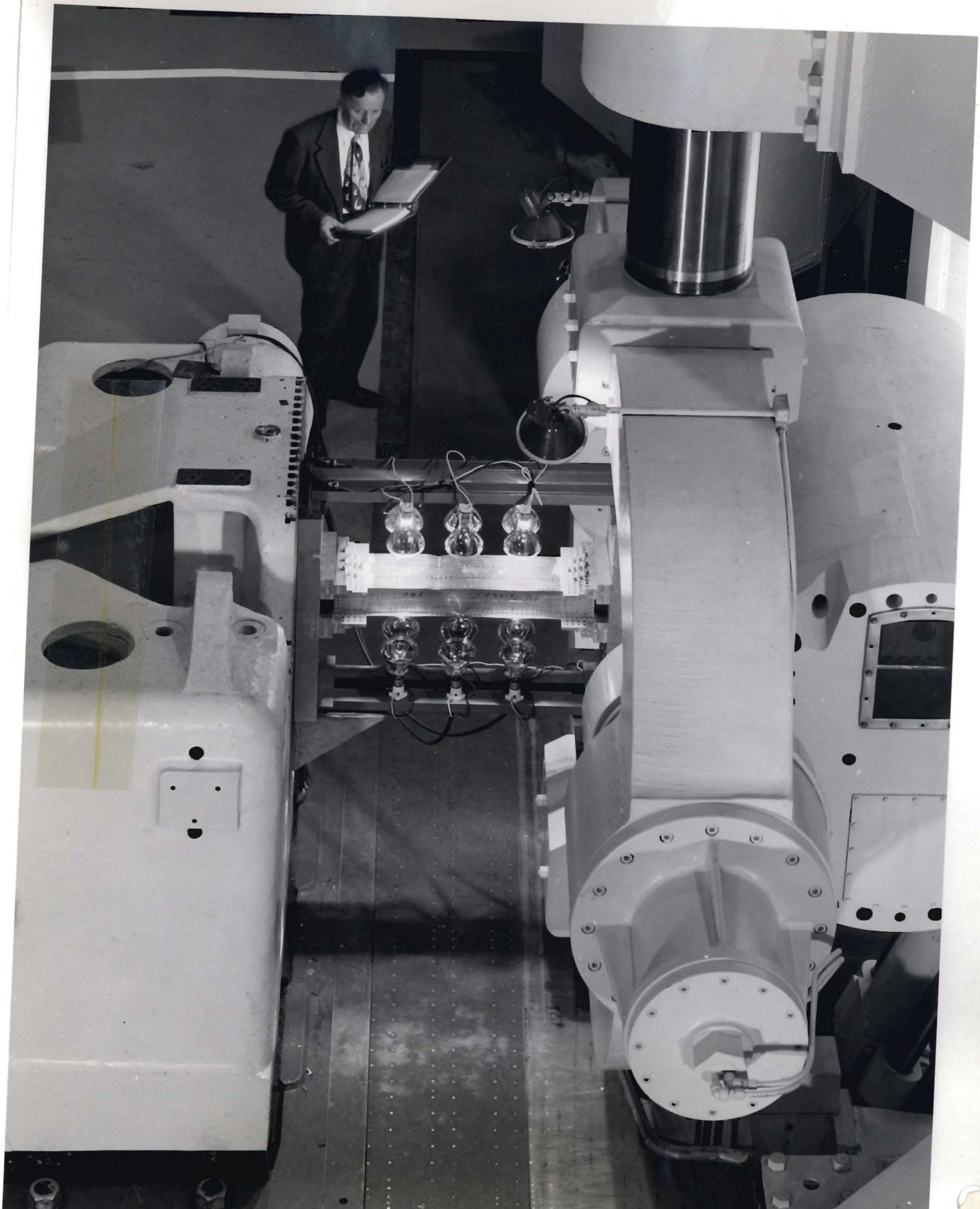
NACA

LAL 84111



A portion of an aircraft wing structure is exposed to intense heating from an array of incandescent carbon rods on a radiator used in research investigations at the NACA's Langley Aeronautical Laboratory. An NACA scientist, shielded from the white-hot brilliance of the radiator rods, is observing instrumentation which records the temperatures and distortions of the structure at high rates of surface heating. Such tests, conducted at Langley by the Structures Research Division, provide valuable data on aircraft structures, which experience high rates of heating and elevated temperatures at flight speeds many times the speed of sound.

LAL 84111

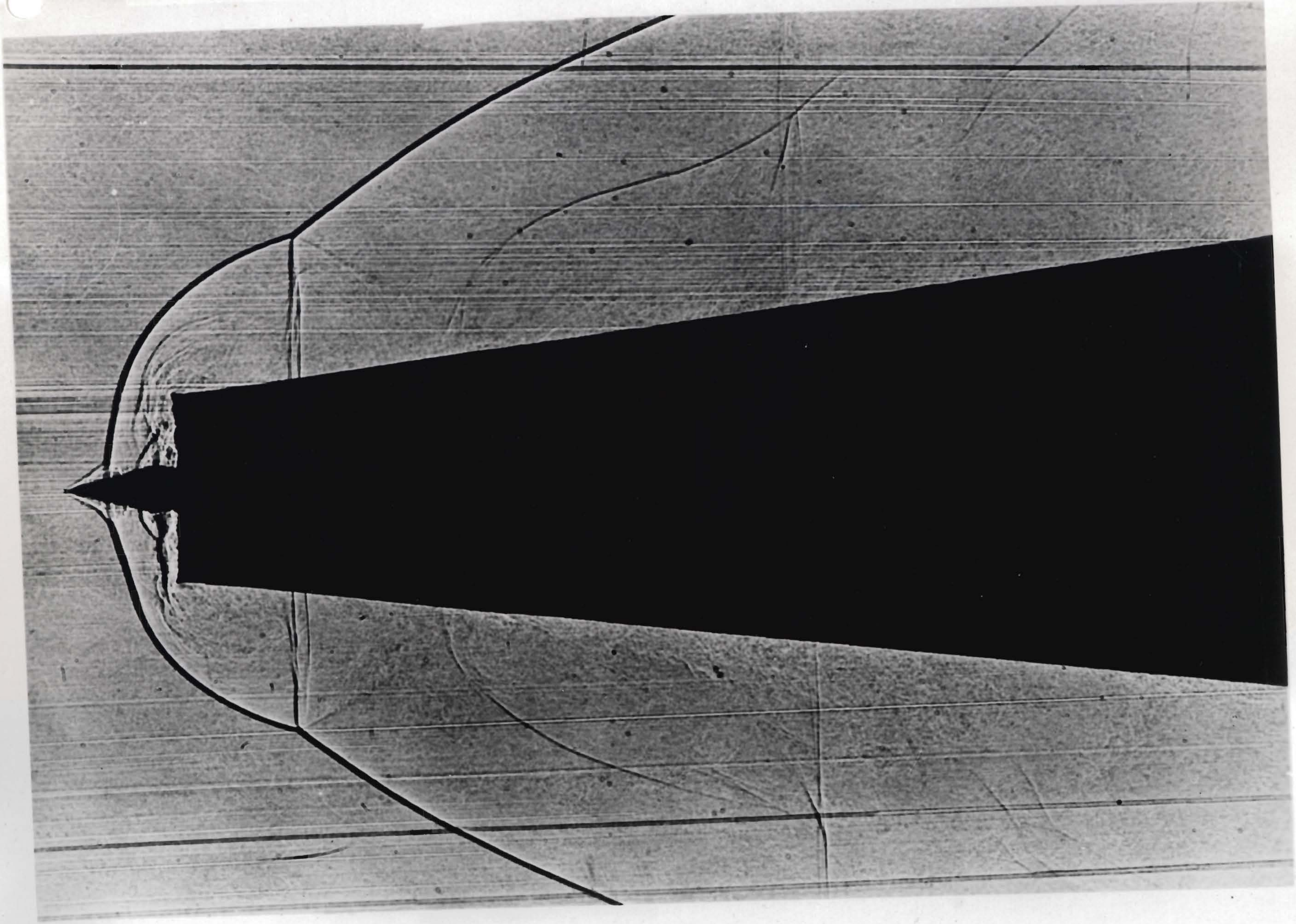


LAL 82578

A box beam, such as might be used in an aircraft wing, is subjected to simultaneous heating and loading by an NACA research scientist at the Langley Aeronautical Laboratory. The conditions of heat and load reproduce those encountered by an airplane when it flies at high supersonic speed and experiences aerodynamic heating. The test is being conducted in the unique combined load testing machine of the laboratory's structures research division. The machine can simultaneously apply six components of load; the heat is being applied by banks of infra red lamps.

LAL 82578

NACA
-19306

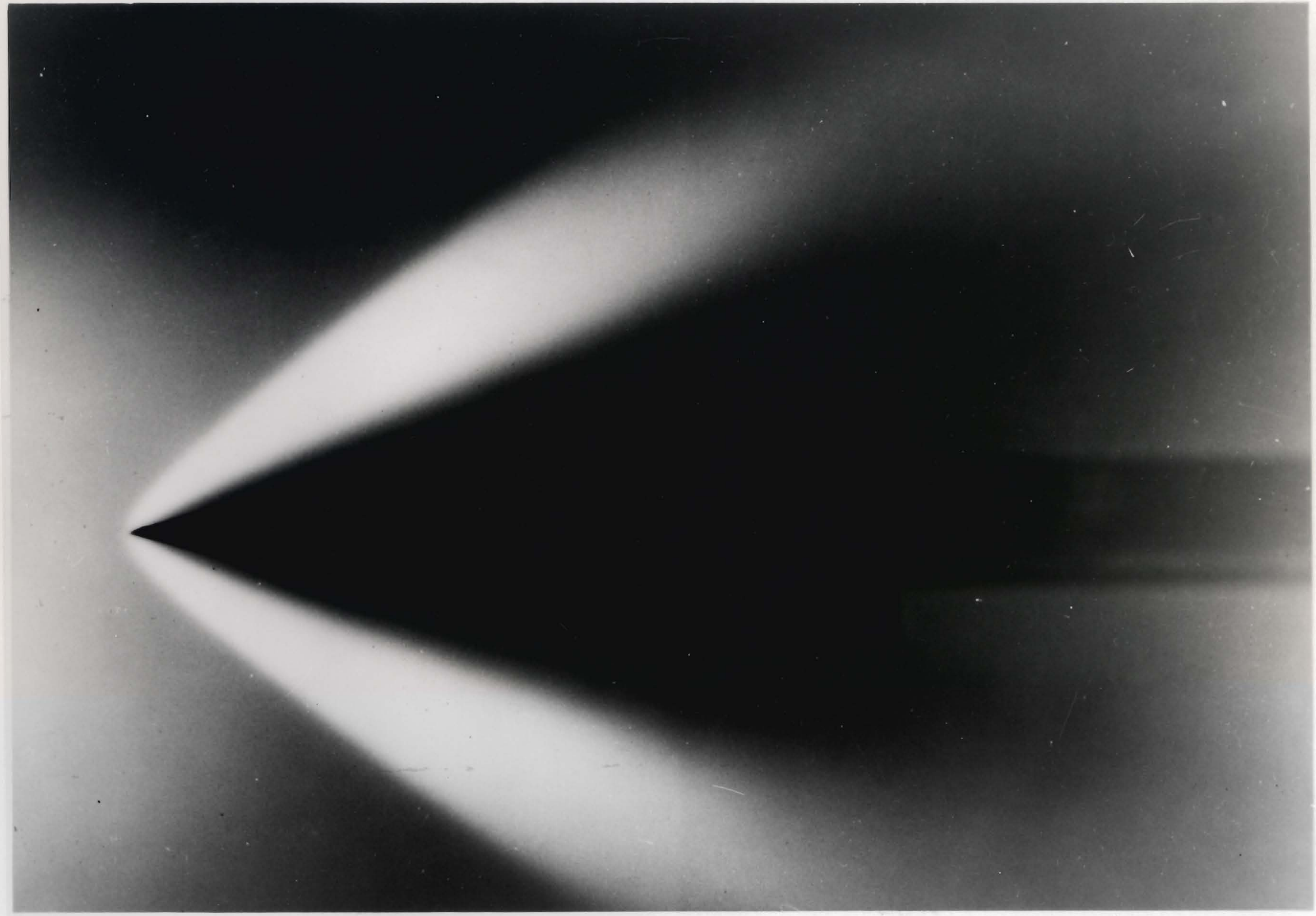


FIG

Extremely high-speed photography made possible this shadowgraph picture showing a shock wave pulsating approximately 7,000 times per second around a blunt nosed body mounted in the 10- by 14-inch Supersonic Wind Tunnel at the NACA's Ames Aeronautical Laboratory, Moffett Field, Calif. With an exposure time of only one ten millionth of a second the rapidly pulsating shock wave on the model's nose is effectively "stopped." This photographic technique has been made possible by a new high intensity spark source recently developed at Ames Laboratory. These photos were made with the tunnel operating at a Mach number of 3.5 or approximately 2500 miles per hour.

A-19306

19310



To study shock wave formations at the very low densities which missiles would experience at extremely high altitudes, NACA scientists use what is called a nitrogen afterglow technique. Nitrogen instead of air fills the wind tunnel in which this photograph was taken at the NACA's Ames Aeronautical Laboratory at Moffett Field, California. The nitrogen is electrically charged, causing it to glow. Brightness of the glow increases with density and reaches its greatest intensity at the shock wave location. This model is being tested at a Mach number of 3 in an atmosphere equivalent to an altitude of 30 miles, or 158,000 feet. The air at such an altitude would be only 1/1500th as dense as at sea level.

A-19310