UNITARY PLAN WIND TUNNELS

presented by

Unitary Plan Wind Tunnel Division

This wind tunnel is one of three NACA Unitary Plan Wind Tunnels, one located at each of the three Laboratories. General arrangements of the other two installations are shown on this chart (chart #1). These wind tunnels are being constructed under authority of the Unitary Wind Tunnel Plan Act of 1949 and have been designed for use primarily in conducting developmental research on airplanes, missiles, and engines for the aircraft industry.

Although the primary responsibility of the NACA is the study and solution of fundamental problems in aeronautics, it is also our function to assist the aircraft industry and the military services in development testing when our resources are needed and it is considered to be in the best national interest. Strategic requirements during World War II caused us to emphasize developmental research, and the balance between fundamental and developmental research effort was upset. It was also apparent that with the rapid advances being made in aircraft and engine performance, the needs for development testing would continue - hence plans were made to build these Unitary Wind Tunnels in order to restore the proper balance of effort.

The Unitary Plan was given the green light in 1950 when Congress appropriated funds for the construction of these three wind tunnels and the Air Force's Arnold Engineering Development Center at Tullahoma, Tennessee. The Langley Unitary Plan Wind Tunnel, which is currently undergoing calibration tests, has been designed to operate over a Mach number range of 1.2 to 5.0 using two separate nozzles and test sections. The test sections are 4 by 4 feet in cross section. This wind tunnel is to be devoted to aerodynamic studies of airplanes and missiles and it is expected that the first investigations will commence sometime this summer.

The Lewis Unitary Plan Wind Tunnel will be devoted to studies of aircraft propulsive units. Studies will also be made here of air inlets, inlet diffusers, internal ducting, jet exits, and other aircraft components associated with the propulsive system. This wind tunnel has a design Mach number range of 2.0 to 3.5 provided in a single 10- by 10-foot test section. It is now in the final construction phases.

The Ames Unitary Plan Wind Tunnel, like the one at Langley, will be devoted to aerodynamic investigations of airplanes and missiles. Tests can be conducted over a Mach number range of 0.7 to 3.5 in three separate test sections, an 11- by 11-foot transonic test section with a range of

This compressor is the largest of its type in operation in the world today. The rotor is 18 feet in diameter and weighs nearly 450 tons. This photograph (chart #2) shows one of the 11 rotor discs being lowered into place. The slots around the edge of the disc are for blade attachment. Also pictured here during final assembly is the entire machine with the outer case open, and a closer detail of the individual rotor blades. At full load this compressor circulates air at the rate of 60 tons per minute.

In order to utilize this compressor to operate both supersonic circuits, it was necessary to develop two extremely large two-way valves, as was mentioned previously, one situated at each end of the common branch of these circuits. This common branch has been reproduced schematically on this next chart (chart #3). The valves are shown here in position for operation of the 9- by 7-foot circuit. Note that the passages of the 8- by 7-foot circuit are blocked. When operation of the 8- by 7-foot circuit is desired, the valves are rotated thus. The guide vanes rotate with the valve and serve in either position to guide the air smoothly around the corner. The valves are operated only when the tunnel is not running and is open to atmospheric pressure. Total rotation of 180° is accomplished in about 3-1/2 minutes. (The photograph is of this value before installation of the compressor. The vertical strips are the corner guide vanes.) The 11-stage compressor is driven by four tandem-mounted wound rotor motors with a combined rated output of 180,000 horsepower. For limited intervals these motors are capable of an output of 216,000 horsepower. You can get some idea of the size of these motors by reference to this photograph of the motor assembly (chart #4). The motors and compressors are sketched here to show their relative positions.

The three-stage compressor which operates the transonic circuit is of the same general construction as the 11-stage compressor. Since the rotor of this machine has only three stages, its weight is less than that of the 11-stage compressor rotor. However, the large transonic test section requires that the three-stage compressor circulate air at the rate of about 290 tons per minute, or approximately five times the rate of flow of the 11-stage machine. This compressor is driven from the opposite end of the drive motor assembly. Disconnects are provided on the shaft extensions at both ends of this motor assembly, which permit coupling to either compressor. Only one circuit may be operated at any one time, however.

In the process of compression as the air passes through the compressor considerable heat is developed. For example, the temperature of the air as it leaves the 11-stage compressor is 450°F. Heat is removed from the air in these large cooling sections to keep the air temperature down to 120°F. Cooling is provided by circulating water from this large cooling tower through finned coils or radiators. Pictured here (chart #5) is the complete installation in the transonic circuit cooler from which you may get an idea of the size. Notice the man standing at the bottom of the bank of coolers. Also shown here is one of the coil units being lifted into place during installation.

The air pressure in each wind tunnel circuit may be set at any value from near vacuum to twice atmospheric pressure by use of pumps and compressors located in this building. Once set, the pressure is very accurately maintained by an automatic control system. These spheres serve as pressure and vacuum reservoirs for use with the automatic control system.

I would now like to introduce Mr. ______ who will discuss some of the accommodations for aerodynamic testing provided by this wind tunnel.

In the center portion of this building on the upper two floors are six shops with adjoining offices for use by the manufacturers' representatives while models are being readied for test and while investigations are being conducted. Here preparation of models and special instrumentation as well as minor modifications may be made all within the requirements of security and proprietary interests. On your way to the following presentation you will pass one of these shops and we invite your inspection of these facilities. On the second floor of the east wing of this building is the central computing room where our electronic computing machinery is located.

The manner in which this computing equipment is used may be illustrated by reference to the simplified schematic hookup shown on this next chart (chart #6). The equipment shown here represents that in each of the three test chambers - this equipment is located in the central computing room. Data from the model are received in the form of electrical impulses. These impulses are sent to a recorder at the control panel where visual indication is presented on dials and the uncorrected data are automatically tabulated for future reference and check purposes. Data are then transmitted to the central computing room electrically. Data may be sent here for processing from any of the three test chambers. The information is then fed into the computer which performs previously programmed computations. The corrected data emerge through an electric typewriter and are tabulated by a receiving typewriter in the test chamber control room.

In addition, the output of the computing machine may be used to actuate a plotting machine in the test chamber control room. Here corrected test results may be viewed within minutes after the data are taken. This arrangement allows the test operator to monitor the tests as they are in progress and permits current evaluation of the test program. This is a very important feature as it allows us to detect aerodynamic problems as they occur and may save unnecessary testing.

This Unitary Plan Wind Tunnel will enable us to provide for the aircraft design engineers much needed information for proposed designs as well as for airplanes and missiles in the developmental and operational stages. Many types of investigations will be conducted in this wind tunnel; for instance, we can accommodate models such as this - of sufficient size that movable controls may be incorporated to permit the measurement of control forces needed by the aerodynamicist. Models such as this can be tested. By connecting separate pressure measuring instruments to each of the many tiny

Mach number from 0.7 to 1.5, a 9- by 7-foot supersonic test section with a Mach number range of 1.4 to 2.6, and an 8- by 7-foot supersonic test section with a Mach number range of 2.4 to 3.5. The wind tunnel is nearing completion and calibration tests in this 9- by 7-foot circuit are just beginning.

Test programs and schedules of all of these Unitary Plan Wind Tunnels will be coordinated through two allocation and priority groups which have already been established - one for aircraft and missile projects, and one for propulsion projects. These groups are made up of one member and one alternate each from the Army, the Navy, the Air Force, and the NACA.

Models will be furnished by the aircraft company, and the actual testing will be carried out by wind-tunnel staff members.

The Unitary Plan Wind Tunnel here at Ames is unique in its general arrangement. For a more detailed description of this wind tunnel I would like to introduce Mr. ______.

This scale model will give you a good idea of what the Ames Unitary Tunnel looks like from above. It is in reality a three-in-one arrangement, consisting of a transonic circuit and two supersonic circuits, as was pointed out by Mr. ______. The transonic circuit covers a Mach number range of 0.7 to 1.5. Air is circulated around the closed circuit in a counter-clockwise direction by this large three-stage axial flow compressor. Tests are conducted in the 11- by 11-foot test section. The lower supersonic circuit provides Mach number variation from 1.4 to 2.6 in a test section 9 feet wide and 7 feet high. You are now seated here - in the test chamber enclosing this test section. Air is circulated in a clockwise direction around this circuit by this 11-stage axial flow compressor. Note that this compressor is located in a section common to both supersonic circuits. For operation of the higher supersonic circuit it circulates air in a counter-clockwise direction. To accomplish this dual role requires the use of large two-way valves at both ends of the common section. These valves will be described later in more detail. This higher supersonic circuit provides Mach number variation over a range of 2.4 to 3.5 in the 8- by 7-foot test section.

This unique arrangement was evolved because it was found that satisfactory test section flow fields throughout the desired Mach number range could best be provided by three separate nozzles. The construction of three separate nozzles was found to be feasible economically only if they could be operated from a single source of power, for the drive system is the most costly component of a large wind tunnel. Because of the wide variation of flow requirements of the three nozzles and the limited range of flow quantities over which a compressor can be designed to operate efficiently without undue complexities, it was not feasible to design a single compressor to operate all three circuits. By incorporating these bypass channels in the higher Mach number range where the nozzle flow is restricted, it was possible to design a single compressor to operate both supersonic circuits.

holes on this wing we can determine the distribution of air pressure and consequently the load distribution, of great interest to the structural design engineer. Internal flow models such as this may be studied - models large enough to permit comprehensive measurements of the air flow through internal air ducts. These are, of course, but a few of the many types of investigations which will be conducted, but they do serve to illustrate how this wind tunnel will be used to improve the performance and effectiveness of the aircraft of today and tomorrow.

To complete your visit to this Unitary Plan Wind Tunnel, we invite your inspection of this test section and its associated test apparatus. A typical model is mounted in the test section on the sting support and may be viewed from the far side of the tunnel. You will recall that air flow here is from right to left as viewed from your present position. In the control room, the data recording machine and plotter are in operation. There you may see the form in which final data are tabulated and plotted. We request that you cross the tunnel here at the west end of the building and return by the stairway at the east end. Members of the tunnel staff will be nearby to answer any questions which may occur. The next presentation is in this building down the corridor through the door at the foot of this stairway. May I remind you that on your way to the next presentation you will see one of the manufacturers' shops and offices.

I thank you for your attention.

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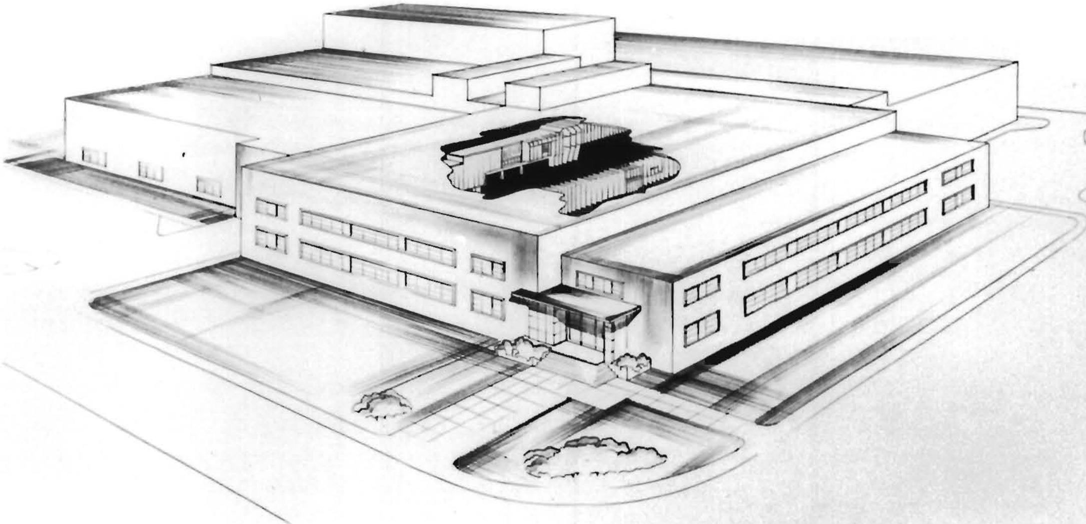
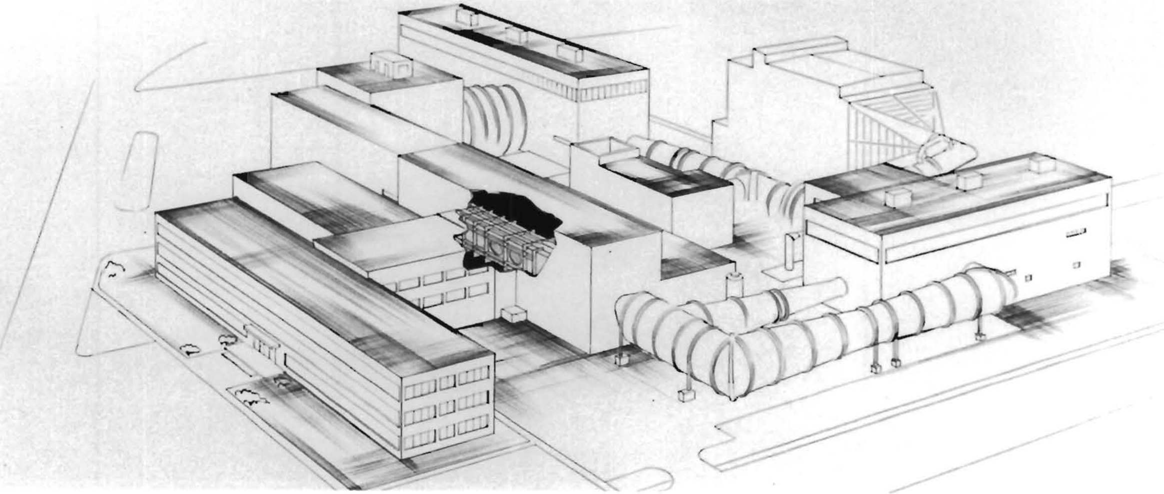
AMES AERONAUTICAL LABORATORY, MOFFETT FIELD, CALIF.

UNITARY PLAN WIND TUNNELS



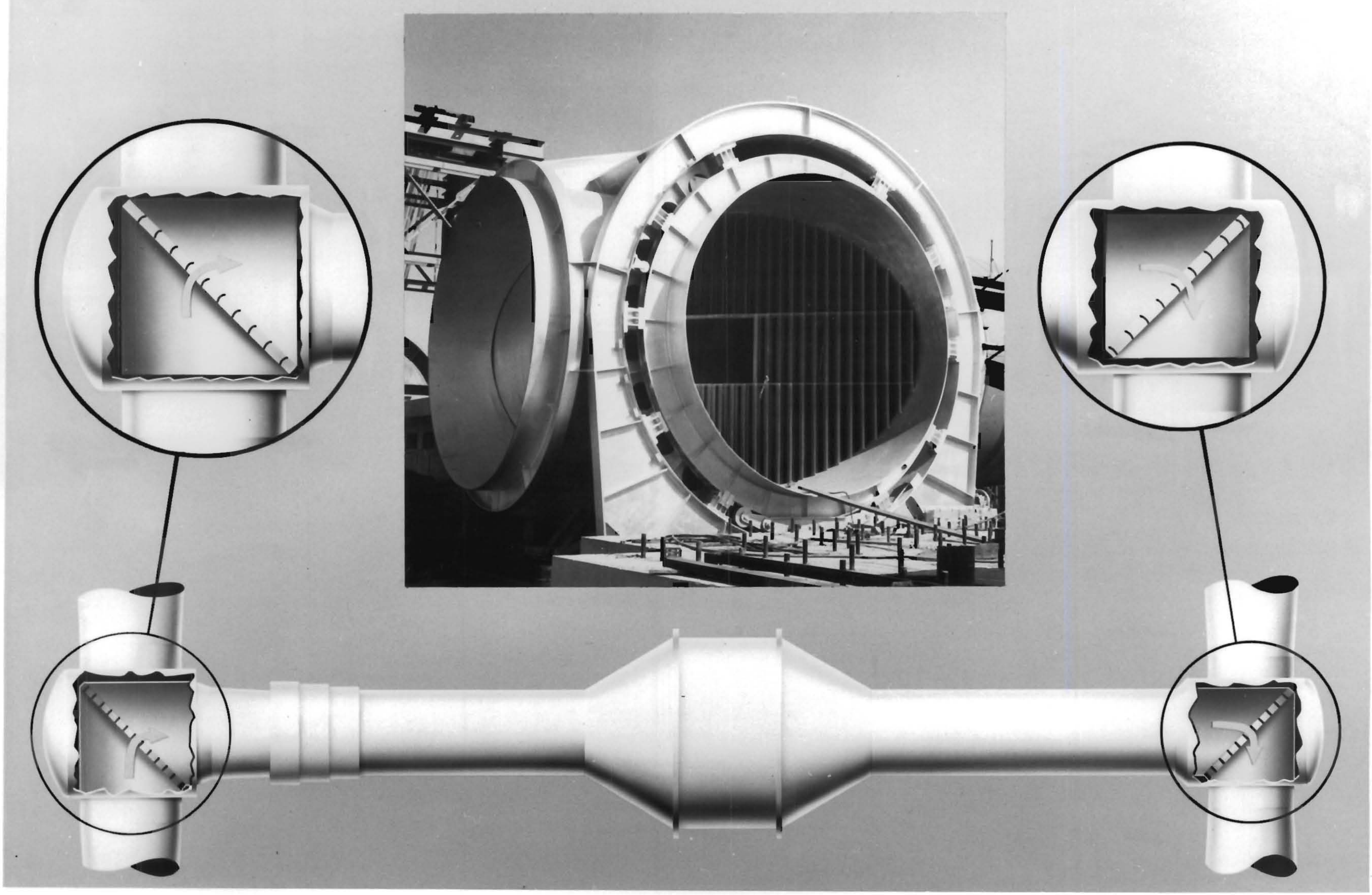
LANGLEY
4 x 4 FOOT SUPERSONIC
WIND TUNNEL



LEWIS
10 FOOT SUPERSONIC
WIND TUNNEL

11-STAGE AXIAL-FLOW COMPRESSOR

TWO-WAY VALVES



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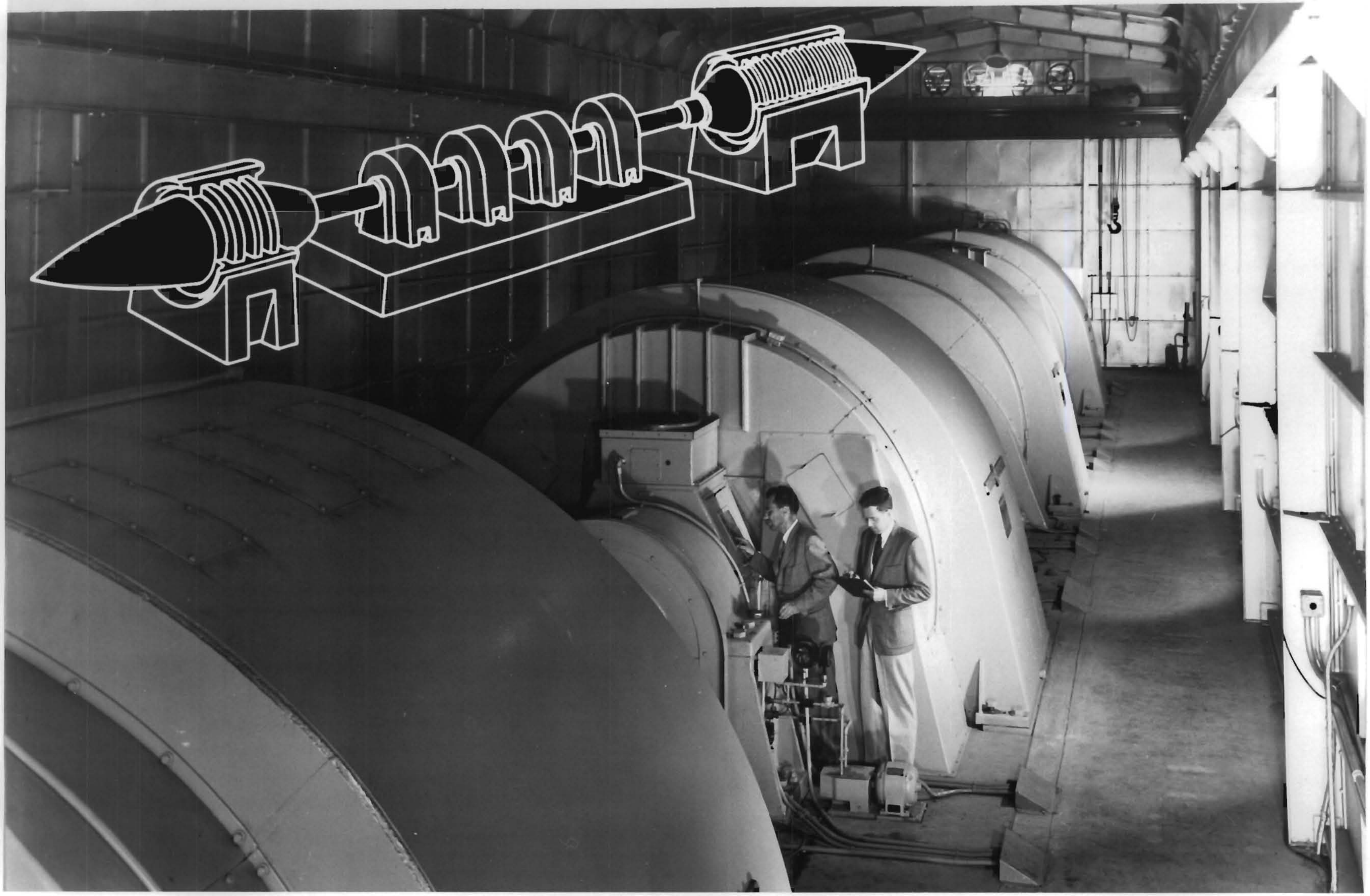
DRIVE MOTORS



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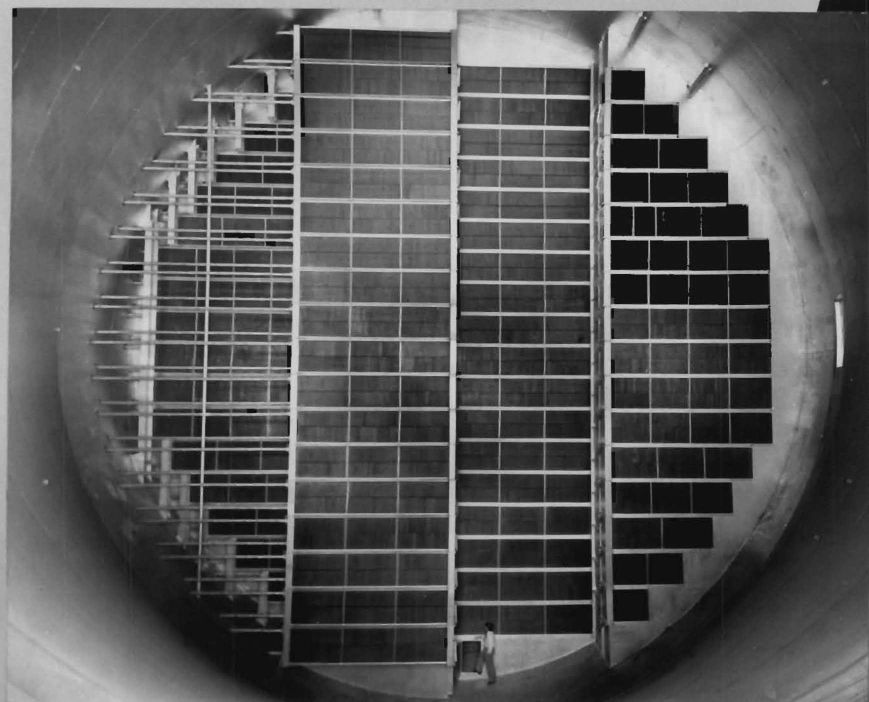
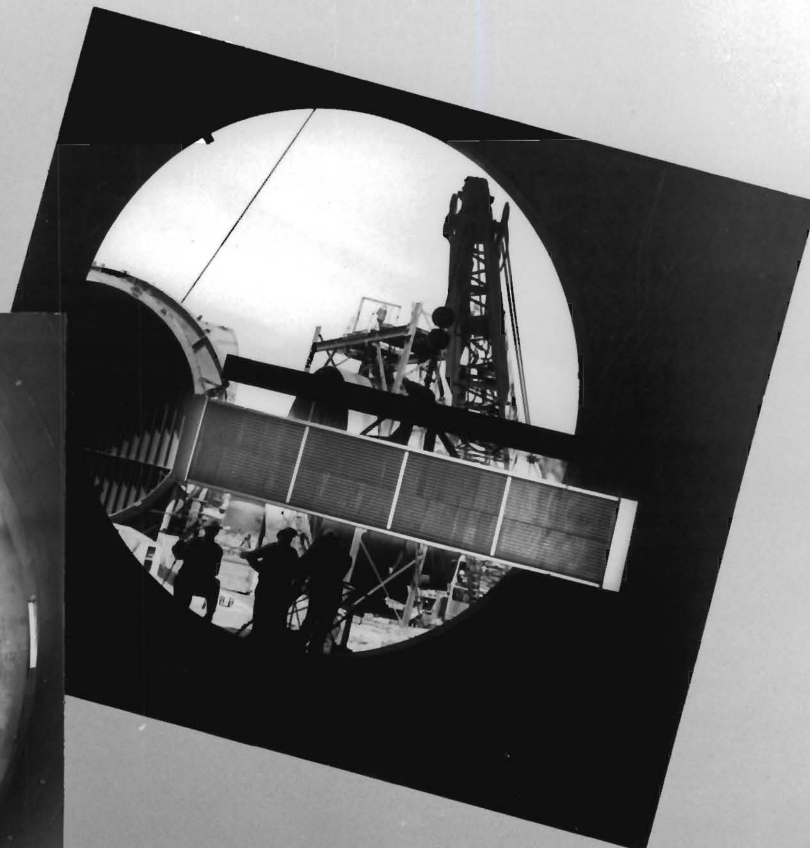
AIR COOLER





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AUTOMATIC DATA-REDUCTION SYSTEM