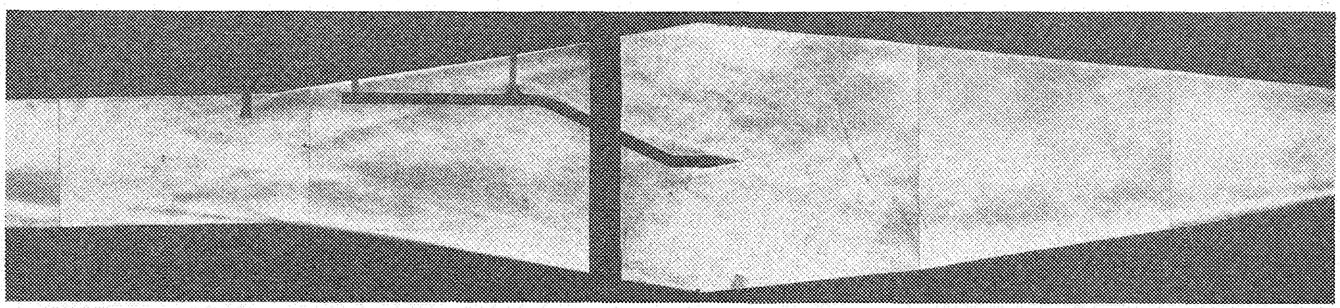


*Schlieren picture of a rocket model in the tunnel—which is operating at ten times the speed of sound. Shock waves from the nose of the model are hard to see because of the low density of the air in the tunnel test section.*

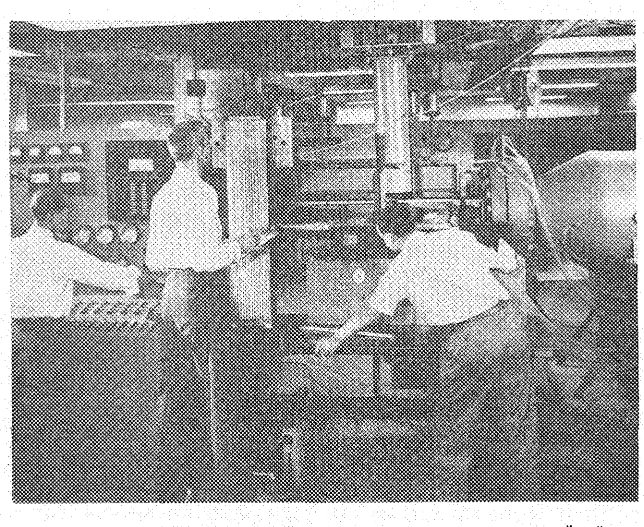
# The Hypersonic Wind Tunnel

**In this new Caltech-Army Ordnance tunnel men can study the inevitable intercontinental missiles of the future.**

A NEW "HYPERSONIC" wind tunnel which has just been completed in the Guggenheim Laboratory of Aeronautics has already attained a speed of more than ten times the speed of sound. This not only surpasses all other highspeed wind tunnels now in operation; it opens up a whole new, unexplored range of air speeds to the designers of rockets, planes, and projectiles. For the first time now man has an apparatus that will allow him to make tests at speeds well above those of our most advanced rockets and missiles.

The top speed for a rocket officially reported to date (E & S—March '49) is 5,200 miles an hour, or a little more than seven times the speed of sound. This record was established by the two-stage rocket—a WAC Corporal launched from the nose of a German V-2 in flight—fired by the Ordnance Department at White Sands, New Mexico, on February 24, 1949.

A guided missile designed with the aid of the new hypersonic tunnel should be able to travel at speeds above 7,500 miles an hour. It could take off from San Francisco and land in Sydney, Australia (7,600 miles) in about an hour. Or it could span the Atlantic, from New York to London, in less than half an hour.



*The tunnel requires intricate instrumentation and three men to operate and record data when it is running.*

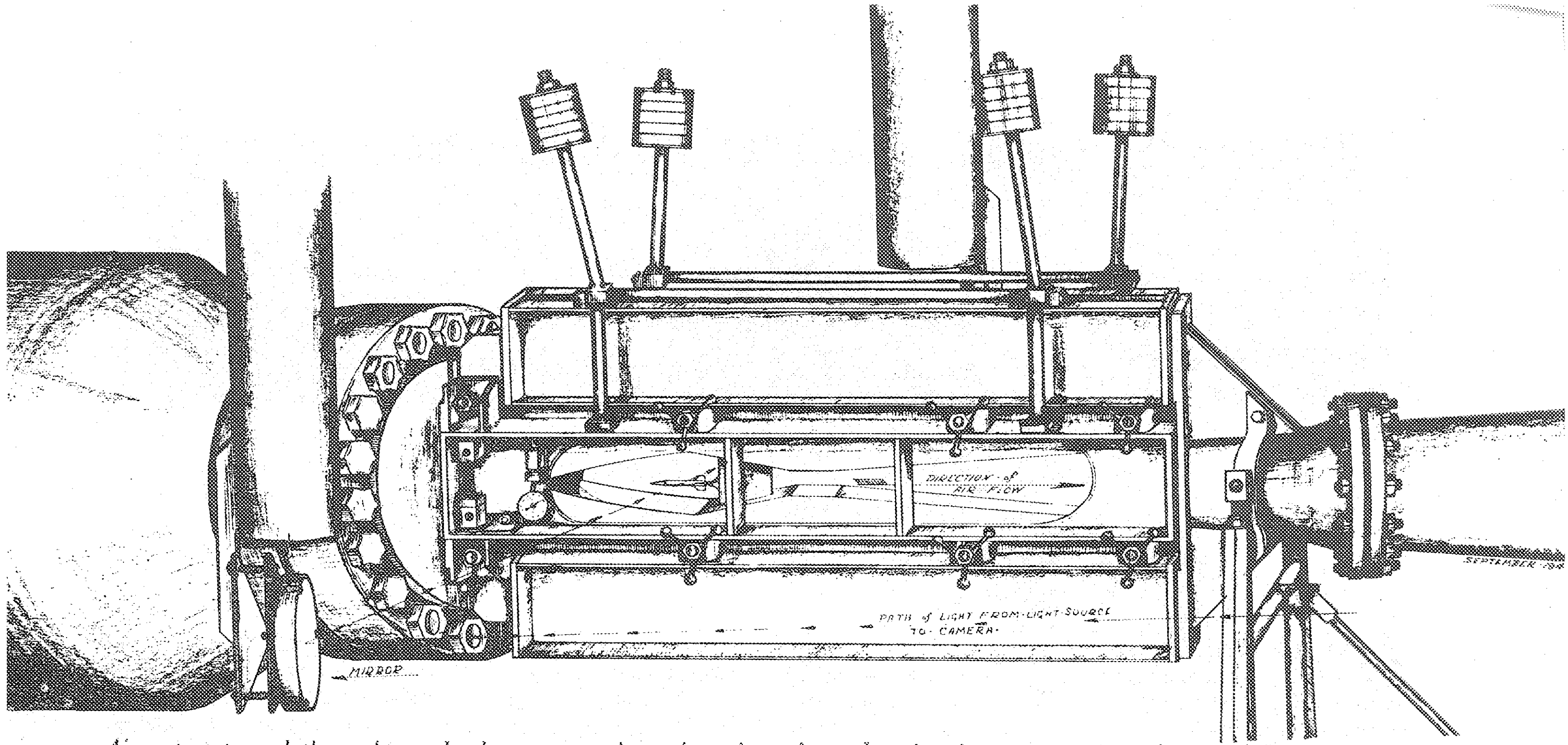
The new tunnel was built for the Army Ordnance Department, whose ballistic experts foresaw the need for tunnels capable of extremely high speeds in which to study the inevitable intercontinental missiles of the future. It will be operated under Ordnance Department contract and, as the pioneer tunnel in the hypersonic range, it will be used to obtain basic information about the design, performance, and instrumentation of hypersonic tunnels. Basic experimental data will also be obtained on shock waves, boundary layers, and the flow past models at hypersonic speeds—along with other information essential to the design and construction of future rockets and missiles.

In all wind tunnels a uniform stream of air is blown through a test chamber in which a scale model of an airplane, rocket or projectile is mounted. The test section of the hypersonic tunnel is only five inches high by five inches wide, though the entire working section stretches to an overall length of four feet. The air enters this working section through a slot, or throat, only a few thousandths of an inch high (the exact height depending on the air speed desired). Thus, at Mach 10*,

* A "Mach number" expresses the ratio of the speed of a moving body to the speed of sound.

When a body moves through the air at a very low speed the disturbance it makes is propagated to all parts of the air so rapidly—as far as the body is concerned—that the air is effectively incompressible. However, as the speed of the body becomes higher, relative to the speed of sound, the rate at which the disturbance is sent through the air may affect the appearance of the flow pattern around the body. Thus the important criterion of speed is the ratio of the speed of the body to the speed of sound (750 mph at sea level and normal atmospheric temperature).

This ratio is known as the "Mach number"—after the Austrian scientist who made some fundamental investigations in gas dynamics in the 19th century. When the Mach number is less than 1, the flow is said to be subsonic; greater than 1, supersonic; in the region of 1, transonic. Aerodynamicists now say little about actual speed in miles per hour, but talk only of Mach number.




*Air enters tunnel through nozzle throat, goes through region of acceleration into test section, then to diffuser section.*

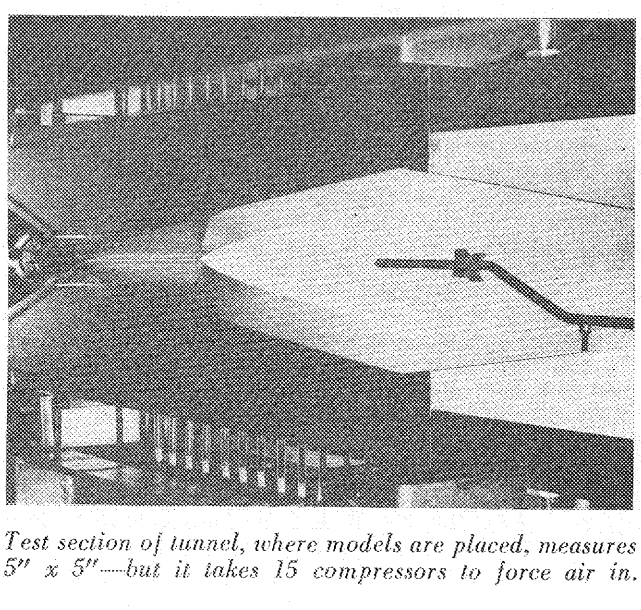
which means ten times the speed of sound, air at tremendous pressure blasts through the tiny slot.

As the air expands into the test section, the temperature drops to about 430 degrees below zero Fahrenheit. Stationary air at this temperature would turn to liquid, but here the air apparently moves so fast through the cold zone that it hasn't time to freeze.

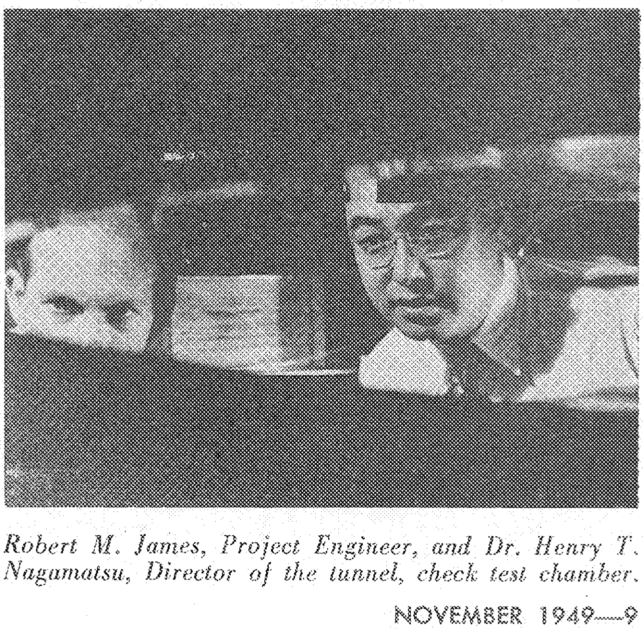
Along with the drop in temperature the pressure in the test section drops to about one millimeter of mercury, or 1/1,000 of normal atmospheric pressure. Consequently, the air is so thin—like that of the atmosphere dozens of miles above the earth—that it is extremely difficult to observe its flow patterns. A schlieren optical system is used to photograph these patterns, made by the fast-moving air as it speeds past the models in the test section. Shock waves in the air stream act as miniature lenses to disturb a parallel light beam, and the disturbance is recorded by a specially-designed camera. The camera can photograph an eight-inch circular area at a time, and the whole system can be moved along the tunnel on an overhead track to get a complete picture of what happens ahead of, and behind, the model.

The tunnel is housed in a building specially designed for it in the Guggenheim Laboratory. The building has two basements, one for the tunnel proper, the other—under it—for the enormous power plant which is needed to operate the tunnel. It takes no less than 15 compressors to supply air for the tunnel. And this air flows first into a large supply reservoir tank, 12 feet long, 3 feet in diameter, and weighing approximately six tons.

From the standpoint of the speed ranges it explores the hypersonic tunnel is "the fastest in the world." It has already been operated at higher than Mach 10. The fastest speed ever reported in any tunnel before is approximately Mach 7, and that could be maintained for only a few seconds in an intermittent-type tunnel. The hypersonic tunnel operates continuously and air velocities of Mach 10 can be maintained for any length of time. In raising the Mach number to 10, the new tunnel makes it possible for the aerodynamicists to move on to the design of rockets, planes and missiles with speeds far greater than any yet attempted.



*Test section of tunnel, where models are placed, measures 5" x 5"—but it takes 15 compressors to force air in.*



*Robert M. James, Project Engineer, and Dr. Henry T. Nagamatsu, Director of the tunnel, check test chamber.*