N-12060

TECHNICAL ORIENTATION PROGRAM

FOR ENGINE RESEARCH DIVISION

LECTURE NO. VIII FACILITIES AND EQUIPMENT

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INTRODUCTION

In some of the previous talks in this series the discussion concerned the performance of aircraft propulsion systems. This talk will cover briefly our test facilities for determining engine performance.

Because of superior performance at high altitudes aircraft equipped with the latest propulsion devices are essentially high altitude machines. Consequently, a determination of performance under simulated flight conditions at high altitudes is of major importance. Because of the large quantities of air involved, the facilities required to investigate engine performance at altitude temperatures and pressures are very extensive and the cost is generally so great as to be almost prohibitive for private industry. Our facilities of this kind are thus valuable and unique tools for testing aircraft engines. It is important that they be used to the fullest extent.

In order to subject an engine to flight conditions of altitude and speed, we may:

(a) Place the engine in a wind tunnel where altitude and flight velocity conditions are simulated. The altitude wind tunnel is such a facility. The tunnel is especially valuable for testing engines with propellers. Furthermore, because of the tremendous volume of the tunnel, tests involving transient engine operation can be satisfactorily accomplished without greatly affecting the simulated flight conditions. Complete aircraft-engine nacelles can be tested in this facility.

(b) Place the engine in an altitude chamber where intake and exhaust flight conditions are closely simulated as though the engine were operating in the nacelle of an aircraft. The altitude chambers in SW-23, SW-24, and CE-22 of the Engine Research Building (ERB) and the new Propulsion Sciences Laboratory (PSL) chambers are examples of such equipment. Obviously, propellers cannot be used in altitude chambers. Consequently, the shaft power from propeller engines must be absorbed by a dynamometer if tested in altitude chambers.

(c) Connect the intake supply and the exhaust-discharge ducts directly to the engine. In this case the exterior of the engine housing is subject to sea-level temperatures and pressures. The setups in SW-21 and SW-22 are examples of this arrangement.

Sea-level test stands are used mainly for exploratory or preliminary test work and for endurance testing. The six cells at the Jet Propulsion Static Test Laboratory are examples of facilities for testing jet engines. Likewise the four cells at the Engine Propeller Research Building provide facilities for testing either jet or propeller engines.

ENGINE TEST FACILITIES OF THE

ENGINE RESEARCH DIVISION

Altitude Wind Tunnel

Tunnel and balance system. - The altitude wind tunnel (fig. 1) is of the return type with a 20-foot-diameter closed throat. Access to the throat is provided by a hatch covering the top portion of the throat. Models are mounted on a stub wing supported by trunnions on each side of the throat. The trunnions are mounted on a balance frame arranged for measuring the various force components, such as thrust, drag, etc. These forces are measured by Toledo remote-indicating weigh scales. The maximum thrust and lift capacities are 12,000 and 20,000 pounds, respectively. Engines mounted on the stub wing may be tilted through a range of angles of attack during test.

Tunnel fan and drive motor. - A newly designed 31.5-foot-diameter variable-pitch tunnel fan has just been installed. This fan has 18 wooden blades mounted in steel shanks. The pitch is varied by means of motors mounted on the propeller hub.

An 18,000-hp variable-speed electric motor drives the tunnel fan. The motor speed can be varied from 10 to 400 rpm by means of a special type of control (Clymer). In this control the rotor of the synchronous motor is supplied with a variable frequency from an alternator driven by a variable-speed direct-current motor.

With the new fan, now being installed, an open-throat velocity of 500 mph at 50,000 feet altitude is expected.

Air-supply system. - Air for the tunnel is taken from the atmosphere, passed over primary cooling coils, through a dryer system, through secondary cooling coils and enters the tunnel through (a) the tunnel pressure regulator valve (b) the directional nozzle (ram pipe) ahead of the engine or (c) the combustion-air line leading to the engine. The latter can be used for supplying ram air to a propeller engine or air to a tail-pipe cooling jacket. The present modernization contracts for the tunnel will provide a 30-inch-diameter combustion-air line tie-in with the combustion-air system of the Engine Research Building.

The air dryer consists of beds of activated alumina through which the air is passed. Reactivation is accomplished by heating with steam at 300° F for a period of about 3 hours. Water from the cooling tower and cooling from the refrigeration system are used to cool the dryer system after reactivation. The complete reactivation cycle requires about 8 hours time.

Exhaust system. - The modernized tunnel will exhaust through a 60-inch-diameter air scoop located aft of the engine (original scoop was 40-inch diameter) by means of four Worthington and three new Ingersoll-Rand reciprocating compressors. The new exhausters will increase the capacity approximately 75 percent. This capacity will be further augmented by means of a 72-inch-diameter pipe connecting with the system in ERB. Exhaust from the tunnel air scoop is passed through a large spray-type cooler situated under the tunnel.

Cooling system. - Cooling is provided by one of the largest refrigeration plants in the country. This system is housed in a separate building with a cooling tower at one side. Refrigerant (Freon) is supplied to primary and secondary coils for cooling the air entering the tunnel and for a large heat exchanger located in the return passage of the tunnel.

The present cooling tower (also being used by ERB) shown in figure 1 has a rating of 38,000 gpm with a 10° F drop. The temperature is limited to 85° F because of requirements of the refrigeration system. The pumping capacity of the altitude wind tunnel unit is 26,000 gpm at 45 psi. Present construction will increase the capacity of the cooling tower 12 percent.

Altitude Chambers in SW-23 and SW-24, ERB

The altitude chambers in SW-23 and SW-24 are roughly the same with differences in equipment. For brevity, only the SW-23 chamber will be described.

Description of chamber and thrust platform. - Each chamber (fig. 2) has an inside diameter of 10 feet and a total length of 60 feet. Two bulkhead walls divide the chamber into three compartments. The front compartment provides a plenum chamber

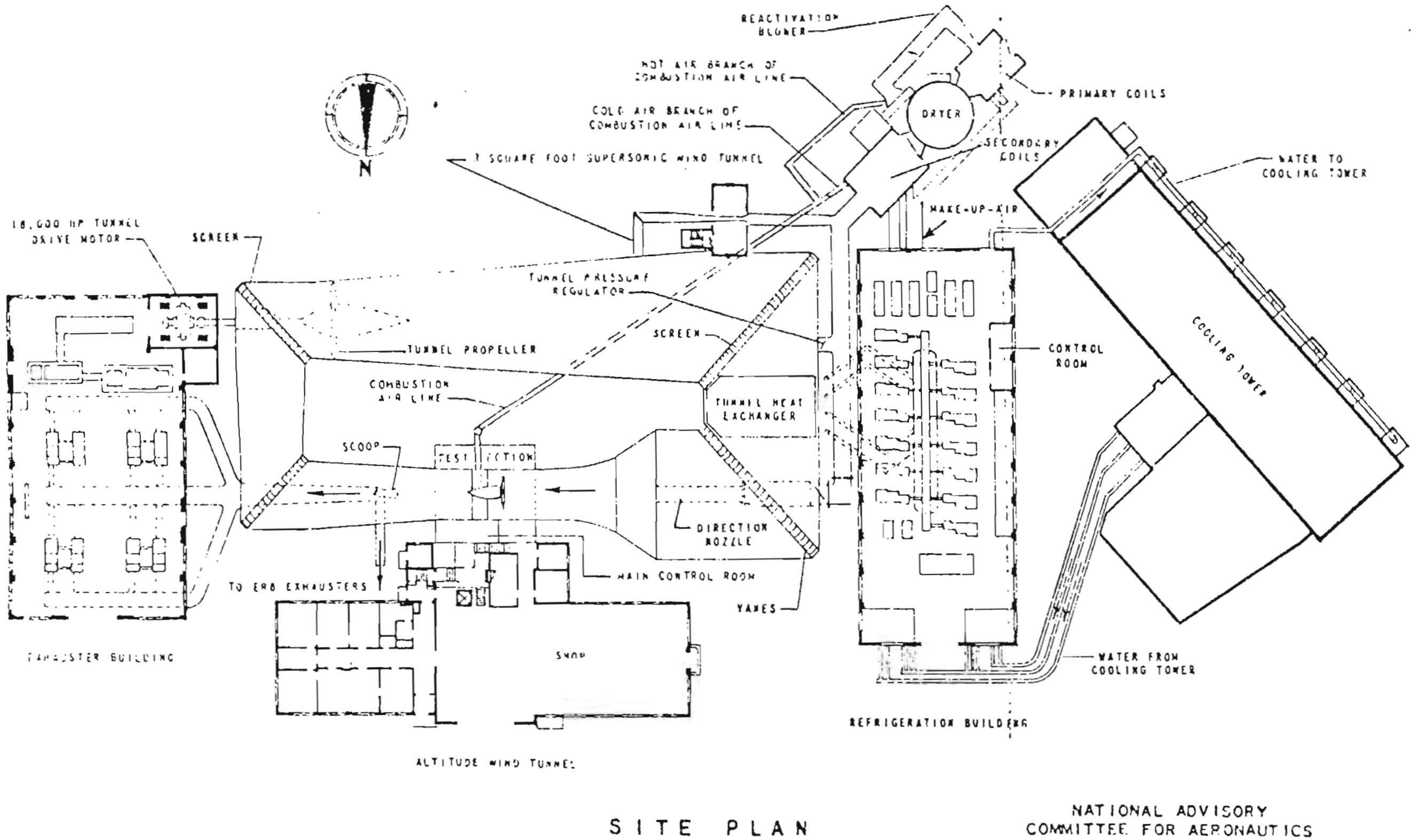
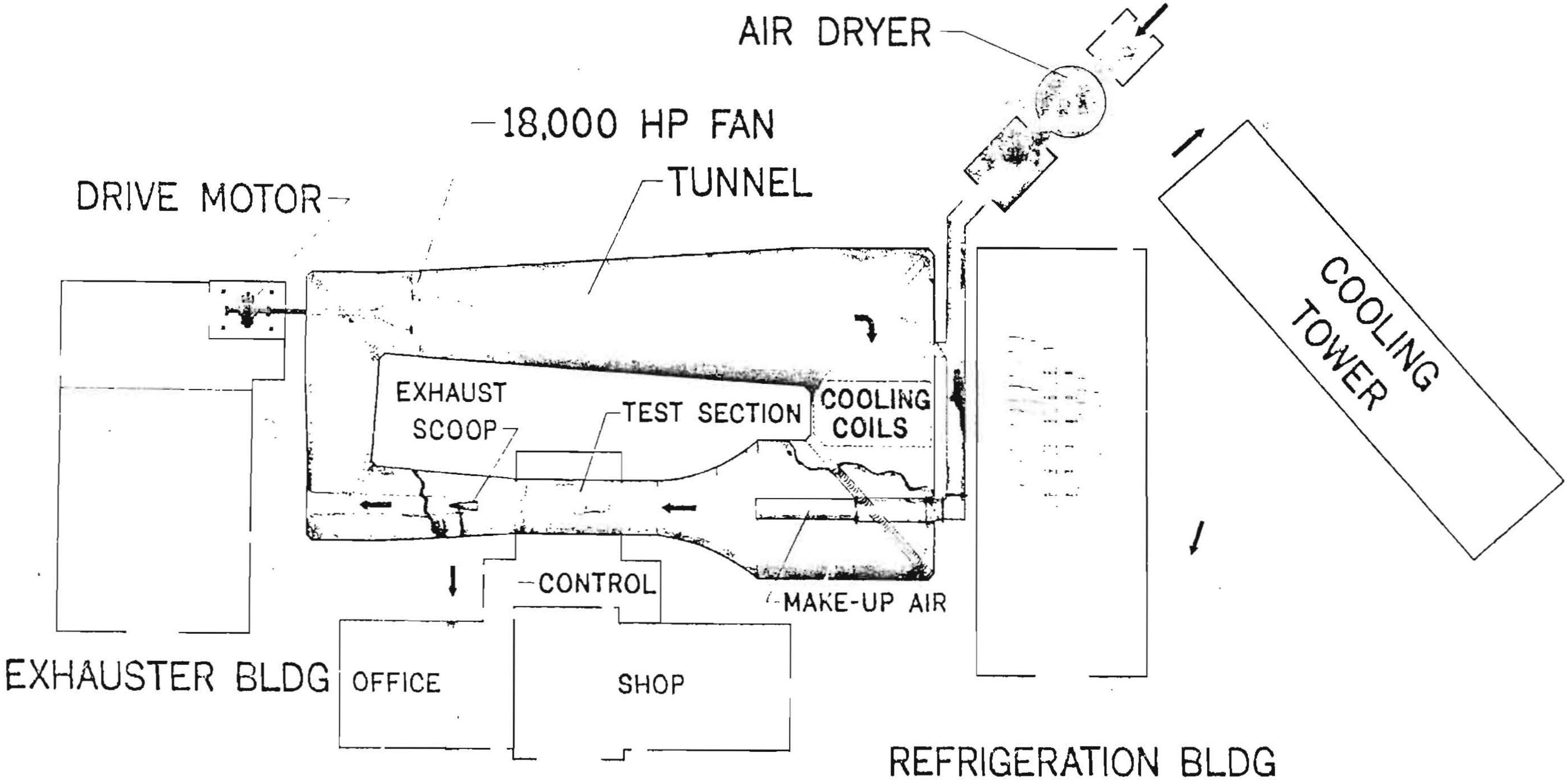


Figure 1. Altitude wind tunnel group.

ALTITUDE WIND TUNNEL FACILITIES



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