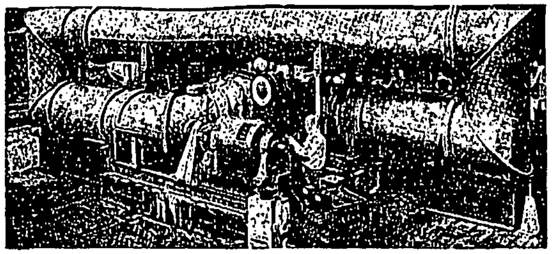
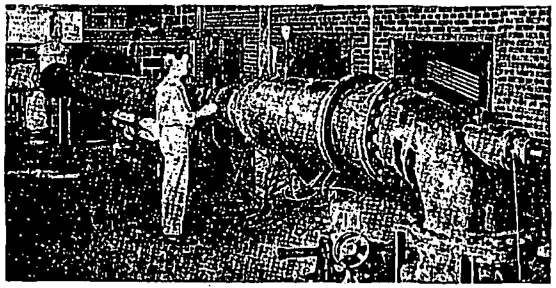
Lab Speeds Gas-Turbine Development (Continued from page 95)

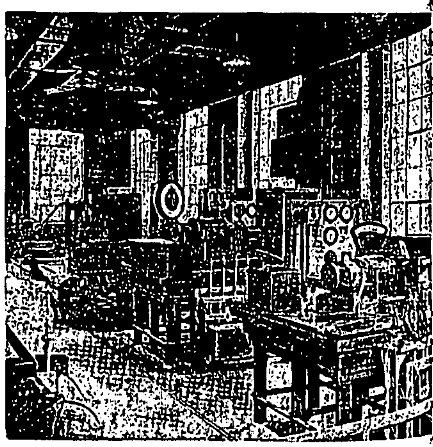


MODEL TESTER of highly flexible design permits economical screening of many experimental designs. Symmetrical about the center of the shell-and-finned-tube cooler, it contains all functional elements of high-capacity test facilities



COMBUSTION LAB contains two test stands like one shown. A control room beyond wall at right is equipped for simultaneous operation of stands, with any combination of pressurized, atmospheric or altitude conditions to 45,000 ft

HOT-SPIN TEST PIT evaluates high-temperature properties of disk and blade alloys. Pit is heavily armored so the tests may be carried to destruction



MECHANICAL LAB aids development of accessories and components. View of one side shows bearing-test stands at rear, governor stand next, and then two electric dynamometer stands

▶ TODAY, LESS THAN four years after a cold start in early 1944, Westinghouse engineers work to capacity in a $5-million gas-turbine development laboratory unequalled by any other private facility. This continuous probing into characteristics of aircraft power-plant components yields design know-how needed to meet today's demand for better jet engines and gas turbines.

The job of designing and building a completely American jet engine, taken on at Navy request only one day after Pearl Harbor, was brought to a successful conclusion without recourse to research and development facilities other than those Westinghouse had when war began. But late in 1943 it became apparent that larger facilities were essential to successful realization of the potentials of the gas-turbine power plant. Under Bureau of Aeronautics sponsorship, Westinghouse agreed early in 1944 to design, erect, equip and operate a gas-turbine component lab.

Testing Requirements. A gas-turbine power plant comprises compressor, fuel pump, combustor and turbine, plus lubrication, control and heat-transfer apparatus, and starter, generator and ignition equipment. Separate investigation of the secondary components involves no special testing problems, but the compressor, turbine and combustor require heavy power and heat inputs and dissipations. With this in mind, the laboratory was built to handle full-scale tests for power plants of net output up to 4000 hp. This in no way represents a judgment of engine-size limits. It means the lab can handle units large enough to avoid errors from scale factors without excessive expenditure of materials and manpower.

Availability of steam from a powerhouse, built in 1940 to serve a plant expanded for wartime production of marine propulsion equipment, dictated both lab location and type of equipment drive. As built, the laboratory comprises four major test areas: (1) high-power turbine (2) high-power compressor and low-power model (3) variable-pressure combustion and (4) engine accessory, lubrication and mechanical development. Some idea of the power services required can be gained from these demand figures: 80,000 lb per hr of 600-psi 800-F steam, 7500 gpm of river water, 1000 gpm of well water, 1350 kva of 6600-v ac and 200 kw of 250-v dc.

Lab Layout. High-power test areas (see diagram, p 95) are side by side. For turbine testing, two multistage axial-flow wide-speed-range steam-turbine-driven compressors (one with 4:1 compression ratio, the other with 2:1) can be operated individually or in series with intercooling to supply air up to 118 psia at flows up to 58 lb per sec. A combustor capable of releasing up to 85-million Btu per hr heats air to provide gas to operate experimental turbines at pressures up to 8 atmospheres and temperatures up to 1800 F. Turbine output, which may reach 18,000 hp at 15,000 rpm, is absorbed by a specially designed water brake. The gas-turbine housing, a permanent piece of house machinery, accommodates a series of single- or multiple-stage spindles and blade rings, and can sustain temperatures to 1500 F.

Compressors to be tested are driven by a controlled-torque wide-speed-range cradle-mounted steam turbine, which gives direct measurement of power input. The unit is rated at 6000 hp at 10,000 and 20,000 rpm, but may develop in excess of 7000 hp in the more-efficient intermediate range. The compressor-test housing consists of a heavy section of pipe parted at the center line and two vertical joints, and an end bell with bottom discharge. This provides a universal support for stationary members of experimental compressors. Housing is sufficiently strong to stand compressor inlet pressures from 4 to 90 psi and discharge pressures to 150 psi.

Compressor-test housing is in a closed circuit, which includes a streamlined grid valve, shell-and-finned-tube cooler

EXPLOSIONPROOF AREA permits use of high-octane gasoline in tests of fuel pumps, governors and injection spray nozzles. Altitude chamber (right) tests accessories under pressure from sea level to 70,000 ft and from −67 to 158 F

and an 8-position pneumatically operated variable-area orifice. The closed circuit gives flexibility, by pressure-level control, that would be partly lost with open circuit and intake throttle.

In both high-power test areas, planed steel rails define a main floor level about 14 ft above grade, with all steam, oil, fuel and auxiliary piping, and much of the functional air and combustion-products piping, below it. A scavenging system of capacity equal to full required ventilation input confines need for explosionproof units to under-floor areas.

Control operations are segregated from the machinery space in a soundproofed room between turbine and compressor test areas, making for maximum safety and efficiency. Pressure- and temperature-measurement connections are permanently installed from the control room to bulkheads adjacent to the test equipment, reducing length of temporary leads and speeding test setups. Provision is made for complete remote control and communication.

A low-power model tester, comprising a closed circuit with all the functional elements of the high-power facilities, permits economical and flexible evaluation of experimental turbine and compressor designs, screening out developments not worthy of expensive and time-consuming high-power tests. It is symmetrical about the center of the cooler, with a 50-hp dc dynamometer at inboard end of each test section. Each may carry a single or multiple-stage rotor. For testing turbine models, a stock compressor, dynamometer-driven, provides motive fluid.

Combustion Lab. In the combustion laboratory, three setups are available: (1) blower-powered atmospheric-pressure tests (2) elevated-pressure tests using compressed air from high-power turbine area, and (3) altitude testing using main compression plant in conjunction with a water-jacketed shell-and-tube cooler.

In the engine accessories, lubrication and mechanical development areas, individual projects on control apparatus, fuel and oil pumps, starters, ignition equipment, bearings, etc, are assembled on bedplates equipped with dynamometers and auxiliary drives ranging from 2.5 to 125 hp.

To minimize explosion and fire hazard, three of the accessory bedplates, supplied with gasoline, are installed in a room entirely equipped with explosionproof fittings and services. Opening into the hazardous-accessory test area is an altitude chamber where an entire complement of engine accessories can be operated over a range of atmospheric conditions to 70,000 ft.

An armored hot-spin test pit, a completely equipped model and general service shop, store rooms and offices complete the facilities.

A comprehensive discussion of the laboratory's design features is given in a paper presented by Winston R New at the ASME annual meeting of 1947.