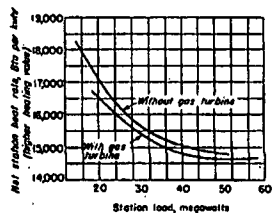


16 Gas turbine lowers plant heat rate at all turbine-condenser pressures



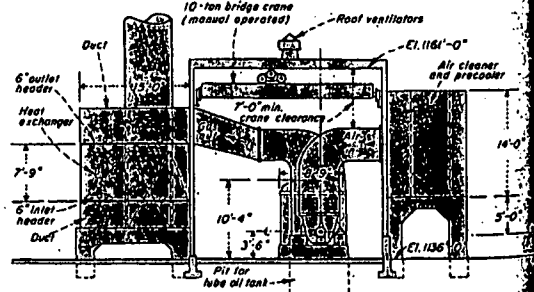
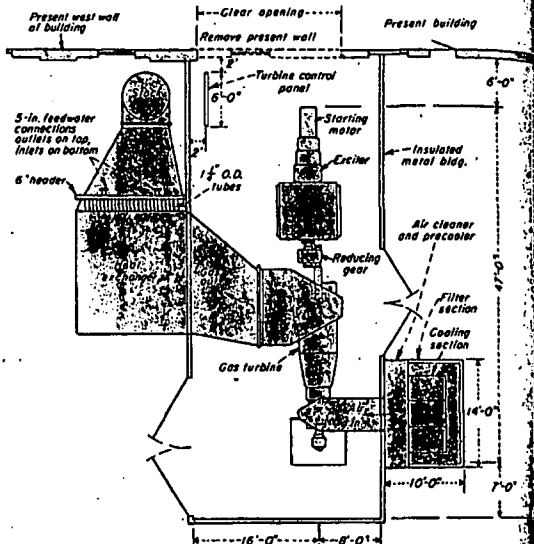
17 Gas turbine improves overall plant performance at all load magnitudes

temperature. Use of a "minimum" open cycle hookup permits the unit to be simple in design, lightweight and inexpensive. Normal rating of the unit will be 3500 kw based on ambient temperature of 80 F and an altitude of 1500 ft.

The turbine, direct connected to the compressor, runs at 6700 rpm. A precision helical gear couples the turbine to a conventional 4000-kw 3600-rpm generator and exciter, see Fig. 18. The OGE-Co requested the oversize generator.

Atmospheric air enters the compressor to be raised to about 87 psia at full load. The high-pressure air then enters six cylindrical combustors where burning fuel raises the temperature to that required for the load. With the essentially constant air flow, turbine inlet temperature will vary directly with load. Hot high-pressure gas then expands through the turbine.

Since the net power equals the difference of gas-turbine output and power required to drive the compressor, and power needed to drive the compressor remains constant, efficiency falls off as load reduces. The unit design, as far as gas turbine and compressor are concerned, is identical with the one which has been on test at the General Electric plant, Schenectady, New York, for some time, (see *POWER*, May 1948, pp 95, 98,



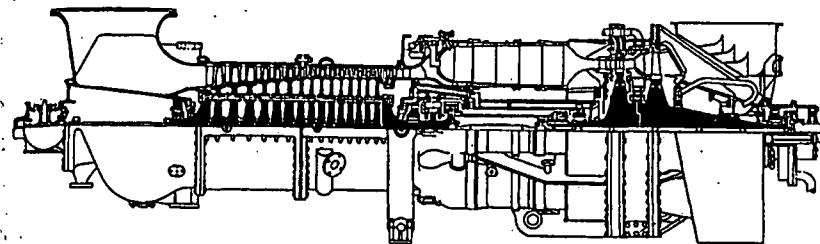
18 The gas-turbine unit will be housed in a new building abutting present station building, with both heat exchanger and combination air filter and pre-cooler situated outdoors. Unit will burn natural gas and have own exhaust.

and August, 1947, pp 68-70). Fig. 19 shows a cross section of the unit.

Compressor. The axial-flow compressor has 15 stages, for a compression ratio of about 6:1. The built-up rotor has separate wheels held concentric by fits near the center with through bolts holding the wheels together. This permits complete freedom of selection of materials for each stage. For example, in the low-temperature section, the first six stages, a light aluminum alloy is

used for the wheels, reducing weight and rotating inertia, while on the high temperature section steel wheels are used. Steel blades are used throughout. Fig. 12 shows the complete rotor. The vortex-type blading similar to that on aircraft gas turbines is secured by the wheels by dovetails.

The stator has similar blading, but they are in dovetails in half rings which are inserted in grooves cut in the casing. The casing is made up of two halves



19 Simple-cycle gas turbine unit develops 3500 kw at 1400-F turbine-inlet temperature. Left to right: compressor inlet, 15-stage compressor, 6 combustion chambers, 2-stage impulse gas turbine, exhaust hood. Unit runs at steady 6700 rpm

each split on the horizontal centerline, bolted together. This construction allows easy disassembly without sacrificing the casing's strength to resist distortion under transient conditions. As in the rotor, the low-temperature section of the casing is aluminum and the high-temperature end is of steel, Fig. 13.

Combustors. Six combustors are equally spaced around the body of the unit between turbine and compressor. Fig. 22 shows the elements of one combustor. Because of the high operating temperature it is reasonable to expect that the metallic inner liners will be the highest single maintenance item, hence this design permits easy and inexpensive replacement of the liners, if necessary. The inner liners, about 35 in. long and 10 in. dia. are of stainless material and outer casings of carbon steel.

To mix the combustion products adequately and avoid possibilities of local hot spots, the inner liner permits air to enter through annular slots between the various sections as well as through radial holes and louvers. The design gives excellent combustion over a wide range without sacrificing stability or ignition characteristics.

While the tests in Schenectady are being made on Bunker C and diesel oil, this installation will use natural gas fuel. It is felt that no fundamental problems will be involved with gas as compared to oil, but to be sure, tests are now being conducted using combustors fired with natural gas.

Combustion starts by means of spark plugs located in two of the six combustion chambers; cross fire tubes ignite the remaining combustors. Aircraft units have used this arrangement for some time and it proves reliable and effective. As in a gas-fired boiler, combustion is a continuous process after the initial start.

Turbine. The two-stage gas turbine achieves compactness and simplicity and keeps the first-stage bucket temperature as low as feasible. With an inlet temperature of 1400 F, the first-stage buckets operate at 1160 F, not much higher than the buckets in some high-temperature steam turbines.

The turbine rotor consists of two wheels, each integral with its own shaft. The two shafts bolted together form the complete rotor, Fig. 15. Each wheel is made up of two parts, the rim of high-temperature stainless material and the center portion of low-alloy high-strength steel suitable for 700 F, Fig. 11. Welding the stainless rim to the wheel allows using the proper material for each section of the rotor. This composite construction has proven wholly successful in airplane jet units. In addition, the forging and quality control problems are materially reduced.

The considerable step-up in height of buckets between the two stages keeps the leaving losses to a low value.

The first-stage nozzles, Fig. 14, of the welded type, are not split on the horizontal center line as is common in steam turbines. The partitions are welded to an outer ring and come through closely fitted holes in an inner ring. These two rings welded to two additional rings form the completed diaphragm. This construction permits free expansion radially and maintains concentricity without the use of pins or keys.

The second-stage nozzles use the same construction except that the partitions are welded to the inner ring also and the assembly is split on the horizontal centerline.

The casing is made up of circular rings opposite each wheel with L-shaped pieces bolted at the inside diameter to form the gas path and surface opposite which the blade tips run, Fig. 19. The rings are of ordinary carbon

steel while the inner pieces are of stainless. These rings are bolted to the casing of low-carbon steel. The ring opposite the second stage is welded to six struts inside the exhaust hood and supports the low-pressure turbine bearing.

Air Cooling. Air from an intermediate stage of the compressor cools various parts of the turbine. It reaches the wheels by being bled into the space between the wheel and its adjoining diaphragm wall. Pipes also carry extracted air through the nozzle partitions across the gas path to the packing. A small fan on the turbine shaft sucks air through axial holes in the casing ring to cool the exhaust casing. Cooling air also passes through hollow tubes over the struts in the exhaust casing, thus keeping them from coming in contact with the hot exhaust gas and minimizing any distortion that might be caused by uneven temperatures. The exhaust hood is of ordinary steel with insulating lagging.

Auxiliaries. Normal turbine accessories are supplied with the unit and in addition many protective features are included. An accessory gear box mounted on the front end of the unit drives a tachometer, overspeed governor, lubricating-oil pump and fuel regulator.

The speed governor is electro-hydraulic, similar to those used for some steam turbines and diesel engines. A permanent-magnet electric-tachometer-generator gives the speed indication which is transmitted hydraulically to the fuel regulator. The latter varies the gas supply to the combustors in terms of load requirements. In addition to the speed regulating equipment the governor has an over-riding control to limit the exhaust temperature.

An auxiliary 400-cycle motor-generator set provides power for operating the motor control. A conventional over-