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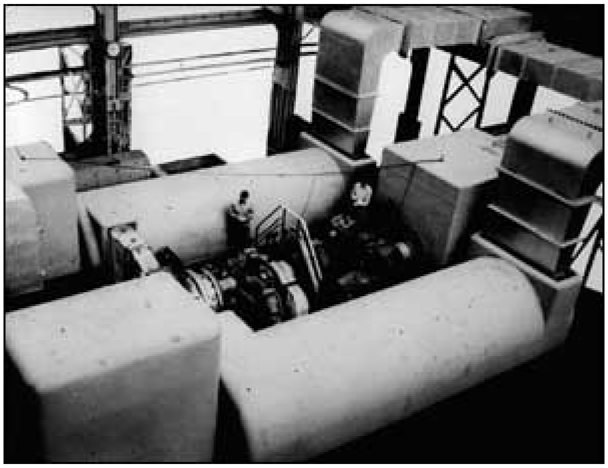
TURBO NEWS



Rutland on the Leading Edge

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Rutland, Vermont is probably not a place one would expect to participate in a new technology in power generation, unless perhaps it was in hydropower. Even less likely would one expect an involvement with one of the first land-based gas turbines to drive an electric generator. But that is just what happened a half century ago. In 1951, three new gas turbine plants installed by General Electric in Rutland put this small New England city on the leading edge of power technology.

The Turbine Era

The world was introduced to a new technology toward the end of the Second World War: fighter planes powered by turbo-jet engines. After the war, engineers were anxious to apply this new technology to commercial transportation. Jet-powered aviation was of course a logical choice. Other brainstorms would follow. The Union Pacific railroad, for example, accepted delivery of the first of many gas turbine-powered locomotives manufactured by General Electric in 1948.

In Europe, based on the design of English engineer and war hero, Sir Frank Whittle, aero-derivative engines were being considered for other modes of transportation. The first gas turbine powered automobile, the Rover Jet-1, ventured out of the Solihull factory and onto a test track near

Birmingham, England in 1950. This motorcar applied the innovations of Whittle and other engineers of Rover Co., Ltd, trying to bring them to the English motorways. The first-of-a-kind, turbine engine developed about 200 horsepower, powering the two-seater roadster to track speeds of 90 miles per hour.

Across the ocean from England, another application of the combustion turbine was being developed and applied by GE in America. Late in 1950, Rutland became the focal point for the installation of three innovative GE gas turbine/generator power plants for Central Vermont Public Service Company (CVPS). According to the CVPS unit operator log books, the first of three plants went into commercial operation on October 1, 1951.

Kilowatt Machines

The Rutland plant was very advanced for its time. In fact, it would be considered extraordinary even today. Unlike the simple-cycle, peaking gas turbine power plants that became popular in the late 1960s, as a consequence of the great Northeast Blackout of 1965, these first plants were very complex. Dubbed the "Kilowatt Machines" by GE engineers, the indoor plants in Rutland were both regenerative cycle and inter-cooled (see Figures 2 and 3). Each plant could develop approximately 5,000 kilowatts when operating at an ambient inlet temperature of 80 degrees Fahrenheit. Crisp and clean mountain air was sucked into the inlet of the low-pressure (LP), axial-flow compressor. The LP compressor was driven by the LP turbine shaft. Air from the discharge of LP compressor was not only higher in pressure but its temperature was also elevated, which hurt performance. So GE used twin intercoolers to reduce the temperature (while maintaining the pressure) before entry into the high-pressure (HP) compressor.

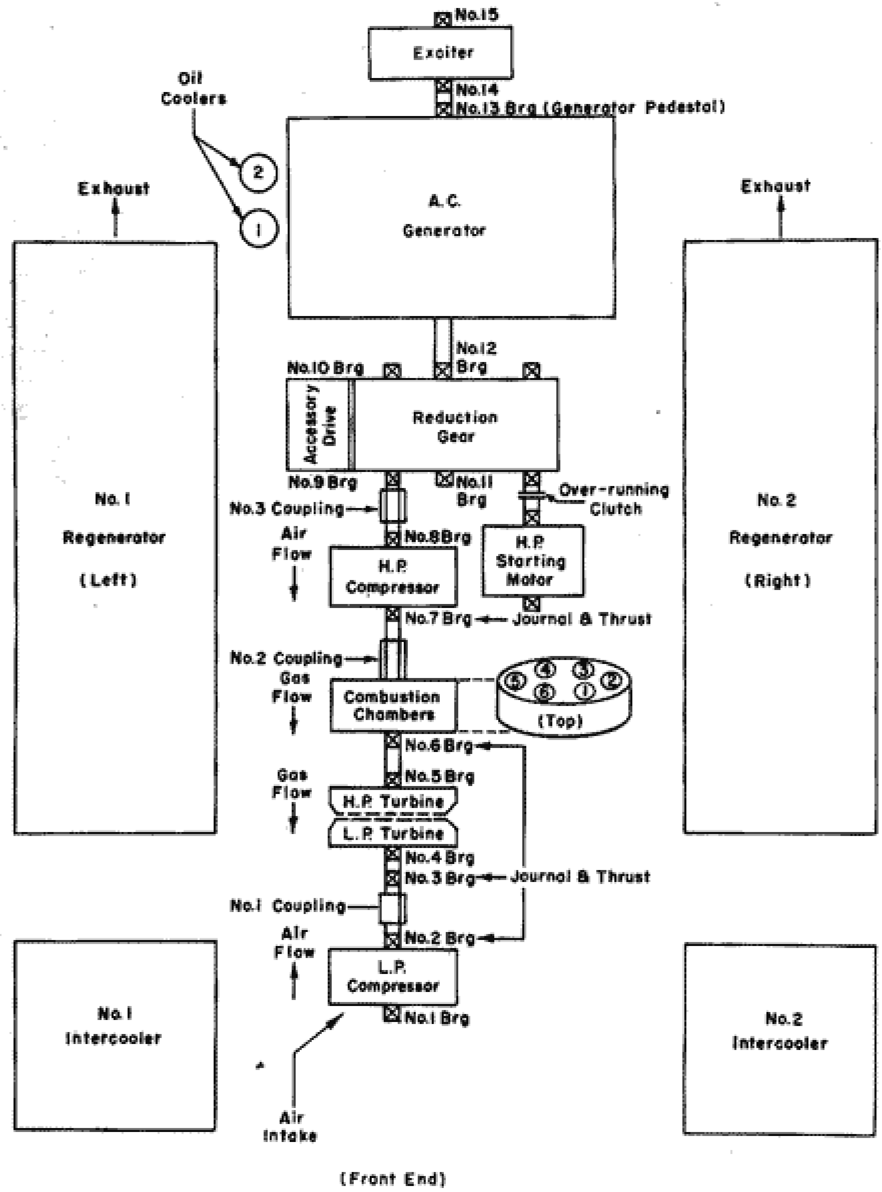
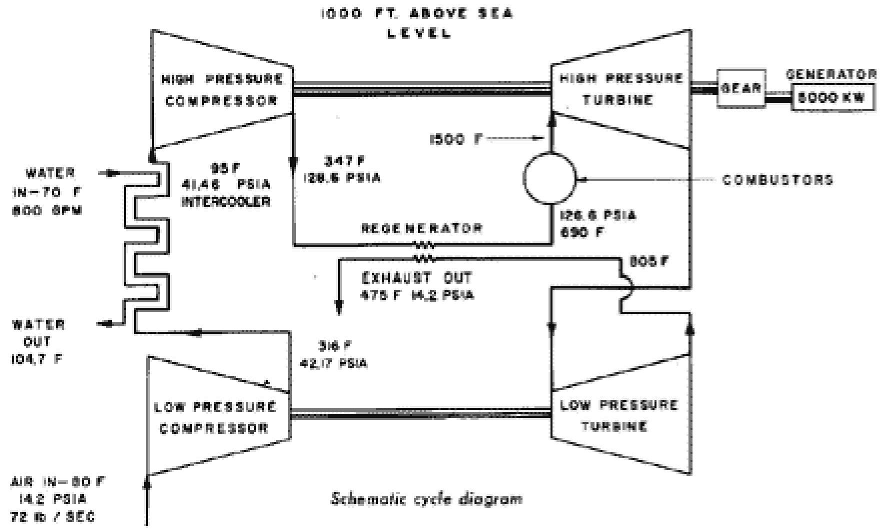


Fig. 2 Block diagram showing arrangement of gas turbine-generator unit components



Schematic cycle diagram

The air from the HP compressor discharged into twin regenerators. Installed in parallel to divide the airflow, the regenerators transferred heat from the turbine exhaust. This compressed and pre-heated air was then directed into the six combustors.

CVPS would start the plants on #2 diesel oil and transfer to the heavier Bunker “C” fuel. The ultra-hot combustion gas, firing at 1,500 degrees Fahrenheit when at base load, was then expanded through the two sections of the turbine. The HP turbine provided the power to both the HP compressor on one end and, through a speed reduction gear box, the generator on the other. Approximately two-thirds of the power developed was needed to drive the two compressors. The remaining one-third was used to generate electrical power. Finally, after transferring most of the heat to the air from the HP compressor through the regenerators, the gas was discharged the exhaust back into clear mountain atmosphere.

Even by today’s standards, the power plants installed in the building at the CVPS plant at the end of Greens Hill Lane over a half-century ago would be considered advanced and sophisticated. The plants were retired and the last one was removed in the late-1980s. According to the logbooks, the last of the three plants to be retired (Unit #1) ran its final time in 1987. It had over 100,000 operating hours when mothballed and later sold for scrap.

General Electric sold many regenerative cycle plants over the years, mostly to gas pipelines and process plants where the load device was a compressor rather than a generator. The main advantage of regeneration was the reduction in fuel consumption (heat rate) for plants that operated continuously for thousands of hours per year, as was often true in the industrial market. In the power generation field, however, this cycle lost its popularity, primarily due to the high repair costs associated with the regenerators. Regenerators that are started and stopped frequently experience tube cracking that can be costly to keep in good operating condition. Inter-cooled gas turbines became even less popular, probably because GE was able to manufacture more efficient axial-flow compressors with more stages. Typical GE compressors today have 17 or 18 stages with discharge pressures exceeding 150 pounds per square inch (psig).

Long before waxed hickory boards with bear trap bindings helped put the city on the map for skiing at nearby Killington, Rutland was truly a proving ground for a new means of electrical power production. Only the building at the end of Green Hills Lane remains, but it has been greatly modified for by CVPS for servicing pole transformers. The three old Kilowatt Machines are gone now, but their contribution to the application and development of gas turbine technology should never be forgotten.

Specifications:
Gas turbine- GE "Kilowatt Machine"
type- 2-spool, with regenerator and intercooler
LP spool- 9-stage axial compressor, 1-stage axial turbine; speed = 7,500 rpm
HP spool- 13-stage axial compressor, 2-stage axial turbine, speed = 8,694 rpm
pressure ratios- 3:1 for both compressors
combustors- 6
regenerators- 2
intercoolers- 2

rated power output- 5,000 kW
Generator- GE Type ATB-2, air-cooled, 2-pole, 3,600 rpm, 60-Hz, 3-phase, 7,500 kVA at 0.80 PF, 6,000 kW
Exciter- GE Model 53A410, Type EDF-93, 4-pole, 125 VDC, 40-kW, 320-ampere armature current
Starting motor- GE Model 5M1505CB2, Type M, Frame 505S, 100-hp, 440-V, 3,600 rpm, 60-Hz, 3-phase, 3,500 rpm full-load speed
Reduction gear- GE Type S-243-A, 8,694/3,600 rpm