District Steam and the St. Louis Steam Loop

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ABSTRACT

Owned and operated by large public electric utilities, district steam systems flourished in most northern U.S. cities in the first half of this century. Following World War II, however, district steam systems became minor and, in some cases, unprofitable portions of the utilities' operations. Consequently, public utilities ceased promoting district steam to existing and potential customers, leading to the decline of their use. In recent years, district steam systems have been revitalized by independent enterprises that have the commitment and expertise to make these systems once again reliable and cost-effective energy sources. This paper reports on one such system, The St. Louis Steam Loop. The St. Louis steam loop consists of 22 miles of insulated underground steam piping encompassing a 400-square block area in the city's downtown business district. The loop is supplied with steam by the Ashley Plant, which was built in 1904 for the St. Louis World's Fair. Due to the rising cost of oil, which has been used to fuel the Ashley Plant since 1972, and the subsequent loss of customers, many people considered the steam system a dinosaur in the jet age. In 1982, Trigen-St. Louis Energy Corporation purchased the steam system and embarked on an aggressive campaign to upgrade all aspects of the system, including valves, piping, and meters. In 1999, Trigen-St. Louis will install an ISMW state-of-the-art combustion turbine cogenerator to provide 95% of the steam to the steam loop. A primary reason for the St. Louis Steam Loop's longevity is that it has reliably supplied steam to many downtown buildings for the better part of the 20th century.

INTRODUCTION

District steam energy is an American technology dating back to 1877. The Scotchman, James Watt, in addition to developing the steam engine, also contributed to the advancement of steam heating in 1784 when he devised the first steam "radiator," an iron box in the room in which he did his writing, which was supplied with steam through a pipe leading from a boiler in a room below. However, it was not until 1877 that the American Birdsill Holly (Figure 1) first supplied steam to a community from a central steam station (in his house) and succeeded in proving the practicability of the idea. He was then able to organize the Holly Steam Combination Company, Ltd., with capital of $25,000, and obtained a franchise to lay steam pipes in the streets of Lockport, New York. The company built a small boiler house and laid about 2,350 feet

Figure 1 *Birdsill Holly, father of district steam heating.*

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of mains, ranging from two to four inches, with connections to the principal churches, residences, and hotels. Shortly thereafter, in 1882, Wallace C. Andrews brought district steam heating to New York City.

Owned and operated by public utilities, district steam systems flourished in most northern U. S. cities in the first half of this century. Following World War II, however, these steam systems become minor and often unprofitable portions of the utilities' operations. Consequently, public utilities ceased promoting district steam to existing and potential customers, leading to the decline of their use.

In recent years, steam systems have been revitalized by independent enterprises that have the commitment and expertise to make these systems once again reliable and cost-effective energy sources. Trigen Energy Corporation, the largest of these independent enterprises, is responsible for the renewal of steam districts in seven cities with plans in the works to purchase and revitalize several more.

The district steam system in downtown St. Louis, Missouri, is known as the St. Louis Steam Loop and consists of 22 miles of insulated underground piping encompassing a 400-square-block area in the city's downtown business district. The loop is supplied with steam by the Ashley Steam Plant (Figure 2), which was built in 1904 for the St. Louis World's Fair. This plant has undergone several major modernization projects and is in excellent condition.

St. Louis is perhaps unique in that the city had a central station refrigerating system before it possessed district steam. In 1887, the St. Louis Automatic Refrigeration Company was founded and built a small cold storage plant in the area now known as the Jefferson National Memorial Park, close to where the St. Louis Gateway Arch stands. As early as 1903, the company constructed the refrigeration pipeline system to serve some of the downtown businesses. On the other hand, the St. Louis Steam Loop did not have its beginning until the 1904 World's Fair.

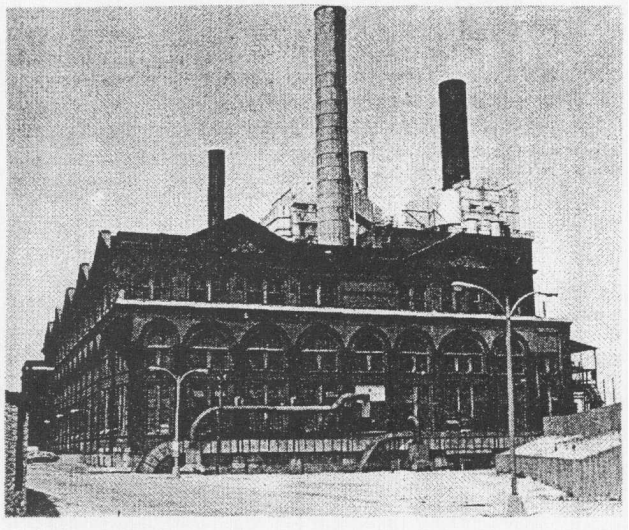

Figure 2 The Ashley Plant.

UNION ELECTRIC'S ASHLEY STREET PLANT

The start of the St. Louis Steam Loop is directly tied to the beginning of the Union Electric Light and Power Company, now known as the Union Electric Company (UE), which was formed in 1902 through a merger of several power companies. Original total plant electric capacity was 6,400 kW. Work was launched immediately on the Ashley Street plant to serve the growing city's needs and to supply power to the World's Fair of 1904. The achievement of illuminating the fair was a dramatic turning point in the history of the electric industry. As a result of the fair, more and more homes were wired for electricity and customers began to appreciate more effective illumination along with such "modern" conveniences as electric fans and irons.

For a number of years, the Ashley Plant was the main source of electricity for all of St. Louis. Contractor for the original construction of the plant was O'Rourke Engineering Construction Company of New York. The project took several years to complete and presented unique engineering and construction problems. A necessary river/sea wall has its foundation on bedrock under the river, and work on this aspect of the plant could only be done during the winter months when the river was at its lowest point.

The St. Louis district steam system is actually a by-product of this local electric industry. Its beginning occurred just after the start of this century when there were many small electric and gas companies. Each large building had its own boiler plant and generated its own electricity, using exhaust steam from the steam engines for building heating in winter. In effect, at many intersections, there were four steam plants operating four electric generating units. The program to eliminate individual electric generating plants and add those loads to Union Electric's electrical distribution system was successful. It posed a big problem, however, in that it left the young UE company with over a hundred isolated steam power plants, leased for a nominal fee but with an obligation to operate during the winter for building heating. Elimination of these isolated steam plants started about 1910 and continued through the 1920s. Initially, UE selected the most capable plant at an intersection and connected the other three buildings to that plant's steam generating system.

In 1911, the block bounded by Ninth and Tenth streets, St. Charles, and Washington was connected to an original UE steam plant, known as 904 St. Charles. Several buildings there, including the Wainwright and Arcade buildings, were tied together with an underground main. These lines formed the nucleus of today's steam distribution system, which covers the area shown in Figure 3.

The steam system actually started to expand in 1924, when additional electrical generating plants were added to the UE system. This freed the venerable Ashley Plant to supply steam to the heating system.

In 1924, the first main, a 20-inch pipe known as the west header, was taken out of the Ashley plant and tied into underground steam distribution lines being supplied from the

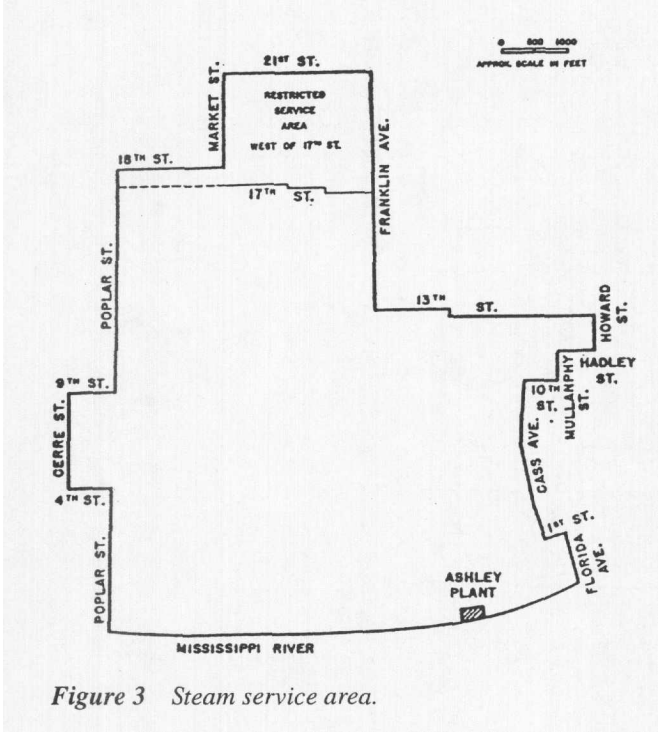

Figure 3 Steam service area.

isolated plants. The installation made it possible to eliminate many of the old plants.

In 1926, extensive improvements were made to the boiler plant at the Ashley plant, converting the boilers to use pulverized fuel with improved economy and increased steam generating capacity, and at the same time the boiler plant was made "practically smokeless." During 1927, the remaining four lower deck boilers in the Ashley Street power station were converted to the use of pulverized fuel, completing the modernization of the plant. The Ashley plant's electric generating capacity grew to 122,000 kW.

The year 1931 saw increased connected radiation on the district steam system. To supply these increased requirements, the steam heating system was extended by the installation of a second main feeder out of the Ashley plant. This 24-inch pipe, known as the east header, afforded additional capacity of approximately 600,000 pounds of steam per hour. It tied into the system at 11th and Washington. Ultimately, the east header was connected to the west header at 17th Street and Clark Avenue, forming a circle, or loop, around downtown. This design added to the reliability of the underground steam distribution system, since steam could be supplied from either direction, and is the basis for the St. Louis district steam system being known as the St. Louis Steam Loop.

Later, major extensions picked up the main Post Office in 1937 and the UE General Office Building at Gratiot Street in 1951. The general plant modernization plan of 1946 is shown in Figure 4.

A detail of a typical underground pipe installation is shown in Figure 5. The time, effort, and expense taken to install this steam distribution system is the reason why it is around today and can continue to serve the city for years to come.

With the boundaries of the steam system fixed, new customers became a rarity. In fact, by the 1960s, the number of steam customers actually decreased; however, even then, the rebuilding program in downtown St. Louis enabled steam sales to remain constant.

The coal-fired steam generating units of the Ashley Plant, shown in Figure 6, were converted after 68 years to oil-fired units in 1972 as part of an air pollution control project.

The steam loop, a 22-mile network of underground pipe and the Ashley Street Steam Plant, has been a part of the St. Louis heritage since the 1904 World's Fair. It was threatened with extinction because Union Electric, like many other public utilities across the country, wanted to divest itself of what had become a less than profitable portion of the utility's total oper-

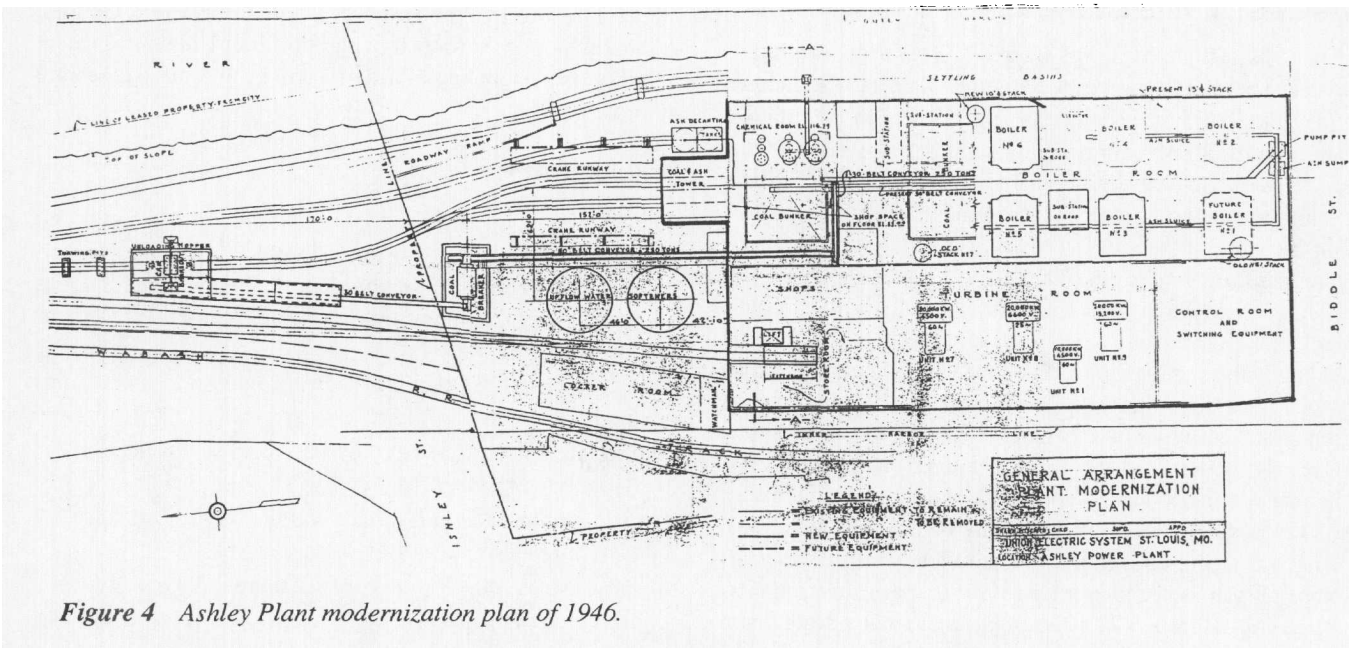

Figure 4 Ashley Plant modernization plan of 1946.

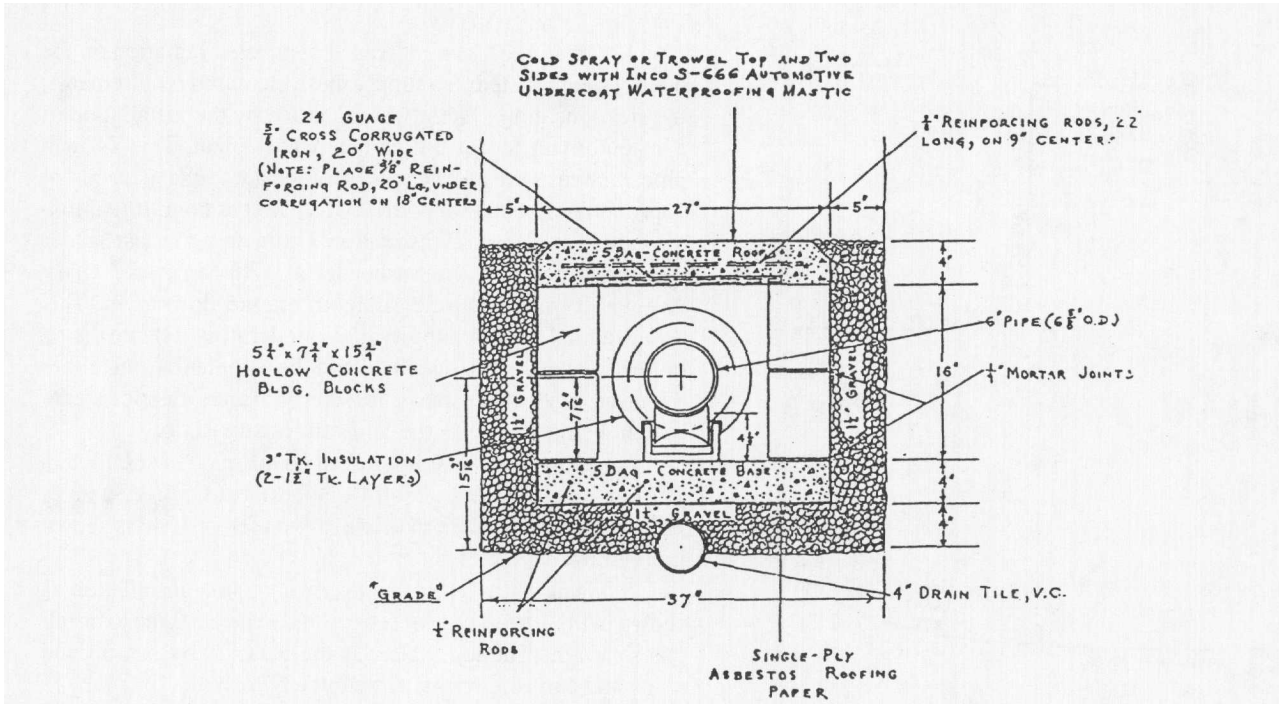

Figure 5 *Section showing hollow concrete block steam conduit.*

ation. Due to the rising cost of oil, which has been used to fuel the Ashley Street Steam Plant since 1972, and the subsequent loss of customers, many people considered the steam system a dinosaur in the jet age.

Ashley was designated in 1972 as an official landmark of the City of St. Louis. Pertinent statistics on the status of the steam loop in 1976 are shown in Figure 7, excerpted from a copy of a speech made by the late John W. Gillies, assistant to the manager, Underground Steam, Union Electric Company.

Ashley was a pioneer plant in central station electrification and with major modifications over the years continued to serve Union Electric customers until 1982.

TRIGEN-ST. LOUIS ENERGY CORPORATION

In 1982, Trigen-St. Louis Energy Corporation, originally known as Thermal Resources of St. Louis, came into the picture.

Trigen-St. Louis, a company specializing in centralized steam operation and energy management, believed that the steam system could be saved. Joining forces with the Bi-State Development Agency, which had purchased the underground steam distribution network, Trigen-St. Louis purchased and began operating the Ashley Plant.

Upon purchasing the steam system, Trigen-St. Louis embarked on a campaign to upgrade all aspects of the system, including valves, piping, and meters. These measures have provided increased reliability for the more than 185 customers currently served by the steam loop. Trigen-St. Louis's Ashley plant has five boilers, and only two are required on the coldest day of the year. An extra boiler is kept on hot standby for emergencies.

The Ashley plant's function today is to supply steam for heating and process use to the downtown business district. A primary reason for Ashley's longevity is that it has reliably supplied steam through 22 miles of piping to many downtown buildings for the better part of the 20th century. Many of the newer buildings in downtown St. Louis, such as the Merchantile Tower, One Bell Center, Busch Stadium, and the TransWorld Dome, are heated by the steam loop. In addition, the new Federal Courthouse will be heated with steam from the steam loop when it is completed.

TODAY AND TOMORROW

In today's increasingly competitive and complex marketplace of energy supply, Trigen-St. Louis Energy Corporation has implemented plans to install a state-of-the-art combustion turbine cogeneration plant at the Ashley site (Figure 8). By lowering operating costs and expanding into the power sales market, the future of the St. Louis Steam Loop seems secured. A system having its roots in a plant built in 1904 and a steam distribution system begun in 1910 will be around to celebrate its centennial.

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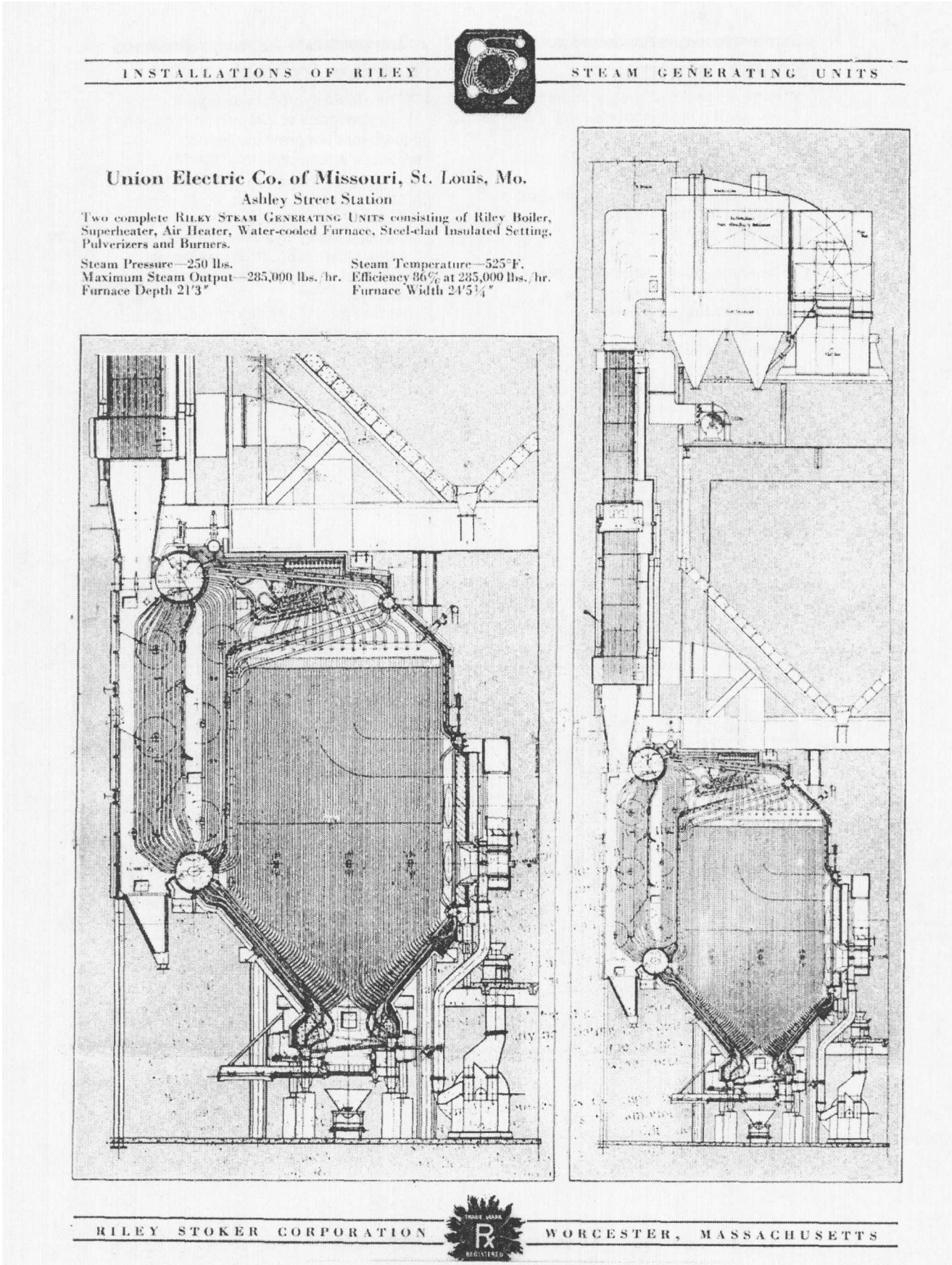

Figure 6 *Ashley Plant steam generating unit.*

Steam statistics

These are some of the numbers that describe the Steam Heating system:

Miles of high pressure line: 22
Manholes: 500
Largest pipe (diameter): 24 inches
Smallest pipe: one-half inch
Customers on system: 271

The Ashley Plant, which supplies steam for the heating loop, is described by these statistics:

Boilers: 5
Average capacity: 300,000 pounds per hour
Total capacity: 1,500,000 pounds per hour
Steam generated at 225 pounds per square inch of pressure
Steam distributed at 160 pounds per square inch of pressure
Peak demand: 450,000 pounds per hour

4 miles/minute

The steam system is designed to operate at 250 psi (pounds per square inch) of pressure, which produces a temperature of 500°F; however, the system operates at 160 psi pressure.

Flow—or steam velocity—is another factor of a steam system. In the case of the downtown loop, flow can reach 20,000 feet per minute on an extremely cold day.

At that rate, if a chunk of steam could be marked at Ashley Plant, it would show up at the General Office Building at 18th and Gratiot—four miles away from Ashley—one minute later.

Figure 7 *Steam loop statistics.*

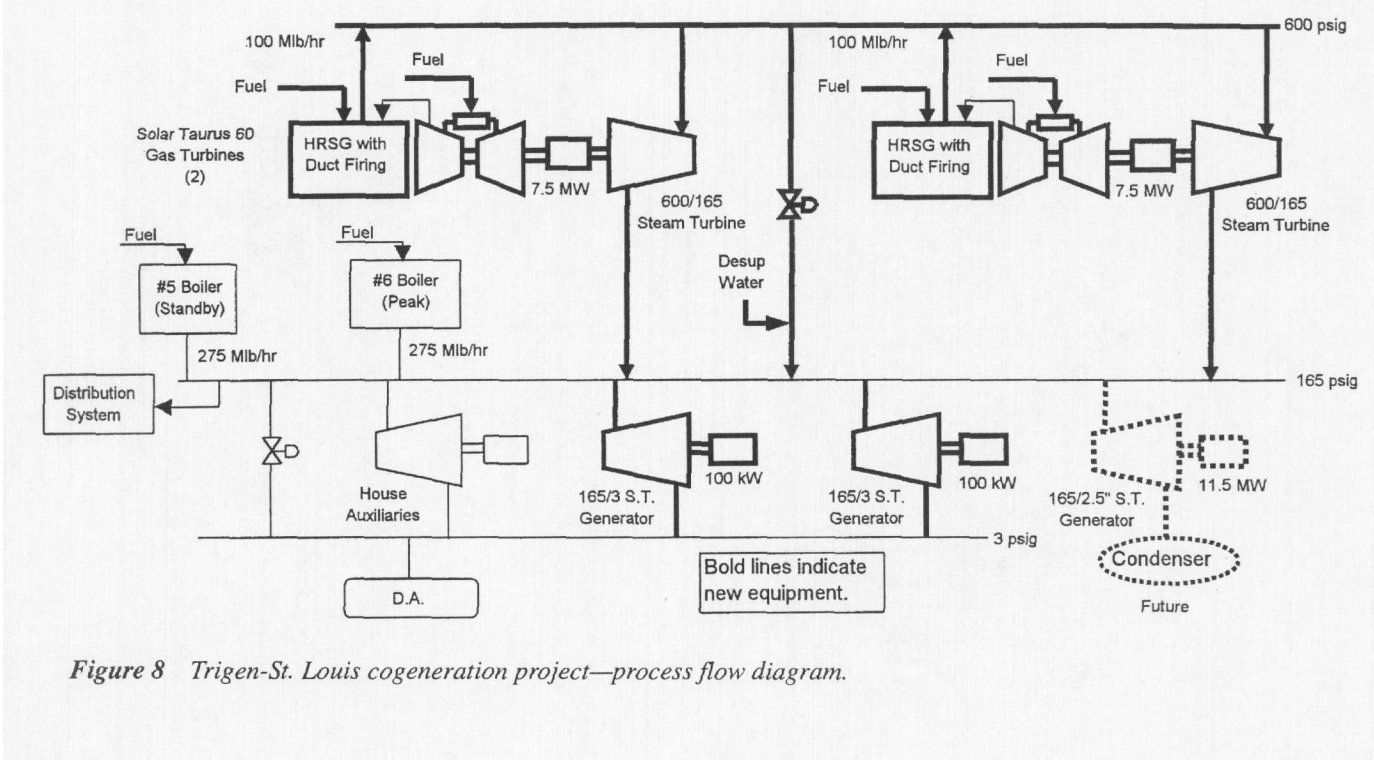

Figure 8 *Trigen-St. Louis cogeneration project—process flow diagram.*