THE BELLEFIELD BOILER PLANT

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A Review of the Origin, Expansion, and Modernization of the Plant and the Growth of the Steam Load it Serves

The Bellefield Boiler Plant is a Long-Time Member of NDHA.

Origin and Early History: 1904-1932

The original Carnegie Library and Music Hall, built in 1893-1895, was heated by a small boiler plant located within the original building. In 1900, a large sum of money was donated by Mr. Andrew Carnegie for the purpose of greatly expanding the facilities of the Carnegie Library Building. The new construction enlarged the Library, added the foyer to the Music Hall, and expanded the facilities to include the Museum, Art Galleries, and the large Hall of Architecture and Sculpture. (Fig. 1).

This huge educational and cultural complex of libraries, music hall, museum, and art galleries occupies land donated by the City of Pittsburgh, and extends for 440 ft along Forbes Avenue and along the entrance to Schenley Park for 660 ft. The size of the building is most impressive, enclosing an interior volume of nearly 14,000,000 cu ft with a total floor space of over 15 acres. The roof required about six acres of copper sheets in its original construction.

To serve the extensive requirements of this new structure for light, heat, and power, one of the largest institutional power plants ever to be constructed at that time was required. The original boiler plant, of course, was entirely inadequate to serve the expanded structure. Owing to the important character and value of much of the contents of the building and the dirt, smoke, and noise attendant to a boiler plant, it was considered advisable to eliminate from the building proper the hazards of a boiler plant of the size necessary to supply the enlarged facilities. However, electricity for lights and power continued to be generated in an engine room under the museum until 1957.

By fortunate circumstance, Junction Hollow, located directly in back of the new building, offered the ideal site for the proposed new boiler plant. By ordinance enacted October 26, 1903, the City of Pittsburgh authorized and empowered the Board of Trustees of the Library to occupy and hold so much of the land in Junction Hollow as might be necessary for the erection of a suitable steam generating plant to serve the Library complex.

The Architects for the Library (Alden and Harlow) prepared the designs for the new plant. At the outset, the sole purpose and use of the boiler plant was to furnish steam for light, heat, and power to the Carnegie Library complex. The capacity of the boiler plant, as described at the time in The Engineering Record, was "To supply over 30,000 incandescent lamps, power for over 500 hp in motors, and steam for heating an interior volume of nearly 14,000,000 cu ft."

The boiler plant was completed in 1907, and occupies a site on the western side of Junction Hollow. It is of steel frame construction, with brick exterior walls. The original structure, which remained unchanged until the current expansion in 1965-66, is approximately 150 ft long by 65 ft wide, with a height of 70 ft from grade to eave.

A siding from the adjacent Baltimore & Ohio Railroad, which runs through the Hollow, serves the boiler plant. Coal is delivered via a siding into the south end of the building, where railroad car platform scales weigh in the coal, which is dumped direct from the cars into a receiving hopper.

From the receiving hopper, the coal is discharged through a coal crusher onto a McCaslin, overlapping, gravity, bucket-type conveyor. The McCaslin conveyor, more familiarly known in later years as a "Peck Type Carrier", encircles the boiler plant vertically on the longitudinal centerline. This arrangement permits the coal to be received from the railroad cars, conveyed vertically at the south end of the boiler house to the top of the building, and carried horizontally the full length of the building in a conveyor gallery over the top of the coal storage bunker, which has a total capacity of about 2,000 tons. A tripping device permits discharging the coal from the conveyor into any part of the coal bunker at the selection of an operator.

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The concrete-lined, steel-framed bunker is divided into four equal compartments, separated by concrete and steel fire walls. Each compartment served a pair of boilers in the original plant.

A similar, but somewhat smaller bunker over the railroad car unloading bay was used for the storage of ashes. The same encircling conveyor on its return path runs the length of the boiler house in the basement and directly under the individual ash hoppers attached to the furnaces of the originally-installed boilers. Ash from the boilers was periodically discharged from the hoppers onto the conveyor and was transferred to the main ash bunker for storage. This stored ash was then discharged, as required, to empty coal cars and was removed from the plant.

The original equipment for the generation of steam consisted of eight, 300 hp, water tube, Babcock & Wilcox straight tube, header type boilers set in four batteries of two boilers each. Each boiler was equipped with two longitudinal steam drums designed for 160 psi working pressure and with a Williams feed-water regulator. The boilers were fired with Greene, natural draft, chain grate stokers. The eight stokers were driven through a line shaft in the basement, powered by a Kreibel steam engine. Coal was fed to the stoker hoppers through two traveling weigh laries and extension spouts from the overhead bunker. This enabled the operators to check the fuel consumption of each boiler, as well as total fuel consumption. The eight boilers were drafted through a rectangular steel breeching placed along the inside rear wall of the boiler house and to the 195 ft high radial brick chimney, which was placed in back of the boiler house with its foundation in the solid rock of the cliff wall of Junction Hollow. The chimney was constructed by Alphons Custodis Chimney Construction Company.

The other essential boiler plant auxiliary equipment included two Wilson-Snyder, compound duplex, steam-driven, outside-packed, plunger-type, boiler feed pumps, either pump capable of supplying the full boiler capacity. Feed water was heated in two Warren-Webster open heaters conveniently located in the engine room in the Library basement so as to use the exhaust steam from the engines located there. Additional boiler feed water heating and conditioning equipment in the original installation consisted of Gunning filters, reheaters, and purifiers.

The 16 in. main steam header was sectionalized into two parts, each serving four boilers, and the two sections were cross-connected so that in an emergency at least half of the boiler capacity always was available. A dual-feed, auxiliary steam header assured the supply of steam to the auxiliary equipment under all circumstances. From the main headers, dual 12 in. steam mains extended from the boiler plant through an underground tunnel into the Library engine room. An interesting, and advanced, feature at that time was the installation of an electrically-driven and remotely-controlled motorized steam valve in each of the two mains leading to the Library. The 12 in. mains were so sized that either could carry the full steam load.

Connecting the boiler plant and the Library, a walking tunnel 7½ ft wide by 12 ft high and 500 ft long was constructed. It bridged the short distance between the back wall of the boiler plant and the cliff side, then continued through solid rock into the sub-basement of the museum section of the Library. The tunnel enclosed the two steam mains, a condensate return main, certain other services, and provided ample walking space.

The two 12 in. steam mains terminated in a 24 in., high pressure, steam header in the basement beneath the engine room, from which separate leads extended up to the five engine generators which supplied the total electric light and power requirements of the Library-Museum complex. Exhaust steam collected from the engines at about 5 psi was utilized for heating the main building.

It is well worth calling attention to the sound design and construction of the boiler house, and to all of the mechanical equipment that was selected for both the boiler plant and the engine room. The boilers and stokers, the pumps, the engines and generators, the coal and ash handling equipment, and the piping systems were the best and most modern obtainable at the time the plant was built.

The boiler house structure stands today, after 60 years, in excellent and sound condition. The original coal handling equipment is still in use. The steam engines and their generators were operated for 50 years before giving way to more modern electrical equipment. The original boilers were operated until 1934, when they were removed for gradual replacement by larger capacity units to serve not only the original Carnegie Library but the expanding educational facilities in the Oakland area.

**Development of the Bellefield System:**

**1933-1945**

For the first 25 years, or until 1932, the Carnegie Library was the sole user of steam from the boiler plant. In 1932, the City of Pittsburgh, at its own expense, constructed an underground steam pipe line from the boiler house to Phipps Conservatory in Schenley Park. This event marked the beginning of the distribution of steam to other users.

The original eight 300 hp boilers had a total installed steam generating capacity of about 96,000 lb/hr at the conservative rating of 125 per cent, or a firm capacity of about 72,000 lb/hr with one pair of the battery-set boilers not operating.

The total connected steam load of the Carnegie Library and Museum was 40,000 lb/hr for power, light, and heat, and the connected load of the Phipps Conservatory was approximately 12,500 lb/hr for heating only. Thus, the total connected load of 52,500 lb/hr left a comfortable operating margin under the firm capacity of 72,000 lb/hr.

In 1926, the University of Pittsburgh began the construction of the Cathedral of Learning, and shortly thereafter planning was begun for the construction of the new Mellon Institute of Industrial Research. With the construction of the Cathedral of Learning in progress, and the construction of the Mellon Institute scheduled to start in the early 1930's, negotiations were begun between the various parties for supplying steam from the boiler plant to the new buildings. (Fig. 2).

The negotiations ultimately led to an agreement, executed on March 30, 1933. The parties to this agreement are Carnegie Free Libraries of the City of Pittsburgh, Carnegie Institute, University of Pittsburgh, and Mellon Institute of Industrial Research. Generally, the agreement provides for the extension or enlargement of the boiler plant so that steam could be supplied to Carnegie Library, Carnegie Institute of Technology, if desired, Phipps Conservatory, Mellon Institute, and the University of Pittsburgh. The agreement also provides that, after the steam requirements
of Phipps Conservatory were provided for, the steam capacity would be equally available to the Carnegie group and the University-Mellon group. At the time of agreement, the boiler house was given the name of "Bellefield Boiler Plant".

Carnegie Institute of Technology, although invited to become a party to the 1933 agreement, decided not to become a member of the group, and has throughout its some 60 years of operation maintained its own boiler plant.

The Bellefield Boiler Plant agreement recited that Carnegie Library was the owner of the boiler plant, and provided for the creation of a supervisory committee. This committee, as the agent of Carnegie Library, is given full power to maintain and operate the boiler plant, provide for additions thereto, and permit other public or semi-public institutions to receive steam therefrom.

The agreement, in detail, provides for the creation of a reserve fund; the University-Mellon group to put up an amount equal to the investment of the Carnegie Library for the creation of a depreciation and obsolescence fund and for the creation of an enlargement fund.

The mode of operation of the boiler plant is clearly specified in a provision of the agreement quoted as follows: "It is the intention and direction of the parties hereto that no profit shall be realized from the furnishing of any steam to any such public or semi-public institution, but in each such agreement the Supervising Committee shall make adequate provision so that there shall be paid by or on account of such public or semi-public institution its fair proportion of the cost of the maintenance and operation of said boiler plant and also such contribution to the Boiler Plant Reserve Fund as shall be fairly commensurate with the service rendered to such institution". The Supervising Committee has consistently abided by the foregoing provision and has refused to supply steam to institutions which do not qualify for exemption under Section 101 of the Internal Revenue Code.

The agreement was to be continued for a period of fifty years, ending on the last day of March, 1983; however, any of the parties would have the right to terminate the agreement on the last day of March in any year subsequent to the year 1962, but only after giving each of the other parties at least two years' written notice of its desire to terminate the agreement. The determination of the terms and conditions of any termination is vested solely in the Supervising Committee.

The plan to expand the Bellefield Boiler Plant to accommodate the steam requirements of the Cathedral of Learning and the Mellon Institute involved two separate but related projects: first, the steam generating capacity of the plant had to be increased; and, second, the steam distribution system had to be extended to deliver steam to the two new buildings.

The Supervising Committee wisely recognized the probability that the distribution of steam would be extended, in the future, to other educational and institutional buildings within the Oakland area. Consequently, sound estimates were made of the probable future loads, and the new steam distribution lines were sized accordingly. It also was recognized that the original boilers and auxiliary equipment in the boiler house were approaching the end of their useful life, that modern equipment would be more efficient in operation, and that space in the boiler plant could be preserved by the installation of higher-capacity units.

Rust Engineering was engaged to modernize the steam generating facilities. The eight old boilers, occupying four bays, with a total steam generating capacity of about 96,000 lb/hr, were removed. Two new Springfield Boiler, cross-drum, sectional header, water tube boilers were installed, each having a maximum continuous capacity of 75,000 lb/hr. Thus, a total steam capacity of 150,000 lb/hr was accommodated in only two days, leaving the remaining space for future boiler installations.

The new boilers were designed for a working pressure of 250 psi without superheat, but were operated at 150 psi, this limitation being set by the existing five steam engines driving the electrical generators in the Museum. The design maximum steam temperature for the engines was saturation temperature at 150 psi.

The two steam generators were provided with Vulcan soot blowers and Swartwout feed water regulators, and were fired by Westinghouse, nine-retort, continuous ash discharge, underfeed stokers, which received coal from the overhead bunker through Richardson coal scales and Stock Equipment non-segregating coal distributing hoods. Draft was provided by Sturtevant forced draft fans driven by Elliott steam turbines. Both boilers were drafted through a new, common breeching to the original, 195 ft, brick chimney. Each boiler was provided with modern combustion controls furnished by Hagan and with complete boiler instrumentation by Bailey Meter equipment.

All old boiler plant auxiliaries were removed and were replaced with the following up-to-date equipment: a Scaife hot process lime and soda-ash water softener, complete with pressure filter (Fig. 1); an Elliott deaerating feed water heater, rated at 180,000 lb/hr; two Manistee centrifugal boiler feed pumps, both turbine-driven, with a smaller motor-driven Manistee boiler feed pump added later for summer operation; two Frederick Iron & Steel motor-driven condensate pumps; and a new condensate receiving and storage tank located in a separate structure back of the boiler house and adjacent to the pipe tunnel. Ash from the two new boilers was handled by the original McCaslin conveyor.

The selection of good equipment, well engineered, resulted in economical operation of the plant. The combustion control equipment permitted almost smokeless combustion, and constantly maintained the 150 psi steam pressure within less than two lb variation. Production efficiency with the new equipment was high; steam generated, including that used by plant auxiliaries, has been 9.5 lb/lb of coal or higher.

Concurrent with the modernization of the boiler plant, an underground steam distribution system was constructed to serve, initially, the Cathedral of Learning and the Mellon

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Institute. The steam piping was designed for 250 psi, the maximum working pressure of the new steam generating units, but was operated at 150 psi, the normal boiler operating pressure.

The new steam distribution system consisted of one 12 in. and on 8 in. steam main, originating at the high pressure header in the engine room basement under the Museum and extending through the Museum to the Forbes Ave. side of the building. The underground lines, encased in tile conduit, extend from the building line under Forbes Ave. and continue on the western side of Bellefield Ave. to steam vault No. 4, near the rear of Heinz Chapel. From this vault, the main lines extend west under the campus through vault No. 6 to a terminal vault, No. 7, at the eastern side of the Cathedral of Learning. From the same vault, No. 4, on Bellefield Ave., the mains are continued to a second vault, No. 5, opposite the southwest corner of Mellon Institute.

Branch steam lines are extended east from vault 5, under Bellefield Ave., into the basement of Mellon Institute; from vault 6 into Heinz Chapel; from vault 7, branch lines lead into the basement of the Cathedral of Learning, and a smaller branch is extended underground into the Stephen Foster Memorial. Condensate is returned from the connected buildings through a 5 in., red brass, condensate main and a 2 in. trap discharge line running parallel to the steam mains in the underground conduit and back to the boiler plant.

Accordingly, the original underground distribution system, terminating in vaults 5 and 7 and supplying the heating and hot water requirements of the Carnegie Library and Museum, the Cathedral of Learning, and the hospital group to determine what the ultimate capacity should be. The total steam load of the upper campus buildings, at that time heated with individual boilers, was determined. Estimates of the steam requirements for the Bellefield System: 1946

First Major Expansion of the
Bellefield System: 1946

Agreement having been reached between the Bellefield Boiler Plant, the University of Pittsburgh, and the hospital group to supply steam, initially, to Children's, Presbyterian, Eye and Ear, and Women's hospitals, and the University's upper campus, the Supervising Committee again engaged Rust Engineering to extend the underground steam system to serve the proposed new steam loads and to increase the capacity of the plant.

Prior to the engineering design of the system extension, careful estimates were made by the University of Pittsburgh and the hospital group to determine what the ultimate capacity should be. The total steam load of the upper campus buildings, at that time heated with individual boilers, was determined. Estimates of the steam requirements for proposed future University buildings, and for both the immediate requirements and future extensions to the hospital buildings, were made. To these total projected future requirements a liberal contingency factor was added to cover other probable future load increases which at the time were unknown.

The load estimating, and the planning for the steam line extension, was so thorough that today, 20 years later, with most of the then-planned construction completed and some buildings added that originally were not contemplated, the steam line is adequately serving the area with some capacity to spare.

Total Connected Load

The total connected load represents the undiversified total steam demand at design conditions, which of course in practice is never reached. However, in January 1945 the maximum 15-minute metered demand on the system reached 72,000 lb/hr. This demand gradually decreased during that heating season, but in December 1945 it reached 78,000 lb/hr. Demand slightly exceeded the firm steam generating capacity of the plant.

At this time, negotiations were in progress between the Supervising Committee and the four hospitals comprising Pittsburgh's growing medical center to supply steam to Children's, Presbyterian, Eye and Ear, and Women's hospitals. These negotiations resulted in the decision to extend the steam distribution system to supply not only the four hospitals, but also to serve buildings of the University of Pittsburgh's upper campus. Thus, with the steam demand slightly in excess of the installed firm steam generating capacity of the boiler plant, and with additional loads to be served, it was necessary to increase the steam generating capacity of the Bellefield Boiler Plant.

This boiler also was provided with a Westinghouse, nine-retort, continuous ash discharge, underfeed stoker. Forced draft was provided by an Elliott steam-turbine-driven, Sturtevant forced draft fan, similar to the equipment on the companion units. The combustion control devices and boiler instrumentation provided for the new unit matched the Hagan and Bailey Meter equipment which were serving the other Springfield boilers.

Two new Buffalo Pumps four-stage boiler feed pumps were added, each having a capacity of 215 gpm against a head of 755 ft. These two pumps were driven by Elliott
steam turbines with differential pressure governors. One additional Frederick Iron & Steel single stage, motor-driven, condensate pump was added, a duplicate of the original two condensate pumps. One new filter was added to the feed water treatment system, a duplicate of the original filter. New coal handling equipment between the bunker and the stoker hopper for the new boiler consisted of two Stock Engineering automatic coal scales and two Stock conical coal distributors.

Because of the greater steam production for the growing distribution system, and the corresponding increase in coal consumption with the attendant increase in ash production, it was decided to divorce the ash handling from the coal handling on the common conveyor system. The unloading of a greater tonnage of coal would require longer operation of the McCaslin conveyor on coal service, the scheduling of the conveyor for ash handling from three stokers would cause operational problems, and the labor for moving ashes from the three stokers to the conveyor was becoming excessive. Therefore, a modern, pneumatic, ash handling system, manufactured by United Conveyor, was installed to serve the three boilers and transport the ash direct to the overhead ash bunker. This new ash system greatly reduced the operating labor time on ash handling, and provided a much cleaner operation.

With the installation of the new 85,000 lb/hr steam generator and the other auxiliaries, the boiler plant had an installed capacity of 235,000 lb/hr and a firm generating capacity of 150,000 lb/hr with the largest unit out of service.

It was decided to build the steam line extension with the same total steam-carrying capacity as the original line. The original line up to the Cathedral of Learning consisted of one 12 in. and one 8 in. steam line, one 5 in. condensate return, and one 2 in. trap discharge line in tile conduit, as previously mentioned. The new extension consisted of two parallel metal conduits; one containing a 10 in. steam line and a 5 in. return, and the other a 10 in. steam line and a 2 in. trap discharge line. The two 10 in. lines are equivalent to the 12 in. and the 8 in. lines. The conduit selected for the extension was Ric-wil's spiral corrugated steel conduit with asphalt-saturated felt protective covering and internal moulded thermal insulation, which probably was the best underground conduit for the insulation and protection of steam lines available at that time.

The new lines, more than twice the length of the original line, extend for about 2,850 ft, beginning at the Cathedral of Learning, vault 7, and terminating at vault 15 adjacent to Women's Hospital. The route of the new lines leads around the Cathedral of Learning to vault 9 on the Fifth Ave. side, thence under Fifth Ave. and north on Lytton Ave. to vault 12 on Bigelow Blvd.-O'Hara St. The line then continues west under O'Hara St. through vault 13 at Thaw Hall, on through vault 14 near the Western Psychiatric Institute, and then to the terminal vault at Women's Hospital. Branch lines were run from the Thaw Hall vault through Thaw Hall and extended to the various upper campus buildings of the University of Pittsburgh.

From vault 15 adjacent to Women's Hospital, steam and return lines are extended through the building to serve Presbyterian, Women's, and Eye and Ear hospitals. Underground mains extend from this same vault to vault 16 at the original Children's Hospital.

When the underground steam line extension was completed in 1947, and the new buildings were supplied, the connected loads on the boiler plant were:

| Sub-total; Connected Load | 103,500 |

Upon completion of the extension, the total connected or diversified load amounted to 141,000 lb/hr, and the maximum 15-min demand recorded was 98,000 lb in November of 1947 and 116,000 lb in January of 1948. These demands were approached, but were not exceeded until December and January of 1953-1954. To supply these loads, the boiler plant had a total installed capacity of 235,000 lb/hr and a firm generating capacity of 150,000 lb/hr.

**Minor Extensions to the Steam Lines: 1947-1957**

For the first five years after the completion of the steam distribution system to the hospital group, no additional steam loads were added and the total annual steam generation remained fairly constant, varying only with the normal deviations in the weather. During the second five years of this decade, however, four new buildings and two existing buildings were connected to the system. The first building added in this period was the new Nurses' Residence, adjacent to the Presbyterian and Eye and Ear hospitals. Construction on the Nurses' Residence was completed in 1952, and steam was supplied by an underground extension from vault 16.

In 1953, two existing buildings were connected to the system. The Board of Education Building on Bellefield Ave. was added by a short connection out of existing vault 3A, which is on the branch line supplying the adjacent Y.M. & W.H.A. Building. A considerably larger steam load, that of the Western Psychiatric Hospital, was connected at about the same time. This was accomplished by a branch line extending from vault 14 in O'Hara St. which was suitably placed in the original design of the underground system to conveniently serve the Psychiatric Hospital.

In 1954, the City of Pittsburgh decided to install boilers in Phipps Conservatory and to generate steam for that building. Consequently, the steam service from Bellefield Boiler Plant to the Conservatory was terminated. The underground steam line to the Conservatory was abandoned but not removed, and it has remained out of service since 1954.

Planning was nearing completion for the expansion of the University's medical school facilities and a new science building. Construction was started soon on the School of Health Professions, the Child Guidance Center, and Clapp Hall.

The School of Health Professions, now known as Scaife Hall, and the Child Guidance Center, immediately adjacent to Women's Hospital, were supplied with steam from an (Continued on Next Page)
extension to vault 15, which was constructed integral with the new buildings and into which the dual steam mains were extended full size. These two buildings were completed and began receiving steam from the Bellefield Boiler Plant in the Fall of 1956. These two buildings use steam not only for heating but also to supply the steam turbines driving an emergency generator for lights and essential power as well as an emergency fire pump.

Concurrently with the construction of the two new buildings in the Medical Center, the University also had under construction a new science building, Clapp Hall. Since no section of the underground steam system was adjacent to Clapp Hall, and additional buildings were being planned for future construction in the same block, the University engaged Peter F. Loftus Corporation to investigate several possible routes for extension of the underground system and to select the most economical and advantageous course for the new line to follow.

The points on the existing piping system nearest to Clapp Hall are vaults 5 and 11. Of the several routes considered, a line extending from the vault at the rear of Heinz Chapel was determined to be the most economical and desirable. Consequently, this new line was constructed and steam was supplied to Clapp Hall beginning in the Fall of 1956.

The University contemplated that additional buildings would be built at some time in the future not only adjoining Clapp Hall but also on the adjacent land along Bigelow Boulevard. To accommodate these proposed buildings, estimates were made of their steam requirements, and the steam line that was installed was sized accordingly. The branch to Clapp Hall consists of two 6 in. steam lines, a 3 in. condensate return, and a 1 1/2 in. trap discharge line. Only a small fraction of the total carrying capacity of the line was needed for this first building, thus leaving ample capacity for expansion in the area.

With the completion of these new buildings and the connection of the existing Western Psychiatric Hospital and the Board of Education Building to the steam lines, the connected loads on Bellefield Boiler Plant were:

<table>
<thead>
<tr>
<th>Connected Steam Loads</th>
<th>Pounds of Steam per Hour</th>
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<tbody>
<tr>
<td>Initial System: 1932</td>
<td>103,500</td>
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<tr>
<td>Less Phipps Conservatory: 1954</td>
<td>12,500</td>
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<tr>
<td>Sub-total; Connected Load</td>
<td>91,000</td>
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<tr>
<td>System Expansion: 1946-1947</td>
<td>37,500</td>
</tr>
<tr>
<td>System Additions: 1947-1957</td>
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<tr>
<td>Nurses Residence</td>
<td>8,000</td>
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<tr>
<td>Board of Education Building</td>
<td>5,000</td>
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<tr>
<td>Western Psychiatric Hospital</td>
<td>11,300</td>
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<tr>
<td>School of Health Professions (including emergency service and fire pump)</td>
<td>39,000</td>
</tr>
<tr>
<td>Child Guidance Center</td>
<td>900</td>
</tr>
<tr>
<td>Clapp Hall</td>
<td>3,500</td>
</tr>
<tr>
<td>Sub-total; Connected Load</td>
<td>67,700</td>
</tr>
<tr>
<td>Total Connected Load</td>
<td>196,200</td>
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</tbody>
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Toward the end of this period, with a connected load of 196,200 lb/hr, the corresponding maximum 15-minute demand of approximately 140,000 lb/hr was approaching the firm steam generating capacity of the boiler plant.

At this time, the University had under construction the Graduate School of Health, and Children's Hospital was planning to construct a new wing. So, again, the Bellefield system had reached a point where additional steam generating capacity was imminently needed.

Second Major Expansion to Boiler Plant: 1956-1957

Early in 1955, about a year and a half before the School of Health Professions and Clapp Hall were ready for connection to the steam system, the Operating Committee engaged Peter F. Loftus to make an economic and engineering analysis of the steam problem of the Bellefield Boiler Plant. The analysis was to cover the current operations of the plant, to determine the magnitude of the steam load that would be added by the inclusion of new university and hospital buildings then either under construction or planned for early erection, and to estimate the additional steam capacity that would be required for other buildings that were contemplated to be constructed in the following period of about ten years. From this load analysis, it was established that a new steam generating unit of about 100,000 lb/hr would be required. Preliminary layouts of several steam generating units were made and it was confirmed that a 100,000 lb/hr boiler would be the largest capacity unit that could be installed in a single day, the space available for the new steam generator.

A part of the steam generator investigation was to determine the most suitable fuel-burning equipment for the new unit. The three Springfield boilers were fired with Westinghouse, multiple-retort, underfeed stokers. Operation of these units had been entirely satisfactory. Maintenance costs, however, were rather high. Some years previous to 1955, Westinghouse had ceased the manufacture of this stoker. In 1955 only two major stoker manufacturers were still building the multiple-retort machine, which was being superseded in modern boiler installations by chain or traveling grate, spreader, and vibrating grate stokers, because of the high cost of maintenance and repair parts and because of the limited range of coals which could be burned successfully on the multiple-retort stoker.

Of the several firing methods investigated for the new boiler, a chain-grate stoker was selected for several reasons; low maintenance cost, good efficiency, acceptability without a dust collector under the recently-tightened City of Pittsburgh Smoke Control Ordinance, and the ability to burn not only the presently available coal but also to burn the lower-grade coal which might have to be used in future years.

Upon completion of the steam study and report, Peter F. Loftus was authorized to proceed with the engineering and design work in connection with the purchase and installation of a new steam generator and auxiliary equipment. The principal new equipment installed in 1956-57 consisted of one Babcock & Wilcox two-drum, open pass water tube, steam generator with complete water-cooled furnace walls designed for 250 psig working pressure and with a continuous capacity of 100,000 lb/hr, fired with a B&W chain-grate, forced draft, jet ignition stoker. Its auxiliary equipment included a Bailey Meter feed water regulator, Vulcan soot blowers, and complete combustion control and boiler instrumentation selected to match the Hagan Corporation and Bailey Meter equipment which was serving the other three boilers. Forced draft for the stoker was provided by a Buffalo Forge forced draft fan driven by an Elliott steam turbine.

The existing radial brick chimney, at that time drafting the three Springfield boilers, did not have sufficient capacity to handle the gases from the new boiler in addition to the other three; therefore, it was necessary to construct a second stack. Because of the limited space in the area between the rear of the boiler house and the cliff, it was found advantageous to re-arrange the smoke breeching to draft the new
boiler only, from the original stack, and to provide a new stack to draft the three older boilers with sufficient spare capacity to draft a future boiler of 100,000 lb/hr. Thus, a new reinforced concrete stack, 11 ft inside diameter by 255 ft high, was constructed some 30 ft northeast of the boiler house and close to the cliff wall.

Other new boiler plant auxiliary equipment installed in the 1956-1957 program included: an Elliott deaerating feed water heater capable of heating and deaerating 300,000 lb/hr of feed water; an Ingersoll-Rand, four-stage, centrifugal boiler feed pump rated at 500 gpm against a discharge head of 275 ft, driven by a Terry steam turbine equipped with a differential pressure governor; two chemical feed pumps and mixing tanks; one Nash Engineering water-sealed instrument air compressor; and Stock Equipment coal scales and non-segregating coal spouts to serve the new stoker.

In the same program, the boiler plant electrical system was completely overhauled, including a new motor control center, new power wiring systems, and new building lighting. The pneumatic ash handling system was altered to accommodate the new steam generator; and, to improve the cleanliness of operations, a new secondary dust separator and discharge air washer were installed.

In 1953, the hot process water treatment system which had been in operation for twenty years had reached the point of major repair or replacement. An investigation indicated that reduced operating and replacement costs could be gained by the installation of a zeolite softening system instead of replacement or repair to the hot process softener. Consequently, a Permutit two-unit 150 gpm zeolite softener was installed. This equipment provided a safe margin over the anticipated maximum requirements, including the new 100,000 lb/hr steam generator; therefore, no additional softening capacity was required at the time.

In the early 1950’s, a special research project was carried out in Mellon Institute which required heat at a higher temperature than could be obtained with the 150 psig steam available. To accommodate this service, the operating pressure of the boiler plant was raised to 175 psig. The engines in the Museum were altered for operation at this higher pressure, boiler safety valves were replaced, and other minor adjustments in controls and equipment were made for the new operating conditions.

From that time on, the Bellefield system has operated at 175 psig. Construction was completed, and the new steam generator and auxiliary equipment was placed into operation, early in 1957.

**Growth of the Bellefield System: 1957-1965**

Concurrently with the installation of the newest steam generating unit in the boiler plant, construction was in progress on the building for the University’s Graduate School of Public Health. Installation work was completed, and the new boiler had been in operation for several months, when the Graduate School was connected and began receiving steam from the system late in the Fall of 1957.

Shortly after the Municipal Hospital was taken over from the City of Pittsburgh, an investigation was made for the University to determine whether the continued operation of the hospital’s boiler plant or the purchase of steam from the Bellefield system would result in lower operating costs for supplying the building’s total heating and process steam requirements. The investigation determined that an investment in a steam line extension and the purchase of steam from the Bellefield Boiler Plant would be more economical than the continued operation of the hospital’s isolated boiler plant.

After the acceptance of this recommendation, the University directed Peter F. Loftus to design a new steam service to serve the Municipal Hospital. Comparative construction cost estimates were made for several alternate routes; one considered traversing part of Pitt Stadium and supplying steam to the basketball courts and locker rooms, and another possible route extended through the basement areas of Scaife Hall. The route finally selected originated in vault 15 adjacent to Women’s Hospital, extended through the steam meter room at the rear of the Child Guidance Center, then under the paved service area of Scaife Hall. From this point, the line continued under sidewalks and lawns to Municipal Hospital. This service line consists of a 4 in., high-pressure steam main, a 3 in. condensate return, and a one inch trap discharge line, which was sized to supply not only the Municipal Hospital but also a future building of comparable steam requirements. The Hospital, now known as Salk Hall, first began taking steam from the system early in 1959.

The next extension of the steam service was made to the new addition to Children’s Hospital. To serve this building, a steam line was extended under the walkway of DeSoto Street from vault 16 and steam service began in the Fall of 1960.

Early in 1961, Langley Hall, directly adjacent to Clapp Hall, was completed and, as originally planned, the steam mains were extended from the Clapp Hall basement steam room directly into the new building, and steam supplied in January 1961.

When the Schenley Hotel and Apartments were acquired by the University, the existing boilers located in the sub-basement of the apartment structure were continued in operation. Consideration was given to the construction of a branch steam line and to the purchase of steam from the Bellefield system. However, the existing main steam lines of the system were located so far from the Schenley buildings that the cost of constructing a branch line was found to be too great to make the purchase of steam economical.

By late 1959, planning by the University for the new Library and Professional Schools Complex had established the site at Forbes Ave. and the entrance to Schenley Park, directly across Forbes Ave. from the Schenley Hotel. It also had been decided to immediately construct three Men’s Dormitories just west of the Schenley Apartments. The size of the proposed buildings and the general steam requirements also had been determined.

With proposed buildings adjacent to the Schenley Apartments and Hotel, it now became feasible to consider supplying these existing buildings from the central system. Consequently, the proposed new steam line should have capacity to supply not less than the new Library, Professional Schools Complex, Men’s Dormitories, and the Schenley buildings. The estimated steam demand for this group of buildings was set at about 60,000 lb/hr.

Since the proposed new steam line would terminate in the new Men’s Dormitories close to the Fifth Ave, side of the buildings, and since this point would only be about 700 ft from the existing steam lines in O’Hara St., it was agreed that provision should be made in the design of the new line for a future tie between the new and existing steam mains, thus providing a loop feed which would add to the reliability of the system. The steam-carrying capacity (Continued on Next Page)
of the future tie line was set at 110,000 lb/hr, or the combined steam demands of the hospital group including the emergency turbine generator and emergency fire pump in the School of Health Professions. Therefore, the basis for the design of the proposed new steam line was set at the sum of the two estimated steam demands, or 170,000 lb/hr.

Thus, with the locations and approximate steam requirements for the new buildings known, and the capacity for the future tie line determined, various routes for the proposed steam line were established. For each proposed route construction costs were estimated and the relative advantages and disadvantages of the various routes were considered. Construction of the new steam line was carried out concurrently with the construction of the Men's Dormitories. The steam line was completed, tested, and placed into operation, and both the Schenley buildings and the Men's Dormitories began receiving steam from the Bellefield system at the end of December 1962. This new line consists of a 10 in., high pressure, steam line, a 6 in. condensate return, and a 2 in. trap discharge line. (Fig. 3).

In 1961, the Board of Education of the City of Pittsburgh began negotiations with the Bellefield Boiler Plant and the University of Pittsburgh for the purchase of heating steam for the Frick School. It was agreed that steam could be furnished when the new steam line had been completed and the final tie line had been constructed. In 1963, the University and the Board of Education agreed to construct part of the tie line extending from the Men’s Dormitories steam room to a vault opposite the Frick School. The Board of Education would then have a branch main extended from the new vault into the school’s boiler room. This construction was completed late in 1963, and, although the line was tested and ready for use, the Frick School has not yet begun to take steam from the system. No additional steam lines have been constructed since 1963. However, three additional buildings have been added to the system by extension of service branches from existing vaults or adjacent buildings.

In the Fall of 1963, the extension to the Eye and Ear Hospital was completed and steam was supplied by extension of mains within the main building. A year later, the Frick Fine Arts Building, located in Schenley Park and adjacent to the new steam line constructed in 1962, was completed and began receiving steam in October 1964. The new addition to Presbyterian-University Hospital, which had been under construction following the addition to the Eye and Ear Hospital, essentially was completed and was connected to the system in the Spring of 1965.

The connected load on the system in 1965 can be summarized as follows:

<table>
<thead>
<tr>
<th>Connected Steam Load</th>
<th>Pounds of Steam per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected Load in 1956</td>
<td>196,200</td>
</tr>
<tr>
<td>Electrical generation in Carnegie Library and Museum terminated in 1957</td>
<td></td>
</tr>
<tr>
<td>engines retired: deduct</td>
<td>-16,000</td>
</tr>
<tr>
<td>Connected Load Corrected — 1957</td>
<td>180,200</td>
</tr>
</tbody>
</table>

**Loads Added, 1957-1965**

<table>
<thead>
<tr>
<th>Load Description</th>
<th>Pounds of Steam per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduate School of Public Health</td>
<td>14,500</td>
</tr>
<tr>
<td>Municipal Hospital (Salk Hall)</td>
<td>8,000</td>
</tr>
<tr>
<td>Children's Hospital — Addition</td>
<td>7,000</td>
</tr>
<tr>
<td>Langley Hall</td>
<td>3,000</td>
</tr>
<tr>
<td>Schenley Hotel and Apartments</td>
<td>32,000</td>
</tr>
<tr>
<td>Men's Dormitories</td>
<td>18,000</td>
</tr>
<tr>
<td>Eye and Ear Hospital — Addition</td>
<td>1,500</td>
</tr>
<tr>
<td>Frick Fine Arts Building</td>
<td>6,000</td>
</tr>
<tr>
<td>Presbyterian-University Hospital — Addition</td>
<td>6,100</td>
</tr>
<tr>
<td><strong>Sub-total, Connected Load</strong></td>
<td><strong>99,100</strong></td>
</tr>
<tr>
<td><strong>Total Connected Load — 1965</strong></td>
<td><strong>279,300</strong></td>
</tr>
</tbody>
</table>

In the eight years following the installation of the last steam generating unit of 100,000 lb/hr continuous capacity, the net increase in connected loads was about 83,100 lb/hr. The firm steam generating capacity of the boiler plant was still adequate, but the margin of spare capacity had been considerably reduced. Planning for expansion of University and Hospital facilities for the period through 1970 included projected connected steam loads in the order of 100,000 lb/hr. Faced with this increase in steam loads within the next several years, the Bellefield Boiler Plant again commissioned Peter F. Loftus to determine accurately the steam load growth in the immediate future and to recommend the most economical solution to the problem.

**Third Major Expansion to the Boiler Plant: 1965-1966**

The planning department of the University furnished data on all contemplated construction through 1970. The hospital group furnished similar information on proposed hospital expansions. From the data gathered, the total new steam demand for the period 1963 to 1970 was estimated to be in the order of 135,000 lb/hr undiversified, or a diversified maximum 15-minute demand of approximately 100,000 lb/hr. The study recommended the installation of one 100,000 lb/hr stoker-fired steam generator, duplicating generally the unit installed in 1956-1957. Since no space remained within the boiler house, it was recommended that an extension be constructed at the north end of the building. This recommendation was based on the following: land was available, and placing a new boiler north of the existing units permitted an uninterrupted continuation of

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**Fig. 3 — Pipe bridge carrying new line from plant to tunnel.**

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the operating floor; space at the south end was needed for a new ash storage silo; and coal handling equipment could best be extended north.

The study was completed, and the engineers were authorized in June 1964 to proceed with the preparation of drawings and specifications for the purchase of a 100,000 lb/hr steam generator, and to begin the engineering design for the construction of the plant extension to house the new facilities. Construction was started in the Fall of 1965.

The extension is of steel-framed construction with front and rear walls of brick selected to match the existing plant, in order to carry out the same architectural details. The extension is 36 ft long by 53 ft deep. The roof is an extension of the existing roof. The north wall is a temporary wall of transite panel construction, designed for removal whenever future expansion might require space for an additional unit.

The operating experience with the chain-grate-fired, open-pass, steam generator installed in 1956 has been so satisfactory that the new unit was specified essentially as a duplicate of the earlier unit. Thus, the principal new equipment installed during 1965-1966 includes one Erie City Iron Works, two-drum, open-pass, water-tube, steam generator with completely water-cooled furnace walls, designed for 250 psig working pressure and with a continuous capacity of 100,000 lb/hr, fired with a Laclede chain grate, forced draft stoker. (Fig. 4).

The auxiliary equipment for the new steam generator includes a Bailey Meter two-element feed water regulator, Vulcan soot blowers, and complete combustion-control equipment and boiler instrumentation furnished by Bailey Meter. Draft for the unit is provided by Clarage forced and induced draft fans, each driven by an Elliott steam turbine.

In the decade between the installation of the Babcock & Wilcox steam generator and the new Erie City unit, the smoke control ordinance has been changed both in administration and in stringency. Originally, the ordinance was enforced within the City by the Bureau of Smoke Prevention of the City of Pittsburgh; in the area within the County, but outside the City, it was enforced by the Bureau of Smoke Control of Allegheny County. About 1960, the administration and enforcement of smoke control for the entire County, including the City, was taken over by the Allegheny County Department of Health, and the installation and operation of fuel-burning equipment is now governed by the "Smoke Control Ordinance of Allegheny County."

The key to both ordinances is the permissible amount of fly ash in the gases emitted from stacks. In the earlier ordinance, the limit of emission of fly ash was set at 0.85 lb per 1,000 lb of gases adjusted to 50 per cent excess air. In the current ordinance, the permissible emission of fly ash has been reduced to 0.65 lb per 1,000 lb of gases adjusted to the same amount of excess air. It is also recognized that within a few years the ordinance, in all probability, will be stiffened to a permissible limitation of 0.45 lb of fly ash per 1,000 lb of gases.

The chain-grate stokers installed under the B&W unit, and recently installed under the new Erie City steam generator, are inherently clean-burning stokers. The operation of the first stoker has consistently met the limitation on fly-ash emission in accordance with the ordinance under which it was installed. It is quite probable that the new stoker and Erie City unit also would have met the more stringent limitation on fly-ash emission set by the current ordinance; however, since the ordinance will be made even more stringent within a few years, it was decided to install fly-ash dust-collecting equipment on the new unit and forestall any possible grounds for complaint if and when the ordinance is revised. It was felt by the Operating Committee that the boiler plant, being in the center of the Oakland cultural district, should be provided with the most modern equipment to ensure clean operation and cause no annoyance to the neighboring community.

The dust collector was manufactured by the Fly Ash Arrestor Corporation, and the energy required to compensate for the pressure loss across the collector is provided by the turbine-driven induced-draft fan mentioned previously. The flue gas from the fan is discharged through a new breeching section into the reinforced concrete chimney constructed in 1956.

Other auxiliary equipment which was installed early in 1966 includes: one additional Permutit zeolite water-softerning unit, space and piping connections for which were provided in the previous construction; and one additional turbine-driven Ingersoll-Rand boiler feed pump, a duplicate of the unit previously installed.

Complete rehabilitation of the coal handling facility was originally considered. This would have included replacement of the McCaslin bucket-type conveyor with two belt conveyors; one, a reclaiming belt, traversing the basement, and the other, a tripper belt, traversing the gallery above the coal bunker. A new bucket elevator also would have had to be included to raise coal from the car-dumping hopper to the upper conveyor and to raise reclaimed coal from the basement conveyor to the upper belt conveyor.

Planning for part of this system, the unloading of railroad coal cars and transferring the unloaded coal into the boiler house, was contingent on the arrangement of the buildings in the proposed Panther Hollow development by
the Oakland Corporation, which would have been adjacent to the Bellefield Boiler Plant. Due to the uncertainty of the Panther Hollow development and the continued growth possibilities of the University of Pittsburgh, it was decided to continue operation of the existing coal-handling equipment until a sixth boiler is installed.

In order to supply coal to the new Erie City boiler, a temporary coal conveyor and a feeder, manufactured by Webster Manufacturing, Incorporated, were installed to transfer coal from the existing McCaslin conveyor into the new section of the coal bunker. Coal is fed from the new bunker through Stock Equipment Company’s coal scales and non-segregating spouts into the new stoker hopper. (Fig. 5).

The existing ash piping system was extended to collect ash from the new steam-generating unit and fly ash from the new dust collector. To complete the modernization of the boiler plant, a new tile silo was constructed at the southern end to store ash from all the units. New primary and secondary ash receivers and separators, and a new air washer were installed on the roof of the silo, and new main ash piping was installed to connect the existing ash riser line to the new equipment on the ash silo. In order to ensure dustless unloading of the ashes into trucks, a new automatic ash conditioner and unloader was installed beneath the silo.

The old ash-handling equipment located on a platform above the main building roof will be removed, thus returning the roof to its original appearance. The old ash-storage section of the bunker will no longer be used for this purpose, and consequently a source of dust both in the plant and out-of-doors during truck loading has been eliminated.

The construction of the boiler house extension was completed during the summer of 1966. The steam generator and all auxiliaries were erected, piping installation completed, so that the new unit was placed into operation during November of 1966. (Fig. 6).

With the completion of this new unit, the Bellefield Boiler Plant has an installed capacity of 435,000 lb/hr and a firm capacity of 335,000 lb/hr with either of the two larger units out of service. The system’s total connected load at the end of 1965 was 279,300 lb/hr, and the estimated total additional steam load to be connected because of new construction during the next five years will be about 135,000, or a total diversified load of 414,300 lb/hr, representing a diversified load of approximately 300,000 lb/hr, which is well under the new firm generating capacity.

The Bellefield Boiler Plant has experienced a steady load growth in the past thirty years, from a connected load of about 100,000 lb/hr when the Cathedral of Learning and Mellon Institute first were connected, to the anticipated connected load of over 400,000 lb/hr when the currently planned expansion has been completed. During all this time, careful planning has provided ample steam-generating capacity. Properly-timed expansion in the boiler plant always has preceded the system’s increasing growth.

New equipment added through the years always has been the most modern and efficient available. With the completion of the present construction program, the Bellefield Boiler Plant is not only one of the largest central heating plants but also one of the most modern, efficient, and economical plants in its pressure class.

From 1946 to 1966, the total annual steam produced and the maximum 15-minute demand has grown from 249,828,000 lb and 73,000 lb/hr to 617,002,00 lb and 203,000 lb/hr respectively. The average cost, in the last 10 year period, has progressed from about 58.5 cents per 1,000 lb of steam to 68.5 cents.

It seems reasonable to predict that with the anticipated continuing growth of the educational, health, and cultural facilities in the Oakland district, the capacity of the Plant will again have to be increased within the next ten years to keep pace with the growing steam requirements.

ACKNOWLEDGMENTS

Andrew C. Herold, Jr. — University of Pittsburgh.
