

NEW HEAT AND POWER PLANT

OF THE STATE UNIVERSITY OF IOWA,
AND VENTILATION AND LIGHTING OF THE HALL OF LIBERAL ARTS.

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THE question of the Heating, Lighting, and Ventilation of a modern building is one that requires more than a superficial study by both architect and designer. Vast improvements along all these lines have been made of late years, yet investigations are continually bringing to light new methods, each of them backed by its promoters, and guaranteed *par excellentum* under any and all conditions. In former times, the candle and pine knot furnished light, the open fire-place heat, and chinks in the walls ventilation, yet a spirit of dissatisfaction led to development, and to-day we enjoy gas and electric lights, steam, hot water and electric heat, and forced ventilation by fans. And so, perhaps, while we may not now be satisfied in all respects with modern methods, yet there is a deal of satisfaction in knowing that the installation of a plant in which we are all interested is up to the most approved ideas of modern practice; that we are presumably getting the best there is. The plans and specifications called for a complete and up-to-date system of Heating, Lighting, and Ventilation, and a study of methods to attain this end would seem to indicate that the prospect is good for getting what was demanded.

The new building has 99 rooms on its four floors, including library, museum, general lecture room with a capacity of about 300, recitation rooms, offices, and various others.

The most important constructive features in the system as planned were the power plant building and furnishings, smoke-stack, tunnel, fan and motor rooms, sub-basement conduits and flues.

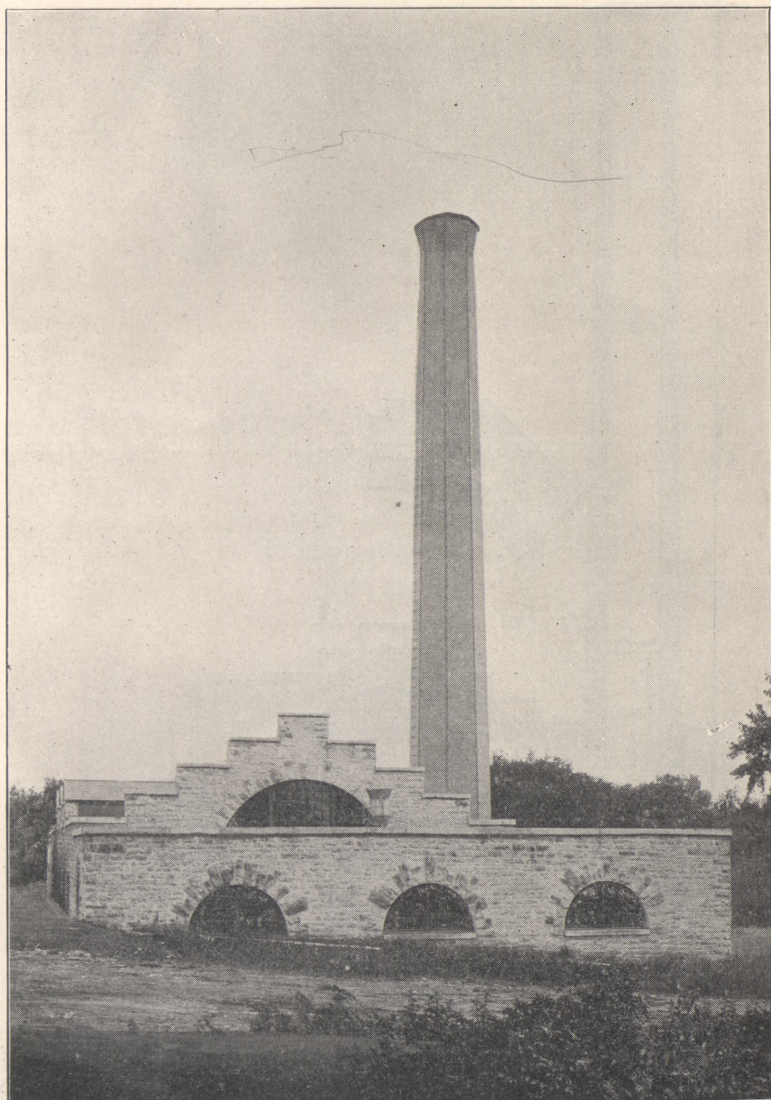


PLATE I. POWER PLANT OF THE STATE UNIVERSITY OF IOWA.

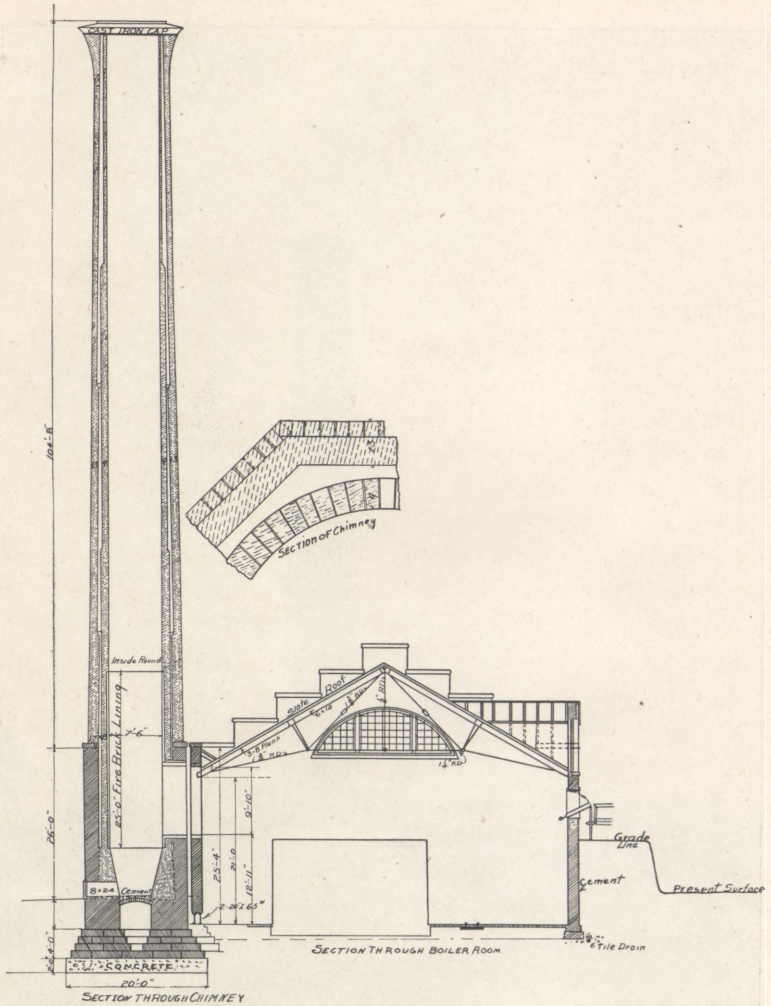


FIGURE I.

Figure I shows a sectional elevation of the power building through the boiler room, viewed from the south. The walls of the building are uniformly 18 inches thick, exclusive of footing courses. They are built of the best Cedar Valley rubble stone, trimmed with Bedford lime stone, laid in Portland cement mortar below grade, and natural cement and lime

mortar above grade line. The boiler foundations are 20 inches deep, built up of concrete and brick. The space reserved for the future installation of boilers has a brick floor, the remaining floor space being covered with a 4 inch layer of concrete, on which is a $\frac{1}{2}$ inch layer of Portland cement mortar. A 20-inch gauge car track runs close in front of the boilers to the coal storage room and a branch runs out of the building by way of the incline at south end of boiler room. This track is flush with the cement floor and provides means for carrying coal to, and ashes and cinders, from the furnaces. Various pipe trenches and drains are placed wherever necessary; the latter having direct sewer connection.

The smoke stack shown in section on Figure I is built quite close to the west wall of the boiler room; provision being made by means of I beams for unequal amounts of settling in the two. The breeching opening at the base for ingress of smoke and gases from the furnace grates is 4 feet 6 inches by 9 feet 6 inches. The flue throughout its total height is circular, 7 feet 6 inches in diameter. The various other dimensions may be seen by reference to Figure I.

The tunnel begins at the northeast corner of the Power Plant house, extends due north 412 feet with a rise of 2 feet, then east 287 feet with a rise of 34 feet, then branches, one short branch extending north 26 feet to the Old Capitol building and one running southeast with a rise of 1.6 feet to the new Collegiate building, which it enters on the west side at the center of the semicircular section. The total length is 883 feet; deepest cut was 18 feet; shallowest 8 feet; total number of cubic yards excavated 2,665. See Figure II.

The tunnel proper is 5 feet in width and 7 feet in height, internal dimensions, with a semicircular arch. It is built throughout of hard burned brick, two layers in thickness, laid in natural cement mortar, and plastered on the outside with a $\frac{1}{2}$ inch coat of mortar—natural cement and sand in equal parts. The foundation and floors are of Portland cement concrete 8 inches thick under the walls and $6\frac{1}{2}$ inches at center of tunnel floor, thus making it slightly concave. The

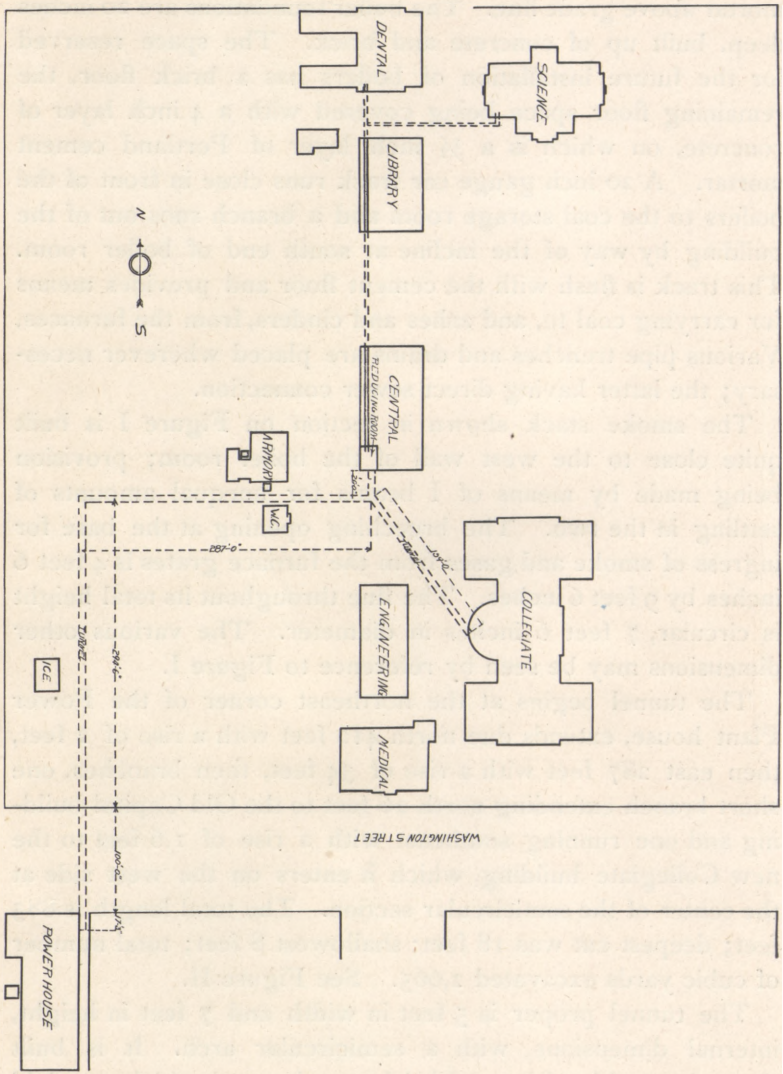


FIGURE II.

floor is covered with a 1/2 inch layer of Portland cement mortar, and is drained by means of a 4 inch tile laid in a 6 inch trench beneath the concrete base, the trench being back-filled with gravel. At different points in the tunnel are anchorage

piers, six in number, built into the foundation and flush with the upper surface of the floor. These piers extend across the tunnel and are about 4 feet long and 2 feet deep. Around the steam main at these points are bolted circular blank T flanges, these being in turn bolted to the anchorage pier by four bolts about 2 feet long, thus providing an immovable



PLATE II. IN TUNNEL, LOOKING SOUTH TOWARD POWER HOUSE.

anchorage. The expansion caused by changes in temperature of pipe is provided for by five slide expansion joints, the intermediate pipe resting on roller bearings.

Along the sides of the tunnel at the springing line of the arch, and spaced every 9 feet, are placed cast iron brackets which support a gas main, and also wrought iron bars, $\frac{1}{2}$ inch by $1\frac{3}{4}$ inches, shaped to the arch, and fitted with insulators for carrying the electric wires. At short intervals connections are made for incandescent lights and also for gas jets.

Plate I is a view of the power house and smoke stack.

Plate II shows a cross sectional view of tunnel and contents.

Plate III shows the engines and dynamos of the Power Plant.

Plate IV is from a photograph and shows the fittings in the tunnel at the point where it branches near the Old Capitol.

Plate V presents the pumps and water heaters.

The fan and motor rooms are located in the basement of the new building, on the west side in the semicircular portion. The fan room is located centrally, having a motor room in direct connection on both north and south. The

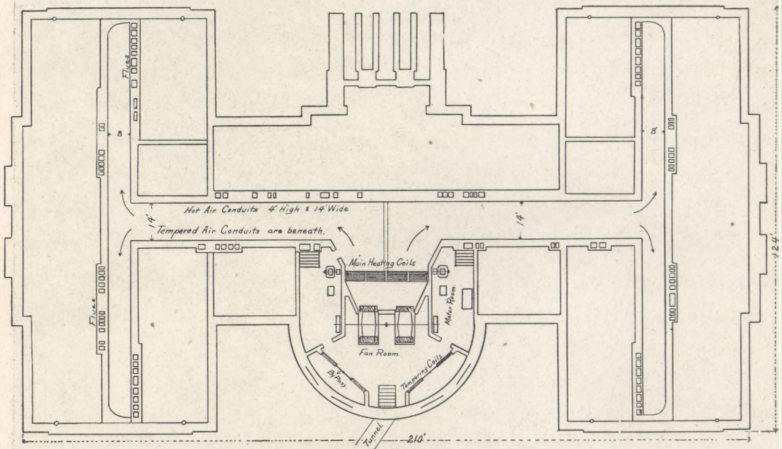


FIGURE III. SUB-BASEMENT PLAN.

entrances to motor rooms are by iron stairways direct from main basement corridor. An iron stairway also provides exit from the fan room on the west, under which stairway is the tunnel entrance previously mentioned. See Figure III.

In the front walls of the fan room are situated the tempering coils and by-pass dampers. The fans are located in the rear center of the room, discharging directly into a tempered air chamber, bounded on its opposite side from the fans by the main heating coils. The foundations for the two fans are built several feet into the floor, and form a part of the fan housing.

The blast wheels of the fans are ten feet in diameter, and are covered by a steel housing 15 feet in diameter. This

style of wheel, having openings on each side for ingress of air, is styled a blower. The openings in this case are 86 inches in diameter. Each fan has two ten-arm spiders on which are fastened curved blades of steel. The fan shaft is $4\frac{1}{2}$ inches in diameter, and so fixed as to be easily disconnected between the fans in case of the disabling of one, or a desire for reduced capacity. The shaft extends either way into the adjoining motor rooms, and has on each end a 72 inch belt wheel, with 12 inch face, over which runs the motor belt from a 9 inch driving pulley on the motor. Each of these motors requires about 99 amperes at a voltage of 220, and runs at a speed of about 1,000 revolutions per minute. This would give a peripheral speed to the fans of about 4,000 feet per minute, which is guaranteed as sufficient to produce the required changes of fresh air. Each motor is provided with an automatic regulating rheostat and a switch board.

The boilers which supply the steam for heating, for running the engine which drives the dynamos, and also for the pumps, are located in the north end of the main room of the power plant. The present equipment is composed of three 200 horse power Heine Safety Water Tube boilers, 18 feet in length and 48 inches in diameter, with a complement of 92 tubes to the boiler, each tube $\frac{1}{2}$ inch by $3\frac{1}{2}$ inches. The boiler shell is of $\frac{1}{2}$ inch steel with single lap riveting circumferentially and double lap riveting longitudinally, all rivets with 3 inch pitch. Each boiler with castings and fittings weighs about 18 tons. They are tested to 250 pounds pressure and are intended to supply steam at 125 pounds. The water tubes are arranged beneath the boilers in eight rows, all tubes opening into a plate steel water leg at each end, in which are hand holes directly opposite each tube end to provide for cleaning. The water leg is braced by double thread ended stay bolts, which are hollow, and thus permit of a hose and tube combination by means of which the interior around the tubes may be cleaned of ashes, etc., by admitting steam.

The grate has an area of about 44 square feet, and the

flames, before reaching the hood, pass about three times the length of the boiler. This is effected by the placing of fire brick deflecting bridges on the tubes at top and bottom. The total heating surface is about 2,000 square feet to each boiler. The purpose in having three boilers is to hold one in reserve so as to admit of repairs and cleaning.

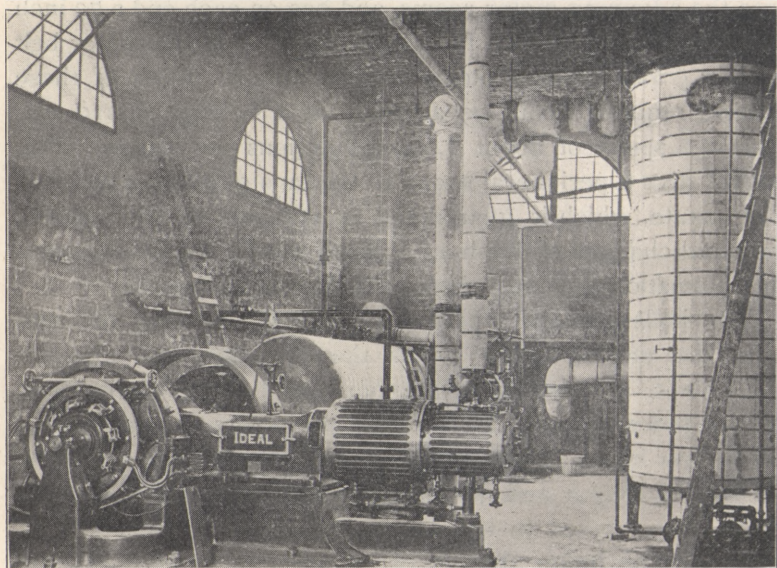


PLATE III. ENGINE ROOM, REHEATER, ENGINE, DYNAMO AND RECEIVER AND ENTRANCE TO TUNNEL.

The steam pipes from the boilers uniting in a header, form a main 12 inches in diameter, which enters the tunnel, where the latter unites with the building. Its position is quite plainly shown on the tunnel photographs. This 12 inch main continues to a point opposite the Old Capitol, where it is divided into four systems, each controlled by its proper valves. One 8 inch pipe continues north to supply steam for the buildings on the north side of the campus, a 5 inch main goes to South Hall, a 5 inch to the Medical building, and a 6 inch continues on in the main tunnel with its supply for the new

building. On entering the fan room this main is raised to near the ceiling, where a 9 inch pressure reducing valve reduces the pressure to 15 pounds. From this a 5 inch pipe supplies steam for the four tempering coils, by dividing into four 3 inch branches, and a 7 inch pipe continues to a point directly over main heating coils. The tempering coils, which

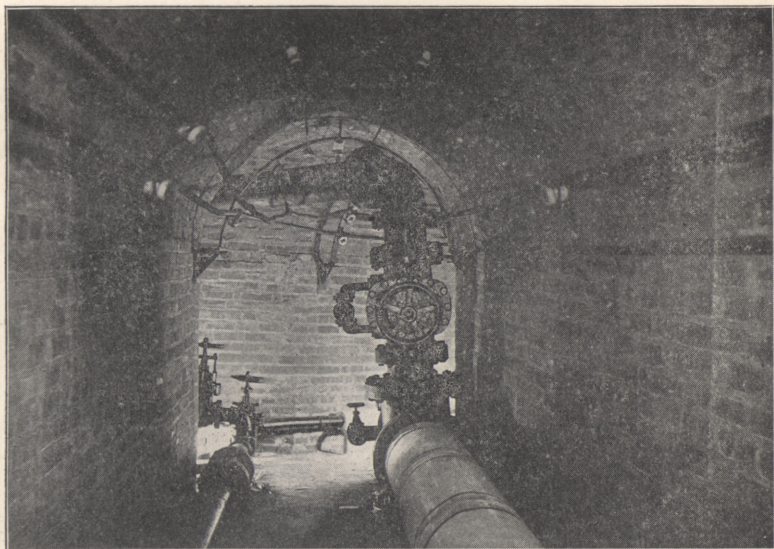


PLATE IV. IN TUNNEL, LOOKING EAST TOWARD BRANCHES TO CENTRAL AND LIBERAL ARTS BUILDINGS.

are situated somewhat to the side and front of the fans, stand on edge on foundations about eight feet high, the lower edge of coils being on a level with the bottom of basement windows. Each coil stands in front of a window, distant about four feet from it, and the cold air entering is sucked either directly through the coils or through the by-pass between them. The by-pass is a vertical door about 4 inches by 8 inches, revolving on its center, and operated automatically by a thermostat regulator. Each tempering coil is about six feet wide and eight feet high, containing six rows of 1-inch pipe, or about 1,700 lineal feet. All these pipes, as well as

those in main heating coils, are tested to 150 pounds pressure. Between the pipes of each coil is a free area of 13,000 square inches for the influx of air. Each coil is divided into two sections—the two rows of pipes in rear constituting one section, and the four rows nearer to the fan the other. The latter is operated by an automatic valve controlled by a thermostat placed in the tempered air duct. These thermostats are set so that the one operating the by-pass damper will open at about 60° , and should the weather be such that this would not keep the temperature below 65° , then the other thermostat will cut off the steam from the coil, thus preventing the over-heating of the tempered air.

The main heating coils stand about eight feet in the rear of the fans, and form one side of a room about 24 feet long by 14 feet high and 8 feet wide, the fan openings being in opposite wall. The four main heating coils stand on edge on a foundation about 5 feet high, through which foundation are four openings about 4 feet square, fitted with doors swung at the top, and controlling the entrances to the tempered air conduits, which are directly under the hot air conduits and separated from them by an air tight fire-proof floor. Standing on their edges each of the main heating coils presents a front of about 6 feet in width by 8 feet in height, and a rear depth of fourteen rows of tubes, divided into four sections, the section closest to fan containing two rows, and the other three sections four rows each. Thus we see that the fans force tempered air through a labyrinth of coils presenting a front of 6 feet \times 24 feet and fourteen rows deep, containing about 26,000 lineal feet (nearly 5 miles) of 1 inch pipe, or a heating surface of approximately 6,800 square feet.

The steam supply for these coils comes, as has been previously stated, from a 7 inch main directly above. This main enters a header from which lead a 6 inch main for direct radiation, and four 4 inch pipes, each controlled by an automatic valve. Each 4 inch pipe then enters a header and divides again into four $2\frac{1}{2}$ inch pipes, these going directly to the entire width of the four coils, and supplying a definite

section of each main coil. Thus if valve No. 4 is closed the rear section consisting of four rows of pipes in each of the four coils is shut off; if valve No. 3, the section of four rows just in front of the rear section, and so on. The steam enters at the bottom of each section at 15 pounds pressure. The return is connected to base of coil by a $1\frac{1}{4}$ inch drip with $1\frac{1}{4}$ inch swing check. From each coil the return then enters a 4 inch

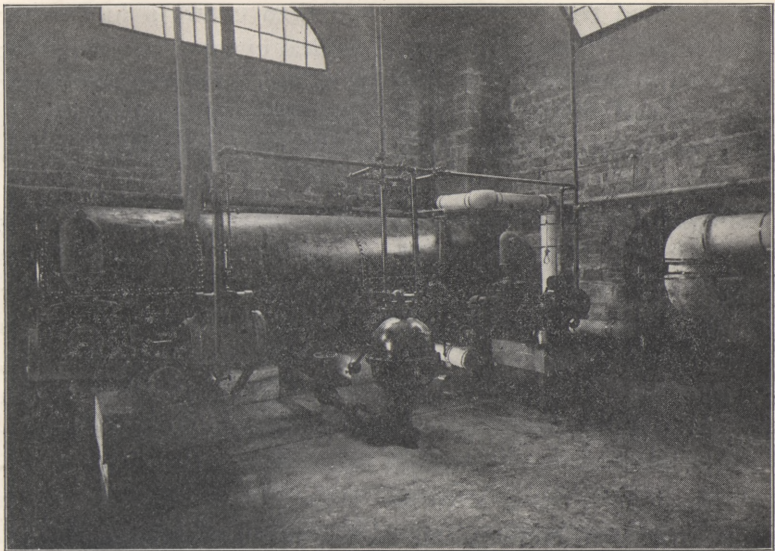


PLATE V. ENGINE ROOM, SHOWING PUMPS AND RECEIVER, AND ENTRANCE TO TUNNEL.

steam trap discharging into a 3 inch main, which proceeds directly to the mouth of the tunnel, near which point the return from the tempering coils enters by a $2\frac{1}{2}$ inch steam trap.

In addition to this heating by indirect radiation, certain rooms and corridors will be heated by radiators directly, steam being supplied to these from the 6 inch branch which continues from the 7 inch main above main heating coils. There will be in all thirty-nine radiators, varying from 30 to 144 feet to each radiator. These are also regulated by auto-

matic valves. The return from these radiators joins with that of the main and tempering coils and flows by gravity back through the tunnel in a 5 inch main. On reaching the north room of power house it enters a horizontal cylindrical receiving tank 5 feet \times 16 feet. From here it is pumped by two 6 \times 10 \times 12 steam pumps, regulated by a Kieley Positive Acting Pump Governor, through a main having connection with city water, by which the loss experienced by the steam in its round trip is made up, and then enters a feed-water Heater and Purifier, which is a vertical cylindrical tank about 4½ feet \times 12 feet. Here the feed-water is further heated by the exhaust from the engine which drives the dynamos. It then enters the boilers and is again vaporized and sent on its round trip.

Following the air in the same way, we find that on coming through the windows in the rear of the tempering coils at various temperatures, it goes either through these coils or through the by-pass as may be desired and regulated. It is then drawn into the fans, blown into the chamber in the rear, and there forced as desired in part or in whole either through the four large by-passes under the main coils into the tempered air conduit, or through the main heating coils themselves, into the hot air conduit. If the air is sufficiently warm as it enters the building, the valves on all coils are closed and the fresh air fanned through without any further heating. If it is very cold all by-passes are closed, the valves opened, and the air forced through all the heated coils before reaching the rooms. Between these two extremes, by means of the various automatic valves each controlling a certain section, any modification in temperature can be provided for.

The situation of fans, motors, air compressor, tempering and heating coils, conduits, flues, etc., is shown on the sub-basement plan. The hot air conduit is about 4 feet high, and immediately under it is the tempered air conduit about 3 feet high. In the sides of these passages are the openings to the flues leading up to the various rooms. Each flue has two openings one from the hot air, and one from the cold air

passage. At the junction of these openings there is placed what is known as a double mixing damper, a combination of two dampers so arranged and regulated by a thermostat in the room which the flue enters above, that either the hot or the cold air passage is open as the case demands. Figure IV

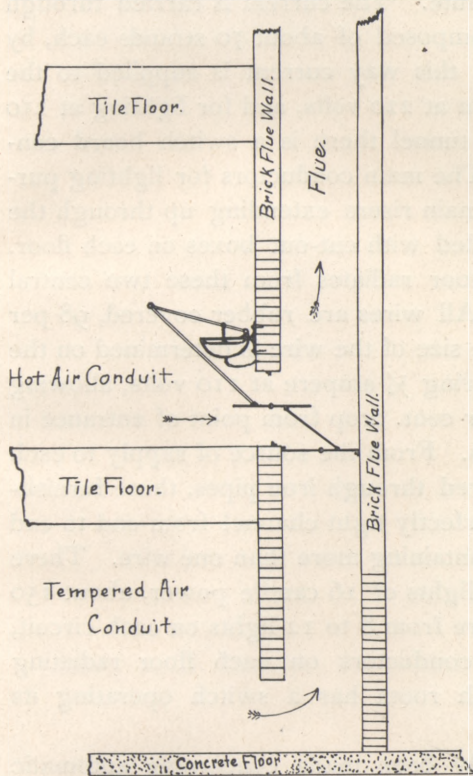


FIGURE IV.

shows a section through the automatic valve operating attachment. Deflecting dampers are placed at the register above to provide an even distribution of air throughout the room.

At the bottom of the light court near the south center of the building, is placed a Sturtevant full housing steel plate exhaust fan, 3 feet in diameter, with a 28 inch inlet, and 23 inch outlet. The inlet has connection, by means of foul air ducts, with the general and private toilet rooms, discharges the foul air drawn from the same into a large vent stack,

which passes directly out of the roof, and whose outlet is controlled by a pivoted damper operated from the motor room. The fan is run by a direct connected motor of about four horse power capacity, controlled by an automatic starting rheostat, so that the speed can be regulated between 300 and 500 revolutions per minute. It has also an automatic device for cutting out the motor when the current is cut off at power house.

The current supplied to these various motors is generated at the power house by two Sturtevant dynamos direct connected to a 125 horse power Ideal engine, a high speed tandem compound of the latest make. Each dynamo furnishes 346 amperes at a voltage of 110, number of revolutions about 290 per minute. The current is carried through the tunnel on cables composed of about 70 strands each, by the 3 wire system. In this way current is supplied to the motors for fan propulsion at 220 volts, and for lighting at 110 volts. On leaving the tunnel there is a switch board controlling all the wires. The main conductors for lighting purposes branch into two main risers extending up through the building, and are provided with cut-out boxes on each floor. The wiring on each floor radiates from these two central points of distribution. All wires are rubber covered, 98 per cent. pure copper. The size of the wire is determined on the basis of each lamp requiring $\frac{1}{2}$ ampere at 110 volts, allowing for not to exceed a 2 per cent. drop from point of entrance in building to farthest lamp. From the source of supply to each outlet the building is wired through iron pipes, these furnishing a continuous and perfectly tight channel from end to end of wires, with no tube containing more than one wire. There are approximately 600 lights of 16 candle power, about 150 on each floor. There are from 8 to 12 lights on each circuit, necessitating about 15 conductors on each floor radiating from main risers. Each room has a switch operating its ceiling lights.

Mention has frequently been made concerning automatic valves and dampers regulated by thermostats, concerning which a short description may be interesting. The thermostat consists of a compound strip of brass and steel, and a small double valve. The mechanism is provided with an index by which it is set to operate at any reasonable temperature, and can be so accurately adjusted that it will operate on a variation of one degree. The compound strip of brass and steel contracts and expands as the temperature falls and rises, thus opening and closing the double valve. This valve

controls the flow of compressed air through a system of concealed armoured lead tubing, to and from the valves where the heat is controlled. This armoured lead tubing is about $\frac{3}{8}$ inch exterior diameter and $\frac{1}{8}$ inch interior, wrapped strongly with wire and tested to 30 pounds pressure. In the whole system there is about $3\frac{1}{2}$ miles of this tubing. The valves work with a pressure of 15 pounds per square inch, or a total pressure on a 7 inch valve of about 575 pounds. The air is compressed by a steam compressor in the south motor room. This is run by about 50 pounds steam from the main pipe and stores the compressed air in a strong steel reservoir of about 100 gallons capacity. The regulating diaphragm valve has an umbrella shaped top, about 6 to 8 inches in diameter, which is provided with a flexible diaphragm. When the action of the compound strip opens the double valve in the thermostat, the compressed air enters the top above the diaphragm and closes the valve, thereby cutting off the steam supply. When the room has cooled a degree or so, the action of the thermostat is reversed, the flow of compressed air is cut off, and the valve is allowed to open and admit steam. All these operations are perfectly noiseless. The mixing dampers are controlled in much the same way as is indicated in Figure IV.

The following is a schedule of rooms with their fittings:

Floor	Rooms	Thermostats	Dampers	Valves
Basement	19	19	19	4
First floor	22	22	23	7
Second floor	28	29	31	7
Third floor	21	21	21	3
Heater coils		4		4
Tempering coils		4		4
By-pass damper		2	2	2
Total	<u>90</u>	<u>101</u>	<u>96</u>	<u>31</u>

The delivery of air on each floor is intended to be approximately as follows:

Basement	24,000	cubic feet	per	minute.
First floor	25,000	"	"	"
Second floor	24,500	"	"	"
Third floor	26,500	"	"	"

A total of 100,000 cubic feet per minute.

The heating apparatus is put in under the following guarantee:

First. That it will deliver the air as scheduled above.

Second. That all defects in work or materials will be made good for a period of two years.

Third. That the coils will heat the entire building with a steam pressure of 5 pounds, and will operate in the coldest weather without snapping or pounding.

Fourth. That the plant will heat the entire building to a temperature of 70° when the weather outside is 20° below zero.

Fifth. That the system will control the temperature of rooms to within 1° either way of the point at which the thermostat is set.

Sixth. That the contractor has full authority and permission from the proper parties for the installation of this special heat regulating system.

The following are contract prices for the various constructions:

POWER PLANT.

Excavation, 2,240 cubic yards @ 27½c	\$ 616.00
Concrete footings, 55 cubic yards @ \$6.65	352.45
Stone footings, 42 cubic yards @ \$7.60	319.20
Rubble walls, 870 cubic yards @ \$6.40	5,568.00
Cut stone	700.00
Drain tile	90.00
Brick arches	650.00
Concrete arches	450.00
Plastering walls to grade outside	80.00
Steel I beams	750.00

10 roof trusses @ \$50	\$ 500.00
10 coal doors @ \$50	500.00
Wood work on roof	550.00
Steel and copper	650.00
Frames, sash, etc.	325.00
Painting	125.00
Cement and concrete floor	600.00
Brick floor	40.00
Car track	65.00
Total	<u>\$12,930.65</u>

SMOKE STACK.

Excavation, 163 cubic yards @ 35c	\$ 57.05
120 M brick @ \$16	1,920.00
Iron top	105.00
Cut stone	235.00
Stone work above grade, 92 cubic yards @ \$7.60	699.20
Stone work to grade, 33 $\frac{1}{3}$ cubic yards @ \$7.60	253.30
Concrete, 30 cubic yards @ \$6.65	199.50
Stone footings, 43 $\frac{1}{4}$ cubic yards @ \$7.60	328.70
Total	<u>\$3,797.75</u>

TUNNEL.

Excavating and filling, 2,665 cubic yards @ 28 $\frac{1}{2}$ c \$	\$ 759.50
Concrete, 158 cubic yards @ \$6.65	1,050.70
Brick work, 216 M @ \$11.40	2,462.40
Cutting through old walls	150.00
Drain tile	59.00
Total	<u>\$4,481.60</u>