ILLUSTRATING THE

Heating, Ventilating and Power Plant

FOR THE

Carnegie Library Extension

PITTSBURG, PA.

AS DESIGNED AND ERECTED BY

BAKER, SMITH & COMPANY, Inc.,

NEW YORK AND PITTSBURG

Mechanical Equipment of the Carnegie Library Building Extension, Pittsburg, Pa.

The Carnegie Library Building, at Pittsburg, is being greatly enlarged and extended, for the accommodation of the increased requirements of the library and the educational institute, and to provide for the addition of museums, art galleries and a large hall of architecture and sculpture. The original library buildings and the music hall, which were built in 1893-5, are retained, the extension forming an enlargement which harmonizes in architectural treatment and proportion, and makes it the largest educational institution of the kind in the world. The extended structure occupies a ground plan of about 440 x 660 ft., and has a total floor space of over 15 acres. For the operation of the mechanical equipment of the building there is provided one of the largest power plants that has been installed in a public building in this country, which supplies over 30,000 incandescent lamps, power for over 500 h.-p. in motors, and steam for heating an interior volume of nearly 14,000,000 cu. ft. The architects are Alden & Harlow, of Pittsburg, and the plant will be under the direct supervision of Mr. C. R. Cunningham, superintendent of the building.

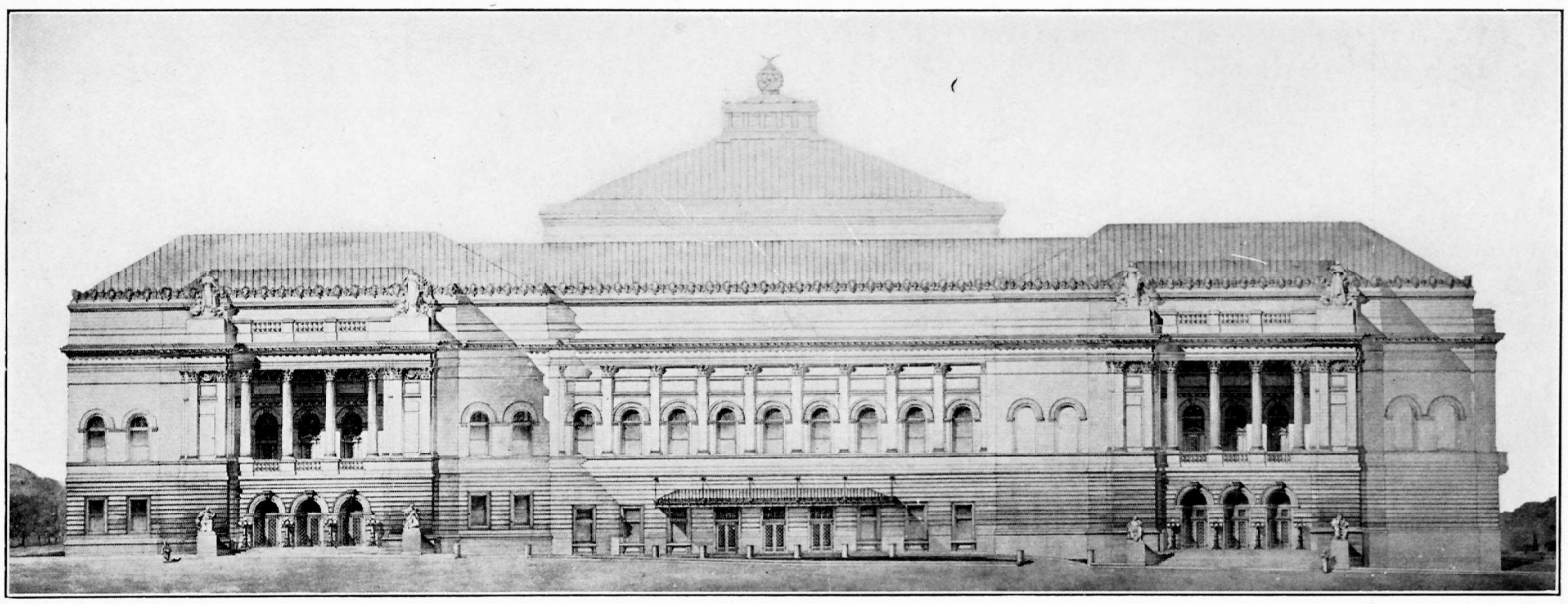
The original Carnegie Library Building was a three-story stone structure, 150 x 250 ft. in plan, located in Schenley Park, in the residential center of Pittsburg, and attached to it on the Forbes St. front was built the Carnegie Music Hall, the two combined forming a structure 150 x 375 ft. in plan. In 1900, a large sum of money was donated by Mr. Andrew Carnegie for the purpose of making needed extensions to the library, and subsequently the scheme was extended to include a number of important departures in the addition of museums, art galleries and a hall of architecture and sculpture. As the site of Schenley Park offered ample facilities for expansion, it was decided to enlarge upon the same site extending eastward from the older building. The original structure forms a part of the west side of the new building, which surrounds the former on the Forbes St. and east sides.

The combined building occupies a ground plan of irregular shape with maximum dimensions of 440 x 660 ft., and is, for the greater part, three stories in height, excepting in the book stack section which has eleven floors. It is of stone construction with pleasing treatment architecturally, and has steel and concrete interior construction for fireproofing, little combustible material having been used. The interiors are high, ceiling head room ranging from 14 to 75 ft. All rooms are well lighted, unusual amounts of window area having been installed.

In providing for the mechanical plant of the extension, it was thought advisable to replace the equipment of the original library by a new and more modern installation of sufficient capacity to operate the service of the entire building, as by centralization it was evident that a maximum of economy could be obtained with a minimum of attendance and difficulty of operation. It was further evident that, from the immense size of the building, a power plant of unusual size would be required, a suitable location for which would be difficult to find. Further, owing to the important character and value of much of the contents of the building, it was desirable that the power plant be located at a distance, if possible, which requirement was most advantageously provided for by a ravine or gulley conveniently located nearby, in which a boiler house building could be located, almost entirely concealed from the library building. A site was accordingly secured there for the plant, and piping connections for steam supply to the main building were provided by a tunnel 500 ft. long, cut through solid rock underneath the building directly to the machinery section of the basement. With this arrangement, the disadvantages of steam generating equipment and the handling of fuel with resulting dust and dirt are removed effectually from the building, while the distance is not sufficient to render piping connections difficult.

The mechanical equipment of the new building is of the most complete order, involving electrical generating, heating and ventilating, refrigerating, elevator, vacuum sweeping, and air compressing apparatus, all of which is, on account of the size of the building, of large capacity. Power is also required for the steam cooking equipment of the kitchen of a restaurant contained in the building, and for the operation of an extensive book bindery and printing establishment for the library, the latter having two linotype machines and a large cylinder press. One of the most interesting and important portions of the mechanical equipment, is the heating system, which is of unusual magnitude, and involves some unique features.

Heating Systems.—The heating of the building has been provided for throughout by direct radiation, the equipment of which has been de-



Front View of the New Carnegie Library Extension, Pittsburg, Pa.

[illegible] a genero[illegible] treme conditions. V[illegible] has been most extensi[illegible] fresh air supply and exhau[illegible] air supply is tempered only, a[illegible] ception of the music hall, no atte[illegible] at heating on the indirect system. The[illegible] system has been proportioned upon the the[illegible] unit system, the distribution of radiation depending entirely upon the exposure of the various rooms. Unusual conditions were introduced by the enormous amounts of skylighting over nearly all sections of the building, which, in some cases, constitutes the only exterior exposure. The design of the system provides for maintaining the usual average temperature of 70° Fahr. throughout the building during zero weather; but, in fact, there is sufficient reserve capacity to accomplish these results with outside temperatures considerably below zero.

The direct radiation and the air tempering coils of the ventilating equipments are operated with steam at atmospheric pressure from the exhaust system of the extensive power plant, the Webster vacuum system of steam circulation having been installed. Owing to the immense size of the building embracing a floor space of over 600,000 sq. ft., an enormous equipment of heating surface was required, amounting to over 50,000 sq. ft. of direct radiation, and the steam supply and return piping systems are likewise of great magnitude. The steam supply system consists of nine distinct supply mains which originate at two points in the exhaust steam system in the power plant, namely, at opposite ends of the engine room. Three of these mains, two of which are 16-in. lines and the other a 12-in. line, are devoted solely to the supply of steam to tempering coils of the ventilating systems, which are concentrated at three distinct portions of the basement of the building. The remainder, which embraces one 10-in., one 8-in. and four 6-in. lines, deliver to distributing mains which encircle the outside wall lines of all portions of the building for the supply of heating risers to radiation upon the upper floors. The general arrangement of these mains and the branch connections supplying heating risers, is shown in the accompanying basement plan of the building. These supply and distributing mains are carried upon the ceiling in the basement, graded with the flow of steam and drained to trap relief connections at all pocket points, and all heavily covered with 85 per cent. magnesia pipe insulation covering, with canvas jacketing. Owing to the length of some of the large supply mains pro-

expansion were made by U-loops in- at points midway between anchorages, although in most cases, right-angle turns in the pipe lines, made through long radius bends, provide for ample expansion and contraction.

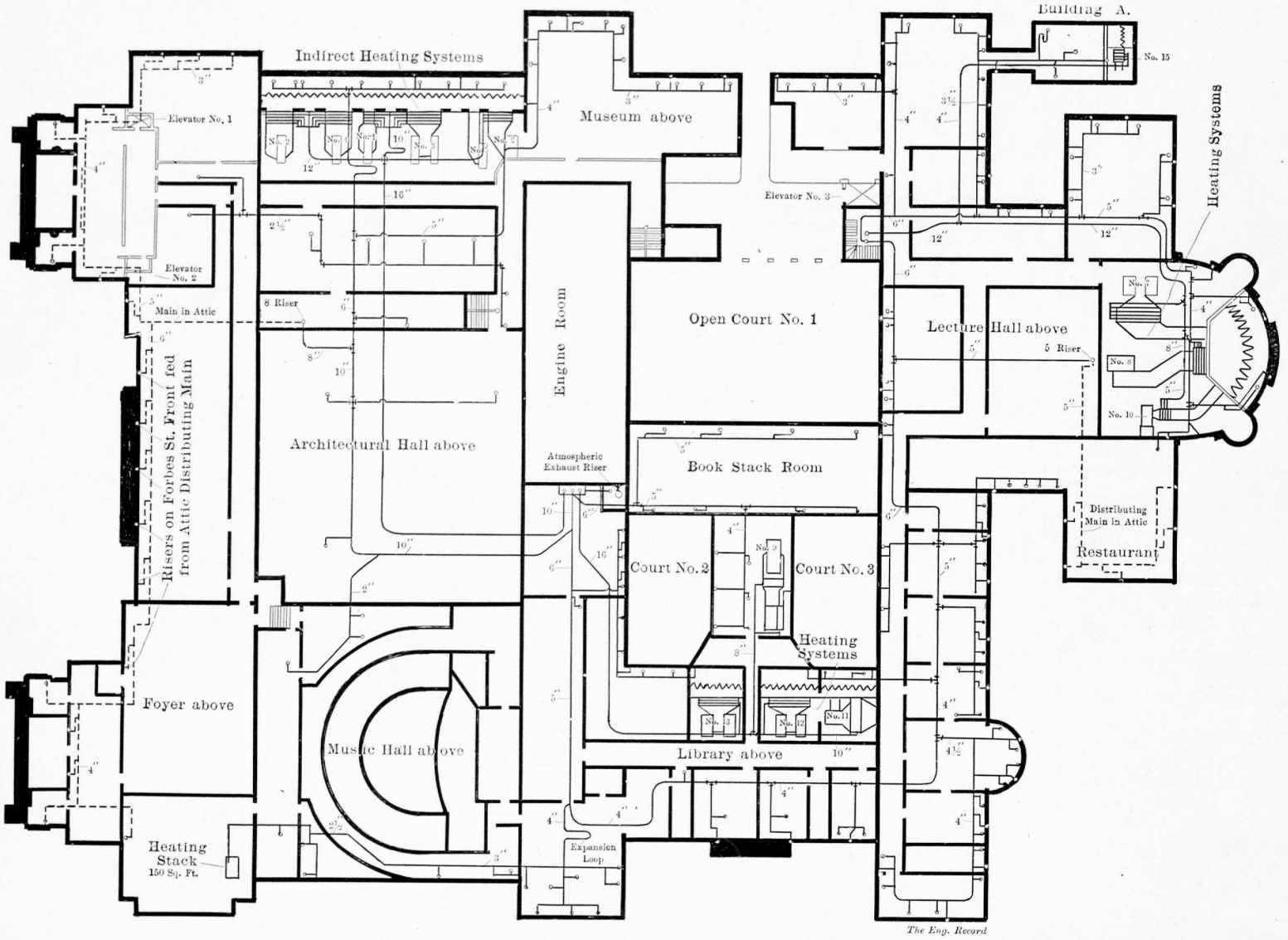
There are in all 116 riser lines carried up for the supply of 36,545 sq. ft. of radiation upon upper floors, which range in size from 1¼ to 2½-in. pipe, and supply amounts of radiation varying from 42 to 972 sq. ft. each. They all have drainage connections at their lower ends and are anchored at the base, expansion being provided for upwards. All risers are concealed in chases in the wall construction. Branch connections from the risers to radiation connections are made under the floor in practically all cases, provision for expansion being made by swivel joints. The branch supply connections to the radiators have been fitted in the following sizes: Radiators up to 40 sq. ft. of heating surface, through ¾-in. branches; from 40 to 90 sq. ft., 1-in. connections; from 90 to 160 sq. ft., 1¼-in. connections; from 160 to 250 sq. ft., 1½-in. connections, and all larger sizes by 2-in. supply connections. The return connections are in all cases of ½-in. pipe, except on radiators of more than 250 sq. ft., where ¾-in. returns are used.

The arrangement and distribution of direct radiation was largely the result of conditions of window exposure, all portions of the buildings with exterior windows having in general radiators located underneath them. In the art galleries, the architectural and sculpture halls and other rooms without side window lighting, Bundy circular radiators are distributed in central portions of the floor, by which arrangement both the skylight exposure and the side wall heat losses were counteracted in the most advantageous manner. In rooms with skylighting, special coils were installed to counteract the cooling effect of the exposed glass surface. Special conditions are introduced in these sections by the location of domed lights underneath the main skylighting so that between the domed lights and the skylights there are enclosed air spaces which are effective in reducing largely the heat losses that would otherwise occur through the glass. The skylight coils are located above the domed lights so as to entirely surround the main skylights at the edges, and they were designed with ample capacity for maintaining those enclosed air spaces at sufficient temperatures to prevent serious heat losses from the rooms below through the domed lights. The result of this arrangement has been that in the art galleries, the architectural hall and the hall of sculpture, there is practically no exterior exposure (there being no side window lighting), and very small amounts of floor radiation were installed.

Bundy standard radiators varying from 26 to 48 in. in height and fitted with Jenkins radiator valves on the supply and Webster thermostatic relief valves at the return end, have been installed in the building. The return connections are ½ in. on all radiators up to 250 sq. ft., all larger than this having ¾-in. return valves and connections. The Bundy circular radiators used in the large rooms were resorted to where owing to the absence of side window lighting and the use of the side walls for the exhibition of works of art, the installation of radiators at the side was prohibited. All of the skylight coils are provided with drip pans of 22-oz. copper suspended below them, which have drainage connections to the basement to carry off possible leakage.

All radiation is operated with the Webster vacuum system of steam circulation, which system is particularly well adapted to the conditions of an extensive building plan, with condensation to be returned considerable distances to a central point. The supply mains are paralleled throughout the building by return mains for the vacuum return system which connect with return risers leading to radiation upon the upper floors. There are 114 return risers to the upper floors, into which the Webster thermostatic relief valves on the radiators discharge, of which risers all but nine are of ¾-in. pipe; four of the latter are 1-in. lines and five 1¼-in. lines. The return lines lead to a return header in the engine room in the sub-basement, from which the air and condensation is pumped by a duplicate equipment of vacuum pumps, returning the water to the boiler-feed system, as will be referred to in the description of the power-plant equipment. These pumps deliver first to a 3x6-ft. steel-plate tank with 4-in. vapor connection leading above the roof, by which air and vapor is separated and removed. The condensation flows thence by gravity to the open feed-water heater, from which the boiler-feed pumps at the boiler house take suction.

All of the radiation installed is under automatic temperature control, for which the Johnson system of temperature regulation is used. In the principal rooms, large groups of radiators are operated from a few thermostats placed in representative locations to indicate average temperatures, while in the various smaller rooms a single thermostat is usually installed which controls all the radiators provided for their heating; in some cases as many as ten and eleven radiators are controlled from a single thermostat. In an air-supply



Basement Plan Showing Arrangement of Steam Mains for Heating System.

delivery connection to a smoking room underneath the foyer, there is a reheating coil installed for indirect heating, as here radiators were prohibited, and this coil is controlled from a thermostat so located as to indicate average temperatures in that room. There are in all 333 thermostats installed in the building, which together control a total number of 646 heat sources, including both direct radiation and tempering coils. The thermostats are of the standard Johnson pneumatic type, which control the radiation by pneumatic pressure acting through the usual diaphragm steam valves on the supply connections of the radiation. The pneumatic pressure is supplied at about 15 lb. by an air compressor equipment in the engine room, the air supply being distributed to the thermostats throughout the building by a system of wrought-iron piping with armored lead tubing for branches to the thermostats and for connections from thermostats to the diaphragm valves.

A special feature was introduced in the installation of thermostatic control, in the use of push-button control for skylight radiation in some of the larger rooms of the building. In rooms 362 and 364, large class rooms on the third floor at the rear of the building, the skylight coils are thus controlled, a double push-button switch in the former controlling three skylight coils and in the latter a single push-button controlling a single skylight coil. In the control of the tempering coils of the ventilating systems, each of the heating stacks is controlled in two sections, one by a thermostat located in the cold-air duct, and the other by a thermostat located in the delivery connection.

Ventilation.—Owing to the free public use of the Carnegie Library Extension, mechanical ventilation has been provided in all parts, and the apparatus, having been designed for conditions of maximum occupancy, is an equipment of great magnitude. In fact, it is one of the largest installations of ventilating fans ever placed in a single building, having an aggregate capacity of over 600,000 cu. ft. of fresh air per minute, and similar capacity for exhaust ventilation. To avoid excessively large units and properly sectionalize the equipment, the fresh-air apparatus has been arranged in fifteen stations, having nineteen fans, and the exhaust equipment in twenty-one stations with thirty fans.

The ventilation is independent of the heating throughout the building, the fresh air supply systems being designed to deliver air tempered only to the normal temperatures of the rooms supplied. The heating is accomplished by direct radiation throughout. In only one instance is this arrangement departed from, namely, in the music hall, where it was thought desirable to provide in the fresh-air supply system sufficient radiation to permit indirect heating if it should be convenient. In the music hall section the building arrangement is such that there is little exterior wall exposure requiring heating to counteract the cooling effect, this division being almost entirely surrounded by other sections of the building, and the purpose of this indirect heating equipment is rather for quickly raising the temperature in the hall prior to occupancy than for general heating. In another instance, also, a smoking room underneath the foyer has been equipped for indirect heating by a reheater stack in the fresh-air delivery duct supplying that room; this arrangement is due to limitations of space in the smoking room, by which radiators were prohibited. An incidental advantage of this independence of the heating and ventilating systems is that while the fresh-air supply systems are not intended for indirect heating, the tempering coils in all of them are of sufficient capacity to provide satisfactory heating of the building in moderate weather, in case of possible derangement of the direct radiation system.

Fresh Air Supply.—Fresh air is supplied to the building by nineteen centrifugal blowers, arranged for convenience in making duct connections in three general divisions. One division includes systems 1 to 6 in the northeast corner of the basement under the museum; the second comprises systems 7, 8 and 10 underneath the lecture hall, and the third division embraces systems 9, 11, 12 and 13 underneath the library division. Even with this distribution of the various equipments the connections in some cases are over 500 ft. in length; in general, however, a convenient workable installation was secured. In two cases isolated fan systems were necessary, one system 14 in the attic to supply the reading room, and the other system 15 in building A, a small extens[ion] of the museum at the southeast corner, to provide for alcoholic specimens, which, owing to fire risk, it was thought desirable to isolate from the remainder of the building. The arrangement of these systems and the enormous systems of duct work is illustrated in the accompanying basement plan.

The group of fans for systems 1 to 6 occupies a 50 x 130-ft. space in the northeast corner of the basement, where nine large outer windows provide for the air in-take. The entire outer portion of the room, 14 ft. in width, is devoted to one large continuous air filter, through which all the fans have a common in-take. Immediately within the filter enclosure are the seven fans in a continuous row, with their in-takes from the filter chamber containing tempering coils. Five of these systems have single fans, driven by direct motors, and one system has two fans, driven by one motor. All six have three-quarter housed steel-plate fans with discharge outlets under the floor in all cases, thus providing ample head room unobstructed by overhead duct work.

The second group for systems 7, 8 and 10 occupies the greater portion of an 80-ft. square room in the basement in the south end of the building. In the outer circular portion of this room is the filter chamber, having two large windows for the cold air inlets, and a large air filter of the usual staggered-frame cheesecloth type. Owing to a less convenient arrangement of the fans in this room, in-take connections of considerable length were necessary, two of which are galvanized iron ducts carried above the floor and the other an underground flue. Similarly, two of these systems have overhead galvanized iron delivery ducts, while the third has an underground connection to a flue in a nearby wall.

The third group of fans, for systems 9, 11, 12 and 13, is located underneath the library section of the building. Equipment 9 is in the basement of the wing connecting the old section of the library with the new book stack section, which it supplies, while the remaining three are underneath the old section of the building. This latter room is 32 x 86 ft. in size, and has several window openings into interior court 3 for the fresh air

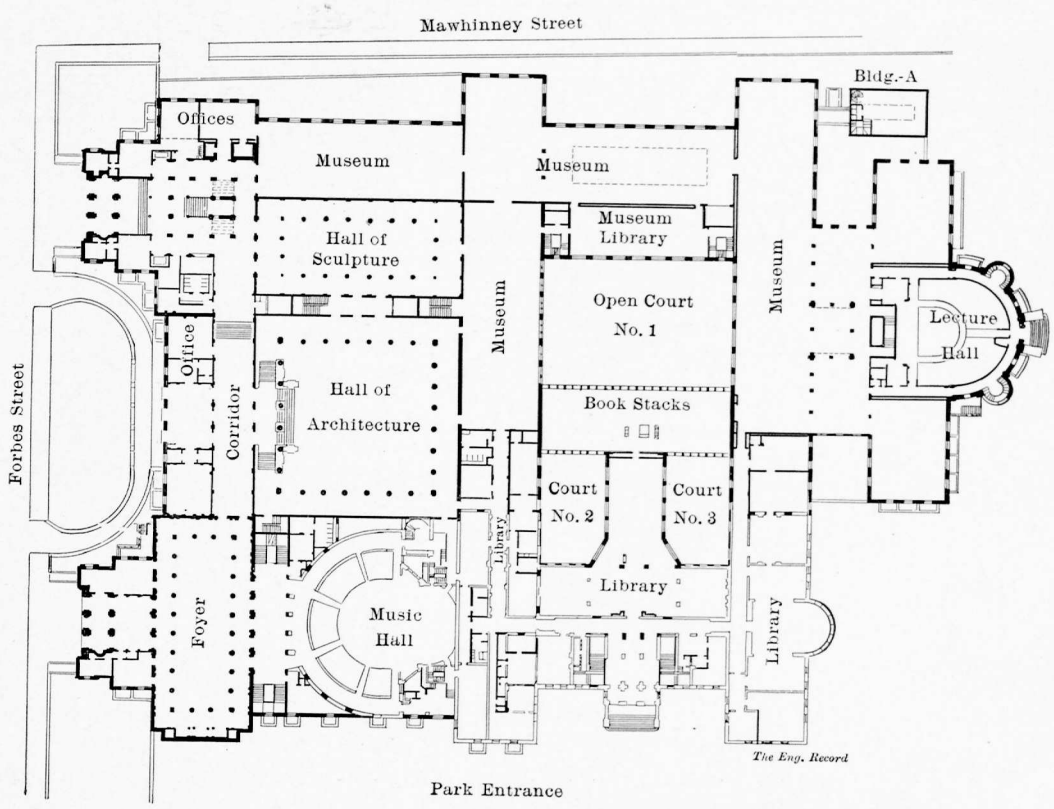


Diagram of Carnegie Library Showing Arrangement of Interior.

upply. The fans are arranged in a row in the center of the space adjacent to a long filter rack at the outer side of the room, similar in arrangement to that of the first group. This filter chamber is 12 ft. wide and continuous throughout the length of the room, and from it the fans have intakes through short direct ducts containing tempering coils. The delivery connections are through overhead ducts in systems 11 and 12, while those of systems 9 and 13 are underground. Systems 9, supplying the book-stack section of the building, is fitted with an air-wash equipment to cleanse the air before delivery to the book storage. For this reason the cheesecloth air filters are replaced by an air-wash spray chamber, eliminator and necessary tempering and reheating coils.

Air Cleansing.—The air filters are all of the usual cheesecloth type with frames mounted in zigzaged racks to secure the maximum area of filtering surface. The large filter for the first division of fans has 164 frames and a total filtering area of 5,412 sq. ft. The filter for systems 7, 8 and 10 has 80 frames, and a total net filtering area of 2,400 sq. ft. The filter for systems 11, 12 and 13 has 97 frames, and a total net filtering area of 4,655 sq. ft. The isolated equipments of systems 14 and 15 have filters of 450 and 175 sq. ft., respectively. The areas of these filters are proportioned for velocities of 30 to 45 ft. per minute, with the exception of the large filter for the first group, which, owing to its size and the improbability of all its fans being operated to full capacity at the same time, is designed for a maximum filtering velocity of 50 ft. per minute.

The filters have substantial wooden frames with exterior dimensions of 3 x 11 ft., and are covered with copper wire netting to support the cheesecloth. The frames are supported by galvanized steel framework fitted tightly to the floor and ceiling, and fixed in place by fastenings which enable them to be readily replaced, a large number of extra frames being provided for use while cleaning those which have been in service. A feature of the chamber arrangement is the use of rolling shutters for cutting off the in-take supply to any fan in case it is out of commission temporarily. The in-take openings in the filter chamber partition are fitted with Wilson rolling shutters which close tightly and prevent recirculation from the fan chamber back into the filter room.

The air-wash equipment for system 9 was considered preferable to the usual type of filter for air to be delivered to rooms in which books are stored. It was thought that in this way dust could be most effectively kept out, and at the same time the humidity maintained more nearly uniform, two important factors in the preservation of books. The equipment consists of a spray chamber, an eliminator for separation of entrained particles of water from the air, and the two sets of tempering coils, one to raise the temperature of the entering air above freezing point in very cold weather, and the other for tempering the air delivery to the desired temperature. The spray chamber contains nozzles spaced close together in staggered rows, in order to deliver a continuous sheet of spray at right angles to the line of flow of the air, the result of which is that all the air is brought into intimate contact with the spray and thoroughly cleansed. The nozzles are of the side outlet type, but have attachments by which they may be opened for a direct stream to clear out any possible obstructions; the levers operating these nozzle openings are operated by handles outside of the casing. The spray chamber casing has a cross-sectional area of 100 sq. ft., so that at the full capacity of this system, the velocity of the air through the spray is not over 10 ft. per second.

The eliminator, located between the spray chamber and the fan in-take, separates any particles of water which may be carried along mechanically by the passing air. It consists of a number of rows of inclined baffle plates, made up of vertical strips of sheet copper 6 in. wide, with hook edges on the sides toward the fan to engage the particles of water coming in contact with the strips. The eliminator has a free flow area slightly less than that of the spray chamber, to cause an increased velocity of flow during the separating action. The base of the eliminator chamber is inclined toward a drip pan below it to which drainage from the baffles flows readily. The water for the nozzles is used over and over continuously until it becomes dirty. It is circulated by a small motor-driven centrifugal pump having a capacity of 470 gal. per minute, which has an in-take through a series of coarse and fine screens and a 5-in. suction, and delivers to the nozzles through a 4-in. line. The motor is of 5-h.-p. capacity and runs at 500 r.p.m.

Fans and Coils.—The supply fans are all of the Sturtevant steel-plate centrifugal type of the dimensions and capacities indicated in the accompanying table, and the greater part have three-quarter housings with steel bottom pans. Their casings are No. 10 B.W.G. gauge steel plate heavily braced, and have carefully balanced blast wheels with curved floats of No. 12 steel plate mounted on cast-iron spiders. They are in all cases driven by C. & C. slow-speed multipolar motors, operated from 220-volt power circuits. The motors are direct-connected to the fans through flexible couplings and are fitted for a speed range of from two-thirds to full speed through field control. They are controlled through combined starters and speed control rheostats, operated by a single lever, but no resistance is used except for starting purposes. These controllers are all fitted with no-voltage release and overload circuit breakers.

Heating coils have been fitted to all but one of the supply systems for tempering the fresh air in cold weather. The system supplying the engine room is not thus equipped as, owing to the heat given off by the steam-using machinery, cold fresh air only is needed for ventilation. Each of the other systems has a tempering coil only, except No. 9, which, owing to the use of the air-washing equipment, has both a tempering and a reheating coil; there are thus a total of 15 coils, which have a total heating surface of 87,042 lin. ft. of 1-in. pipe. The distribution of heating surface in each system is indicated in the accompanying table of apparatus. The coils are for the greater part made up of six and seven two-row sections, each of the Sturtevant mitre pattern. They are 1-in. pipe screwed on 2½-in. centers into separate corrugated cast-iron headers on steam and return ends. The coils are encased in jackets of No. 10 steel plate with connections to the filters and fan in-takes of similar weight.

Tempering Control.—The tempering coils of the fresh air systems are, like the direct radiation of the heating system, under automatic thermostatic control. Each of the fifteen heaters is controlled in two groups of sections, one embracing the two outside sections and the other the remaining four or five. The outside sections are controlled by a thermostat in the filter chamber or cold air in-take, and the larger group by a thermostat in the delivery duct. These thermostats have different settings, that in the main delivery duct being adjusted to operate the larger group of sections as the temperature of the air passing through the duct rises above or drops below 73°, or whatever temperature the thermostat is set for, depending largely on the length of duct and resultant heat losses therein; the supply of these sections is, therefore, continually being opened or closed in order to maintain the temperature of the fresh air delivered as nearly constant as possible. The thermostat in the cold-air chamber is set for 38° Fahr., and admits steam to the two outside sections only when the outside temperature drops below this point, which would cause objectionable cool drafts from the supply registers, whenever the larger groups were cut out temporarily. The various sections of each heater are also independently fitted with hand valves.

Ducts.—The connections from the fans to the sections of the building are, in eight of the systems, made through brick ducts underneath the floor, joining at distant points the flues of galvanized iron, while the remaining seven fan sys-

DETAILS OF EQUIPMENT OF FANS FOR THE VENTILATION OF THE CARNEGIE LIBRARY EXTENSION.

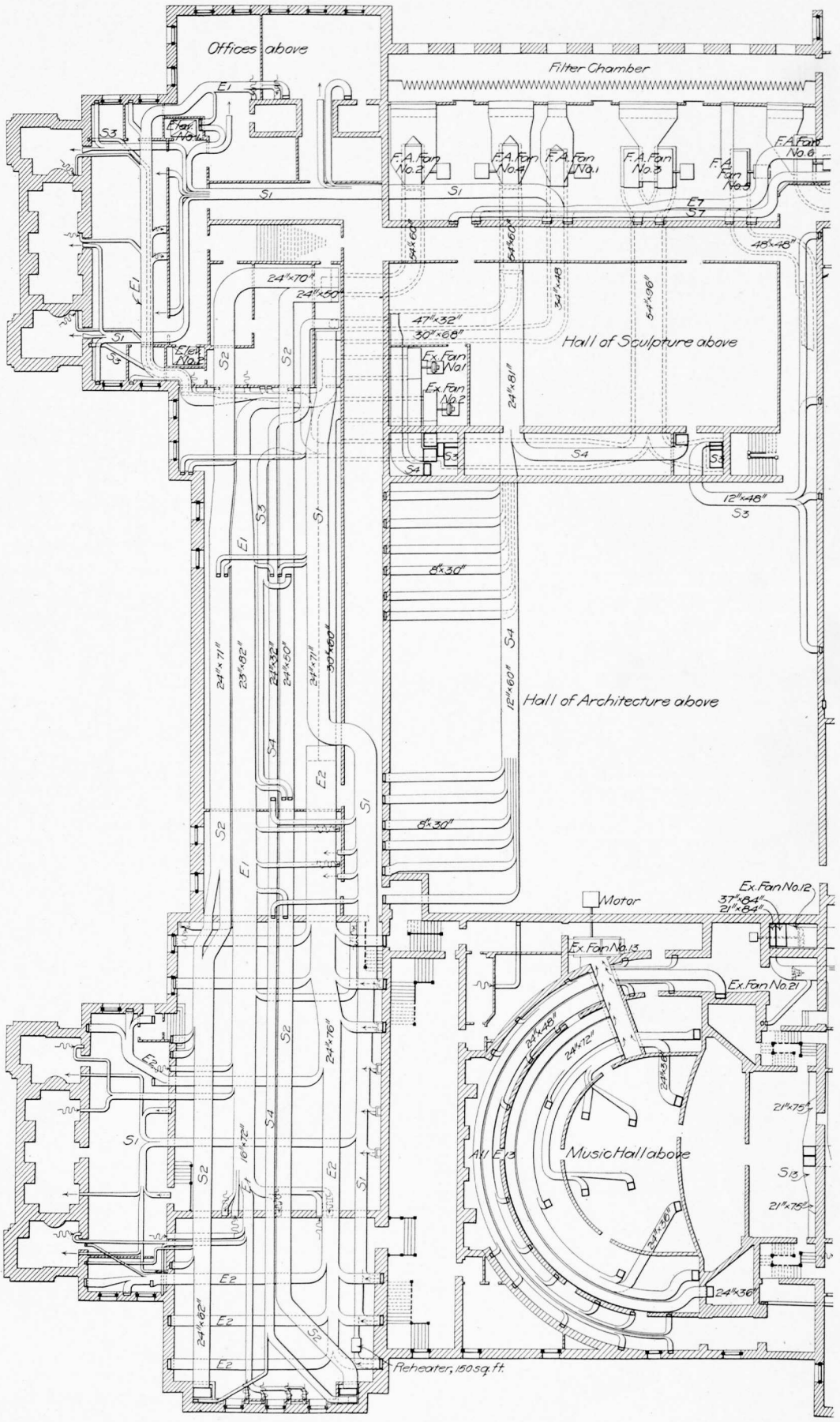
Station.	Section Served.	Fans, No.	Fans, type.	Fan wheels, diam.	Fan wheels, width.	R.P.M.	Cu. ft. per min., supply.	Cu. ft. per min., exhaust.	Motor, h.-p.	Tempering coils, sections.	Tempering coils, ft. of 1-in. pipe.
1.	First floor and basement	1	Cent.	7 ft.	4 ft.	185	32000	.....	15	6-2 row	3,234 lin. ft.
		1	Cent.	7	4	204	.....	35000	20		
2.	Foyer	1	Cent.	9	4½	160	50000	.....	25	6-2 row	6,500 lin. ft.
		1	Cent.	7	4	204	.....	35000	20		
3.	Architectural & sculpture halls.	2	Cent.	8	4	130	54000	.....	15	7-2 row	10,000 lin. ft.
		1	Disc.	6	..	300	.....	35000	10		
4.	All art galleries	1	Cent.	9	4½	183	57000	.....	35	6-2 row	7,710 lin. ft.
		1	Disc.	5	..	275	.....	21000	5		
		1	Disc.	4	..	400	.....	15000	4		
		1	Disc.	6	..	300	.....	35000	10		
5.	Engine room	1	Cent.	7	4	204	35000	.....	20		
		1	Cent.	8	4	180	.....	39000	24		
6.	Museum (constant)	1	Cent.	9	4½	144	45000	.....	20	6-2 row	5,640 lin. ft.
		1	Disc.	5	..	250	.....	18000	5		
		1	Disc.	6	..	300	.....	35000	10		
7.	Museum (occasional)	2	Cent.	8	4	163	70000	.....	30	7-2 row	10,000 lin. ft.
		1	Disc.	4	..	350	.....	13000	4		
		1	Disc.	6	..	250	.....	28000	7		
8.	Lecture hall	1	Cent.	7	4	167	28000	.....	20	6-2 row	3,936 lin. ft.
		1	Cent.	7	4	167	.....	28000			
9.	Book stack room	1	Cent.	10	5	130	57000	.....	40	Tempering	4,284 lin. ft.
		1	Cent.	9	4½	130	.....	45000		Reheating	6,426 lin. ft.
10.	Kitchen	1	Cent.	4½	2⅔	289	11000	.....	12	6-2 row	1,284 lin. ft.
		1	Cent.	5	2⅔	289	.....	15000			
11.	Library—south wing	1	Cent.	10	5	120	52000	.....	18	7-2 row	9,005 lin. ft.
		1	Disc.	7	..	275	.....	52000	12		
12.	Library—west wing	2	Cent.	6	3½	200	44000	.....	15	6-2 row	6,504 lin. ft.
		1	Disc.	4	..	400	.....	15000	4		
		1	Disc.	6	..	225	.....	25000	7		
13.	Music hall	2	Cent.	8	4	150	64000	.....	20	6-2 row	8,394 lin. ft.
		1	Cent.	9	4½	160	.....	50000	30		
		1	Disc.	4	..	350	.....	13000	4		
14.	Reading room	1	Cent.	6	3½	170	20000	.....	10	6-2 row	3,045 lin. ft.
		1	Cent.	6	3½	170	.....	20000			
15.	"Building A"	1	Cent.	3	1½	400	4500	.....	4	6-2 row	1,080 lin. ft.
		1	Cent.	3	1½	400	.....	4500			
16.	Toilets, front of building	1	Disc.	3½	..	400	.....	11500	4		
17.	Toilets, left center	1	Disc.	3	..	400	.....	7000	2		
18.	Toilets, service	1	Disc.	4	..	350	.....	13000	4		
19.	Toilets, library	1	Disc.	4	..	425	.....	17000	5		
20.	Toilets, library, upper floors	1	Disc.	2½	..	500	.....	5000	2		
21.	Toilets, music hall	1	Disc.	4	..	350	.....	13000	4		
	Total =	49	(28 centrifugal and 21 disc.)				623500	659000	501		87,042 lin. ft.

tems deliver to the supply branches through ceiling ducts of galvanized iron, their arrangement being shown in the accompanying drawings of the basement. These basement ducts are in general proportioned for comparatively high velocities, the average being about 1,200 ft. per minute. In the vertical flues the velocities are reduced one-half, or even more, ranging from 500 to 600 ft. per minute. All curves have been planned to permit an easy flow, the inside radius in every bend being greater than the width of the duct. A feature of the work in the basement is that the ducts have been run in general below the steam piping systems by which the disadvantages of passing pipes through them are avoided. All branch ducts have dampers with quadrants outside indicating their position, and are fitted with adjustable deflectors to obtain the proper distribution of the flow. The galvanized iron ducts are of particularly substantial construction, all having one dimension of 48 in. or over, being made of No. 18 gauge iron, braced with angle iron; ducts 30-in. size and over are built of No. 20 gauge, those 12 in. and over of No. 22 gauge, while all smaller ducts are of No. 24 gauge.

For temperature records, all of the five filter chambers and the main tempered air ducts of the fresh air systems have accurate thermometers with indicating dials. The fourteen thermometers inserted in air supply ducts have long stems projecting 12 in. into the ducts. All thermometers have 6-in. dials with scales graduated, for the tempered air ducts, from 20° to 180° Fahr., while for the cold air chambers they are graduated—from 10° to 120° Fahr. System 9, which is fitted with the air-washing equipment, has a thermometer in the cold air in-take as well as in the supply duct connections, by means of which the temperature adjustments may be made in the tempering and reheating coils of that system, as may be desired.

All duct work in the basement connected with the fresh-air supply systems have coverings of magnesia blocks 1 in. thick, wired on and finished with an outer protecting covering of 10-oz. canvas. The tempering coils, fan casings and connections between them, as well as the centrifugal exhaust fan casings, are similarly protected by magnesia blocks 1½ in. thick, wired in place, cemented and encased in jackets of 10-oz. canvas. All tempered air flues at points above the basement, whether in walls, suspended ceilings, or attic spaces, are covered with 1-in. magnesia blocks similarly wired on and encased in 10-oz. canvas jackets. The tempered air flues carried in outside walls are insulated by air cell covering, ½ in. thick, held in place by galvanized iron angle pieces on each corner and copper wire fastenings. Additional insulation in the basement is provided above the ceilings of the cold-air filter chambers by 2-in. magnesia blocks supported on wire lath suspended from the ceiling beams by 1-in. T-irons; this finish is subsequently covered with hard-finished plaster, to prevent leakage of cold air into the building. All of this insulation covering is 85 per cent. magnesia.

Delivery connections for the supply of fresh air to the rooms are in practically all cases planned for downward supply, the registers being located in the upper portions of the rooms or in the ceilings, while all exhaust ventilation registers are in or near the floor. The fan of station 1 is intended solely to supply air to the front portion of the basement and a section of the first floor near the front entrance. The duct connection is extended from it underground for a considerable distance beyond the corridor, where a 14 x 48-in. branch leads off to supply the northeast corner of the basement and auxiliary rooms at the northeast entrance; in the front portion of the basement it rises to ceiling ducts, which similarly supply the northwest corner of the basement and portions of the northeast entrance. System 2, of somewhat larger capacity, supplies air to the foyer on the main floor, a column room 60 x 140 ft. in size at the northwest corner, through which entrance is



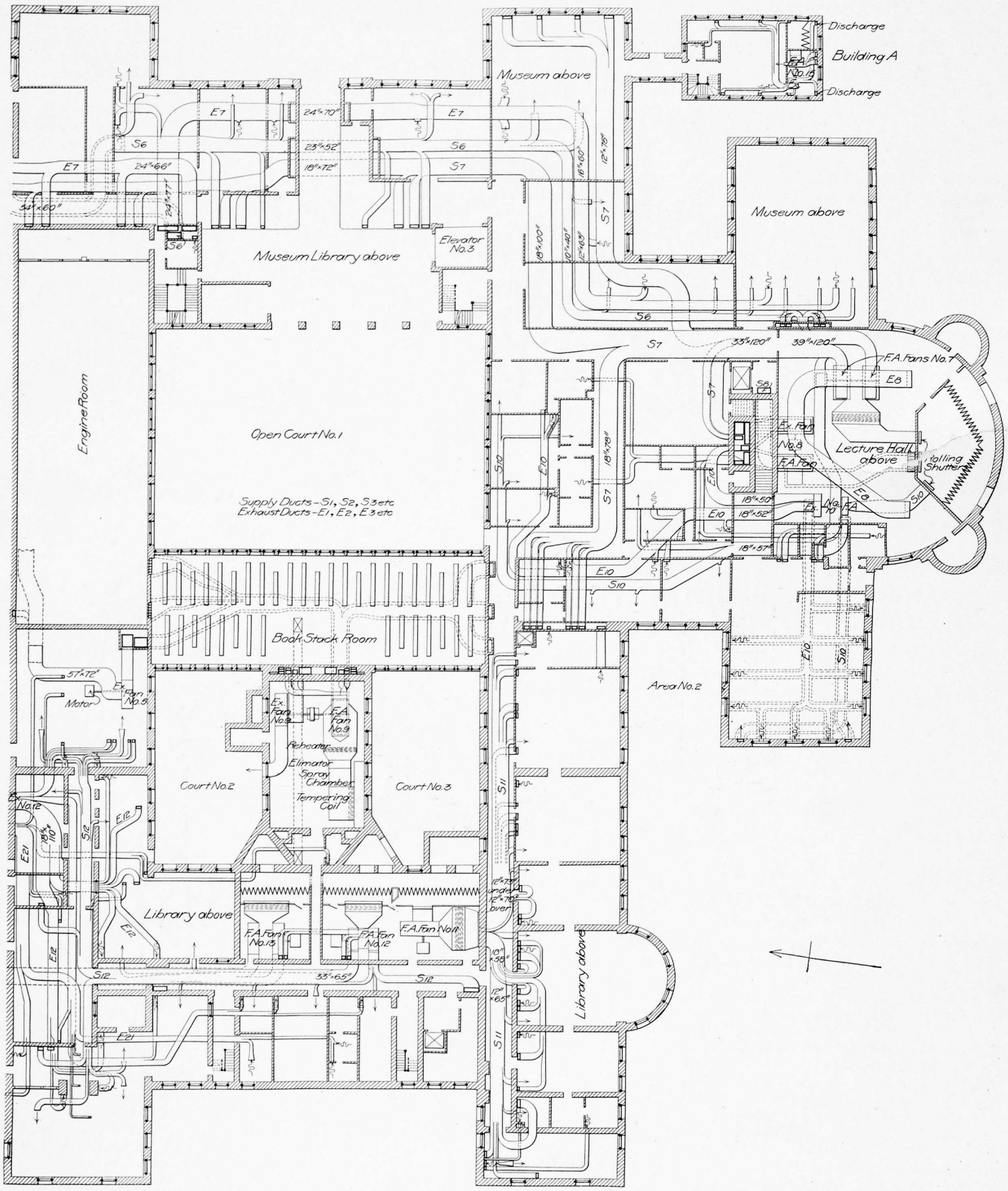
Northerly Portion of the Basement Plan.

had to the music hall; this room is especially intended for social functions during art exhibitions and the like, and provision has been made for an ample supply of air when it is heavily crowded. The duct work for this system is similarly carried in the basement, with numerous branch connections to the risers supplying the ceiling delivery ing court 1, in all of which cases comparatively short, simple connections were possible from the fan deliveries to the ceiling registers. System 5 is devoted wholly to the supply of cold fresh air to the engine room.

The duct work for fans 7, 8 and 10 is carried entirely upon the ceiling, with the exception of outlets. System 3 supplies the architectural ha and hall of sculpture, system 4 supplies the art galleries, and system 6 is intended for a constant supply to the museum reading room, a room fac-

system 8, from which a short underground connection is made from the fan to a flue in a riser shaft nearby. System 7 has an extensive system of distribution duct work, being intended for the at either end of the book stack room. Systems 11 and 12 are both used for different sections of the library, while system 13 supplies the music hall.

been installed for this purpose of capacity somewhat in excess of that for delivering fresh air, even though exhaust from the Architectural Hall is omitted and a number of rooms have supply



Southerly Portion of Basement Showing Arrangement of Ventilating Equipment.

occasional supply of air to the different portions of the museum whenever increased occupancy may warrant it. Ceiling duct distribution systems are also used for fans 11 and 12, while for fan 9 underground flues distribute the air to wall risers

Exhaust Ventilation.—In the ventilation of the Carnegie Library Extension, the provisions for fresh air supply are supplemented by exhaust ventilation in all parts of the building, except the Architectural Hall. An exhaust equipment has

equipments of capacity in excess of those for exhaust, for the purpose of maintaining plenum within them. The total combined exhaust capacity is over 650,000 cu. ft. per minute, distributed among 30 fans, of which a considerable portion

is for toilet rooms, which have exhaust ventilation connections only.

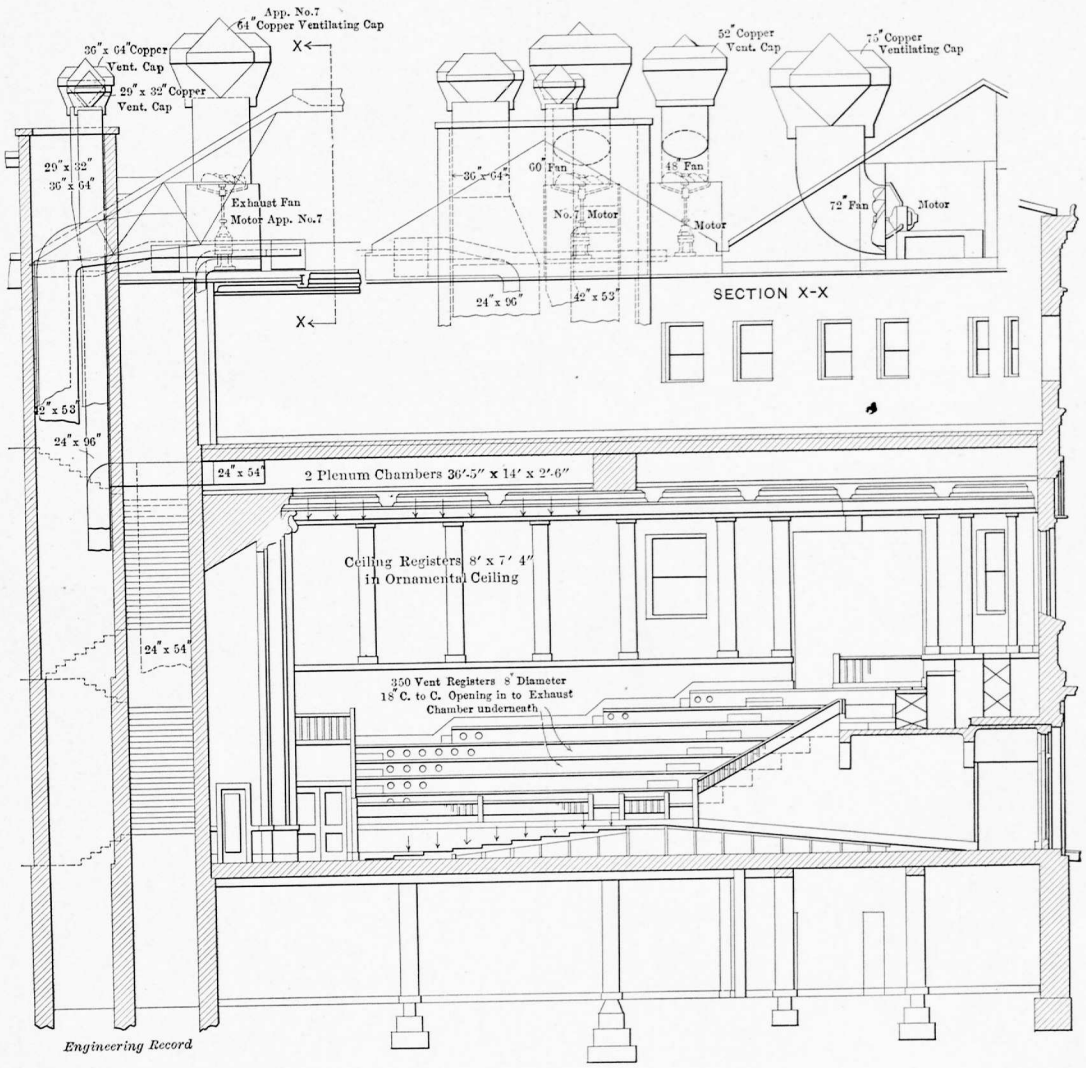
In arrangement of apparatus stations, the exhaust fan equipment differs widely from that of the fresh air equipments which, for convenience of in-take and filter arrangement, were distributed in three general groups. The exhaust fans, while bearing the same station numbers as the supply fans in accordance with the rooms or portions of the building from which they exhaust, are more generally distributed throughout the building, either in the basement or attic, as proved most convenient for duct connections and discharge. The equipments of systems 1, 2, 5, 8, 9, 10, 12, 13, 15 and 21, serving some of the large rooms on the lower floors, are located in the basement, but the larger number are in the attic in convenient positions relative to the exhaust flues and short discharge connections through the roof. For a number of the systems several fan equipments are used, one having as many as five, entirely in accordance with the character of the departments supplied and the extent of occupancy. While the fresh air supply stations in no case have more than one supply equipment, located at one point, it was found expedient to sub-divide the exhaust equipments of certain stations in order to simplify connections and avoid long duct lines.

Exhaust Fans.—Disc fans were used for all of the exhaust systems where conditions of duct arrangement and discharge connections were favorable, offering little resistance to the flow. There are 21 equipments of this type installed, all but two of which are located in the attic, and draw through vertical vent flues from below and discharge through roof discharge hoods. In nine cases, however, long gathering duct lines and the necessity of discharging through long vent risers made the centrifugal type of fan necessary; all but one of the centrifugal exhaust fans are located in the basement and serve extended duct systems. The purposes, sizes and capacities of all exhaust fans are indicated in the table.

The centrifugal exhaust fans are in all details of construction similar to the centrifugal blowers used for the fresh air supply systems. The disc fans are of the Blackman type, and the greater part of them are arranged horizontally with drives from vertical shaft motors arranged directly underneath. These fans have the usual two-hub construction; from one hub radiate spokes, carrying the blades and connecting with a tire, while from the other hub ribs extend to reinforce the curved edges of the blades. Each fan is mounted within a circular ring with three or more arms, which support the shaft bearings. These fans are, like the supply fans, driven by C. & C. multipolar direct-current motors. The motors are operated through speed-controlling starting boxes, which are fitted for a speed control ranging from two-thirds to full speed through field regulation.

Fan Locations.—The centrifugal exhaust fans of stations Nos. 1 and 2, which serve the front portion of the basement, portions of the main floor corridor and the foyer, are located in a convenient position underneath the architectural hall for short direct connection to vent flues in an adjoining pipe shaft for discharge. Each exhausts from the rooms served through extensive lines of duct work carried on the ceiling of the basement, as shown in the basement plan of duct work. Station 5 has a centrifugal exhaust fan serving the engine room, which is in the library basement at the west end of this room, convenient to duct work connections and for discharge through a vent flue in an adjoining pipe shaft. The centrifugal exhaust fan of systems 8 and 10, which are located underneath the lecture hall, discharge through flues in a common pipe shaft at the rear of the lecture hall, fan 8 having a two-duct in-take from the vent space underneath the floor of the lecture hall, while fan 10 has both overhead and underground duct connections from the kitchen and restaurant in an adjoining section of the basement. Centrifugal fan 9 serving the book-stack room, is installed beside the fresh-air fan supplying that section, and drawing from a down-take connecting with the vent registers on the upper floors, discharges into the adjacent interior court 2. Centrifugal exhaust fan 13, serving the music hall, is located in the basement, drawing from an exhaust chamber with a multiplication of in-take ducts leading to floor and wall vent registers, and discharges through a flue in an adjoining interior court of the building. System 15 is a localized system of small size, serving building A, in which are housed the alcoholic specimens of the museum.

The disc-fan operated vent systems are, as above stated, for the greater part located in the attic, where connection could most easily be made to vent risers. The sub-division of equipments was due in part to the great size of the building, but more to the varied purposes for which the rooms served will be used. In all departments of the building some portions will be used more constantly than others, for which reason many of the systems were designed with special reference to temporary service at infrequent intervals. The disc fans of systems 3 and 4 are located in the attic in the front portion of the building where they are most convenient to duct connections from the sculpture hall and art galleries, respectively, which they serve. Disc fan 6 and the five



Details of Ventilation of the Lecture Hall and Typical Exhaust Fan Arrangement in Attic.

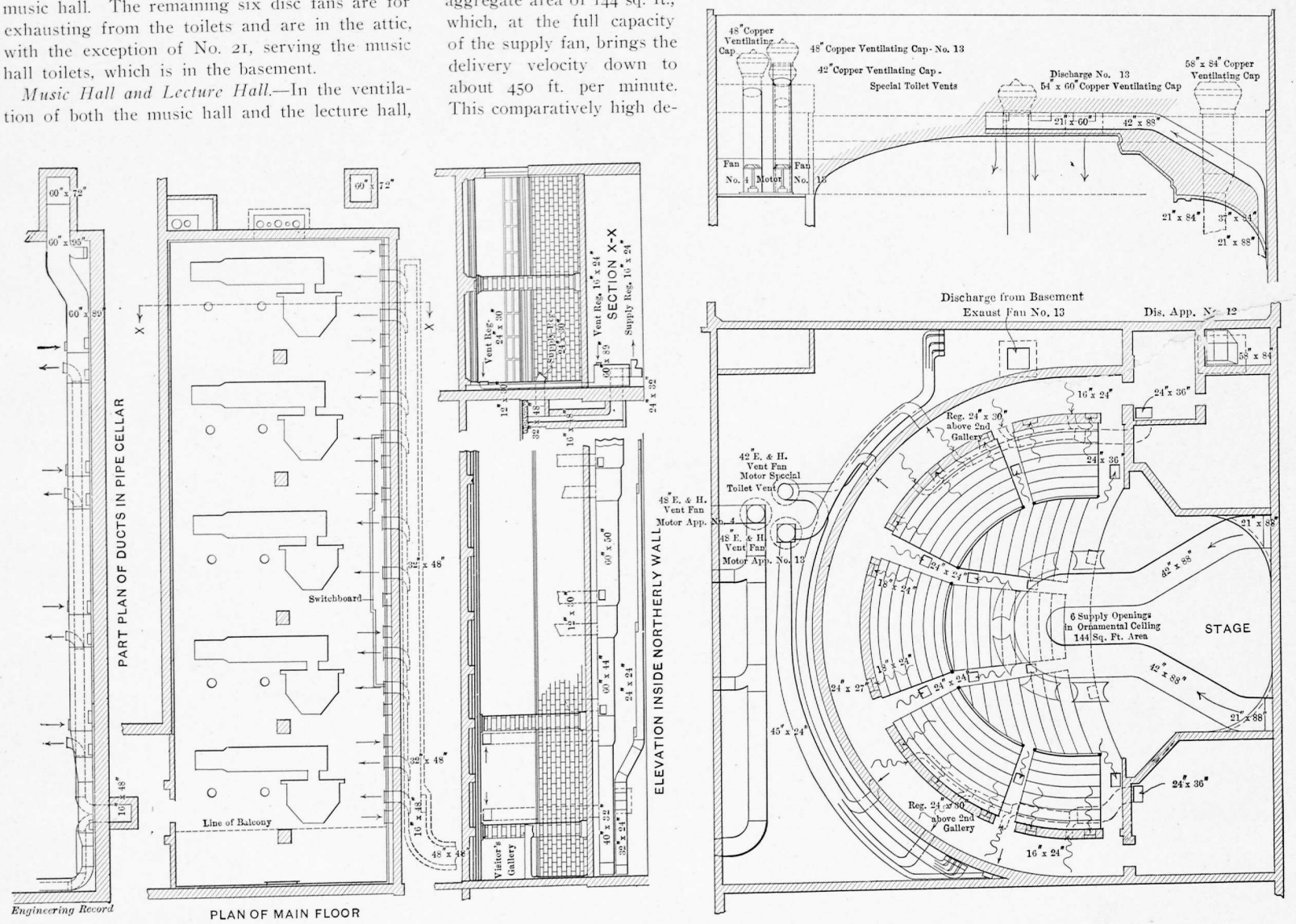
fans of system 7, which exhaust from the various parts of the large museum, are distributed in different portions of the attic above it, where most convenient to the exhaust riser flues. Stations 11 and 12, serving the south and west wings of the library, have each a disc fan in the attic, while the latter has also a disc fan in the basement which serves a system of exhaust ducts from small rooms of this department on the main floor. Systems 7 and 11 are exceptions in that they exhaust through extensive gathering ducts in the basement, connecting with rooms on the first floor. The music hall has an auxiliary disc exhaust fan in the attic which was installed for special ventilation of the upper gallery of the music hall. The remaining six disc fans are for exhausting from the toilets and are in the attic, with the exception of No. 21, serving the music hall toilets, which is in the basement.

Music Hall and Lecture Hall.—In the ventilation of both the music hall and the lecture hall, problems analogous to theater and public hall ventilation were encountered. The music hall is of typical theater construction, while the lecture hall is an amphitheater with high ceilings, a stage and sloping floors with terraced seats. The former is utilized for concerts and musical entertainments, seating 2,100 people in both the main floor and galleries. The lecture hall seats about 600, and is intended for class lectures for students. The ventilation in the music hall has been designed on the basis of a supply of 30 cu. ft. of fresh air per minute per occupant, with a capacity of exhaust ventilating equipment slightly less, effecting a plenum within the hall. The lecture hall has supply and exhaust equipments of equal size, which are capable of supplying 40 cu. ft. per minute to an audience of 700.

In accordance with the general scheme of ventilation in the building, the supply and exhaust connections to both halls are arranged for downward ventilation, fresh air entering at the ceiling and being removed through floor registers. The fresh air supply to the music hall is from equipment 13, through a basement distributing duct of 21 sq ft. cross-section, which, at maximum duty, provides a velocity of 50 ft. per second. This leads to two riser flues at the rear corners of the stage, each 21 x 88 in. in section, each of which expands above the ceiling finish into 42 x 88-in. ducts for reduction of flow velocity to approximately 1200 ft. per minute. These are extended over the center of the auditorium to six delivery outlets in the ceiling, and the branch connections to these outlet registers are also proportionately increased in area for further reduction of the delivery velocity. These six openings having an aggregate area of 144 sq. ft., which, at the full capacity of the supply fan, brings the delivery velocity down to about 450 ft. per minute. This comparatively high delivery velocity is not, however, objectionable, owing to the 75 ft. height of the ceiling at this point above the floor, and the fact that the galleries are situated somewhat to the rear of this center of supply, so that the incoming air has an ample opportunity to spread and diffuse before reaching the audience.

The vent connections for removal of foul air from the music hall consist of registers in the main auditorium floor and in the wall underneath the galleries. The floor registers are twelve in number, consisting of four 24 x 36-in. registers located immediately in front of the stage and eight registers, 2 ft. square, distributed in the aisles. For the ventilation of the confined spaces under the galleries, there are under the first gallery, twelve 18 x 24-in. top wall registers facing the auditorium and eight 16 x 24-in. wall registers opening into the corridor at the rear, surrounding the circular seating area. The space between the first and second galleries is ventilated by ten 18 x 21-in. top exhaust registers, which are distributed in the circular wall at the rear. These registers, which together provide a total combined area of exhaust openings for the auditorium of 124 sq. ft., connect through gathering duct lines to an exhaust chamber in the basement underneath the auditorium floor, from which the 9-ft. centrifugal exhaust fan draws. This fan has a maximum capacity of 50,000 cu. ft. per minute, at which duty the velocity of inflow at the registers is about 400 ft. per minute. The space above the second gallery has special provisions for ventilation in cases of unusual crowd in the hall, consisting of a 48-in. disc fan in the attic above, which exhausts 13,000 cu. ft. per minute through five 24 x 30-in. registers in the upper rear wall; this is intended to prevent a vitiated condition of the air in the upper rear portion of the room, which is, in fact, out of range of the circulation of air from the fresh air supply outlets in the central portion of the ceiling. The total capacity of exhaust ventilation is thus slightly less than that of the supply, which provides for a slight plenum within. The design of the music hall equipment was planned for about ten changes of air per hour.

The lecture hall is without galleries and has a much lower ceiling, the maximum head-room in the central portion of the auditorium being about 34 ft. Some difficulty was experienced in arranging for the supply through the ceiling at this height in order to distribute effectively the incoming air and prevent drafts on the audience. Delivery is made through a number of registers in the ceiling of ample area to permit very low velocities of delivery. The supply to these is furnished from the 7-ft. fan in the basement through



Engineering Record

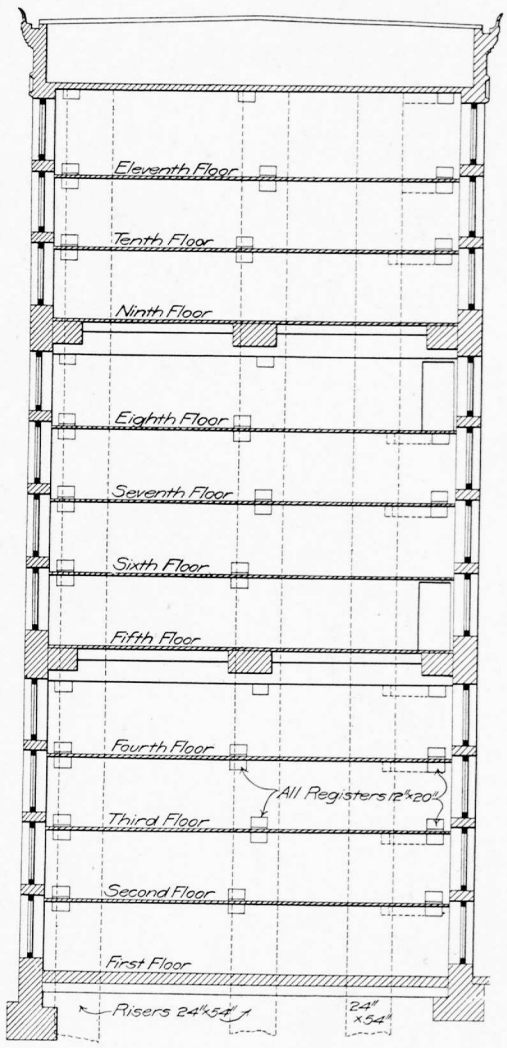
Ventilation of the Engine Room and Pipe Cellar and Arrangement of Ventilation Connections to the Music Hall.

two 24 x 54-in. ducts in riser shafts at the rear of the rostrum to two plenum chambers above the ornamental ceiling from which the registers open. These chambers are each of No. 18 galvanized iron, 36½ ft. long, 14 ft. wide and 30 in. deep, and each supplies three registers, 7 ft. 4 in. by 8 ft. in area, which are partly concealed by the ornamental ceiling finish of the room. The six registers have thus a combined area of 352 sq. ft., which permits of a delivery velocity of not more than 80 ft. per minute at maximum capacity of the supply fan.

The exhaust ventilation of this room is accomplished, like that of the music hall, through floor registers served by the exhaust fan in the basement. The registers are here, however, universally distributed, consisting of 8-in. circular openings, which are spaced on 18-in. centers in the floor underneath the rows of chairs in the central portion of the seating and in the risers of the terraced seating at the rear. These open directly into a large exhaust chamber built under the floor, from which connection is made at two points through 20 x 72-in. ducts to exhaust fan 8. There are 350 of these vent registers, which, having a combined area of over 120 sq. ft., provide for an average exhaust velocity into the registers of about 230 ft. per minute at the full capacity of the fan. In this hall, the capacities of supply and exhaust fans are the same, the design providing for about 12 changes of air in the room per hour.

Book-Stack Room Ventilation.—The book-stack section of the building is a wing 40 x 120 ft. in plan and contains eleven floors, rising to a height of 84 ft. above the first floor level. The ventilation system of this room has been designed with particular reference to the conditions most favorable to the preservation of books. All of the windows are hermetically sealed and all fresh air supplied is passed through an air washing apparatus. The capacity of the supply equipment being considerably in excess of that for exhaust, in order to provide for a plenum within, which measure was resorted to as the most effective means of eliminating dust and dirt from the room. The fresh air is furnished by a 10-ft. centrifugal fan in the basement, which has an intake through air-wash apparatus and discharges through a group of distributing ducts under the floor. This duct work consists of a 60 x 57-in. main duct, which delivers into two 36 x 54-in. branches, one leading toward either end of the book-stack room. At the south end, three 24 x 54-in. flues are supplied, which are carried up to the outlet registers on the various floors. At the opposite end of the room, the underground duct branches into one 34 x 36-in. and two 12 x 30-in. ducts, the former delivering to a 42 x 60-in. flue in an adjoining pipe shaft and the two smaller branches to six 10 x 12-in. individual flues in the northerly wall of the room. The supply registers on all floors are 12 x 20-in. in area and in all cases, except where construction prevented, there are three of these at both floor and ceiling lines at either end of the room. There are in all 53 of these registers in either end wall of the book-stack division of the building, 31 of which are at the ceilings of the various floors and the remaining 22 at the floor line, distributed as shown in the accompanying wall elevation. Those in the south wall are fed by the three 24 x 54-in. risers, while in the north wall eleven are fed by each group of 10 x 12-in. risers and the remainder by the 42 x 60-in. duct in the adjoining pipe shaft. The principal feature of this system of supply is the distribution of practically duplicate arrangements of supply outlets at floor and ceiling lines on all floors of the wing, those at the ceiling being intended for the air supply under all normal conditions, while those near the floor are installed for the purpose of cooling in summer time. This was considered essential, as the windows are hermetically sealed and only in this way could direct drafts be obtained in hot weather, for the comfort of the attendants. The capacity of the equipment is comparatively small, providing for but six to eight changes of air in the wing per hour, and the outlets are designed for delivery velocities of 300 to 500 ft. per minute, according to the number of registers in use.

The exhaust ventilation of the book-stack section is provided by wall registers near the floor line in the middle portion of the west wall of the wing. Connections are made from these to the exhaust fan in the basement by two lines of flues, each 36 x 54 in. in section, which are carried full size up to the eighth floor, reducing above that to 15 x 36 in. and at the tenth floor to 18 x 20 in. Each duct connects with eleven 18 x 20-in. exhaust registers, one upon each floor, which, at the full capacity of the fan, effect a velocity of intake of over 700 ft. per minute. The



Supply Connections to Book Stack Wing.

vertical exhaust flues join in the basement into a 5 x 8-ft. connection to the exhaust fan, the latter discharging directly through a short connection, into the adjacent interior court, No. 2

Sculpture and Architecture Halls.—In both the sculpture and the architectural halls special problems were encountered in providing for the delivery outlets, owing to ornamental finish of the interior preventing a convenient arrangement of duct work. The outlets for fresh air supply were concealed in the cornices of the ceiling finish around the edges. The architectural hall, which is 60 x 150 ft. in plan and has an interior height of about 65 ft., has sixteen supply register openings, each 15 x 24 in. in size. These registers are supplied by two 45 x 64-in. risers from the basement supply fan connections to distributing ducts carried in the large space between the domed lights and skylight above the hall. The sculpture hall is similarly supplied through four 30 x 48-in. registers, two at either end of the room, which are supplied by a separate 16 x 45-in. riser from the basement. These supply registers in both halls are designed for comparatively high velocities of delivery, ranging up to 700 ft. per minute at the maximum capacity of the supply fan.

The architectural hall is entirely without exhaust ventilation connections, as owing to the large openings into adjoining corridors and rooms, ample exhaust provisions are made through the systems of adjoining rooms. The sculpture hall has, however, exhaust ventilation operated by the 4-ft. disc fan in the attic space above the architectural hall. This fan serves a system of gathering ducts, connecting with 16 x 27-in. wall registers near the floor, of which there are eight provided, four on either side of the room.

An interesting provision of ventilating equipment for preventing the intense heating effect of the skylighting in the summer has been installed, consisting of disc exhaust fans which exhaust from the spaces between the domed lights and the main skylights above all of the sections of the buildings fitted with this sort of lighting, embracing the architectural hall, the sculpture hall, the art galleries, portions of the museum, and a number of study rooms on the third floor at the southerly end of the building. The air in the enclosed spaces between the domed lights and skylighting is apt to become highly heated by the sun in hot summer days with resultant unpleasant heating effect in the rooms below. This is obviated to a large extent by connections from the exhaust fans which enable the air to be circulated in these spaces.

Engine Room Ventilation.—Special attention was given to the problem of adequately ventilating the engine room, a 46 x 140-ft. sub-basement room with 25-ft. headroom, underneath the central portion of the building, and a pipe cellar with 12-ft. clear headroom underneath. Cold fresh air is supplied to this division by the 7-ft. No. 5 supply fan, while the heated air from the machinery is exhausted by the 8-ft. exhaust fan in the basement under the library adjoining, at the westerly side. This air supply is untempered, as heating is not required in the engine room, and also the usual arrangement of downward supply is here deviated from, fresh air being supplied at points near or a few feet above the floor level, while the air heated to high temperature by the steam-using machinery is exhausted through registers at the top of the rooms. The fresh air supply to the engine room is less than that for exhaust, in order to effect a vacuum which will tend to prevent the escape of heated air from this division into the corridors or other portions of the building.

The cold fresh air is delivered from the supply fan by a 48 x 48-in. duct under the basement floor to a distributing duct under the floor of a corridor adjoining the engine room on the north side, from which the delivery outlets are supplied. This distributing duct is 32 x 48 in. in section and supplies air to ten 12 x 30-in. branches, which open into the engine room through 24 x 30-in. registers. These branch ducts are carried through the engine room wall and at the outlets are inclined downward at an angle of 45 deg. These openings are all so spaced as to deliver directly against each of the engines and generators of the five direct-connected electrical units. These supply outlets are designed for comparatively high delivery velocities, each discharging at full capacity of the supply fan, 2,400 cu. ft. per minute, at a velocity of approximately 500 ft. per minute. For the supply of air in the pipe cellar underneath the engine room, a 16 x 48-in. branch is taken from the fan delivery duct to a second distributing duct on the floor at the front of the

cellar. This connection divides in the cellar into two branches, each 32 x 24 in. in section, one of which extends the length of the cellar and the other off to the rear into an L-extension under another portion of the building. Each of these branch ducts has four delivery outlets, each of which is 8 x 24 in. in section and supplies 1,500 cu. ft. per minute. All of these outlets are enlarged to register openings 16 x 24 in. in area, by which the delivery velocity is reduced to about that of the engine room registers.

The arrangement of exhaust connections in the engine room and pipe cellar is similar to that for supply, excepting that the exhaust openings are all located near the ceiling line. The exhaust fan in the library basement draws through a 60 x 95-in. underground galvanized-iron duct, which is carried through the pipe cellar immediately above the fresh-air supply duct for that room and decreases in section as branches are taken off. The duct has eight intake openings in the pipe cellar, each an 8 x 24-in. branch with a 16 x 24-in. register, and in addition has ten branch riser connections leading to wall registers near the ceiling of the engine room and four branches carried up to the pump room section of the L-extension from the engine room. The ten branches to the engine room are 12 x 30-in. ducts with 24 x 30-in. vent openings, while those for the pump room are 8 x 16-in. branches. The design of this duct system and the proportions of register area are such as to provide for velocities of intake similar to the register velocities in the engine room, which average 500 ft. per minute. The exhaust discharge riser, 48 x 54 in. in section, is carried up to the roof through a pipe shaft at the end of the engine room and is covered with 1 in. magnesia blocks, wired on and encased with 10 oz. canvas, this being, in fact, the only exhaust duct with insulation covering.

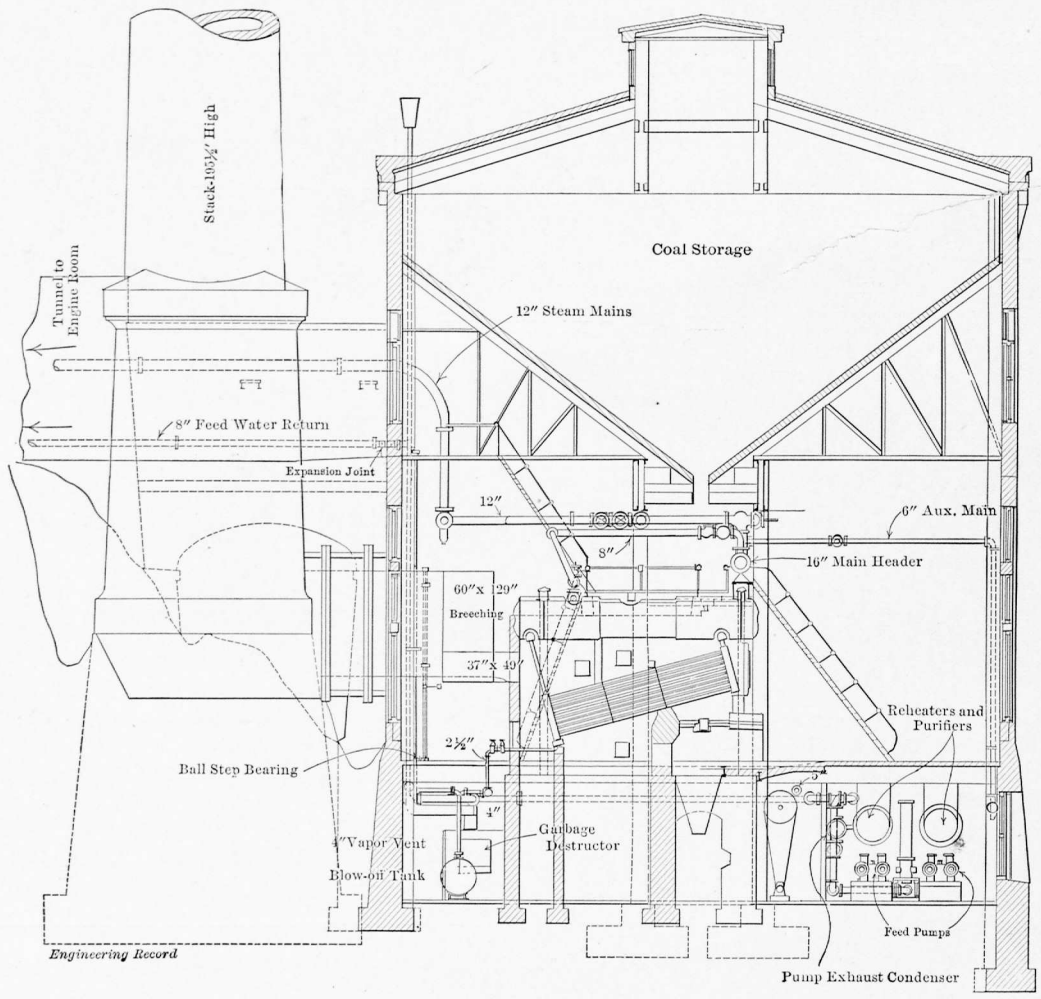
The Boiler House.—The power plant is one of the largest ever installed in a public building, having a rated capacity of 2,500 h.-p. in boilers, 2,200 h.-p. in electrical generating machinery and an extensive equipment of pumping and elevator machinery. The installation is notable for the universal use of the most expensive apparatus and fittings, for its convenient and workable arrangement, and for the unusually attractive and comfortable engine and machinery rooms. The arrangement is unusual in that the engine and machinery room, in the central portion of the basement of the library building extension, is about 500 ft. distant from the boiler plant, which has been placed away from the main building to keep the dirt and noise of handling fuel and ashes as far from the library as possible. Fortunately the library was in proximity to a ravine extending past the rear and east side of the building, and it was possible to locate the boiler house in this ravine in such a manner that only the chimney would be noticeable from the library grounds, piping connections being made through a tunnel.

The bottom of the ravine is occupied by the Baltimore & Ohio R. R., but a site for the boiler house was secured part way up the slope on the side toward the library, where a level plot was blasted out of solid rock. The site was chosen at a level low enough to permit constructing a spur from the adjoining railway for coal cars. The boiler room is about 60 ft. below the grade of the library site, and the brick stack rises 195 ft. above the boiler-room floor. The stack is back of the boiler house. A 7½ x 12-ft. tunnel 32 ft. above the boiler-house floor was driven through the rock to contain the pipes for delivery of steam to the engine room and return of condensation from the heating systems.

The boiler house is a brick and steel structure with concrete floor, roof and coal bunker. It is 65 x 150 ft. in plan; it has a 12-ft. basement, a main floor with 30 ft. clear headroom and a height from main floor to eaves of 58 ft. The entire upper portion of the structure is devoted to continuous coal bunkers, which are carried on the side walls and two lines of columns, 12 ft. apart in the middle, between which the delivery outlets project. The sides of the bunkers, which are of concrete, slope about 40 deg., and are continuous from base to side walls. Light and ventilation above the entire bunker are supplied by a roof monitor, which also contains the coal conveyor. Access to elevated piping connections is afforded by an extensive system of steel grating platforms, connected with a gallery at the tunnel entrance at the rear by a convenient stairway. This gallery is carried throughout the entire length of the building at the rear. The interior of the building is attractively finished with white enameled brick on both floors.

Coal Storage and Handling.—Space is provided for the storage of 8,000 tons of coal, the coal and ash bunkers extending the entire length and width of the building and permitting an average depth of fuel of about 18 ft. This space is divided by concrete walls into four coal bunkers, each extending 30 ft. lengthwise of the building. The remainder of this space is an ash pocket of 15 ft. clear inside length, holding about 1,000 tons. The inclined side walls of the bunkers are of reinforced concrete, and are carried by triangular trusses between the center columns and the outer building walls. In the space between the two center lines of columns the bunker outlets project, and to these are attached inclined delivery spouts, which bring the coal forward to the fronts of the boilers. There are sixteen of these spouts, two to each boiler, which terminate in cut-off gates above a trolley runway, which carries two sets of weighing hoppers. These hoppers are each of 1,000 lb. capacity, consisting of scale hoppers suspended in weighing mechanism carried by four-wheel trucks which run on channel runways. The hoppers have downspouts projecting over the stoker hoppers, and may thus be run in front of any boiler and coal weighed out of the bunker above, directly into its stoker, or coal taken from any of the bunkers may be transferred to any of the stokers by traversing the weighing hopper. The car is moved on the runway by a gear operated from the firing floor by a chain. The weighing lever mechanisms are suspended to within convenient distance of the floor and enclosed in cases of the "banjo" type.

Coal is delivered to the plant in hopper-bottom cars on a siding which passes transversely through the south end of the building at the boiler-room level. Underneath the receiving track in the building there is a concrete hopper into which the coal is dumped from the cars, this hopper holding an entire car load. The section of the track over it, 42½ ft. in length, is suspended upon scale beams to provide for weighing the coal cars as received, the section of track and weighing mechanism being suspended from the steel frame-work of the building above. A scale beam at one side of the room permits of easily weighing the coal car as received and again after dumping the coal into the receiving bin, the tare weight of the empty car, from which figures the net receipts of coal are secured. Underneath the receiving hopper is located a McCaslin single-roll coal crusher, through which the coal is passed before entering the bucket elevating conveyor. This crusher has a single roll, which works against a corrugated breaker plate, the latter being pivoted and held against the roll by heavy counterweights. Coal is reduced in size by this, but the action of the counterweighted plate is such that pieces of iron or other foreign material, which may be accidentally delivered into the crusher, will be passed through, merely forcing the counterweighted plate away from the roll, and thus not damaging the



Cross Section of Boiler House Showing Connection to Piping Tunnel.

latter or any part of the driving mechanism.

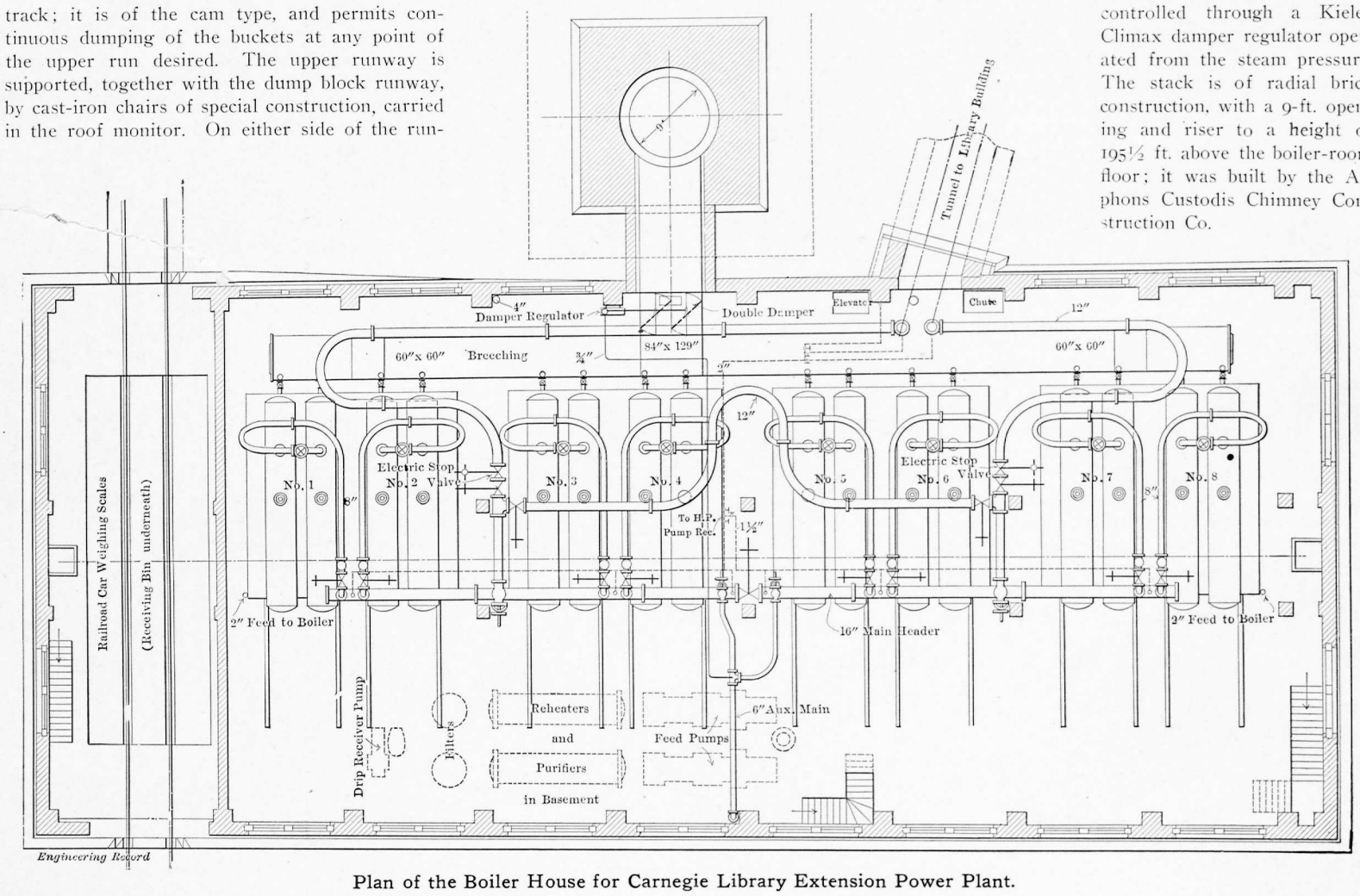
The conveyor is of the McCaslin overlapping gravity bucket type and encircles the entire boiler house longitudinally at the center. The lower run passes directly underneath the ash hoppers, and the upper run through the roof monitor above the coal bunkers, the vertical legs of the system passing up the end walls of the building, enclosed in steel casing for preventing escape of dust into the boiler room. The driving mechanism is at one end of the upper run, above the ash bunker, and consists of a motor, which operates the conveyor link pinion through triple gear reduction. The slack tightener is located at the corresponding end of the lower run, beyond the coal crusher. The horizontal runs of the conveyor are 30-lb. T-rails, supported on special cast-iron chairs. The buckets are automatically dumped on the upper run by an adjustable tripping mechanism, which is carried on a track underneath the conveyor track; it is of the cam type, and permits continuous dumping of the buckets at any point of the upper run desired. The upper runway is supported, together with the dump block runway, by cast-iron chairs of special construction, carried in the roof monitor. On either side of the runway at this point there is a platform giving access to the conveyor mechanism.

The ashes are similarly delivered to the ash bunker by this conveyor, into which delivery is made from dumping gates at the lower outlets of the boiler ash-pits. The latter are of steel plate, 4½ ft. square at the top and 6 ft. in depth, and terminate over the lower conveyor run with under-cut gates. The steel has a reinforced concrete lining 3 in. thick, and clean-out openings are fitted near the base for access to the interior in case the ashes become lodged. Conveyor runway guards are provided over the tracks of the lower run to protect the conveyor link wheels from ashes falling into them; this protection extends the entire length of the lower run underneath the boiler ash-pits. The ashes are delivered to the ash bunker at the end of the building over the receiving track, from which they may be chuted directly into cars. The ash bunker has a divided bottom with two delivery chutes, by means of which the load may be properly trimmed when filling a car. The chutes are fitted with under-cut gates, operated from the floor below. The weighing scales in the receiving track are of convenience in weighing out ashes.

Boilers.—There are eight 300-h.-p. Babcock & Wilcox water-tube boilers, designed for a working pressure of 160 lb. They are set in four batteries of two each, with 6-ft. spaces between for access to cleaning doors, and have a 24-ft. firing floor at the front with 11-ft. space at the rear for breeching and blow-off piping connections. The steam drums and tube sections are flexibly hung in suspensions from above. The side and rear walls are 12 in. in thickness; those at the side are lined with fire-brick, and at the rear of the furnace there is a 36-in. solid fire-brick bridge-wall. The tops of the steam drums are covered with 2-in. magnesia blocks supported on wire netting to form a 2-in. air space. The boiler fronts are finished with white enamel brick to correspond with the interior of the building.

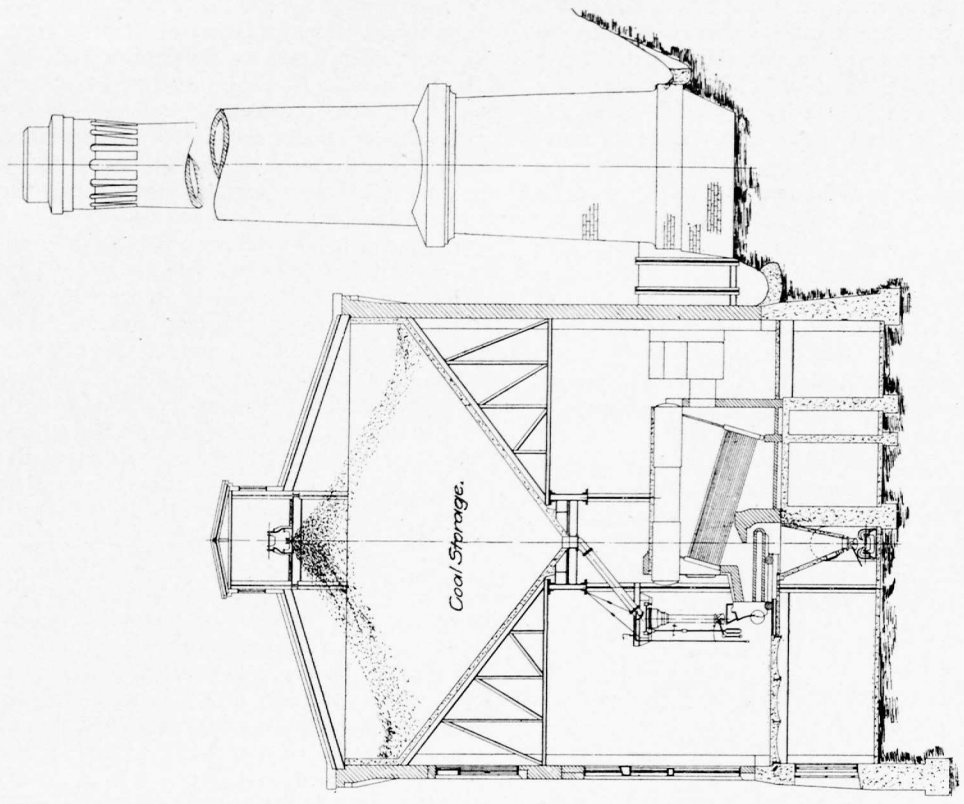
The boilers are of the maker's standard heavy pressure type, with wrought steel headers. Each boiler has 144 4-in. tubes 18 ft. in length, arranged in sixteen-tube sections, each nine tubes high. The total heating surface of each boiler is 3,051 sq. ft. Each boiler has two steam drums, 42 in. in diameter by 23 ft. long, and a 12-in. cast-iron mud drum tested to 400 lb. Each boiler has 8-in. delivery nozzles and two 4-in. nickel-seated safety valves set for 160 lb. The Williams feed-water regulator is used in the gauge column for the automatic control of the water level.

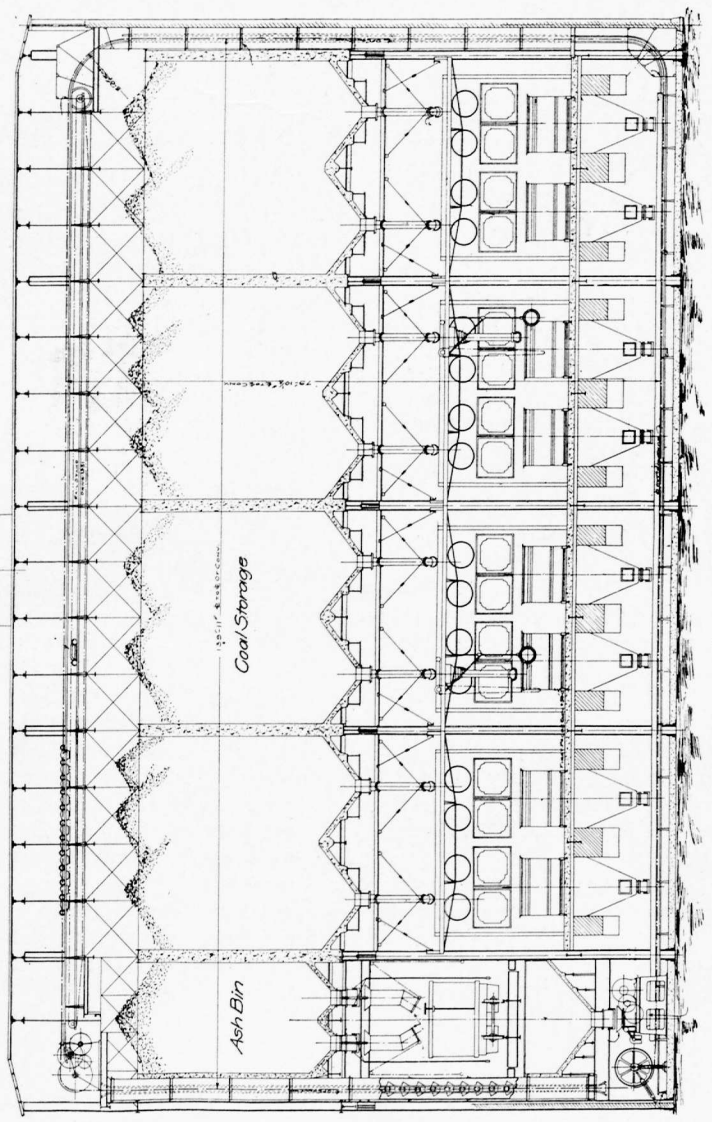
The boilers have 7 x 7½-ft. furnaces in which are fitted Greene chain-grate stokers, each of 52 sq. ft. grate area. They have the grate gear mounted on a cast-iron framework, removable from the boiler setting, and have adjustable drives for varying the grate speed, and consequently the rate of combustion. The stoker mechanisms are driven from a shaft underneath the firing floor, operated by a 6 x 9½-in. Kreibel engine, the drives consisting of a ratchet and pawl mechanism on each stoker which is reciprocated by a connecting rod from an eccentric on the driving shaft, with a 12-in. throw; the adjustment of driving speed is secured by changing the radius of the point of the pawl connection to the reciprocating rod. The products of combustion are delivered to the stack through a rectangular breeching, built up of No. 8 wrought iron with heavy angle-bar corners, which extends longitudinally through the building at the rear of the boilers with a connection to the stack at the middle. The boiler connections are 37 x 49 in. in size and are fitted with balanced dampers. The breeching increases in size toward the middle of the building, entering the stack as a 7 x 10¾-ft. flue. In the main stack connections there is a set of double vertical dampers, mounted on ball step bearings below the casing, the opening of which is controlled through a Kieley Climax damper regulator operated from the steam pressure. The stack is of radial brick construction, with a 9-ft. opening and riser to a height of 195½ ft. above the boiler-room floor; it was built by the Alphons Custodis Chimney Construction Co.



Plan of the Boiler House for Carnegie Library Extension Power Plant.

The boiler feeding equipment consists of two pumps in the basement which return condensation from the heating system and steam-using machinery to the boilers, make-up being supplied from the city mains. They are compound duplex Wilson-Snyder steam pumps, with 8 and 14 x 8 x 18-in. cylinders. They are of the outside-end-packed plunger pattern, brass-fitted for handling hot water, and are cross-connected in both suction and delivery connections for interchangeability. The feed-water is heated in two Warren Webster open heaters, which, for convenience of connection to the exhaust system, are located in the engine room in the library basement, delivery to the boiler house being made through the piping tunnel. These heaters are both of the Star vacuum type with connections to the vacuum pumps of the exhaust steam circulation system to prevent air binding, and each is of 1,500 h.-p. capacity. All feed water is delivered to the boilers through, first, a Gunning filter, next a Gunning reheater and purifier, and thence through a





Details of the Receiving Equipment and Coal and Ash Handling Apparatus.

Worthington hot-water meter for measurement. There are two Gunning reheaters and purifiers installed, each of 1,200 h.-p. capacity and capable of raising the temperature of the feed water to 310° Fahr., at the same time purifying it. They are 40-in. steel tanks, 15 ft. in length, and are fitted with 800 ft. of 1⅞-in. copper tubing. The filters are cast-iron tanks 15 in. in diameter by 8½ ft. high, designed to withstand a pressure of 160 lb. They have manholes and handholes for convenience in cleaning, and have by-pass connections if desired

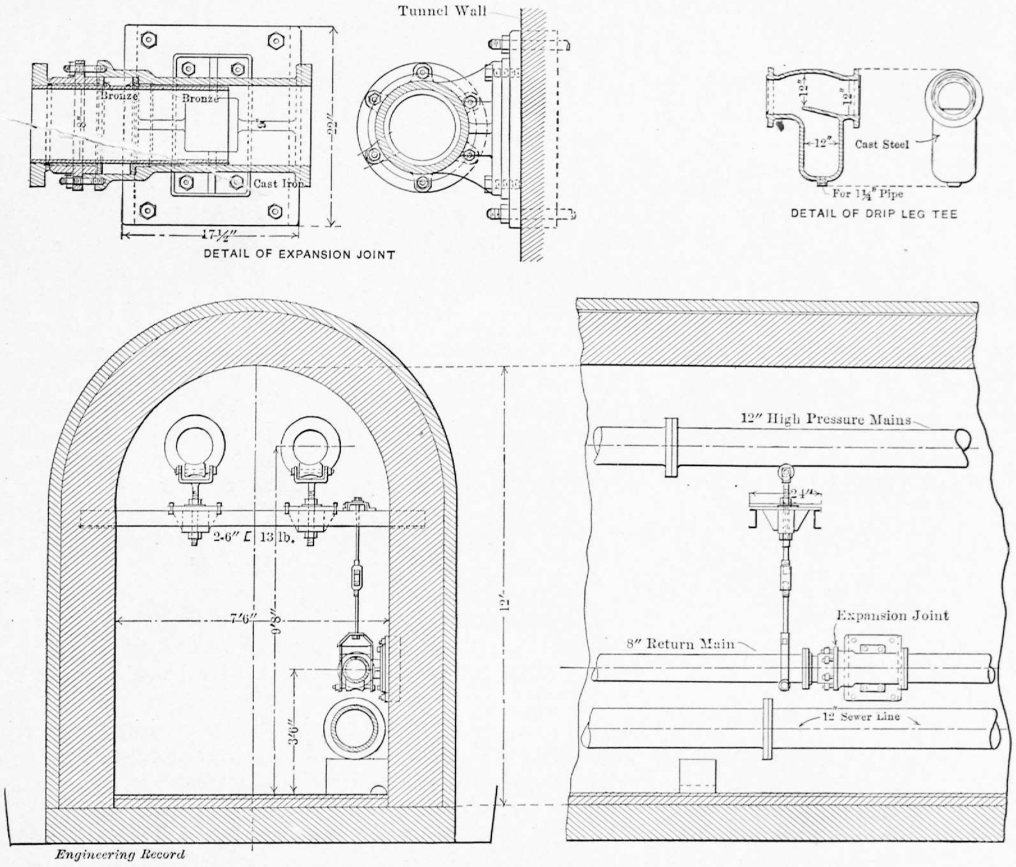
Steam Piping.—The steam piping system is unusually extensive, owing to both the size of the plant and the distance between the boilers and the steam-using machinery. There are a main and an auxiliary header in the boiler house, a distributing header in the engine room pipe cellar, some 500 ft. distant, and two 12-in. supply mains, each containing about 600 ft. of pipe, connecting the two. The main boiler-house header is a 16-in. steel pipe drum with forged steel connecting nozzles riveted on and is built in six sections. It has a total length of 93 ft. and is carried over the extreme fronts of the boiler settings on roller supports. Steam is fed from the boilers to this header by 8-in. branches, with long-radius steel U-bends, each of which has a Chapman non-return stop and check valve for safety in case of accidental rupture of a boiler tube or connection.

The main header is sectionalized by a stop valve in the middle, each half having connections to four boilers and one of the delivery lines leading to the engine room, thus enabling the service to be maintained in case of disablement of either delivery line or section of the header. For further protection, the two delivery mains are interconnected at a point near the main header by a 12-in. tie line, which is so valved that either half of the main header may deliver steam to either one of the delivery mains independent of the other. Steam is supplied to the pumps, stoker engine and auxiliary equipment at the boiler house by a 6-in. auxiliary main spanning the firing floor transversely at the middle, which has a connection to the main header on either side of the sectionalizing valve. It drops at the outer wall into the basement, where 2-in. branches are taken off to supply the two feed pumps and the two reheaters and purifiers, and a 1½-in. branch to the drip pump.

The two supply mains, which are carried through the tunnel to deliver steam to the engine room in the main building, connect through electrically-operated stop valves with main boiler-house header at the middle point of either half section, and extend thence horizontally to the rear, connecting through long radius bends and return loops to drip pockets underneath the tunnel entrance platform. From here the lines rise vertically 15½ ft. and enter the tunnel through 6-ft. radius bends. The electric valves are 12-in. Chapman gate valves with electric motors operated from the engine room, by means of which instantaneous control of the steam supply is possible; the motors are mounted on the valve yokes and drive the yoke nuts through double gearing, which may, however, be detached for hand operation of the valve. The mains are carried in the tunnel on roller expansion chairs, spaced 12 ft. apart, being rigidly anchored at a bend in the tunnel near its middle point, expansion being allowed toward both ends. The chairs consist of 8-in. rollers conforming to the shape of the pipe and carried in trunnions on the upper ends of 2-in. screwed rods, which are mounted vertically in cast-iron bed blocks; adjustment is made by nuts on the screwed rods above and below the blocks. The blocks are in turn supported by pairs of transverse 6-in., 13-lb. channels 24 in. apart bedded in the tunnel masonry at 12 ft. in-

tervals. Expansion from the anchorage toward the engine-room end is provided for by 20-ft. U-loops extending horizontally at right-angles to the mains, near the ceiling line, the engine-room ends of which are firmly anchored by base ell fittings to a 10-in., 35-lb. channel attached horizontally to the steel work of the building.

The tunnel mains are graded with the flow of the steam, and each has a drip leg at the base of the riser from the boiler house to the tunnel, another at the bend near the middle of the tunnel, and a third at the free end of the expansion loops in the engine room. The last legs are connected to the engine room drip system and the two others to a drip system in the boiler house. The legs at the ends of the lines are open drip pockets of usual construction, but those at the midtunnel points are of a novel separator type, indicated in an accompanying detail drawing. The boiler-house header is drained by four 1-in. drip connections in either half, which deliver into 1½-in. drip mains underneath. These drip mains are joined by two 1¼-in. lines from the drip legs at the boiler-house end of the tunnel mains and a 1½-in. line from the mid-tunnel drip legs, and are carried down into the basement as a 2½-in. main to the receiver of the drip pump. This receiver has 2-in. drip connections from each of the reheaters and a 1¼-in. connection from the auxiliary steam header in the basement. The condensation accumulating in the receiver is automatically delivered by the 7½ x 4½ x 6-in. Wilson-Snyder duplex drip pump through a 3-in. connection to the boiler feed main in the basement. All drips, which are liable to be impure, such as those from exhaust heads, hot-water heaters, pumps, and exhaust piping, will lead directly to the blow-off tank.



Details of Piping Tunnel Construction and Arrangement of Piping.

Feed and Blow-Off Piping.—The feed-water piping is also of unusual arrangement owing to the location of the feed heaters in the engine room, over 500 ft. from the feed pumps. They were located there for convenience of connection to the exhaust steam system and also to the return systems collecting condensation from the heating systems and steam lines. The heaters form the reservoirs of feed supply for the boiler, make-up being added from the city mains automatically by a float valve as required. The heated feed water is thence delivered to the feed pumps in the boiler house by a line of 8-in. extra-strong wrought-iron pipe, which is carried through the tunnel, dropping in the boiler house to the basement. It is fitted with flanged joints and suspended in the tunnel by flexible hangers from the cross supports for the steam mains, the hangers being a simple type of stirrup carrying a roller block for the pipe, adjustment of height being secured by a turnbuckle support. Expansion is provided for in this line by three slip expansion joints, one at either end of the tunnel and one near the middle.

The feed-water main, at the boiler-house end of the tunnel, drops vertically to the basement, where it is carried across, connecting first to a surface condenser, with by-pass connections, and thence to a special air chamber at the pump suction, from which 6-in. branches lead to each feed pump. In this condenser the exhaust steam from all pumps and steam-using machinery in the boiler house is condensed to prevent its escape from the exhaust head above the roof. The air chamber consists of a section of 12-in. wrought-iron pipe and fittings, standing 10 ft. high, into which the feed water is delivered at the bottom and from which the pump suction is taken off through a cross fitting, 3½ ft. above the floor; the 6-ft. section of pipe above this is capped with a blank flange and forms the air chamber.

The feed pumps deliver through a common 5-in. copper main, which connects first into the reheater and purifiers, thence to the filters, and through the water meter to the feed main, a 5-in. copper line on the basement ceiling, extended longitudinally underneath the boiler fronts. In the discharge connection from the pumps, both the reheaters and filters are by-passed to permit of direct delivery to the boilers if necessary. From the 5-in. feed main 2-in. brass pipes are carried up through the floor, one at the side of each boiler. The branches deliver to the boilers through a graduating valve about 4 ft. above the floor and thence through combination check and stop valves [illegible] of the boiler connections.

The blow-off system consists of a main 4-in. line in the basement at the rear of the boilers to which two 2½-in. connections are made from each boiler. The boiler blow-off connections lead from opposite ends of the mud drums and are each fitted with two gate valves in a series to insure freedom from leakage. Where the blow-off connections lead through the interior of the setting to the rear wall, they are covered with terra-cotta pipe to prevent burning the pipe. The 4-in. glow-off line leads to a tank at the rear of the basement into which the hot discharge as well as the dirty drips are delivered for cooling before running to the sewer. This blow-off tank is of ½-in. steel plate, 4 ft. in diameter by 12 ft. long, and is heavily braced to withstand pressure. It has a 4-in. vapor connection leading to an exhaust head above the roof to discharge steam and vapor, and it has a cooling coil to insure the delivery of the blow-off discharge at a temperature low enough to avoid injury to the sewer. The cooling coil consists of ten loops of 2-in. brass piping, containing in all 238 ft. of pipe, which is fitted between two bronze manifold headers, having 3-in. connections to the water service for the hot-water supply of the building. The blow-off tank has an overflow to the sewer at a point 8 in. from the top of the tank, so that the latter is kept filled with water continuously, which serves to reduce the temperature of the blow-off discharge as it is received.

The Tunnel.—The tunnel, which has a width of 7½ ft. and a height to the crown of the arched roof of 12 ft., has a length of 300 ft. from the boiler house to the end of the pipe cellar, underneath the engine room. It enters the main building at the pipe cellar level, 12 ft. below the engine-room floor and 41 ft. below that of the main library floor, and extends from the latter section southward 150 ft. to the south wall of the museum division. There it bends at an angle of about 35 deg. to the eastward and thence continues 150 ft. further to the power house. The tunnel has a total length of 410 ft. from the engine room to the boiler-house wall and enters the latter 32 ft. above the boiler-room floor, as previously stated. At a point about 60 ft. from the boiler house it emerges through the slope of the side of the ravine and is carried thence to the boiler house above ground, being carried across the last 30 ft., where the ground drops precipitously, by a heavy concrete arch. The tunnel is of concrete construction with side walls and arch 22½ in. thick, consisting of 18-in. inner walls, a course of waterproofing and a 4-in. outer wall.

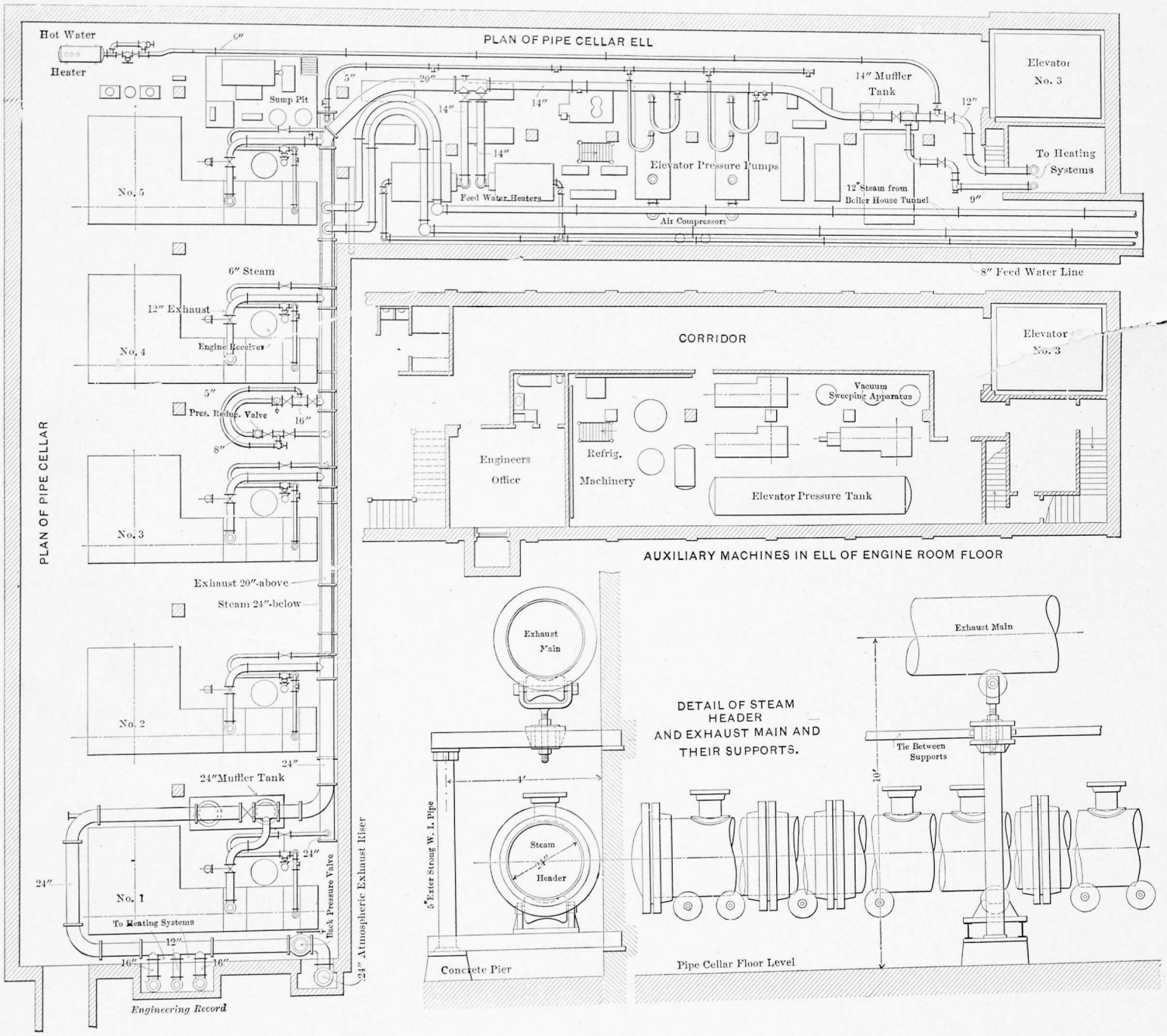
Engine Room.—Owing to the utilization of the exhaust from the steam-using machinery for the heating of building, the electrical generating and auxiliary mechanical equipment were, for convenience of low-pressure piping connections, separated from the boiler plant and located in the basement of the main library building. Furthermore, as the engine and electrical equipment are to be utilized as one of the educational features of the technical instruction system included in the library plan, the engine room was located in a large, convenient and well-lighted portion of the basement adjoining the interior court No. 1, and was especially equipped for convenience and accessibility in making inspections and tests. Unusual care was taken to make the engine room sightly and the result is probably one of the most attractive that has ever been secured in a power plant.

The engine room is located in the basement underneath a portion of the museum in a transverse section of the building between the hall of architecture and the large open court, which affords an unusual amount of daylight lighting. It is 45 ft. 7 in. wide by 106 ft. long and has a clear headroom of 24 ft., the engine-room floor being

...e basement ...below that of the main floor of the ... In it are located the electrical generat... units and the switchboard. Underneath the engine room there is a pipe cellar with 12-ft. clear headroom, in which ample space is afforded around the engine foundations for the location of the various piping systems. At the east end of the engine room there is an ell extension 34 ft. in width, which extends 120 ft. to the southward, under the museum reading room. This extension also has two floors, one at the engine-room level and the other an extension of the pipe cellar. is 11 ft. wide and 13 ft. above the engine-room floor and there is above it a clear headroom of 10½ ft. The ceiling and walls above the wainscot have a light tint. There are six large windows on the southerly side of the engine room which open into the large interior court No. 1, and afford ample daylight illumination. For artificial lighting, an attractive arrangement of studded incandescent lamps in rows along the ceiling molding has been provided.

Equipment.—The equipment of this portion of the plant includes five 300-kw. direct-connected electrical units, pumps and tanks for the operathis leved is the greater portion of the refrigerating machinery, the vacuum cleaning apparatus and air compressor and storage tank, and the pressure tank for the elevator system. In the portion of the pipe cellar underneath, the entire space, 34 x 120 ft., is given over to the remaining auxiliary apparatus and the various piping systems.

Steam Supply.—As stated before, steam is delivered from the boiler house some 500 ft. distant by a pair of duplicate 12-in. high-pressure mains, which are carried through a 7½ x 12-ft. tunnel entering the library building at the pipe cellar floor, some 40 ft. below the main floor. These



Arrangement of Steam Piping Systems in Power Plant in the Main Building.

The upper floor has less headroom than the engine room, being depressed entirely underneath the basement floor; both floors, however, have a clear headroom of 12 ft. In the southerly end of this portion of the pipe cellar is the portal of the piping tunnel from the boiler house.

Every effort has been made to secure a handsome interior in the engine room. The floor is of white marble and the side walls are finished with a wainscot of white enameled terra-cotta to a height of 11 ft. Five structural columns of the building, located between the electrical units, are similarly covered and across the east end of the room there is a visitors' gallery at the basement floor level, similarly finished. This gallery floor tion of five hydraulic elevators, absorption refrigerating machinery of 10 tons capacity, air pumps and separators for the Kenney vacuum cleaning system, compressors and storage tanks for the Johnson system of temperature control, vacuum pumps and receiver for the Webster system of steam circulation and miscellaneous auxiliary machinery. Practically all of the equipment, excepting the electrical machinery, is located in the ell extension. On the engine-room floor, there is a 10-ft. corridor, with toilet rooms and engineer's office at the end adjoining the engine room, and stairways and a freight elevator communicating with a driveway at the basement floor, at the south end. In a 24 x 60-ft. space remaining on mains end in 20-ft. expansion loops, from which connection is made directly to a 24-in. steam header and receiver in the cellar underneath the engine room. This header is near the floor of the cellar on the southerly side and has a total length of 110 ft. It was built in six sections of 24-in. pipe, outside diameter, with shell 5/8 in. thick, each section approximately 20 ft. long. All connections to this header are made through special forged wrought-iron nozzles which are double riveted to the upper side of the pipe. The header is supported at a distance of 36 in. above the floor on roller blocks of a simple design, illustrated in an accompanying detail drawing, which permit ample expansion and contraction.

All piping connections to the electric units are made in the pipe cellar so that the engine room is entirely free from obstruction by piping. Steam is supplied to each unit by a 6-in. branch which is carried up through a long-radius bend to a gate valve and thence through a return-loop bend to the throttle valve at the easterly side of each engine. The gate valve is a hand-operated shut-off valve, operated from the basement, while the throttle valve is a bevel-geared globe valve operated from a wheel on a floorstand in the engine room above. Each of the engine branches has a 2-in. connection from a point between the throttle and the valve chest to the engine receiver for reheating purposes. Steam is supplied to the auxiliary equipment by another 6-in. branch, which extends from the easterly end of the header to the rear and southward in the extension of the pipe cellar, where six branches are taken off to supply the various groups of units. These are two 3-in. branches to the large compound-duplex elevator pumps, another 3-in. branch to two elevator pumps and four air compressors, two 2½-in. branches to the vacuum pumps, refrigerating machinery and vacuum sweeping apparatus, and a 2-in. branch to the drip receiver pump and oil circulation pumps. The remaining supply connection from the steam header is an 8-in. branch which connects through two pressure-reducing valves in tandem to the exhaust [illegible]ystem for the addition of live steam to the heating mains to supplement the exhaust supply in extreme weather. The main header and all supply branches have drip connections to a receiver pump which returns condensation automatically to the feed-water heater; this pump is located, together with the cylinder oil pumps and oil collecting system, in a pit depressed 7 ft. below the pipe-cellar floor level.

Owing to the distance between the boiler and engine plants and the impossibility of immediate communication between them, it was thought advisable to provide some means of steam control from the engine room. There are, for this purpose, electrically-operated valves in each of the 12-in. delivery mains at points near their connection to the boiler-house steam header, which valves are under control from various points in the engine room and pipe cellar. They are 12-in. Chapman gate valves with small electric motors mounted on their yokes and driving the yoke nuts through double-reduction gears. The driving mechanism is so arranged that the motors are started and brought to speed before clutching the valve operating gear. The motors are connected to the 110-volt, direct-current lighting circuits of the building and are in parallel so that both valves are closed simultaneously from the engine room. There are five control points, two in the engine room and three in the pipe cellar, each having an automatic switch fastened to a bracket on the wall and fitted with an indicator which shows at a glance the position of the valves in the boiler house. This equipment has been specially designed by the Chapman Valve Manufacturing Co.

Exhaust Steam System.—The exhaust steam system serves as the low-pressure supply to the heating mains and to the open feed-water heaters. It consists of a 20-in. main, carried longitudinally under the engine-room floor and above the steam header-receiver, enlarging at the westerly end to a 24-in. pipe, and extending to the rear in the ell extension of the pipe cellar as a 14-in. line. Into this main all the exhaust connections from the engines and pumps are made, those from each of the electric units consisting of a 12-in. connection having, close to the engine, a beveled-geared gate valve operated from a floorstand on the engine room floor. In the pipe cellar two 6-in. exhaust connections from the two large elevator pumps are made to the 14-in. line and a number of smaller connections from the small pumps in this portion of the cellar and on the floor above. This exhaust main and branches are of full weight standard pipe, supported 10 ft. above the floor. In the pipe cellar under the engine room, it is carried near the ceiling on roller supports, similar to those in the tunnel that carry the steam mains. These supports have 8-in. rollers carried in trunnions on the upper ends of 2-in. screwed rods, which are mounted vertically in cast-iron chairs; the adjustment of the rod and roller block vertically is obtained by means of nuts [illegible] rods above and below the bed blocks. [illegible] are supported by 5-in. 12-lb. channels, 12 in. [illegible] the wall ends of which rest on cast-iron plate[illegible] built into the wall and the outer ends on stands of 5-in. extra-strong wrought-iron pipe, as shown in an accompanying detail drawing.

Delivery of the low-pressure steam to the heating systems is made from either end of the exhaust main through Utility combined grease extractors and muffler tanks. At the westerly end of the pipe cellar, the exhaust main, here enlarged to 24-in. pipe, is connected into a 5 x 14-ft. muffler tank, and is thence extended to the end of the room where connection is made to two 16-in. and one 12-in. heating mains and beyond this, through a Kieley back-pressure valve to a 24-in. atmospheric exhaust riser, in an adjoining pipe shaft, for relief to the system in case of excessive back pressure. At the southerly end of the ell extension, the 14-in. end of the exhaust main is connected into a 4 x 9 ft. muffler tank, from which delivery connections are made to a 9-in. and a 12-in. heating main and to a 6-in. line supplying a hot-water heater. Near the middle point of the exhaust main at the end of the 20-in. section, two 14-in. branches connect to the heaters in the cellar extension, which are of the Webster horizontal open type with oil extractors. The entire exhaust system is dripped to traps in the sump pit which discharge to the sewer. For the live-steam supplemental supply to the low-pressure system, an 8-in. connection is made between the high-pressure header underneath the engine room through two Kieley pressure-reducing valves to the exhaust main, with a 5-in. by-pass for manual operation if necessary. The reducing valves consist of an 8-in. high-pressure reducing valve and an 8 x 16-in. low-pressure valve, the purpose of the two being to reduce the pressure gradually from 160 lb. to about atmosphere at the exhaust main. All of the steam piping, both high and low-pressure, is covered with sectional 85 per cent. magnesia covering, 1 in. thick; all steam mains carrying boiler pressure are double covered and all covering is recovered by 10-oz. canvas sewed on.