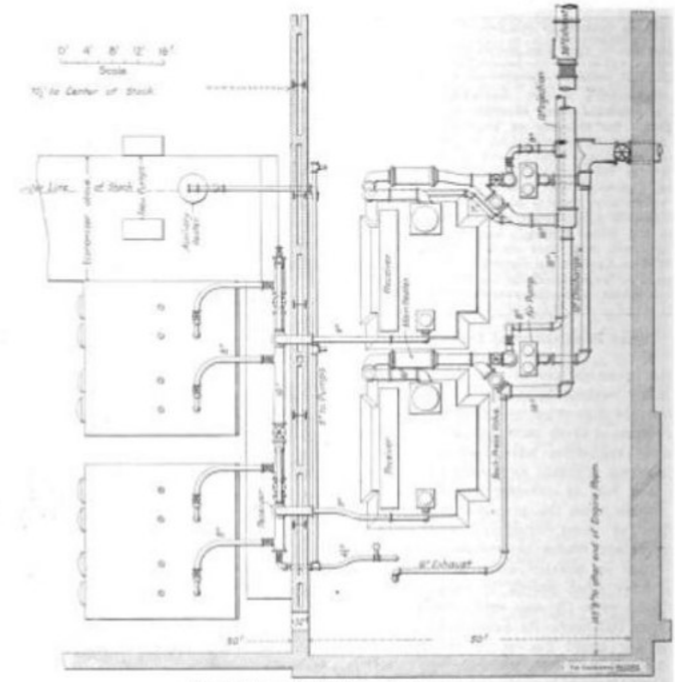
Power Plant of the Cambridge Electric Light Company, Cambridge, Mass.

The Cambridge Electric Light Company has recently completed a distinctly modern electric lighting and power plant, on Western Avenue near the Charles River, in Cambridge, Mass. The new plant is an alternating-current one with a three-phase 60-cycle supply furnished from direct-connected vertical compound condensing generating units, of which the steam engines are to receive superheated steam. In addition to both main and auxiliary feed-water heating, economizers have been provided, to utilize the heat of the flue gases. Among other notable features of the plant may be mentioned the lofty character of the building, which has resulted in well lighted and ventilated boiler and engine rooms, an unusually light basement under the engine room, due to numerous outside windows in that story and to several openings in the engine room floor, the use of a traveling crane in the boiler room as well as in the engine room, and an extensive provision of special pipe hangers to allow for expansion changes in practically all classes of piping. The old plant, near which the new one has been built, had been outgrown by a rapidly increasing business and is to be entirely dismantled.

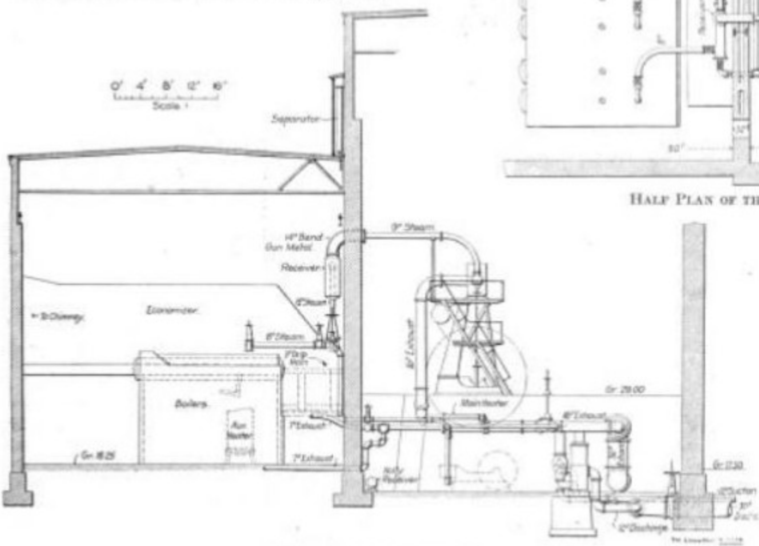
The power house is a steel frame building with brick walls and a timber roof supported by steel trusses. The street walls of the building are built with an enclosed air space of 8 inches, and are faced on the outside with a cut-stone base course and surmounted at the roof by a heavy balustrade. In main dimensions the building is 106 feet x 151 feet 4 inches and is of the class in which the engine and boiler rooms are side by side, the longitudinal partition being composed, similarly to the street walls, of two 12-inch walls with 8 inches air space between. The boiler and engine rooms are of the same width, 50 feet, and are 145 feet 8 inches long, but if desired, one end wall may be torn down and indefinite extension made. The floor of the engine room is 10 feet 9 inches above the level of the boiler room floor, and the basement floor 4 feet 3 inches below it, leaving a clear height in that story of 13 feet 8 inches. In the boiler room, the lower chord of the roof trusses is 41 feet 9 inches above the boiler room floor; in the engine room, the distance is about 52½ feet. In the case of each room, the roof has a large monitor, and in the engine room, in addition, there is a row of windows in the upper part of the main walls above the main windows. The interior walls of the boiler room are of red glazed brick for perhaps the first ten feet, and are painted white above; the under side of the roof is white, while the roof trusses are painted green. The floors are all of cement. The cranes are 25-ton hand-power Maris traveling cranes.

The boiler room contains two batteries of Babcock & Wilcox water-tube boilers, two boilers in each battery. There is space for a future installation of two similar batteries in the present building. Located in the center of the present boiler room are two boiler feed pumps, the auxiliary feed-water heater and the economizer, the latter supported overhead, so that the floor space underneath could be utilized for the pumps and heater. Incidentally the flue gases do not have to be carried downward in their passage from the boilers to the stack, which rises outside of the building as an entirely independent structure.

Each boiler contains 192 4-inch tubes 18 feet long, arranged in 16 sections 12 pipes high, and two 42-inch steam drums 23 feet 3⅝ inches long. They were built to carry 200 pounds pressure, and the steam connections are made so that before entering the steam header all the steam from each boiler must pass through a superheating coil which contains 125 square feet of heating surface. Grates have been provided for burning soft coal, and the grate surface in each boiler is 67.6 square feet, bearing a ratio to the total heating surface of each boiler, which is 3,964.5 square feet, of 1 to 58.7. No provision has yet been made for mechanically handling coal, as it is conveniently brought to the boiler house by water.



HALF PLAN OF THE LIGHTING STATION.

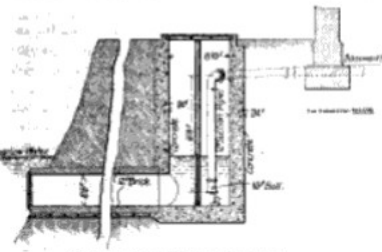


CROSS-SECTION OF THE STATION.

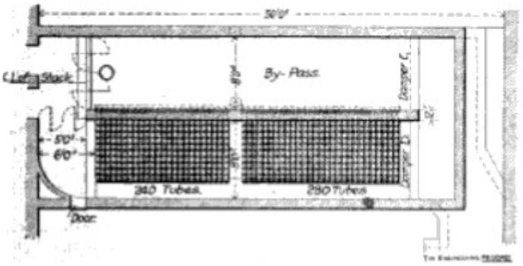
The smoke passage is located immediately behind the boilers and is of brick, its floor and ceiling consisting of arches sprung between light I-beams that extend from the partition wall to the boiler setting. The wall of the passage back of the boilers is 12 inches thick. The floor and the roof above the ceiling arches are both covered level with Portland cement mortar, composed of equal parts of sand and cement, with the mortar 4 inches thick above the I-beams in the floor construction. The inside area of the smoke duct is constant its entire length, 36 square feet, which is not quite 54 per cent. of the aggregate area of the four openings into the smoke passage from the four boilers.

At the center of the boiler room the breeching is carried upward into the economizer setting, which is a brick structure of 12-inch walls, carried on steel columns from the boiler room floor and having brick arch floors and roof finished with Portland cement plaster. The setting is constructed to have a central direct smoke passage to the chimney with two sets of economizer tubes on each side. Half of the full boiler plant only having been installed, the second set of tubes has not been put in place and as now built, the economizer setting comprises one set and the by-pass. The by-pass pas-

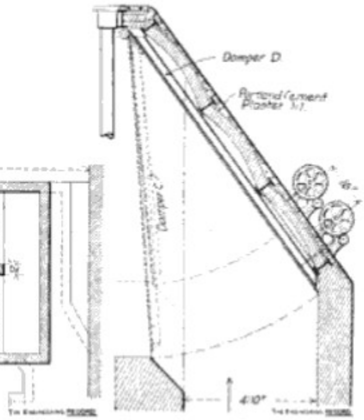
sage has an area of 60 square feet, which is 1 2/3 times the area of the present smoke passage. The economizer was built by the Green Fuel Economizer Company and consists of the usual 4-inch tubes 9 feet high, arranged in two groups, one of 280 tubes and the other of 240 tubes. An accompanying drawing indicates the method of operating the dampers controlling the entrance to the setting. Each of the two dampers is



CONDENSING WATER INTAKE.



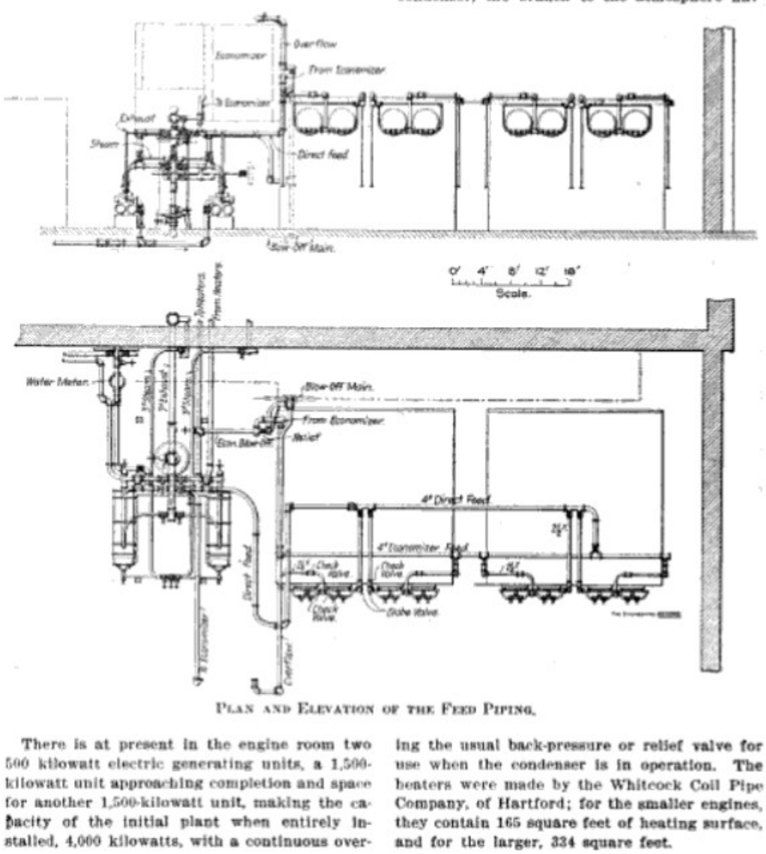
PLAN OF ECONOMIZER.



INLET END OF ECONOMIZER.

hinged at the top and is lifted or lowered by means of a chain at the bottom, the winding drum operated in each case by a hand crank through spur gearing. The dampers at the exit of the passages are suspended by chains at their axes, the chains passing through the top of the setting and being twisted to turn the dampers. The economizer extends below the by-pass passage and the clean-out doors are located on the inner side of the economizer wall and under the by-pass passage. The chimney, which is located a short distance outside the boiler room, is of brick of the double-shell type, with a constant inside diameter of 9 feet and a height above the grate bars of 252½ feet.

The steam from each boiler is carried from the cross-connection joining the outlets of the two superheating coils in each boiler to a 16-inch header by means of a horizontal 8-inch wrought-iron pipe bent horizontally. This pipe is connected into the side of the header, with a valve at the cross-connection and at the header. The header, which is of steel and supported by cast-iron roller bearing chairs fastened by extension pedestals to the top of the smoke duct, is divided into four sections, corresponding to the four boilers, by gate valves. These are readily accessible from the roof of the smoke passage. The supply pipes to the engines already completed rise 8 inches in size in a long upward bend to a steam receiver, which is suspended in position by means of a special bend of gun metal passing through and anchored in the partition wall. From the top of the receiver, the engine supply continues 9 inches in diameter, with resultant reduction in velocity, roughly 6,000 feet per minute, and passes through the gun metal bend into the engine room where it reaches the high-pressure engine cylinder by means of long downward bend. The receivers are 30 inches in diameter and 6 feet high and, besides being a reservoir of steam, used to lessen the chance of pipe vibrations by the periodic cut off of steam and to supply a sudden demand of steam, act as separators. These receivers and each section of the header are drained into a 3-inch drip main suspended below and run parallel with the header; from this the water is conducted into a Holly receiver and returned, together with other clean high-pressure drips, into the boilers by means of the Holly system. For the supply of the various pumps, a 5-inch main is carried along the partition wall in the basement of the engine room, this main supplied by a 5-inch pipe from each end of the main header. The high-pressure piping throughout is provided with the Vanstone joints with copper gaskets.



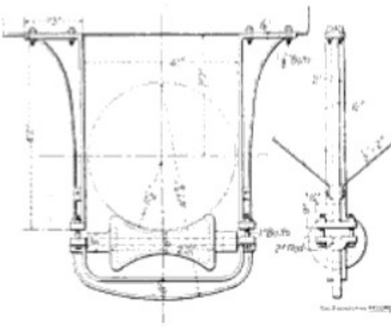
PLAN AND ELEVATION OF THE FEED PIPING.

There is at present in the engine room two 500 kilowatt electric generating units, a 1,500-kilowatt unit approaching completion and space for another 1,500-kilowatt unit, making the capacity of the initial plant when entirely installed, 4,000 kilowatts, with a continuous overload capacity of 1,000 additional kilowatts. The units consist of McIntosh & Seymour vertical cross-compound engines and General Electric three-phase 60-cycle alternators, the alternator and a fly-wheel being located between the two cranks. The governing mechanism is of the interia fly-wheel type, under control of a ⅛-horse-power motor, mounted on the wheel and controlled from the switchboard, for moving the weights to the desired position and thus securing facility in synchronizing. The smaller engines have 18 and 38-inch cylinders and a common stroke of 42 inches, and the large engine 31 and 64-inch cylinders and 48-inch stroke. The rotative speed of the smaller units is 120 revolutions per minute and that of the large combination, 120 revolutions; the alternators generate a voltage of 2,300 volts. Current is transmitted, at this pressure, throughout Cambridge, being stepped down by transformers at the points of use. The switchboard, which was built by the General Electric Company, is located against the outside wall of the engine room, and the conductors pass out of the building through a wiring tower, which is a small shaft built against a rear corner of the boiler room.

Each engine is provided with a receiver for the passage of the steam from the high-pressure to the low-pressure cylinder, and the high-pressure cylinder is jacketed for high-pressure steam and there is a high-pressure steam coil in the receiver. The condensation from each source is returned to the boilers by means of the Holly system. The exhaust steam from the low-pressure cylinder passes first through the main heater and then may be conducted to the atmosphere or to the condenser, the branch to the atmosphere having the usual back-pressure or relief valve for use when the condenser is in operation. The heaters were made by the Whitcock Coil Pipe Company, of Hartford; for the smaller engines, they contain 165 square feet of heating surface, and for the larger, 334 square feet.

The condensers are of the Blake vertical twin type of jet condenser, with 12-inch steam cylinders, 25-inch air pump and 18-inch common stroke. The reciprocating members rise into the engine room, and a light well has been built around them, giving considerable light to the basement in that way, in addition to that obtained from the basement windows. The condensers are located on the far side of the engine foundations from the boiler room and the main exhaust line is carried to the outside of the building independently of the exhaust from the pumps and auxiliary machinery. The exhaust piping throughout is of cast iron.

The condensing water is drawn from the Charles River through a tunnel to a well near the power house and from there through a 12-inch injection pipe. The tunnel is circular in section, 4 feet 6 inches in diameter, of 12-inch brick walls and about 85 feet long. Its inlet is protected with a grill of 1-inch iron bars, set vertically. The well is 8 feet 6 inches in diameter, built with concrete walls 24 inches thick, and capped with a cast-iron cover; it is about 23½ feet deep. It is fitted with a partition of wood with a copper-wire screen in the bottom, the partition dividing the well into two compartments, one in which the screened water is taken through the enlarged mouth of the injection pipe and the other in which debris collecting outside the screen can be removed. The screen consists of ⅛-inch copper wire, with ¾-inch mesh and has a free area of about 14 square feet. The discharge pipe from the condensers, which is 30 inches in diameter, ends 75 feet beyond the condensing water intake.



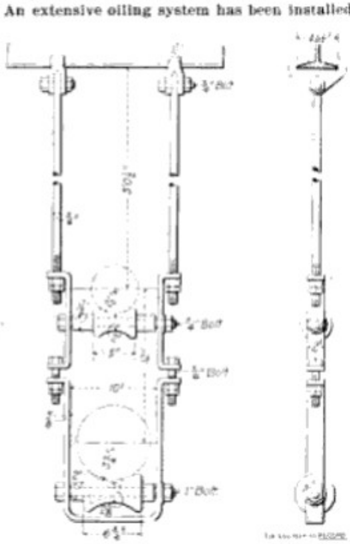
HANGER FOR 36-INCH EXHAUST PIPE.

The condensing water piping throughout is of cast iron, and in the power house is carried in a cement lined trench below the basement floor.

Besides the condensers and the boiler-feed pumps, which are supplied from the auxiliary steam main, there is a steam-driven exciter unit in the basement, supplied from the same source. This consists of a 10x12-inch Armington & Sims horizontal engine, running at 275 revolutions per minute, and a 120-volt Westinghouse direct-current dynamo of 25 kilowatts capacity. This is intended to supply the field current for starting the alternators, but under normal running conditions the field excitation will be obtained from a 35-kilowatt motor driven set in the engine room. This comprises an induction motor directly connected to a direct-current dynamo. Space has also been reserved for a larger set to care for the entire plant upon the addition of the fourth unit. The three make a very flexible and practically a duplicate combination for excitation.

Feed-water ordinarily is taken from a rain water tank of 40,000 gallons capacity, and when necessary, from the city water mains through a water-meter. No purification or water softening has been found necessary. There are two feed-pumps situated, as stated, underneath the economizer, one the reserve of the other. These are of the Blake outside packed plunger type, designed for high-pressure work, with 6½-inch plungers and duplex compound steam cylinders, 8 and 12 inches in diameter and 12 inches stroke. They deliver the water usually through the main heaters in the main engine exhaust pipes, then through the auxiliary heater, for the utilization of the exhaust from the pumps and auxiliary apparatus, then through the economizer and into the boilers. Any one of the heaters may be by-passed, as may also the economizer. The feed-pumps are governed automatically by means of a Locke governor. The by-pass around the economizer is extended into an independent boiler feed main, while that from the economizer makes a second feed main. The method of taking connections from both mains, which, it may be pointed out, can be connected together, is shown in an accompanying drawing of the feed piping systems. The auxiliary heater is of the closed type, of the same make as the main heaters, and contains 500 square feet of heating surface.

An extensive oiling system has been installed



HANGER FOR A PAIR OF PIPES.

for the generating machinery. It includes a duplicate installation of filters and oil tanks under a compressed air system of circulation. The equipment is located in the basement against the engine foundations and facing the basement windows. The oil tanks rest on brick piers on the basement floor and are 4 feet in diameter and 3 feet high with dished heads, the heads turned in the same direction. The filters, which are of the Cross make, are 35 inches in diameter, 4 feet 4 inches high, supported immediately above the level of the top of the oil tanks. The compressed air is furnished by a 5-horse-power motor-driven Ingersoll-Sergeant Drill Company air compressor, and a compressed air tank 3 feet in diameter and 6 feet 9 inches long is provided, suspended from the basement ceiling. A 1-inch pipe leads from the air tank to the tops of the two oil tanks, with valves so that either tank can be put into use, and there is a branch to this pipe for filling with fresh oil. The oil is forced from the bottom of each tank through 1-inch piping to the lubricating system. On its return it is delivered by 2-inch piping into the filters and thence by a ¾-inch pipe into either oil tank to be recirculated. The air is maintained at 50 pounds pressure.

The power plant was designed by Messrs. Sheaff & Jaastad, of Boston. The general contractor for the structure, including the chimney, was Mr. F. B. Gilbreth, of that city, and the contractor for the piping was the Walworth Manufacturing Company. It will be interesting to note that in the construction of the foundations for the building and machinery, the portable gravity concrete mixer made by the Contractors' Plant Company was used, combined with the concrete set-up invented by Mr. Gilbreth, which is moved away from the mixed concrete instead of removing the concrete from the concrete mixer. Mr. D. E. Badger, chief engineer of the plant, supervised the construction, while the electrical end was looked after by the chief electrician, Mr. W. R. Eaton.

The Hydraulic Power Plant of the Riverside Power Company.

The city of Riverside, Riverside County, Cal., owns an electric generating system driven by steam, using crude oil as a fuel. In addition to the steam plant the city buys electricity from several different sources and sells electricity for lighting and power. The conditions of irrigation around and in Riverside are such that the plants pumping water for irrigation, either from wells or from the various canals, are considerable consumers of power, and the majority of these pumping plants may be so operated as to utilize the surplus electric power without materially interfering with the lighting load. Some of the choicest orchard land is above all existing or projected canals, and the city has been making a determined effort to increase its sales of electric power to the irrigators of such land, and, in fact has somewhat oversold the supply.

The Riverside Power Company is one of several companies that were gotten up to sell electricity to the city at wholesale. The Riverside Power Company utilizes the water supply of the Santa Ana River by passing it through a canal which heads three miles below the city and extends six miles along the bank to a power station, where two 300-kilowatt General Electric generators are to be driven by turbines. The design of the system, as worked out in a report of Samuel Storrow, consulting civil engineer, of Los Angeles, Cal., included a concrete-lined canal having a capacity of 120 cubic feet per second and leading to a reservoir capable of storing 12 hours' flow. The original scheme provided for a power plant so designed that the day load on the electric equipment could be taken care of by one generating unit, and the night load by two units, the intention being to allow the reservoir to fill up during the day by the excess of the capacity of the canal over the demands of the wheels, and then to allow the reservoir to empty through the power house during the peak of the lighting, thus giving a fluctuating delivery to correspond with the fluctuating demand upon the system.

The intake of the canal is placed at the "Narrows" of the Santa Ana River, where its channel is crossed by a granite dike and the wide valley contracted as the river enters the canyon. This is a particularly strong and satisfactory site for a diversion weir, and has but one objection—that the river carries an extraordinarily large amount of sand, which is constantly moving down stream at all stages of the river and more especially at times of flood. This difficulty was obviated by building sand-boxes, or "blow-offs," in the bottom of the canal at a point about 1,000 feet below the entry, where the canal enters the flume and