DESCRIPTION OF THE FRESH AND SALT WATER SUPPLY AND PUMPING PLANTS USED FOR THE AQUARIUM.

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Fresh-water supply.—The water for the fresh-water aquaria was supplied from one of the water mains under the aquarium building at an average pressure of about 60 pounds per square inch, and before passing into the supply pipes erected over the aquarium this water was filtered by two pressure filters of the Jewell patent, having a rated guaranteed capacity for filtering 125,000 gallons of water each in twenty-four hours. After the water had been filtered it passed through the galvanized iron supply pipes which were erected above the aquaria and into which were screwed brass jet cocks, through which the delivery of the water for the aquaria was regulated.

Each aquarium had an overflow or waste pipe that was so arranged that the surplus water was allowed to discharge into a waste pipe which emptied into the lake, and by this method the water was being constantly changed in the aquaria. The piping, valves, fittings, etc., in connection with this system were either of galvanized iron or brass.

Pumps and electric motors.—There were two independent reciprocating direct-acting geared force pumps with water ends of hard rubber, having a capacity of about 4,000 gallons of water per hour each at 90 strokes per minute.

They were driven by belts from a counter shaft that was driven by two electric motors of about 6 horse-power each, at a speed of about 1,500 revolutions per minute. The current for these electric motors was about 500 volts.

The pumps were so arranged that one or both could, if necessary, deliver their water direct into the main supply pipe for the aquaria.

The pumps and electric motors were located in a separate room under the floor of the main building of the Fisheries Exhibit near the salt-water reservoir from which they obtained their water.

Salt-water reservoir.—There was located under the floor of the main building of the Fisheries Exhibit a reservoir constructed of brick and Portland cement, with a capacity of about 68,000 gallons. The bottom of the reservoir was of concrete and the surface of asphalt.

Distributing tank.—There was located in the top, under the roof of the main building of the Fisheries Exhibit, about 54 feet above the aquaria, a cylindrical wooden distributing tank having a capacity of about 2,500 gallons, into which the pumps delivered their water through hard-rubber piping.

The distributing tank was connected to the salt-water reservoir by an overflow pipe of hard rubber.

Filters for salt water.—There were located under the floor of the main building of the Fisheries Exhibit two pressure filters of the Jewell patent, each 6 feet in diameter, 5 feet in height, connected to operate independently or together. The rated guaranteed capacity of these two filters was 250,000 gallons in 24 hours.

During the first month or two of the Exposition it was not found necessary to work the filters to their rated capacity, but during warm weather they were frequently worked beyond this capacity. The rate of filtration at some periods was as high as 750,000 gallons per day, and although the filters were taxed to this great extent their work was satisfactory.

The filters worked under a pressure of 60 pounds to the square inch in the inlet, and from 50 to 60 pounds in the discharge pipe; the difference in the pressures varying according to the time the filters were in operation between washing, or in other words with the accumulation of the impurities.

The filter beds were composed of white machine-crushed quartz, and were 2 feet 4 inches in depth.

The water before it entered the filters was treated by the addition of a very small quantity of alum solution. The amount of alum used averaged about $\frac{1}{5}$ of a grain per gallon, or 1 pound for about every 30,000 gallons of water filtered. The expense of this alum was about 2 cents per pound.

The action of the alum upon the water was a chemical one, and served to remove the dissolved-coloring matters and invisible impurities, such as bacteria, etc., and it also served to assist the retention of the extremely fine particles of suspended matters, which would otherwise pass through a filtering bed of the nature and porosity of that which was used in the filters during a high rate of filtration.

Analysis demonstrated that not the slightest trace of alum that passed through the filters appeared in the filtered water. The apparatus used for introducing this solution of alum was located about 150 feet from the filters on the inlet pipe, and was exclusively an auxiliary apparatus.

There were also located under the floor of the arcade, at the end nearest the aquaria, two box filters, 12 feet long, 4 feet wide, and 2 feet deep, constructed of 2-inch plank. These were filled with layers of coarse gravel and fine sand, through which all the waste water from the aquaria was filtered before passing to the main reservoir.

Apparatus for regulating the temperature of the fresh and salt water supplies.—For the purpose of regulating the temperature of the water for the aquaria in summer and winter, there were secured to the joists under the arcade two sections of 12-inch wrought-iron pipe, each 20 feet long, and on the ends of each section were screwed cast-iron caps. One of the caps on each section had two holes drilled in, to allow $2\frac{1}{2}$-inch pipes to pass through.

The section of 12-inch pipe used for the salt water contained four lengths of drawn-brass pipe, $2\frac{1}{2}$ inches diameter and 20 feet long, tinned inside. These four lengths of pipe were so connected as to form a continuous coil. The ends of these coils passed through holes in one of the caps of each section, and were fitted with inside and outside lock-nuts, thus making the sections or reservoirs steam and water tight.

These coils were afterwards connected, by proper valves, to the supply pipes to aquaria, and were so arranged that the supply water for the aquaria could be made to pass through these coils if necessary.

The section of pipe and its coil which was used for the fresh water was similar in construction to that used for salt water, except that the coil was made of galvanized-iron pipe instead of brass.

The coil of this section was connected to the fresh-water supply pipe of the fresh-water aquaria between the Jewell filters and fresh-water aquaria, and so arranged that the fresh water could be made to pass through the coil or pass direct to the aquaria.

These sections of 12-inch pipe were connected to a steam boiler located under the aquaria building, so that steam could be introduced into them and around the coils; in this way the fresh and salt water supplies to aquaria could be raised to the temperature desired.

In order to regulate the temperature of the salt-water supply for aquaria during the warm weather, the section of 12-inch pipe containing the brass coil was connected to the fresh-water supply pipe between the water main and the Jewell filters, and was so arranged that a continual flow of fresh water could be introduced into the 12-inch section and around the coil through which the salt water was passing; the fresh water being at a lower temperature than the salt water, it was used as a medium during the hot weather to cool the salt water supply to aquaria.

Salt-water pipe, pumps, etc.—All piping, parts of pumps, valves, jet cocks, etc., in contact with the salt water were made of hard rubber, with the exception of the drawn brass coil, described above, tinned inside in the section of 12-inch iron pipe, which was used to regulate the temperature of salt-water supply.

Operation of salt-water plant.—The pumps having separate suction and delivery pipes and run by separate motors, each pump was independent of the other and interchangeable, making two separate and distinct plants; and in case of accident to one pump or motor or of any of its attachments, the other pump was capable of supplying enough water for the aquaria. It was not found necessary at any time to run both pumps at once.

The water was drawn from the reservoir by the pumps through hard-rubber pipes and pumped into the distributing tank. From the distributing tank the water was conveyed by gravity through hard-rubber pipes to the apparatus for regulating the temperature, and into the supply pipes located over the aquaria. From this supply pipe it was delivered through jet cocks into the aquaria.

The overflow or waste water from the aquaria passed into the box filter filled with sand and gravel, and from them through hard-rubber piping to the main reservoir.

Air circulation for salt-water aquaria.—The Bishop and Babcock Company of Cleveland, Ohio, courteously lent the U. S. Fish Commission two of their hydraulic pumps, which were operated by water taken from the fresh-water main, and it was found that one of the pumps having $3\frac{3}{8}$-inch diameter water cylinder, $5\frac{7}{8}$-inch diameter air cylinder, and 8-inch stroke, would furnish sufficient air, at a pressure of 7 pounds per square inch, to aërate all the salt-water aquaria.

The air pumps delivered the air into a galvanized air cylinder at a pressure of about 7 pounds per square inch. From this receiver the air was conveyed to the backs of each salt-water aquarium by iron piping, and there connected with each aquarium by rubber tubing, into which were inserted wooden liberators through which the air was forced into the water.