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THE LAKE BIWA-KIOTO CANAL, JAPAN.

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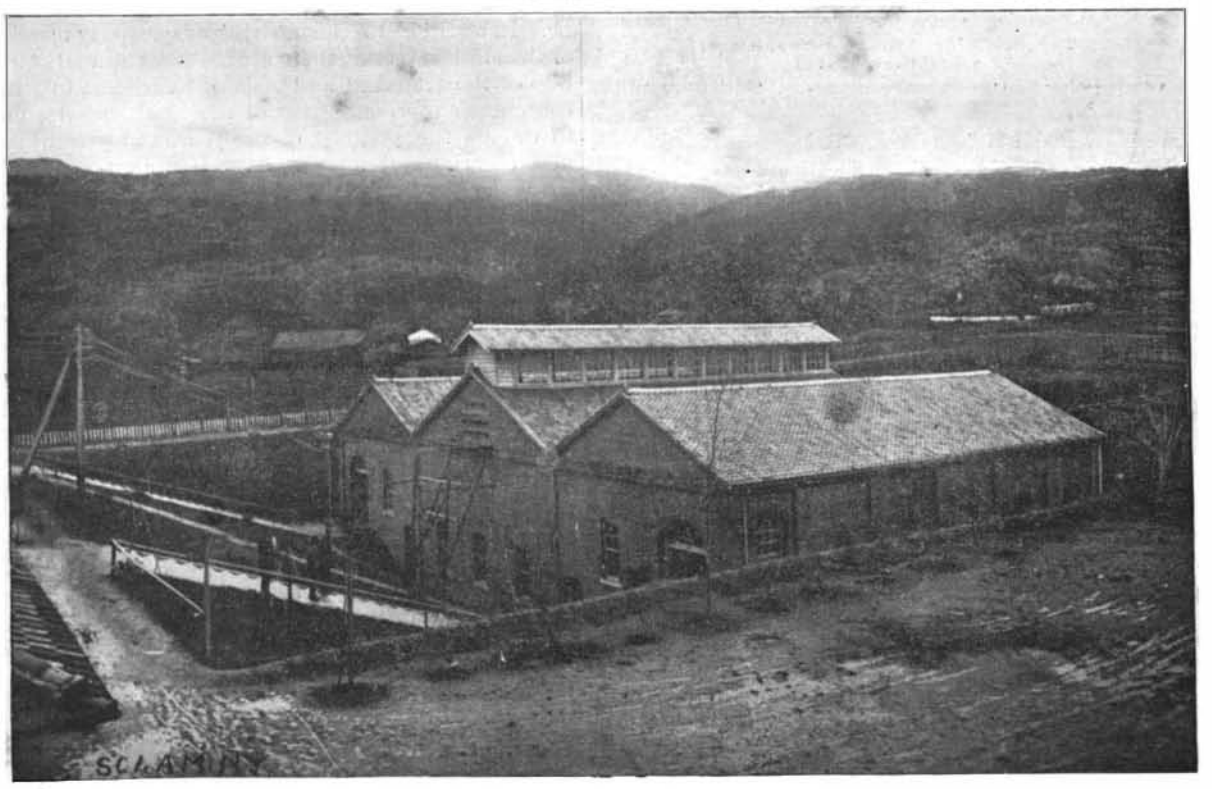
Lake Biwa, which is the largest lake in Japan, covering some 500 square miles, is 280 feet above sea level and is 36 miles from the Bay of Osaka, on which is situated a city of the same name, which is the commercial center of Japan. The lake has an outlet called the Yodo River, whose course for the first 13 miles is impeded by cliffs and rapids, when it reaches the town of Fushimi. From this point to Osaka on the sea, a distance of 23 miles, the Yodo is navigable. It will thus be seen that the lake navigation is separated by natural barriers from the river navigation. About half way between Fushimi, the navigation terminus of the Yodo, and Lake Biwa, is the city of Kioto, which is connected with Fushimi by a canal, but is separated from the lake by the Nagara and Hino-oka ranges of hills.

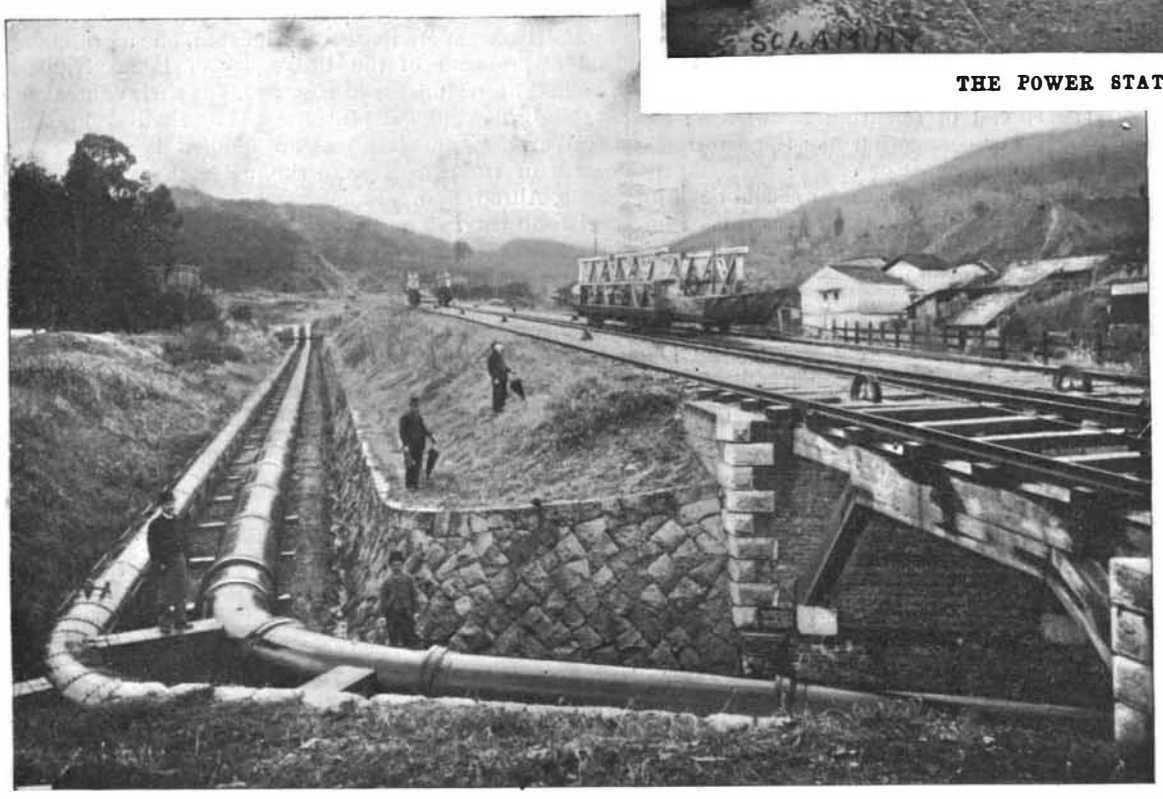
The objects of the construction of the canal between the lake and the city were:

1. To open a line of boat navigation between the Lake and Yodo River through Kioto.
2. The production of water power and the distribution of power and light in the city by electricity.
3. The irrigation of rice fields in the vicinity.

The work was commenced in 1885 and completed in 1891, under the direction of Sakuro Tanabe, Assoc. M. Inst. C.E., who was the engineer-in-chief.



THE POWER STATION—CAPACITY, 2,400 HORSE POWER.



THE CANAL INCLINED PLANE AT KIOTO—LENGTH, 1,815 FEET. LIFT, 118 FEET.

Main Canal from Lake Biwa to the City of Kioto.—The main canal connects the southwest extremity of Lake Biwa with Kamo River in the city of Kioto. The length of the canal is 36,650 feet, and it has two locks, one inclined plane and three tunnels. The difference of level in this distance is 140 feet, of which 129 feet are overcome by a lock and an incline, and the remaining 11 feet by the canal gradient, which is between one in 2,000 and one in 3,000, except in the last stretch in Kioto, where it is almost level.

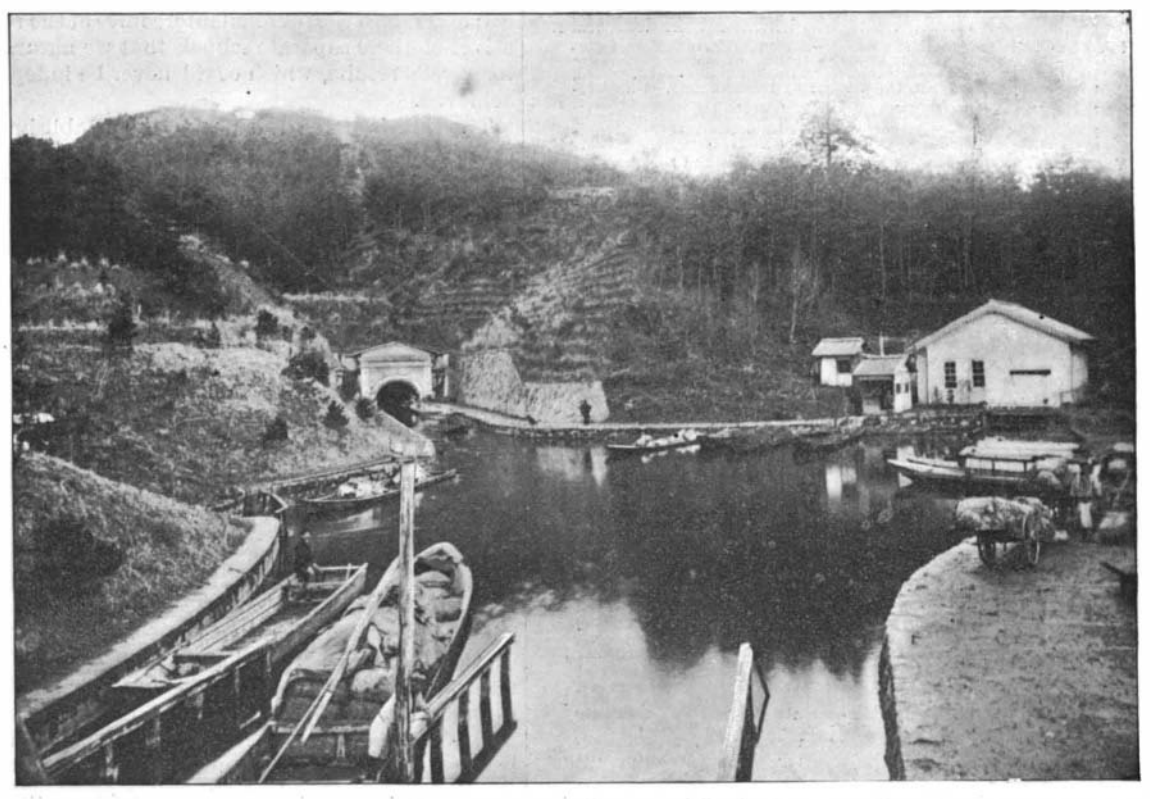
At the lake end the entrance to the canal is formed on land reclaimed from the lake by debris from the canal and tunnel excavations, and extends about 1,000 feet from the old shore; a breakwater protects this entrance. The first stretch of open canal is 28 feet wide, 5 feet deep and 1,800 feet long, and leads to the first and principal tunnel. The level of the lake fluctuates several feet, according as the season is wet or dry, and a regulating lock and sluice gate on this first section are necessary to maintain a constant flow of 300 cubic feet of water per second through the canal.

The first tunnel, 8,040 feet long, passes through the Nagara range of hills and is the longest navigable tunnel in Japan. It has a horseshoe section 16 feet wide and 14 feet high, providing for 6 feet depth of water, and is pierced through a formation of clay slate, hornstone, sandstone and quartz porphyry. It is lined with masonry and brickwork. There is no tow path; the boat being propelled by a chain laid at the bottom and ropes at the sides. The tunnel was excavated from both ends and from a 10½ feet by 9 feet elliptic permanent brick-lined shaft, 150 feet deep, sunk at about one-third the distance from the west or Kioto end. The tunnel was begun in March, 1886, and completed in February, 1890; the headings from the shaft and from the west entrance met in July, 1887.

Some difficulty was experienced in dealing with the water from the shaft and from the lake. There was only one accident on the lake side, where the soil was treacherous. In October, 1888, about 15 yards of timbering fell, inclosing 65 miners inside the break. Happily, after 47 hours they were rescued. The tunnel was constructed almost entirely by hand labor, on account of the very frequent change of hardness and nature of the rocks, which were full of fissures, and to the cheapness of labor and inability of the miners to manage rock drills.

From the west end of the first tunnel there are 14,511 feet of open canal, sometimes in cutting and at other times on embankment, but mainly skirting the hill side. Water is led off from certain points in this section of canal to irrigate rice fields to the southward. Then comes the range of Hino-oka hills, pierced by two tunnels 411 feet and 1,802 feet long respectively, through clay slate, hornstone and sandstone. Just

(Continued on page 345.)



UPPER POOL OF THE CANAL INCLINED PLANE, SHOWING DRUM HOUSE AND ENTRANCE TO TUNNEL