of the hard rigid roadbed thus formed the wear and tear on skip and rails was very great, and the bolts and clips were continually working loose. The scheme was therefore abandoned in favor of a combination wood and concrete stringer.

Fig. 4 shows the method in use at the Copper Range Con. Company's mines, and the Mohawk and Wolverine scheme is illustrated in Fig. 5. Both methods made a very satisfactory road bed.

At some of the mines where the foot is subject to "heaving" concrete stringers cannot be used advantageously.

In sinking through some loose ground at one of the Champion shafts it became necessary to close-timber, or line the shaft. Concrete 12 to 18 inches thick was put in, reinforced with old rails and wire rope. The concrete extended across the hanging and down on both ends, and sometimes across the foot, and there were also heavy concrete dividers 4 feet high by 10 inches thick, placed 10 or 12 feet apart. At several levels the whole plat was arched over with reinforced concrete. The lining has been in place about two years and has proven satisfactory.

Drift sets built of concrete have been tried to some extent at the Wolverine and Mohawk mines in some of their crosscuts where loose ground was encountered. These sets consisted of legs 6 by 6 inches in section, and a cap 6 by 8 inches, reinforced with ½-inch rods and wire rope. Concrete planks, reinforced with Kahn expanded metal, or woven wire, were used for lagging. Above the caps they were 4 by 14 inches in section and behind the legs 2½ by 14 inches.

The use of reinforced concrete in the form of shaft sets and lagging is well described in a paper read before the Michigan College of Mines Club, at Houghton, Mich., by E. R. Jones.

Concrete floors for shaft houses are being tried at several places and are proving satisfactory in many respects, although subjected to the hardest usage. The floors built at the Champion Copper Company's shaft houses were made 6 inches thick of 1:3:5 concrete, with a top finish 1-inch thick of 1 to 2 Portland cement and coarse stamp sand. The total cost was 13 cents per square foot. The materials used for the concrete were crushed trap rock, coarse stamp sand and Portland cement.

Question has been raised from time to time as to the suitableness of wire rope for reinforcement. Some tests of concrete beams reinforced with wire rope strands were made at the Baltic mine in 1910 by C. G. Mason.

THE HETCH HETCHY WATER SUPPLY OF SAN FRANCISCO.

For the past ten years, the engineering force of the city of San Francisco has been scouring the State for possible means of future water supply. A dozen different projects have been examined, and the one which has seemed the most feasible is that of the Hetch Hetchy development, the principal reasons for this adoption being that of lower cost, more abundant supply and purer quality of water than any other obtainable. In May, 1908, the permit was obtained to use Lake Eleanor, situated near the Hetch Hetchy Valley, as a site for a storage reservoir, with further permission to use the Hetch Hetchy Valley when the limit of storage of Lake Eleanor had been reached. This latter permit was later called in question by the Department of the Interior, as two objections had been raised to its granting. The one was, that prior rights to the waters were being jeopardized, and the other that the natural beauty of a great scenic national park would be destroyed.

The first proposition, to bring these waters to San Francisco, outlined by C. E. Grunsky, engineer of the city of San Francisco, was to bring the water from Lake Eleanor and the Hetch Hetchy down across the San Joaquin Valley to Altamont. At this point he proposed to pump these waters over the coast range into San Francisco. The power for this pumping was to be gotten from power generated in the drop of the water from the Sierra Nevada side of the valley. During the last season, however, Mr. John R. Freeman, the noted water expert, has been called into consultation by the authorities in San Francisco to outline a comprehensive plan of development. Mr. Freeman's report is by far the most daring and all-comprehensive of municipal projects ever proposed. He has carefully estimated that by the year 2000 the population in the cities around the Bay, including San Francisco, Oakand, Berkeley, Richmond, Alameda, San Jose, Palo Alto, Redwood City and San Mateo will total 3,632,000, and will require a daily water supply of 441,000,000 gallons. In addition, it is proposed to obtain a supply of about 100,000,000 gallons a day for irrigating 95,000 acres. The general features of Mr. Freeman's scheme are as follows:—

A dam 300 ft. high is to be erected at the dam site of Hetch Hetchy by which the floor of the valley will be flooded to a depth of 270 ft.; a wagon road is to be built to Hetch Hetchy Valley equal in point of construction to the State highways with no grade exceeding 8 ft.; a scenic road is to be constructed at Hetch Hetchy Valley on both sides of the lake— this, as shown in the illustration, will make available the wonderful attractions of a region now inaccessible. And finally, the Hetch Hetchy aqueduct is to be built from this valley to San Francisco. This aqueduct will consist largely of a tunnel 10 ft. in diameter, for the most part deeply below the surface of the ground. This tunnel extends to the easterly edge of the San Joaquin Valley. Thence continuing westward across the valley, the suggested aqueduct will consist of one steel pipe 7 ft. 6 in. in diameter, and ultimately of two steel pipes side by side of similar proportions, about 45 miles in length. On the westerly side of the San Joaquin Valley the steel portion is to end about 8 miles westerly from the San Joaquin River. From this point the aqueduct proceeds westerly for the most part in the form of tunnels about 12 to 13 ft. in diameter to a point near the village of Irvington, at which point the terminal chamber and gate-house will be built, and branch aqueducts lead off as desired to Oakland, San Jose, San Francisco and other communities. From this point the aqueduct would proceed in the form of a steel pipe submerged across the Dumbarton Narrows near the head of the Bay, or it could be carried on dry ground around its head to a suitable point in San Mateo County, whence it could discharge by gravity at an elevation of 320 ft. through a new tunnel into Crystal Springs Reservoir or could feed branch lines leading to neighboring communities and to a main aqueduct line leading directly to San Francisco. The proposed aqueduct between Hetch Hetchy and the Irvington gate-house would be designed to deliver by force of gravity without pumping a quantity somewhat in excess of 400,000,000 gallons daily, equivalent to 620 ft. per second. All the tunnels will from the first be built to their full size and smoothly lined with concrete. During the early year, with only the single pipe line across the San Joaquin Valley, the delivery of the aqueduct would be in excess of 200,000,000 gallons daily, possibly 240,000,000. The branch line to supply the San Francisco peninsula will have a capacity of about 100,000,000. It is proposed to utilize the water until the population requires it for domestic use in the reclamation of arid land in and about the Bay region.

That portion of the tunnel, as shown in the illustration, which is about 12 miles in length and lays down stream from Hetch Hetchy, is to be delayed in construction for