"A few years later this machine was largely superseded by the Leader machine, brought out by Lester & Wasley, of Norwich, Conn. This machine performed the work of about twenty girls, and is one of the principal machines in use at the present day, although most of the patents thereon have now expired.

"The next envelope machine of note was the Richards invention, which gummed, printed, folded and counted the envelopes, delivering these upon a table in completed bunches of twenty-five envelopes, with a band around the bunch. These machines perform the labor of about thirty girls, and are running in the factory of the United States Envelope Company (White, Corbin & Company department) at the present time.

"The consumption of envelopes in the United States amounted in the year 1899 to about 6,000,000,000. The cost of a commercial envelope sold to the jobbing trade in 1860 was $2.40 per 1,000. The same grade—but really a better article and put up in a more attractive manner—is sold to-day for seventy-one cents per 1,000."

THE TWIST DRILL.

A prominent Ohio manufacturer, J. D. Cox, Jr., of the Cleveland Twist Drill Company, manufacturers of twist drills, reamers, milling cutters and other tools of precision, states that:

"Beginning in 1876, the firm with whom I was connected found that with the appliances then used they could make only a very moderate profit. The writer took up the question of improved appliances, as you know, about the year 1880, introducing machines in every department—some of your invention and some of the writer's—the sole object being to reduce the amount of labor and not considering the cost of the machines. The selling price of our class of goods has been reduced more than 60 per cent. during the past 20 years, all of which I can say without hesitation has been accomplished by the introduction of labor-saving machines and appliances."

These reports come from gentlemen of wide experience in their respective lines of business. With one exception they are members of this association and all have given attention to the questions involved in this subject. We can, therefore, safely accept their conclusions as being reliable. Their testimony is, in fact, conclusive.

Since the close of our Civil War the productiveness of trained labor in the United States has increased threefold, and this has been accomplished principally by the work of American inventors, encouraged and supported by the American patent system.

SANTA ANA CANAL.*

By J. B. Lippincott.

GENERAL STATEMENT.

The area discussed in this report is in Southern California, lying for the most part easterly from the city of San Bernardino and consisting of the upper or higher part of the valley in which is situated the town of Redlands. It is about 50 miles distant from the ocean and has an elevation of from 1,000 to 1,500 feet in the vicinity of San Bernardino and Redlands. Northerly and easterly from the valley the mountains rise abruptly, reaching altitudes of from 6,000 to 7,000 feet, a few of the peaks rising to 10,000 or even 11,000 feet. The abrupt slopes by which the valley is bounded aid in producing a rainfall relatively heavy for the arid region. The waters, uniting into streams, descend rapidly through narrow gorges, issuing finally upon accumulations of bowlders and smaller débris which stretch in fan-shaped masses away from the mouth of each canyon. The region, though dry, has thus a notable water supply, and the exceptional climate and soil have resulted in an extraordinary development of agriculture by irrigation. Lands and crops have reached high values in San Bernardino Valley and expensive irrigation works have been built. A denser population is supported than in any other farming region of the West. This has been accomplished in spite of the fact that the cost of constructing works and of reclaiming the lands has been very great.

The topographic conditions of this locality favor the production of high-grade fruits. The ranges of mountains to the north and east shut out the cold desert winds, leaving the southwestern exposure tempered by breezes from the sea. The distance inland is sufficient to admit of the high summer temperatures necessary to the successful ripening of citrus fruits. The success of this industry has rendered it possible to secure capital for the construction of the works for water storage and distribution, and has resulted in a correspondingly great economy in the quantity of water employed. In this valley water is made to do more work and earn greater returns, probably, than in any other portion of the arid region of the United States.

The discussion of the water resources given in the following pages relates particularly to the systems taking water from Santa Ana River and its tributaries and supplying Crafton, Highlands, Redlands, and Old San Bernardino. There has also been included a discussion of Mohave River, which rises on the northern slopes of the mountains and flows northerly into the desert, for it is probable that by means of certain storage works now under construction much of this water will be caught and turned southward by diverting lines or tunnels to supply portions of San Bernardino Valley.

The Santa Ana Canal was designed to carry the waters of Santa Ana River and its main tributary, Bear Creek, as well as the waters turned into the latter stream from the Bear Valley reservoir in times of scarcity, to the lands of the Perris and Alessandro districts, some 15 miles from the headworks of the canal. When this work was started a line of steel pipe of a capacity of 900 miner's inches had already been constructed from Alessandro to Mill Creek, 9·7 miles of the distance.

The capacity of this canal was fixed at 12,000 miner's inches (240 second-feet), but the main portions of the conduit were constructed for a capacity of only one-half of this, or 120 second-feet, with the idea of afterward enlarging it. It was not supposed that Santa Ana River and its tributaries would furnish a constant supply of 12,000 miner's inches, but it was intended that the conduit would serve to carry the surplus waters of the rainy season to suitable reservoirs, where the water could be stored and distributed to users when needed in the summer and fall months. Bear Creek has a large reservoir near its head waters—the Bear Valley reservoir, with a present capacity of 26,463 acre-feet, or 3,675 miner's inches, not including evaporation.

Santa Ana River proper has no storage reservoir, and as it has 188 square miles of drainage basin above the head of the Santa Ana Canal there is necessarily a great deal of water that runs to waste nearly every year during the winter and spring months. It is proper to mention in this connection that a small reservoir site was surveyed and work commenced on the outlet tunnel for the purpose of storing the water of Santa Ana River, but on account of the financial embarrassment of the company this work was never finished. In fact all construction work was stopped, and the Santa Ana Canal was turned into a temporary conduit to conduct 900 miner's inches of water from the river to the Alessandro pipe line.

This reservoir would necessarily have been a regulating one, as it had a very small capacity for a very high and expensive dam. In other words, it would never have paid as a simple storage reservoir, but in case Santa Ana River and Bear Creek were flowing for a few days more than the Santa Ana Canal could carry some of the surplus water could have been held in this reservoir until the discharge of the stream had fallen below the capacity of the canal, and in this way the reservoir might have been filled and emptied several times during the year.

The Santa Ana Canal, which has been completed for only about 6 miles, offers some valuable lessons to the engineer, not only by the excellence of the work done in some places, but by its weak points in others.

FIRST DIVISION.

The first division of the Santa Ana Canal for about 3 miles consists of tunnels, flumes, and pressure pipes, being located on the rocky, steep side of Santa Ana Canyon. The design for the permanent headworks of of the canal provides for a low crib weir, or overflow dam, crossing the canyon from wall to wall and built upon the natural bowlder of the stream. A sluice gate is to be constructed on the left bank that will maintain the channel of the river on that side of the canyon and which when closed will raise the water to such an elevation as to command entrance through the gates shown on the right hand side of Fig. 1, into a fore bay, and thence through the headworks tunnel cut through the rock to the canal. Regulation will be accomplished by means of entrance gates, shown on the right of Fig. 1. At present, diversion of water is made by means of a bowlder dam and wooden gate into a rock-lined canal leading to the headworks tunnel, the gates on the right now acting as regulators.

The river falls rapidly through the canyon; and as the canal does not have in any place a greater grade than 10 feet per mile, it results that at the place where the canal leaves the canyon it has an elevation of 300

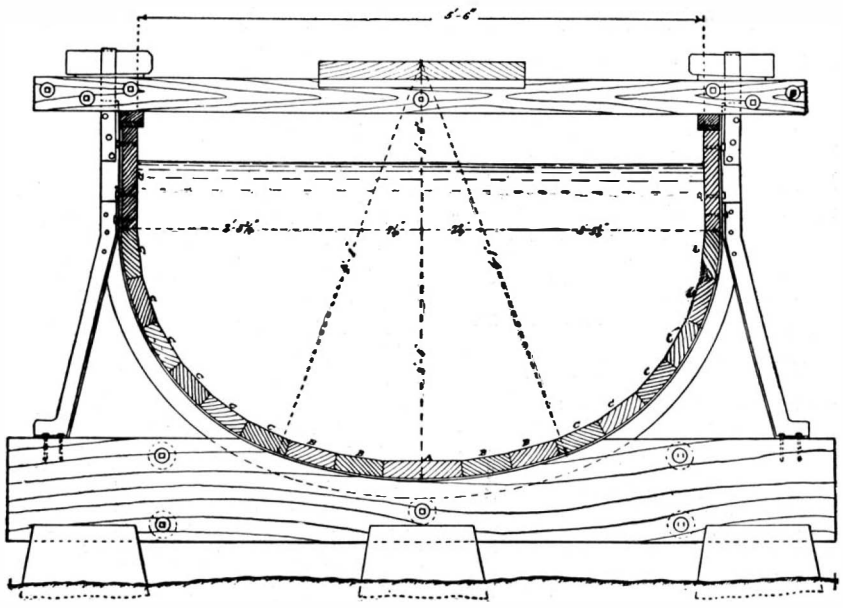

Fig. 3.—SECTION OF COMBINATION IRON AND WOOD FLUME.

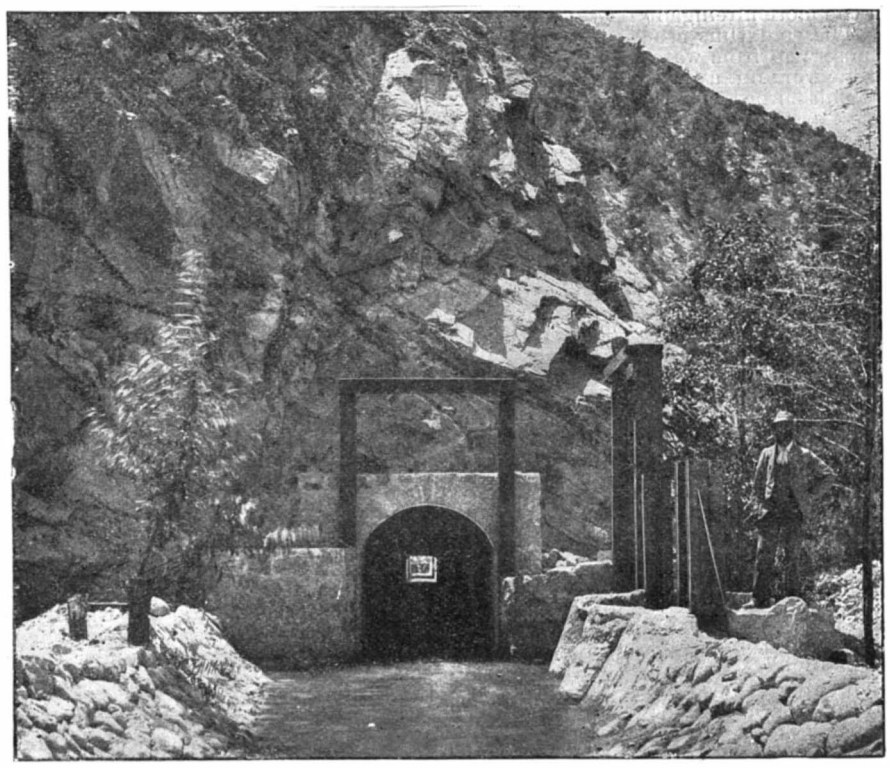

Fig. 1.—Temporary Headworks.

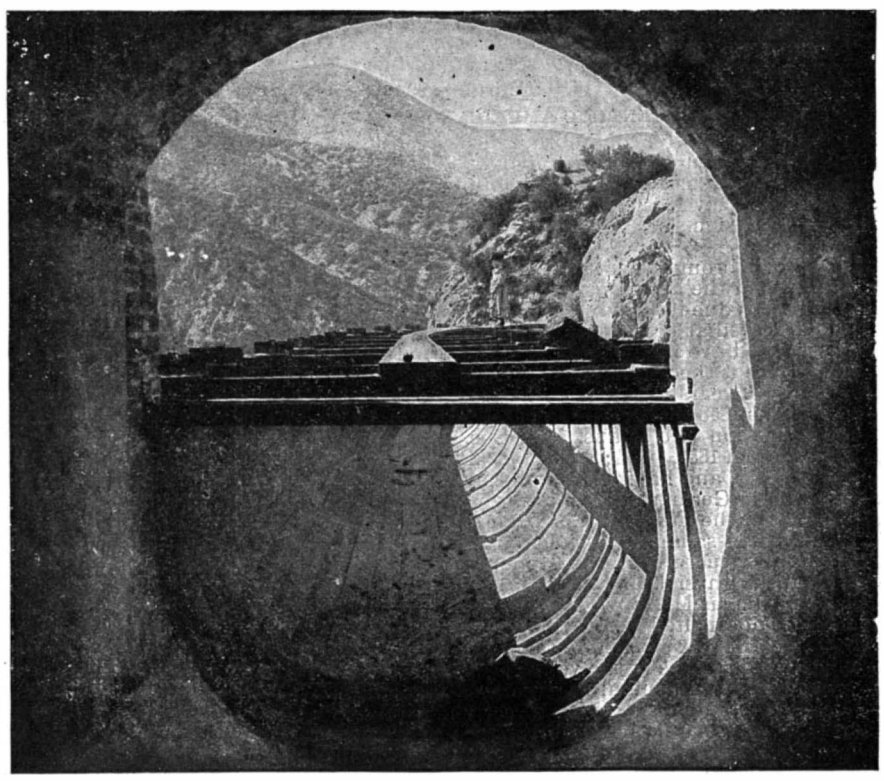

Fig. 2.—Connection Between Tunnel and Flume.

SANTA ANA CANAL, CALIFORNIA.

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