

the right-hand side of the tunnel, the lifter on this corner having been exploded last for the purpose of clearing away the muck and leaving plenty of room for the men to operate jack-bars. The drillers and the foreman attended to this work while the helpers were busy bringing forward the hose, air-pipe, water-pipe and steel. Even with the tremendously heavy charges fired, most of the broken rock lay within 30 ft. of the face and rarely exceeded 5 ft. in depth at any point, making it easy to bring the bar and drills over the muck pile.

The fuses were always ignited and the charges fired in rotation.

The usual practice of tamping the holes over the explosive was soon discontinued, as it was found that with such heavy charges the powder formed its own tamping, with the further advantage that when the holes were loaded to the collar the rock was more thoroughly pulverized and consequently much easier shoveled into the cars than when lighter charges were used.

Holes will occasionally miss fire, even when loaded with the greatest care; and when no tamping is employed they can be afterwards fired by simply pushing a primer down tightly upon the unexploded charge, without taking the risk of performing that most dangerous of all operations, picking the tamping out of a "missed" hole.

At first, each pair of fuses was lighted about ten seconds before the next—which, on 40-second fuse, gave 3-in. steps on the receding line of fire. This interval, however, being repeated on 10 pairs of holes, occupied considerable time, and the smoke became so intolerable that some method of expediting the rate of fuse-lighting had to be adopted. The one which proved most satisfactory was exceedingly simple. The foreman cut 22 ins. from the ends of the fuse protruding from the short cut holes; 20 ins. off the fuse from the upper cut holes; 18 ins. off the fuse in the lower cut holes, and so on. This automatically provided a difference of 2 ins. in the distance the fire had to travel, and, even when the fuse-ends were lighted as rapidly as possible, at least another inch was represented by the time between the lightings, so that the two shot-firers could secure the necessary interval between the explosions, and yet get away from the face before the smoke from the burning fuse became too dense.

The following tabular recapitulation of the drilling-operations shows that the men could not only complete a round in an 8-hour shift, but had sufficient extra time to provide for shooting missed holes or taking care of any of the minor difficulties which often arise in tunnel work.

#### Time Occupied in Various Operations.

Exhausting smoke from face .....	10 to	12 min.
Picking down roof and sides .....	5 to	10 min.
Jacking cross bar in place .....	6 to	8 min.
Attaching drills, making hose and water connections .....	5 to	15 min.
Drilling from top set-up .....	3 hr. to 4 hr.	15 min.
Dropping horizontal bar to lower position .....	15 to	20 min.
Drilling on lower set-up .....	1 hr. to 1 hr.	15 min.
Removing drills, cross bar, hose, etc.	15 to	20 min.
Blowing out holes, loading and firing	20 to	25 min.
Ignition to explosion of last hole ....	8 to	8 min.

Total time required to complete cycle of operations ..... 5 hr. 24 min. to 7 hr. 28 min.

During March, April and May, 1911, the record months for driving, the following data were gathered, showing the amounts of work done:

	March.	April.	May.
Ft. of tunnel driven .....	653	583	635
Number of holes drilled .....	1,965	1,759	1,985
Linear ft. of holes .....	14,330	12,510	15,263
Ave. lin. ft. of holes daily .....	154	139	164
Sticks of powder used .....	14,808	16,171	18,311
Cars (16 cu. ft.) of muck sent out	4,983	4,765	5,156

Considering the hardness of the rock, the speed attained in drilling, as shown by the figures above, was exceptionally good; but even these averages fall considerably below what was possible with the equipment used. For instance, a number of the best drill-runners were able to average over 60 ft. of holes per shift, one of them making a monthly shift average of 61.68 ft.; another of 61.75 ft.; and a third of 61.86 ft.

While this work shows a great advance over current American practice, it still falls behind the records obtained in the best examples of European tunnel driving. A direct comparison, however, is not quite fair to the United States, since the Alpine tunnels are very much longer than anything yet attempted in this country. At first sight, it would seem that additional length would tend to retard instead of accelerate the rate of progress; but this is not the case. It has been clearly shown that the increased length of transportation and difficulty of ventilation are much more than offset by the improved conditions and the perfection of organization effected by time and experience. As a rule, the greater the magnitude of the undertaking the more thorough the preparation; and the time and labor expended in studying conditions and designing plants for the different Alpine tunnels have been more than justified by the results obtained. European tunnel engineers have also the advantage of being able to select their employees from an almost unlimited supply of highly-skilled workmen from the Tyrol, Switzerland and Piedmont, which gives them an incomparably better selection than can be drawn from our heterogeneous labor supply.

#### ILLINOIS WATER SUPPLY ASSOCIATION.

The fifth annual meeting of the association will be held at the University of Illinois, Champaign-Urbana, Illinois, March 11 and 12, 1913.

Titles of papers to be presented at the meeting should be sent to the secretary before February 20, 1913. A number of good papers have been promised, but we have room on the programme for more. Prepare a short paper, 1,000 to 1,500 words, on some topic that has been interesting you and that may help someone else. Send to the secretary items that are troubling you. The programme committee can arrange to have a discussion on the subject.

Associates intending to exhibit, please notify Mr. G. C. Habermeyer, Engineering Hall, University of Illinois. The usual arrangements have been made for the exhibits. If the exhibits are sent in care of Mr. Habermeyer they will be delivered at the University.

In the hydraulic laboratory there will be an exhibit of apparatus illustrating the principles of washing filters. In the water survey laboratory there will be an exhibit of water softening by permutit and water sterilization by ultraviolet light.

The University band will give an informal concert for the association. A subscription dinner will be held Tuesday evening, March 11. In order that suitable arrangements may be made, sign and return the enclosed card to the secretary at once. Programmes showing railway lines and hotel accommodations will be mailed February 24 to members and to others who return the card. Edward Bartow, secretary.