



Fig 12

PLAN

gular block of masonry 25'-0" X 26'-0" X 4'-0". It was laid as first class work, and the bond with arch was made by creepers. It was held that it was necessary to support these head-walls by buttresses, it being known that unsupported head-walls in tunnels in the same section of the State had failed under a gradually increasing movement of the material on the portal slope, this movement sometimes only commencing years after the completion of the work. The buttresses built were 8'-0" X 3'-0" in plan, and were stepped back towards the head-walls commencing at the springing level.

The prices on this work were \$9.00 a cub. yd. for portal masonry, \$5.00 for side-walls and \$14.00 for arch sheeting. This cost was not included in the tunnel estimate before given, as the work was only partially done, and because the detail of the lining would probably be altered by the employment of a cheaper material when transportation facilities were obtained. The cost of one portal complete was :

76.5 cub. yds. portal masonry @ \$9.00.....	\$688 50
6.1 arch masonry @ 14.00.....	85.40
	\$773.90

and the cost per lin. ft. of lining was :

Sidewalls 2.57 cub. yds. @ \$ 8.00.....	\$20.56
Arch 1.53 @ 14.00.....	21.42
Packing 1.19 @ 1.75.....	2.08
	\$44.06

In the estimate before given the cost of excavation, timbering, etc., was \$44,127.60 for 624 ft., so that the total cost per lin. ft. of completed tunnel would be (excluding portals, fallen material, etc.) :

Excavation.....	\$53.55
Packing.....	2.08
Timbering.....	14.57
Side-walls.....	20.56
Arch.....	21.42
Packing.....	2.08
	\$114.26

The whole work was carried through in a style that was entirely satisfactory to the chief engineer. Mr. Jos. N. Allston was resident engineer in charge, and the management of the construction was in the hands of Mr. John E. Dongher of T. J. Steers & Co., and most of the practical points in the system above described were an outcome of his great experience as a tunnel builder.