was also penetrated to the shale immediately below. From this point the inside lining and puddling and permanent partition was begun, working upward from the bottom and removing the temporary buntons and cross-timbers as the work advanced. The inner linings had been built up about 8 feet, when suddenly the curbing gave way just above it, at the east end, flooding the shaft with sand and water. Fortunately this happened at lunch time, when all were on top but two men who were looking after the pumps; these barely got out, for in a few minutes the shaft had filled half way up.

This happened July 14, 1889. Not discouraged, the company soon arranged for another attempt. The shoe having proved successful, a duplicate one was ordered, but thicker cribbing was used for the lower part, namely, 2-inch by 14-inch planks flat. At one time the experiment was tried of alternating 2-inch by 12-inch and 2-inch by 14-inch plank, made flush inside, but presenting a rough exterior; the idea being to give the shaft a better hold on the ground, also to make it less easy for the sand and water to wash down outside the cribbing. However, in practice it did not prove of any particular advantage in these respects. On the other hand it occupied as much space as a solid 14-inch wall and was not so strong; thereafter, 2-inch by 14-inch timber was used exclusively. Another improvement was in the use of hangers or iron lugs spiked to the cribbing, instead of the oak cross-pieces which had been set into the cribbing, thereby weakening it, and which were often broken under the pull, and also were in the way in handling the pumps. The shaft was located 100 feet east of the fourth attempt. As a daily journal was kept by Mr. James Anderson, then engineer of the company, of all attempts after the third, and as this sinking was typical of the difficulties, the diary will be given unchanged and uncolored by the views of the writer, except for such slight additional words as are necessary for clearness:

August 9—Shoe arrived from Chicago; unloaded and put it together in place.

August 10—Sunk shoe down into the ground and moved trusses into place; sunk 4 feet through grade filling. Depth, 4 feet.

August 11—Got tower up and started sinking, 3 p.m.: sunk 4 feet through grade filling and soil. Depth, 8 feet.

August 12—Put in hangers and rods, and started buntons in east end; sunk 7 feet through yellow clay. Depth, 15 feet.

August 13—Buntons now in both ends and going in regular fashion; sunk 7 feet, through 4 feet yellow clay, 3 feet blue clay. Depth, 22 feet.

August 14—Some water; handled by barrels; amount of water, 3 gallons per minute; sunk 6 feet through blue clay. Depth, 28 feet.

August 15—No trouble; water 3 gallons per minute; sunk 5 feet through blue clay and gravel. Depth, 33 feet.

August 16—No trouble; water 3 gallons per minute; sunk 4 feet through muddy clay. Depth, 37 feet.

August 17—No trouble; water 3 gallons per minute; sunk 5 feet through blue clay. Depth, 42 feet.

August 18—Water came in fast at 9.30 p.m.; put in a No. 9 Blake pump; water 104 gallons per minute after tapping; sunk 5 feet through blue clay and sand. Depth, 47 feet.

August 19—No trouble; water 104 gallons per minute; sunk 4 feet through blue and yellow clay, sand and gravel. Depth, 51 feet.

August 20—Sand all around south side and one-half of east end; hard clay and gravel under the rest, causing rushes. We do not dig out below press plates; water averaged 90 gallons per minute; sunk 5 feet through clay, sand and gravel. Depth, 56 feet.

August 21—We bored 2-inch augur-holes to relieve pressure and prevent rushes; Did not do much good; drove spiles but rushes threw them out again; water averaged 104 gallons per minute; sunk 3 feet through clay, sand and gravel. Depth, 59 feet.

August 22—Caved clear to the surface at the east end; a crack in the curbing was caused by rushes below the last clamp; shaft swung 6 inches out of plumb, inclining to west; water averaged 104 gallons per minute; sunk 1½ feet through clay, sand and gravel. Depth, 60½ feet.

August 23—The material is getting soft all over, principally sand and gravel; the shoe sets square, and we also got the timbering levelled; water 140 gallons per minute; sunk 1½ feet through clay, sand and gravel. Depth, 62 feet.

August 24—Had to stop on account of shortage of suspending rods; put in a Deane pump in the west end; the trusses are pulled down about 1 foot; water, 140 gallons per minute; sunk none. Depth, 62 feet.

August 25—Have now good solid clay all around, except under the northeast corner, where it is sand as yet; water 140 gallons per minute; sunk 2½ feet through clay and sand. Depth, 64½ feet.

August 26—Rushes of sand and water occurred all day; water 140 gallons per minute; sunk 2½ feet through clay and sand. Depth, 67 feet.

August 27—Had a very bad rush of sand, filling about 8 feet up the shaft; trusses almost broke down; water averaged 140 gallons per minute; sunk none. Depth, 67 feet.

August 28—Cleaned out the rush and blocked with wood between timber and shoe in place of jack-screws; withdrew the pumps; started to tear down trusses; shaft filled with water.

August 29—Finished tearing down; got levelled up for new trusses.

August 30—Started to build up trusses and top works.

August 31—Finished them and started pumping out water in shaft.

September 1—Got the water all pumped out and shoe cleaned out ready for sinking; water still coming in at rate of 140 gallons.

September 2—Rushes of sand with the water all day; started a Nye pump in the caved-in shaft of the previous attempt, located about 50 feet away, to try to relieve the pressure of water; water 140 gallons per minute; sunk 1 foot through clay, gravel and sand. Depth, 68 feet.

September 3—Same as yesterday; sand running up from a hole in the northeast corner; lowered the water in the neighboring shaft to 85 feet from the surface, so it is 17 feet below bottom of present shaft, but without any effect in relieving from water; water averaged 140 gallons per minute; sunk 1½ feet through sandy clay and sand. Depth, 69½ feet.

September 4—Got through with the sand pocket at northeast corner, but as a consequence of the rushes of the past few days, a hole came to the surface, causing the upper part of the shaft to swing 2½ feet east; threw in bales of hay till it stopped running; then filled up with clay; water 140 gallons per minute; sunk 2 feet through sandy clay and sand. Depth, 71½ feet.

September 5—Got all the water cut off from below; what there is comes in through the timbering; water 140 gallons per minute; sunk 2½ feet through sandy clay with gravel pockets. Depth, 74 feet.

September 6—No trouble; water 108 gallons per minute; sunk 3 feet through blue clay. Depth, 77 feet.

September 7—No trouble; water 83 gallons per minute; sunk 3 feet through blue clay. Depth, 80 feet.

September 8—No trouble; lowered pumps and water in neighboring shaft 20 feet, making water 105 feet from surface; water 70 gallons per minute; sunk 2 feet through blue clay. Depth, 82 feet.

September 9—No trouble; water 70 gallons per minute; sunk 3 feet through blue clay. Depth, 85 feet.

September 10—No trouble; water 70 gallons per minute; sunk 3 feet through blue clay. Depth, 88 feet.

September 11—No trouble; water 83 gallons per minute; sunk 3½ feet through blue clay and sandy silt. Depth, 91½ feet.

September 12—No trouble; water 83 gallons per minute; sunk 3 feet through sandy silt. Depth, 94½ feet.

September 13—Very fine sand running in with the water; water 104 gallons per minute; sunk 2½ feet through sand, very fine. Depth, 97 feet.

September 14—Some small rushes at east end; lowered Nye pump in neighboring shaft 10 feet; water 104 gallons per minute; sunk 2 feet through sand and gravel. Depth, 99 feet.

September 15—Small rushes again on east side, and one on south side; had to split a boulder in the southwest corner; water 104 gallons per minute; sunk 2½ feet through sand, gravel, and clay. Depth 101½ feet.

September 16—No more rushes, but still pretty soft on east end, so we cannot dig below shoe; hard jacking; water 83 gallons per minute; sunk 2½ feet through cemented clay and gravel. Depth, 104 feet.

September 17—Hard now all over; cannot make any room for shoe, as sand above is so very fine that it washes down through the smallest cracks; water 83 gallons per minute; sunk 2½ feet through cemented clays and gravel. Depth, 106 feet.

FIG. 3

PLAN OF FINISHED "B" SHAFT.

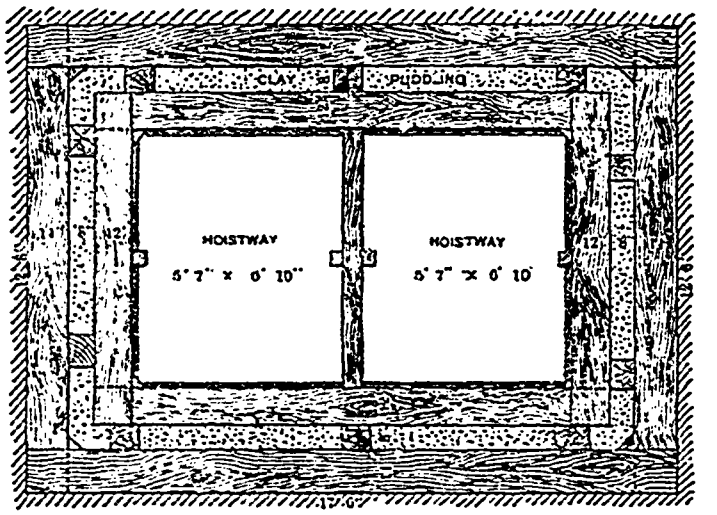
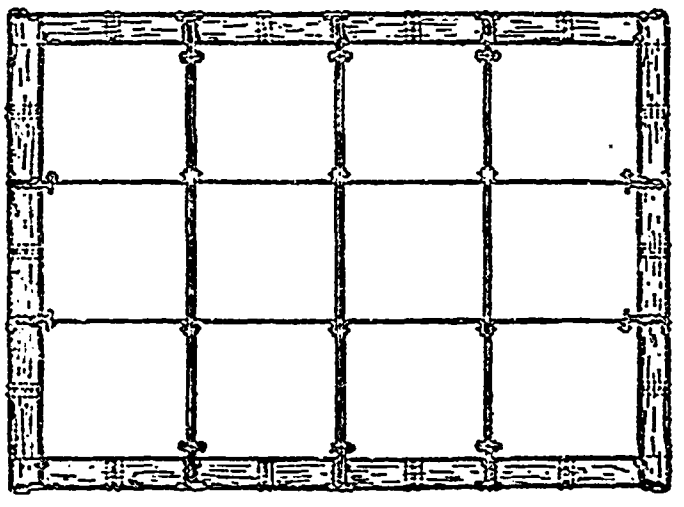


FIG. 4

GROUND PLAN OF SHOE.



September 18—Had a bad rush in the northwest corner, filling the shoe with fine sand, and causing at the surface a circular cave 100 feet north of shaft; water 83 gallons per minute; sunk 2 feet through sandy blue clay with boulders. Depth, 108 feet.

September 19—Had some large boulders, but the clay, while soft and sandy, is quite tough, and it seems probable that on jacking the shoe through it, the rushes will be cut off; water 70 gallons per minute; sunk 2 feet through sandy blue clay with boulders. Depth, 110 feet.

September 20—Lots of little boulders, but good jacking; water all cut off from the bottom; water 56 gallons per minute; sunk 4 feet through sandy blue clay with boulders. Depth, 114 feet.

September 21—Same condition as yesterday; water 56 gallons per minute; sunk 4 feet through sandy blue clay with boulders. Depth 118 feet.

September 22—No difficulties: water 42 gallons per minute; sunk 3½ feet through mucky clay. Depth, 121½ feet.

September 23—Changed Blake pump from east end to the centre and hung a Deane pump in east end; water 42 gallons per minute; sunk 3 feet through mucky clay. Depth, 124½ feet.

September 24—No difficulties; the mucky clay started to swell or heave up in bottom of shoe; water 42 gallons per minute; sunk 4½ feet through mucky clay. Depth, 129 feet.

September 25—No trouble; for some reason the neighboring fourth attempt shaft is making far more water than this shaft; water 42 gallons per minute; sunk 5½ feet through mucky clay. Depth, 134½ feet.

September 26—Put in another Blake pump in place of one removed for repairs; water 42 gallons per minute; sunk 5½ feet through mucky clay. Depth 140 feet.