exact location of the trench instead of from a circular area mostly outside the limits of the excavation and within a certain radius of the sump.

Jetting down Well Points 16 Feet.

Two men were timed while using a 1-inch pipe for jetting down the well points. The water pressure was about 100 pounds per square inch, and the men sunk four 1¼-inch well points to a depth of sixteen feet in one minute. This obviously does not include time making connections with main pipes through rubber hose.

Comments on Pumping System.

It is a fact worthy of note that the hundreds of connections between flanges, rubber hose, ells and suction pipes cannot be made absolutely air-tight, and that, with the high vacuum inside, a considerable amount of air must find access to the suction of the pumps. This fact does not seem to hinder the working of these pumps, owing probably to the large volume of the chambers in which the condensed steam forms the vacuum. Mr. G. H. Olmstead, of 407 Dearborn Street, Chicago, who furnished most of the pumping equipment, stated in an interview with the writer: "A centrifugal or reciprocating pump could not be used under these conditions without needing frequent priming, owing to the air in the suction. Moreover, the sand which comes in with the water would necessitate a frequent renewal of the valves, brasses, etc., a trouble which we have not experienced, as is proved by an uninterrupted run, night and day, for four months."

Mr. Sargent, representing the consulting engineers for the job, as well as Mr. Green, the contractor, is highly pleased with the novel arrangement and economy in labor which it is effecting. They say that were shut-downs to occur, which will cause a delay of even half an hour, it would make the excavation so wet as to become extremely dangerous to the workmen, and make the costs much higher, owing to the unusual fluidity and fineness of the sand.

In commenting upon the leakage of air into the vacuum pumps, one of the men interested said that the amount of air is possibly augmented by the entrance of air through the well points, for, when the water is drained from any section, the vacuum at that point still being undiminished, would, under certain conditions, be likely to inhale air at that point also.

It is interesting to contrast this vacuum method with its diametrically opposite method—the pneumatic caisson process of penetrating water-bearing strata. In the latter compressed air forces the water downward away from the sand or other soil, and the excavation can frequently be carried down below the edges of the caisson. In this new, or vacuum method, the digging is carried two or three feet below the bottom of the wooden sheeting—and this in very fluid material—showing that the **draining of water from below** is as effective in this case as is the **displacing of the water from above,** as in the pneumatic process.

Disposal of Seepage Pumped and Back-water.

The discharge pipes of the first three pumps empty into a 10-inch tile drain, laid in a small trench by the side of the main excavation. This, in turn, discharges into the completed sewer on the far side of a dam of sand-bags. The amount of water so discharged has not been accurately measured, but it is a rushing stream, two-thirds filling the 10-inch drain pipe, and flowing at a rapid rate, owing to a drop of over twenty feet in two hundred.

The "back-water" in the completed sewer is about four feet in depth, and the seepage through this dam, as well as that which enters the sewer through other channels, is sufficient to keep a fourth Emerson pump working continuously night and day. A temporary manhole was built in the centre of the arch, and in this was suspended an Emerson pump, No 1, with a capacity of about 250 gallons per minute.

Speed in Damp Sand most Rapid, compared with Wet or Dry.

The contractor, in speaking of the new method, said that he has already proved his earlier estimate to be correct—that the small investment for the pumping plant was more than offset by the remarkable saving in labor and the increased speed of the work. He states that a laborer can handle several times as much sand in a damp state than he could if it were either dry or very wet, as the dry sand falls off the shovel and the wet sand is washed off.

It is claimed by some who have followed the work pretty closely that if completed at the present rate, there will be a saving made of about $40,000, because the excavating gang is working under the best conditions, though twenty-two feet below water level, and that with ordinary wood sheet piling driven by mauls.

Another advantage of the damp sand is that it can be packed, and thus affords a firm bed for the brick sewer invert.

After the brick work is completed, pumping in that part of the trench is continued for about half an hour to make sure of the proper setting of the cement mortar. To hasten this process half Universal Portland and half Utica hydraulic cements are used.

The lowest trench braces were taken out after the invert was completed and before work was begun on the arch. This was made possible because the sheeting extends one foot below the top of the invert, and is thus held in place.

Industrial Railway.

An industrial railway of 2-foot gauge, with wood ties and 12-pound rails, parallels the sewer route for 2,800 feet. This is of considerable use in carrying materials from the railway switches and distributing along the job. Teams of horses, and then mules, were tried to haul these side-dumping cars on the track, but owing to rapid progress and frequent changes in the track, together with the extreme softness of the sand, it was found that laborers could go where the teams would not.

Summary of Contractor's Plant.

Piping system as described.
Three hundred (approximately) well points.
Two No. 3 Emerson standard vacuum pumps.
One No. 1 Emerson standard vacuum pump.
One small duplex force pump for jetting.
One Lidgerwood pile-driver; boiler used for supplying small Emerson pump.

Three horizontal 30 horse-power boilers for supplying large Emerson pumps.

One 2-yard Page & Schnable drag-scraper bucket excavator, 40 horse-power engine.

One 1-yard Hayward clamshell, for back-filling.
One engine and derrick for same.

Two thousand eight hundred feet of industrial railway, with 12 side-dump cars.

Back-filling.

An 8¼ x 10-inch Lidgerwood engine and derrick, with a 1-yard Hayward clamshell bucket, is now working night and day putting in the back-fill. Since the entire coal bill for the job averages $25 a day for twenty-four hours, and assuming that the four Emerson pumps together, with the small duplex force pump, consume half this fuel, then the clamshell and the bucket excavator will use approximately a total of $12.50 worth of coal per day, with coal at $3.60 per ton, delivered. The clamshell and the scraper bucket we will assume equal amounts of fuel, and so the cost of 500 yards, put in in nine hours, figures as follows:—

One engineer	$ 5 00
One fireman	3 00
Three laborers	6 00
Coal	6 25
Total	$20 25

which, divided by 500, gives about four cents per cubic yard as the unit cost. But part of the refill is done by shovellers immediately after the arch is finished.