one side, as is usually the case in side-hill construction, a single line of pipe, cutting it off before it reaches the road, will be sufficient. In low and swampy land, not having a well defined under flow, and in heavy retentive soils a line of tile on each side will be necessary to properly protect the road. In the latter kind of soils the tile should be laid on about 4-ins. of coarse sand or fine gravel, and then covered to a depth of at least 1-ft. with similar material. This not only insures that the joints and pores of the tile will not become clogged with the almost impervious clay, but it also gives a larger collecting area for the percolating soil water.

One of the later methods employed to drain the subsoil, which has given satisfaction, is the construction of the V-drain. In this work the subgrade should be excavated for the full width of the surfaced roadway and from 6 to 8-ins. deeper at the sides and from 12 to 18-ins. deeper at the center than usual, thus producing a flattened V-shaped trench. This extra excavation is made in order to be filled with pebbles and boulders varying in size from ½ to 12-ins. in their longest dimensions and having the largest stones

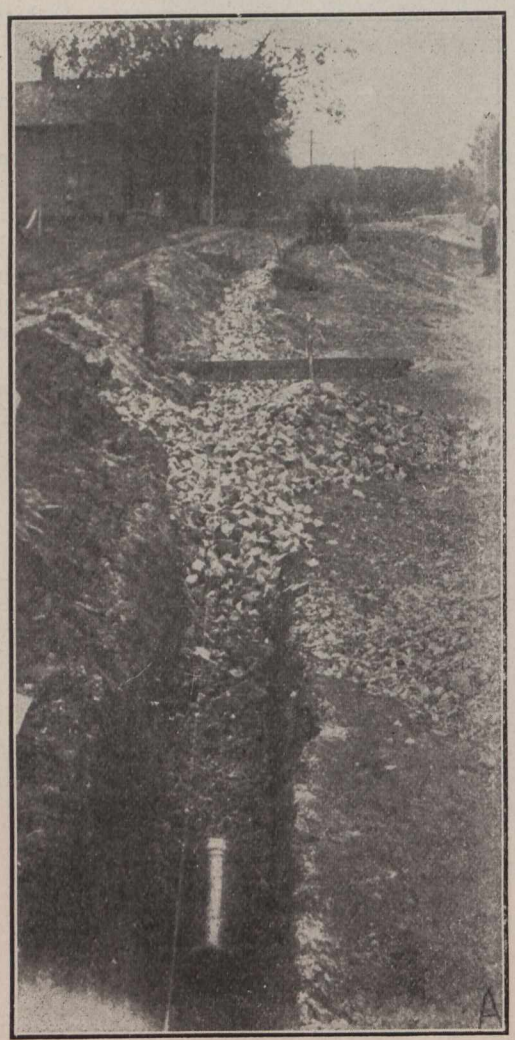

**Fig. 3—Tile Under Drain at Side of Road.**

placed in the bottom of the trench, which should be graded longitudinally so that the water will run along easily. These stones do not have to be deposited carefully, but should be so placed that they may be compacted with a roller to form a suitable foundation for surfacing. The water drained by such construction should be carried to the outlets provided, through narrow trenches filled with similar sized stones, as should the water drained by all forms of sub-surface drainage be carried to the side ditches, culverts, or open waterways through their own similar forms of construction.

Details of the practice of sub-drainage vary largely in the different sections, but the employment of longitudinally tiled and V-shaped drains to collect and carry off the water is very extensive and rapidly increasing. Road builders are learning more and more from experience, that as a rule it is cheaper in the end and more satisfactory to drain than to

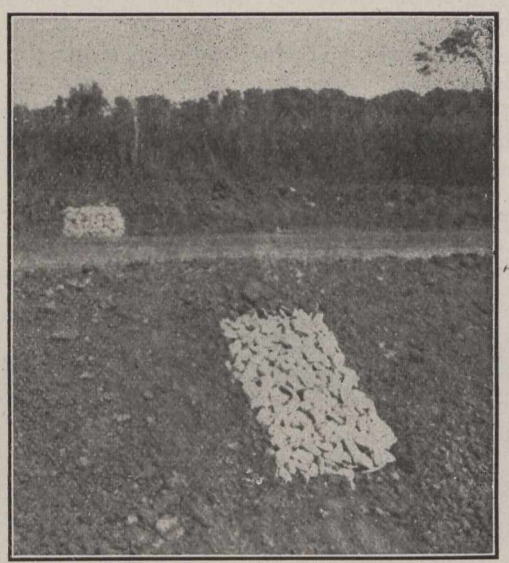

**Fig. 4—Shoulder Drain Provided for Outlet for Under Drainage.**

lay expensive foundations. To keep the earth dry, hard, and unyielding is necessary to secure the low cost of maintenance and long life of a road. Therefore, the water falling on the road must be carried off quickly and effectively and the water from below must be intercepted and removed before it reaches the roadbed where it can do damage.

All previous records for excavation in the rainy season were broken in the Central Division and in Culebra Cut of the Panama Canal during the month of August, when 1,377,992 cu. yds. of rock and earth were taken out of the cut and 234,404 cu. yds. from the Chagres section.

## PROGRESS IN DRAINAGE WORK AT TORONTO.

(Continued from Page 690.)

Mr. Blanchard showed some excellent views of the works in course of construction as they appear at present. A population of 600,000 for Toronto is provided for, the sewers being then half full. In laying the pipes across the bed of the Don River it was necessary to drive piles for bearing them. Thirty-foot piles were driven with a penetration of twenty feet, placed four feet apart. In testing one of the pipes for compressive strength it was proven that 32 tons of pig iron piled on top of a pipe 5 ft. 6 in. in diameter gave a deflection, or increase in width, of only about ¼-in. There are 2,000 feet of steel pipe in the lake now. No plugging up of these drainage works is anticipated, owing to velocity of flow and relatively small amount of solid matter at all times, but in case of any possible stoppage there are manholes, and ample means of immediate relief are provided for. The capacity of the combined sewers will be about 300 cubic feet per second. The residents in the neighborhood of the sludge tanks will suffer no inconvenience from their presence. Septic tanks are not necessary, as these will, it is expected, more than meet the needs of the city.