minion; one-quarter payable by province; one-quarter payable by county. With forty counties in Old Ontario, this would mean an annual expenditure in the average county of $50,000 per year. One-quarter of this ($12,500) would be added to the county rates, or, if the county council found it necessary, this amount could be raised by debentures guaranteed by the province and sold direct to investors in the mother country instead of being peddled around to our local people at a comparatively high rate of interest.

Conclusion.—Proper supervision of this great national undertaking is absolutely necessary. Let the Dominion Government establish a Highway Commission with expert engineers to advise the provinces how to proceed and to inform Parliament of the results obtained.

Let our Ontario Government establish a Highway Commission or a department with a minister at the head of it. Then employ engineers to assist the counties in building roads adapted to their needs. This will be a simple matter in some counties, but in others it will call for the most careful consideration. Adopt as a motto for the future, "Be sure you are right, then go ahead."

NOTABLE WORK ON THE CATSKILL AQUEDUCT.

The construction work going on in connection with the carrying out of the Catskill Aqueduct project is deservedly attracting widespread attention. It is inevitable that important problems have to be solved when it is proposed to bring an enormous supply of water from a mountain district one hundred miles distant conducting it across a score of valleys some of them several miles in width, as well as across so deep and broad a river as the Hudson. The problems have especial interest for the municipal engineer because of the very character of the enterprise. They have large interest for the concrete engineer for the reason that the construction of the aqueduct is everywhere involving the use of Portland cement and concrete. The steel siphon work should have the earnest attention of the engineer and manufacturer concerned in the possibilities of steel construction. The mining engineer has his interest claimed by the shaft and tunnel construction. Portland cement (in cement mortar or in concrete) plays a most important part in all of this. It is not only involved in the concrete of the cut-and-cover sections, but it is relied on to make possible a protective covering for the inside and outside of the steel siphons. It has been found of exceedingly great value in the sinking of one of the deep working shafts; in fact, it may be questioned whether the sinking of this shaft would not have failed without it. Consider, then, the Rondout pressure tunnel and the steeel siphons.

The Rondout Pressure Tunnel.

The Catskill Aqueduct may be said, if one speaks broadly, to parallel the Hudson River. Consequently, the route cuts across the tributary streams. These are creeks or brooks of no especial importance, so far as size goes. However, they mark the positions of valleys, some of which are a number of miles in width. One of the largest is the valley of Rondout Creek In making the crossing at this point the aqueduct drops far below the surface of the ground, far below the bottom of the creek, and thus makes the 4½ mile passage from one side to the other. A vertical shaft at each end, and a third located at an intermediate point will remain permanent features. In addition, five other shafts were sunk to the tunnel grade in order to facilitate construction. One of these, Construction Shaft No. 4, is 500 feet deep. It is 10 x 22 feet in horizontal section. Eighteen months were occupied in putting down this shaft. It was flooded six times. The strata passed were:—

	Feet.
Glacial drift	6
Helderberg limestone	226
Binnewater sandstone	39
High Falls shale	92
Shawangunk grit	134
Total	497

The trouble with the water came, no doubt, almost altogether from the sandstone and the shale. But the water made its presence felt long before these strata were reached. The site of the shaft included the location where a 4-inch test-hole had been put down. When a depth of about 80 feet had been reached a sudden inrush occurred through this hole filling the shaft half full. The emergency pumping plant had not yet been delivered, so that the contractors were caught unprepared. However, by the use of an air-lift and a couple of sinking pumps the water level was lowered to a point near the bottom. A nipple was driven into the hole and casing attached to it. The purpose was to grout up the hole. In order to carry out this plan a 1-inch pipe was put down to the level of the Shawangunk grit; that is, to the 363-foot level. The water was now permitted to return. Pressures were thus equalized and currents prevented. The grout was made according to the formula 1:1 and poured down the 1-inch pipe. This latter was withdrawn as the grout filled in.

The problem of this one hole was solved in this way. But fears began to be entertained as to whether the ordinary methods of shaftsinking would prove successful. It was understood that there was below a great deal of water under considerable pressure. With subsequent events in mind, it is not difficult to see that a special pumping chamber in the side of the shaft should have been provided before permitting the excavation to pass out of the limestone. This arrangement was made later, but the delay was the source of much trouble. However, excavation went on, and the sandstone was penetrated. At the 260-foot level the amount of incoming water was only about 225 gallons per minute. However, during the drilling of the sump an additional 600 gallons per minute came in suddenly through one of the drill-holes, with the result that the shaft was flooded again. After some trouble the shaft was unwatered, only to be flooded three additional times in as many weeks. Pretty much all this water came in through bore-holes, none of which was probably over two inches in diameter. When the fifth unwatering had been completed the conditions below were known to forbid further progress apart from special precautions. In fact, it had been ascertained that large crevices were a short distance beneath the bottom of the excavation. One of the largest of these crevices was distant only a foot and a half. The size of the crevices ran up to 8 inches. As compared with the 2-inch bore-holes, they promised plenty of trouble.

Grouting up the Crevices.—It was now proposed to deal with the water question by means of grout. Four special machines were set up at the mouth of the shaft. A 2½-inch pipe led down the shaft to the bottom where a 2-inch hose carried the grout to the point of use. At the beginning of operations the grout gave trouble by leaking back. It would come in through the spaces around the pipes and through cracks in the bottom. This difficulty was successfully met by mixing finely ground hose manure with the grout. The manure produced a clogging effect. Some grout was wasted, but success was eventually obtained. In this procedure a