(*b*) By making a slight angular deflection measuring a certain distance until just opposite the obstacle, then deflecting back twice, the first deflection measuring an equal distance and then deflecting again on to tangent, by an angle equal in amount and direction to the first one, the error in chainage is usually disregarded; this method introduces three angular measurements and is not likely to give an exactly straight line for this reason. (See fig. 19.)

(*c*) By laying out an equilateral triangle, this fixes the chainage beyond the obstacle, and presumably the direction and line; but as this method introduces three angular measurements and two linear ones, it is not apt to give as good results as the first two. (See fig. 19.) It is understood that if by placing a transit on top of a secure obstacle the line can be prolonged directly over it, it is best to do so even at considerable personal inconvenience.

If very accurate transit work is desired, it is not best to trust to the adjustment of the instrument, but take two points on each hub, and use the mean. In the same way, equal backsights and foresights in levelling should be obtained wherever possible, to minimize the result of a level being out of adjustment, and also it is best to adjust instruments for about the distance that the ordinary sights are to be in any given class of country. The travel of the tube in a large change of focus often throws an instrument out of adjustment for very short or very long sights.

It is often found that a survey party, before being disbanded, has time to do cross-sectioning for construction; this is a mistaken economy, and a source of errors and mutual accusations. The members of a survey party do not take interest in work; they are not to superintend, and the cross-sections will probably be poorly chosen and executed. Then the centre line will very likely be altered in various places, which will invalidate all sections at those points. Generally speaking, it is best to have the engineer of construction do everything of an engineering nature which appertains directly to his work.

(*To be continued.*.)

THE PETROLEA WATER WORKS.

In January, 1893, the town of Petrolea, Ont., made an agreement with the Petrolea Waterworks Company to lay about 40,000 feet of pipe, with 70 hydrants. The water was to be taken from wells in the gravel beds in the townships of Enniskillen or Plympton. In August, 1894, an extension of time was granted to the company, which had then laid only about two miles of piping. In 1895, the company having failed to carry out its agreement, owing to the difficulty in finding a well with a sufficient yield of water, the corporation began operations on its own account by sinking a test well about 4½ miles east of the town, which yielded 70,000 gallons per day, but which was not found to be permanent.

At this point Willis Chipman, C.E., Toronto, was engaged to report on the whole question of water supply. In his first report, August 27th, 1895, four sources of water supply were discussed, of which the River St. Clair and Lake Huron were found to be the best. A second report was presented to the town council by Mr. Chipman, which discussed the Lake Huron scheme. The plan here discussed was adopted by the council, upon the following estimates submitted by the engineer:

Pumping station at Lake Huron, including pump house machinery, intake detached residence for engineer	$ 15,000
Force main, including right of way and damage..........	103,000
Distributing system in town, including a sum to purchase the mains already laid by the company............	35,000
Standpipe	8,500
Meters....................................	3,000
Engineering and contingencies	7,000
	$171,500

The late Alan Macdougall, C.E., made a report upon the plans prepared by Mr. Chipman, in which he suggested a filter bed in the lake, protected by crib work, and having an area of 7,500 square feet. E. H. Keating, C.E., city engineer of Toronto, was asked to pass upon both schemes. He was in favor of an enlarged conduit pipe and intake, and other alterations which increased the estimate by about $50,000. The town council decided to proceed with the work as planned by Mr. Chipman in his report originally adopted. Work was commenced April 1st, 1896, with Mr. Chipman as engineer in charge.

During April and May the conduit line was located and staked out, the point of intake and site for building selected, and plans and specifications prepared. During this time the right of way for the conduit was secured by the committee. The contract for the whole work except machinery was let to W. Garson & Co., St. Catharines, Ont., for $131,945. The contract for the machinery and boilers was let to the Hughes Steam Pump Co., of Cleveland, Ohio, for $14,289.

The intake pipe is 1,089 feet long from the well to the strainer, and 12 inches in diameter. The depth of water at the outer end is 15 feet, with the lake at 580 feet above the sea level. The intake is so designed that it can at any time be tested for leakage, or flushed out from the pump room. At the outer end is placed a cylindrical crib, or strainer, of ¼ inch boiler plate, 4 feet in diameter and 5 feet high, the upper part being perforated with ½ inch holes, spaced 1½ inches centre to centre. The top of the strainer is about 10 feet below the lake surface. It is protected by ten twelve-inch piles. The intake pipe was completed and lowered to grade in April, 1897. Considerable difficulty had been experienced in laying the intake pipe, as a sand bar 150 feet from the shore refilled the trench, which was dredged for the pipe several times.

The pipe also parted on a couple of occasions. Upon subjecting the pipe to a test pressure of 20 lbs. to the square inch, a leakage of 25 gallons per minute was determined. It was discovered that the strainer had lost its upright position owing to the sandy clay washing out from one side. It was righted by dredging under the other side, and was then connected with the wooden piles, which surround it by a heavy iron chain. It is the opinion of the engineer that the strainer will eventually have to be protected against accident by a stone filled cribwork.

The pump well is circular, with an interior diameter of 14 feet, and a depth of 12 feet below the surface of the lake when it is at 580. The floor level of the engine-room is 6 feet above this lake level, and 11 feet below the ground surface. The material passed through in excavating for the well below the floor level of the engine-room, was entirely a blue clay through which no water whatever percolated from the lake. The walls of the well are of hard brick laid in Portland cement. The top of the intake where it enters the well is at elevation 576, thus giving about four feet of head in the pipe with the present lake level. By an arrangement of pipes and valves in the well, water can be pumped directly through the intake, and water can be turned back through the intake by an 8-inch connecting pipe from the discharge main. The lower four feet of the well cannot be pumped out by the main engines, this space being left for sediment to collect, but it can be pumped out at any time through a flexible iron section pipe by boiler feed pump. The well is entirely outside the building, and is covered.

The pump-house is located on the northeast corner of lot 9, 8th concession of the township of Sarnia. It is a white brick building 30 x 100 feet, divided into engine-