

a fine scratch on the face of the plug; the rod is then subdivided into feet, tenths and hundreths in alternate white and black spaces of one one-hundreth of a foot. When observing the rod the readings are made to thousandths, the hundreth spaces being subdivided by estimation. As it is impossible to subdivide a black space accurately at the distance the rod is usually observed, two sets of graduations are placed, side by side, one on each side of the centre line of the rod, the white spaces of one adjoining the black spaces of the other; thus the observer has always a white space to subdivide by reading on the right hand or the left hand set of graduation marks, as the case may be. The bottom of the rod is formed of a cast steel foot block with a hemispherical knob on the bottom, suitable for holding on flat surfaces.

Another piece of apparatus which can hardly be classed under the heading of instruments, but which is very necessary nevertheless, is a large carriage umbrella with a handle about 8 feet long, provided with a spike at the end to insert it in the ground. The umbrella is used whenever the sun is shining while observations are in progress to shade the instrument from its rays; without this the parts would become unequally heated and irregular and unreliable action of the bubble would follow.

While carrying the instrument between sights a cover of duck or cravenette is used for the same purpose, this also is used to protect it when working during a light rain; in a heavy rain the work has to be discontinued.

**Field Operations.**—A precise levelling party consists of 7 men, the observer, the recorder, umbrella man, two rodmen, cook and railway man, usually a section man or brakeman, to pilot the hand-car. Camps are made at the stations along the line, the distance apart of camps varying from ten to twenty miles according to the location of towns and villages and to the condition of the intervening track or to grades. The levelling is carried continuously forward, day by day through the camp and to a point about half way to where the next camp ahead will be; permanent and temporary bench marks being put in so as to divide the line into sections of one mile or less. From this point backward levelling is commenced and carried along to the point where the line was taken up, probably about half way from the previous camp, all bench marks being checked upon on the backward run.

I will quote from the general instructions issued to levellers:—"All lines are to be levelled twice, in opposite directions called forward and backward levelling. Backward shall in every respect be independent of forward levelling and the same tuning points shall not be used. If the forward levelling is made in the forenoon, the backward—over the same section—should be made in the afternoon. In this respect the opposite conditions as to intensity of light are desirable, but the work must not be delayed for this purpose..... When a discrepancy in the thread intervals, or any other error is discovered, even although the nature of the error may appear to be self-evident, the section involved must be re-levelled from the preceding bench mark, and the word "cancelled" written across the page of the level book containing the readings along the discarded section.

"The field books shall in every respect be self-evident records of the work on the ground. The difference of elevation, as indicated by forward and backward levelling—between two permanent bench marks—shall correspond within 0.017 square root of M—feet, M being the distance in miles between the benches.

"If the difference between a forward and backward levelling is greater than allowed, the section shall be level-

led anew, both forward and backward, until two measurements within the limit of error are secured. In this way, four, six, or more measures are made, the mean of all being taken and the individual residuals determined. Reject all those results whose residuals are greater than 0.015 feet; then take a mean of the remaining measures for a final result."

This requirement, that the discrepancy shall be within 0.017 times square root of the distance in miles has been adhered to as closely as possible through out the work; this means that for 1 mile forward and backward levels shall correspond within 0.017 foot, for 4 miles within 0.034 foot, for 100 miles within 0.170 foot and so on. Quite frequently the total discrepancy of a line shows a constant, and often unaccountable, tendency to accumulate in one direction. Various precautions are used to guard against this. If, when reading from the successive instrument stations, or set up points, the rear rod were always read first and the forward rod last, any settlement of the level between the backsight and foresight would have a constant tendency to make the foresights too small in comparison with the backsights, and on the backward levelling this effect would be repeated, causing the discrepancy to accumulate rapidly; this is obviated by reading on the rear rod first at one station and on the forward rod first at the next station so that any settlement at one will be counteracted by the settlement at the next; this method also has the advantage of eliminating the effect of a uniformly changing refraction in the atmosphere, such as usually occurs most noticeably in the early morning and late afternoon hours. It of course has the effect of holding back the progress of the work considerably, a at every second set up the leveller has to wait for the front rodman to reach his turning point, and afterwards wait for the rear rodman to overtake him before going forward (these remarks are intended to apply where the levelling is carried along a railway track and a hand-car used between sights). However, in precise levelling, accuracy is the first consideration and speed is secondary.

(To be continued.)

## EDMONTON INVESTIGATES TOFIELD'S GAS SUPPLY.

A heavy flow of natural gas has been struck at the town of Tofield, on the main line of the Grand Trunk Pacific, forty miles east of Edmonton. The town has been conducting boring operations as a municipal enterprise for about a year past. For some time strong indications of gas were evident, and it was obtained in comparatively small quantities, and could not be considered a commercial proposition until a few days ago, when there was encountered an enormous flow under very heavy pressure. The volume of the flow is variously estimated at from 1½ to 2 million feet per day. Edmonton city council has taken action with a view to obtaining expert information as to the practicability of piping this gas into the city. The city is about to embark on the installation of a municipal gas plant. The work will be immediately proceeded with so far as the mains are concerned; but action on the ordering of the generating plant will be suspended until the possibilities of the Tofield discovery have been investigated.

Practically at the same time a strike of gas in large volume and under heavy pressure was made at Pelican Rapids, about 175 miles north of Edmonton, on the Athabasca River. Boring has been going on there for oil in the interests of a syndicate of Edmonton capitalists, and will be proceeded with, with the expectation of finding oil in strata below.