of sacks of sand. Having thus created over one-half of the river, at a time, a comparatively impervious barrier, and raised the waters on the inside of it to the quiescent state of a lake, he could thus employ divers pnt in his temporary dams, and lay out his foundations in a more leisurely manner, though even so, as quickly as possible, and under almost constant anxiety that some flood would occur in the interval and wash everything away.

To bring this paper down to date in its conclusions, the author refers to the engraving published in The Canadian Engineer in February, 1903, showing the second failure of the Chambly dam, but this time of a section where there were no sluice gates to weaken or lighten the structure, as in the portion previously washed away. The conclusion is therefore inevitable that the dam was not of sufficient weight, nor was its base so grooved into the underlying bedrock, to prevent it from being pushed bodily forward.

THE GRADIENT-TELEMETER LEVEL AND ITS ADVANTAGES ON PRELIMINARY WORK.*

Now-a-days, when events are making such rapid history in the engineering world, the most deeply-felt want is for methods which will yield the necessary information at the minimum cost of time and expense. With this object in view, instruments of the Gradient-Telemeter type have been invented and placed before professional men for trial from time to time. The present article merely deals with the particular class of instrument mentioned above, as in the writer's opinion it is in many respects unique and worthy of a separate niche in the temple of instrumental fame.

Now that transcontinental railways, colossal irrigation systems and other engineering enterprises are actually taking definite and practical shape, the question of improving upon the old-time methods of gathering preliminary details (especially in unexplored territory) becomes a momentous one, which is to some extent satisfactorily solved by the telemeter. The instrument consists of an ordinary Y level (14 inch), with the addition of a compass and a gunmetal circle. The whole principle upon which the instrument works is contained in this circle, which is a casting made in the shape of a cam; that is, in place of the circle being truly horizontal or at right angles to axis it is curved out of the horizontal, and consequently causes the telescope to tilt either upwards or downwards when revolved, through a vertical angle. The circle (or gradient limb) is graduated around three-fourths of its circumference with numbers commencing at 1,200 and terminating with 10. Certain numbers are selected and classified as pairs, each pair being engraved on the remaining one-fourth of the gradient limbs circumference for reference. The advantages of the telemeter are: 1. The automatic measurement of distance, which dispenses with the services of two chainmen; (2) increased accuracy in measurements through rough and broken country; (3) the measurement of vertical distances either up or down hill from 1 to 140 feet (in ordinary practice) with one sight and from one station, in place of the limit being length of rod as with an ordinary level; (4) compass being adjusted to read at right angles to line of sight, so that telescope can be clamped on rod and magnetic bearing taken, thus dispensing with picketman. Briefly, then, two men (an instrument man and rodman) can make a traverse, with accompanying levels at all necessary points, leaving the two chainmen and picketman available for duty elsewhere. For more accurate traverse work, the makers add a horizontal circle at small additional cost.

As to the method of using the instrument, it may be understood that no particular technical or mathematical difficulties bar the way, in fact, the strong point in this instrument is its perfect simplicity in design and theory. By clamping the index at zero on the cam, the telemeter becomes an ordinary Y level, and any readings taken at this stage are treated exactly as those of a level in the field-book. By moving the index from zero to 100 in the cam, we use the first pair, i.e., 0 and 100, and the difference between the two readings (on rod) gives the horizontal distance without any calculation, each vertical foot on the rod representing 100 feet horizontal measurement. With all succeeding pairs, however, the telescope is necessarily tilted for each reading, being directly influenced by the position of index on cam, and although the method of obtaining horizontal distance remains unchanged throughout the pairs, the calculation for difference in elevation follows this formula: For a rise reading (uphill), divide the distance measurement by either of the pair numbers used; add height of instrument to quotient; deduct the rod reading belonging to the pair number used as divisor, and the result will be difference in elevation between ground surface at instrument and ground surface at rod. For a fall (or downhill) reading, the same formula applies, except that the rod reading is added and the height of instrument deducted.

A most important automatic check on each pair of readings, together with the calculated result, can be obtained by unclamping the index and swinging the telescope until the horizontal cross-hair intersects the rod at the exact height of instrument, which is measured by a tape with a plumb-bob attachment hanging beneath centre of instrument. Assuming the H.I. to be 4.85', the leveler moves telescope around gradient limb until he obtains this reading on rod; the vernier is then clamped and the reading on 8. limb taken; this reading is the distance in which a rise or fall of one foot occurs between ground at instrument and ground at rod, so that the difference in elevation (between these points), divided into the distance, should give gradient reading as quotient. This check is especially valuable in tracing clerical errors where the pair numbers are correctly entered, etc., and in obtaining the grades of country traversed with rapidity.

In telemeter work it is necessary to reduce the levels as they are taken in the field. This of course involves constant calculation all day long, but a little practice soon renders it a mechanical process performed mentally, and the prospect of reducing several miles of telemeter levels after reaching camp is a strong incentive to rapid field-work.

As regards the distance that can be covered in a day with the telemeter, the writer has completed nine miles through fairly rough country, but this included the picketing of a line by the writer and his rodman, and the sketching of all topography along the line in a specially designed field book. Generally speaking, the telemeter is at a slight disadvantage with the level in level country, as two readings must always be taken, but this is more than compensated for by distances being obtained without the aid of chainmen; also, all the information is entered in the leveler's field book, and thus condensed. In rough country, however, the telemeter (being able to negotiate vertical heights up to 140 feet in one sight) can leave any level a long way behind, to say nothing of the chainmen. Of course, to obtain a large vertical difference in one sight, a long base is necessary, owing to the fact that the vertical angle increases in direct proportion to distance between rod and instrument. It, therefore, follows that, to obtain the best results with a telemeter, a really first-class telescope, with powerful lenses, is necessary, and any telemeter telescope not fulfilling this condition should be promptly rejected. The instrument used by the writer gives a very clear reading at 1,200 feet distance (horizontal). It may here be noted that the distances obtained by telemeter pairs are in all cases horizontal ones between rod and instrument.

For setting out railway curves, the maker combines a graduated horizontal circle with the gradient limb or cam at a small additional cost, thus adding to the instrument's efficiency. For setting out distances the subtense method is used, based on the following rule:

If any two integers whatever be taken and used as divisors into the distance required, the result will be a gradient pair, which, being applied as any ordinary pair, will give on the rod a subtense in feet that is equal to the difference between the two selected integers.

* From a Paper read before the Canadian Society of Civil Engineers, by R. W. Macintyre, A.M. Can. Soc. C.E.