

handyman for occasional use in emergencies ; a cross-head is very accurate and never falls asleep at inopportune moments.

During survey, people naturally resent injury to crops and premises, even when the least possible is inflicted, and polite words and sincere endeavors to minimize the loss are rightful and expedient. Many survey parties constitute themselves armies of invasion ; trees are needlessly cut down, growing grain trampled on, fences torn down to make stakes, and a general tone of overruling ruthless power is prevalent, all of which is wrong and foolish. Many life-long enemies to the road have been made in just this way, and the probable immediate consequences will be that all stakes will be torn up and thrown aside as soon as the party has passed by, and, in addition, the purchase of right of way will be made needlessly difficult and expensive ; the far-reaching consequences to a railway company of the actions of survey parties in this respect are beyond calculation.

After preliminary surveys are completed, and it is desired to obtain approximate estimates of the quantities and cost of construction for a comparison of routes, various short-cuts are used. Excavation tables can be purchased or made for taking out quantities of earthwork. General plans of trestles, culverts, etc., can be used, and tables drawn up of the cost per lineal foot for various sizes and heights, but the larger structures will each require special calculations. In taking out approximate quantities, remember—

(a) That embankments require more than cross-section measurements indicate, by about 5 per cent. if of sand, 10 to 12 per cent. if of clay, and 15 to 25 per cent. if of loam or peat, but that rock expands 25 to 75 per cent., depending on the size of the rocks. This shrinkage will not take place fully for a year or two, and may not exist at all during hurried construction, and will be made up afterwards by train.

(b) That unless the depths of foundations are known, a liberal allowance should be made for possible deep ones.

(c) That side-hill quantities are not indicated by the centre line profile and should be specially provided for.

(d) That the classification of material is likely to be higher than surface indications would seem to warrant.

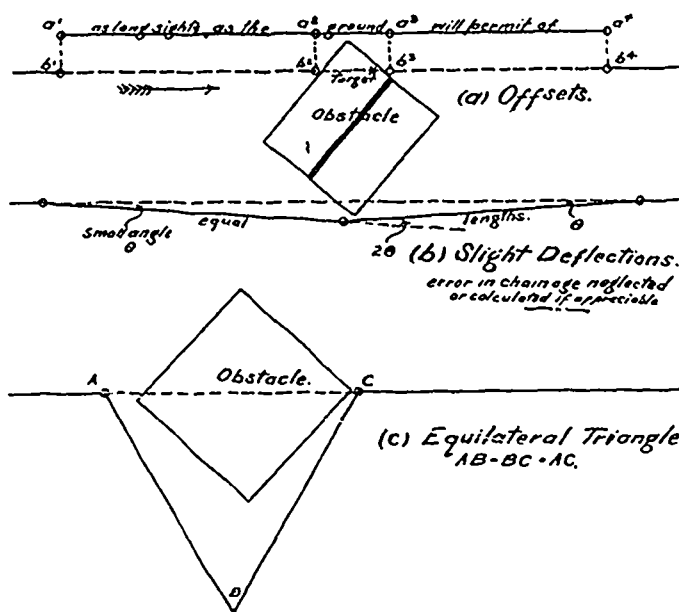
#### ARTICLE 14.—LOCATION SURVEYS.

The duties of each engineer of a survey party are considerably increased when the location of the selected preliminary line is decided on. The chief and transitman note the foundations for all structures, and should be given time and facilities to have soundings of the beds of the streams, etc., made, so as to determine the depth of foundations quite accurately. This may be made a part of the leveller's duties, if he has more time for it. They should carefully note the natural resources of the country passed through, whether good quarries and ballast pits exist or not ; whether timber suitable for trestles, piles, or ties is available, and the probable traffic on various intersecting highways, so as to determine at each one whether it will justify the company in expenditure sufficient to pass the road over or under the railway. In fact every item of information necessary for a complete knowledge of each structure, etc., so as to be able to say definitely what structure is best at each point and why. If the topographer is not a land surveyor it will now be necessary to add one to the party, whose duty it will be to fix the exact position and angle of crossing of each property line, and measurements to nearest monuments, the bearings being taken by compass. Also to obtain the full names of all owners and tenants

whose properties are to be affected, the exact positions of all buildings or highways within 400 or 500 feet of the centre line, and all prominent natural topography. The leveller, in addition to those duties already noted for preliminary work, will need to establish and witness bench marks about every 1,000 feet, not closer than 30 feet or 40 feet to the centre line, nor more than 50 feet or 55 feet in a bush country, while in an open country any convenient distance laterally will answer. Very few places should be deemed suitable for a bench mark ; the root of a large green stump, or the top of a small one, cut off for the purpose, is the best. If the root of a tree is used it will grow a little in the course of years ; it is liable to be invalidated by the wind blowing the tree over, or lifting the roots in loose soils, and worst of all, if on the right of way it is liable to be burnt up or cut down below the blaze made on the side of the trunk for reference, thereby being lost entirely. Bench marks should be selected at elevations close to structures, but otherwise at heights nearly that of the proposed grade line, so as to be convenient in running grades, ballast heights, etc. When a located line is laid down without much revision, it will, in any difficult

Fig. 19.

Methods of producing a straight line past an obstacle



country, pay by many times the expenses of a survey party, to revise the whole line, when numerous small changes will be made from point to point.

In finally staking such a revised line, it should be thoroughly done, and hubs and stakes stout and well driven, good strong nails (1-inch tinned) used. No hub should project more than half an inch above the ground, and in a settled country stakes should be bought at a saw-mill and carried along a day at a time ; the using of fence rails for stake material creates more ill-feeling than the trifling economy warrants. Unless construction is imminent, all hubs should be referenced by cross lines or otherwise. Nothing is much more disheartening to the constructing engineer than to find a located line almost obliterated and untraceable. There are three general methods of prolonging a straight line beyond an obstacle.

(a) By offsets, where the necessary offset is not very long ; this is the most accurate method. The measurements  $a_1b_1, a_2b_2, a_3b_3, a_4b_4$  are identical and made very carefully with a steel tape and plumb line ; the transit sites would be at  $b^1, a^2, b^4$ , with a target placed on top of the obstacle, if possible, as a back sight check. (See fig. 19.