tribution of material from cuts, to enable overhaul calculations being made, and for approximate estimates where errors of 5 per cent. or even more are not objectionable, as the company, in its monthly payments to contractors, reserves 10 or 15 per cent. for just such exigencies. In taking monthly estimates, the only certain method is to make each one a total estimate in fact as well as in name, and derive the current estimate by deducting the total one for the month previous from it, that is, never take notes only of what is thought to have been done during the month, for nothing is more difficult or more apt to lead to error—whereas if the total work done or material delivered at each point is noted, the errors of each month are eliminated in the next one—the extra labor involved in this is usually insignificant.

Specification for Excavation.—Materials excavated will be classified as earth, quicksand or dry hard-pan, loose rock and solid rock. Earth includes everything except the other classes mentioned. Hard-pan includes all cemented clay or gravel, or any combination of these that it is not practicable to plow with a four-horse team. Loose rock includes all stone containing not less than one cubic foot, and masses of detached rock containing not over one cubic yard; also all slate, shale or other soft rock which can be removed without blasting, although blasting may be resorted to. Solid rock includes all loose rocks containing over one cubic yard, and all rock in place which requires drilling and blasting.

(N.B—.The earth and hard-pan are sometimes placed in one class as earth, at a higher rate, thus saving much contention.)

ARTICLE 30.—SURFACE DRAINAGE.

In addition to the provision for flow of water under or through the track, there is yet the question of track and slope protection which is of almost equal importance. Where, on side-hills, the surface flow toward the top of the cut slopes and toe of the embankment slopes is considerable, ample provision should be made to intercept it. In general, catch water ditches three or four feet wide, and one to one and one-half feet deep, should be dug so as to run in a continuous line along the upper side of the cuttings and embankments from each lateral watershed to the nearest culvert or stream--which should set back five or six feet, generally, from the edge of the slopes leaving a solid berm; the material from these ditches, cast on the lower side will form an additional protection. In very porous soils, these ditches may need to be lined with pitch or planked; but in any case will prevent that heavy washing down of cut slopes which, otherwise, fills up the track ditches and floats the track, making the roadbed soft.

The track (cut) ditches themselves should be turned into these catchwater ditches at the upper grade points, so as not to empty down along the toe of the embankment, eating it away; and in very wet cuttings, it may be necessary to run a farm tile about three feet under the track ditches and parallel to them to aid the drainage. In case of quicksand, which will soon fill up tiles, the tile must be covered with straw and laid with collars, or longitudinal round pole drains may be substituted for the tiles.

The slopes of cuttings themselves also need protection to prevent erosion; in ordinary cases the sowing of grass seed on the slopes of cuts and fills will answer the purpose, but where the cut slopes are wet and springy it may be necessary, in addition, to cut a series of diagonal ditches on the slopes to bring the water to the cut ditches by easy grades; in extreme cases the construction of a network of tiles on the slopes may be necessary to effect complete protection. Perhaps the most imperative matter of all is to have the ordinary cut ditches always cleaned out—free from boulders, ties, ballast, etc., which tend to accumulate during maintenance. The form which such ditches assume is of a wedge shape, with a slope from the track of about 3 to 1 and an outer slope the continuation of the cut slope. This form will tend to maintain itself better than one with a flat bottom and steeper slopes.

(*Conclusion Vol. I.*)

For THE CANADIAN ENGINEER.

SEWAGE DISPOSAL THROUGH THE ACTION OF BACTERIA.

BY W. M. WATSON, TORONTO.

Toronto and several other cities and towns, as well as private places, are contemplating putting in sewage works. Perhaps a little information, gathered from the leading bacteriologists, chemists and engineers, who have with the assistance of the best appliances been studying and experimenting on sewage for the past fifteen years, with the object of solving the knotty problem, viz., how to purify foul fluids, may be useful. My own experience in this connection will also be of interest.

Up to the present time precipitants of lime, powdered clay, alumina, ferrozone, sulphurous powder, sulphate of iron, and other chemicals, have been used to clarify or clean sewage by settling in tanks, generally extracting about a twentieth part of a pound of sludge per gallon of sewage treated, at a cost per head of population ranging from 25 to 75 cents, and often having considerable difficulty in disposing of the solids, even when expensive pumps, presses, and other machinery are used. The average composition of domestic sewage is: organic matter, 27.72 grains per gallon; nitrogen, 6.21; phosphoric acid, 1.17, and potash about 2.03 grains per gallon, which is principally in solution, and can only be removed by filters that contain numerous colonies of a very small rod-shaped bacteria that can be seen only by the assistance of a very powerful microscope. These organisms feed and thrive on the foul contents of sewage matter. Trade sewage may contain any chemical, and in some cases may need special treatment, which ought to be given it before it is allowed to enter the public sewers. Sewage heavily charged with grease may require a precipitant of bisulphide of carbon. Sewage from sugar factories which contains vegetable organisms, oscillaria alba, or beggiatoa, which act like ferments, rapidly decomposing, may require a magnesium chloride, quicklime and coal tar preparation, to extract its foul contents, and sewage from slaughter houses should have the blood and fat extracted before entering the public sewers.

To discharge clarified sewage that has only passed through settling tanks into fresh water is simply undoing the work done, because the dissolved putrefactive matter is held in solution after the solids are thrown down by the precipitants, and after being delivered into fresh water the dangerous microbes increase rapidly, and putrefaction is set up. Almost the same end is reached by allowing the sewage to enter fresh water after it has been carefully screened through a fine sieve, and it is probably more to the advantage of the public to allow sieved sewage to go in raw, than after it has been settled by the use of precipitants, because precipitants add somewhat to the chemicals held in solution, and make the sewage harder to purify.

Sewage placed under a microscope shows various decaying matters, multitudes of dangerous microbes, amoebiform bodies, infusoria, fungi, etc., including all the classes discharged from the skin and intestines of man and the animals. When water carriage is used to remove