I in 50. The longitudinal fall of water channels should not be less than I in 100 for a granite channel, and I in 150 for asphalt.

Improvement of Existing Roads.—Inadequate Foundations.—The majority of the old highways of this country have come into existence in a more or less haphazard fashion, and in the past the provision made for their maintenance has been uncertain and inadequate. The entire absence of foundations suitable for carrying modera weights brought upon the surface is revealed by the upward movement of the sides of the roadway into the channels—a weakness to be observed generally throughout the country.

Vast sums are now being spent in laying down expensive so-called waterproof surface crusts of various kinds, in order to give an immediate show for the money expended, but the writer is of opinion that, wherever there is evidence of underlying weakness, money may be more advantageously applied by first putting in proper foundations and drainage. However excellent, well laid or expensive may be the surfacing material, it can never prove really satisfactory on a weak foundation. There will be gradual but constant movement of the road crust, local sinkages of the central portion and rising of the sides, and generally the annual expense of wear and tear of the surface will be greatly enhanced in cases where no solid and unyielding foundation exists.

The initial cost of such work is, of course, necessarily heavy, but where suitable foundations do not already exist, it is submitted that it is the only sound course to pursue, both from an engineering and financial point of view, and is essentially a capital work for which State "grants" on liberal terms should be made.

Thin Crusts.—The wisdom of recent practice in laying thin surface wearing crusts or armourings of asphalt and bituminous preparations over existing macadam surfaces is open to great question, except where an absolutely rigid and dry foundation can be relied upon. In the absence of this, most ordinary road surfaces are subjected to consider movement under modern speeds and weights, and in these circumstances, thin wearing crusts are liable to fracture and disintegrate. Great caution in the selection of a suitable site is necessary, except where laid on a good concrete foundation, which, unfortunately in most cases, would make the cost of the work prohibitive.

Bituminous Methods.—In what are now known under the general name of "bituminous methods," the presence of coal-tar and pitch is the distinguishing feature, and the main object of all such processes is to exclude water from the crust of the road. These methods consist mainly in the revival and extended use of "tar-macadam," "pitchgrouting," "tar binders," and other like forms, and in suitable situations and conditions give very serviceable surfaces at a not unreasonable cost, but much discrimination is needed in their application.

The arch enemy of the tar-macadam road is the traction engine, and this cumbersome vexatious contrivance is, unfortunately, rather in evidence in the writer's district, especially during the spring and early summer months. These engines, with destructive diagonal steel strips on the wheels, weigh over 16 tons on the road, and haul three lumbering wagons weighing about 12 tons each when loaded. Under this burden the very best of tarmacadam work suffers substantial damage. Even after having been laid many months the material, owing to its plastic nature, will slightly soften on a hot day, sufficient to permit of its being crushed out of shape and torn up und r traffic of the class named. A well-made granite macadam road surface withstands this class of traffic very much better than tarmacadam, or any of the bituminous processes.

To the enthusiast for tar-macadam, in addition to the above caution, the writer suggests that consideration of the following points will help to keep him out of trouble:

1. The quality of tar available for such work is very variable and unreliable, and requires constant watching to avoid failure.

2. Good fine weather is an important factor for successful work. If the weather is too cold there is great risk of too much tar being used, thus causing the tarmacadam to become very soft and easily damaged during the warm weather.

3. Tar-macadam is hopeless on a weak, yielding foundation.

4. It cannot be satisfactorily repaired during wet, cold weather. This is important in streets where much opening of trenches for gas, water, electric and other services is likely to be required.

5. Where there is much traffic a continual watch must be kept on the work for some time after it has been completed, which considerably adds to its cost.

6. Tar-macadam is liable to "creep" during hot weather towards the sides of the roads, especially in country districts, where the lateral support of a curb and footpath is not usually available, and some provision to meet this tendency should be made.

7. The cost of tar-macadam is, as a rule, much beyond that of a granite macadam tar-painted surface, and its serviceable life cannot always be so accurately predicted.

The foregoing matters are mentioned, not with any desire to discourage the use of this type of road surface, but simply with the object of drawing attention to a few points which require consideration to ensure successful work.

With regard to the "pitch-grouting" of road macadam, the writer is of opinion that this process has not yet been proved to be so satisfactory under like conditions of traffic, as good class tar-macadam well laid. The work is expensive, its serviceable life is not great, the surface soon becomes deeply corrugated and carries much slippery mud during wet weather.

Coatings of tar-macadam of a total thickness of $4\frac{1}{2}$ inches are sometimes laid with a layer of coarse material at the bottom, and finished with a fine grade for the surface. A coating of the thickness named is best laid in two layers, but there is no advantage in separating the fine and coarse grades; the same mixed grade material should be used for both coats.

Rolling of tar-macadam is best done with a "light" steam roller (6 or 7 ton weight), and there is nothing to be gained by an excessive amount of rolling.

Tar-macadam may be laid on gradients as steep as about 1 in 25, and even sharper if the surface is kept clean. The degree of slipperiness experienced depends greatly on the weather and the skill of the driver.

It is a great mistake to lay tar-macadam, or any other bituminous road surface, over an existing macadam roadway as a foundation, without first lightly scarifying the surface all over and consolidating by rolling to a *uniform* condition before the bituminous material is laid. Where this precaution has been neglected the old inequalities and "pot-holes" in the road crust will soon re-appear on the surface of the newly laid coat, as the greater depth of bituminous material over the "pot-hole" consolidates more than the thinner coating around.