and the cracks must open. In well-drained roads in which the water content does not far exceed the optimum, there is generally ample room for the ice to expand between the stones. Where, however, by the choking of the sub-crust drainage, or by continued condensation of sub-crust dew, the air spaces in the road are more completely filled with water, the frozen crust has to expand, and expanding detaches itself from the rest of the road, and rises as the cavernous blisters which we know so well. Then comes the thaw, and the bursting, disintegrating and disarranging work done by frost becomes evident; but much of the winter damage ascribed to frost is really the work of sub-crust dew, and can be minimized by the provision of a proper porous make-up layer in which water does not accumulate.

The discovery of Macadam was that road stones so broken that they would pack are held together by films of water. Makers of modern roads follow Macadam in preparing road metal aggregates by breaking stones to a more or less uniform mesh, but with the coming of motor traffic and its attendant dust they have had to find binders stronger than water, in order to hold their stones together under the increased stress of traffic. Except for raw flint, the road materials known to Macadam were all substances which water wets with avidity, but in these modern days this is altered, and materials which water cannot bind have now to be reckoned with upon our roads.

When carbonaceous binders are new laid they are viscous and resilient, and yield under stress without breaking; but when, with lapse of time, by differential evaporation of the tempering oil they become hard, they break under the hoof or wheel, and make a mud, or rather an emulsion, which is devoid of strength. When looked at with a lens, spent tar or pitch which has been scraped from a wet road and laid on blotting paper, shows the water curled up as globules between the pitchy splinters, and without raising the temperature all my attempts to make it into briquettes have resulted in failure. Water will not bind it, and if a proportion of it be mingled with powdered road stone the strength of the water-bound mixture is diminished as the proportion of the powdered pitch increases. Users of cars have learned to respect the iniquities of the churned-up mud which in certain places accumulates on tar-painted or pitch-bound roads. Mud rich in animal or vegetable refuse has similar characters.

There is also another side to this question, and this involves the success or otherwise of these carbonaceous binders. Water does not wet the binder, but water does wet the stones, and if water has spread itself as a film over the surface of the stone the carbonaceous binder cannot "wet" the water, and therefore cannot get into contact with the stone. Even if by drying the water has been removed from the stone surface, it is likely to remain in the narrow cracks and capillaries, and when the carbonaceous binder spreads over and adheres to the general surface, it fails to make contact with the damper spots, and its hold upon the stone is incomplete.

The Road Board's Trials.

The speaker told how he had watched with interest the Road Board's trials along the Eltham-Sidcup road and elsewhere, and had visited the trial strips at a good many stages of their history, and has studied the interim reports. Were he to make a special report of his own he should say that the success of each individual strip has depended, and depended only, upon the hold which the binder has maintained upon the stones. Some of the strips are most certainly worn out, but in every case it has been the binding which has ceased to hold the stones, and not the stones which have collapsed within the binder. In these trials, and, indeed, elsewhere, the patent "Tarmac," made up of furnace slag (a road stone which, as a geologist, he could never place higher than third class), takes a high place, and he opines that the chief reason for its success is to be found in the circumstance that the slag, cooled directly from the state of fusion, can never have had any water spread or condensed upon its surface. Other successful aggregates are those in which the stones have been heated above the boiling point of water before they are mixed with the binder. By this heating the stones must of necessity be made dry, and hence, if the binder will spread upon them, a successful junction is assured. Next best are the processes by which boiling tar, pitch or bitumen is mingled with cold stones, but the removal of water by this means is never complete, and the method, as a rule, is not quite satisfactory.

The formula adopted by the British Cork Asphalt Company interests Professor Fearnsides. It excludes a certain quantity of Portland cement, and he was anxious to know why. It occurred to him that cement is an excellent dehydrating or drying agent, so he tried some experiments which lead him to believe that cement sprinkled over the surface of damp stones licks up the water, and makes it possible for tar or asphalt to spread over and make firm contact with the stones. About a year ago he wrote to one in authority suggesting that this method of chemical drying ought to be tried, but was given to understand that the cost would be prohibitive. Personally, he thinks otherwise, and is convinced that if those whose business it is to make tar or pitch macadam will dry their stones by mixing with them a little quicklime before the carbonaceous binder is added, the increased efficiency of contact between stones, the binder will more than repay the increase of cost.

Conclusions.

(1) The chemical action of water upon materials in roads is small as compared with the rate of mechanical wear, but care should be exercised in choosing materials which are to be buried in road foundations. Furnace slag for this purpose is not above suspicion.

(2) The power of water to bind is an effect of surface tension, and for maximum strength and efficiency it is important that the proportion of water should be kept at the optimum; "as dry as it can be drained" is the first approximation to the optimum for most water-bound road materials. Potholes grow by the wear of traffic at those places where by local water-pockets the proportion of water is kept above the optimum.

(3) Certain site-rocks, the argillaceous or clay rocks, owe their strength to water binding, and are subject to the same conditions of optimum water content. The importance of cambering and draining the site is, therefore, equal to that of arranging the configuration of the road surface.

(4) The effects of dew, more especially the dew which distils from below, are noteworthy, and in this, as in the question of the strength of the road, the importance of complete sub-crust drainage is to be emphasized.

(5) Water among solids which it does not wet acts as an insulator, and in the making of tar, pitch, asphalt or bitumen macadam should be rigorously eliminated