condition. Dragging this top soil was only effective during a rain or while the road was saturated. Where different kinds of material are found on the same line of road, the grading should be so planned that the difference of material will be of advantage to the road. By hauling clay on the sandy portions and sanding the heavy sections, more satisfactory results will be secured, and in many cases at practically no greater expense. Probably the worst condition we have to contend with is the heavy gumbo soil of the Red River Valley, of which Manitoba has considerable. We have experimented a great deal with that soil and have found that best results can be obtained by the construction of deep ditches and high, wide We require a minimum depth of 21/2 feet in grades. ditches with a distance of 50 feet outside to outside, and build up the grades by the use of tractors and graders. By running the tractor on the roadway all the time and bringing up the material in thin layers, the roadbed becomes very well compacted and therefore more impervious to water and capable of sustaining greater loads without Measurement of grades built in this manner rutting. show in some cases a compression or shrinkage of 50% from excavation. It is in such locations as this that drainage is especially important. A gumbo road is perhaps one of the best roads to drive over when it has dried smooth, but even with proper construction and an efficient dragging system it becomes almost impassable under heavy traffic during wet weather. To meet this condition and also on very heavy clay soil we have found that three or four inches of sand or fine gravel spread to a width of about 16 feet makes an impervious crust after travel has mixed it somewhat with the heavy soil, and provides an excellent road.

There are many different kinds of machinery used on highway construction but the most common implement is the ordinary blade grader, and it is the promiscuous use of this machine without regard to drainage or final grade lines that results in so much poor road work. Blade graders are essential to both construction and maintenance work and have the advantage of low cost and will move material from ditches to roadway cheaper than any other method, but there is nearly always a tendency when using these machines to make the work too light and the requirements for drainage are overlooked in the desire to cover a large mileage at a low cost. In many cases, blade graders are used where earth should be hauled along the line of the road rather than borrowed from the sides, and in such locations drainage is not secured, knolls are increased in height and mudholes result in the depressions. It is necessary in all cases where blade graders are used, to have, in addition to the grader crew, a grading or ditching outfit to cut down the knolls and open lines of drainage.

An important point in road specifications, particularly in cut and fill work, is to require what we call "construction dragging," which means that a road drag shall be used constantly during the building of grades and that the roadbed is kept smooth at all times during construction. In that manner the formation of chunk holes and ruts is prevented.

A question confronting those in charge is whether road work shall be done by contract or day labor. Our experience has shown that light grading and blade grader work can be more economically done under force account or day labor, but in heavy work requiring considerable equipment and on which measurements can be more accurately made it is better to handle the work by contract.

Any road construction is without permanent value unless an adequate system of maintenance is established,

and on earth roads it is absolutely necessary that a continuous system of dragging and general maintenance be provided immediately after construction. The most effective and cheapest method of maintenance is by the use of the ordinary road drag. The surface of a road which has been travelled for some time becomes consolidated by what may be called a puddling action and if the road is kept crowned and smooth this surface will permit the water to run off before damaging the roadbed. The constant use of a road drag will, by spreading at frequent intervals a thin layer of puddled earth over the road surface, tend to build up an impervious crust which will resist the action of moisture and abrasion of vehicles. The work of dragging must be organized if the best results are to be secured. The maintenance in each road district should be placed in charge of one man for the season, who should be held personally responsible for the condition of his roads. This element of personal responsibility is valuable in any branch of road work. Forces should be organized before the spring break-up, for the most effective work can be done while the frost is leaving the ground. Those living along the road must of necessity be employed to do the dragging, but the limits of each man's work must be fixed in order that responsibility may be placed for the good and the indifferent work. To secure good-natured rivalry and encourage better work, contests may be organized and prizes given for the best dragged sections of road. This has been very effective and a good roads sentiment may be created by arranging these contests with good road picnics, at which the prizes are awarded. Commercial clubs of the cities and villages can aid by putting up drag prizes and taking an interest in the work.

There are many patented drags and various dragging devices on the market, but the home-made wooden drag, whether built on the plan of the split log drag or similar to the Minnesota planer, are the best for maintenance of earth roads, but the planer gives a smoother roadway than the drag, for it levels out the longitudinal inequalities which the log drag seems to accentuate. The wooden drag renders the road surface more impervious by a smearing action which the iron or steel drag does not give, and is therefore recommended and most generally used. The best time to drag is as soon after a rain as the material will move without gumming, but no attempt should be made to drag when the road is dry and hard.

I have endeavored in this paper to bring out the essential points on earth road construction and maintenance which have been encountered in the supervision of over four million dollars' worth of that class of work, and in conclusion I wish to emphasize the fact that surfaced roads must at best be limited to a very small percentage of the road mileage, especially in the newer sections of the country, while the proper construction and maintenance of the earth roads will provide good roads for the whole community.

## ENGINEERING IN ENGLAND.

The British House of Commons has given the Imperial Government authority to take over the control of the entire engineering trade of the country and to place it under a combined management for the purpose of increasing the output of munitions of war. Mr. Lloyd George declared that the government proposed to organize the entire engineering community through a committee headed by business men, with the idea of assisting in the increase of output.