

tural condition, and raking out the stones and placing them in the base of the metal bed. The screened gravel produces a road which in the spring and fall and during excessively wet weather, sustains the traffic better than the unscreened material but the screened gravel road, is a rough and objectionable road to drive upon during the greater part of the year. The unscreened gravel road is a little muddy during wet weather and ruts more readily than the screened gravel, but the mud soon dries and the ruts are readily filled with the road drag, and the road is much more pleasant and useful, in that the surface is easily maintained in a smooth and satisfactory condition, provided always that the traffic is not excessive.

On ordinary market roads, and all other roads of less importance, gravel can be used, and will form a good road surface upon a sub-grade that has been properly prepared and adequately drained. Open side drains, as used in the old specifications, are unsightly and ineffective. Their construction was justified in 1854, but under present traffic conditions there is no place for them on the highway, and no reasonable excuse can be offered to justify their construction or their maintenance. They are jealously protected by the farmers of the adjoining lands, who use them as outlets to their tile drains, but they are of little value to the road for drainage purposes, and should be replaced by adequate under-drains, which, when completed, will render an improved service to both the farmer and the highway.

It is essential that the surface water be cared for at the sides of the grade, but seldom is it necessary to make the open drains so deep that they cannot be crossed without danger of an upset. When it is impossible to avoid the use of a deep open drain, they should be properly guarded.

The drainage of the sub-soil can be taken care of much more effectively and with less money with under-drains than similar results can be obtained with open drains, and always you have a safe road grade that is easily maintained and pleasant to work upon.

With the water line at the road sides lowered  $2\frac{1}{2}$  feet to 3 feet below the shoulder of your road grades, you still have a road imperfectly drained, for on the inclines of the grades and on higher elevations of the road the metal crust of the roads frequently breaks up in the springtime, and so accustomed have we become to this condition, we have succeeded to a great extent in making ourselves believe it is impossible to prevent their breaking, and without hesitation we proceed, as soon as the road surface is sufficiently dry, to level up the broken parts, add sufficient new metal to restore the crown, and annually repeat the operation instead of removing the cause of the trouble by placing a few feet of stone and the drain from the pocket containing the water to the side drain.

In the construction of a new road, no surface material should be placed until the new grade is perfectly consolidated and adequately drained, and the drainage of the old gravel highways should be perfected if they are to be maintained in good repair at the least possible outlay.

I am of the opinion that it is not advisable to screen or in any way attempt to treat the ordinary pit gravel, neither do I believe it is necessary to use a road roller in the construction or the maintenance of an ordinary gravel road. A harrow, a drag and a hand roller can be used to good advantage. There is no objection to a road roller if available.

The screened gravel road, built with the stone placed in the base and finished with the fine material, produces a road, the base of which is very deficient in binding the round stones pushed from under the wheels, and ruts are readily formed, and are quite as difficult to fill as the ruts in the crushed stone road. On this account I have discontinued the screening of the gravel. Where a pit contains a large percentage of stone over two inches in diameter, a stone crusher, screen and road rollers can be used to good advantage, and with this material a water-bound macadam road can be built that will compare favorably with the quarried stone road, and will, if the sub-grade has been properly drained, render good service, but is not better than a road built of a good quality of pit-run gravel; and the gravel road always can

be maintained at a lower cost than the stone or crushed gravel road.

Throughout this paper I have emphasized the fact that gravel is an unsuitable material to use for the construction of main roads. Living, as I do, in a section of the country where the gravel deposits are plentiful and of a superior quality, and, having made a study of the effect of present-day traffic upon the gravel road, I have decided it is not advisable to use it on trunk road construction.

Good roads cannot be built on heavily-travelled highways without the expenditure of large sums of money. It is a mistake to claim it can be done, and any attempt to do so must result in loss and disappointment to those responsible for the work. A large percentage of the less important roads of Canada will be maintained and constructed with gravel surface, and they will in the future, as they have in the past, render good service.

## ROAD MACHINERY\*

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HIGH wages of unskilled labor in 1917, 1918 and 1919, and the uncertain status of the labor supply of the future, has resulted in a thorough analysis of highway construction data to determine economical methods of using road machinery. The trend of wages of unskilled labor was ably covered in the 1919 report of the the "Committee on Unskilled Labor Supply" of the American Road Builders' Association, wherein it was stated that the average rate per hour in the United States in 1912 was 19 cents; in 1913, 20 cents; in 1914, 20.9 cents; in 1915, 22.5 cents; in 1916, 26 cents; in 1917, 30 cents; and in 1918, 39 cents.

In the opinion of the writer, American highway officials must face high wages for unskilled labor for several years. The basic economic law of supply and demand naturally applies to labor conditions. It is not probable that the war shortage of unskilled labor will be changed over night. It is not logical to expect that unskilled labor which entered the Service will rush back to the pick and shovel after demobilization. Emigration records show that thousands of laborers are leaving America every month. Immigration, the usual source of supply of unskilled labor, is an unknown quantity and agitation in the United States for restricted immigration further complicates the situation. It is not surprising, therefore, that the reconstruction period finds highway officials, engineers and contractors investigating all types of labor-saving machinery.

The selection of equipment for the construction and maintenance of highways should be based upon a consideration of the following factors: (1) Character of work; (2) specification requirements covering plant equipment; (3) amount of work; (4) portability of plant; (5) large and small units; (6) ease of manipulation; (7) adaptability to different classes of work; (8) funds available; (9) depreciation of plant; (10) transportation facilities. The practical necessity for the consideration of many of the above factors is self-evident.

*Character of Work.*—In the case of contractors whose work is confined to the construction of sheet asphalt pavements, and in the case of a department such as, for instance, that of Wayne County, Michigan, where the highway work consists primarily of grading operations and the construction of cement concrete pavements, the problem is materially simplified. On the other hand, where a contractor's work covers the construction of all the various types of roads and pavements used in a municipality, county or state, the selection of the several units of plant equipment should be based upon their adaptability to different classes of work. For example, where cement concrete pavements as well as concrete foundations are to be constructed, in many cases a type of mixer should be purchased which is satisfactory

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