

piece of work may be done each year and the whole effort should be to produce ultimately a road which may be adapted to this service, and which shall require low annual repair and maintenance charge. You must see that no such scheme of work can be planned and carried out by any road official who sees only the expenditures of one year ahead.

To get a little nearer to details, there must be begun a systematic set of highway accounts. All operations of repair and maintenance, as well as construction, should be classified as grading, ditching, repairing culverts, dragging, etc., and the unit costs of the various items must be obtainable from the records. To accomplish such a result, distributing tables may be printed on the backs of warrants and vouchers for labor paid. A great defect in maintenance and in repair has been the unintelligent management of materials and machinery. If a macadam road is to be maintained, there must be a supply of No. 2 stone stacked in considerable quantity at intervals along the road. The hauling of this material should be done at the most economical season of the year, and it should be continuously available for small repairs. The same applies to gravel. A great many roads may be constructed successfully and maintained as gravel roads with good results. For this purpose the location of the sources of supply of gravel and gravel pits should be plotted on the road map and a record of the quantity in each pit kept. Very frequently gravel is hauled necessarily great distances for various insufficient reasons. Too often the owner of the gravel pit is also managing some of the roads and may prefer to haul a mile or two from his pit when there exists a supply of good gravel within a quarter of a mile of his job. There is frequently, however, good gravel handy to work, but which has never been discovered or developed. It will pay to make a most careful investigation of the source of gravel supply along every road.

With reference to the repair of earth roads, the custom of scraping sod and refuse of all kinds into the road centre with a scraping grader cannot be too severely condemned. It is a universal cause of bad roads and waste of highway funds. In repairing an earth road with a scraping grader, the sod may first be scraped off and carted away or the sod may be raked off or picked out with forks and carted away, but never should sod or rotten leaves or manure or any organic substance be placed on the road. The operations of the road grader have been positively damaging in some cases. Many country roads have gutters that are too far from the travelled way and the road supervisor runs the scraping grader a little outside of the wheel tracks to form a new gutter which wanders in and out and up and down and has no outlet. The cost of operating a scraping grader with from two to eight horses attached is very great, and unless very effectively managed is a source of tremendous waste. Where new gutters must be formed, lines must be run before work is commenced, and broad shallow outlets should be constructed through the turf at all low points and all intermediate points on hillsides. Frequently the repair operations with a road grader can best be accomplished by scraping old material off the road toward the gutter and carting it entirely away. A great defect in most country roads is a high shoulder just outside the wheel track. The road grader can be used effectively to lower the shoulder by beginning at the wheel track and working in successive trips toward the gutter. The earth can then be moved to the centre of the road more quickly and without moving a constantly increasing mass. Very frequently the blade of the road scraper is run too deep at the gutter and not deep enough upon the shoulder.

When an earth road has been put in repair, it can be maintained by the road drag. The original form of the road drag was a split-log drag made from the split halves of a

six to eight-foot log, six to eight inches in diameter. The two halves of the log are placed face forward and are set two and a half feet apart and at an angle of 45 degrees to the axis of the road. They are suitably braced and supplied with double-trees. In using the split-log drag, two horses are usually needed. Dragging begins at the outside edge or the gutter line of the earth road and proceeds toward the centre. The effect of the drag is to pair off ruts and move a small quantity of earth toward the centre of the road. It also has the capacity to puddle the surface material and form more or less impervious layers which prevent moisture from soaking into the roadbed. To drag a road twenty-four feet wide will require three round trips. A team of horses can draw a drag in ten hours about twenty-four miles, so that with three round trips, about four miles of road can be dragged in a day. This is probably the maximum. On steep grades or with unfavorable conditions, such as irregular gutters or stones in the road, the performance will be less. The minimum cost, figured on a four-mile basis, depends on the price of a man and team; at \$4 a day, a complete dragging for three round trips is \$1 per mile. In the experimental work by the United States Office of Public Roads in Alexandria County, Virginia, the cost of dragging has been about \$1.25 per mile of three round trips.

The first year of dragging an earth road will require a greater number of trips than in subsequent years. Possibly 24 draggings will be required. As the road gets harder under continued dragging and traffic, fewer trips are needed. Important problems to determine immediately are how to establish the dragging system. Probably the best way will be, for the present, for road officials to contract with men who live along roads to drag sections from two to four miles in length. The dragging should be done after every rain and the section men may be required to fill out and forward to the supervisor a post card for each day of dragging. As time goes on, it may be possible for many communities to combine the road patrol and dragging system. This will require the continuous employment of men for probably seven months in the year. If they are paid \$45 per month with the understanding that they are to do all dragging, when necessary, the annual cost will be \$31.50 per mile on a ten-mile section. This is not an excessive cost per mile. It would no doubt pay to establish such a system in those counties which are spending around \$40 per mile on any considerable mileage in the community. The presence of the patrolman during storms to prevent erosion and keep drainage in working order is a great permanent benefit to the road. In the experiment by the United States Office of Public Roads, as above referred to, about 43 per cent. of the patrolman's time was devoted to repairing, cleaning and improving ditches and under-drains and 23 per cent. to dragging. Whatever system of dragging or continuous maintenance is adopted, and the continuous maintenance is the best system, there must be competent inspection and daily reports to the inspector.

On the continent of Europe, the road men are frequently supplied with written instructions covering the slightest detail of their work. There is no reason why such a system could not be adopted on this continent. There is need for written instructions covering a great variety of details; for example, the care of the road at driveway entrances, particularly on hill-sides, is extremely imperative to prevent wash from adjacent lands. This is also true of road intersections.

With reference to the method of maintenance of macadam, gravel and bituminous macadam roads, there is much to be said. Written instructions should be issued covering all such points as the selection of stone, the preparation of worn holes and ruts to receive repair material, sweeping, scouring and picking up of the old road, etc. Wherever a