

for the construction of pavements, the requirements for which are more specific than in the case of mixers used only on foundation work.

Specification Requirements Covering Plant Equipment.

In the modern practice of highway engineering, many specifications include stipulations which must be met by machines and accessories employed. As illustrations there might be cited the weight of rollers, pressure limitations in distributors, grouting apparatus, and details of mixers for the manufacture of bituminous concrete.

Amount of Work, Portability of Plant, Large and Small Units.—It is evident that a contractor or a department will be justified in the purchase of an ideal equipment if the work is to be extensive in character. If the work is centralized and large in amount, as in the case of sheet asphalt work, in many municipalities a large, well-equipped permanent plant will prove economical. If, on the other hand, the work is large in amount but distributed over considerable area, small portable units will prove more satisfactory, as in the case of mixing plants for the manufacture of bituminous concrete to be laid on provincial highways.

Ease of Manipulation.—In cases where contractors are engaged in general highway work and their organization does not include foremen who are specialists in the manipulation of various types of complicated machinery, it is of utmost importance that simplicity of machines and ease of manipulation should be given great weight in the selection of equipment. This is particularly true in connection with various types of machines used in the construction of bituminous surfaces, bituminous macadam and bituminous concrete pavements.

Adaptability to Different Classes of Work.—It is well known that specifications for different classes of work, requiring the same type of machine, call for differences in detail. For grading work, specifications might require rollers weighing from 12 to 15 tons, while in the construction of wearing courses of some types of pavements a 10 to 12-ton roller is stipulated. A contractor who is handling a small amount of general highway work would, therefore, find it advantageous to purchase a 12-ton roller suitable for both classes of work mentioned above.

Funds Available.—Departments and contractors are necessarily forced to consider first cost of equipment, as the funds available may not permit the installation of the most economical and efficient machines. In many cases where such conditions are encountered, it is obvious that it will not be practicable to anticipate that the work can be accomplished with the same degree of rapidity and at the same cost as if more efficient machinery constituted the plant equipment.

Depreciation of Plant Equipment.—Depreciation charges on plant equipment should be given careful consideration prior to the purchase of machines and accessories, as well as in the consideration of the cost of highway work.

Transportation Facilities.—Facilities for the transportation of machinery and materials materially affect the efficiency of the several units of plant equipment. Brief consideration will be given to the plant equipment suitable for grading, quarrying, construction of the several types of roads and pavements, and snow removal. It is also evident that normal conditions usually will be assumed as the basis for suggestion of plant equipment for the various items of highway work enumerated.

Transportation Equipment.—Motor trucks and wagons usually will be found a necessary part of the equipment for all classes of highway work. Tractors and trailers are of particular value on long haul work where load-proving apparatus require motor trucks to remain idle during several hours a day. Industrial railroads have proven efficient equipment on highway work where a large tonnage is to be handled quickly on long hauls.

Grading.—Grading operations vary from the scarifying of an old road surface, preparatory to the construction of a new wearing course, to heavy cut and fill work requiring the moving of thousands of cubic yards of material. It is apparent that only extreme conditions can be mentioned in this discussion as the economics of the utilization of various

classes of machines on average grading work would necessitate a comprehensive discussion. For the lightest class of grading mentioned, scarifiers drawn by rollers have proved more economical and efficient than the use of picks in roller wheels or any one of the several types of plows drawn by rollers or tractors. For the heaviest class of grading work, in many instances steam shovels loading into wagons will be found economical. In connection with all grading work except light scarifying, one or more of the following types of machines should form a part of the plant equipment for grading: Road drags; grading and roter plows; drag, buck and wheel scrapers; elevating graders; and rollers. It should be noted that the utilization of the elevating grader has not been fully developed by many contractors.

There are on the market many types of steam and gasoline traction engines suitable for hauling grading machinery. For many classes of grading work, their use is more economical than the employment of horses and mules. Essential features which should be based by a contractor for grading work are as follows: (1) Sufficient power for hauling the several types of grading machines under the variety of conditions on which it is expected to be used; (2) adequate mechanical strength; (3) simple mechanism enabling it to be easily steered, controlled and otherwise operated; (4) driving wheels of large diameter and of such width as to enable the tractor to operate efficiently on soft ground.

Quarrying.—Plant equipment for quarrying depends primarily upon the kind of rock, the required output per day, and the length of time during which the quarry will be worked. Drills and blasting devices are a necessary part of all equipment for rock work. Contractors or departments working the quarry to supply material for a specific highway would use the ordinary portable crushing and screening plant, consisting of boiler, engine, jaw crusher, elevator, screen and bins. Small quarries, more or less continuously operated, are generally equipped with the above plant except that in many cases the gyratory crusher proves more economical. Passing to the largest quarries, modern equipment for the economical manufacture of broken stone should consist of steam shovels for removing the rock masses from the quarry face to steel cars. In such quarries the pieces of rock transported to the crusher may vary in size up to masses weighing 7 or 8 tons. The rock should be first crushed in a mammoth jaw crusher, from which the rock should be passed through a series of gyratory crushers, jaw crushers and rolling mills and thence to elevators, screens and bins. In some plants of this type, washing devices are a necessary part of the equipment in order to produce stone chips free from dust.

Earth Roads.—In the construction of earth roads on a large scale, the following equipment has been found to be economically efficient: Elevating grader drawn by horses or by a tractor, scrapers, disc and straight-tooth harrows, road drags, rollers and watering carts. The combinations of the machines mentioned which will be used will depend upon the amount of work, character of the soil and the cross-section to which the road is to be built.

Gravel Roads.—Spike-tooth harrows, scrapers, road drags, rollers and watering carts constitute the equipment for the construction of gravel roads. Many engineers and contractors have found grooved rollers more satisfactory for this class of work than smooth-faced rollers.

Broken Stone Roads.—The average equipment consists of rollers and watering carts. For many types of construction and kinds of rock, rolling for long periods with 10 or 12-ton rollers has secured a better compaction and economical bond than in cases where 15 and 18-ton rollers have been used for short periods. Some contractors have found automatic screening spreaders a valuable addition to the plant equipment.

Bituminous Surfaces.—The equipment required for the construction of bituminous surfaces depends upon the amount and character of the work and the rapidity with which it must be accomplished. For example, the construction of a bituminous surface on a broken stone road will require an equipment of rotary brushes or coarse fibre