

tainly exceptionally low in cost per kw.h. for a plant of this size.

In the accompanying Table II. are given the results for the 12 months' period from March, 1912, to February, 1913. It will be noted that the total cost of production per kw.h. was 6.78 mills with fuel oil at \$1.05 per barrel of 42 gallons.

The plant at Cleburne consists of three 225-h.p. units similar to those at Sherman, with the exception that each engine is direct connected to a three-phase, 2,300-volt, 60-cycle alternating current generator. It is worthy of note that no trouble whatever has been experienced in paralleling these machines.

In the accompanying Table III. we give the results of 12 months' operation at this plant.

In conclusion, the writer wishes to state that for small and medium sized plants, he believes the Diesel oil engine to be the most efficient prime mover available, and while the engine is now built only in comparatively small sized units, there is no doubt in the future it will be developed in large sizes and made available where a large quantity of power is desired. The first cost of the engine is high, and in some cases this may be a drawback.

It is also essential to have a good mechanic as head plant engineer, as the engine requires intelligent handling. They are, however, far from being the trouble-makers internal combustion engines are supposed to be, and are giving excellent service in both of the plants above mentioned.

### SUITABLE ROAD SURFACES FOR VARIOUS KINDS OF TRAFFIC.

THE study of the effect of different kinds of traffic on roads and of the most suitable surfaces to withstand them, as carried on by the Massachusetts Highway Commission, was the subject of a paper entitled "Traffic Census of Roads in Massachusetts," by Mr. William B. Sohler, chairman of the commission, and presented at the convention of the American Road Builders' Association last December. The commission has come to the popular conclusion that roads used by large numbers of swiftly moving vehicles require special attention to prevent disintegration and rutting, and that such traffic cannot be carried on successfully over gravel or water-bound macadam roads unless amply protected. The results of the investigation in Massachusetts show that the use of some dust layer or binder is an absolute necessity. Where a road is subjected to traffic varying from light, swiftly moving vehicles to heavily laden trucks, the adoption of a surface to prevent excessive wear is arrived at by re-surfacing with some form of bituminous mixture to a depth of several inches of the road.

**Motor-Vehicle Traffic.**—Some oiled gravel roads are satisfactory and very economical, if they are constantly and properly maintained, even where there are large numbers of swiftly moving automobiles a day, at least, in the summer months, but where there are not many heavily loaded wagons. Some of these roads have 500 automobiles or more a day, and yet they are cheaply built and cheaply maintained. Roads built of sand and asphaltic oil also stand up well under heavy motor-vehicle traffic, but these roads have very little heavy teaming on them. Heavy wagons and many heavy motor trucks rut such roads quickly and soon wear them out.

**Maintenance Costs.**—When the motor vehicle appeared in fair numbers upon the roads Massachusetts had 600 to 700 miles of state highways (now over 900), and they were mostly water-bound macadam, with some few miles of gravel road.

These highways had been built from 1 to 14 years previously, very few miles had been resurfaced, and the Highway Commission had only \$100 a mile a year to spend for maintenance and resurfacing, and not that much except for the last few years. The maintenance of these old roads was our problem in 1908, and has been ever since.

Automobile travel has increased 40% and the total traffic 14% a year, and these roads must be maintained, or the state's money, borrowed on long-time bonds, would be lost and wasted; the good roads would be gone, but the bonds would still remain to be paid.

The state doubled its appropriation for maintenance in 1908, giving the Highway Commission \$200,000 a year instead of \$100,000. The motor-vehicle fee was also increased, and the right to use the net fees for the maintenance of roads was obtained. These two sources of revenue for the last three years have provided about \$500,000 a year, for maintenance; an average of \$450 a mile a year, and we are at least holding our own.

#### Bituminous Binders and Dust Layers for Old Roads.

—Many miles of old roads have been saved by spreading a coat of asphaltic oil, light or heavy, or tar over them. To-day some asphaltic binder or dust layer has been used on over 80% of our state highways. The only roads on which it has not been used are those located in the country districts where there is very light traffic.

During the year 1912 we used nearly 2,000,000 gal. of bituminous material in construction or maintenance. Over 800 of the 930 miles of our state highways received some form of bituminous treatment. We have resurfaced as many miles of road every year as we could; using, where the traffic was heavy, a bituminous macadam on the top 3 in.

**Effect of Traffic on Bituminous Surfaces.**—Massachusetts has four division engineers, on its highway work. They were asked the same questions relating to different tars, oils, asphalts, etc., and for their opinions of the relative merits or demerits of each.

The answers were all different. One had used tar on the surface successfully, another had not. One liked tar for penetration or mixing; another preferred an asphaltic compound. The same was true of the use of various asphaltic oils as a blanket coat, or as a dust-layer. One preferred a heavy cold oil, another a heavier hot oil. There was, however, if the traffic and other conditions in each case were carefully studied, a real agreement in all essentials.

**Where Heavy Oils Fail.**—We have a good many miles of old macadam road which have been saved and maintained by  $\frac{1}{2}$  gal. of hot asphaltic oil spread upon each square yard of surface and properly covered with sand and pea stone or gravel. Many of these roads have worn three years, and in their fourth year are still in good condition. A few miles have worn four years and are now on their fifth year. The patching has cost but little, from 1 to 3c. per sq. yd. a year.

These roads often have very heavy automobile travel, possibly over 1,000 cars a day. They often have large numbers of teams daily. One has over 500 teams and 1,000 automobiles, and a heavy blanket oil surface has worn reasonably well for three years, and will for a fourth