may possibly be superior, the residuum asphalts are, nevertheless, suitable for the purpose.

Fully as important as the quality of the bituminous material is the quality of the workmanship in applying it. In the preparation of the broken stone surface, extreme care should be taken to sweep and remove every particle of dust and dirt, so that the stones will be absolutely bare. Many failures of bituminous surfaces can be traced directly to the improper preparation of the broken stone surface, the heavy oils being distributed on dusty and dirty sections, and, consequently, peeling up through lack of adhesion. In order to get the best adhesion of asphaltic oils, it appears that the stone surface should also be somewhat moist rather than extremely dry. In distributing the oil, if the stone surface is comparatively new and smooth, the best results appear to be obtained by applying the oil under pressure in two applications, each of ¼ gallon per square yard, covering the first application with grit or pea stone before putting on the second, and covering the second application with the same material as soon as possible after it has been made. The effect of applying the material in this manner is to make the distribution more uniform and prevent surplus oil from flowing on the sloping crown of the road, thereby causing ridges and bunches to appear after the work has been done. If the stone surface is full of slight depressions, however, a single application of ½ gallon per square yard, applied with or without pressure, has proved satisfactory. The oil tends to run to the depressions, causing a slight surplus of oil in them, so that when the grit is applied on top of the oil, the portions over the depressions absorb more grit, consequently rendering the road smoother.

The character of the grit or other material used for covering the oil is of great importance. Where the traffic is confined exclusively to motor vehicles, sand appears to be as effective as any material for covering, but if there is some steel-tyred horse-drawn traffic, a coarse material like pea stone or fine gravel is necessary.

The cost of a bituminous surface as just described will vary, of course, with the availability of the material to be used for covering, and the length of haul of all materials. In Massachusetts, during the last four years, several hundred miles of macadam road have been improved or preserved by a bituminous surface of this kind. The average cost during 1910 was a little less than $0.08 per square yard, and, during 1911, a little more than that price, with labor costing from $1.75 to $2.00 per 8-hour day, and asphaltic oil costing $0.06 per gallon delivered in cars.

In maintaining these bituminous surfaces a re-treatment of about ¼ gallon of bituminous material per square yard is only made on those places from which the bituminous material has disappeared. The present condition of these roads indicates that the expense for patching and sanding in 1912 will not exceed $0.01 per square yard, in which case the total expense of maintenance for four years will have been $0.1076, making the average cost $0.0269 per square yard, or approximately $236.72 per mile per year for a 15-foot road. Whether such a surface on a macadam road will withstand the traffic of heavily loaded motor trucks cannot now be determined, as such trucks have not been in service sufficiently long to permit of determinations.

On roads where the prevailing traffic consists of steel-tyred horse-drawn vehicles, this application of bituminous surface, consisting of heavy asphaltic oil and grit, has proved unsuccessful, in most instances, the surface being cut and dented to such a degree that it soon disappears. On such a road, it is possible that a heavy, refined tar surface may be economical, or it may be economical to use oil of a lighter grade, applying it with sufficient frequency to keep the surface of the stone covered with oil at all times.

EXPERIMENTS ON CONCRETE WATER BARRELS AS APPLIED TO FIRE PROTECTION OF RAILWAY BRIDGES.

By Hunter M'Donald.

The maintenance of water barrels for fire protection on bridges and trestles may seem to the uninitiated to be a comparatively small matter. To the person upon whom the responsibility for their maintenance and efficiency rests the matter presents an entirely different aspect. To be efficient, water barrels must be kept full of water and be easily accessible, which essentials entail the following requirements:

The water must not freeze; the barrels must not leak; the water must not evaporate or be drunk by cattle; frequent inspections must be made; the barrels must be filled when installed and frequently refilled; the barrels must be placed at proper intervals for effective use in case of fire; they should be provided with small cans or vessels, in which the water can be carried to the point where it is needed.

The principal damage other than fire risk, caused by freezing, is that it makes the barrels leak. This can be prevented to some extent by fastening in the barrel a stick running in a slanting direction from near the top to the bottom. The addition of salt will, of course, lower the freezing point, but will not prevent freezing. The only consolation to be derived from frozen water barrels is the fact that fires in bridges are not likely to occur in freezing weather.

Where water barrels are completely buried in the earth at the ends of the trestles, they seldom leak until the wooden staves become rotten, which occurs in about four years. If wooden barrels are not buried they require frequent refilling If carefully covered to prevent evaporation, the interval of filling is lengthened. Should the water in the barrel get low from any cause, the barrel is usually permanently injured by having the tops of the staves dry out—a condition very difficult to remedy. A prolific cause of leaky barrels is the tendency of the idle man or boy with a gun to use them for targets. Axes and hammers are sometimes used as a means of destruction.

Barrels must be substantially covered to prevent evaporation. When tight barrels are buried at the end of the trestle and well covered, refilling is seldom needed more than once a year. Covering is also necessary on account of the tendency of cattle in the dry season to drink the water up. It seems impossible to cover them so tightly as to prevent large crops of mosquitoes from being raised. Barrel covers which sink below the outer rim of the barrel are very advantageous, as they catch all the rainfall and allow it to run into the barrel. Where no leaks occur, this is sufficient in many climates to keep the barrels full.

Unless inspections of the barrels are made at frequent intervals by a responsible officer, they are likely to go to pieces early and be absent or empty at the time most needed. It is not sufficient for the inspector to merely call attention to the defects, but each one should be followed up immediately and remedied.

When barrels are first installed, they should be filled by the party installing them; after this, they should be given over to the section foreman, whose duty it should be to keep them properly filled.

Water barrels can be effective only in the incipiency of a fire. More effective means must be had when the fire has assumed some headway. How to get the water out of the barrel and put it on the fire is a question. On some divisions oyster and tomato cans are sunk to the bottom of the barrel

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