THE TARRING OF ROADS.*

HOW THE WORK IS DONE.

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CRUDE tars, as well as specially prepared tars and tar emulsions, have been used extensively for dust prevention ever since the subject was first seriously considered, and many experiments have been conducted with these materials in France, England, and the United States. The results obtained have to a great

of a sufficient quantity of lighter oils will serve the same purpose, but a corresponding loss in the binding quality of the material will be produced by this dilution.

Experience has shown that in order to get the best results from applications of tar the road should be

FIG. 1.—APPLICATION OF TAR TO MACADAM ROAD.

extent been contradictory, even when the experiments have been carried on in the same manner and under the same conditions, and for this reason much confusion has arisen in the minds of road engineers as to the real value of tars.

Composition of Tars.—There are three kinds of tar—crude coal tar, refined coal tar, and water-gas tar—and, as these are the principal ones used as dust preventives, their approximate composition in percentage volumes as determined from fair representatives of each type is given below for the purpose of comparison. The notes to the table refer to the condition of distillates and residues when cold.

SPECIFIC GRAVITY AND COMPOSITION OF TAR PRODUCTS.

Kind of Tar.	Specific Gravity.	Ammoniacal Water.	Total Light Oils to 170° C.	Total Dead Oils, 170°-270° C.	Residue, by Difference.
Water-gas tar . . .	1.041	Per Cent. 2.4	Per Cent. a21.6	Per Cent. b52.0	Per Cent. c24.0
Crude coal tar . . .	1.210	2.0	d17.2	e26.0	f54.8
Refined coal tar . .	1.177	0.0	b12.8	g47.6	f39.6

a Distillate mostly liquid.

b Distillate all liquid.

c Pitch very brittle.

d Mostly solid.

e Distillate one-half solid.

f Pitch hard and brittle.

g Distillate one-third solid.

In many gas plants it is the custom to manufacture both coal gas and carbureted water gas. When this is done, the coal gas is produced at a higher temperature in order to obtain the maximum amount, and the carbureted water gas is used to raise its illuminating value. The tar thus produced is a mixture of coal and water-gas tars and will usually be of an inferior quality.

THE APPLICATION OF TARS.

There are two general methods by which tar can be used upon roads, one by applying it to the surface of the road and the other by constructing the road of tar-covered material. The application of tar to the road proper may itself be considered under two heads, and for the sake of convenience will be taken up in this way: (1) its application to the finished road, and (2) its application during construction.

Application to Finished Road Surfaces.—As early as 1867 the process of spreading or painting road surfaces with tar was considered in France, but it was not until the year 1902 that work of this kind was begun in earnest. Crude coal tar was first tried, as it was easily obtained and comparatively cheap, but little attention was paid to its character and quality.

Most crude tars are too viscous to apply satisfactorily when cold, and the use of heat to render them more fluid has been generally adopted. The addition

free from dust, perfectly dry, and comparatively warm. If dust and other fine material are present the tar will not be properly absorbed by the surface and, owing to a lack of bond, will soon peel and be removed by traffic. For this reason it can be applied successfully to hard surfaces only, such as are presented by well-swept macadam roads. The presence of moisture will also prevent the tar from penetrating the road, and as a cold surface will chill and stiffen the material it is necessary that all applications be made in dry, warm weather. Before applying the tar the road should be repaired where necessary, in order to secure a smooth and even a surface as possible. If ruts and hollows are present, the tarred road will not only present a poor appearance, but accumulations of water in these depressions will produce rapid disintegration of the tar, followed by its complete removal under the action of traffic. It is desirable that repairs be made for some time previous to the tar application in order to obtain a well-bonded and consolidated surface to start with,

The road should then, if possible, be closed to traffic and the tar allowed to remain untouched for about twelve hours in order to allow it to soak in. At the end of this time, or sooner if necessary, a coat of clean sand or stone chips should be applied to absorb the excess of tar, and the surface should then be rolled several times to bring it to proper condition quickly. The preliminary sweeping of the road is sometimes done by hand, but an ordinary mechanical street sweeper is often to be preferred, as it performs the work more economically and with greater expedition. The tar is heated in an open kettle preferably mounted on wheels and fitted with a portable fire box. It is usually brought to its boiling point—about 190 deg. F.—before being spread upon the road, although a lower temperature is sometimes sufficient, and, if the kettle is of the type described above, the tar may be run out upon the road as required by means of a hose, the kettle being kept just in advance of the work. By using two kettles the process may be made continuous, one being charged and heated while the other is in use. Kettles holding easily 9 barrels, or about 450 gallons, of tar without danger of spilling over, and mounted on comparatively large wheels, are to be preferred for this purpose when long sections of road are to be treated. When it is impossible to obtain kettles mounted on wheels, a number of smaller ones holding about two barrels each are sometimes used. These kettles are moved along the side of the road as the work progresses and the hot tar is drawn off into flat-nosed watering pots, hods, or ladles, and spread by hand. In either case it is necessary to have the hot tar well broomed into the surface to obtain a smooth and uniform coat. This spreading is usually done by laborers with stiff, long-handled brooms, similar to those used in street sweeping, who follow the tar spreaders and broom carefully every portion of road surface. The excess of tar is thus pushed ahead and can be used for covering fresh surfaces.

After the tar has been spread it should be allowed to remain undisturbed for at least twelve hours, as has been stated. In cases, however, where it is impossible to keep traffic away for this length of time, one of two methods may be followed. Either one-half the width of the road may be covered at one time, thus allowing the other half to be open while the first is drying, or a coat of sand or fine stone chips may be applied at once in sufficient quantity to prevent the tar from sticking to the wheels of vehicles. If the first method is followed more lasting results are to be expected, but unless considerable care is taken the finished road will present a poor appearance owing to the overlapping of the second application on the first, which produces a seam along the center of the road. More time will

FIG. 2.—FINISHED TAR MACADAM. UNTREATED PORTION IN FOREGROUND.

for it has been found that fresh patches which have been tarred are not unlikely to ravel if traffic is at all heavy.

The primitive method of application which has been largely employed in this country up to the present time is as follows: The road surface is first thoroughly swept in order to remove all dust. The hot tar is then spread on and thoroughly broomed in.

also be consumed, as the length of the road will have to be gone over twice. If the second method is employed, there is danger of the tar being absorbed by the loose material rather than by the road proper, and this will result in a lack of sufficient bond. If the tar is allowed to remain undisturbed for about twelve hours it will, under ordinary conditions, be fairly well absorbed by the road, and then only enough top

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dressing need be applied to take up the surplus. Either clean coarse sand or one-half inch hard stone chips are to be preferred as a top course, as these afford a harder and better wearing surface than most other materials, such as road dust and gravel. It is customary to finish the road by rolling this fine material into the tar, but when only a light coating is applied the rolling may be unnecessary, as the action of traffic will in a short time produce the same result.

If the tar does not contain much heavy binding material and it is found necessary to patch the road during tarring, the addition of heated pitch to these patches will better tend to consolidate them and prevent them from being torn up by passing vehicles.

If the temperature of the crude tar is raised above 190 deg. F. when being heated it is very likely to foam up, boil over, and catch fire. Bad results which have been obtained from the use of crude tar are often charged to the presence of ammoniacal liquor, and it has become customary in certain localities to use only water-free tar. A good tar from which the ammoniacal water, light oils, naphthalene, etc., have been removed and the pitch diluted with a sufficient amount of the heavier tar oils to give a proper consistency should give the best and most lasting results. There are several preparations on the market which are claimed to have these qualities. They should not be taken on faith, however, but should be examined to see if they are really what they are claimed to be. The writer has examined different lots of some of these preparations and found essential and inexcusable differences to exist.

The application of tar by mechanical means may now be considered. Owing to the considerable expense involved and the time consumed in applying the tar from kettles, a number of schemes have been devised to apply it by means of various apparatuses. In France a specially constructed sprinkler has been used with some success, which can be manipulated by three men, and which, it is stated, will cover 3,000 square meters (3,588 square yards) of ordinary roadway per day. Tar is pumped into a reservoir, and, after being heated by petroleum in a manner similar to that employed in heating the boiler of a steam-motor car, is sprayed upon the road by means of compressed air contained in an adjoining reservoir under a pressure of 5 kilos per square centimeter. If the road is first thoroughly swept and all remaining dust removed by means of a vacuum cleaner, the tar is expelled with sufficient force to penetrate well into the macadam, and therefore does not require brooming. A thin top dressing of sand should afterward be applied to the tarred surface.

In England the application of tar by mechanical means has been studied by means of a trial competition of various machines carried on by a representative committee of engineers and others interested in road matters. Some exceedingly ingenious devices were produced at this contest, which give promise of good results. A number were designed to carry on the whole operation of tarring at one passage of the vehicle. Some are propelled by steam and so arranged that the road is first swept to remove the dust, which is drawn up by vacuum into a receptacle connected with the machine. The tar is heated and sprayed upon the road under considerable pressure, thoroughly broomed in, and the dust, previously removed, is distributed over the tarred surface. A full description of these machines has already appeared in print.*

Some attempts have been made in France to apply the crude tar cold and afterward set fire to it. By this means it is claimed that the road surface is caused to absorb the tar to a considerable extent; and as the lighter oils will be consumed and the water and ammoniacal salts driven off, all of the advantages of applying a refined tar will be obtained. It is extremely doubtful, however, if this method will ever be extensively employed, as it seems entirely probable that some of the valuable binding materials will be burned and that the remainder will become brittle and useless on account of absence of oils which give the heavier products life. If the material is to be applied cold, it is far better to dilute it with the necessary amount of suitable oils, which, while lowering the percentage of true binding base, will nevertheless act as a dust layer until they are saturated or lost by evaporation.

Use of Tar in Road Construction.—So far we have dealt only with the methods of applying tar to a finished surface. Where a new road is under process of construction, or an old road is being resurfaced, it is often desirable to apply the tar in a somewhat different manner. In these cases the road should first be shaped and consolidated as well as possible without the addition of water. The voids should be well filled with clean, fine stone chips free from dust, but an excessive amount of rolling should be avoided in obtaining this condition. If the roller is used too freely the larger stones will become rounded and covered with dust, which prevents the tar from adhering properly. Hot tar may be applied to all of the courses if desired, but sometimes only the upper course is so treated. After the tar has been applied a dressing of

fine material is spread on in the manner described in the other methods of application and the whole road is well rolled. A road so treated will have all of its interstices filled with hard material and only sufficient tar to surround each individual particle. Thus all wear will be sustained by the stone aggregate and the tar will act solely as a binder. It will be seen that a road so constructed will approach very closely the road built of material which has been previously tarred.

If the tar is applied by hand, a great deal more will be taken up by the road than is absolutely required. As this means an unnecessary expense, attempts have been made to devise a method which will produce good results with a minimum amount of tar. A tar spreader similar to those already described has been tried with some success for this purpose in England and in Scotland. A brief description of this apparatus and the method of using it may serve to illustrate the most important points relative to a treatment of this kind. The spraying apparatus is mounted on wheels and is so arranged that the tar is forced from the tank in which it is heated into an air receiver under a pressure of from 150 to 350 pounds per square inch. The necessary power for pumping the air and the liquid into the receiver is obtained by means of a chain drive from the road wheel of the vehicle. From the receiver the tar is distributed upon the road by means of specially designed spraying nozzles.

In considering the relative value of these different methods of application and the character of the material which will give the most satisfactory and economical results, it is necessary to take into account many factors which have a most important bearing on the subject. There is probably no one practical and economical method which can be used under all conditions, but there are certain facts which have been demonstrated that will serve as a guide in ascertaining the proper method to follow under given conditions. Many of the results obtained, as has been pointed out, have been undoubtedly influenced by causes which were not given sufficient consideration, but the general characteristics of roads treated with tar in different ways have been ascertained and should be understood.

A properly tarred road after being subjected to traffic for a short time closely resembles asphalt. It is smooth and firm, of a more resilient character than asphalt, and is practically noiseless. While in good condition it is to a great extent waterproof and almost dustless; and, if the proper amount of tar has been applied, the resistance to traction is less than that of untreated macadam road. If too much tar has been applied, the road is apt to become soft and sticky in warm weather, thus causing a notable increase in the draft of vehicles, and it is also apt to rut badly. A few days after application almost all objectionable odor will disappear. Decayed vegetation, prolonged rains, and frost are the worst enemies of the tarred road.

The tar retains its hygienic and germicidal properties for some time. To determine this point, an investigation of the relative number of living germs existing in the atmosphere just above a tarred and an untarred road in the same neighborhood was made in France by Christiani and Michelis. They found less than one-half the number in the former case as in the latter, both in damp and dry weather.

Amount and Cost of Materials.—The amount of tar required to treat a road will depend upon the fluidity of the material when applied and the absorbing power of the road. Soft rocks, such as limestone and dolomite, will take up more tar than granite or trap and will in general give better results owing to the greater penetration of the tar and stronger bond formed in consequence. According to conditions and methods of application, a surface-treated road will require from 0.35 to 0.70 gallon of tar per square yard when application is made by hand. When applied by machine as small an amount as 0.21 gallon has been used with good results for a first treatment. With either method the application of tar must be repeated from time to time, though less is required at each successive application. If the tar is applied as the road is built as much as 1.5 gallons per square yard is often consumed if application is made by hand. By means of devices like the pneumatic tar sprayers, however, it is claimed that the road stones to the depth of 3½ inches may be well covered by the application of about 0.6 gallon per square yard.

Crude coal tar varies in price according to locality, but it can ordinarily be purchased from gas or coke companies at from 3 to 5 cents per gallon. The price of the refined tars runs from 6 to 12 cents per gallon and even higher. On account of this difference in price the use of a good crude tar is often to be preferred.

The cost of treatment for a surface-tarred road will, of course, depend upon a number of factors. In France, when done by machine, it will average about 3 cents, and when done by hand 5 cents per square yard. In this country, where it is generally applied by hand, the cost is hardly ever less than 6 cents and in a great many cases as high as 12 cents and more per

square yard. This is largely due to the poor condition of our roads before treatment, which necessitates the application of more tar and more surface dressing than if they were in good condition in the first place. The cost of tarring a road during construction is very hard to estimate. In England it is claimed that the pneumatic tar sprayer will apply the tar at a cost of about \$5 per mile of 18-foot roadway exclusive of the cost of the tar. It is needless to say that this figure would be greatly increased if the tar were spread by hand.

It has been stated that on account of its cheapness a crude tar is sometimes to be preferred to a refined material. In very severe climates, however, where a single application of tar is unlikely to last through the winter, it would seem advisable to apply a tar which has been diluted with dead oils or with water-gas tar in order to give it sufficient fluidity to apply cold. In this way the cost of application will be greatly reduced, and although the percentage of true binding base will be somewhat lessened, the results should under the conditions named be satisfactory. Where a road is being tarred during resurfacing or during the process of construction it is very essential that the tar contain a large proportion of binder. The use of a properly refined tar is certainly to be preferred to the crude material in this instance. While water-gas tar may be used to dilute the heavier tars, it can hardly be considered in the same class owing to its lack of true binding material. It, however, readily finds its place in competition with the lighter oils and emulsions.

Before leaving the subject of applying tar to macadam roads, those built of material which is tarred before being placed on the road should be briefly considered, at least in so far as the properties and application of the tar itself are concerned.

The tarred material may either be applied as a surface dressing to an old or new road or the whole road may be built of such material. Owing to the consistency of the tar or pitch usually employed, it is absolutely necessary that it be heated before applying, and in some cases the road stone should also be heated. It is evident that, within certain limits, the greater the proportion of pitch contained in the tar the firmer will be the bond produced. As very stiff pitch, however, exhibits a tendency to chip when cold, it is advisable to use one which contains enough of the heavier tar oils to give it life and maintain its resiliency. Attention should also be paid to the composition of the pitch with respect to its free carbon content. The same general methods are employed as those which have already been described.

On account of its hardness and porosity, blast-furnace slag is particularly suitable for work of this sort, and has been extensively used in England. The construction of asphalt macadam similar to tar macadam has also been suggested, and natural sandstone impregnated with asphalt has been employed in some localities.

In dealing with an old macadam road the application of a 3 or 4-inch course of tarred stone to the freshly cleaned surface has in some cases proved a success. If crude coal tar is used it should be thickened with a considerable quantity of pitch in order to give it the proper binding qualities, and in a case of this sort it is well to cover the old surface with a light application of hot tar, in order to secure a good bond between it and the new course.

One of the most promising roads of this type is constructed according to what is known as the Gladwell method. The old road is first covered with a matrix composed of tar and stone chips. Broken stone is then applied to the depth of 4 inches and the road well rolled. By this means the tar matrix is forced upward and binds the broken stone firmly together. A surface application of tarred chips, which should be well rolled, gives the road the proper finish.

It has long been known that sea water contains gold in solution, but in quantities so small that all attempts to extract it have proven unremunerative. Luther Wagoner has recently revived the hopes of the gold seekers by demonstrating that the quantity of gold varies greatly in different parts of the ocean, the ratio between the extremes being 1 to 30, and that the richer specimens of sea water may repay working for gold. In the first place, Wagoner finds that both gold and silver are more abundant in sea water taken from great depths than in the shallow waters near the shore. The following table shows, approximately, the number of grammes of gold and of silver that he finds in a cubic yard of deep-sea water from various localities:

Locality.	Gold.	Silver.
East of Georges Bank.....	3.9	23.1
South of Georges Bank.....	1.6	4.4
Delaware Bay	1.7	11.9

It would be difficult and costly to bring these waters to land but possibly floating extracting establishments could be used.

* Surveyor, 1907, 31. Supplement, p. 67; Surveyor, 1907, 32, 461.