system evolved by Mr. J. A. Maffei, it is being widely adopted upon the railroads of Bavaria. One or two improvements and modifications have however been incorporated, since in some instances the coaches are intended for running upon local light roads. The most important alteration is the removal of the coupling rods in the tank locomotives. The water-tube boiler is also being employed in some instances in lieu of the ordinary locomotive type. In such cases, instead of placing the chimney at the rear of the engine room in the motor coach, it is placed at the front end, immediately behind the foot plate.

DUST PREVENTIVES.*

THE TEMPORARY TAR AND OIL BINDERS, EMULSIONS AND SIMILAR PREPARATIONS.

BY PREVOST HUBBARD.

For the sake of convenience tars and oils will be considered under two headings, according to the condition in which they are applied. The first class will comprise those materials which are applied in their natural state, and the second those which are applied in the form of water emulsions. Materials of both classes are most easily and satisfactorily applied by means of an ordinary watering cart and usually upon the unprepared road. As in the case of water and salt solutions, a number of applications at more or less frequent intervals is generally necessary to lay the dust for a season.

MATERIALS APPLIED IN THEIR NATURAL CONDITION.

Among those materials which are applied in their natural condition are some which exhibit no actual road-building qualities, while others are to be found which contain a relatively small quantity of the substances which have been considered in preceding papers as permanent binders. The former act merely as palliatives and lay the dust in much the same manner as water, by wetting, or, in this case, oiling the dust particles to such an extent that they are held together by force of capillarity. Vegetable oils, paraffin petroleums, and certain tar oils, such as the heavy, dead, or creosote oils, belong to this class of materials. Their effect is of longer duration than that of water owing to the fact that they evaporate much more slowly. Like water, they have a definite point of saturation for the dust particles, and when this point is passed the road again begins to grow dusty. If they are present in too great an amount, a soft, greasy surface condition is produced, which is very undesirable. Heavy rains are apt to wash them out of the road, and the presence of water upon road surfaces to which they have been applied is productive of an oily, disagreeable mud under the action of traffic, and pools of oily water form in any ruts or depressions which may exist. They have been tried in many places, and, while they have proved to be fairly efficient dust layers, the disagreeable results produced in wet weather and the fact that they do not improve the road permanently have brought their use into general discredit.

The oils and tars which contain a certain amount of true binding base are much to be preferred for the purpose of dust laying to the materials just described. While for the most part they volatilize slowly, they nevertheless leave behind upon evaporation some binding material which is not removed by water and which tends to harden and bind together the surface cushion of fine material. Successive applications result in an accumulation of this binding material, and at the end of a season's treatment a very noticeable improvement in the wearing quality of the road surface is found to exist, and in some cases the resulting condition is similar to that produced by a single application of a permanent binder containing the same kind of base. A material of this kind holds an intermediate position between the palliatives and the permanent binders and possesses some of the qualities of each. The volatile oils, constituting by far the greatest portion, act through force of capillarity to lay the dust, and when they are evaporated or become saturated another application is required. At the same time the true binding base present actually cements some of the loose particles together and, as it works into the road proper, produces the results already described. If too heavy an application is made at one time the road surface will become soft and greasy and easily rutted, or if an appreciable amount of a non-binding base, such as paraffin, is present, as in the case of some semi-asphaltic petroleums, the same disagreeable mud will be formed in wet weather as that produced by the oil palliatives. Besides being disagreeable, this mud is ruinous to clothes and the paint and varnish on vehicles. In both cases the oil is apt to prove injurious to rubber tires.

Water-gas tar is perhaps one of the best temporary binders that can be applied in its natural state, although it has not been very generally employed. It can be obtained for about 3 cents a gallon, and when applied at the rate of 0.3 gallon per square yard on an ordinary macadam road will lay the dust successfully for some time. The number of applications required during a season will, of course, depend upon various conditions, but under ordinary circumstances a comparatively few will suffice. This material is readily absorbed by the road, and contains a sufficient amount of pitch to reduce dust formation to a considerable extent. It has a rather objectionable gassy odor, which, however, soon disappears. When used on roads having a great amount of fine material it is sometimes necessary to apply more than 0.3 gallon per square yard. In a case of this sort the tar does not bind the dust down firmly to the underlying surface, but it holds the particles well together and keeps them from being raised by passing vehicles or winds. Under the action of traffic, this loose or shifting surface is alternately compacted and broken up, but it does not form a disagreeable mud. During rainy weather, in fact, it has been known to produce a compact, uniform surface, which appears to advantage in comparison with the surface in dry weather. In localities where water-gas tar can be readily obtained with but little cost for transportation it can undoubtedly be used to advantage, and in many cases should successfully compete with other temporary binders.

Besides water-gas tar some of the lighter semi-asphaltic oils in their crude condition may be applied as temporary binders, as has already been indicated. When not too much paraffin is present, the residue left upon the road after the volatile constituents have evaporated forms a permanent binder. Successive applications will therefore result in a condition similar to that obtained by the single application of a heavy asphaltic oil, and the wearing quality of the road will be improved. As an example of a preparation insoluble in water which may be employed in its original condition might be mentioned a mixture of creosote, shale, or other mineral oil, and coal tar.

In regard to method of application, it may be said that in general the best method of applying to a road surface this kind of material or, in fact, any temporary binder is the same as that described for calcium chloride; that is, the middle of the road is given twice as heavy treatment as the sides, owing to the tendency of the material to be carried to the sides by gravitation and by running water. Of course the system described under the subject of calcium chloride for diluting concentrated material is only applicable to those substances miscible with water, as in the case of emulsions, which will next be considered.

EMULSIONS OF OILS WITH WATER.

Emulsions of oils or fats with water may be made either by mechanical or chemical means.

Chemical emulsions have up to the present been most generally used for the purpose of dust prevention, but before considering them it may be well to mention an apparatus which has recently been devised for the purpose of spreading a mechanical mixture of oily substances and water upon a road surface. This is a cart with two tanks, one containing the oil or tar and the other containing water. These two substances are led through pipes into a box where they are thoroughly mixed by means of rapidly whirling blades, which also force the mixture upon the road in the form of a spray. The water either evaporates or is rapidly absorbed by the road, thus leaving the tar or oil in a fine film over the surface, where it acts both as a binder and a dust layer. The number of applications required during a season will, of course, depend upon the character of the binder and quantity employed at each application, as well as upon local conditions. This method of application has proved satisfactory in some English experiments, but it has so far not been employed to a sufficient extent to warrant a general recommendation. It has some advantages over the chemical method of forming emulsions which will now be described.

Chemical emulsions are oily substances made miscible with water through the agency of saponifying materials. These saponifying materials react with a part of the fats or oils to form more or less soluble soaps, solutions of which are capable of mixing with oils and tars. Alkalies, such as potash or soda, are probably the most widely known saponifying agents, but other substances may be employed for the same purpose. Ammonia and also crude carbolic acid have been used to a considerable extent in preparing emulsions for the purpose of laying dust. In some cases no direct saponifying materials have been added to the oily material, but cheap soap solutions have been used instead. A number of these oil and tar emulsions have appeared on the market during recent years, and many have given good results when properly applied.

It is quite impossible to describe all of these preparations, as the exact composition of most of them is kept secret by the manufacturers. A few simple mixtures which are typical of these preparations will, however, be presented in order to give a general idea of their properties, method of application, and the results obtained from their use. In preparing an article of this sort, it is usually the endeavor of the manufacturer to produce a material which will contain the maximum amount of binding material per unit volume and at the same time be economical. Waste products from the various arts can frequently be utilized in these preparations, and of course tend to cheapen the material. Deliquescent substances, such as calcium chloride and certain soluble resinates, are sometimes incorporated in the preparations for the purpose of retaining moisture, while in others certain chemicals are employed for the purpose of oxidizing or hardening the binder upon evaporation of the volatile constituents. Before taking up the separate types in detail, it may be said in regard to their application that all are dependent upon a convenient water supply. As it is necessary to dilute them before using, a method similar to that described for calcium chloride, by which portions are first distributed at the different hydrants along the road, is the one which is likely to prove most economical.

The first type of emulsion which will be considered is the asphaltic or semi-asphaltic oil emulsion, which has in this country undoubtedly been used to a greater extent than any other. In some of our large cities these emulsions have been prepared under the supervision of the experimenter, in which case a soap solution has generally been employed to emulsify crude oils containing asphaltic bases. In other cases special preparations have been purchased which contain a residual asphaltic or semi-asphaltic oil emulsified by means of saponifying agents.

In Boston a number of the park roads are treated with an emulsion prepared as follows: To every 50 gallons of water 18 pounds of cotton-seed oil soap, costing 4½ cents per pound, are added, and the solution is hastened by the application of steam heat. This solution may be made in barrels and afterward pumped into the sprinkling wagons or into a reservoir. One hundred gallons of crude petroleum is then added to every 50 gallons of soap solution and the mixture is agitated until emulsification is complete. The emulsion thus produced contains about 66 per cent oil and is considerably diluted before applying to the road. The percentage of asphaltic base will of course depend upon the amount contained in the original oil. A 16 per cent oil solution is applied to the road at first, and the succeeding applications vary from 5 to 10 per cent, according to the needs of the road. The number of applications required during a season will vary with conditions. They are usually made, however, from ten to twenty-five days apart. By the use of a soap emulsion of this kind the loose material on the road is held down, but is not bound firmly together nor to the road surface. A thin rolling cushion is produced, saturated with oil, which prevents dust formation and protects the underlying surface. A very light coating of sand or fine stone screenings is sometimes spread on the road before applying the emulsion. This produces a cushion which will be hard and firm and take a considerable amount of wear. The main objection to this thin rolling cushion is that under the action of traffic it is apt to be worked to the sides of the road and finally into the gutters. It is then necessary to throw the old material back or apply fresh material, and this of course requires constant attention and considerably increases the cost of

* Abstracted from Bulletin 34 of the Office of Public Roads, Department of Agriculture.

the work. In certain cases the cost of applying sufficient emulsion to lay the dust for a season has been as low as 2 cents per square yard, as compared with the cost of watering in previous seasons of 3 cents per square yard. The cost of applying sand and throwing back material which is carried to the gutters should, however, be added to this in order to obtain the actual cost of maintaining the road in proper condition. Except for a rather faint oily odor, no unpleasant results are obtained from an emulsion of this sort. The principal advantage is its cheapness, which is due to the fact that it is manufactured by the experimenter. It has been found that if too much is applied at one time an undesirable loose scale is formed when the surface dries out. This is undoubtedly due to the soap used, which to some extent destroys the true binding value of the asphaltic base, owing to the presence of fixed alkalies. Light applications at more frequent intervals are therefore to be preferred. As shown by experiments conducted on park roads in Chicago with soap and oil emulsions, a number of factors have to be taken into account when preparing the emulsion. The selection of soaps will be regulated to some extent by the character of the water used, and an oil or oil mixture should be obtained which will properly emulsify with the soap solution. Where the water is hard, a naphtha soap has been found to give the best results.

When for any reason it is inconvenient to install an emulsifying plant, asphaltic-oil emulsions may be purchased which are already prepared in concentrated form. One of these which has been used with good results consists of a heavy Texas residuum emulsified by the addition of ammonia, crude carbolic acid, and creosote, which is incorporated with the oil under the action of heat and agitation. As an emulsion of this sort carries a high percentage of asphaltic binder, it can be diluted considerably before applying. One of these preparations which was examined by the writer was found to contain about 60 per cent of good asphaltic base after most of the volatile constituents had been removed. The quality of the oil employed is, of course, a very important factor in the binding value of the preparation, and therefore in its road-building properties.

When employing this class of asphaltic-oil emulsions it is customary to give the road either one treatment or else two, with a short interval between, of a 15 to 18 per cent solution. The surface is thus thoroughly impregnated with the asphaltic binder, and as the emulsifying agents are more or less volatile, an insoluble and almost waterproof deposit is finally formed upon drying. This binder is not easily removed by rains or traffic, and if weaker solutions containing about 5 per cent of the original emulsion are applied from time to time the dust will be well laid. At the end of a season the road should not only be in better condition than at the beginning, but its wearing quality should be more or less permanently improved, according to the amount of binder which has been retained.

These emulsions can be purchased for about sixteen cents per gallon in concentrated form, and are usually contained in iron drums holding 120 gallons each. In the first treatments 1 gallon of the original emulsions is applied to about every 30 square yards, and for succeeding treatments the same amount is made to cover from 60 to 90 square yards, according to the strength of solution employed. The total cost per square yard during an average season will run from 4 to 6 cents, according to locality and traffic conditions. While this is somewhat higher than the cost of treating with soap emulsions of oil, the results obtained are more permanent, and this fact should be taken into account when comparing the two. Up to the present time the oil emulsions have been used principally upon parkways and suburban roads, as the cost of frequent treatments precludes their use on rural highways.

The next type, the tar emulsions, have up to the present time been more generally used in France, England, and Germany than in our own country. A number of these preparations are sold under trade names and several have been patented. In their simplest form they differ from the oil emulsions only in the fact that coal-tar bitumens are employed in place of the asphaltic bitumens. Coal tar emulsified by means of ammonia and crude carbolic acid might be mentioned as a parallel preparation to the oil emulsion just described. The method of application and results obtained are practically the same as for oil emulsions. At the present time it is impossible to determine the relative value of different oil and tar emulsions. Nearly all of those which have been tried have proved to be effective temporary dust layers, but a number of competitive experiments under similar conditions would be required to determine which is capable of producing the most permanent results at the least expense. At the present time tar emulsions sell for about the same as oil emulsions.

During the past year a tar-preparation competition was held in England in connection with the motor dust trials and spreading-machine competition which have already been mentioned.

Besides the two simple types of emulsions which have so far been considered, many others have been tried, and before leaving the subject it may be well to describe briefly some of them for the purpose of showing how many different materials have been used. It is impossible to classify them satisfactorily owing to their heterogeneous composition. No very systematic arrangement can therefore be followed in describing them.

Glue and bichromate of potash have in some instances been added to an oil or tar emulsion to cause it to harden upon the road surface. Under the action of light this preparation is claimed to become insoluble. Acid-treated cotton-seed oil and tar, emulsified by the action of caustic soda, is another type. A carbolic-acid oil emulsion to which has been added asphalt tar and the residue from glycerin distillation is also on the market. A caustic potash emulsion of coal tar, creosote, pitch, and resin has been patented. There are also a number of English, French, and German preparations which form emulsions with water, but their composition is kept secret by the manufacturers. A Scotch preparation composed of wool grease, soap fats, and potash is sold. A French compound of powdered asphalt and water has also been used. An emulsion of asphalt and creosote with water is another French compound, and there are many others, in some of which wood tar is employed.

A number of patents have been taken out in this country on preparations of various compositions, many of which are interesting because of the fact that waste products from different sources are utilized. One of these patents covers an emulsion of tar or oil to which casein has been added. Another makes use of the water lyes obtained from wood-pulp factories. These water lyes are for the most part waste products; they contain resinous and salt ingredients which form not only binding but more or less hygroscopic compounds upon evaporation.

The fat or grease obtained from wool scourings, when emulsified with deliquescent salt solutions and sometimes creosote, is made the basis of another patent. And still another covers the application of an oil emulsion containing a deliquescent salt and a waste sulphite cellulose liquor produced in the manufacture of paper from wood pulp. The use of waste-molasses solutions, as well as mixtures of saccharine materials and lime, which form adhesive calcium saccharates, has also been suggested.

Nearly all of the materials and preparations described in this bulletin have some desirable qualities, and it is extremely difficult to make a selection among them. In general it may be said that those substances which can be applied in their natural condition have an advantage over the emulsions in the fact that their use is not dependent upon a constant water supply. On the other hand, they are more bulky to store, and transportation charges are proportionately greater than for the special preparations which are sold in a concentrated state. In regard to the emulsions themselves, it would seem that the mechanical emulsion, if it can be properly made and applied, may in some cases prove more desirable than the chemical emulsion, as no non-binding emulsifying agents are required and the original binding material remains for the most part unaltered. Where strong alkalies, such as soda or potash, are used in connection with asphaltic material in particular the high binding bitumens are apt to be split up into substances of lower binding value. This fact has been practically demonstrated by the results obtained from the use of asphaltic oils upon alkali soils, as has been previously noted.

The use of these temporary binders in road construction is advocated by some experimenters. While somewhat better results may be obtained by this means than by the use of water alone, it is very doubtful if they will prove to be economical or of a very lasting character when the small proportion of binding material present in most of these preparations and emulsions is taken into account. In cases, however, where the material approaches the permanent binders in character and quantity of base present, this criticism would not apply. It would seem, however, in any event that the use of a sufficient amount of permanent binder would be preferable when application is to be made during construction, as a better bond between the fragments of road metal is formed than when a water solution of the binder is employed.

A SO-CALLED LOST ART.

It has been claimed that tempering copper is one of the "lost arts." According to Prof. Hopkins, of the department of chemistry at Amherst College, the idea that copper was tempered in ancient times arises from a thirteenth century misunderstanding of the Greek word *baphé*—a word used by the Græco-Egyptian alchemist writers of the third century. Prof. Hopkins states that Berthelot, the eminent authority on alchemy, has shown that this word tempering may mean coloring cloth, glass, and metals, coloring materials, or the coloring bath. He says that Egyptian alchemy busied itself originally in producing brilliant bronzes on copper and the copper alloys, and that this expression "the tempering of copper" means and always has meant bronzing copper so that it may simulate silver or gold. It would thus appear that copper may never have been tempered, after all. This is a more probable conclusion than that the way to do it has been lost.—Railway and Locomotive Engineering.

THE RHONE 350,000-HORSE-POWER PROJECT.

It will be remembered that there was brought forward some time ago a project for securing a large amount of current for the city of Paris from a hydraulic plant on the Rhone lying about 250 miles distant. Since that time the authors of the project, Messrs. Blondel, Harlé, and Mahl, have modified it and adopted another method as concerns the electrical operation of the turbine plant and the pole line. Should the project be carried out, and this is within the range of possibility because a current supply for the city is greatly needed, the enterprise will be by far the largest of the kind in Europe. The turbine plant is to be laid out for no less than 350,000 horsepower. Most of the current will be sent over the power line to Paris, but a small part will also serve for the surrounding region of the plant. The radical change lies in discarding the high-tension direct-current system and employing the alternating three-phase current. Many objections had been made by leading engineers to the old project. It had the disadvantage of using a system which although it works with success in the limited number of plants where it is used, such as the power plants from Moutiers to Lyons and St. Maurice to Lausanne, was not widely adopted in different countries such as we find for the three-phase method of operating. Accordingly the latter has been considered better on the whole, and the plans were entirely modified so as to use the alternating system.

The hydraulic work for the 350,000-horse-power turbine plant will, of course, be a great undertaking. A site has been selected on the Rhone about 30 miles from where it flows out of Lake Leman and lying below the important Swiss turbine plant at Chèvres which we have already illustrated.

The present plant will be located (according to the project) at Genissat, across the French frontier, where the Rhone flows in a deep gorge. Owing to this formation of the banks, the water can be backed up for a considerable distance so as to form a large basin, which will be valuable as a reserve supply. The dam will have a slope at the front of some 40 degrees, but at the rear side next the basin it will be practically vertical. The wall will be faced with a continuous sheet steel surface formed by the electric welding process, so that there will be an entire absence of fissures. Such a facing will give an excellent protection for the dam. The latter will be 250 feet high and about the same width at the base. At the water side it is protected first by a masonry wall 60 feet high and 30 feet wide built along the base of the dam. Farther in the rear is a masonry dike of triangular section and somewhat larger than the wall. In order to build the dam upon dry ground there will be erected a temporary dam completely across the gorge so as to retain all the water, and an outlet for the latter is provided by cutting a number of tunnels in the rock so as to lead the water to a point below the construction work. The temporary dam and tunnels will be suppressed after the hydraulic work has been finished. From the dam the water will be taken to the turbine house which lies not far below the present construction, by using a flume of 350 feet width and 25 feet depth. Arrangements are made for taking off twenty-five penstocks from the flume, each penstock having a separate water-gate for shutting it off. Each of the penstocks, of sheet steel, has a capacity of 700 cubic feet per second.

The turbine plant located below the dam will undoubtedly be the largest in the world, both as to the size of the building, about 1,000 feet in length, and the number and size of the wheels. The plant is laid out from the start to take twenty-four turbines of about 15,000 horse-power each, or as already stated, 350,000 horse-power in round numbers. Such wheels are to run at a speed of 250 R. P. M., and each one coupled direct to a three-phase alternator. These latter will give current of 12,000 volts. Situated near the plant will be a separate building in order to contain the transformers and the various apparatus for the power line. Here will be used banks of transformers which will raise the current to 120,000 volts for use on the power line. For the main line running for 250 miles to Paris there will be two distinct conductors upon the poles, each being made up of six cables connected in two sections of three cables each, using a 20-millimeter section cable.