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METHOD OF MAKING BITUMINOUS
PAVING MATERIALS

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This invention relates primarily to those road materials which are composed of mineral aggregate, such as stone, sand or slag, the pieces of which are preferably provided with a coating of a bituminous material, such as asphalt, tar or other bitumen adapted to be spread upon a road-
way as a course or stratum of a pavement, the pieces of aggregate of which are bound together by the bituminous material, the course or layer preferably having the physical structure, consistency and character as that described in Letters Patent of the United States No. 1,611,444, granted to Donald McKnight Hepburn on December 2, 1926.

One of the objects of the present invention is to improve the method of making and mixing the materials and forming a pavement such as is described in the said Letters Patent, by reducing the cost of making and laying the pavement, by eliminating the step of drying the stone and by making it unnecessary to heat the asphalt at any stage in the process.

A further object of this invention is to substantially reduce the cost of plant equipment by the elimination of such apparatus as heaters, heating coils, jacketed pipes and boilers, making it necessary to use in the preparation of the material only a suitable and readily obtainable mixing apparatus, such as a standard asphalt mixer.

A further object of this invention is to provide a process which makes it unnecessary to ship the stone forming the aggregate from the quarry or other source of supply to the plant for treatment and thence to the road paving operation. The present invention contemplates and has for its object, the providing of a process whereby only one shipment of the aggregate is necessary and that, in an undried, unheated condition, merely from the quarry directly to the road building operation, where the stone may be coated with the bituminous binder without the application thereto of any artificial heat and without any heating of the bituminous composition.

A further object of this invention is to provide a process for the performance of which an inexpensive and readily constructed plant only is needed and further to provide a process which readily lends itself to a portable plant in which, for the coating of the aggregate, a simple mixing mill is the only apparatus required.

A further object of this invention is to provide a process whereby the cost of transporting the material to the road operation is greatly reduced, by making it necessary to transport, from the

plant to the road operation, only the bituminous composition to be used in coating the stone, and by making it possible to ship the stone from the quarry directly to the road operation and to coat the stone at the place where the road is being constructed, thus eliminating completely the step of transporting coated stone from a mixing plant to the road operation.

A further object of this invention is to provide a process of laying a course of bituminous pavement using an aggregate which may be damp and water absorbent, without being first required to expel the moisture from the aggregate.

A further object of this invention is to provide a process for making under ordinary atmospheric temperatures a bituminous pavement wherein the aggregate, even though damp, may be coated with a bituminous binder which firmly adheres to the aggregate; and in which the paving material may be mixed and prepared and then placed without being required to use any of the heating apparatus and appliances heretofore employed to dry the aggregate and to reduce the bituminous composition to a fluid condition.

A further object of this invention is to provide a bituminous coating composition which has a relatively low surface tension, at ordinary atmospheric temperatures, so that the composition quickly makes a firm contact with the aggregate, thus substantially reducing the time required to effect a thorough coating of the aggregate, and the mixing operation.

Further objects of this invention will appear in the specification and claims below.

Since the process, forming the subject-matter of this invention, is particularly adaptable to the mixing and compounding of the materials at the place where the road is being constructed, that mode of practising the invention will be first described.

At the place, where the road is being constructed, a suitable mixer, preferably of the pug-mill type, is provided. It may be operated by electric power, if that is available, or by a gasoline engine.

The bitumen which is used in the practice of this invention is preferably a residual asphalt having a high penetration (e. g. from 135 to 145), which is a solid cement at atmospheric temperatures. Such an asphalt may be readily produced by mixing or compounding a harder asphalt with a suitable involatile fluxing oil in proportions sufficient to bring the penetration index of the resulting asphalt high enough to readily coat the stone when admixed with a liquefier.

In the practice of the invention a liquefier is employed. As a liquefier, we may use any suitable solvent of the asphalt or other bitumen, such as gasoline, kerosene, painter's naphtha and generally any tar solvent or a mixture of such solvents but the liquefier preferred for the practice of this process is one which is quite volatile at atmospheric temperatures and which is a solvent of the hard bitumen under agitation. Gasoline or a mixture of gasoline and kerosene is well adapted for the purpose.

In carrying out the process, and particularly if the aggregate be damp, we employ materials which will cause a firm adherence of the asphalt to the aggregate even though the aggregate is wet. A sulphonated fatty oil, such as sulphonated castor oil or Turkey red oil, may be used. The acid reaction of such oil, however, is preferably partially neutralized with a suitable alkali, preferably sodium hydroxid. A sulphonated fatty oil which has been partly neutralized so that its acid reaction is reduced, is readily obtainable on the market and if that is used it may be unnecessary to further neutralize it. If, however, the oil is strongly acid, its acidity should be partly neutralized by the addition thereto of a suitable alkaline neutralizer as above indicated, but the acid reaction should not be entirely neutralized for the best results.

Instead of a sulphonated oil, a small quantity of oleic acid, partially neutralized with potassium hydroxid or other alkali, may be used, or we may use a small quantity of a water soluble soap. For the purposes of this invention, these ingredients are substantial equivalents. As an indication of the small quantity of neutralizer that is employed in this process, it may be stated that the weight of the neutralizer is about one-tenth of that of the oleic acid.

Another ingredient which is used in the practice of this invention, is a powdered asphalt, that is to say, an asphalt having so low a penetration that it can be and has been reduced to a finely powdered condition.

In order to obtain a loose friable powdered asphalt, which may be handled in bulk, it is usual to comminute the same in the presence of and together with lime, which for the purposes of this invention may be either hydrated lime, or quicklime, or limestone. We make no claim herein to the method by means of which the hard asphalt is reduced to a powder. A hard powdered asphalt may be readily obtained containing about 6% by weight of hydrated lime. That product is well adapted to the process forming the subject-matter of this invention and is the ingredient preferably used.

In addition to the lime which may thus be contained in the powdered asphalt, it is desirable, in many instances, to add to the ingredients while they are being mixed together, and preferably near the end of the mixing operation, or even after placement of the materials on the roadway, a further relatively small quantity of lime, preferably hydrated lime or powdered limestone.

Fine mineral matter, such as sand or "sandy fines" or fine screenings are usually employed as a component of the finished mixture, to produce on the stone a heavy coating of bituminous material and, when used, is one of the last ingredients to be added to the mixture in the practice of this invention.

With this recitation of the various components which are applicable to the practice of this process, reference thereto in general terms only is

necessary in describing the manner of compounding and making the paving material therewith.

Into the mixing apparatus of the type above referred to is first placed the graded mineral aggregate, preferably consisting of broken stone in an undried and unheated condition. The stone is kept under continuous agitation throughout the treatment and without particular reference thereto hereafter, it is to be understood that the mixing apparatus is being continually operated until all the ingredients have been added and thoroughly mixed together.

To the stone thus being agitated in the mixer, we add, in proper proportions and generally speaking, in any order of introduction, (1) the liquefier, (2) the asphalt of substantially 140 penetration, (3) the sulphonated oil or oleic acid and (4) the neutralizer which may be added to the mixture as a separate ingredient or admixed with the oleic acid or sulphonated oil and the mass is agitated until the aggregate is thoroughly and uniformly coated with a bituminous composition. The quantities of ingredients thus added to, for instance, 2000 pounds of stone aggregate, are:

140 penetration asphalt	90 pounds
Crude naphtha	3 gallons
Sulphonated oil (partially neutralized)	1 pound

If the sulphonated oil is insufficiently neutralized or if oleic acid is used, the quantity of the alkaline neutralizer for the above mixture would be substantially one-tenth (.1) of a pound of potassium hydroxid, or possibly less, care being taken not to add more alkali than will substantially half neutralize the acid reaction of the oil or the fatty acid.

In the practice of the above process, we preferably dissolve the sulphonated oil or the oleic acid and potassium hydroxid or other neutralizer in the liquefier and add these ingredients simultaneously, but this is not essential and these ingredients may be added in any suitable manner.

After the aggregate has thus been thoroughly coated with the bituminous composition containing the ingredients above specified, we add thereto and thoroughly mix and distribute throughout the mixture, the powdered asphalt, the quantity usually being from 10 to 15 pounds and this powder may contain 6% by weight of hydrated lime as a consequence of the process by means of which it was reduced to a powder.

All the ingredients above mentioned may be added to the aggregate without the application of heat, that is to say, at atmospheric temperature. The quantity of soft asphalt (140 penetration) and liquefier first added to the aggregate may be more than would be retained upon the stone were the agitation to cease. It might run off the stone if the mixer were stopped. In the mixer the naphtha is a ready solvent of the powdered bitumen at atmospheric temperatures and, upon the agitation of the aggregate, is effective to immediately begin to dissolve the powdered asphalt and to distribute the softening powder throughout the mixture, imparting thereby body sufficient to produce in the resultant bituminous cement after the hard asphalt has completely dissolved and blended with the softer asphalt, and after the solvent has been evaporated out of the mixture after placement. The desired penetration may readily be made like that result-

ing from the practice of the process of the said Letters Patent of the United States No. 1,611,444.

The small quantity of powdered hard asphalt thus added to the mixture, quickly dissolves in the liquefier and the cement becomes homogeneous after one or two minutes of agitation or stirring. It imparts body to the cement and makes it firmer. It stiffens it somewhat, but not enough to prevent the facile handling, spreading and placement of the same upon the roadway. The rapid setting up or hardening of the mixture is prevented by stopping the stirring promptly after the stone is coated and by the relatively large quantity of liquefier employed, and it is operative to perform two functions, to wit, (1) to maintain the mixture in a loose, friable condition and (2) to dissolve the powdered asphalt with the result that the hard asphalt and the soft asphalt (of high penetration) are quickly homogeneously blended and united into a liquid or semi-liquid coating.

After the powdered asphalt has been added, it is often desirable to add an alkaline earth or similar mineral matter, such as lime or powdered limestone, the quantity being preferably from 0.5% to 1% of the weight of the mixture.

In order to form and retain on the stone a heavy coating of bituminous cement, we preferably add to the mixture, when the mixing step has been nearly finished, sand or "sandy fines" or rock screenings, the quantity being preferably from 4% to 8% of the weight of the mixture under treatment.

When the resultant mixture so compounded has been thus produced, it is dumped and spread over the roadway in a layer or course of suitable thickness and subjected to compaction by a heavy roller.

With the exposure of a relatively large surface of this mixture to the atmosphere, in a relatively thin course of paving, the volatile liquefier disappears in a short time after placement and compaction, leaving the aggregate bound together with a bituminous cement of sufficient firmness and rigidity to hold the stone permanently in place, substantially like that disclosed in the said Letters Patent No. 1,611,444 but without the application of any heat thereto and without necessitating the heating of the stone to expel the moisture which may be contained therein.

If the stone is dry and does not contain any water, the use of the sulphonated oil or its equivalents might be omitted without departing from the spirit and scope of the invention, but, since the composition makes a better and firmer contact, even with dry stone, when the fatty acid ingredients are present, and since the surface tensions of the fluid cement is substantially reduced, thereby reducing substantially the time required for the coating operation, and the affinity of the composition to the stone is increased, we prefer to use the same whenever it is available.

The cement for first application to the stone at the place of laying the roadway, may be prepared in advance, at a suitable plant, there mixing together the soft asphalt, the liquefier and the sulphonated oil (partially neutralized) or the oleic acid (partially neutralized) in a suitable mixing apparatus with or without heat. This relatively fluid composition may be shipped in tanks or tank cars to the paving operation and the powdered asphalt may also be shipped separately in bags or other suitable containers.

When the process is thus practised, the stone or other aggregate for making the roadway may

be shipped directly to the place of operation instead of being required to be shipped to an expensive coating plant whence it is re-shipped to the place of operation, thus entailing but one shipment of the aggregate over a single route, instead of from the quarry to the plant, and thence, coated, to the operation.

It is to be understood that the process above described is applicable to the ordinary atmospheric conditions under which roads are built, to wit, in late spring, summer, and early fall. If the weather becomes exceedingly cold during an operation, the ingredients, including the stone and the cement, may be warmed to temperatures of, for instance, 70° to 90°, which are termed summer temperatures for brevity, although even that heating might be avoided by increasing the quantity of the liquefier sufficiently to produce a fluid condition of the composition first added to the aggregate, prior to the introduction of the powdered cement.

If the bitumen having the desired high penetration is not available, it is to be understood that an involatile fluxing oil may be admixed with a lower penetration cement in sufficient quantities to soften such harder cement to the desired penetration either before or after such asphalt is placed in the mixer.

The invention is not to be construed as limited to the use of asphalt as a bituminous binder, for other bitumens, such as coal tars and coal-tar pitches separately or admixed with asphalts may be employed with the liquefier and aggregates in the same manner.

Coal tars and coal-tar pitches bear a relationship to each other very similar to those existing between the hard and soft asphalts above discussed, in that by the distillation of the viscid coal tar, solid and semi-solid coal-tar pitches are obtainable. These pitches are the residues that remain after the lighter oils have been distilled out of the coal tar, and may be obtained in different degrees of hardness, ranging from a relatively soft to a relatively hard amorphous solid which is brittle and may be readily reduced, as hard asphalt is, to a pulverized condition, dependent upon the extent to which the distillation therefrom of the fluxing oils has been carried.

The gasoline or a mixture of gasoline and kerosene used as the liquefier in connection with the asphalts above described, are also solvents of the hard and softer pitches. It is only necessary to select of these coal-tar pitches those which are physically the counterpart of the hard and soft asphalts above described. It is, of course, to be understood that in lieu of or mixed with the solvents of asphalt above described, we may use solvents which are usually regarded as coal-tar pitch solvents, and which are volatile and which will dissolve the harder powdered pitch at atmospheric temperature under agitation as, for instance, such as naphtha, benzol and the like.

The proportions of the hard to the soft bitumens which have been above given are to be considered merely by way of example, for if the bitumen available for the first coating of aggregate be of a higher penetration than 140, more of the powdered bitumen might be required and if the powdered bitumen should, for instance, be softer than of no penetration, as for instance, an asphalt of 10 penetration, which is about as soft an asphalt as can be reduced to a powder, more of the powdered bitumen or less of the soft bitumen would be proper so long as the liquefier is in sufficient quantities to dissolve the hard bitumen

summer temperatures and is operative to quickly blend it with the bituminous coating first added to the aggregate.

Since the lime in the mixture containing the sulphonated oil or oleic acid and its neutralizer, or the soap, tends to convert the water-soluble soap into a water-insoluble soap, it may be and often is desirable to omit the addition of the lime or other alkaline earth substance to the mixture during the mixing operation and to postpone the introduction of the lime until after the coated material has been dumped and spread upon the roadway at which time it may be sprinkled over the surface of the course and rolled in by the compacting roller.

This invention is not limited to the use of unheated ingredients or to summer temperatures only, for it is obvious that the heating of the stone and/or of the bitumen enables one to use in the first coating to be applied to the aggregate, bitumens of lower penetration than those above indicated; to use a smaller quantity of a powdered asphalt; and to compound paving materials which are to be placed on the roadway hot, and in which the desired firmness and rigidity of the cement in the finished roadway is due to the cooling of the bitumen as well as to the evaporation of the volatile liquefier.

The practice of the present invention is not avoided by merely using a lower penetration bitumen and a liquefier in the composition first applied to the aggregate, and by the application of heat to such bitumen and/or the aggregate and/or to the mixture of bitumen and aggregate. The application of heat to applicant's process, where heat is available, may be desirable to reduce the time required for its performance; and/or to produce a type of pavement, like sheet-asphalt, which is placed on the roadway hot or warm, and the desired rigidity of the cement which ultimately binds the aggregate in permanent relationship is due partly to the cooling of the bitumen and partly to the volatilization of the liquefier. Such processes or modifications are fully within the aim of the present invention.

In heating such mixtures, however, care must be taken not to apply so much heat to the mixture or to the bitumen to be mixed with the liquefier, as to substantially reduce, by volatilization, the quantity of the volatile liquefier to a point where the fluidity of the bituminous coating, first applied to the aggregate, is substantially impaired, or the stones are imperfectly coated with bitumen or the mixture, when dumped, is too thick and sticky for ready spreading.

With these considerations in mind this invention is to be construed as broadly applicable to the mixing of paving compositions made by first applying to the stone or other mineral aggregate, heated or unheated, above or below summer temperatures, a liquid bituminous cement containing a substantial quantity of a volatile solvent operative to cause the bitumen to readily cover and coat each individual piece of aggregate therewith, and preferably containing a partially neutralized fatty acid, or a sulphonated oil the acidity of which is partially neutralized, and thereafter, while the mixture is being agitated, adding to the mixture a relatively small quantity of a powdered bitumen which is readily soluble, under agitation, in the liquefier, and which quickly blends with and forms, with the fluid mixture, a substantially homogeneous bituminous cement which, after the mixture has been placed on the

roadway and the volatile liquefier has escaped, possesses the firmness and rigidity requisite for permanently holding the individual pieces of aggregate in fixed relationship in the finished pavement.

Having thus described our invention, what we claim and desire to protect by Letters Patent of the United States is:

1. The method of making a paving material, which comprises agitating a mineral aggregate and thoroughly mixing therewith a relatively high-penetration bituminous cement admixed with a sufficient quantity of a slowly volatile solvent therefor to render the composition sufficiently fluid at atmospheric temperatures to readily cover the individual pieces of aggregate therewith, and a small quantity of a fatty acid partly neutralized with an alkali, and then adding to the mixture, while the agitation of the mass is being continued, a relatively small quantity of a powdered bitumen, readily soluble in said solvent when agitated therewith, and operative, after the said solvent has evaporated therefrom, to impart to the resulting bituminous cement the firmness and high ductility required to hold the pieces of aggregate in a substantially fixed relationship, the whole process being operable without the application of artificial heat to said mixture or to said ingredients.

2. The method of making a paving material, which comprises agitating a mineral aggregate and thoroughly mixing therewith a relatively high-penetration bituminous cement admixed with a sufficient quantity of a slowly volatile solvent therefor to render the composition sufficiently fluid at atmospheric temperatures to readily cover the individual pieces of aggregate therewith, and a small quantity of a material containing a fatty acid and a neutralizing agent in quantities sufficient to only partially neutralize said fatty acid, and then adding to the mixture, while the agitation of the mass is being continued, a relatively small quantity of a powdered bitumen readily soluble in said solvent when agitated therewith, and operative, after the said solvent has evaporated therefrom, to impart to the resulting bituminous cement the firmness and high ductility required to hold the pieces of aggregate in a substantially fixed relationship, the whole process being operable without the application of artificial heat to said mixture or to said ingredients.

3. The method of making a paving material, which comprises agitating a mineral aggregate and thoroughly mixing therewith a relatively high-penetration bituminous cement admixed with a sufficient quantity of a slowly volatile solvent therefor to render the composition sufficiently fluid at atmospheric temperatures to readily cover the individual pieces of aggregate therewith, and a small quantity of an acid soap, and then adding to the mixture, while the agitation of the mass is being continued, a relatively small quantity of a powdered bitumen, readily soluble in said solvent when agitated therewith, and operative, after the said solvent has evaporated therefrom, to impart to the resulting bituminous cement the firmness and high ductility required to hold the pieces of aggregate in a substantially fixed relationship, the whole process being operable without the application of artificial heat to said mixture or to said ingredients.

4. The method of making a paving material, which comprises agitating a mineral aggregate and thoroughly mixing therewith a relatively

high-penetration bituminous paving cement admixed with a sufficient quantity of a slowly volatile solvent therefor to render the composition sufficiently fluid, at atmospheric temperatures, to readily cover the individual pieces of aggregate therewith, then adding to the mixture, while the agitation of the mass is being continued, a relatively small quantity of a powdered bitumen, admixed with lime, said powdered bitumen being readily soluble in said high-penetration cement and in said solvent, when agitated therewith and operative after the said solvent has evaporated therefrom, to impart to the resulting bituminous cement the penetration, firmness and high ductility required to hold the pieces of aggregate in a substantially fixed relationship, the whole process being operable without the application of artificial heat to said mixture or to said ingredients.

5. The method of making a paving material, which comprises agitating a mineral aggregate and thoroughly mixing therewith a relatively high-penetration bituminous paving cement admixed with a sufficient quantity of a slowly volatile solvent therefor to render the composition sufficiently fluid at atmospheric temperatures to readily cover the individual pieces of aggregate therewith, and then adding to the mixture, while the agitation of the mass is being continued, a relatively small quantity of a powdered bitumen, admixed with an alkaline earth substance, said powdered bitumen being readily soluble in said solvent and in said high-penetration cement, when agitated therewith, and operative, after the said solvent has evaporated therefrom to impart to the resulting bituminous cement the penetration, firmness and high ductility required to hold the pieces of aggregate in a substantially fixed relationship, the whole process being operable without the application of artificial heat to said mixture or to said ingredients.

6. The method of making a paving material, which comprises agitating a mineral aggregate and thoroughly mixing therewith a relatively high-penetration bituminous paving cement, admixed with a sufficient quantity of a slowly volatile solvent therefor to render the composition sufficiently fluid at atmospheric temperatures to readily cover the individual pieces of aggregate therewith, and then adding to the mixture, while the agitation of the mass is being continued, a relatively small quantity of a powdered bitumen, admixed with substantially 6% by weight of hydrated lime, said powdered bitumen being readily soluble in said solvent and in said high-penetration cement when agitated therewith, and operative after the said solvent has evaporated therefrom, to impart to the resulting bituminous cement, the penetration, firmness and high ductility required to hold the pieces of aggregate in a substantially fixed relationship, the whole process being operable without the application of artificial heat to said mixture or to said ingredients.

7. The method of making a paving material, which comprises agitating a mineral aggregate and thoroughly mixing therewith a relatively high-penetration bituminous cement admixed with a sufficient quantity of a slowly volatile solvent therefor to render the composition sufficiently fluid at atmospheric temperatures to readily cover the individual pieces of aggregate therewith, and a small quantity of a fatty acid partly neutralized with an alkali, and then adding to the mixture, while the agitation of the mass is being continued, a relatively small quantity of a

powdered bitumen, admixed with an alkaline earth substance, readily soluble in said solvent when agitated therewith, and operative, after the said solvent has evaporated therefrom, to impart to the resulting bituminous cement the firmness and high ductility required to hold the pieces of aggregate in a substantially fixed relationship, the whole process being operable without the application of artificial heat to said mixture or to said ingredients.

8. The method of making a paving material, which comprises agitating a mineral aggregate and thoroughly mixing therewith a relatively high-penetration bituminous cement admixed with a sufficient quantity of a slowly volatile solvent therefor to render the composition sufficiently fluid at atmospheric temperatures to readily cover the individual pieces of aggregate therewith, and a small quantity of a material containing a fatty acid and a neutralizing agent in quantities sufficient to only partially neutralize said fatty acid, and then adding to the mixture, while the agitation of the mass is being continued, a relatively small quantity of a powdered bitumen, admixed with lime, readily soluble in said solvent when agitated therewith, and operative, after the said solvent has evaporated therefrom, to impart to the resulting bituminous cement the firmness and high ductility required to hold the pieces of aggregate in a substantially fixed relationship, the whole process being operable without the application of artificial heat to said mixture or to said ingredients.

9. The method of making a paving material, which comprises agitating a mineral aggregate and thoroughly mixing therewith a relatively high-penetration bituminous cement admixed with a sufficient quantity of a slowly volatile solvent therefor to render the composition sufficiently fluid at atmospheric temperatures to readily cover the individual pieces of aggregate therewith, and a small quantity of an acid soap, and then adding to the mixture, while the agitation of the mass is being continued, a relatively small quantity of a powdered bitumen, admixed with lime, readily soluble in said solvent when agitated therewith, and operative, after the said solvent has evaporated therefrom, to impart to the resulting bituminous cement the firmness and high ductility required to hold the pieces of aggregate in a substantially fixed relationship, the whole process being operable without the application of artificial heat to said mixture or to said ingredients.

10. The method of making a bituminous composition for coating wet aggregate, which comprises thoroughly mixing together without the application of artificial heat thereto, a bituminous cement having a penetration of from 135 to 145, a slowly volatile liquefier which is a volatile solvent of hard powdered bitumen at summer temperatures, and operative to make the resulting composition fairly fluid at summer temperatures, and a material containing a small quantity of a fatty acid partly neutralized with an alkali, the quantity of said material containing a fatty acid being substantially, by weight, 1% of the weight of said composition, adding said ingredients to a mineral aggregate which is being stirred, then adding to the mixture under agitation and without the application of artificial heat thereto, substantially one-half of one per cent of powdered bitumen which promptly, under agitation, dissolves in said liquefier and in quantities sufficient to impart to the bituminous composition, after 75

the liquefier has evaporated therefrom, the firmness and high ductility required to hold the pieces of aggregate in a substantially immovable relationship.

- 5 11. The method of making a paving material, which comprises agitating a mineral aggregate and thoroughly mixing therewith a relatively high-penetration bituminous cement admixed with a sufficient quantity of a slowly volatile solvent therefor to render the composition sufficiently fluid at atmospheric temperatures to readily cover the individual pieces of aggregate therewith, and a small quantity of a fatty acid partly neutralized with an alkali, and then adding to the mixture, while the agitation of the mass is being continued, a relatively small quantity of a powdered bitumen, readily soluble in said solvent when agitated therewith and operative, after the said solvent has evaporated therefrom, to impart to the resulting bituminous cement the firmness and high ductility required to properly hold the pieces of aggregate in a substantially fixed relationship.

- 25 12. The method of making a paving material, which comprises agitating a mineral aggregate with a mixture of a paving asphalt having a penetration higher than approximately 135, solid at atmospheric temperatures, and a slowly volatile solvent therefor, at a temperature below that at which said solvent passes off in substantial quantities and at which the mixture is sufficiently fluid to coat and cover the aggregate therewith, and then adding to said mixture a relatively small quantity of powdered bitumen soluble in said solvent and in said paving asphalt under agitation, the quantity of powdered bitumen being sufficient to impart to the resulting cement, after the solvent has volatilized, the penetration, firmness and high ductility requisite to hold the pieces of aggregate in a substantially fixed relationship.

- 40 13. The method of making a paving material, which comprises agitating together, at ordinary atmospheric temperatures,

- 45 A mineral aggregate, substantially----lbs-- 2000
A high-penetration asphaltic cement, solid at atmospheric temperatures, substantially-----lbs-- 90
A slowly volatile solvent of asphalt, substantially-----gals-- 3

- 50 and when the aggregate is thoroughly coated therewith and while the agitation is being continued, adding to the mixture,

- 55 Pulverized bitumen----- from 10 to 20 pounds

14. The method of making a paving material, comprising agitating together, at ordinary atmospheric temperatures,

- 60 A mineral aggregate, substantially----lbs-- 2000
A high-penetration asphaltic cement, solid at atmospheric temperatures, substantially-----lbs-- 90
A slowly volatile solvent of said cement, substantially-----gals-- 3

- 65 and when the aggregate is thoroughly coated therewith, and while the agitation is being continued, adding to the mixture,

- 70 Pulverized asphalt----- from 10 to 20 lbs.
Hydrated lime----- from .6 to 2 lbs.

15. The method of making a paving material

which comprises agitating together, at ordinary atmospheric temperatures,

- A mineral aggregate, substantially----lbs-- 2000
A high-penetration asphaltic cement, which is solid at atmospheric temperatures

- lbs-- 90
A slowly volatile solvent of said cement, substantially-----gals-- 3

and when the aggregate is thoroughly coated therewith and while the agitation is being continued, adding to the mixture,

- Pulverized asphalt----- from 10 to 20 pounds
Lime----- from .6 to 2 pounds
Sandy fines----- from 80 to 160 pounds

16. The method of making a paving material, which comprises agitating together

- A mineral aggregate, substantially----lbs-- 2000
A high-penetration asphaltic cement, solid at atmospheric temperatures, substantially-----lbs-- 90
A slowly volatile solvent of asphalt-----

in quantities sufficient to render said high-penetration asphaltic cement quite fluid without the application of heat thereto and when said aggregate is thoroughly coated with said high-penetration cement and while the agitation is being continued, adding to the mixture a small quantity of pulverized asphalt sufficient to impart to the resulting cement the penetration, firmness and high ductility requisite to hold the pieces of aggregate in fixed relationship after said solvent has volatilized therefrom.

17. The method of making a paving material for road making, wherein the aggregate is required to be bound together with a bituminous cement of a specified penetration, which comprises the mixing of said mineral aggregate with a bituminous cement, normally solid at atmospheric temperatures and normally having a penetration substantially higher than said specified penetration, but reduced to fluidity at atmospheric temperatures by the presence of a slowly volatile solvent in said mixture, whereby the pieces of aggregate may be thoroughly coated with said higher penetration cement without the application of artificial heat thereto, and thereafter adding to said mixture, with agitation, a small quantity of hard pulverized bitumen, soluble in said solvent and in said higher penetration cement, the quantity of pulverized bitumen so added being merely sufficient to produce in the finished material, when the solvent is evaporated, a cement of said specified penetration and no lower.

18. The method of making a material for road making, which consists in adding to the mineral aggregate, wherein the aggregate is required to be bound together with a bituminous cement of a specified penetration, a slowly volatile fluxing oil and liquefier, a bituminous paving cement having a penetration higher than approximately 135, and then adding, with agitation, a hard powdered bitumen and mixing said ingredients thoroughly before laying the same as a pavement course, the quantity of said hard powdered bitumen being small and merely sufficient to bring the penetration of the resulting cement down to but not lower than the specified penetration.

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