Dec. 7, 1937. S. E. FINLEY 2,101,388

PROCESS OF CONSTRUCTING PAVEMENTS

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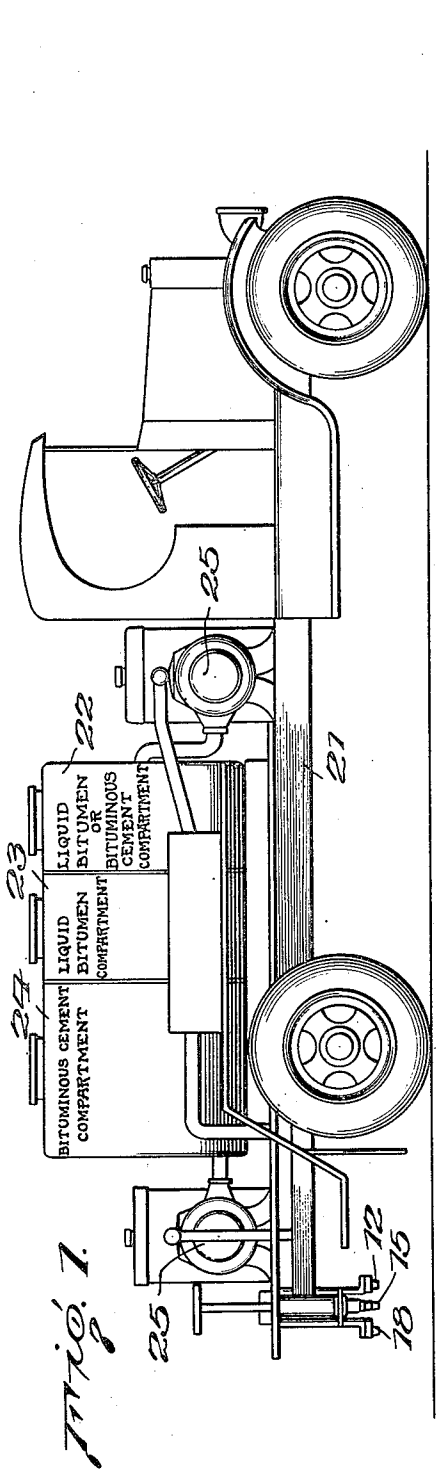


Fig. 1.

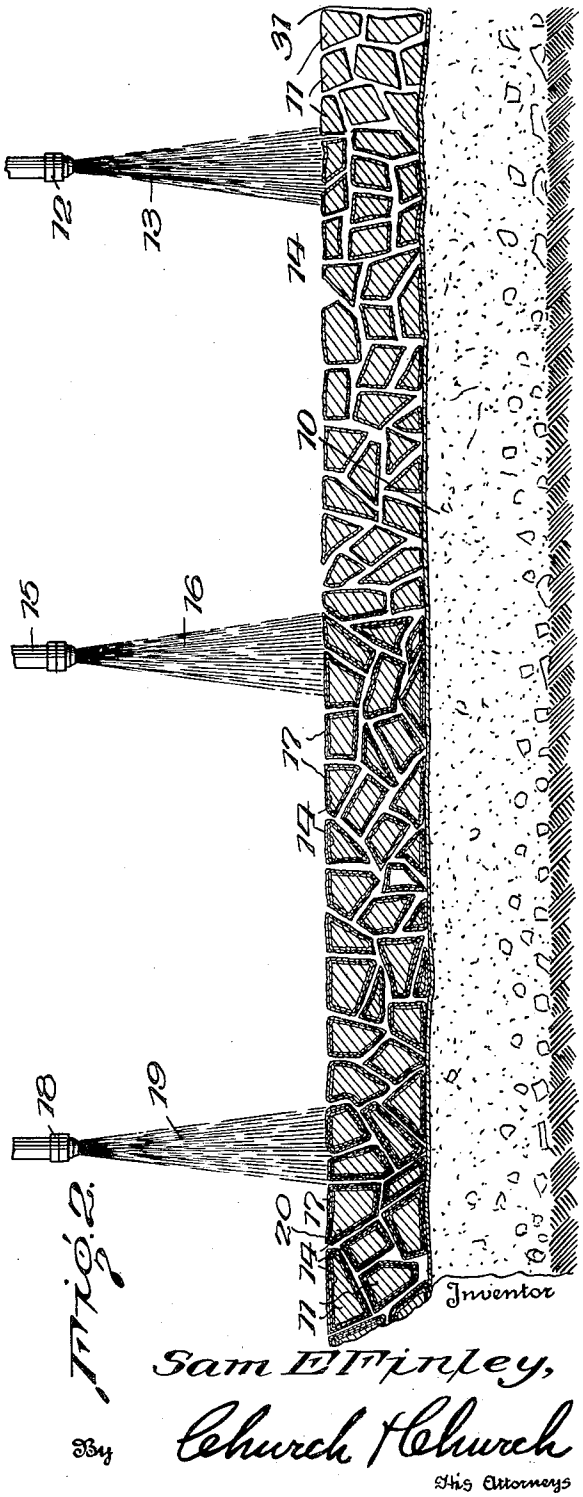


Fig. 2.

Inventor

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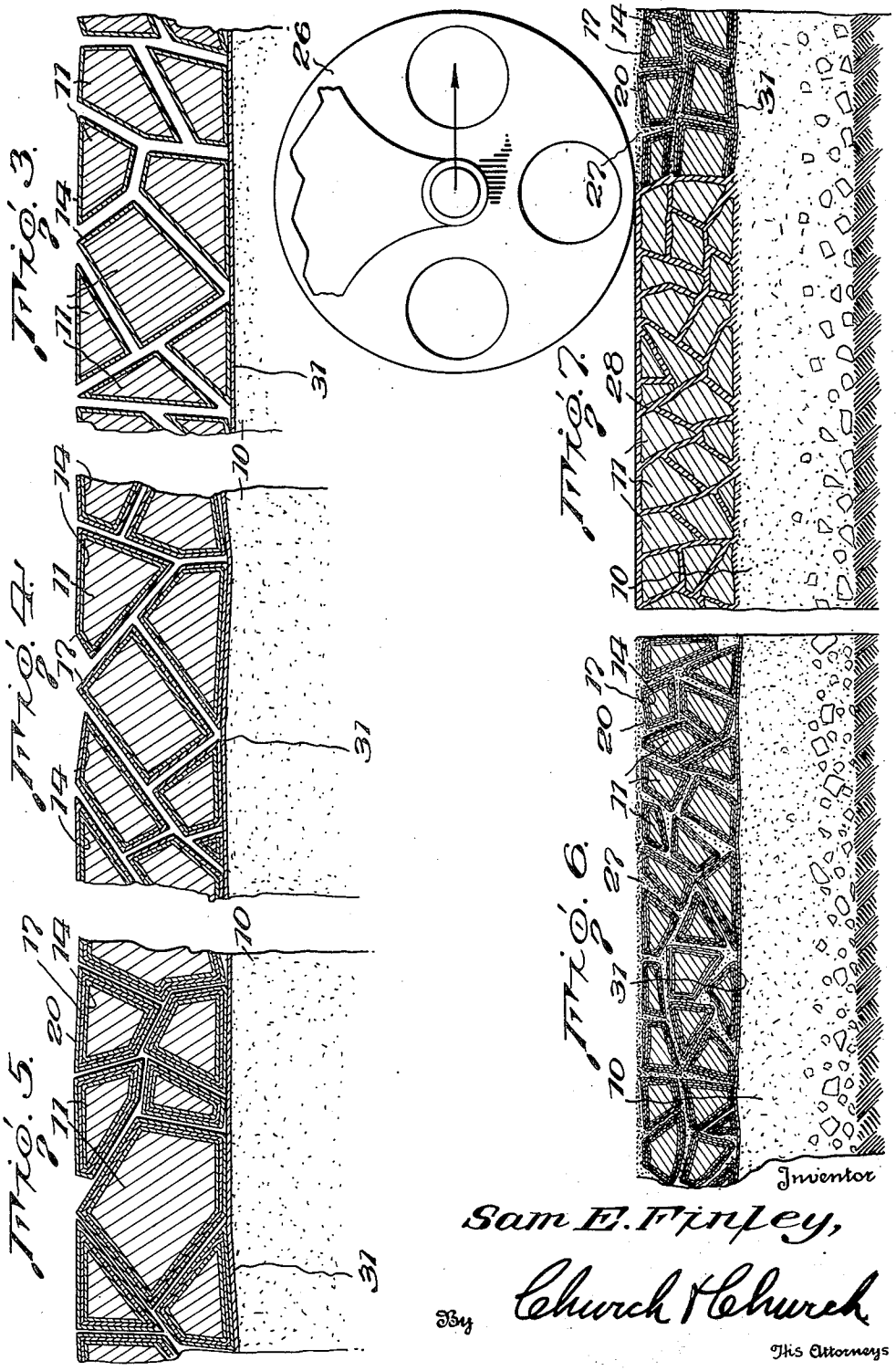
By Church & Church

His Attorneys

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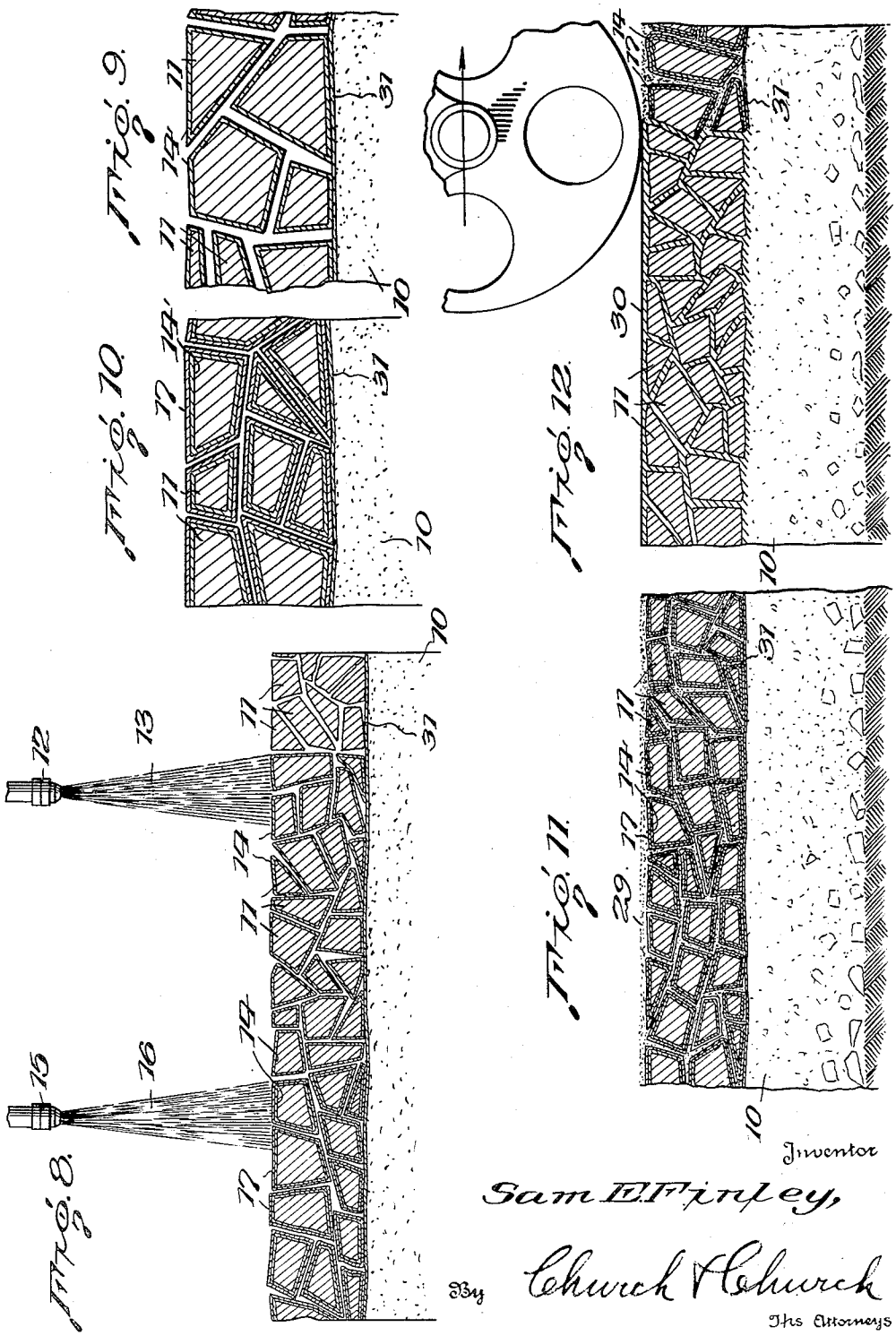
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PROCESS OF CONSTRUCTING PAVEMENTS

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Patented Dec. 7, 1937 2,101,388

UNITED STATES PATENT OFFICE

2,101,388

PROCESS OF CONSTRUCTING PAVEMENTS

Sam E. Finley, Atlanta, Ga.

Application February 7, 1935, Serial No. 5,485

7 Claims. (Cl. 94—23)

My invention relates to improvements in the process of constructing pavements, and has to do, more particularly, with a novel and improved method of constructing bituminous pavement in which mineral aggregates are bonded together by a bituminous cement so as to form a tough, malleable, durable, wear-resistant and water-excluding pavement.

My present invention is, in certain respects, an improvement upon that disclosed in U. S. Letters Patent No. 1,845,405, issued to me on February 16, 1932, and also upon that disclosed in my pending application for U. S. Letters Patent, Serial No. 741,312, filed August 24, 1934, upon which U. S. Letters Patent No. 1,991,319, issued on February 12, 1935.

The principal object of my present invention is to provide a method by which a tough, malleable, durable, wear-resisting and water-excluding bituminous pavement may be constructed more economically than by any methods heretofore known.

One of the objects of my invention is to provide a process for making pavements which does not have the defects characteristic of the present standard practices. For instance, in the present state of the art, a large proportion of the material cast over the previously applied asphaltic cement in surface treatments is wasted, and one of the principal objects of my invention is to provide a process which eliminates this waste. According to the present standard practice in single surface treatment, the road foundation is first primed with a suitable material, either a coal tar product or an asphalt cut-back, and, after this has been allowed to dry out, or the volatile matter allowed to escape, which requires from ten days to three weeks depending upon the weather, there is then applied an asphaltic cement, usually having a penetration greater than 150 at 77° F., and over this stone chips, crushed gravel or slag, in the desired quantity, are cast and rolled and the roadway then opened to traffic. A large percentage of the aggregates so cast upon the surface does not adhere thereto immediately with the result that the traffic sweeps the same into windrows at each side of the roadway and much of it falls over the sides and away from the roadway proper. This waste cannot be estimated accurately but it is certainly not less than 10% and, in some instances and seasons of the year, it will run as high as 20%. Even under the most favorable conditions, only a portion of the aggregates is ultimately coated with the bituminous cement. In this single surface treatment, the crushed mineral aggregates are small in size, such as those that will pass through a ¾" ring and be retained on a ¼" ring.

In what is known as double surface treatment, a larger size of aggregate is used for the first course over the previously applied asphaltic cement, the coarser aggregates being in some instances as large as 1¼". Over the previously primed base there is applied a stable bitumen. Over this bitumen there is spread a layer of coarse aggregate, which is rolled and given over to traffic. From one to six months later a seal coat is applied, but in the interval between spreading the coarse aggregate and the application of the seal coat much of the aggregate is swept off by traffic or broken up under traffic, thereby causing considerable waste. At the time the final or seal coat is applied it is common to sweep by mechanical or hand brooms all loose aggregate that remains on the surface, and that has not become bonded by the asphaltic cement, and then to apply a final coat of bitumen, which in turn is covered with a finer aggregate. This finer aggregate is in part swept off and broken up by traffic, with the result that there is another major waste of materials.

One of the main objects of my invention, therefore, is to provide a process of constructing bituminous pavements of better quality than those produced by the standard practices just described and in which no considerable portion of the aggregates will be wasted or swept off of the road by traffic or in the construction of the pavement.

In U. S. Letters Patent No. 1,845,405, mentioned above, I have disclosed the construction of a bituminous pavement from a mobile and workable road surfacing material, which is laid cold and then set up to form a paved roadway by the application of pressure at ordinary atmospheric temperatures, as by a road roller or by traffic. This road surfacing material consists of a mineral aggregate, the individual particles of which have an inner coating of stable bituminous cement and an outer coating of bituminous flux, devoid of light volatile matter, fluid at atmospheric temperatures and capable of amalgamation with the inner coating to form a bituminous cement of higher penetration than said inner coating. This material is plant-mixed, that is to say, the inner and outer coatings are applied to the individual particles of the aggregate at a mixing plant from which the material is transported to the job and spread into place on the roadway, the finished pavement being formed by the application of pressure to cause an amalga-

mation of the inner and outer coatings, forming a bituminous cement which bonds the individual particles of aggregate together.

In U. S. Letters Patent, No. 1,991,319, I have disclosed an improvement upon the invention of said Patent, No. 1,845,405, in which the pavement is formed of mobile and workable road surfacing material consisting of a mineral aggregate the individual particles of which have applied thereto a three-ply bituminous coating of varying consistency comprising an intermediate layer of stable bituminous cement sandwiched between inner and outer layers of bituminous material, liquid at atmospheric temperatures. This road surfacing material is also plant-mixed, that is to say, the individual particles of the aggregate have the three coatings applied to them at a mixing plant, after which the material is transported to the job, laid on the roadway and set by the application of pressure.

One of the main objects of the present invention is to provide a process of constructing bituminous pavement which will give results very nearly approaching, if not quite equaling, those obtained with the plant-mixed material heretofore mentioned, but with a great saving in cost to the taxpayer.

Certain of the objects which I seek to attain by my present invention may be made more clearly apparent by a general consideration of the function of bitumen, or bituminous cement, in the construction of pavement. Of course, it must serve as a bond between the individual particles of the aggregate but, in order to give a product having a certain amount of workability when cold, the bitumen should be adhesive, stable and fluid, and should exclude water; the bitumen must be adhesive so that it may adhere at all points to the aggregate to which it is applied or else the aggregate and bitumen will fall away from each other into a heterogeneous disintegrated mass having no value as a road structure. The bitumen or bituminous cement must also be stable or the road structure will shove, rut, and wave, with an increasing plasticity until it can no longer be used by traffic. On the other hand, the bitumen or bituminous cement should be fluid under construction so as to permit shoveling, raking, screeding, and other manipulation, prior to the application of pressure thereto to cause it to set up to form the finished road structure. Finally, the bitumen must exclude water so that the resulting structure is waterproof, because, the penetration of water into the structure is very objectionable and may be characterized as the worst enemy of all pavements.

Unfortunately, there is no bitumen which, in itself, combines each of these required characteristics in high degree. Some grades of bitumen are so adhesive that neither temperature nor moisture can separate the bitumen from the aggregate, but such bitumens have little or no stability. Other grades of bitumen are sufficiently stable to withstand traffic stresses, but they are fluid only when hot and cannot be used by themselves as the bonding material in a product of the type which is laid cold. Still other grades of bitumen have ample fluidity, so as to allow ready manipulation or working of the material prior to set-up, but they are entirely lacking in stability. A high value in one required characteristic could, therefore, under the prior art, only be had by sacrificing needed values in other characteristics. As a result, refiners and road-builders were forced to compromise by using grades of bitumen having some of each required property, but lacking high value in any. The use, by itself, of bitumen of this compromise character as a bonding material in a product to be laid cold, has proven unsuccessful. One of the main objects of my invention is to provide a process of constructing a bituminous pavement, in which the aggregates are cemented together by a bonding material of bituminous character but having the maximum adhesion, stability, and liquidity prior to set-up, and the maximum power of excluding water. In other words, a leading object of my invention is to provide a process for constructing bituminous pavements in which the individual particles of the aggregate are coated with a bonding material made up of bitumens of different characteristics, applied where the characteristic is most needed, and yet co-acting to form a bituminous bonding agent that provides maximum adhesion to the aggregate; maximum stability of the bonding agent as a whole; maximum fluidity or workability of the particles of the aggregate prior to set-up; and maximum ability to exclude water after the material has been set up or amalgamated by the application of pressure thereto, the said coatings being applied to the aggregate in situ, that is, after the aggregate has been spread in proper position upon the roadway or surface to be paved.

Further objects, and objects relating to details and economies of operation, will definitely appear from the detailed description to follow. In one instance, I have accomplished the objects of my invention by the devices and means described in the following specification. My invention is clearly defined and pointed out in the appended claims. The application of the improved process of my invention in the construction of roadways is diagrammatically illustrated in the accompanying drawings, in which:

Figure 1 is a view in side elevation of the spreader, or spraying equipment, for applying the successive coatings to the individual particles of the aggregate in situ;

Fig. 2 is a diagrammatic view of a section of roadway under construction illustrating the successive application of three coatings to the particles of aggregate;

Fig. 3 is an enlarged diagrammatic view illustrating the aggregate with the inner coating applied thereto;

Fig. 4 is a corresponding view illustrating the aggregates with the inner and intermediate coatings applied;

Fig. 5 is a similar view illustrating the aggregates with the inner, intermediate and outer coatings applied thereto;

Fig. 6 is a similar view of a section of the roadway showing the application of finer aggregate to the triple-coated aggregate so as to remove excessive stickiness and fill surface voids;

Fig. 7 is a corresponding view showing the application of pressure by a road roller to cause the material to set up to form the finished pavement;

Fig. 8 is a diagrammatic view of a section of roadway showing the application of two coatings of bituminous material to the individual particles of the aggregate in situ;

Fig. 9 is a diagrammatic view of a portion of this roadway showing the particles of the aggregate having the inner coating applied thereto;

Fig. 10 is a similar view showing the double-coated particles of the aggregate;

Fig. 11 is a similar diagrammatic view showing a layer of the double-coated aggregate having

its surface voids filled with a fine aggregate which has been coated with liquid asphalt; and

Fig. 12 is a view showing the application of pressure to the material shown in Fig. 11, to cause it to set up to form the finished roadway.

In the drawings, the same reference numerals indicate the same parts throughout the several views.

In general, my invention consists in a process of constructing bituminous pavement by coating the mineral aggregates, in place, at air temperature, whether such aggregates be placed to form the foundation, or placed on any suitable foundation such as concrete, brick, water-bound macadam, clay-gravel, sand-clay, and the like, to ultimately become the wearing surface. My present invention is equally meritorious in relatively thin surfaces, such as those commonly termed "surface treatments" as it is in the heavier types of surfacing such as black base, and penetration and bituminous macadam, the latter usually ranging in thickness from 1½" upward.

I propose, instead of applying the inner and outer coatings of my patent, No. 1,845,405, or the three coatings of my patent, No. 1,991,319, to the individual particles of aggregate in a mixing plant, to, first, lay the aggregate in position upon the roadway or surface to be paved and, then, apply to such aggregate, in situ, the successive coatings, after which pressure is applied to the double-coated or triple-coated aggregate to cause the amalgamation of these coatings and the setting-up of the structure into the finished pavement. In other words, I find that I can extend the basic principles of the plant-mixed multi-coated product with all its advantages, to a surface-coated multi-coated pavement. By the term "surface-coated" I mean that the aggregates used in the pavement are placed on the roadway in an uncoated condition and there given a multiple coating of bitumen, as for example, by mechanical spraying machines designed and operated to properly coat the aggregates with the proper amount of bitumen, and in the desired sequence.

In general, my improved process consists in, first, spreading on the area to be paved a uniform layer of mineral aggregate of the proper gradation, quality and amount. I, next, by means of a spraying machine or its equivalent, apply a plurality of coatings of bitumen to these aggregates. I, then, seal the surface against the entrance of water by filling the upper voids with fine aggregate, which may be coated with bitumen prior to spreading, or which may receive its priming coat of bitumen from the third or outer layer of bitumen sprayed on the coarse aggregates. Finally, the whole structure is thoroughly compacted by rolling and traffic to secure a complete amalgamation so as to cause the material to set up to form the finished roadway.

It is common knowledge that aggregates of the size used in road construction are completely wetted on all sides during a rain, when exposed to it, although no rain strikes directly against the under sides of such aggregates. This wetting without direct application is due to the high fluidity of the water, its surface tension and capillarity, when sufficient dust adheres to the aggregate to provide the necessary capillary tubes or the equivalent. For the same reasons, the liquid bitumen that I use for the initial coating of such aggregates will also follow the surface of each particle of the aggregate until it is properly coated, even though this liquid bitumen is not applied directly to all sides of the particles. The grade of bitumen that I prefer for this initial or priming coat is a petroleum product free from light volatiles and containing between 50% and 80% of 100 penetration asphalt at 77° F. Such material known to the art as "liquid bitumen" is an asphaltic base straight run residual oil having a penetration in excess of 350 millimeters when tested for one second at 77° F. with a needle weighted with 50 grams. The definition "50% to 80% of 100 penetration asphalt at 77° F." is used, in accordance with common practice in the art, to describe a range of products such that the heating would have to be continued to reduce the liquid to between 50% and 80% of its original volume in order to obtain a 100 penetration asphalt, that is, an asphaltic residue having a penetration of 100 millimeters when tested for five seconds at 77° F. with a needle weighted with 100 grams, which are the standard test conditions. By the term "free from light volatiles", is meant a liquid bituminous material containing no volatiles that will readily evaporate from the pavement at the temperatures to which a pavement would be subjected, that is up to approximately 120° F. A common test for such light volatiles is to determine the "flash point" by slowly heating the asphalt and applying a flame to the surface as the temperature rises, and observing at what temperature ignitible volatiles are driven off. This bitumen is heated to proper fluidity for quickly flowing over the surface of each piece of aggregate so that it will prime its entire area, entering into the surface voids and pores of each particle of aggregate to form a perfect waterproof bond between aggregate and bitumen and leaving sufficient free bitumen on the surface to combine or amalgamate with the heavier asphalt of the second coating so as to form with that heavy asphalt, after amalgamation, a binding medium of the desired quality. Immediately after the first application of liquid bitumen, I apply my second bitumen coating which is preferably a standard asphaltic cement having a penetration of between 80 and 100 at 77° F. under standard test conditions. This second coating is applied directly upon the first coating and so soon thereafter that no material physical or chemical change occurs in the first coat prior to the application of the second coat, thus allowing the second coating to flow along with the first coating and over its surface to give the desired double coating.

I thus secure a double coating of each particle of aggregate such that all dust particles on the surface of the uncoated aggregate either have been driven off by the force of the spray or are embedded in the bitumen; the surface of each piece of aggregate is fully primed and waterproofed, that is, the bitumen has entered into each pore, crevice, and re-entrant facet on the surface to provide full contact therewith so as to prevent water from seeping between the surface of the aggregate and the first coating to destroy the pavement; it is the lighter portion of the liquid asphalt that first penetrates and primes the aggregate so that the heaviest portion remains on the surface of each piece of the aggregate and there is sufficient, after such absorption, to combine with the heavy stable bitumen applied as a second coating and amalgamate with it to form a bituminous cement of the desired quality, stability and durability.

In accordance with the process of my present

invention, the coarse aggregate laid on the roadway may there be coated with a coating of liquid bitumen followed by bituminous cement, after which I apply a layer of fine aggregates which has first been primed or coated with a liquid bitumen, so that it will combine with the heavy bitumen on the outside of the coarse aggregate, thus leaving the heavy bitumen as a sandwich between the first coating of the coarse aggregate and the liquid coating of the fine aggregate. This application of fine pre-coated aggregate constitutes a seal coat filling the surface voids of the structure.

I also contemplate, as within my present invention, the triple-coating of the aggregate, when in place in the roadway, with coatings of the character described in my patent, No. 1,991,319. That is to say, instead of applying the third coating through the precoated fine aggregate, I apply the third coating directly to the coarse aggregate so soon after the application of the previous coatings that no material change occurs in the heavy bitumen prior to receiving its outer coating of liquid bitumen. I prefer to use for this third coating the same bitumen used for the initial coating.

After completing this triple-coating of the aggregate, the following conditions obtain in the mass of aggregate. Each particle of aggregate carries three superimposed layers of bitumen with a soft layer of bitumen in contact with the surface of the aggregate as an inner layer, and a similar soft layer of soft bitumen as an outer or third layer, while between these layers there is sandwiched a coating of heavy bitumen which, under pressure, such as that of a road roller, will combine or amalgamate with the soft bitumen on each side to form a stable and enduring binding agent of the desired quality. The mass of triple-coated aggregate, which is now ready for amalgamation under the pressure of the road roller or traffic, may, however, be moved readily by blading or otherwise, so that a perfect smoothness of the mass may be secured or any inequalities of the road foundation taken out and there will be no set-up during such manipulation, but, upon compacting by means of a road roller or traffic, amalgamation of the heavy bitumen sandwiched between the two layers of light bitumen takes place and set-up occurs from such pressure, resulting in a stable and durable pavement.

Whether I apply to the particles of aggregate, directly, two or three layers of bitumen, I fill the surface voids in the coated coarse aggregate with a fine aggregate before final compaction. This fine aggregate may be coated and primed, first, with the same bitumen used for the initial coating of the coarse aggregate. I prefer to use this pre-coated fine aggregate to fill the surface voids after double-coating the coarse aggregate, and in case the coarse aggregate is triple-coated I prefer to use an uncoated fine aggregate seal, because this fine aggregate absorbs and is coated by the outer layer of bitumen on the triple-coated coarse aggregate and thus becomes primed and entirely covered with bitumen.

For applying these multiple coatings to the aggregate in situ, I prefer to use a single spraying machine, although I may use ordinary bituminous distributers driven in tandem and so closely following each other that no material physical or chemical change occurs in any one coating prior to applying the succeeding coating. The single spraying machine, that I prefer to use for applying these multiple coatings, is illustrated somewhat diagrammatically in Fig. 1. It consists of a tank having separate compartments **22**, **23**, and **24**, for the different bituminous materials used, each compartment being connected with a separate system of header-bars and spray nozzles so that the correct amount of bitumen from any compartment may be forced by the pumps **25** through its spray nozzles and, thence, over the roadway. The header-bars are placed at the rear of the tank, in parallel rows at right angles to the line of travel and equally spaced above the road surface to be treated. The compartmented tank and distribution system is mounted on a motor truck **21** or other vehicle so that it may be moved over the aggregate at the proper speed for correct coverage. Each header-bar is designed for attaching sets of nozzles of different size so that the proper ratio of application can be secured. Thus, the nozzles **12** will be connected with a compartment **23** containing liquid bitumen, the nozzles **15** with the compartment **24** containing bituminous cement and the nozzle **18**, if a triple coating is to be applied, with the compartment **22** containing liquid bitumen. The valves admitting bitumen to the nozzles are arranged to open in such sequence that the forward nozzles **12** begin to spray bitumen in advance of the central nozzles **15**, which in turn begin to spray in advance of the rear nozzle **18**. This timing is desirable to secure, at the start, a triple-coating in which the heavy bitumen is sandwiched between the liquid bitumen of the first and second coatings.

Referring to Figs. 2 to 7, inclusive, the base or surface upon which the pavement is to be constructed is shown at **10**. To this base a priming coat **31** of liquid asphalt is applied. The coarse aggregate comprises the particles **11**, which are deposited upon the primed base in substantially the positions they occupy in the finished pavement, before the priming coat has dried or set. As the spraying machine passes over this bed of uncoated aggregates, the nozzle **12** delivers a spray **13** of liquid bitumen upon the uncoated particles of aggregate so as to apply thereto the inner coating **14** of liquid bitumen. Then, as the nozzles **15** pass over the particles to which the inner coating has been applied, a spray **16** of bituminous cement is applied therefrom upon such coated particles so that the intermediate coating **17** of bituminous cement is applied to each of these particles. Then, as the nozzles **18** pass over these double-coated particles of aggregate the final coating **20** of liquid bitumen is applied to such particles by the spray **19**. Finally, a quantity of fine aggregate **21**, such as screenings or sandy material, is spread over the layer of triple-coated aggregate so as to close the surface voids therein and, then, the structure is compacted by the application of pressure thereto, as by the road roller **26** or by traffic thereover, with the result that the heavy bitumen of the intermediate layer or coating amalgamates with the liquid bitumen coatings to form a bituminous binding medium **28** which cements the particles of aggregate together in a finished roadway which is tough, durable, wear-resistant and water-excluding.

In Figs. 8 to 12, inclusive, I have illustrated diagrammatically the embodiment of my invention in which the particles of aggregate are double-coated and a pre-coated fine aggregate then applied. Referring to Fig. 8, a layer of ag-

gregate is placed upon the base or surface 10, primed as indicated at 31, and the particles 11 of said aggregate are given an initial coating 14 of liquid bitumen by the spray 13 coming from the nozzles 12. This is immediately followed by the application of the second coating 17 of bituminous cement by the sprays 16 coming from the nozzles 15. A quantity of fine aggregate 29, which has been previouly coated with the liquid bitumen such as that used for the coating 14, is then distributed over the surface of the layer of double-coated aggregate 11, so as to fill the surface voids therein, and then the structure is compacted by application of pressure, as by means of the road roller 26, causing the amalgamation of the liquid bitumen and bituminous cement to form a bituminous binding medium 30 which forms the surface of the roadway and cements the particles 11 together to form a tough, durable, wear-resistant and water-excluding pavement.

In order to make my invention entirely clear and to give full instructions to the art as to the practice thereof, I give the following specific examples of construction methods embodying my invention:

Upon a properly shaped and compacted base of suitable material that has been primed with tar or asphalt, I spread 40 lbs. per square yard of crushed stone having a toughness of at least 6 and 95% of which will pass a ¾" ring and be retained on a ¼" ring. This layer of crushed stone is rolled once with a 5-ton roller to give it proper smoothness. I, next, pass over the smooth layer of uncoated stone with a spraying equipment and, in passing, apply an inner coating to the particles of aggregate consisting of .15 of a gallon per square yard of liquid asphalt containing 65% of 100 penetration asphalt at 77° F., and containing no light volatiles, heated to proper fluidity for a full coverage of the stone particles. As a second or intermediate coating of heavy asphalt, I apply from .35 to .45 of a gallon per square yard of asphalt having a penetration of 85 at 77° F. I, next, roll the surface to increase its smoothness, after which I fill the surface voids in the double-coated coarse aggregate with a fine aggregate, which has been coated when air dry with from 1% to 2% of liquid asphalt of the same character as used for the initial coating of the coarse aggregate. This coating of the fine aggregate may be done in any approved ordinary mixing plant such as a concrete mixer. This fine aggregate is preferably of such gradation that 95% will pass a ¼" ring and not over 30% will pass a 10-mesh screen. I use from 10 to 15 lbs. per square yard of this coated fine aggregate, which is swept into the surface voids in the coated coarse aggregate. I, then, compact the entire structure thoroughly by application of pressure thereto, as by rolling with a road roller or traffic, and thereby effect complete amalgamation of the several bituminous coatings, so as to form therefrom a bituminous binding medium of higher penetration than said second coating, which cements the particles of aggregate to form a tough, durable, wear-resistant and water-excluding bituminous pavement.

Another specific example of a method of construction embodying my invention is, as follows: Upon the same type of primed base, as in the previous example, I spread a layer of crushed stone, which is rolled to get a proper smoothness and to which a first coating of liquid asphalt and a second coating of heavy asphalt is applied, as described in the previous example. I, then, by the spraying machine, apply .15 of a gallon per square yard of the same type of liquid asphalt as used for the initial coating, to form the third or outer coating of the particles of coarse aggregate. Over this triple-coated aggregate I, then, cast sufficient sandy material to remove excessive stickiness and fill the surface voids. The entire structure is then thoroughly compacted by the application of pressure, as by rolling with a road roller or traffic, causing the amalgamation of the several bituminous coatings to form a bituminous cement of higher penetration than the second coating, which acts as a bond for the particles of aggregate so as to form a tough, durable, wear-resistant and water-excluding bituminous pavement.

The utility of my invention, as embodied in the practice set forth in the preceding example, will be apparent when compared with standard practice, as indicated in the specifications of State highway departments for construction approved by the U. S. Bureau of Public Roads. For instance, the standard practice set forth in the current specifications of the North Carolina Highway Department require that the primed base should be first swept, a cut-back asphalt then applied thereto and a layer consisting of 40 lbs. per square yard of 1" stone then spread thereon. This is under maintenance for from two to six months, consisting of rolling, repairing of breaks and sweeping back upon the surface stone that has been whipped off by traffic and lost. The surface is then cleaned of all foreign matter carried into the surface by the two to six months traffic and all the loose stone is swept off. Then, a cut-back asphalt is applied and the surface is covered with a ¾" stone aggregate, which has to be rolled, dragged, swept and maintained for thirty days, repairing all pick-ups and breaks, sweeping back onto the surface stone that has been whipped off by traffic and adding new stone, when there is insufficient recovered from the material whipped off.

It will be noticed that a surface constructed under the foregoing specifications, which represent standard practice, requires from three to seven months after priming the road before it is completed. Under such common practice, much of the aggregate placed on the roadway is ground into dust and blown away during the three to seven months and thus wasted. Other aggregate is whipped off into the ditches on either side and lost. Some is thrown into the air at high velocities by automobile wheels and is likely to break headlights, windshields and do other damage. On the other hand, in accordance with the method of construction of my present invention, a mile of triple-coated surface may be started, finished and turned over to traffic as a dustless, completed pavement in less than five days. All of the aggregate that I apply to the road becomes pavement, thus avoiding the capital loss and the likelihood of damage to automobiles which is characteristic of the present standard practice, as described above.

Another specific example of the use of my invention, in this instance for the construction of 1½" penetration or asphalt macadam, is as follows: I spread two inches, loose, f crushed stone, 95% of which will pass the 1½" ring with not more than 10% passing the ¾" ring. This layer of aggregate is then rolled, brought to the desired

cross-section and graded. I, then, apply from .3 to .4 of a gallon per square yard of liquid bitumen to form a first coating on the particles of aggregate and follow this immediately with from .8 to 1 gallon per square yard of bituminous cement to form the second coating, such as an asphalt having a penetration of between 60 and 80 at 77° F. Over this I spread from 15 to 25 lbs. per square yard of fine aggregate as a choker course, this aggregate being of a size such that all of it will pass a ½" ring and not more than 10% will pass a ¼" ring. This fine aggregate is swept or otherwise manipulated so as to fill all the surface voids and the surface is then rolled to the desired cross-section and graded. I, then, apply from .15 to .2 of a gallon per square yard of liquid bitumen, which is followed immediately by the application of from .2 to .3 of a gallon per square yard of bituminous cement of the grade specified. If necessary, this structure is then covered lightly with stone screenings, coarse sand, or the like, and the entire structure is then thoroughly compacted by the application of pressure, as by a road roller, to cause the amalgamation of the various bituminous coatings and the set-up of the structure.

My invention is also applicable in the construction of a black base or foundation course. The following is a specific example of constructing such a foundation course. To form a black base for a 3" to 4½" base or foundation course, I first spread a layer of crushed mineral aggregate. This should be of such size that 95% to 100% of it will pass a 2½" ring; 50% to 75% of it will pass a 1½" ring and not more than 20% of it will pass a ¾" ring. This layer of mineral aggregate having been spread and rolled to the desired thickness and cross-section, I then apply, as a first coating, from .3 to .6 of a gallon per square yard of liquid bitumen, which is immediately followed by the application, as a second coating, of from 1½ to 2 gallons per square yard of asphaltic cement, or its equivalent, having a penetration of from 50 to 60 at 77° F. This is followed immediately by the application of from .1 to .2 of a gallon per square yard of liquid bitumen, such as was used for the first coating. The structure is then thoroughly compacted, as by rolling, so that the pressure exerted causes the amalgamation of the several bituminous coatings to form a bituminous cement as a bond between the several particles of aggregate.

In surface treatments, I prefer that the foundation should first be primed with any suitable liquid bitumen and that the mineral aggregates that are to form the wearing surface, and be coated ultimately as hereinafter described, be placed over the previously primed foundation while the same is wet, that is, before the prime coat has had time to completely set, so that the aggregate subsequently spread over the primed surface may be coated in part, on the under portions, by the bitumen used in the prime coat.

Wherever I have used herein, or in the following claims, the phrase "liquid bituminous material" or "bituminous material liquid at atmospheric temperatures and substantially free from light volatiles", there is meant a straight-run residual bituminous material containing between 50% and 80% of 100 penetration asphalt under standard test conditions. Similarly, wherever I have used herein, or in the following claims, the phrase "bituminous cement", there is meant an asphaltic cement having a penetration of from 80 to 100 millimeters, under standard test conditions, that is, when tested at 77° F., for five seconds with a needle weighted with 100 grams.

I am aware that my invention is susceptible of variation without departing from the spirit thereof and, therefore, I claim my invention broadly as indicated by the appended claims.

What I claim is:

1. The process of constructing pavements comprising the depositing of a layer of mineral aggregate upon the surface to be paved, the application to the individual particles of aggregate, while in place in such layer, of a first coating of bituminous material liquid at atmospheric temperatures and substantially free from light volatiles, the application to such coated particles of a second coating of bituminous cement also free from light volatiles, and the subjecting of said layer of coated aggregate to pressure to cause amalgamation of said coatings to form a bituminous cement of higher penetration than said second coating.

2. The process of constructing pavements comprising the application of a priming coat of liquid bitumen substantially devoid of light volatiles to the surface to be paved, the depositing of a layer of mineral aggregate upon said primed surface, the application to the individual particles of aggregate, while in place in such layer, of a first coating of bituminous material liquid at atmospheric temperatures and substantially devoid of light volatiles, the application to such coated particles of a second coating of bituminous cement, and the subjecting of said layer of coated aggregate to pressure to cause amalgamation of said coatings to form a bituminous cement of higher penetration than said second coating.

3. The process of constructing bituminous pavements comprising the depositing of a layer of mineral aggregate upon the surface to be paved, the application to the individual particles of said aggregate, while in such layer, of a first coating of bituminous material liquid at atmospheric temperatures and substantially devoid of light volatiles, the application to such coated particles of a second coating of bituminous cement, the application to such double-coated particles of a third coating of bituminous material liquid at atmospheric temperatures and substantially devoid of light volatiles, and the subjecting of said layer of triple-coated aggregate to pressure to cause amalgamation of said coatings to form a bituminous cement of higher penetration than said second coating.

4. The process of constructing bituminous pavements comprising the depositing of a layer of mineral aggregate upon the surface to be paved, the application to the individual particles of said aggregate, while in such layer, of a first coating of bituminous material liquid at atmospheric temperatures and substantially devoid of light volatiles, the application to such coated particles of a second coating of bituminous cement, the application to such double coated particles of a third coating of bituminous material liquid at atmospheric temperatures and substantially devoid of light volatiles, the depositing upon said layer of triple coated aggregate of fine aggregate, and the subjecting of said layer to pressure to cause amalgamation of said coatings to form a bituminous cement of higher penetration than said second coating.

5. The process of constructing pavements comprising the depositing of a layer of mineral aggregate upon the surface to be paved, the appli-

cation to the individual particles of aggregate, while in place in such layer, of a first coating of bituminous material liquid at atmospheric temperatures and substantially devoid of light volatiles, the application to such coated particles of a second coating of bituminous cement, the depositing upon said layer of coated aggregate of fine aggregate precoated with bituminous material liquid at atmospheric temperatures and substantially devoid of light volatiles, and the subjecting of said layer to pressure to cause amalgamation of said coatings to form a bituminous cement of higher penetration than said second coating.

6. The process of constructing pavements comprising the application of a priming coat of liquid bitumen substantially devoid of light volatiles to the surface to be paved, the depositing of a layer of mineral aggregate upon said primed surface, the application to the individual particles of aggregate, while in place in such layer, of a first coating of bituminous material liquid at atmospheric temperatures and substantially devoid of light volatiles, the application to such coated particles of a second coating of bituminous cement, the depositing upon said layer of coated aggregate of fine aggregate pre-coated with bituminous material liquid at atmospheric temperatures, and the subjecting of said layer to pressure to cause amalgamation of said coatings to form a bituminous cement of higher penetration than said second coating.

7. The process of constructing pavements comprising the depositing of a layer of mineral aggregate upon the surface to be paved, the application to the individual particles of aggregate, while in place in such layer, of a first coating of bituminous material liquid at atmospheric temperatures and substantially devoid of light volatiles, the application to such coated particles of a second coating of bituminous cement, the depositing upon said layer of a course of finer aggregate, the application to the individual particles of said finer aggregate of a first coating of bituminous material liquid at atmospheric temperatures and substantially devoid of light volatiles, the application to said coated particles of finer aggregate of a second coating of bituminous cement, and the subjecting of said layers to pressure to cause amalgamation of said coatings.

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