

May 15, 1951

G. A. FASOLD ET AL

2,552,947

COATED ROOFING

Filed Aug. 7, 1943

5 Sheets-Sheet 1

Fig. 1.

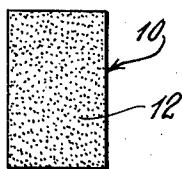


Fig. 2.

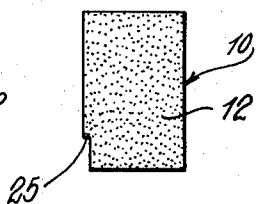


Fig. 3.

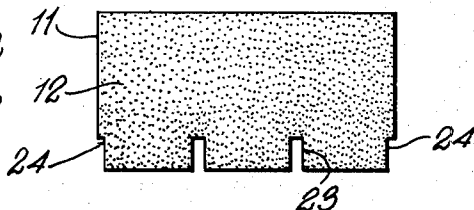


Fig. 4.

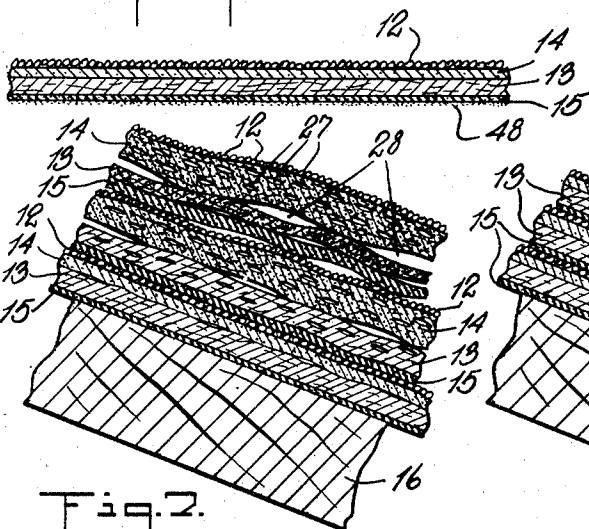


Fig. 5.

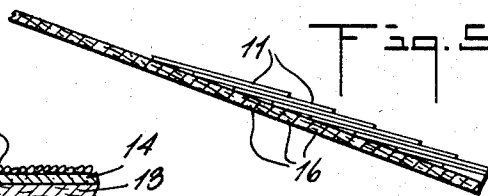


Fig. 6.

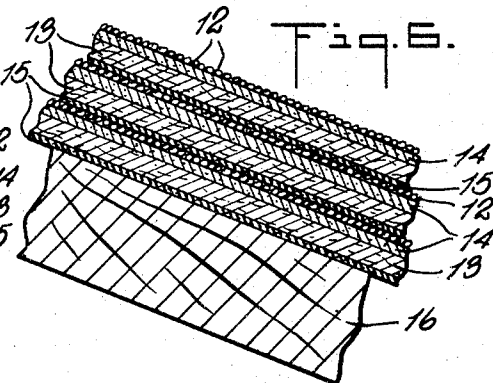


Fig. 7.

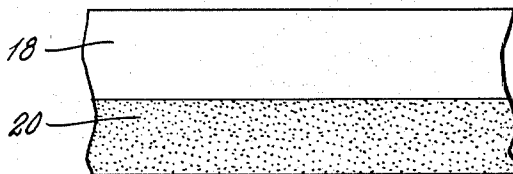
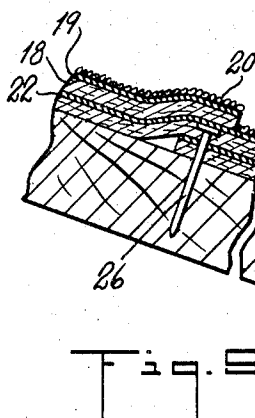
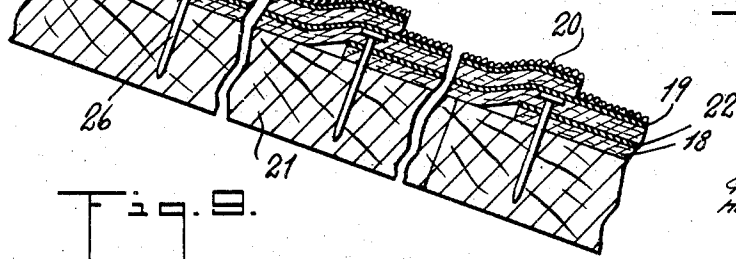


Fig. 9.

Fig. 10.



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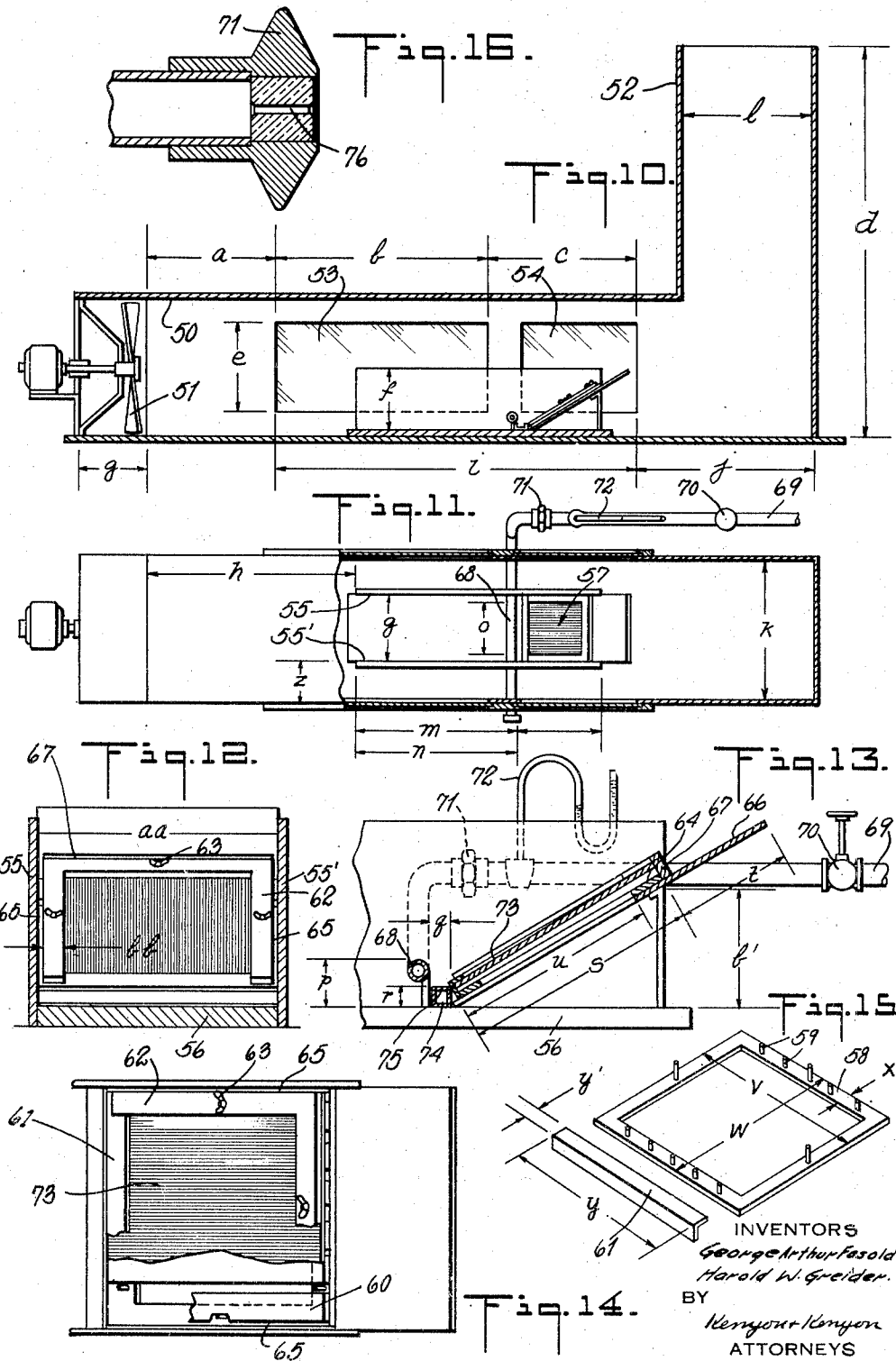
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5 Sheets-Sheet 2



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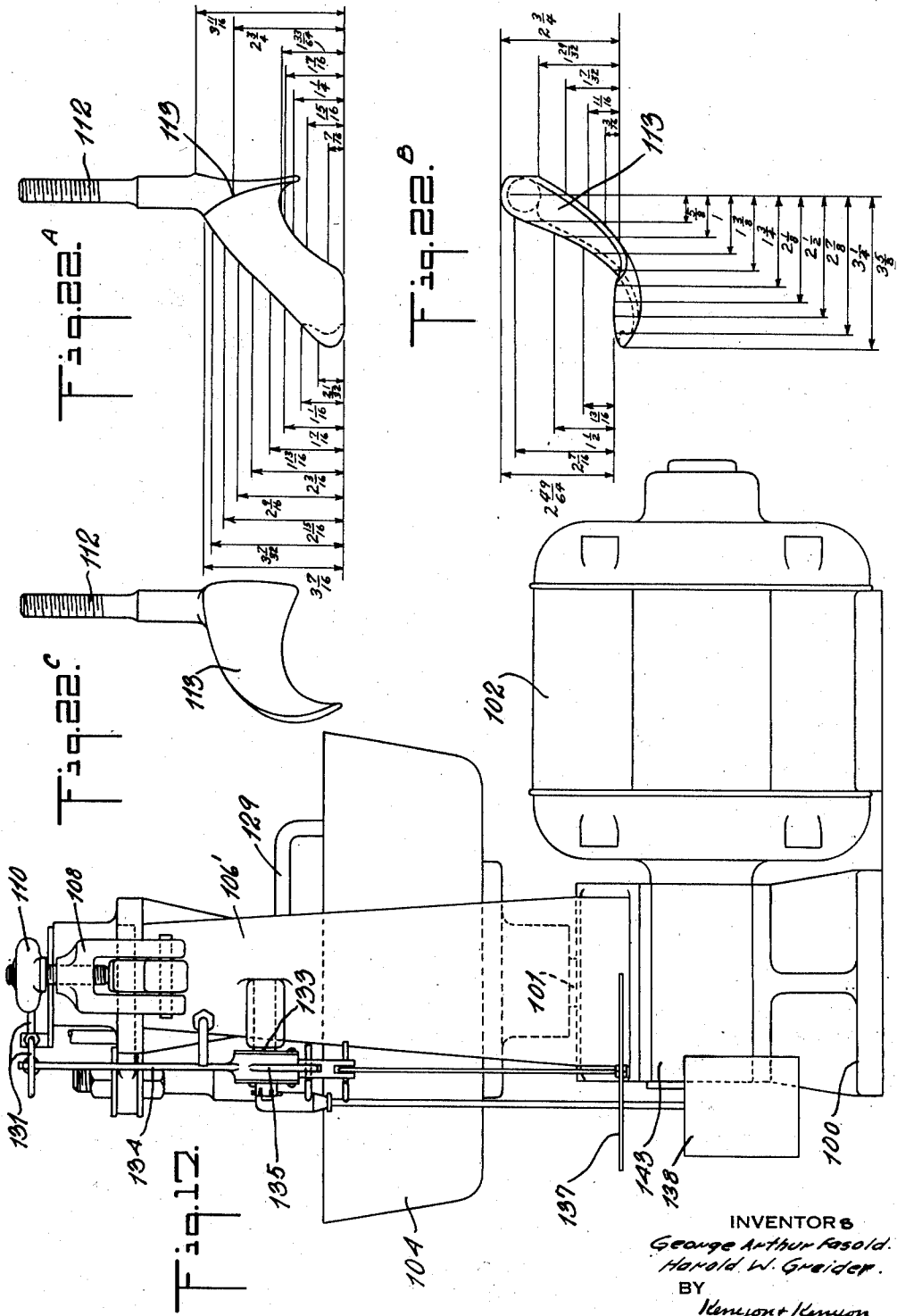
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5 Sheets-Sheet 3



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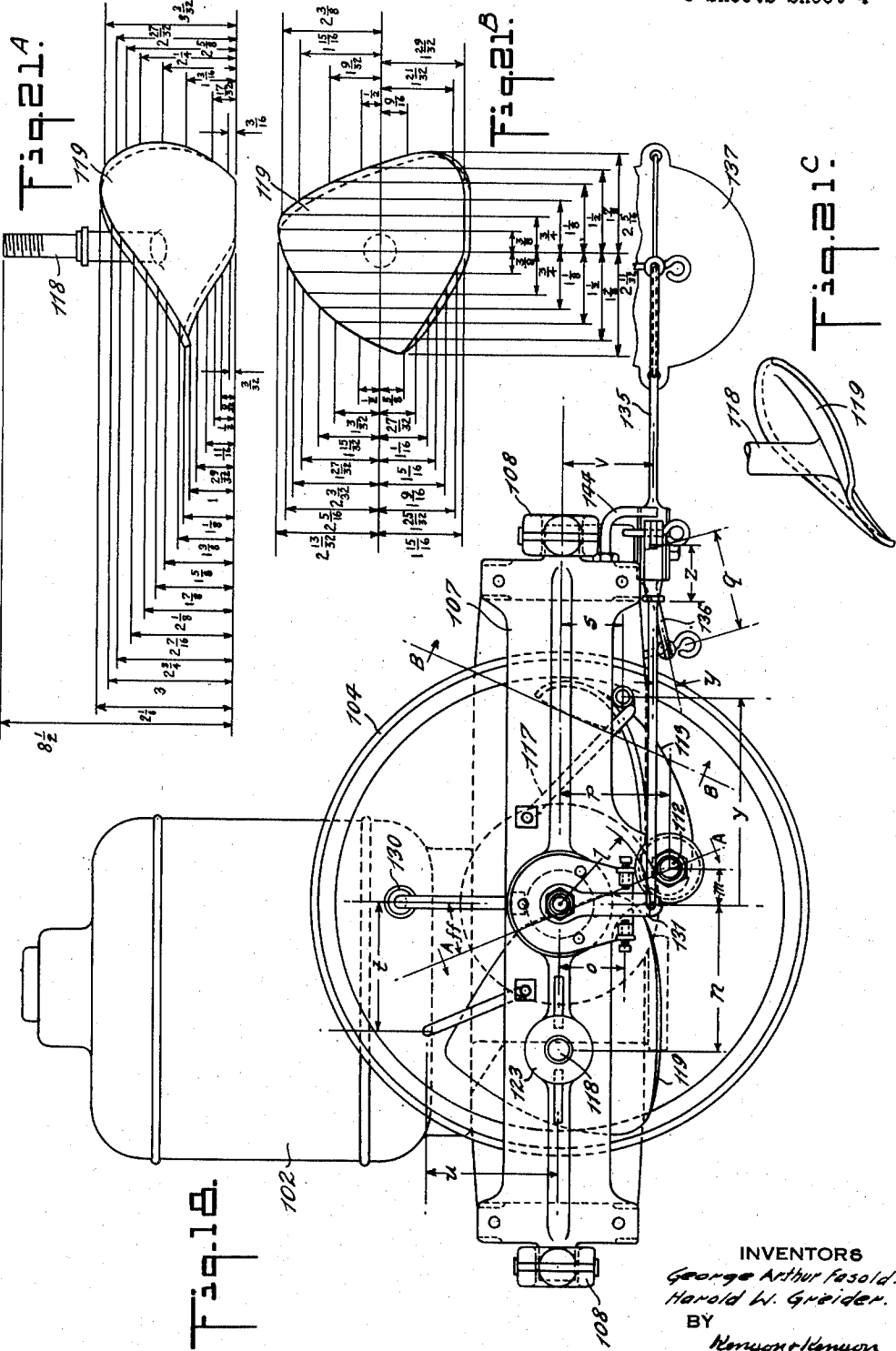
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5 Sheets-Sheet 4



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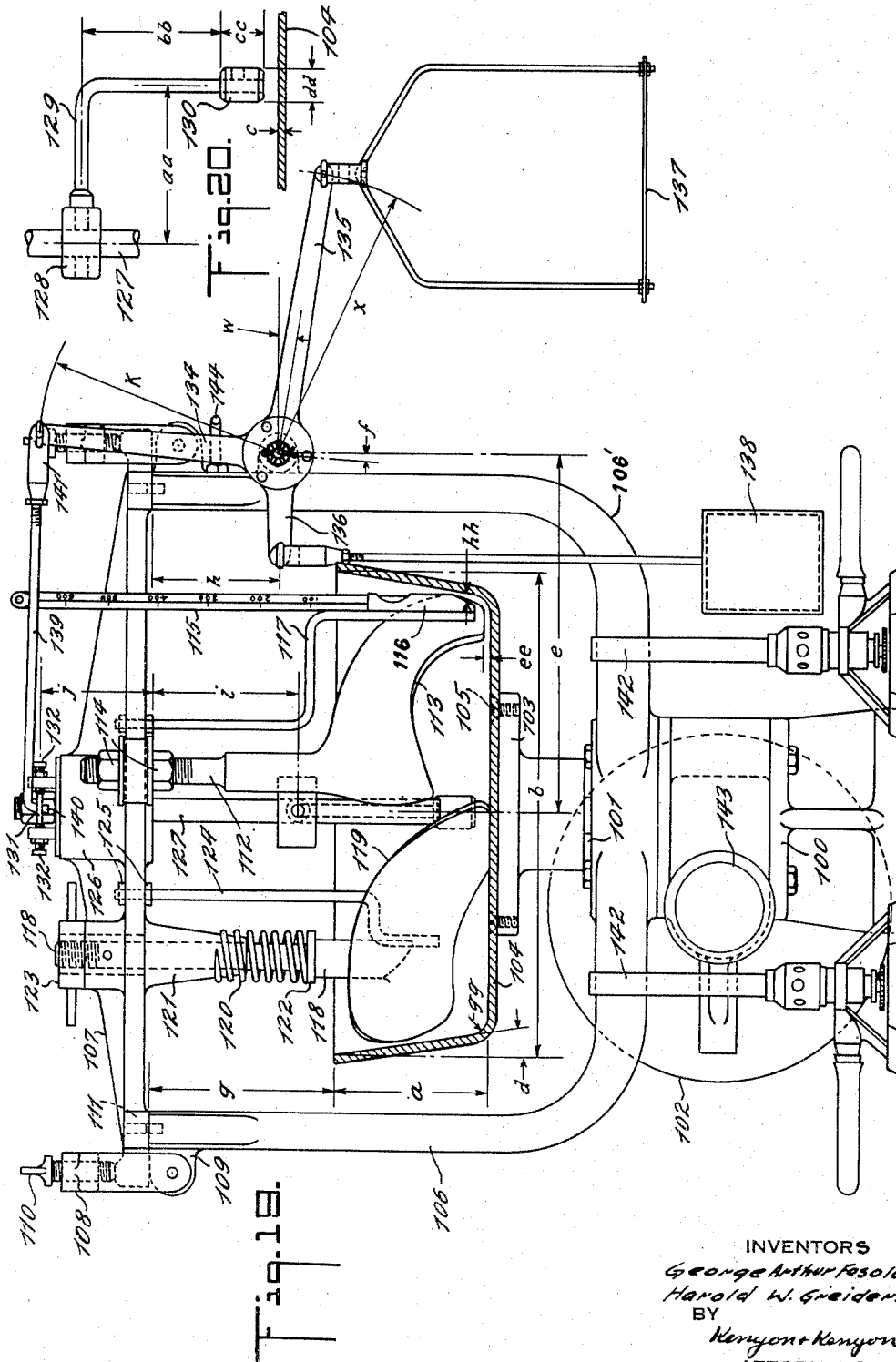
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UNITED STATES PATENT OFFICE

2,552,947

COATED ROOFING

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Application August 7, 1943, Serial No. 497,803

15 Claims. (Cl. 117—30)

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This invention relates to roofing. It relates particularly to roofing embodying bituminous material as waterproofing.

Heretofore bituminous prepared roofing has been very extensively manufactured using as a base a fibrous web such as roofing felt, impregnating the fibrous web with a bituminous material, and coating the impregnated web with a weather-resistant bituminous coating composition. The bituminous coating composition usually contains a mineral filler such as slate flour or powdered limestone in amounts less than about 40% by weight of the bituminous coating composition. Usually there is applied to the bituminous coating on the surface intended to be exposed to the weather a suitable granular material such as slate granules or more finely-divided mineral surfacing material such as talc or mica. Finely-divided materials such as mica flakes, talc, silica dust or the like may be made adherent to the non-weather exposed surface of the roofing to prevent sticking of adjacent layers of the roofing material in the package.

The term "roofing" is used herein in the broad sense as referring to water- and weather-resistant coverings such as shingles (individual or strip shingles), roofing tiles, cap sheets, sidings, roof deck coverings made from such preformed materials, built-up roofings, and the like.

The bituminous roofings of the character aforesaid that have been manufactured and sold heretofore have relatively low fire-resistance. The most widely-accepted tests for determining the fire-resistant properties of roofing are those prescribed by Underwriters' Laboratories, Inc., of Chicago, Illinois. According to the tests prescribed by Underwriters' Laboratories, Inc., fire-retardant roofings are placed in three classifications, depending upon their ability to pass the tests required for each classification; these classifications being class "A," class "B" and class "C." The class "C" rating is the lowest fire-retardant rating and serves to distinguish roofings having appreciable fire-retardant properties from roofings having little or no fire-retardant properties such as untreated wood shingles which, of course, are readily ignited and tend to burn freely. So far as we are aware, prepared bituminous roofings of the type heretofore on the market made on an organic fiber felt base have not been able to attain, regardless of the thickness thereof or the number of thicknesses, a rating of Underwriters' Laboratories, Inc. higher than a class "C" rating. The class "A" rating is the highest rating awarded by Underwriters' Laboratories, Inc. and is reserved for such highly

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fire-retardant roofings as asbestos-cement shingles of the double-coverage type. Class "B" is an intermediate rating and is, for example, awarded to roofings such as single-coverage asbestos-cement shingles. A brief description of the class "A," class "B" and class "C" fire-retardant tests of Underwriters' Laboratories is contained in our pending applications for Roofing, Ser. No. 370,636, filed December 18, 1940 (Patent No. 2,326,723), and Ser. No. 399,024, filed June 20, 1941 (Patent No. 2,326,724).

It is a purpose of this invention to improve the fire resistance of roofings comprising a layer of thermoplastic material such as bituminous material. Thus, for example, we have found that a roofing material which comprises an organic fiber felt base and a bituminous waterproofing coating can be made according to this invention, at the cost of ordinary bituminous roofing material, that is so highly fire-retardant that a three-layer covering on a combustible roof deck will satisfactorily withstand exposure to the class "A" fire-retardant tests prescribed by Underwriters' Laboratories, Inc. We have found further that such roofing material embodying our invention, when applied so as to provide two layers, will satisfactorily pass the class "B" fire-retardant tests prescribed by Underwriters' Laboratories, Inc.

The importance of fire-resistant properties for roofing is self-evident. Certain roofings such as asbestos-cement shingle, tile and the like have high fire resistance but such roofings are very costly as compared with asphalt felt roofings, and for this reason asphalt-felt roofings are very extensively used on all kinds of structures notwithstanding the limited fire-protection that is afforded by this type of roofing. According to this invention, asphalt-felt roofings can be made without substantial increase in cost which are comparable in fire-retardant properties to relatively much more costly roofing constructions such as asbestos-cement, tile and the like.

Substantially all bituminous roofings comprise a strain-resisting base or foundation sheet such as roofing felt which is coated with a bituminous coating that provides waterproofing and weather resistance. This invention has to do with the coating material rather than the base sheet. While the base sheet might be made of non-combustible material, the non-combustibility of the base sheet does not solve the problem if the bituminous coating itself burns or tends to flow so as to spread the flame. According to the present invention, the waterproofing coating is rendered

highly fire-resistant so that, even when applied to a base sheet of combustible organic fibers, roofing can be made which has the high degree of fire resistance mentioned above.

In our aforesaid copending application, Ser. No. 370,636 (Patent No. 2,326,723), we have described and claimed bituminous roofing comprising a bituminous waterproofing composition that, while highly fire resistant, possesses physical properties such as pliability and resistance to flexure that correspond in a general way with bituminous roofings of similar character previously manufactured and sold. The bituminous coating composition of the roofing disclosed and claimed in our application Ser. No. 370,636 contains bitumen having a softening point above 160° F. and of the range 45% to 70% by weight of the coating composition. The coating composition also contains filler material of the range 30% to 55% by weight of the coating composition and in the form of finely-divided solid water-insoluble heat-resistant mineral material of special character that is described, illustrated and defined in our application Ser. No. 370,636.

In our application Ser. No. 497,805, which was filed simultaneously with our present application and which has resulted in Patent No. 2,424,234, we have described and claimed certain bituminous compositions especially adapted for use as mopping asphalt in the construction of built-up roofing, high fire resistance being obtained by the use of finely-divided solid water-insoluble heat-resistant mineral filler within the limits of formulation therein described, illustrated and defined.

According to the present invention, organic filler materials which are not necessarily heat resistant are availed of to increase the fire resistance of the bituminous coating composition of bituminous roofings.

The surprising character of improvements of the present invention may be illustrated in the following way. If, for example, a conventional asphalt filler such as limestone dust or slate flour is mixed with the bitumen and the resulting bituminous coating composition is used as the coating for roofing, little, if any, improvement in fire resistance is attained not only when such filler is employed in amounts such as 25% to 40% by weight of the bituminous composition as has been proposed heretofore, but also when a larger proportion of such filler is employed, e. g., in amounts up to about 55% by weight of the composition. It is also the case that, if one attempts to incorporate an organic material such as cotton fibers, sawdust or the like in a bituminous composition as a filler within the limit as to quantity that can be incorporated while still affording a mass that is spreadable in a heat plasticized condition, the resulting bituminous composition is devoid of effective fire resistance due to the combustibility of such filler. However, by combining an ineffective filler such as slate-flour or limestone dust with an organic filler such as any of those just mentioned which per se is likewise ineffective, one can, if the total filler is within the critical zone to be described hereinbelow, and if the amount of heat-resistant mineral filler is sufficient, obtain a highly fire-resistant bituminous coating composition. Moreover, this amazing result can be obtained even though the mineral filler is present in a relatively small amount such as 35 to 40% that is wholly ineffective in the absence of the additional combustible organic filler material.

By way of further illustration, a bituminous coating composition which contains mineral filler that, for example, consists of a mixture of asbestos dust and slate flour and that does not impart substantially improved fire resistance to the roofing, can be made highly fire-resistant by incorporating in the bituminous composition a combustible material such as finely-divided bituminous coal. This is most surprising since a material such as bituminous coal is commonly used for fuel and one would not expect that the inclusion of bituminous coal would greatly increase the fire resistance of the bituminous coating composition of a bituminous roofing.

Ordinary coating compositions such as those that have been used for the weather-resistant waterproofing coating of bituminous roofings have little resistance to fire, even when, as aforesaid, the coating contains a mineral filler such as limestone dust or slate flour in amounts such as those previously employed. Such bituminous compositions when used as the waterproofing layer for an organic fiber felt tend to burn and become consumed when exposed to flame and to flow down an inclined roof deck, leaving the underlying fibrous sheet exposed to the destructive action of the heat of the flame so that the roofing as a whole burns through quite readily.

We have found that there is a critical point below which a filler material exercises very little effect in increasing the fire-resistance of a roofing. At the critical point, however, slight further additions of filler exercise a very pronounced effect upon the stability of the bituminous composition. When the critical point is reached, the filler in the composition assumes the condition of a stable skeletal mat that holds the bitumen in place so that, even though the bitumen is rendered highly liquid by the heat of a flame, the bitumen is held in place by the skeletal mat. The bitumen when thus held in place carbonizes to form a cementitious binder that causes the mat of filler to become bonded into a continuous coherent protective layer that is prevented from becoming displayed by the carbonized residue of the bitumen. It is thus seen that, when the filler is present in the critical amount, the resultant high fire resistance is due to a combination of factors which are a function both of the filler and of the bitumen. Furthermore, during carbonization of the protective mat, pores form therein which convert the mat-like residue into a heat insulating layer of very high heat insulating efficiency.

The critical point at which a filler material forms a skeletal mat within a bituminous composition, when the bituminous composition is exposed to flame temperature, is a function of what we have found to be a measurable characteristic property that we have called the flow resistance property of the filler. This property is a property which, while an entirely different type of phenomenon, may be likened to the property of a substance in raising or lowering the boiling point of a liquid in which it is dissolved. As will be described in detail hereinbelow, we have devised a test for measuring the flow resistance property of a filler material and expressing this property in terms of a coefficient. The flow resistance coefficients of different filler materials differ considerably. In the case of ordinary filler materials such as slate flour or limestone dust, the amount of filler required to achieve a high flow resistance coefficient is quite large, e. g., is about 60% to 65% by weight of the bituminous composition in the case of slate flour and is about 75% to 80%

by weight in the case of limestone dust. Certain filler materials of the planar-extended particle type such as fibrous material, e. g., asbestos fiber, or thin plates, e. g., mica, are more effective, but, as will be pointed out below, the effectiveness of different screen gradings of such materials differs considerably and it becomes necessary to select suitable screen gradings in order to achieve a high degree of flow resistance effectiveness.

The point at which high flow resistance is achieved is quite sharp, for below the critical point the flow resistance coefficient remains low but suddenly increases when the critical point is reached. This critical point closely approaches the point at which the plasticity or consistency of the composition becomes excessive for satisfactory workability. Hereinbelow we have described a test for ascertaining the plasticity of a bituminous composition at 400° F. The suitable compositions for attaining high fire resistance according to this invention are found in a narrow zone defined by the requirement for high flow resistance and by the requirement that the bituminous composition not exceed the permitted maximum plasticity value at 400° F. The flow resistance coefficient and plasticity value are different properties, each of which is affected by the filler, but these properties are not complementary, for in some cases excessive plasticity at 400° F. results, even though high flow resistance is not attained.

According to the present invention, organic filler material is utilized for its effect in producing a bituminous composition within the zone which is limited, on the one hand, by the minimum flow resistance coefficient and, on the other hand, by the maximum plasticity value of the bituminous composition. Heat-resistant mineral filler preferably is relied upon to afford a non-combustible matrix for the skeletal mat, but the heat-resistant mineral filler need not in and of itself be utilized in the critical amount that affords a high flow resistance coefficient, for the organic filler serves a temporary function of attaining the high flow resistance coefficient. Thus the organic filler upon exposure of the bituminous composition of this invention to flame co-operates with the heat-resistant mineral filler in forming a stable skeletal mat and, upon continued exposure of the bituminous composition, becomes charred along with the bitumen, and, if consumed, leaves voids within the residual mat-like protective layer that augment its heat insulating effectiveness rather than otherwise.

In order to afford a better understanding of this invention, it will be described for purposes of exemplification in connection with a typical embodiment. The roofing material of this embodiment is composed of strain-resisting roofing felt, a top weather surface coating of special bituminous coating composition, a surface layer of mineral granules partially embedded in the surface coating, a thinner layer of the special coating composition on the back of the felt base sheet, and finely-divided dusting material adherent to the back layer of the special bituminous coating composition.

In the exemplary embodiment, the base or foundation sheet is ordinary roofing felt made of vegetable and animal fibers, e. g., a roofing felt made from organic fiber stock weighing about 6 pounds per 100 square feet. The felt is impregnated with a suitable impregnating material, e. g., a conventional bituminous roof-

ing saturant having a softening point of about 120° F. to about 170° F. The base sheet as thus composed has little fire resistance and, when exposed to fire, is consumed quite readily.

A typical example of the special coating composition may be made as follows: The bitumen used in the coating is preferably a residual asphalt flux from the refining of Mid-Continent petroleum which has been oxidized as by air blowing until it has a softening point of about 200° to 210° F. and constitutes about 45% by weight of the composition. With the asphalt there is admixed and uniformly distributed slate flour which constitutes about 47% by weight of the bituminous composition and cotton fiber which constitutes about 8% by weight of the bituminous composition. The cotton fiber is fiber which passes a 6 mesh standard testing sieve and may, for example, be distributed about equally among the screen gradings from the grading just passing a 6 mesh testing sieve down to that passing a 200 mesh testing sieve. Such very fine cotton is of a dust-like character and heretofore has been regarded as a waste product of little commercial value.

In preparing the special coating composition, the asphalt is heated to a heat-liquefied condition and the cotton fiber and slate flour are thoroughly mixed therewith. The mixing preferably is carried out at a temperature of about 400° F. to 450° F. It is important that the bitumen and finely-divided filler be thoroughly mixed together so that the filler becomes intimately commingled and distributed uniformly throughout the mass and the composition should be applied to the felt base sheet while in a thoroughly mixed condition so that the filler occurs uniformly in the coating both as to amount and distribution and so that the resulting layer is substantially uniform in consistency and in thickness. In the typical embodiment herein described, the coating is applied to the felt base sheet at the rate of about 45 pounds per 100 square feet. Before the coating cools to atmospheric temperatures, a conventional surfacing material such as slate granules can be applied to the surface for weather exposure and these granules are partially embedded in the coating composition. The granular surfacing material is preferably non-combustible and, while employed, is not relied upon to impart fire resistance to the roofing. On the opposite side of the roofing material, there may be applied a thin coating of bituminous coating material, e. g., an asphalt having a softening point of about 200° to 240° F., so as to weigh about 5 pounds per 100 square feet, and finely-divided dusting or anti-stick material such as talc or mica dust or similar material may be applied and partially embedded in the back coating. Preferably, for maximum fire resistance, the back coating should be special coating composition embodying our invention.

The roofing thus prepared may be packaged in sheet form, or, alternatively, may be cut into sections suitable for shingles or tile-like units. The roofing weighs about 95 pounds per 100 square feet. Of this weight, about 30% by weight is in the form of mineral granules adherent to one side and finely-divided dusting material adhered to the other side, the balance of the roofing being felt, the bituminous impregnating material and the bituminous coating material.

The special bituminous coating composition

may advantageously be mixed and applied in the manner mentioned in our said application Ser. No. 370,636 (Patent No. 2,326,723). As stated in said application, the coating composition may, if desired in order to increase the resistance of the applied coating to blistering, be applied using the method and apparatus of our Patents Nos. 2,105,531 and 2,159,587, but this is not essential.

The roofing material above described can be made up into suitable preferred roofing materials and into suitable roofing structures, description of typical roofing structures being facilitated by reference to the accompanying drawings, wherein:

Fig. 1 is a plan view of a prepared roofing embodying this invention in the form of an individual shingle of simple rectangular shape;

Fig. 2 is a plan view of prepared roofing embodying our invention in the form of an individual shingle of a preferred shape;

Fig. 3 is a plan view of prepared roofing embodying our invention in the form of a shingle strip;

Fig. 4 is a fragmentary cross sectional view on an enlarged scale of prepared roofing embodying our invention;

Fig. 5 is a sectional elevation of an inclined shingle roof embodying our invention without showing the component layers of individual shingles;

Fig. 6 is an enlarged sectional elevational view of a portion of the roof covering shown in Fig. 5, as installed;

Fig. 7 is similar to Fig. 6 except that the roofing is illustrated as it appears after exposure to flame temperature;

Fig. 8 is a plan view of one form of prepared sheet roofing embodying our invention adapted to be installed in roll form;

Fig. 9 is a sectional elevation of a portion of an inclined deck with the roofing material of Fig. 8 installed thereon, the roofing material being shown with exaggerated thickness for clarity;

Fig. 10 is a side elevation partly in section of a testing device for testing the flow resistance of filler material as incorporated in a bituminous composition;

Fig. 11 is a plan view partly in section of the testing device;

Fig. 12 is a front elevation of the test panel assembly;

Fig. 13 is a side elevation of the test panel assembly;

Fig. 14 is a plan view of the test panel assembly with parts thereof broken away;

Fig. 15 is a perspective view of the frame and guard plate used in the test panel assembly;

Fig. 16 is a longitudinal sectional detail view on an enlarged scale of the orifice in the gas line leading to the burner of the testing device;

Fig. 17 is an end elevation of the Wagner-Bowen plasticimeter testing device;

Fig. 18 is a plan view of the plasticimeter;

Fig. 19 is a front elevation partly in section of the plasticimeter;

Fig. 20 is a side detail elevation of the drag tool and drag tool support of the plasticimeter;

Fig. 21A, Fig. 21B, and Fig. 21C are views of the smoothing blade of the plasticimeter taken respectively in elevation normal to the line A—A of Fig. 18, from the bottom, and in elevation from the back in the direction of the line A—A of Fig. 18;

Fig. 22A, Fig. 22B, and Fig. 22C are views of

the mixing blade of the plasticimeter taken respectively in elevation normal to the line B—B of Fig. 18, from the bottom, and in elevation from the back in the direction of the line B—B of Fig. 18.

The prepared roofing material may be cut into individual shingles 10 shown in Fig. 1. Preferably the roofing material is cut into individual shingles 10 having the shape shown in Fig. 2 or into strip shingles of the type shown in Fig. 3. Of course, shingles or the like of other shapes may be used in the practice of this invention. In cross section the prepared roofing material appears as in Fig. 4 and comprises a base or foundation sheet 13 of bitumen impregnated roofing felt. Overlying this roofing felt is a coating 14 of special coating composition having adherent to the surface thereof and partially embedded therein the slate granules 12. Adherent to the back of the roofing material is a layer 15 of the special bituminous coating material in which is embedded finely-divided dusting material 48. Ordinarily some bituminous coating material and dusting material are employed on the back of the roofing material, but these materials are not essential and are sometimes omitted particularly when the roofing material is to be used in built-up roofing.

In Fig. 5 is shown a typical roofing structure in place on a roof deck comprising boards 16 which serve as a support for the shingles, e. g. strip shingles 11 or individual shingles 10. The individual shingles may be 16 inches long over-all and laid with a 5 inch exposure, thereby affording triple coverage over all parts of the roof deck except for a portion of the spaces between adjacent shingles in each course. The component parts of the individual shingles appear in detail in the enlarged fragmentary view shown in Fig. 6.

In the installation of a fire-resistant roof covering, the employment of strip shingles of the type shown in Fig. 3 is preferred since the recesses or slots 23 only extend partially into the body of the shingle and since the notches 24 provide recesses of similar depth between abutting pieces of strip shingle, thereby preventing penetration of flame into the body of the roof covering. Individual shingles 10 provided with a notch 25 are preferred for similar reasons.

The preformed roofing can of course be laid with a greater proportion thereof exposed and so that the roof covering will be composed of two layers instead of three. Such a roofing is illustrated in Figs. 8 and 9. In Fig. 9 the roofing material is shown as installed on a roof deck with the thickness of the courses exaggerated for clarity. The preformed roofing material consists of a foundation sheet 18 of bituminized roofing material, coated over a part of its width with a coating 19 of the special coating composition. This material may be made up in rolls about 36 inches wide for example with slightly less than half of the width of the asphalt saturated foundation sheet 18, e. g., 17 inches of the width, coated with the special coating 19 and covered with the mineral granules 20, e. g., slate granules. This type of roofing may be laid on boards 21 of a roof deck using suitable securing means such as nails 26, the slate covered portion being exposed and the balance underlying an adjoining sheet as shown in Fig. 9. Where the preformed sheets overlap, they are caused to adhere to each other by a bituminous adhesive material 22 which, preferably, is of the high fire resistance.

of the special coating compositions of our invention.

Instead of burning and flowing as is the case when an ordinary bituminous coating composition is exposed to fire such as that caused by a burning brand resting on the roofing, the special fire-resistant bituminous composition of this invention behaves very differently. The behavior of the roofing material as applied in three layers to a roof deck, e. g., as shown in Figs. 5 and 6, is indicated roughly in Fig. 7. During exposure to fire, the special bituminous composition, instead of burning and running, remains in place due to the stabilizing action of the filler materials contained in the bituminous composition. As aforesaid, the slate flour by itself has little or no stabilizing action, but we have found that, when such filler material is combined with the cotton fiber of the character aforesaid, the bituminous composition remains stable upon exposure to the flame. The cotton fiber by itself does not have this effect, for, in order to effect the stabilizing action, the slate flour is also necessary in order to provide the proper ratio of fiber to asphalt in the composition whereby the high flow resistance coefficient is obtained. During continued exposure to fire, the cotton fiber may be carbonized or entirely consumed, but this occurs as the bitumen becomes carbonized to a coherent cementitious material that holds the matrix of slate flour in place as a protective layer. Small bubbles 27 form in the composition as well as minute voids where the cotton fiber has become consumed, and, as aforesaid, the resulting porosity of the mat-like residue greatly augments its effectiveness as a heat insulation.

In the roof covering as a whole as illustrated in Fig. 7, the upper layer of special bituminous composition has become expanded somewhat and has become somewhat irregular, but the coherent porous mat-like mass has remained and acts as a protective barrier against the flame. The uppermost layer 13 of felt may be carbonized and to a considerable degree may have disappeared leaving air pockets 28 together with some residual carbonized material. The intermediate layer 14 of special bituminous composition is also expanded, but remains in place as a protective heat insulating layer. The intermediate layer of felt is charred, but is better preserved than the uppermost layer of felt. The bottom layer of the special bituminous composition is less severely carbonized than the upper layer and likewise is considerably expanded. The bottom layer of felt is fairly well preserved and the underlying board 16, if charred at all, has not become ignited. The backing layers 15, when composed of the special bituminous composition, likewise augment the heat insulating effect of the roof deck covering, but it is not essential that these layers 15 be composed of the special bituminous composition of this invention. During exposure to fire such as a burning brand, the uppermost layer 14 may become red hot, but the heat insulation effectiveness of the carbonized residues of the layer 14 is so great that the boards 16 may not even become scorched.

When the special bituminous composition of this invention is exposed to flame, the effect of the flame is confined to the area immediately beneath and closely adjacent to the area of direct exposure to flame and, when the flame becomes extinguished, all charring of the roofing soon ceases and the roofing cools down.

According to this invention, one can readily prepare roofing which, when applied triple coverage, e. g., as shown in Figs. 5 and 6, will pass the class "A" fire-retardant tests of Underwriters' Laboratories, Inc. Moreover, such roofing, when installed double coverage, e. g., as shown in Figs. 8 and 9, can be made according to this invention so as to pass the class "B" fire-retardant tests of Underwriters' Laboratories, Inc. This high fire resistance rating can be attained notwithstanding that the roofing is prepared utilizing conventional roofing felt of organic fiber impregnated with a bituminous saturant. We do not know of any commercially prepared bituminous roofing made on a felt base of organic fibers which, irrespective of the number of layers or plies that are applied to the roof deck, will pass the class "A" fire-retardant tests; or even the class "B" fire-retardant tests, prescribed by Underwriters' Laboratories, Inc.

In the above-described typical example of the practice of this invention, the combustible cotton fiber which in and of itself is wholly ineffective, is combined with slate flour, which is ineffective due to its lack of stabilizing action, to form a highly effective filler mixture that has a high flow resistance coefficient and provides a bituminous composition within the limited range wherein high fire resistance is attained.

In order to accurately determine the flow-resistance coefficient and thereby enable us to precisely define the highly fire-resistant roofings of this invention, we have devised a test whereby the flow-resistance coefficient of a particular filler or filler mixture in a bituminous composition under conditions of exposure to fire may be measured. The test consists in directing a flame against an inclined specimen of roofing that carries a coating consisting of the bitumen and the filler or filler mixture to be tested, under precisely-controlled conditions determined by the construction and operation of the testing apparatus. The following is a description of the controlled conditions of the test, reference being made to Figs. 10 to 16 of the drawings.

Samples carrying the bituminous composition containing the filler or filler mixture to be tested are made by applying the bituminous coating composition to the base sheet material so that the coating weighs 30 pounds plus or minus 2 pounds per 100 square feet.

The test is made in a wind tunnel 50 having a fan 51 at one end and a stack 52 at the other end. The tunnel is made of $\frac{1}{4}$ inch thick asbestos-cement lumber and has two windows 53 and 54 therein which can be opened and closed by any suitable means (not shown).

Within the tunnel are the burner and testing deck which are located between two shields 55 and 55' of the asbestos-cement lumber spaced 12 $\frac{1}{4}$ inches apart, and which are rigidly mounted on the asbestos-cement slab 56. The inclined test deck is indicated generally by the reference character 57 and comprises a lower frame-like member 58 having $\frac{1}{4}$ inch pegs 59 projecting from the face adjacent the upper and lower margins. Between the pegs, strips 60 of asbestos-cement boards, 1 $\frac{3}{4}$ x 12 x $\frac{1}{4}$ inches are placed. One ply 12 x 12 inches of the prepared coated sample 73 to be tested is placed on the asbestos-cement boards 60 followed by an L-shaped guard plate 61 which covers the bottom edge of the sample. The assembly is held down by an iron frame 62 and held in place by thumb screws 63.

After the test deck has been assembled, it is

placed on the inclined support 64 which has an opening in the back underneath the strips 59 and which has side flanges 65 to protect each side of the test panel. The support 64 comprises a baffle 66 to prevent the flame licking around behind the test deck. The support, which is made of iron, is mounted on the asbestos-cement slab 56 which measures 12 x 40 x 1 inches. The parts for carrying the test deck are also made of iron. An iron bar 67, 12 x 1 x 1/4 inches is placed across the top edge of the deck to protect the sample at this point.

In front of the test deck is the burner 68 comprising an iron pipe having an inside diameter of .472 inch and an outside diameter of .675 inch with 17 holes .078 inch in diameter and 1/2 inch apart disposed at an angle that is parallel with the plane of the test deck. The burner is provided with an inlet line 69 controlled by a shut-off valve 70. In the line 69 is an orifice 76, 5/64 inch in diameter, that is located in the housing connections 71. Between the valve 70 and the orifice is a manometer 72. By this arrangement, a supply of gas under constant pressure can be obtained, thereby obtaining a steady flame of constant intensity during the test.

At the base of the test deck and between the burner and the deck holder is placed a pan 74, 3/4 x 1 x 10 inches, which collects any bituminous coating material that flows from the sample during the exposure to the flame. This pan is provided with a removable cover 75.

The dimensions of the different parts of the testing apparatus shown in the drawings as used by us are as follows:

a—24 inches	o—8 inches
b—38 inches	p—2 inches
b'—6 inches	q—3/4 inch
c—18 1/2 inches	r—1 inch
d—72 inches	s—12 inches
e—16 1/2 inches	t—7 inches
f—10 inches	u—10 1/2 inches
g—12 1/4 inches	v—12 inches
h—38 inches	w—12 inches
i—64 inches	x—1 inch
j—32 inches	y—12 inches
k—24 inches	y'—1 inch
l—24 inches	z—6 inches
m—40 inches	aa—12 inches
n—27 inches	bb—1 inch

In carrying out the test, the apparatus is first assembled and the burner is lighted so as to provide a pilot flame that is about 1/2 inch in length when the fan is operating. The windows 53 and 54 are then closed and the room in which the apparatus is placed is arranged so that there will be relatively constant conditions during the test. The temperature and relative humidity of the room should be approximately 80° F. and 40%, respectively. The fan should generate a wind velocity of about 150–155 ft. per minute at the portion of the deck exposed to the flame. The valve 70 is then opened until a flame about 8 to 9 inches long is produced having a temperature of about 1325–1370° F. When the valve 70 is opened to produce such flame, a timing device is started. After the sample has been exposed to the flame for a period of five minutes, the flame is turned off and simultaneously the cover 75 is placed over the top of pan 74 so as to prevent any further bituminous composition that may flow down the test deck from collecting in the pan. Before the commencement of the test, the pan 74 is carefully weighed and at the conclusion of

the test is again weighed, the difference in weight being the number of grams of bituminous coating material that has flowed into the pan. Before making the test, the weight of the bituminous coating on the test sample is determined by weighing the base sheet material before the bituminous coating is applied thereto and weighing the complete sample, the difference being the weight of the coating.

The coefficient of flow resistance is computed according to following expression.

$$100 - \frac{\text{weight in grams of coating collected in pan} \times 100}{\text{total weight in grams of coating prior to test}}$$

For example, if the weight of the bituminous coating on the sample was 1000 grams prior to testing and 50 grams of the coating were collected in the pan during the test, the coefficient of flow resistance would be

$$100 - \frac{50 \times 100}{1000} = 95$$

If no coating composition flows into the pan, then the flow resistance coefficient is 100 which is the maximum attainable.

The flow resistance coefficient is primarily a function of the filler contained in the bituminous composition since the greatly-increased flow resistance of the coating, if attained, is due to presence of the filler in an amount that equals or exceeds the critical amount for the filler undergoing test. It may be mentioned, however, that the amount of a given filler that is critical will usually vary somewhat depending upon the bitumen that is used in the bituminous composition. Thus the critical amount of filler for a so-called "cracked asphalt," namely, oxidized asphaltic cracking still residue, is usually somewhat less than for a straight run asphalt residue.

Another factor that influences the flow resistance coefficient somewhat is the character of the surface to which the bituminous coating composition is applied. In the manufacture of roofing material, a typical asphalt saturated felt base sheet weighs about 30 lb. per 100 square feet and is saturated to the extent of about 175% by weight with asphalt having a softening point of about 150° F., so for most purposes an asphalt saturated felt such as this may be used in making the test. However, for bituminous compositions which have incorporated the critical amount of filler to render the composition highly flow-resistant, the asphalt in an asphalt saturated base sheet exerts an effect as a lubricant at the interface between the base sheet and the coating composition which tends, depending upon the amount of asphalt in the base sheet, to lower somewhat the flow resistance coefficient as determined by the test. This effect can be counteracted by indenting or otherwise causing the surface of the felt base sheet to be rougher than normal. By using a dry or unsaturated felt base sheet, especially base sheet material having relatively coarse fibers, the flow resistance coefficient of the bituminous composition per se is attained without being influenced by any effect that the bitumen in the base sheet may have. However, since the special coating composition of this invention may be utilized overlying the surface of different kinds of base sheet material, it is best to carry out the flow resistance test using as the base sheet for the test sample the kind of base sheet that is to be used in the commercial roofing to be manufactured.

According to this invention, the special fire-

resistant bituminous coating composition can be formulated so that the flow resistance coefficient will be as high as 100. However, greatly improved fire resistance is obtained according to the invention when the flow resistance coefficient of the filler in the coating of the roofing in question is 75 or greater, although it is preferable to formulate the bituminous coating compositions so that the flow resistance coefficient of the filler in the bituminous coating composition is 90 or above.

The practice of this invention may be illustrated in connection with another type of highly fire-resistant bituminous composition which contains asphalt, fibrous mineral filler, a non-fibrous mineral filler and a non-fibrous organic filler such as bituminous coal. In the following example as well as elsewhere herein, the percentages given are percentages by weight. The screen grading of asbestos passing a 14 mesh standard testing sieve and retained on a 20 mesh testing sieve is indicated as (-14+20) and the other screen gradings are indicated similarly both in the following example and elsewhere herein.

	Percent
Asphalt (softening point 220° F.)	45
Slate flour	6
Powdered bituminous coal	20
Asbestos dust gradings:	
-14+20	1.5
-20+28	2.0
-28+35	2.0
-35+48	2.5
-48+65	3.0
-65+100	2.0
-100+150	3.0
-150+200	3.0
-200	10.0
Total asbestos dust	29

A bituminous composition such as that described in the foregoing example has high fire resistance. If, in the above composition the 20% by weight of powdered bituminous coal is omitted and the bitumen content is correspondingly increased to 65% by weight, the composition is not particularly effective in providing fire resistance due to the fact that the screen gradings of asbestos fiber in the amount used, coupled with the slate flour, do not provide an adequately high flow resistance coefficient. However, the presence of the bituminous coal increases the ratio of the asbestos fiber to the asphalt so that a composition of high flow resistance coefficient is attained. The result is that, even though the powdered bituminous coal is combustible, it imparts initial stability to the bituminous composition when the bituminous composition is exposed to flame temperature so that the bituminous composition carbonizes while remaining in place, the heat-resistant mineral filler providing a non-combustible matrix for the residual protective skeletal mat of filler.

From the foregoing examples of the practice of this invention, it is apparent that, according to this invention, organic filler material, whether fibrous or non-fibrous, is utilized to increase the stability of the waterproofing bitumen in the bituminous coating. In this way, a combustible material, even one such as coal that burns readily, can be availed of to greatly increase the fire resistance of roofings when utilized in bituminous compositions formulated within the aforesaid limits as to flow resistance coefficient and plas-

ticity value. If, on the other hand, such combustible organic filler is used in a bituminous composition that does not come within such critical limits, it promotes combustibility and the advantages of this invention are not attained.

The highly fire-resistant bituminous compositions of this invention are, generally speaking, bituminous compositions wherein the total filler material is of the range 35% to 80% by weight of the bituminous composition, the waterproofing bitumen being of the range 20% to 65% by weight of the coating composition. While the general range of filler content is seen to be subject to considerable variation, it does not follow that a given filler or filler mixture will be effective within this broad range. In fact, in the case of most fillers and filler mixtures, the critical range within which they can be used to achieve the high fire resistant bituminous compositions of this invention is confined between limits that are imposed by the minimum flow resistance coefficient and the maximum plasticity value and that permit variations of filler content of only about 5% to 15% by weight. However, the critical points for the different fillers and for filler mixtures will differ quite widely and may be, for example, around 35% by weight of the coating composition or may be around 75% by weight of the coating composition, depending upon the particular filler or filler mixture that is employed.

In preferred embodiments of this invention the filler material is provided with a non-combustible matrix for the skeletal mat of filler by utilizing in the bituminous composition finely-divided solid water-insoluble heat-resistant mineral filler, either fibrous or non-fibrous. By "heat-resistant" any material is intended which is sufficiently heat resistant to retain structural integrity when subjected to flame temperature while incorporated in the roofing. In this connection, substances such as chrysotile asbestos, Canadian picrolite, hydrated Portland cement, etc., are regarded as heat-resistant even though they contain water of constitution which may be driven off at temperatures below flame temperatures. The amount of heat-resistant mineral filler that it is desirable to employ in preferred embodiments of this invention depends upon the percent by weight of waterproofing bitumen contained in the bituminous composition which in turn is a function of the percent by weight of the total filler. Thus in preferred embodiments of this invention the heat resistant mineral filler is employed in an amount such that the ratio of the percent by weight of the heat-resistant mineral filler to the percent by weight of bitumen in the bituminous composition is at least 1 to 3. It is even better in the practice of this invention that the ratio of the percent by weight of heat-resistant mineral filler to the percent by weight of bitumen in the composition be at least 1 to 2. The amount of organic filler that is mixed with the heat-resistant mineral filler is subject to wide variation. Thus the organic filler employed in the fire resistant bituminous compositions of this invention may be present in very small amount such as 2% to 3% by weight of the bituminous composition, yet, especially when such organic filler is in the form of fiber of highly effective screen grading, the presence of such small amount of organic filler can be critical to the attainment of a highly fire-resistant bituminous composition. The term "organic filler," as used herein, is intended to include those substances in finely-divided, solid particulate form, within the size

range set forth, which are predominantly organic compounds of carbon, as distinguished from inorganic carbon compounds such as metallic carbonates. Organic fillers may be of vegetable or animal origin, i. e., produced by the life processes of plants and animals, or may have been derived from vegetable or animal matter by chemical and mechanical processes of nature, as exemplified by coal. Cotton, wood cellulose and cork are examples of organic fillers of vegetable origin. Wool and other animal hairs are organic fillers of animal origin.

Organic fillers also may be derived from vegetable and animal materials of natural origin by chemical or mechanical treating processes. Regenerated cellulose or cellulose acetate fibers are produced from cotton or wood cellulose. Coke from coal and "petroleum coke" are other examples. Chemically refined wood pulp, ground wood and defiberated wood and other typical organic fillers. Synthetic resins exemplify organic fillers produced by artificial processes rather than by natural processes.

Organic fillers may be either fibrous in structure, as cotton, wool, hair and wood fiber, or may be non-fibrous, such as coal, coke, petroleum coke, cork resins, etc.

In the formulation of fire-resistant bituminous compositions, it is preferable to utilize fibrous filler, or, more generally a filler of the planar-extended particle type as part or all of the filler material, since such filler materials have the property of affording a high degree of flow resistance. The use of such filler materials is especially desirable when the total filler content of the bituminous composition is less than 55% by weight. As aforesaid, we have found that such filler materials differ considerably in their effectiveness depending upon the screen grading of the filler material in question. This can be illustrated in connection with a mineral filler such as asbestos dust when employed in combination with a filler such as slate flour that has little effectiveness in the stabilization of bituminous compositions. Thus, when the screen grading of asbestos dust is $(-28+35)$, a composition consisting of substantially 23% by weight of this screen grading of asbestos dust, 17% by weight of slate flour about 85% by weight of which is (-200) and 60% by weight of asphalt of softening point of about 230°F . will have a flow resistance coefficient of about 75. If the screen grading of asbestos dust is $(-10+14)$, only about 6.5% by weight of asbestos dust (the balance of the composition being 33.5% of slate flour and 60% of asphalt) will achieve a flow resistance coefficient of about 75. In view of these differences in effectiveness of the different screen gradings of a mineral fiber such as asbestos dust, we have, in order to indicate more definitely the amount of mineral fiber of given screen gradings that is required to effect stabilization of a bituminous composition, assigned to the different screen gradings what we have called the "screen factor" for each of the different gradings. Thus if the screen grading $(-28+35)$ is taken as having a screen factor of unity, any screen grading that requires half the amount as compared with the screen grading $(-28+35)$ will be twice as effective and will have a screen factor of 2. On the other hand, a screen grading that requires twice the amount as compared with the screen grading $(-28+35)$ will only have half the effectiveness and will have a screen factor of 0.5.

0.5. In like manner, screen factors can be assigned to each of the other screen gradings.

The above-described test for measuring the flow resistance coefficient of a filler in a bituminous composition affords a convenient basis for setting up the screen factors of fibrous mineral fillers on a definite scale and, when the screen factor of a given screen fraction of a fibrous mineral is referred to herein, the screen factor as determined in the following manner is intended. The test for determining the flow resistance coefficient is carried out using the test apparatus and procedure above described except that in all cases the total filler is 55% by weight of the bituminous composition. The asphalt in all cases is air blown (oxidized) straight run asphalt having a softening point of about 230°F . Slate flour about 85% by weight of which passes a 200 mesh testing sieve is used in all cases as the standard diluent filler, and the amount by weight of the particular screen grading of fibrous mineral to achieve a flow resistance coefficient of about 75 as ascertained by the average of a plurality of test runs, is determined. Each sample is prepared using the impregnated organic fiber felt above specified, namely, conventional asphalt saturated organic fiber roofing felt weighing about 30 pounds per 100 square feet that has been impregnated to the extent of about 175% by weight with asphalt having a softening point of about 150°F . As a standard, chrysotile asbestos of the grading $(-28+35)$ is taken as having a screen factor of unity and the factor for each of the other gradings is calculated to this standard. By way of concrete example, it being the case that substantially 15% by weight of the bituminous composition of chrysotile asbestos having the screen grading $(-28+35)$ (the total filler being 55% as aforesaid), is required to afford a flow resistance coefficient of substantially 75, and it also being the case that only about 3% by weight of the bituminous compositions of chrysotile asbestos of the screen grading $(-6+8)$ (the total filler again being 55%), also affords a flow resistance coefficient of about 75, the screen factor of chrysotile asbestos fiber having the screen grading $(-6+8)$ is seen to be 5.

By way of further illustration, the "screen factors" of the different screen gradings of a typical chrysotile asbestos fiber on the basis above mentioned are as follows:

Screen Grading	Screen Factor
$-6+8$	5.0
$-8+10$	3.8
$-10+14$	2.5
$-14+20$	1.9
$-20+28$	1.4
$-28+35$	1.0
$-35+48$	.8
$-48+65$	.7
$-65+100$	.5
$-100+150$	.4
$-150+200$	.3
-200	.2

It may be noted that in the case of the screen grading (-200) , a flow resistance coefficient of 75 was not attained even when the total filler (55% by weight) consisted of this particular grading of asbestos dust. However, since this particular screen grading (-200) is nevertheless somewhat effective when combined with the more effective screen gradings, a screen factor of 2 has been assigned to this particular screen grading. Similarly, in the case of any other fibrous minerals, a screen grading which, when employed

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to the extent of 55% by weight, does not attain a flow resistance coefficient of 75 is to be regarded as having a screen factor of 2.

The foregoing is seen to afford a convenient way of knowing and defining the flow resistance effectiveness of a fibrous filler such as asbestos. Given the percentage by weight of each of the screen gradings of fiber contained in a bituminous composition, the percentage by weight of each multiplied by the screen factor for each gives what we term herein and in the claims the "grading index" for each of the screen gradings; and, by adding the grading indices for the several screen gradings together, the grading index for the total mineral fiber is readily determined. By way of illustration, the grading index of the fibrous mineral filler component of the above-mentioned typical embodiment of this invention containing asphalt, slate flour, and powdered bituminous coal is as follows:

Screen Grading	Percent by Weight of Composition	Screen Factor	Grading Index
-14+20	1.5	X	1.9
-20+28	2.0	X	2.8
-28+35	2.0	X	2.0
-35+48	2.5	X	2.0
-48+65	3.0	X	2.1
-65+100	2.0	X	1.0
-100+150	3.0	X	1.2
-150+200	3.0	X	.9
-200	10.0	X	2.0
Total grading index for mineral fiber			16.9

The mineral fiber filler that is preferred in the practice of this invention is asbestiform mineral fiber, chrysotile asbestos dust being especially desirable. Other asbestiform mineral fibers of the particle size mentioned may likewise be employed such as Canadian picrolite, amosite, anthophyllite, tremolite and actinolite.

Another suitable fibrous mineral is a comminuted mixture of hydrated Portland cement and asbestos fiber, the hydrated Portland cement having become set with the asbestos fiber distributed therethrough. A convenient source of such material is asbestos-cement roofing scrap which usually contains about 20% to 35% by weight of asbestos fiber and about 65% to 80% of hydrated Portland cement. Heretofore such scrap has been regarded as an unavoidable waste of no commercial value. However, by subjecting the scrap to a disintegrator such as a hammer mill, the resulting mass contains a multiplicity of short asbestos fibers to which the hydrated Portland cement adheres as nodules and for this reason this material is fibrous and is to be included in the term fibrous mineral.

Another material which is somewhat similar to asbestos-cement in that the material contains mineral fibers together with some non-fibrous material, is disintegrated fiber-bearing serpentine rock. Since disintegrated fiber-bearing serpentine rock contains fibrous particles, such disintegrated serpentine rock is regarded as one form of fibrous mineral which is suitable for use in practicing this invention. However, depending upon the physical structure and fibrous mineral content of the particular serpentine rock that is used, the proportion of fiber contained therein is subject to some variation, but, as pointed out below, this merely has the effect of varying somewhat the screen factors of the various screen gradings of the disintegrated serpentine rock as calculated to chrysotile asbestos dust

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of the screen grading (-28+35) which has a screen factor of unity. Moreover, disintegrated fiber-bearing serpentine rock is of such character that in order to liberate the fibrous material contained therein it should pass a 20 mesh testing sieve, and, when reference is made herein to disintegrated fiber-bearing serpentine rock, only that serpentine rock which has been disintegrated so that it passes a 20 mesh testing sieve is intended, since individual particles of coarser gradings are not fibrous in character but granular (are not fibrous mineral as this term is used herein) and since such coarser gradings are ineffective in producing highly fire-resistant roofings.

Other mineral fibers may likewise be employed, such as mineral wool and glass fibers. The term "mineral wool" includes various products obtained by attenuating into fibrous form suitable fused materials such as rock or slag.

Of the fibrous fillers other than mineral fillers, there is a wide selection of animal, vegetable, and synthetic fibers. In addition to cotton, one may employ wood fibers such as fine sawdust, or defiberated wood and paper and paper fibers such as ground wood, sulphite, and kraft paper pulps. Finely-divided wool fiber is also suitable but is much more costly. Synthetic fibers such as regenerated cellulose (rayon) and cellulose acetate also may be used.

In addition to fibrous fillers, another filler that is similar to fibrous fillers in that it is effective in varying degrees depending upon the screen grading or mixture of screen gradings that is employed, is mica. Mica is characterized by its occurrence in the form of small plates which are thin relative to their lateral extent. Mica and fibrous materials are characterized by the fact that at least one dimension is very small relative to another more extended dimension. Such materials are therefore referred to generally herein as planar-extended filler materials, thereby indicating that the particles are in the form of fibers or are in the form of plates having an extended dimension that is confined essentially to only one of the three dimensional planes. In the case of a filler such as mica that exists in the form of plates, particles which are retained on a 14 mesh testing sieve are undesirable in the composition.

With regard to fibrous fillers other than asbestiform mineral fibers, it is not usually the case that a particular screen grading of, for example, asbestos-cement, cotton, wood fiber, etc., will have the same screen factor as that of chrysotile asbestos fiber. In fact, even as among different types of asbestiform mineral fiber there are some variations in this regard. However, utilizing chrysotile asbestos dust as the standard, chrysotile asbestos dust of the screen grading (-28+35) having a value of unity, the screen factor of the screen grading of other fibrous fillers is determinable in the same way that the screen factor of the different screen gradings of chrysotile asbestos fiber is determinable as has been described hereinabove. By way of illustration, the screen factor of disintegrated asbestos-cement roofing scrap of the screen grading (-28+35) is about 3. For defiberated wood fiber, the same screen grading has a screen factor of about 4 and for cotton of the same screen grading the screen factor is about 6. However, fibrous fillers, particularly in the case of wood fibers, cotton and the like are subject to con-

siderable variation, and for this reason the screen factor and grading index has been calculated to chrysotile asbestos fiber, which is more uniform in its physical characteristics, as the standard. The foregoing with respect to the screen factors of other fibrous fillers also applies to the screen factors of mixtures of planar-extended fillers, calculated to chrysotile asbestos dust of the screen grading (-28+35) which has a screen factor of unity.

In ascertaining the grading index of a filler of the planar-extended particle type for use in a highly fire-resistant bituminous coating composition, the grading index required will vary with the amount of bitumen in the bituminous composition, the amount of bitumen being, of course, an inverse function of the total filler. When the amount of waterproofing bitumen in the bituminous composition is about 45% by weight, the grading index of the planar-extended filler is desirably about 15, while for a total bitumen content of about 65% by weight of the bituminous composition the grading index that is desirable for obtaining a similar stabilization of the bitumen will be about 31. More generally, in the practice of this invention it is desirable to employ filler of the planar-extended particle type having a grading index the ratio of which to the percent by weight of waterproofing bitumen in the bituminous composition is at least 1 to 3, and preferably is at least 1 to 2. This is especially important in the case of bituminous coating composition containing a total filler content of the range 35% to 55% by weight of the bituminous composition.

For a total filler content above 55% by weight of the bituminous composition, it is likewise advantageous to employ a finely-divided filler of the planar extended type, although the ratio of the grading index of such filler to the percent by weight of bitumen in the bituminous composition can be somewhat less. Thus, in the case of total filler contents of the order of 55% to 65% by weight of the bituminous composition, the ratio of the grading index of the planar extended filler to the percent by weight of waterproofing bitumen in the bituminous composition is advantageously at least 1 to 6 and preferably is at least 1 to 4. For filler contents of the order of 65% to 80% by weight of the bituminous composition, the ratio of the grading index of the planar extended filler to the waterproofing bitumen in the bituminous composition is at least 1 to 8 and preferably is at least 1 to 6.

When reference is made herein to "screen factor" and "grading index" of a filler of the planar-extended type, the reference is made to these values when determined as hereinabove described. When, however, reference is made to flow resistance coefficient of a filler or filler mixture, the flow resistance coefficient, unless otherwise specified, is that of the filler or filler mixture in whatever amount it is present as commingled with the kind of asphalt employed in the bituminous composition, the bituminous composition being tested as applied to the base sheet of the commercial product.

In determining the screen fractions or grading of fibrous or other mineral fillers that are referred to herein, 8 inch diameter testing sieves of the W. S. Tyler Company sieve series, meeting A. S. T. M. Standard E11-39 for Sieves for Testing Purposes have been used. A quantity of filler to be screened, ranging from 200 to 300 grams, is placed in the uppermost of a series of

testing sieves and subjected to suitable agitation as in a standard W. S. Tyler Company Ro Tap sieve shaking machine for a period of five minutes in order to separate the original filler roughly into fractions retained in the different testing sieves. This operation is repeated, if necessary, in order to obtain about 100 to 200 grams of the desired screen fraction, which fraction is then individually rescreened for 15 minutes, using the Ro Tap screening machine or the equivalent in order to remove any fines contained therein. The resulting screen fraction is material that has passed the coarser screen and is retained on the finer screen.

When a filler of the planar-extended type is used, such filler should be used in the finely-divided or dust-like form as distinguished from long cotton, wood or asbestos fibers. Fibrous fillers that are retained on a 6 mesh testing sieve are undesirable in the coating composition. It has been mentioned above that mica retained on a 14 mesh testing sieve is undesirable. Accordingly, and somewhat more generally, it is desirable that the filler material of the planar-extended type be confined substantially to that which passes a 6 mesh testing sieve and which does not have more than one dimension greater than about .046 inch, which is the width of the opening in a 14 mesh testing sieve. When a filler of the planar-extended type is used that is coarser than has been mentioned above, such filler material tends to form into clumps or clots which render the bituminous composition non-spreadable to the uniformity that is required in a commercial product and also impairs the fire resistance due to occurrence of zones of insufficient protection and due to poor adhesion to the underlying base sheet upon exposure to fire. For this reason, it is highly desirable to limit the quantity of the coarser planar-extended filler to that which can be incorporated in a bituminous composition that, when heat plasticized, is spreadable to form a layer of uniform thickness and uniform consistency. In this connection, a slightly pebbled appearance of the surface is permissible provided the coating as a whole provides a good waterproof and weatherproof layer. It is usually desirable that less than 10% by weight of the total content of the bituminous coating composition consist of a filler of the planar-extended type which is retained on a 14 mesh testing sieve, although in the case of mineral wool a substantially greater proportion of such coarse material can be incorporated in a spreadable composition. While the presence of any fiber retained on a 6 mesh testing sieve is regarded as undesirable and while the presence of any mica retained on a 14 mesh testing sieve is regarded as undesirable, any small quantity of such excessively coarse planar-extended filler that may be present while still retaining spreadability is to be regarded as having the same screen factor as that of the fraction (-6+8) in the case of fibrous materials and the fraction (-14+20) in the case of mica. Usually, it is desirable that the ratio of the grading index of filler of the planar-extended type to the percent by weight of bitumen in the composition be less than about 1 to .7 and preferably less than about 1 to 1, so as to avoid the inclusion of an excessive amount of the coarser screen fractions.

As aforesaid, the filler material that is used in the bituminous composition is employed so as to equal or exceed the critical point of composition at which the filler or filler mixture in ques-

tion provides within the bituminous composition a skeletal mat that remains stable when the bituminous composition is exposed to flame temperatures. However, excessive addition of filler is undesirable, and in the formulation of highly fire-resistant bituminous compositions according to this invention, it is desirable that the plasticity of the bituminous composition at 400° F. not become excessive. This not only imposes a limit upon the amount of ordinary fillers which may be incorporated but also imposes a limit upon the amount of filler materials of the planar-extended type; particularly in the coarser gradings, that may be incorporated.

The plasticity value of the bituminous composition has been determined by us, using a Wagner-Bowen mixing bowl plasticimeter, manufactured by E. E. W. Bowen, Bethesda, Maryland. For testing bituminous compositions of the character mentioned herein, we have made certain modifications in this test apparatus. In view of this fact and further in view of the fact that we do not know of any available publication wherein this type of apparatus is described in detail, we have shown in the drawings, Fig. 17 to Fig. 22C, the testing apparatus which we have employed and a description of the apparatus and its operation follows. When reference is made herein or in the claims to Wagner-Bowen plasticity value, the plasticity value as determined by this test is intended.

The Wagner-Bowen plasticimeter consists of a suitable base 100 which comprises in housing 143 suitable gear means (not shown) for rotating the vertical shaft 101 by power supplied from the motor 102. The shaft 101 carries for rotation at the upper end thereof the horizontally-disposed disk-shaped support 103 to the top of which is secured the bowl 104 by means of screws 105. By this arrangement, the bowl 104 can be rotated by operation of the motor 102, and any suitable means can be provided for maintaining the rotation of the bowl at a predetermined constant speed.

Emanating from the base 100 are arms 106 and 106' which carry on the upper ends thereof the cross bar 107. At the upper end of each arm 106 and 106' is a yoke 108 which is pivoted to lug 109 and which is provided with a thumb screw 110 in threaded engagement therewith so that, by loosening the thumb screw 110, the yoke 108 can be swung outwardly, permitting removal of the cross bar 107. At each end of the cross bar 107 is a positioning pin 111 by which the position of the cross bar is determined.

The cross bar 107 carries the means determining the plasticity of material in the bowl 104. Carried at the lower end of shaft 112 is the mixing blade 113, the vertical position of which relative to the bowl 104 is adjustable by nuts 114 which secure the shaft 112 to the cross bar 107. Adjacent the end of the mixing blade 113 is the thermometer 115 carried in a guard 116 attached to bracket 117 which in turn is secured at the upper end to the cross bar 107. Carried by the lower end of the shaft 118 is the smoothing blade 119. The shaft 118 and smoothing blade 119 are urged downwardly by the expansion spring 120 between the annular washer 122 and the sleeve 121 in which the shaft 118 is vertically slidable. The vertical position of the smoothing blade 119 is determined by the thumb screw 123 which rests against the upper end of sleeve 121 and which is in threaded engagement with the upper end of the shaft 118. Also rigidly secured to the cross

bar 107 is the rod 124, the lower end of which can be adjusted so as to be a predetermined distance from the bottom of the bowl 104 by nuts 125.

At the center of the cross bar 107 is the bearing 126 for the vertical shaft 127 that is mounted for rotation therein at a given vertical position. Rigidly secured to the shaft 127 by means of the collar 128 is the arm 129 which carries the small cylindrical drag tool 130 at the lower end thereof. Carried by the upper end of shaft 127 and rotatable therewith is the arm 131, the outer end of which has a small amount of play for angular movement with the shaft 127 between opposed adjustable stop screws 132.

A horizontally-disposed stub shaft 133 is fixedly carried by arm 106' and pivotally mounted thereon is the T-shaped scale beam member comprising the vertically-extending arm 134 and the arms 135 and 136 extending horizontally on opposite sides of the stub shaft 133. Pivotally secured at the end of the arm 135 is the weight pan 137 and pivotally secured at the end of arm 136 is the counterweight 138 which substantially counterbalances the weight pan about stub shaft 133. Between the end of arm 131 and the end of arm 134 is the tie rod 139. One end of the tie rod 139 has a turned-down portion 140 which slips through an opening of corresponding size in the end of arm 131 to provide pivotal movement with respect thereto. The other end of tie rod 139 is in threaded engagement with a yoke member 141 which is pivotally mounted with respect to the upper end of arm 134. If desired, a fixed stop arm 144 can be provided for convenience in restraining movement of arm 134 when the tie rod 139 is disengaged from arm 131. The contents of the bowl 104 can be heated as by the gas burners 142.

In the operation of the plasticimeter, the bowl 104 is rotated in a clockwise direction, and, as the bowl continues to operate, the mixing blade 113 scrapes the heated contents of the bowl away from the outside bottom portion thereof and the thermometer 115 records the temperature of the contents of the bowl at this point. The contents of the mixing bowl are next carried under the smoothing blade 119 which smooths the contents of the bowl to a predetermined level above the outer portion of the bottom of the bowl. The lower end of the rod 124 serves as a check to determine whether the smoothing blade 119 is smoothing the contents of the mixing bowl to the desired level, and, if it is not, the vertical position of the smoothing blade 119 is adjusted by thumb screw 123. The heated contents of the bowl at the predetermined desired level therein are then carried past the drag tool 130 and this tends to rotate the shaft 127 in a clockwise direction and to pull the weight pan 137 upwardly through the system of lever arms and tie rod hereinabove described. The greater the plasticity (i. e., the heavier the consistency) of the contents of the bowl 104, the greater will be the drag on the drag tool 130 that tends to elevate the weight pan 137. By placing weights on the weight pan 137 and while continuing to rotate the bowl 104, the device can be brought into a state of equilibrium so that the end of the arm 131 will be approximately midway between stop screws 132—132, and the weight in grams required to achieve this condition of equilibrium for a particular composition contained in the mixing bowl is the Wagner-Bowen plasticity value. This value is dependent upon the dimensions of the apparatus and the manner of use of the appara-

tus in making the determination. The essential dimensions of the apparatus shown in the drawings are:

a— $3\frac{3}{8}$ inches	r— $4\frac{1}{8}$ inches
b— $9\frac{3}{8}$ inches	s— $1\frac{1}{4}$ inches
c— $\frac{1}{8}$ inch	t— $2\frac{1}{2}$ inches
d— 8° angle	u— $2\frac{5}{8}$ inches
e— $7\frac{1}{8}$ inches	v— $11\frac{3}{8}$ inches
f— 4° angle	w— 3° angle
g— $3\frac{5}{8}$ inches	x— $5\frac{1}{8}$ inch radius
h— $2\frac{3}{8}$ inches	y— 11° angle
i— $2\frac{7}{8}$ inches	z—1 inch
j— $2\frac{1}{4}$ inches	aa— $3\frac{1}{8}$ inches
k— $4\frac{3}{4}$ inch radius	bb— $2\frac{1}{2}$ inches
l— $11\frac{3}{8}$ inch radius	cc— $\frac{3}{4}$ inch
m— $1\frac{1}{8}$ inch	dd— $\frac{5}{8}$ inch
n— $2\frac{7}{8}$ inches	ee— $\frac{1}{4}$ inch
o— $1\frac{3}{8}$ inches	ff— $24^\circ 15'$ angle
p— $2\frac{1}{8}$ inches	gg— $\frac{5}{8}$ inch radius
q— $2\frac{3}{8}$ inches	hh— $\frac{1}{8}$ inch

The dimensions of the mixing blade 113 and of the smoothing blade 119 are indicated on the face of the drawings.

The Wagner-Bowen plasticity values at 400° F. given herein are determined in the following way. The height of the lower end of the measuring rod 124 from the bottom of the bowl 104 is adjusted so as to be $\frac{7}{8}$ inch. The height of the bottom of the drag tool 130 from the bottom of the bowl is set so as to be $\frac{1}{4}$ inch. The weight of the composition to be tested is approximately 1500 grams. The weight is not critical provided the thickness of the composition as it leaves the smoothing blade just clears the lower end of the measuring rod 124. The composition is mixed while in the bowl 104. Throughout the test the bowl 104 is rotated at the rate of 60 rotations per minute. The bitumen that is used in the composition while in a heat-liquefied condition is poured into the bowl while the bowl is rotating. The bitumen is brought to a temperature of 490° F. by the burners and, while maintaining the temperature at 400° F., the filler material is added in small increments until it has all been incorporated. The smoothing blade 119 is then adjusted so that the composition as it leaves the smoothing blade just clears the lower end of the measuring rod 124. Weights are then placed on the weight pan 137 until the arm 131 is brought to a position between the stop screws 132, the weight to bring about this condition of equilibrium being recorded. Such recordings are made every five minutes until the recorded weight becomes constant for three consecutive readings. The weight in grams for the last three consecutive readings is taken as the Wagner-Bowen plasticity value of the composition at 400° F.

In the formulation of highly fire-resistant bituminous coating compositions according to this invention, it is desirable that the Wagner-Bowen plasticity value not exceed about 1500 grams and it is preferable that this plasticity value not exceed about 1000 grams.

In addition to the fillers of the planar extended type that have been mentioned and illustrated by a number of examples hereinabove, other finely-divided filler materials may be employed. In the field of finely-divided solid water-insoluble heat-resistant mineral fillers, such fillers may be exemplified by slate flour, limestone dust, silica flour, kaolinitic clay, hydrated Portland cement, talc, fly ash, dead burned calcium sulphate, precipitated calcium silicate hydrate and the like.

In the field of organic fillers of the finely-divided solid water-insoluble type bituminous coal has been found by us to be particularly effective. Moreover, we have found that finely-divided bituminous coal, while not of the planar-extended type, behaves similarly to the filler materials of the planar-extended type in that the coarser screen gradings have a greater stabilizing effect upon the bitumen in bituminous compositions than the more finely-divided screen gradings. However, in the employment of bituminous coal it is essential that the bituminous coal be employed in a bituminous composition wherein there is a total filler content of at least 35% by weight of the bituminous composition and wherein the total filler content has a flow resistance coefficient of at least 75, and wherein the plasticity value as measured by the Wagner-Bowen plasticimeter is not more than 1500 grams. If the bituminous composition is not thus formulated the coal and the asphalt flow and burn and little if any improvement in fire resistance is afforded by the use of bituminous coal.

Since bituminous coal has the peculiar property of behaving similarly to fillers of the planar-extended type in that the different screen gradings differ considerably in their property of stabilizing the bitumen in bituminous compositions, we have assigned screen factors to the different screen gradings of bituminous coal in the same way that screen factors have been assigned to the different screen gradings of the fillers of the planar-extended type. Thus since a composition containing 45% by weight of oxidized straight run asphalt having a softening point of about 230° F., 10% by weight of slate flour about 85% of which is (-200) and 45% by weight of a typical bituminous coal (such as Kentucky bituminous coal) of the screen grading $(-28+35)$ has a flow resistance coefficient of about 75, it is seen that the screen factor of this screen grading of the bituminous coal is about 0.33. The screen factors of the other screen gradings of bituminous coal are determinable in a similar manner and are subject to considerable variation.

Other organic filler materials, while somewhat less effective than bituminous coal likewise may be employed in the practice of this invention.

In addition to bituminous coal other varieties of coal may be employed in highly fire resistant bituminous compositions according to this invention such as anthracite, semi-anthracite, semi-bituminous and lignite.

Another organic filler that behaves analogously to coal, is coke such as coke derived from coal by either high temperature coking processes or by low temperature coking processes or such as so-called petroleum coke which is derived from petroleum. Coke is somewhat less effective than bituminous coal, the screen factor of high temperature disintegrated coke of the screen grading $(-28+35)$ being about .25.

Another organic filler which is similar to coal and coke in that, while not of the planar-extended type, the different screen gradings differ in effectiveness (although not to the extent that different screen gradings of planar-extended fillers or coals and cokes differ in effectiveness) is finely-divided cork. Accordingly we have assigned to the different screen gradings of finely-divided cork screen factors determined in the same way that the screen factors of the different screen gradings of planar-extended filler materials are determined. By way of illustration the

screen factor of the screen grading ($-28+35$) of cork is about 4.

In addition to foregoing, other finely-divided solid water-insoluble organic fillers that are not of the planar-extended type may be employed in highly fire resistant bituminous compositions according to this invention. Examples of such organic filler materials are those produced from hard rubber and from hardened resins such as resins of the phenol-aldehyde type, lignin resins and the like.

In the case of organic filler materials it is desirable that the softening point thereof as determined by the standard cube softening point test (carried out in air) be at least about 500°F . and preferably be at least about 700°F . for if the softening point is substantially lower, the filler will melt and blend with the waterproofing bitumen when the bituminous composition is heat plasticized for mixing and spreading. Finely-divided solid water-insoluble mineral fillers having a softening point above 500°F . and preferably above 700°F . likewise may be employed.

An organic filler which has a softening point above about 500°F . but below about 1000°F . exercises a special effect upon the bituminous composition, for, when the bituminous composition is exposed to flame temperatures, such materials melt and blend with the waterproofing bitumen (which normally is rendered highly fluid upon exposure to flame temperatures) and converts the waterproofing bitumen to a more heavy and viscous mass that has especially high resistance to flow.

Fillers which are not of the planar-extended type can be employed by themselves, but in such case the critical point at which high flow resistance is attained is usually quite high and of the order of 55 to 80% by weight of the bituminous compositions. Thus the critical point for slate flour is about 60 to 65% by weight and is about 75 to 80% by weight in the case of limestone dust. For kaolin clay, the critical point is usually around 58% to 68%, depending upon the particular variety of clay that is employed. In the case of silica flour, the critical point is in the neighborhood of 70%. These data illustrate the fact that, in the case of each filler material, incorporation thereof in a bituminous composition has very little effect upon flow resistance or upon fire resistance up to the critical point, followed by sudden and very great increase in flow resistance and fire resistance as soon as the critical point is reached.

In the case of filler materials such as slate flour, limestone dust, and the like, which are not of the planar-extended type it is preferable that at least 90% by weight pass a 100 mesh testing sieve. Referring to the filler as a whole in the bituminous composition, including the presence of planar extended filler, it is desirable that at least half by weight of the total filler pass a 100 mesh testing sieve and preferable that at least $\frac{2}{3}$ by weight of the total filler pass a 100 mesh testing sieve. This is especially the case when the bituminous composition contains 55% by weight or more of filler. In the ordinary case, if the total filler is between 35% and 55% by weight or even between 55% and 65% by weight of the bituminous composition, the major proportion of the total filler passes a 100 mesh testing sieve and when the total filler is over 65% by weight of the bituminous composition about $\frac{2}{3}$ or more of the total filler passes a 100 mesh testing sieve. In order to prevent the inclusion in the bituminous

composition of undesirable granular material it is ordinarily desirable that the coating composition contain less than about 10% by weight of the total filler in the bituminous composition of particles retained on a 14 mesh testing sieve. While particles of coal, coke or cork that are retained on a 14 mesh testing sieve are regarded as undesirable, any small amount of such coarse particles contained in the bituminous composition is to be regarded as having the same screen factor as the screen grading ($-14+20$) of any of the organic fillers just mentioned.

One reason why chrysotile asbestos is especially desirable for employment in bituminous coating compositions in the practice of this invention is that it contains about 12% to 15% by weight of water of constitution liberatable at or below flame temperature. Canadian picrolite and serpentine rock are similar to chrysotile asbestos in this regard. Other materials such as kaolinitic clay, hydrated Portland cement, and calcium silicate hydrate contain 10% or more by weight of water of constitution. When the filler material in the bituminous composition contains water of constitution liberatable at or below flame temperature, the liberation of moisture causes the bituminous composition to develop pores to a greater extent than otherwise when the bituminous composition is exposed to flame temperature and this is desirable since the pores tend to augment the heat insulating efficiency of the mat-like residue that results from exposure of the special bituminous composition of this invention to flame temperature. It is desirable that the bituminous composition have incorporated therein a filler containing water of constitution, which water of constitution liberatable at or below flame temperature amounts to at least 5% by weight of the coating composition.

With regard to the waterproofing bitumen that is employed in the special fire-resistant bituminous composition, it is usually preferable in the manufacture of shingles or the like to employ an asphalt having a softening point of about 200°F . to 250°F ., although a somewhat broader range is permissible, namely, asphalts having a softening point of about 160°F . to about 275°F . For more flexible products such as roll roofing, an asphalt having a softening point below 160°F . may be used, and roofings of satisfactory fire-resistance can be produced utilizing asphalt having a softening point above 80°F ., although it is usually preferable, even in the case of roll roofings and the like, to utilize an asphalt having a softening point above about 120°F . The softening point of the waterproofing bitumen is determined by the standard ring and ball softening point test. In addition to asphalts derived from Mid-Continent crudes, other asphalts are suitable such as asphalts from Mexican, Venezuelan and Colombian crudes. Moreover, other bitumens such as pitches, coal tar and the like may also be used in the practice of this invention. Moreover, any modifier, e.g., of a resinous or oily character that may be mixed and blended with the bitumen is to be regarded as part of the bitumen content of the composition. While the flow resistance of a filler is usually somewhat higher in the case of cracked asphalts as compared with other asphaltic materials, cracked asphalts do not have as long weathering life and for this reason it is usually preferable to use the usual type of roofing asphalt where the roofing is to be exposed directly to the sun and to weather.

Where reference is made herein to "water-

proofing bitumen," this term is used herein in reference to asphalt, pitch, tar and the like having a softening point below about 275° F. and unmixed with filler. One can employ as a finely-divided solid water-insoluble organic filler, a bituminous material consisting wholly or partially of bitumen, said material having a softening point above 500° F., such as a pyrobitumen, e. g. grahamite, albertite and the like or even an asphalt which has been carried, as by air blowing, to a softening point above 500° F. Any such finely-divided bituminous material is to be regarded as organic filler rather than as part of the water-proofing bitumen in the bituminous composition. When reference is made herein to a bituminous material, or a bituminous composition, or a bituminous coating, or a bituminous layer, reference is made to a material, composition, coating or layer comprising bitumen either with or without filler.

In the foregoing example of the practice of this invention, the special bituminous coating composition was applied in layer form at the rate of 45 pounds per 100 square feet of the roofing. It is usually desirable to apply the special bituminous coating material to the weather-exposed side of the base sheet so that the layer will weigh at least 20 pounds per 100 square feet, the range ordinarily being from about 20 to about 60 pounds per 100 square feet, although about 30 to about 50 pounds per 100 square feet is usually preferable. In the foregoing example, wherein the special bituminous coating material contained substantially 50% by weight of filler and the coating was applied at the rate of 45 pounds per 100 square feet, the amount of filler in the coating composition constituted about 22.5 pounds per 100 square feet of the roofing material. For prepared roofing materials, it is usually desirable that the roofing material contain in one or more layers, such as a surface layer or backing layer, sufficient of the special bituminous composition so that the roofing material will contain at least 7 and preferably at least about 14 pounds per 100 square feet of the filler material. By varying the number and thickness of the layers of special bituminous coating composition of this invention, varying degrees of fire-retardant effectiveness can be attained. The special bituminous composition of this invention is especially effective when it is dispersed in a roofing so as to occur in a plurality of layers represented by felt or other sheet material, for example, as shown in Figs. 5, 6 and 9. In such plural layer construction, it is desirable that the total filler constitute at least about 15 pounds per 100 square feet of the roof covering and preferably about 42 pounds per 100 square feet of the roof covering. It is also desirable that each of at least two layers of the special bituminous composition contain at least 7 pounds per 100 square feet and preferably at least about 14 pounds per 100 square feet of the roof covering of the finely-divided solid water-insoluble heat-resistant mineral filler.

While embodiments of this invention have been shown in the form of preformed roofing materials such as shingles and roll roofing, it is apparent that the special bituminous composition of this invention may be employed in the manufacture of roof coverings installed on the job, such as built-up roofings, certain types of which are exemplified in our aforesaid application Serial Number 370,636.

It is one of the advantages of this invention that the new roofing herein defined possess high fire resistance without sacrifice of other properties required for a roofing and without substantial increase in cost compared with conventional roofings heretofore manufactured. The new roofing of this invention has very good weathering characteristics and is tough and pliable. Thus a typical preformed roofing material such as a shingle can be bent 180° in two seconds around a 4 centimeter mandrel with the fire-resistant special coating composition on the outside without cracking the coating through to the felt base, the test being made at 77° F. It is desirable that a roofing having a bituminous water-proofing coating be sufficiently pliable to be bent 180° in two seconds about a mandrel 10 centimeters in diameter at 77° F. with the coating on the outside without cracking the coating through to the base on which it is applied, and any such coating or layer is referred to herein as "pliable" at ordinary temperatures.

While felt sheet material has been mentioned hereinabove as the strain-resisting sheet-like element of roofings and roof coverings embodying this invention, it is apparent that any other suitable sheet material, either fibrous or non-fibrous, either foraminous or non-foraminous, and either deformed or non-deformed, that is adapted to afford the desired strength characteristics, may be employed. Thus fabrics other than felt may be employed such as woven fabrics or fabrics of unspun bonded fibers. The base sheet may, if desired, be saturated with a bituminous or other waterproofing material or may be dry. Sheet material such as a composition board or insulation material may be employed. Plain or corrugated or indented sheet metal may be employed as the base sheet. Ordinary roofing felt made of organic fibers is, however, the most inexpensive sheet material, and, notwithstanding the combustibility of such sheet material, roofings comprising it can, according to this invention, be made highly fire-resistant. If desired, non-combustible fibers can be incorporated in the felt or other fibrous base sheet to augment the fire resistance of the roofing.

It is apparent from the foregoing that, according to the present invention, organic filler materials which need not be non-combustible, when incorporated in bituminous coating compositions within the critical limits above defined, have the astonishing effect of greatly increasing the flow and fire resistance of bituminous roofings. Use of such organic filler materials is of particular utility in imparting to a bituminous composition a flow resistance coefficient over 75 (and preferably over 90) where the heat-resistant mineral filler in the composition is present in an amount below the critical amount for attaining high flow resistance and high fire resistance. Moreover, bituminous compositions, wherein the heat-resistant mineral filler in itself has high flow resistance, can be further improved both as to flow resistance and as to fire resistance by the incorporation of organic filler as disclosed and claimed herein.

While this invention has been described in connection with certain typical examples of the practice thereof, it is to be understood that this has been done for purposes of exemplification. Accordingly the scope of this invention is to be governed by the language of the following claims construed in the light of the foregoing description of our invention.

We claim:

1. A roofing having high resistance to fire, comprising sheet-like base material and carried by said sheet-like base material a layer of thermoplastic bituminous composition, said bituminous composition containing waterproofing bitumen having a softening point above 80° F. and not above 275° F. and of the range 20% to 65% by weight of said composition, and said composition containing intimately commingled and distributed uniformly throughout finely-divided solid water-insoluble filler of the range 35% to 80% by weight of said composition and having a softening point above 500° F., said filler consisting of a mixture of organic filler and heat-resistant mineral filler, and said filler having a flow resistance coefficient of at least 75 when said composition carried by said sheet-like base material is exposed to flame temperature under the flow resistance test defined herein, said heat-resistant mineral filler without said organic filler having a flow resistance coefficient less than 75, said bituminous composition having a Wagner-Bowen plasticity value at 400° F. not substantially greater than 1500 grams, and said bituminous composition providing a pliable weather resistant layer of the hot-spread coating type integrally bonded with said sheet-like base material.

2. A roofing having high fire resistance, comprising sheet-like base material and carried by said sheet-like base material a layer of thermoplastic bituminous composition, said bituminous composition containing waterproofing bitumen having a softening point above 80° F. and not above 275° F. and of the range 20% to 65% by weight of said bituminous composition, and said bituminous composition containing intimately commingled and distributed uniformly throughout finely-divided solid water-insoluble filler having a softening point above 500° F. and of the range 35% to 80% by weight of said composition, said filler comprising heat resistant mineral filler the ratio of the percent by weight of which to the percent by weight of the waterproofing bitumen in said bituminous composition is at least 1 to 3 and comprising organic filler, the total in said composition consisting in major proportion by weight of particles passing a 100 mesh testing sieve and having a flow-resistance coefficient of at least 75 when said bituminous composition carried by said sheet-like base material is exposed to flame temperature under the flow-resistance test as defined herein, but said heat-resistant mineral filler without said organic filler having a flow-resistance coefficient less than 75, said bituminous composition having a Wagner-Bowen plasticity value at 400° F. not substantially greater than 1500 grams, and said bituminous composition providing a pliable weather resistant layer of the hot-spread coating type integrally bonded with said sheet-like base material.

3. A roofing, according to claim 2, wherein said finely-divided solid water-insoluble filler comprises filler which is selected from the group consisting of planar-extended filler that passes a 6 mesh testing sieve and that does not have more than one dimension greater than .046 inch, coal passing a 14 mesh testing sieve, coke passing a 14 mesh testing sieve, and cork passing a 14 mesh testing sieve and the ratio of the grading index of which to the percent by weight of bitumen in said bituminous composition is at least 1 to 3 and not greater than 1 to 0.7, and wherein the

said organic filler in said composition is essential to said minimum ratio.

4. A roofing having high resistance to fire, comprising sheet-like base material and carried by said sheet-like base material a layer of thermoplastic bituminous composition, said bituminous composition containing waterproofing bitumen having a softening point above 80° F. and not above 275° F. and of the range 20% to 65% by weight of said composition, and said composition containing intimately commingled and distributed uniformly throughout finely-divided solid water-insoluble filler having a softening point above 500° F. and of the range 35% to 80% by weight of said bituminous composition, said filler consisting of a mixture of heat-resistant mineral filler and coal, said filler having a flow-resistance coefficient of at least 75 when said bituminous composition is exposed to flame temperature under the flow-resistance test defined herein, said heat-resistant mineral filler without said coal having a flow resistance coefficient less than 75, said bituminous composition having a Wagner-Bowen plasticity value at 400° F. not greater than about 1500 grams, and said bituminous composition providing a pliable weather resistant layer of the hot-spread coating type integrally bonded with said sheet-like base material.

5. A roofing, according to claim 4, wherein said heat-resistant mineral filler comprises asbestiform mineral fiber.

6. A roofing having high resistance to fire, according to claim 1, wherein said sheet-like base material is fibrous sheet material and wherein the flow-resistance coefficient of said finely-divided solid water-insoluble filler having a softening point above 500° F. is at least 90.

7. A highly fire-resistant prepared bituminous roofing material according to claim 1, wherein said sheet-like base material consists essentially of felted fiber sheet material impregnated with a bituminous waterproofing material, wherein said thermoplastic bituminous composition is applied to said sheet-like base at the rate of about 20 to 60 pounds per 100 square feet of said roofing and wherein granular surfacing material is embedded in the normally weather exposed surface of said layer of thermoplastic bituminous composition that is integrally bonded with said sheet-like base material.

8. A roofing according to claim 1 wherein said filler comprises planar-extended filler which passes a 6 mesh testing sieve and which has not more than one dimension greater than .046 inch, the ratio of the grading index of said planar-extended filler to the percent by weight of bitumen in said bituminous composition being at least 1 to 3 and not being substantially greater than 1 to .7.

9. A prepared roofing material having high resistance to fire according to claim 1 wherein the softening point of said waterproofing bitumen is of the range 120° F. to 275° F. and wherein said bituminous composition is applied at the rate of about 20 to 60 pounds per 100 square feet of said roofing material to provide said pliable weather resistant layer of the hot spread coating type integrally bonded with said sheet-like base material.

10. A roofing having high resistance to fire according to claim 1 wherein a major proportion by weight of said finely-divided solid water-insoluble filler consists of particles passing a 100 mesh testing sieve, wherein there is a plurality

of layers of said thermoplastic bituminous composition integrally bonded with sheet-like base material and wherein said finely-divided solid water-insoluble filler constitutes at least 15 pounds per 100 square feet of said roofing with at least 7 pounds per 100 square feet contained in each of at least two layers of said bituminous composition.

11. A roofing having high resistance to fire according to claim 1 wherein a major proportion by weight of said finely-divided solid water-insoluble filler consists of particles passing a 100 mesh testing sieve, wherein there is a plurality of layers of said thermoplastic bituminous composition integrally bonded with sheet-like base material, wherein one of said layers is on the weather side of said roofing and is applied at the rate of at least 30 pounds per 100 square feet of said roofing, and wherein said finely-divided solid water-insoluble filler constitutes at least 42 pounds per 100 square feet of said roofing with at least 14 pounds per 100 square feet contained in each of at least two of said layers.

12. A roofing according to claim 1 wherein said waterproofing bitumen is of the range 20% to 45% by weight of said bituminous composition, wherein said finely-divided solid water-insoluble filler is of the range 55% to 80% by weight of said bituminous composition, wherein at least $\frac{2}{3}$ by weight of said finely-divided water-insoluble filler passes a 100 mesh testing sieve, and wherein the ratio of the percent by weight of said heat-resistant mineral filler to the percent by weight of said waterproofing bitumen in said bituminous composition is at least 1 to 2.

13. A roofing according to claim 1 wherein said

heat-resistant mineral filler comprises mineral fibers.

14. A roofing according to claim 2 wherein said organic filler comprises organic fibers.

15. A prepared roofing material according to claim 2 wherein the softening point of said waterproofing bitumen is of the range 120° F. to 275° F., wherein said bituminous composition is applied at the rate of about 20 to 60 pounds per 100 square feet of said roofing material to provide said pliable weather resistant layer of the hot spread coating type integrally bonded with said sheet-like base material and wherein said bituminous composition has a Wagner-Bowen plasticity value at 400° F. not substantially greater than 1000 grams.

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