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FRICTION ELEMENTS

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This invention relates to a friction element in the form of a composition brake shoe for braking railway equipment.

The conventional brake shoe utilized with railway equipment has been one of cast iron applied with radial clamping force directly to the tread of the wheel, but there have been proposals of composition shoes consisting of molded or pressed composition material. Such shoes in one form embodied a relatively high proportion of metallic particles together with additional filler such as fibrous asbestos, and these fillers were mixed in a binder matrix of a natural resin or the like. The composition was then shaped in to desired form and then cured under heat and pressure; and in some instances the composition was pressed in to an arcuately configured shell or casing serving as a backing, and finally set to an operative state.

Advantages have been stressed with regard to composition brake shoes of the foregoing kind, but regardless of this cast iron shoes prevail today as the customary friction element for braking railway equipment.

Among the disadvantages of composition or filled shoes of the foregoing kind have been variations in wear characteristics and lack of resistance to shock which contributed to relatively poor life of the shoes in service. Moreover, the coefficient of friction of these composition railway brake shoes under wet conditions does not compare favorably to the coefficient of friction under dry conditions, that is, while friction is good so long as the shoe is dry there is an unfavorable low value in those instances where the shoe is wet, this apparently being an inherent defect not encountered with cast iron shoes.

The advantages stressed for a composition railway brake shoe could be of practical merit if the aforementioned disadvantages were not present, and in view of this the primary object of the present invention is to impart to a composition railway brake shoe desirable friction characteristics such that the coefficient of friction under wet conditions compares favorably to that of the shoe when dry and to achieve this desirable relation of frictional characteristics in a composition railway brake shoe, while at the same time imparting high heat resistance thereto and marked ability to absorb physical shock consonant with the severe conditions encountered in the deceleration of railway equipment.

Another object of the present invention is to achieve a desirable balance between wet and dry friction in a friction element by incorporating therein a mineral filler in the form of an aluminum silicate of the sillimanite group which imparts this desirable characteristic to the friction element regardless of other fillers which may or may not be resorted to for other purposes.

It has been proposed to include a substantial quantity of metal particles in composition railway brake shoes. The frictional heat engendered in decelerating railway equipment is of appreciable magnitude, and it is probable that one of the reasons why composition railway brake shoes when embodying an excessive amount of metal particles have not been considered entirely satisfactory

has been that the metal particles, usually of iron, sometimes become incandescent or even partially fused during braking, thereby tending to weaken and cause thermal break-down of the organic binder material and to disrupt the adhesive forces that bind the metal particles in the matrix. What is more, assertions have been made and evidence shows that the severe heating conditions arising during use of composition railway brake shoes containing metal particles have accounted for scoring, heat checking, and undue wear of the wheel tread and poor life of the shoe.

There are advantages to incorporating metal particles in a composition railway brake shoe, chief among these being satisfactory friction and the resistance to wear inherently possessed by such metal filler, especially if the metal be in the form of hard cast iron particles. Accordingly, a further object of the present invention is to so modify a composition railway brake shoe containing hard metal particles, such as cast iron particles, that the tendency toward overheating or incandescence of such hard metal particles is retarded, thus suppressing the tendency toward disruption and thermal breakdown of the binder and conditions that have a deleterious effect on the wheel tread and the brake shoe; and a further object is to achieve this desirable attribute by an inorganic filler in the form of a particular aluminum silicate possessing high heat resistance and capable of synergistically cooperating with the metal filler particles to impart to the brake shoe long life from the standpoint of wear, the ability to conduct heat away from the face of the shoe, and a coefficient of friction that is satisfactory under both wet and dry conditions.

High friction by itself can be attained with relative ease in a composition railway brake shoe, but the supervening factor which may not be disregarded is that the value of braking friction must in every situation be less than the coefficient of adhesion between the wheel tread and the rail, for otherwise the wheel will lock during braking and skid on the rail causing the wheel tread to wear flat. Because of its good frictional characteristics and high resistance to wear, it is advantageous to include cast iron particles in a composition railway brake shoe, but particularly when braking at high speeds cast iron tends toward an overbalance between brake friction and adhesion of the wheel to the rail. A feature of the present invention is that cast iron as a filler in a composition brake shoe can be replaced in whole or in part by a filler to be described that has equivalent friction and resistance to wear while not partaking of undue increase in friction at high speeds tending toward the overbalance mentioned as characteristic of cast iron in excessive amounts, and so to do is one of the more important objects of the present invention.

Specifically, it is an object of the present invention to achieve the foregoing by resort to an inorganic filler material in the form of an aluminum silicate selected from the group of minerals consisting of naturally occurring kyanite, sillimanite, andalusite, dumortierite and topaz, the calcination product of these commonly known as mullite, all of which are essentially aluminum silicates, and synthetic forms of the foregoing aluminum silicates of the group hereinafter disclosed, either alone, or preferably combined with hard ferrous metal particles such as white cast iron particles in a binder matrix of heat stable rubber selected from the group consisting of heat stable synthetic rubber polymers and copolymers, and heat stable forms of natural latex rubber, and suitable modifications or variations of these.

Other and further objects of the present invention will be apparent from the following description and claims which, by way of illustration set forth preferred embodiments of the present invention and the principles thereof,

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and what we now consider to be the best mode in which we have contemplated applying those principles. Other embodiments of the invention embodying the same or equivalent principles may be used and changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

It has heretofore been proposed that asbestos fibers be used as a filler in composition railway brake shoes. Asbestos fibers when so used have not been found altogether satisfactory, because at the high thermal conditions encountered in decelerating railway equipment, asbestos loses its water of hydration and the fibers break down into elemental abrasive particles readily releasable from the body of the shoe. The manifest result is a consequent scouring or abrading action by these loose abrasive particles not only on the wheel tread but also on the face of the brake shoe. It has been asserted that advantage may be taken of asbestos in critically particulate form as a filler enhancing wet friction of certain brake shoes having limited application, and it was further stated in this same connection that rottenstone, which is a rock of aggregate mineral grains, and diatomaceous earth when of the same critical particle size were equivalent to asbestos. Cognizance was taken even in this instance of the abrading action of the particulate fillers proposed, but it is for this very reason that a filler of this kind is not satisfactory in a railway brake shoe since the life of both the wheel and the shoe is materially lessened to an impractical degree. Moreover, it is known that asbestos does not impart the degree of wet friction necessary for a railway brake shoe where it is desirous that such a property be afforded.

We have found that the objects set forth above as desirable in a composition friction element, especially in the form of a brake shoe for railway equipment, can be achieved and the difficulties heretofore encountered overcome by having resort to a filler in the form of one or more aluminum silicates of the group consisting of the so-called kyanite-sillimanite group of naturally occurring minerals including kyanite, sillimanite (including Detrital kyanite-sillimanite concentrate) and andalusite and the closely related minerals of similar composition, namely, topaz and dumortierite. The first three of the aforesaid naturally occurring minerals, namely, kyanite, sillimanite and andalusite, subscribe to the general quantitative formula Al_2SiO_5. Dumortierite has the general formula $8Al_2O_3.B_2O_3.6SiO_2.H_2O$, and topaz the general formula $Al_2(FOH)_2SiO_4$. Each is inherently of highly refractory nature, that is, displays a very high degree of heat resistance. Accordingly, an aluminum silicate of the group referred to above, when used in accordance with the present invention as an inorganic mineral filler for a composition friction element, does not partake of incandescence which is a characteristic of metal fillers in a composition friction element.

In addition to displaying the desirable refractory quality of heat resistance, an aluminum silicate of the group hereinabove referred to exhibits a high degree of hardness or wear resistance such as to compare favorably to hard ferrous metal particles used heretofore as a hard filler in composition friction elements. Of primary importance is that the aluminum silicates of the group of materials hereinabove referred to when used as a filler in a composition friction element impart thereto a wet friction that compares satisfactorily to the friction of the shoe when dry, and moreover, said aluminum silicates have been found not to partake of increased friction when braking at high wheel speeds which is one objection to cast iron filler material used in excessive quantities or in appreciable quantity as the sole friction enhancing agent. In contradistinction to particulate asbestos, finely divided rottenstone or the like, the aluminum silicates of the aforesaid group do not scour the car wheel or act to self-efface the wear surface of the shoe.

Of the group of minerals found useful in the practice of the present invention, calcined kyanite is the preferred species for the reason that this is the most readily available in large quantities. The naturally occurring members of the group exhibit certain similar chemical and physical characteristics as to composition, hardness and resistance to chemical action, and the appearance of these is manifest primarily in large, flat blade or needle-like prismatic crystal agglomerations. The majority of the members of the group undergo transformation at high temperatures to the needle-like aluminum silicate known as mullite, $3Al_2O_3.2SiO_2$ crystallizing in the rhombic system. This mineral is quite similar physically to sillimanite, and in this connection mullite is reported by some authorities as $2Al_2SiO_5.Al_2O_3$. Accordingly, in some instances it may be advantageous to calcine one of the naturally occurring forms of the group to obtain mullite which is the most stable of the six forms. Moreover, synthetic production of mullite has now been accomplished by bringing together silica and alumina in combining environment. It will therefore be recognized that the several forms of the members of the mineral group referred to above, namely, natural, calcined, or synthetic may be utilized in accordance with the present invention.

All members of the aforesaid mineral group are particularly characterized by chemical and physical stability at elevated temperatures. Thus, kyanite when calcined begins to decompose or transform to mullite at about 1325° C., andalusite at about 1350° C., and sillimanite at about 1530° C. The product of calcination, mullite, is stable at least up to 1810° C. Dumortierite is stable up to at about 1550° C. and topaz up to at about 1000° C.

During calcination, kyanite, sillimanite and andalusite exhibit a decrease in density and accordingly an increase in volume, but except in the instance of kyanite this physical change is not of any appreciable magnitude.

Andalusite crystallizes in the orthorhombic system, developing relatively coarse prisms of practically square cross-section. The crystals, however, are roughly developed as a rule and rude columnar masses are common. It exhibits distinct cleavage, and has a hardness of 7.5.

Kyanite is triclinic, and displays good cleavage. It is usually found in long bladed crystals or columnar to fibrous structure and has a hardness varying considerably from 5 to 7.25, depending upon crystallographic direction.

Sillimanite occurs usually as long, slender, needle-like orthorhombic prisms, often aggregated together to form fibrous or compact masses. It displays perfect cleavage and has a hardness of 6 to 7.

Dumortierite, like sillimanite, crystallizes in the rhombic system and occurs naturally as fibrous or columnar aggregates. It has a hardness of 7.

Topaz occurs also as orthorhombic crystals, being prismatic in habit, and possesses a characteristic perfect cleavage. Its hardness is 8.

The characteristics of friction and the heat and wear resistance of the aluminum silicates of the hereinabove disclosed group in a composition friction element are independent of the other fillers that may advantageously be present, and hence may be used alone or combined with such other fillers which independently possess desirable attributes. This feature of the present invention is particularly advantageous since by combining the aluminum silicate filler with a long-wearing metallic filler which is heat conductive, assurance can be had that during braking of railway equipment the heat engendered will be conducted away from the wear face of the friction element so that there will be no local concentration of heat at the tread of the car wheel. Of particular importance in the present instance is the fact that the above identified aluminum silicate minerals do not break down at temperatures commonly encountered in the deceleration of railway equipment in contradistinction to asbestos fibers or the like which under similar conditions are high-

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ly susceptible to transformation to abrasive powders tending to scour or unduly wear the tread of the car wheel. These same aluminum silicate minerals are distinguishable in the present instance from mineral carbonates which are relatively soft in nature and which break down at relatively low temperatures and are unsatisfactory for the purposes of the present invention.

Preferably, then, in accordance with the present invention, the selected aluminum silicate, or silicates, of the group herein described are combined synergistically in about equal proportion by weight with comminuted metallic filler, preferably particles of white cast iron, which possesses an optimum characteristic of long wear and relatively good heat conduction. By combining the mineral and metal filler in this manner, the two cooperate to afford a high degree of heat resistance and at the same time a degree of heat conduction thereby eliminating the tendency toward overheating were a metallic filler such as cast iron particles alone to be resorted to as the material required to impart the necessary wear resistance to the composition friction element.

In accordance with prior practice as represented by United States Patents Nos. 2,052,779 and 2,267,803, inorganic and organic friction stabilizers, modifers and enchancers may be advantageously present together with the aluminum silicate and white cast iron particles. Such additional filler materials are preferably represented by lead, lead sulphide, and organic or primarily carbonaceous friction-enhancing material of which petroleum coke is an example. Lead and lead sulphide impart desirable friction stabilizing action and non-fade characteristics to the friction element of the present invention, and an organic or carbonaceous filler material such as petroleum coke alone or together with shredded soft rubber particles serves to increase or enhance friction particularly at low brake engaging pressures.

It is important that the binder employed be such as to display relatively high resistance to thermal decomposition while at the same time being strongly resistant to the relatively heavy shocks and forces engendered during the deceleration of railway equipment. A binder of this kind is particularly manifest in heat stable synthetic copolymer rubber of the Buna-S type, that is, a rubber derived as the copolymerization product of butadiene and styrene, as will be described. A Buna-S binder is of relatively flexible nature as compared to shock-sensitive phenolics of the phenol-aldehyde type that have heretofore been employed in composition friction elements, and while flexible synthetic elastomer rubber binders of the Buna-S type have not been viewed as possessing thermal resistance equivalent to phenolics which in fact are infusible, nevertheless, insofar as the braking of railway equipment with the friction element of the present invention is concerned, a heat resistant relatively soft elastomer binder of the Buna-S type performs satisfactorily, and such may be modified if desired with a cashew nut shell liquid polymer binder which, in fully cured condition, is cross-linked. Moreover, it will be borne in mind that present in the rubber binder matrix, in accordance with the present invention, is the highly refractory aluminum silicate filler.

Specification of a binder of the Buna-S type is by way of example only, since the primary consideration in this connection is that a relatively soft or flexible heat stable binder be used in contradistinction to relatively brittle and infusible phenolics. Accordingly, any of the natural or synthetic rubbers which are vulcanizable to a non-thermoplastic or heat stable state may be used, among these being Buna-S, as noted, Buna-N, Butyl rubber, butadiene acryonitrile (Hycar), reclaimed natural rubber, and heat stable variations of these.

It is further of advantage in some instances to modify the relatively soft rubber binder with cashew nut shell liquid polymer subsequently cured or advanced in accordance with conventional procedures with about six percent hexamethylenetetramine during vulcanization of the rubber binder. Moreover, the cashew nut shell liquid polymer in the uncured state or incompletely set-up stage assists in milling the rubber, as will be described, and serves also as an extender for spreading the rubber binder uniformly through the body of filler material. To provide these advantages, the cashew nut shell polymer is initially used in a preliminary or intermediate stage of heat polymerization, and then is advanced during the cure of the composition to a stage manifest in a benzol extractive test of but fifteen percent after a sixteen hour extraction test period.

Generally speaking, the composition railway brake shoe of the present invention, exclusive of solvent, comprises from 10 up to about twenty percent by weight of hard ferrous metal in the form of white cast iron particles; about ten percent by weight or above of comminuted aluminum silicate; about twenty to forty percent by weight of organic or carbonaceous friction-enhancing filler material, as represented, for example, by petroleum coke alone or combined with other organic friction material; about 15 to 20 percent lead sulfide; a relatively minor proportion of finely divided lead; and a synthetic elastomer or rubber binder in an operative proportion, generally about 12.2 to about 15 percent, by weight of the composition, based on the foregoing, exclusive of the vulcanizers and accelerators used to set and cure the bond. In some instances a minor amount of asbestos fibers may be used to the extent that additional body reinforcement is attained. Wide variations are tolerable. For instance, the percentage of cast iron particles may be increased with a corresponding decrease in the amount of friction stabilizer and enhancer as will be described, but operative friction elements may be made according to the formulae set forth in the following examples in which all parts indicated are by weight:

Material	Example (Parts by Weight)		
	I	II	III
Binder (A)	15	12.2	
Binder (B)			13.0
White Cast Iron Particles (G–120)	10.0		20.0
Calcined Kyanite	10.0	13.0	12.0
Lead Sulfide	19.5	22.2	15.0
Lead	4.6	5.6	5.5
Calcined Petroleum Coke	21.6	39.3	25.8
Asbestos (Grade 4K)	10.8		
Curing Agents:			
Litharge	3.4	2.7	3.2
Zinc Oxide	5.1	4.2	4.7
Al_2O_3		0.8	0.8
Naptha (solvent)	9.4	9.0	6.7

Example IV

A BINDER

Ingredient	Parts by Weight
Buna-S (23½% Styrene)	44.0
Cashew Nut Shell Liquid Polymer (Intermediate stage of heat growth)	44.0
Rubber Cure:	
Sulphur	8.8
Benzothiazol Disulfide	0.91
Copper Dimethyl Dithiocarbamate	0.46
Hexamethylenetetramine	1.83

Example V

B BINDER

Ingredient	Parts by Weight
Buna-S (3% Styrene; 8% cumene hydroperoxide)	63.8
Rubber Cure:	
Litharge	14.4
Zinc Oxide	2.18

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The particle size of the filler materials is not critical. Lead, lead sulfide and petroleum coke may be used in powder or like condition of sub-division and the cast iron particles and filler of the sillimanite group may vary between 30 and 100 mesh, about 80 mesh being preferred.

In producing friction elements in accordance with Examples I and II bonded by the binder of Example IV, the rubber and cashew nut shell liquid polymer in a preliminary or uncured state are first worked together intimately in a mill after which the ingredients used to vulcanize, cure and set the binder and advance the liquid polymer are added thereto and the mixture transferred to a blade mixer. The naptha solvent is then added to the ingredients affording the bond, the mixture agitated until a paste condition is obtained and then are added the fillers including the castiron particles, aluminum silicate, the friction modifer and enhancer and the asbestos where such is to be used for enhancing body strength. Mixing is continued until a uniform composition is attained.

It will be noted that the Buna-S type binder of Example IV undergoes vulcanization by sulfur. After removal of solvent from the composition mixture at a temperature below that at which vulcanization commences (150° F.), the resulting composition is pressed to shape and the bond is sulfur-vulcanized, cured and set under heat and pressure, preferably two tons per square inch for three hours at a temperature of 350° F., followed by an oven cure for six hours at 350° F. and then an additional oven cure for twenty-four hours at 500° F. Such cure to produce ultimately the friction element of the present invention is, of course, carried out as a molding operation known in the art.

It will be noted that vulcanization of the bond of Example V is one of catalysis promoted by cumene hydroperoxide. In preparing a composition friction element from this bond in accordance with Example III, the peroxide catalyst is added to the rubber after preliminary milling. Milling is continued to disperse the catalyst, and the litharge and zinc oxide accelerators are then added and dispersed. The bonding material is transferred to a blade mixer, solvent is added and a paste prepared after which the filler materials are added and uniformly dispersed as described above. Solvent is removed at a temperature below that at which the bond ingredients normally commence reaction (150° F.), and the composition is pressed to shape and thereupon the cure is commenced with a pressure of about two tons per square inch at a temperature of 350° F. for three hours. This preliminary cure is followed by an oven cure for six hours at 350° F., a second oven cure for twenty-four hours at 350° to 490° F., and a final oven cure for forty-eight hours at 490° F. In this instance, the elastomer binder is somewhat softer than in the foregoing example, this being due, of course, to the absence of the cashew nut shell liquid polymer which, in accordance with the foregoing example, cures to a relatively hard and infusible condition.

Relatively wide variations are possible. Based on Example I, for instance, we have found that the amount of cast iron particles may be increased to twenty parts by weight with a corresponding adjusting reduction of ten parts by weight (total) of petroleum coke and lead sulfide, the proportion of binder ingredients and filler including calcined kyanite, lead and asbestos, where used, remaining substantially constant. The curing and molding cycle and procedure in this instance being as aforesaid.

It will be appreciated that the foregoing are but exemplary embodiments of the invention illustrative of the compatibility and utility of an aluminum silicate filler of the group herein disclosed with other fillers as heretofore known and used in composition friction elements.

It is to be understood that while the so-called sillimanite or kyanite-sillimanite group of minerals consists of naturally occurring kynite, sillimanite and andalusite, the transformation product of these minerals, known as mullite, and the synthetic forms of these naturally occurring minerals, the closely related group of minerals, namely, topaz and dumortierite are for the purposes of the present invention, included within the term "sillimanite group," and hence this designation as used hereinbefore and as used hereinafter in the claims is to be construed as embracing any and all of these materials or mixtures thereof.

The resultant friction elements of the present invention achieve the objects desired in that friction is satisfactory under both wet and dry conditions, wear resistance is high, resistance to both chemical and physical decomposition is pronounced and satisfactory, and no undue overheating will be encountered.

Thus, while we have described the preferred embodiments of our invention, it is to be understood that these are capable of variation and modification, and we therefore do not wish to be limited to the precise details set forth, but desire to avail ourselves of such changes and alterations as fall within the purview of the following claims.

We claim:

1. A pressed and molded composition friction element displaying substantially equal wet and dry friction and consisting essentially of a non-metallic organic binder matrix subject to thermal decomposition and affording the main body of the friction element, and hard filler particles dispersed uniformly throughout said matrix and affording the essential wet-dry friction equivalence; said filler particles in proportions consisting essentially of about ten to twenty percent by weight of the shoe of heat conductive cast iron particles which tend to incandesce at high temperatures engendered by friction and which serve to conduct heat engendered by friction away from the wear face of the friction element, and in addition about ten percent by weight of a refractory heat insulating aluminum silicate selected from the group consisting of kyanite, sillimanite, andalusite, dumortierite, topaz and mullite, said aluminum silicate particles serving as heat insulating bodies among the cast iron particles tending to suppress the thermal decomposing effect of the incandescible cast iron particles on the organic binder matrix; and said organic binder matrix consisting essentially of a heat stable rubber.

2. A friction element according to claim 1 wherein the binder matrix is present in an amount of about twelve to fifteen percent by weight of the friction element.

3. A friction element according to claim 1 which additionally includes about fifteen to twenty percent by weight of lead sufide and about twenty to forty percent by weight of carbonaceous material.

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