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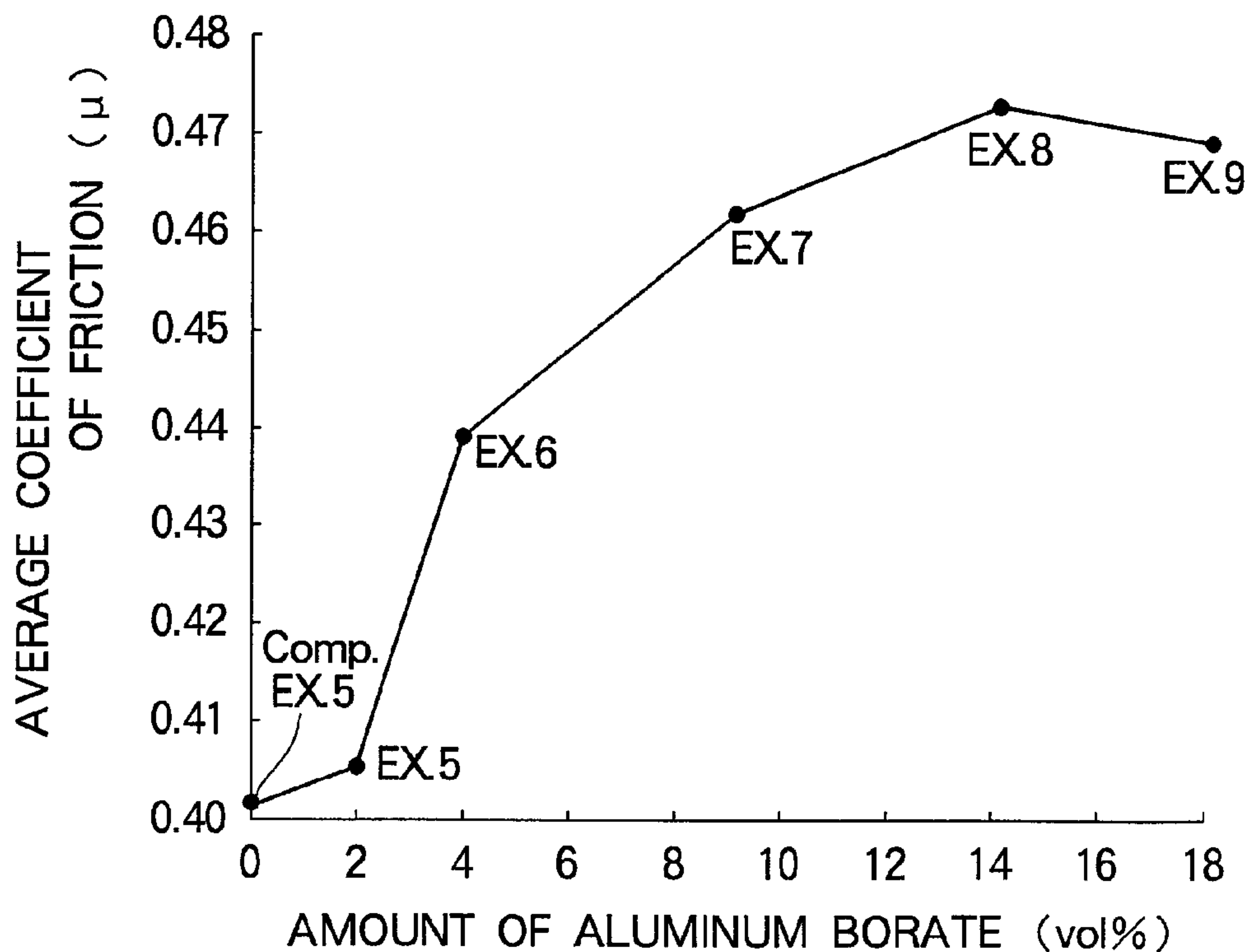
(72) Inventeurs/Inventors:
YOSHIDA, SATOSHI, JP;
SHIBATA, KATSUHIRO, JP

(73) Propriétaire/Owner:
HONDA GIKEN KOGYO KABUSHIKI KAISHA, JP

(74) Agent: DENNISON ASSOCIATES

(54) Titre : MATERIAU DE FRICTION

(54) Title: FRICTION MATERIAL



(57) Abrégé/Abstract:

A friction material having a high coefficient of friction without causing any undesirable wear of a brake disc when used for a brake pad contains 2 to 20% by volume of aluminum borate fibers as a fibrous material and 5 to 20% by volume of barium sulfate as a filler.

ABSTRACT OF THE DISCLOSURE

A friction material having a high coefficient of friction without causing any undesirable wear of a brake disc when used
5 for a brake pad contains 2 to 20% by volume of aluminum borate fibers as a fibrous material and 5 to 20% by volume of barium sulfate as a filler.

FRICTION MATERIAL

BACKGROUND OF THE INVENTION

1. Field of the Invention:

5 The present invention relates to a friction material which is particularly suitable as a material for vehicular brakes.

2. Description of the Related Art:

 A friction material of this kind comprises a fibrous material, a filler and a binder. While asbestos has long been
10 used in a large quantity as the fibrous material, the use of a different material has recently come to be sought in order to create an improved environment for people doing the relevant work and prevent any environmental pollution caused by asbestos.

 Ceramic, metal and organic fibers are known as the fibrous
15 materials replacing asbestos. The known ceramic fibers include glass fibers, alumina fibers, rockwool, and potassium titanate fibers. The known metal fibers include steel, copper and brass fibers. The known organic fibers include aromatic polyamide fibers.

20 Alumina-silica and/or potassium titanate fibers have hitherto been used as the ceramic fibers. Alumina-silica is high in hardness, but potassium titanate is low. Alumina-silica has a high coefficient of friction (μ), but potassium titanate does not have a very high coefficient of friction. Their mixture is
25 sometimes used, since potassium titanate is effective for preventing a brake squeak. An increase in the proportion of

alumina-silica for obtaining a mixture having a higher coefficient of friction (μ), however, results in a material which is more likely to do damage to a brake disc due to the hardness of alumina-silica.

5

SUMMARY OF THE INVENTION

As a result of our research for ceramic fibers replacing alumina-silica, we, the inventors of this invention, have found that aluminum borate ($9\text{Al}_2\text{O}_3 \cdot 2\text{B}_2\text{O}_3$) fibers are useful as a
10 substitute for alumina-silica fibers.

Figure 2 is a graph showing the relationship which we have found to exist between the proportion of aluminum borate in a mixture of alumina-silica and aluminum borate fibers and its average coefficient of friction (μ). As is obvious therefrom,
15 the value of μ begins to show a sharp rise from a mixture containing 2% by volume of aluminum borate and continues to show a general tendency to increase with an increase of its proportion, but if its proportion exceeds 20% by volume, no better result can be obtained any longer.

20 According to this invention, therefore, a fibrous material contains not more than 20% by volume of aluminum borate fibers, since it is also required to contain potassium titanate of low hardness in order to prevent a brake squeak.

We have also found that aluminum borate fibers have a very
25 low wear resistance at a high temperature (300°C), as shown at Comparative Example 1 in Figure 1. We have, therefore, made pads

containing 4% by volume of aluminum borate fibers, 12% by volume of potassium titanate and a total of 15% by volume of BaSO₄ and CaCO₃, as shown in Table 3, and compared them in wear resistance at a high temperature.

5 As a result, we have found that the addition of at least 5% by volume of BaSO₄ enables a reduction of pad wear at a high temperature, and that an undesirable brake squeak is likely to occur if its proportion exceeds 20% by volume.

10 Thus, this invention resides in a friction material comprising a fibrous material, a filler and a phenolic resin, in which the fibrous material contains 2 to 20% by volume of aluminum borate fibers, and the filler contains 5 to 20% by volume of barium sulfate.

15 By employing an appropriate amount of aluminum borate fibers, it becomes possible to produce a material having a satisfactorily high coefficient of friction.

20 Addition of an appropriate amount of barium sulfate makes a friction pad to have a satisfactorily high wear resistance at high temperature, while not causing any heavier wear of a brake disc than a pad of any conventional material does.

25 Thus, the material of the present invention has a high coefficient of friction, while also having the property of not causing any undesirable wear of a brake disc, as well as satisfactorily high levels of fade resistance and thermal conductivity.

Ceramic fibers as a friction material of this invention

takes the place of alumina-silica and is particularly suitable as a material for vehicular brakes. It may also be used for other purposes including its use as a clutch facing material, and as a material for brakes and clutches in industrial equipment.

5

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a graph showing the wear at 300°C of pads, including ones formed from a material containing BaSO₄, in relation to its proportion; and

10 Figure 2 is a graph showing the average coefficient of friction (μ) of mixtures of alumina-silica and aluminum borate fibers in relation to the proportion of aluminum borate fibers.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

15 The present invention will now be described in further detail by way of example onlys embodying it and comparative examples.

EXAMPLES 1 TO 4 AND COMPARATIVE EXAMPLES 1 TO 4

(1) Preparation of Test Samples:

20 (1-1) Constituents:

Samples were prepared from constituents as shown in Table 1.

Explanation will first be made of the preferred proportions of those constituents.

Aromatic polyamide fibers, such as para type pulp-like
25 fibers, are used in the amount of 2 to 20% by volume for making a material of improved durability which is less likely to do

damage to a rotor. If their proportion is less than 2% by volume, there is obtained a composition which is difficult to preform, and if it exceeds 20% by volume, there is obtained a material having too low a coefficient of friction at a high
5 temperature.

Ceramic fibers, such as potassium titanate, alumina-silica or aluminum borate fibers, are used in the amount of 5 to 30% by volume for making a material having an improved coefficient of friction. If their proportion is less than 5% by volume, there
10 can hardly be obtained any material having a satisfactorily improved coefficient of friction, and if it exceeds 30% by volume, there is undesirably obtained a material which is very likely to do damage to a brake disc.

Copper fibers are used in the amount of 2 to 10% by volume
15 for making a material which can prevent a brake squeak and has an improved strength at a high temperature. If their proportion is less than 2% by volume, they can hardly be expected to produce any substantial result, and if it exceeds 10% by volume, there is undesirably obtained a material which is likely to adhere to
20 a rotor.

Proportions of aluminum borate and alumina-silica fibers will be set forth later.

An organic filler, such as cashew, melamine or phenol dust, is used in the amount of 3 to 20% by volume for making a material
25 having a stable coefficient of friction at a low contact pressure. If its proportion is less than 3% by volume, its

addition is of no use, and if it exceeds 20% by volume, there is obtained a material having too low a coefficient of friction at a high temperature.

Graphite is used in the amount of 5 to 20% by volume as a solid lubricant. If its proportion is less than 5% by volume, its addition is of little use, and if it exceeds 20% by volume, there is obtained a material having too low a coefficient of friction.

An inorganic filler, such as molybdenum disulfide, zinc sulfide, lead sulfide or antimony trisulfide, is used in the proportion of 5 to 20% by volume as an oil lubricant. If its proportion is less than 5% by volume, its addition is of little use, and if it exceeds 20% by volume, there is obtained a material having too low a coefficient of friction.

BaSO_4 (barium sulfate) or CaCO_3 (calcium carbonate), or a mixture thereof is used in the amount not exceeding 20% by volume as a filler. If its proportion exceeds 20% by volume, a worse brake squeak will occur.

Metal powder, such as a copper powder, a copper-zinc or -tin alloy powder, or an iron powder, is used in the amount of 2 to 10% by volume for making a material capable of preventing a brake squeak and having a satisfactorily high coefficient of friction at a high temperature. If its proportion is less than 2% by volume, its addition is of little use, and if it exceeds 10% by volume, it will bring about an increased wear of a brake disc.

Phenolic resin is used in the amount of 8 to 20% by volume as

a binder. If its proportion is less than 8% by volume, it produces only a low binding effect, and if it exceeds 20% by volume, there is obtained a material having too low a coefficient of friction at a high temperature.

5

TABLE 1

		(vol.%)								
		Comp. Ex.	Examples				Comp. Ex.			
		1	1	2	3	4	2	3	4	
10	Fibrous Material	aromatic polyamide fibers	4	4	4	4	4	4	4	4
		ceramic fibers	12	12	12	12	12	12	12	12
		copper fibers	3	3	3	3	3	3	3	3
		aluminum borate fibers	4	4	4	4	4	-	-	-
		alumina-silica fibers	-	-	-	-	-	4	4	4
15	Friction Controller	organic filler	18	18	18	18	18	18	18	18
		graphite	10	10	10	10	10	10	10	10
		inorganic filler	14	14	14	14	14	14	14	14
		BaSO ₄	-	5	10	12	15	-	5	15
		CaCO ₃	15	10	5	3	-	15	10	-
		metal powder	3	3	3	3	3	3	3	3
	Binder	phenolic resin	17	17	17	17	17	17	17	17
		Total	100	100	100	100	100	100	100	100

20

The samples were prepared from compositions containing 4% by volume of aromatic polyamide fibers, 12% by volume of potassium titanate fibers, 3% by volume of copper fibers, 18% by volume of organic filler, 10% by volume of graphite, 14% by volume of inorganic filler, 3% by volume of metal powder and 17% by volume of phenolic resin as common constituents, and further containing a total of 19% by volume of other constituents differing from one

example to another as shown in Table 1 and below:

Comparative Example 1 - 4% by volume of aluminum borate fibers and 15% by volume of CaCO_3 ;

Example 1 - 4% by volume of aluminum borate fibers, 5% by volume of BaSO_4 and 10% by volume of CaCO_3 ;

Example 2 - 4% by volume of aluminum borate fibers, 10% by volume of BaSO_4 and 5% by volume of CaCO_3 ;

Example 3 - 4% by volume of aluminum borate fibers, 12% by volume of BaSO_4 and 3% by volume of CaCO_3 ;

Example 4 - 4% by volume of aluminum borate fibers and 15% by volume of BaSO_4 ;

Comparative Example 2 - 4% by volume of alumina-silica fibers and 15% by volume of CaCO_3 ;

Comparative Example 3 - 4% by volume of alumina-silica fibers, 5% by volume of BaSO_4 and 10% by volume of CaCO_3 ; and

Comparative Example 4 - 4% by volume of alumina-silica fibers and 15% by volume of BaSO_4 .

In Comparative Examples 2 to 4, alumina-silica fibers were used instead of aluminum borate fibers, as shown. Details of these two kinds of fibers are shown in Table 2 below.

TABLE 2		
	aluminum borate	alumina-silica
fibers		
chemical formula	$9\text{Al}_2\text{O}_3 \cdot 2\text{B}_2\text{O}_3$	$\text{Al}_2\text{O}_3 \cdot \text{SiO}_2$
brand names	ALBOREX from Shikoku Kasei	RFC400-SL from Toshiba Monoflux
average fiber diameter	0.5 - 1.0 μm	2 - 4 μm
average fiber length	10 - 30 μm	300 - 500 μm

Balance of Comparative Example 2 is 4% by volume of alumina-silica fibers and 15% by volume of CaCO_3 . The balance of Comparative Example 3 is 4% by volume of alumina-silica fibers, 5% by volume of BaSO_4 and 10% by volume of CaCO_3 .
5 The balance of Comparative Example 4 is 4% by volume of alumina-silica fibers and 15% by volume of BaSO_4 .

(1-2) Preforming:

The constituents of each composition as shown above were uniformly mixed by a known mixer and their mixture was subjected
10 to 10 seconds of preforming at ordinary temperature in a molding machine applying a pressure of 100 kg/cm^2 to make a preform.

(1-3) Molding:

The preform was subjected to 15 minutes of molding under heat and pressure in a molding machine having a mold temperature of
15 160°C and applying a pressure of 250 kg/cm^2 .

(1-4) Heat treatment:

The molded product was held in a heating furnace having a temperature of 200°C for eight hours of heat treatment, and was allowed to cool.

20 (1-5) Grinding:

The heat treated product was ground to yield a friction material.

(2) Friction Test:

A general effectiveness test conforming to C-406 of JASO
25 (Japanese Automobile Standards) was conducted on the friction material for obtaining the average of the first to fourth values

of its effectiveness as its "average coefficient of friction (μ)". The results are shown in Table 3 below.

5

TABLE 3

principal consti- tuents (vol%)	aluminum borate alumina-silica BaSO ₄ CaCO ₃	Comp. Ex.		Examples			Comp. Ex.		
		1	1	2	3	4	2	3	4
		4	4	4	4	4	-	-	-
		-	-	-	-	-	4	4	4
		-	5	10	12	15	-	5	15
		15	10	5	3	-	15	10	-
	average μ	0.439	0.444	0.443	0.443	0.444	0.401	0.402	0.398
wear of	100 C	0.17	0.20	0.18	0.16	0.20	0.17	0.15	0.20
pad (mm)	200 C	0.63	0.61	0.64	0.59	0.64	0.61	0.63	0.62
	300 C	1.43	0.90	0.80	0.78	0.75	0.98	0.96	0.97
wear of	100 C	2	5	3	6	7	5	4	5
disc (mm)	200 C	14	13	12	14	13	13	14	14
	300 C	20	19	19	20	20	20	19	20

10

The products of Examples 1 to 4 embodying this invention had an average coefficient (μ) of 0.443 or 0.444, while the product of Comparative Examples 1 had an average coefficient of 0.439, as shown in Table 3. On the other hand, the products of Comparative Examples 2 to 4 had an average coefficient (μ) of 0.398 to 0.402 which was about 10% lower than that of any product embodying this invention. These results confirm that the friction materials containing aluminum borate fibers (Examples 1 to 4 and Comparative Example 1) have a higher coefficient of friction than that of the friction materials containing alumina-silica fibers (Comparative Examples 2 to 4). The average coefficient of friction of any such material is considered to depend on the amount of aluminum borate fibers which it contains, too, but this point will be discussed later.

(3) Pad and Disc Wear Tests:

Wear tests conforming to the standard C-427-83 of JASO were

conducted on pads and discs at different temperatures of 100° C, 200° C and 300° C to determine the wear thereof that would result from 1000 times of brake application. The pads were of the friction materials which had been made as described above, and
5 the discs were of FC250. The test results are shown in Table 3.

The wear of the discs as determined at 300° C was 19 or 20 mm, and did not appreciably differ from one example to another. On the other hand, the pads formed from the materials according to Comparative Example 1 and Examples 1 to 4 showed a substantial
10 difference of wear at 300° C in the range of 0.75 to 1.43 mm, while the pads formed from the materials according to Comparative Examples 2 to 4 showed a nearly equal wear of 0.96 to 0.98 mm at 300° C.

Reference is made to Figure 1, which is a graph obtained by
15 plotting the wear (mm) of the pads at 300° C as shown in Table 3 along the axis of ordinates against the proportion (vol. %) of BaSO₄ along the axis of abscissas. The pad formed from the material according to Comparative Example 1 is inferior to those formed from the materials according to Comparative Examples 2 to
20 4, as it shows a by far larger amount of wear. The pads formed from the materials according to Examples 1 to 4 and containing at least 5% by volume of BaSO₄ are superior to those formed from the materials according to Comparative Examples 2 to 4, as they show a satisfactorily smaller amount of wear.

25 It has also been found that a material containing more than 20% by volume of BaSO₄ is less capable of stopping a brake

squeak. Therefore, the material of this invention contains 5 to 20% by volume of BaSO₄.

EXAMPLES 5 TO 9 AND COMPARATIVE EXAMPLE 5

Discussion will now be directed to the preferred proportion of aluminum borate fibers. Table 4 shows a set of examples of compositions which differ from one another only in containing different amounts of aluminum borate fibers, as well as alumina-silica fibers.

		TABLE 4					
		(vol.%)					
		Comp. Ex.	Examples				
		5	5	6	7	8	9
Fibrous Material	aromatic polyamide fibers	6	6	6	6	6	6
	copper fibers	3	3	3	3	3	3
	alumina borate fibers	-	2	4	9	14	18
	alumina-silica fibers	23	21	19	14	9	5
	organic filler	8	8	8	8	8	8
Friction Controller	graphite	10	10	10	10	10	10
	inorganic filler	9	9	9	9	9	9
	BaSO ₄	18	18	18	18	18	18
	metal powder	5	5	5	5	5	5
Binder	phenolic resin	18	18	18	18	18	18
Total		100	100	100	100	100	100

Figure 2 is a graph obtained by plotting the proportion of aluminum borate fibers in each material and its average coefficient of friction (μ). As is obvious from Figure 2, the material of Example 5 containing 2% by volume of aluminum borate fibers did not show a great increase in its value of μ from that of the material of Comparative Example 5 not containing any

aluminum borate fibers, but Examples 6 to 8 showed a sharp increase in their values of μ . It has, therefore, been concluded that no material containing less than 2% by volume of aluminum borate fibers has a satisfactorily high coefficient of friction.

5 It has also been found that any material containing more than 20% by volume of aluminum borate fibers shows a sharp drop in its coefficient of friction after a gradual lowering from the peak value achieved by the material of Example 8 containing 14% by volume of aluminum borate fibers. Therefore, the material of
10 this invention contains 2 to 20% by volume of aluminum borate fibers.

WHAT IS CLAIMED IS:

1. In a friction material consisting of a fibrous material, a filler and a phenolic resin as a binder, the improvement wherein
5 said fibrous material contains 2 to 20% by volume of aluminum borate fibers while said filler contains 5 to 20% by volume of barium sulfate.

FIG. 1

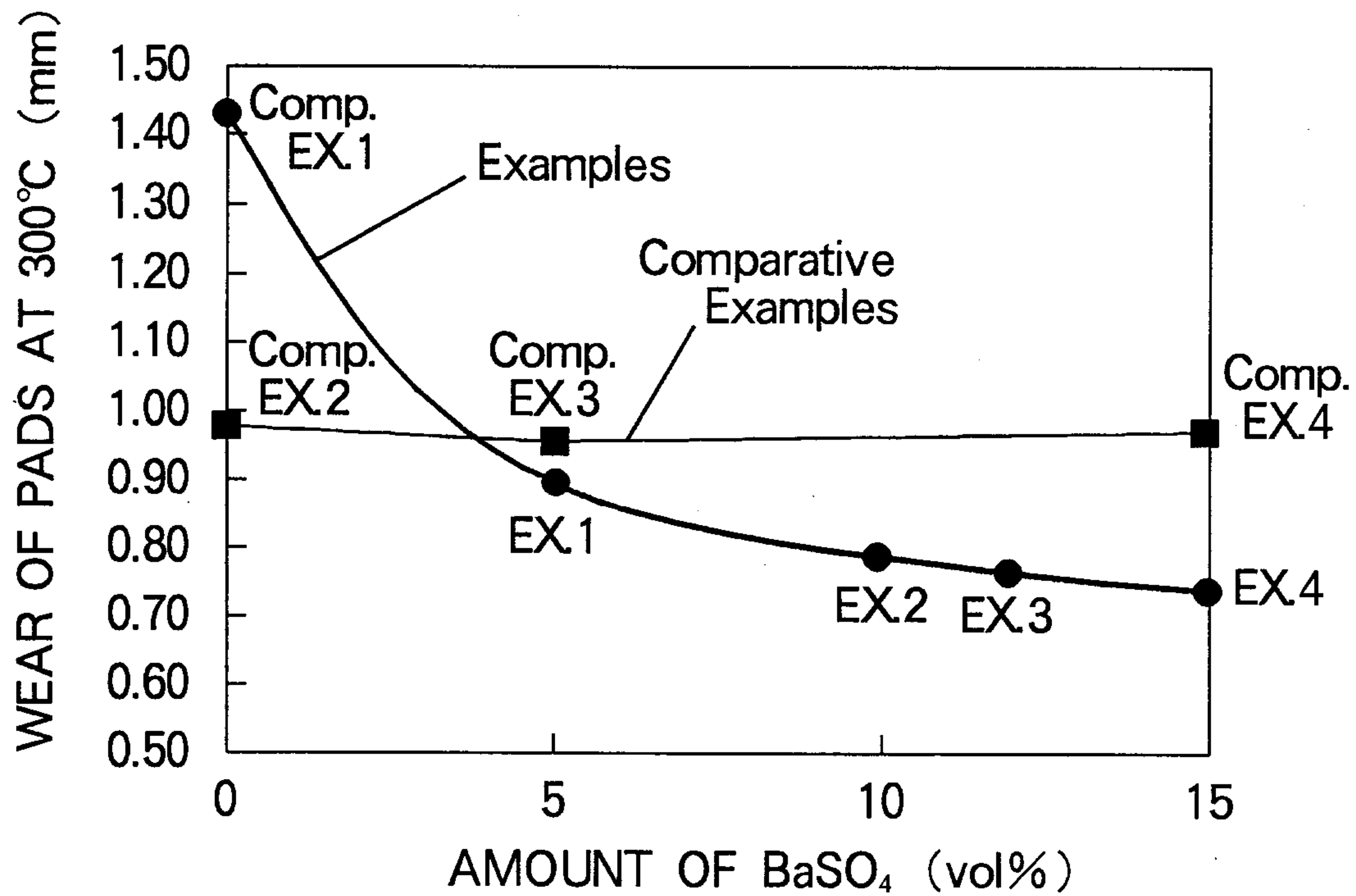


FIG. 2

