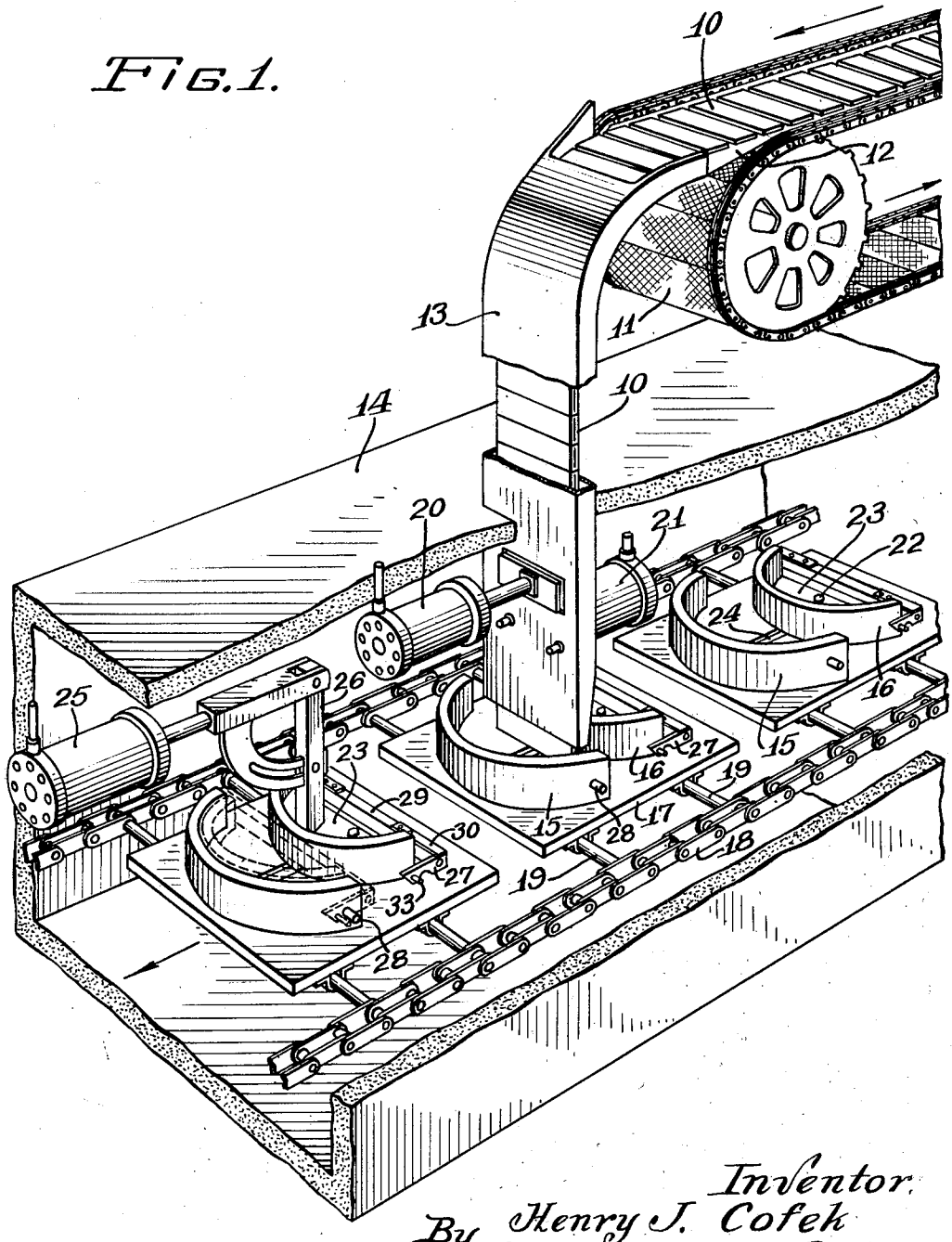
April 30, 1957 H. J. COFEK 2,790,206

METHOD FOR CURING FRICTION COMPOSITIONS

Filed Oct. 8, 1952 2 Sheets-Sheet 1

FIG. 1.



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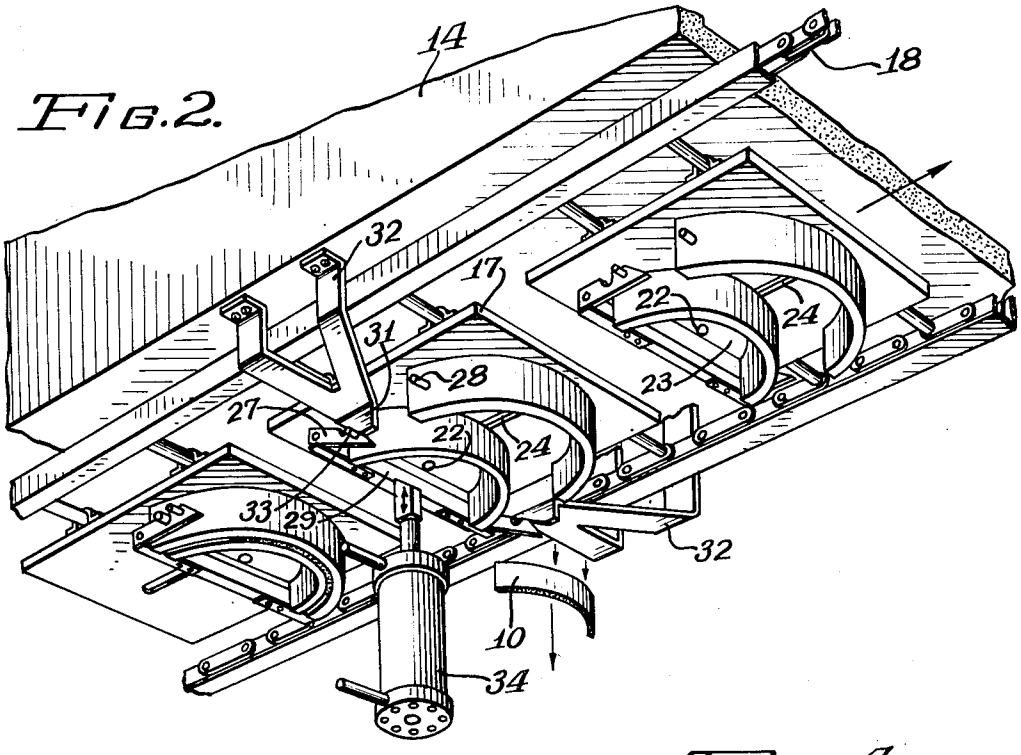
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METHOD FOR CURING FRICTION COMPOSITIONS

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Fig. 2.



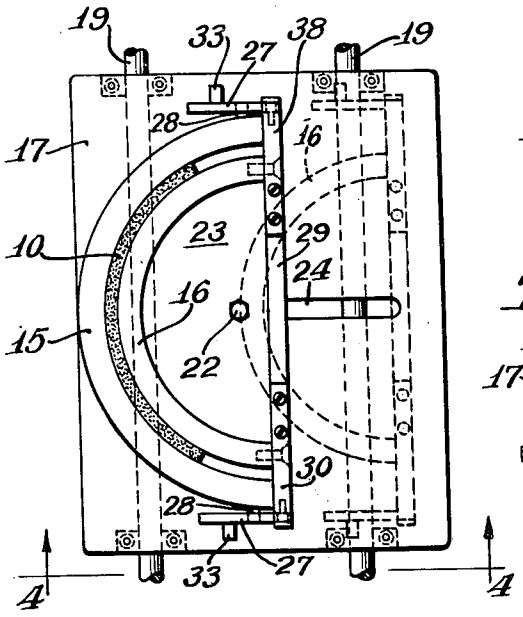


Fig. 3.

Fig. 4.

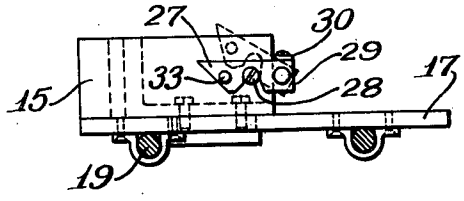
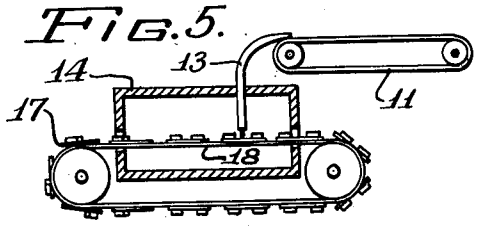


Fig. 5.



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United States Patent Office

2,790,206

Patented Apr. 30, 1957

2,790,206

METHOD FOR CURING FRICTION COMPOSITIONS

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Application October 8, 1952, Serial No. 313,748

4 Claims. (Cl. 18—55)

This invention relates to improvements in the production of friction and other heat hardenable binder containing material compositions.

More particularly, the present invention relates to improvements in the curing of friction material compositions containing heat hardenable binder.

It is a particular object of the present invention to provide a novel method for the curing of friction material compositions adapted for use as automotive brake linings, to a rigid, heat-stable, fixed arcuate shape or form, in a rapid and economical manner.

It is a further object of the present invention to shape and cure friction material, in the form of arcuate brake lining segments, in a continuous, sequential manner.

Friction materials of the class herein contemplated are in general composed of a mixture of fibrous asbestos, friction material fillers, and heat hardenable binder. These mixtures are generally subjected to preliminary processing to form sheets, strips or segments, prior to final shaping and complete cure of the binder. Such preliminary processing may be carried out in various methods or procedural steps known to the art, and by initially employing either dry or wet mixtures.

For example, dry mixes, wherein the binder is in dry particle or powdered form, may be molded to the form of flat sheets or strips or shaped segments under a densifying pressure and heating limited to prevent full cure of the binder. Wet processes are more numerous, and examples of these are the following: wet or dry felted fibrous asbestos sheets later coated and impregnated with binders and fillers from a volatile solvent carrier or varnish; felted sheets formed directly from an aqueous slurry containing fibrous asbestos, friction material fillers and powdered binder; mixes wherein the binder is water soluble or soluble in other solvents with the amount of water or other solvent proportioned so as to permit production of sheets on heated rolls as in the sheeter process; strips formed by means of extruders requiring further densification; or strips formed by means of compacting rolls not requiring further densification; or directly molded wet mixes.

In the practice of the present invention I start with segments or strips that can be shaped to arcuate form and which have, by the indicated processes, been compacted to substantially the desired final density, since, as will hereinafter appear, the process of the present invention does not employ high pressure. As further indicated, some of the preliminary process procedures inherently employ heat for the compacting step and thus remove a substantial proportion of water or other binder solvent, when solvents are employed. In other instances I may subject the pre-form to heat for the purpose of removing a portion of the water or other solvent, and in other instances, particularly where the pre-form is already of desired density, I may not remove the water or solvent before carrying out the process of the present invention.

In any event, where heat is employed in the preliminary forming step or subsequent solvent removal step, the heating is controlled in degree and time so as to prevent complete or final cure of the binder, to the extent that the composition is still deformable, with the aid of heat if necessary.

The binders employed include those known to the art, such as natural or synthetic elastomers in initially vulcanized or unvulcanized form and in powdered condition for dry mixes, and in hydrocarbon or other solvent solution for wet mixes; natural or artificial latices or dispersions of such elastomers for wet mixes; hydrocarbon solvent solutions of drying oils; powdered heat-hardenable or thermosetting natural or synthetic resins for dry mixes or aqueous dispersions; alcohol, water or other solvent solutions for such resins for wet mixes; and mixtures and combinations of the foregoing such as, for example, a mixture of rubber, drying oil and thermosetting resin in hydrocarbon solvent.

The severe use to which brake linings are subjected in automobiles and heavier automotive equipment requires that the linings be strong, and that they be stable under the high temperatures generated by friction so that they do not deform, and that they do not be possessed of a "fading" tendency, that is slippage of the brake under high frictional heat. It is also requisite for reasons of economy and mass production that cure of the binder be carried out in as rapid a manner as possible consistent with a minimum of spoilage or defective product, and that the brake lining be of substantially uniform hardness and density throughout.

Although satisfactory brake linings have of course been produced by the prior methods, various problems exist in each with respect to the proper cure of the binder in the composition, particularly with respect to volatile matter generated in the heat curing step, either from included or entrapped solvent or volatiles generated by the binders in curing, or both.

Thus, for example, a major problem has always existed in the curing of compositions which include a hydrocarbon solvent. Although solvents of a single sharp boiling point might be used, the art for reasons of economy generally employs solvents of mixed boiling point or having components of a range of boiling points, such as gasoline or mineral spirits. The curing of compositions containing such solvents has resulted in many difficulties and loss of much time. For example, in heating to drive off the solvent, and particularly the higher boiling components of a solvent such as mineral spirits, the binder which cures at a lower temperature becomes prematurely cured to entrap some of the solvent. Such premature hardening takes place particularly on the surfaces of the pieces being cured to result in "case hardening" and consequent entrapment of some of the solvent and formation of unhardenable reaction products, leaving soft spots within the pieces. Thus heating to simultaneously cure the binder and drive off all solvents, has required delicate balance of the factors of time and temperature, particularly since, as is well known, heat curing involves the factors of both time and temperature, and in the past has required long periods in convection or other ovens where the solvent is removed and curing by both polymerization and oxidation is accomplished.

Although the use of low boiling solvents, such as alcohol or water, simplifies the problem of solvent removal before cure or case-hardening of the binder, removal of all of the solvent particularly to a uniform extent from the internal portion of a densified piece of composition is slow, and since cure of the binder as previously indicated involves the factors of both time and temperature, problems of uniform and complete cure and a uniform product also arise. There of course also remains the problem of

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volatiles generated by the binder itself during heat cure, and the production of a rigid, heat-stable element such as a brake lining of accurate predetermined arc.

In accordance with the present invention I am able to eliminate the prior problems arising out of volatilization of solvent, whether water or other solvent, or volatilization of gases generated during heat cure. I also avoid any problems of surface or case hardening, and I am able to rapidly cure the binder to the extent that it has lost its "plastic memory," that is, the cured piece is no longer deformable on reheating. For this purpose I employ individual clamps or molds composed of a male and female member, but edgewise open, held together so as to confine a piece of brake lining under a low holding mechanical pressure. This pressure is on the order of 10 to 20 pounds per square inch and just adequate to resist the pressure of volatilization of contained or generated volatiles.

The starting point of the present invention is the employment of short lengths or segments of previously prepared composition containing binder in heat hardenable condition, as previously described, and of requisite predetermined density, since the product of the present process is not subjected to nor amenable to any further densification. This preformed material may first be dried to remove at least a portion of its volatile solvent content, for short periods at relatively moderate heating temperatures, but all limited to prevent cure of the binder beyond the "B" stage for a phenol-aldehyde resin or the substantial equivalent for other resins or binders. Further, the material at this stage should be deformable by light pressure and, if necessary, by the aid of heat so as to enable it to be placed in the retaining clamps and subsequently heat cured therein to final fixed form.

The present invention is further characterized by method for rapid curing whereby the segments to be cured are introduced into a hot oven already heated to the required curing temperature, and discharged therefrom and from the holding clamps in like heated condition without danger of deformation, as distinguished from prior practices requiring gradual elevation of heat from a cold or substantially cold condition, and gradual cooling before discharge.

The invention will be further explained in connection with the accompanying diagrammatic drawings with reference to the shaping and curing of the brake linings, for the purpose of illustration.

Fig. 1 is a fragmentary perspective view, with parts broken away, illustrating means for introducing brake lining segments into retaining clamps continuously moving through an oven for cure therein.

Fig. 2 is a fragmentary perspective view, with parts broken away, illustrating the discharge of the cured brake lining segments after passing through the oven.

Fig. 3 is a plan view of one of the clamp units illustrated in the preceding figures indicating the operation thereof and showing a brake lining segment in clamped position.

Fig. 4 is a side elevational view of the component illustrated in Fig. 4.

Fig. 5 is a diagrammatic side elevational view of an assembly of the apparatus shown in Figs. 1 and 2.

Referring to the drawings, and particularly to Fig. 1, brake lining segments **10** are deposited on the endless conveyor **11** and continuously moved therefrom onto the apron **12** of the vertically disposed chute **13**. From here the segments are individually and sequentially dropped between a pair of open clamp sections **15** and **16** on one of the bed plates **17** supported by and engaged to the endless conveyor **18** by the flight bars **19**. In continuous operation, these clamp sections are in heated condition by reason of having passed through heated oven **14**. Individual and sequential dropping of the segments **10** is accomplished by means of the air cylinders or equivalent means, such as the holding cylinder **20** and the releasing cylinder **21**, having pistons, each projecting through one wall of chute **13**. These cylinders are actuated in timed relation to each other and to the conveyor **18**, by means not shown. These cylinders are disposed one above the other and actuated so that they alternately momentarily arrest downward movement of the segments **10** in chute **13**, and discharge an individual segment onto each of the forwardly moving plates **17**.

Each arcuate clamp section **15** is fixedly secured to a bed plate **17**, whereas its mating section **16** is slidably engaged to the bed by means of a bolt **22** secured to the web **23** of section **16** and extending through slot **24** in plate **17**. The brake lining segments **10** are deformable by light pressure at the time they are dropped from chute **13**, either by reason of their inherent character, or by the aid of heat. When heat is required to place them in deformable condition, heat may be applied at a suitable point, not shown, such as for example during or prior to passing of the segments through chute **13** by suitable means, such as electrical or other heating means.

After a brake lining segment has been deposited between a pair of clamp sections, and as it begins its passage through oven **14**, the clamp sections are closed by means of the closing cylinder **25** which acts to draw the leg **26** forwardly against the concave face of a section **16**. This causes an interposed brake lining segment **10** to become arcuately deformed to the arc of the mold sections, and at the limit of movement of a section **16** it is locked in position with a mold section **15**. Locking may be accomplished, for example, by means of engagement of a pivoted locking lever **27** on section **16** with a pin **28** on section **15**, as shown by the full and dotted positions of one of the mold assemblies in Fig. 1 and in Fig.3. Each mold section **15** has a pair of pins **28**, one adjacent each end portion, and each mold section **16** has a pair of locking levers **27**. The locking levers **27** are spring actuated by means of the springs **30** secured to the end portions of the transverse bar **29** extending across the ends of the mold section **16**. In the alternative, although not shown, other locking means may be employed.

This clamping action is essentially adapted to shape the brake lining segment to the arc determined by the mold and to hold it at merely the minimum required lateral confining pressure. As will be noted, the closed mold is otherwise open to permit escape of volatiles at least from one edge and both ends.

After passage through the length of the oven at the desired predetermined speed, the mold assemblies pass out through an opening at one end of the oven and are inverted beneath the oven as shown in Fig. 2. In the continuous forward movement the mold sections are disengaged by, for example, the cam **31** at the end of the fixed bracket **32** secured to the base of the oven. This cam extends into the path of the pin **33** projecting from the locking lever **27** to thereby depress the locking lever. At about the same time the piston of air cylinder **34** is caused, in timed relation, to project upwardly into the path of the transverse bar **29** across a mold section **16** to slide it away from the mating section **15** and to thereby permit a cured brake lining segment **10** to drop out for discharge. Thereafter the opened mold sections continue their forward movement and are again reversed and enter the oven from the opposite end of the furnace, ready to receive green brake lining segments, all in a continuous manner.

In this arrangement each clamp has a definite arc and is constructed to receive a segment of predetermined thickness and density, so that no pressure other than the light mechanical pressure necessary to hold the clamp closed and in firm contact with the opposed faces of the lining segment is desired or necessary, and the minimum amount of pressure employed will be substantially uniformly distributed.

The pressure produced by the clamp is not a molding pressure, but rather one of a low order, such as for example from about 10 to about 20 pounds per square inch, and only that which is necessary to resist or overcome the

internal vapor pressure created by vaporization, during heat curing, that would normally cause blisters if unconfined. Further, as pointed out previously, the clamps are open at the ends and one side edge so that volatiles may pass out from the segments being cured.

In order to accomplish complete heat hardening to the extent that the segments **10** may be discharged from the clamps in a hot condition, and in a condition wherein the thus cured segments are no longer deformable by heat and retain a set arcuate shape, the oven **14** is heated to a temperature of from 450° F. to about 600° F. and the time of residence of the segments **10** in the oven is from about 1 to about 6 minutes, depending upon the thickness of the segments, the nature of the binder, the extent of its preheating, if any, etc.

Since the nature of this rapid, high-temperature cure is essentially by polymerization, should the character of the binder or any of its components require further curing by oxidation, such further cure may be effected after discharge of the heat-hardened segments from the clamps in a shortened period of time over that previously required, since oxidation is free to proceed thereafter without the shielding effect of the clamps in any suitable manner, such as for example in a convection furnace, and without danger of deformation.

Example I

The following is an example of a composition containing a mixture of binders in a volatile hydrocarbon solvent. This composition was mixed, aged for a day, reduced to a free-flowing granular condition and compacted between rolls to desired density to form a strip of about 3/16 inch in thickness.

	Parts by weight
Short asbestos fiber	60.75
Dry oil	6.08
Peptized rubber material	10.86
Mineral spirits solvent for binders	7.43
Sulfur	5.20
Fillers and friction agents	9.86

Since the solvent content is here originally low and has been further reduced by volatilization at room temperature during the aging period to about 5%, no further densification was necessary nor is it essential to remove any of the removing volatiles before heat curing. Thus this strip material was cut into segments, locked in the shaped clamps, and passed through an oven heated to 600° F. in a period of 5 minutes. The segments were discharged hot in rigid, fixed shape. Since the drying oil binder content required further cure by oxidation, this was accomplished by heating in a convection furnace at a temperature of about 280° F. for a period of 5 hours, without employment of any clamping or other shape restraining means.

Example II

The same procedure was followed as in Example I, except that the green strip material was preheated, before entering the oven and being placed in the clamps, to a temperature of approximately 250° F. for about 10 minutes to drive off some of the solvent, particularly the lower boiling components thereof. This permitted subsequent cure in the clamps in the oven heated to the same temperature in a period of two minutes.

These Examples I and II are contrasted to previous practice on the same green strip material which required an open cure in rolls for a period of 30 hours at progressive temperatures of from 180 to 280° F. to remove the solvent, followed by hardening and curing at a temperature of about 280° F., and then further curing for 15 to 25 hours at progressive temperatures of from 280° to 425° F. in segments in shaped clamping means to a relatively fixed curvature.

Example III

The following is an example of a composition which was mixed, aged for about a day, reduced to free-flowing granules, and compacted betwen rolls into a dense, flexible strip of about 1/8 inch in thickness. The binder here consisted of an aqueous solution of a thermosetting, water-soluble, phenolic binder:

	Parts by weight
53.3% solids aqueous solution of phenol-formaldehyde resin	29.7
Short asbestos fiber	42.2
Friction material fillers, lubricant, resin cure accelerator	28.1

Without any further treatment, such as drying or densification, this strip material was then cut into brake lining segment lengths, placed within clamps of desired arc, as previously described, and passed through an oven heated to a temperature of 500° F. in a period of six minutes, and ten discharged from the clamps while hot. The binder was fully cured to the extent that the arcuately shaped pieces did not deform in the hot condition and could not be deformed on reheating to any temperature up to actual disintegration temperature. Since the binder was all thermosetting phenolic resin, it required no further cure by oxidation, and thus a complete cure in all respects was obtained in six minutes.

Example IV

The following is an example of a composition prepared as in Example III. The binder here consisted of an aqueous solution of a thermosetting, water-soluble, phenolic binder, together with a small proportion of an elastomer.

	Parts by weight
53.3% solids aqueous solution of phenol-formaldehyde resin	25.7
Short asbestos fiber	42.2
Fristion material fillers, lubricant, resin cure accelerator	24.1
Elastomer	4.0
Hydrocarbon solvent for elastomer	4.0

Without any further treatment, such as drying or densification, this strip material was then cut into brake lining segment lengths, placed within clamps of desired arc, as previously described, and passed through an oven heated to a temperature of 500° F. in a period of six minutes, and then discharged from the clamps while hot. The binder was fully cured to the extent that the arcuately shaped pieces did not deform in the hot condition and could not be deformed on reheating to any temperature up to actual disintegration temperature. Since the binder was predominantly thermosetting phenolic resin, it required little or no further cure by oxidation, and thus a substantially complete cure in all respects was obtained in six minutes. If desired, in view of the elastomer content, this may be subjected to further cure in the open, as for example in an oven at 350° to 400° F. for about one hour.

Example V

Procedure was the same as in Example III and on the same material except that the lining was subjected to infra red heating at a temperature of approximately 250° F. for about ten minutes before introduction to the oven and placing in the clamp. This advanced the resin to the "B" stage and removed substantially all the water content. These dried pieces were then introduced to the oven and placed in the clamps while still hot and deformable. It was found that cure could be completed in the clamps to the extent previously indicated in one minute in an oven heated to 450° F.

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Example VI

The following is an example of a compressed asbestos sheeter composition for consolidation between a hot and cold roll on a conventional compressed asbestos sheeter apparatus:

	Parts by weight
Long asbestos fiber	20.13
Rubber	4.86
Curing agents	3.56
Fillers and friction-augmenting agents	23.35
Solvent (gasoline, etc.)	48.10

After the compound was sheeted out and cut into brake lining segments, it was introduced into clamps in a heated oven, as hereinbefore described and illustrated, in a period of three minutes, with the oven heated to a temperature of 485° F., discharged in a hot, fixedly rigid arcuate shape, and then further heated four hours at 400° F. in the absence of clamping means. The product was equivalent to that obtained in the prior conventional process where a group of segments was loaded into a cold clamping frame (lunette and cured by first heating for 1½ hours gradually to 400° F., then for 9 hours at 400° F., plus added time for cooling of the assembly before discharge is possible.

Example VII

The following is an example of a dry molding composition:

	Parts by weight
Asbestos fiber (4 or 5 grades)	48.65
Powdered phenol:formaldehyde resin	17.05
Fillers and friction-augmenting agents	34.30

This is prepared by mixing in tumbling barrels, or any other suitable means, dry-pressed under heat and pressure into slabs, cut into strips, sanded to thickness, width ground, and cut to predetermined flat lengths. In the prior conventional practice these strips were first formed to desired radius by preheating between flexible steel trays in a press and placed in a press with cooling molds, and the curved segments then loaded into curing frames and cured by first heating up gradually to 375° F. for 1½ hours, and then heated further for four hours at 375° F.

Employing the process and apparatus of the present invention, the flat lengths or strips of this example are preheated either by infra-red or radio frequency heat for 40 seconds to 190–200° F., or until they are sufficiently plastic to be deformed to desired radius, and then introduced to the hot oven and clamped therein in the hot molds and passed through the oven heated to 550° F. in six minutes and discharged from the clamps while hot. It required no further cure by oxidation and thus a complete cure in all respects was obtained in six minutes.

Although for the purpose of illustration I have specifically described the process and apparatus of my invention in connection with the shaping and curing of brake lining segments, it will be understood that my invention can be applied to the shaping and curing of other heat-hardenable binder-containing compositions such as clutch facings and other rings, gaskets, insulators, and other odd shapes, providing that corresponding edgewise open molds are employed. It will therefore be further understood that various modifications in the details of construction of the illustrated apparatus may also be made, all within the scope of the appended claims.

I claim as my invention:

1. The continuous method of rapidly and substantially uniformly heat curing units of predensified friction material composition containing heat hardenable organic binder and to drive off volatile matter generated during said heat curing while preventing surface blistering, which comprises abruptly introducing said units into a zone substantially uniformly heated to a temperature in excess of the normal curing temperature of said binder while individually confined between and in surface contact with opposed faces of preheated clamps continuously edgewise open to the atmosphere, passing them through said zone in a period of time sufficient to cure said binder without disintegration, and discharging said units from said clamps in heated condition promptly on emergence from said zone.

2. The continuous method of rapidly and substantially uniformly heat curing and shaping to heat stable arcuate form predensified unitary flat strips of fibrous friction material composition containing heat hardenable organic binder and to drive off volatile matter generated during said heat curing, which comprises abruptly introducing said strips into a zone substantially uniformly heated to a temperature in excess of the normal curing temperature of said binder while individually confined between and in surface contact with opposed faces of preheated clamps continuously open to the atmosphere, the pressure of said clamps being adequate to just overcome the internal vapor pressure resulting from volatilization of said generated volatile matter at the confined faces of the strip while permitting said volatiles to escape edgewise therefrom, passing the so confined strips through said zone in a period of time sufficient to cure said binder without disintegration, discharging said strips from said clamps in shaped heated condition promptly upon emergence from said zone, and promptly reloading said clamps in heated condition with said uncured strips for cure in said process.

3. The continuous method of rapidly and substantially uniformly heat curing units of predensified friction material composition containing heat hardenable organic binder and volatile binder solvent, and to drive off volatile matter generated during said heat curing while preventing blistering and case hardening whereby to produce rigid, heat-stable elements such as brake lining, which comprises abruptly introducing said units into a zone substantially uniformly heated to a temperature in excess of the normal curing temperature of said binder while individually confined between and in surface contact with the opposed faces of clamps continuously edgewise open to the atmosphere to permit escape therethrough of said volatiles, and in heated condition by reason of having passed through said heating zone, moving them on an endless conveyor through said zone in a period of time sufficient to cure said binder without disintegration, discharging said units from said clamps in heated condition promptly upon emergence from said zone, and promptly reloading said clamps in heated condition with said predensified uncured units for cure in said process.

4. The process of claim 3 when the temperature of the heating zone is from about 450 to about 600° F.

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