UNITED STATES PATENT OFFICE.

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METHOD OF TREATING VULCANIZABLE PLASTICS.

1,309,485. Specification of Letters Patent. Patented July 8, 1919.

No Drawing. Application filed December 30, 1911. Serial No. 663,791.

To all whom it may concern:

Be it known that I, RAYMOND B. PRICE, a citizen of the United States, residing at Mishawaka, in the county of St. Joseph, State of Indiana, have invented new and useful Improvements in Methods of Treating Vulcanizable Plastics, of which the following is a specification.

This invention relates to the manufacture of rubber boots, shoes, and similar articles and has for its primary object the devising of a method of manufacturing such articles whereby their wearing properties will be greatly improved.

The fundamental principle involved in building a rubber boot or shoe is to combine the numerous parts so that when final vulcanization is completed the boot will present a unified, compact, solid structure, each part being perfectly united throughout with its adjacent part or parts with an adhesion sufficient to withstand all strains and flexures of service conditions, and this is especially desirable where the upper and lower join, for at these parts the engaging margins are comparatively narrow and limited in area but nevertheless are subjected to the greatest strains and flexure and when they begin to give way the boot becomes weak, leaky and useless. It will thus be seen that if the desired degree of compaction and unification of the wall structure of the boot is not attained, or in other words if there is not a sufficient degree of contact and adhesion between the various parts the intended purpose of the numerous reinforcements and stiffening members will not be accomplished. It has therefore been the desire of rubber footwear manufacturers to continually improve these conditions, and accordingly the advancement in the art of building rubber boots and shoes has been in this direction, and it is with this feature that my invention is directly concerned.

Even with operators of the highest skill it is impossible to produce the desired results of compaction and solidification during the building up operation. The numerous parts are built in the boot under atmospheric conditions and are accordingly more or less stiff exhibiting a tendency of straightening out from the distorted shapes they are forced to take and therefore tending to but loosely adhere to their adjacent plies. This is especially true at the jointure of the plies of the upper with the plies of the lower. The wall structure is thickest at these parts being composed of numerous overlapping plies. The jointures are produced by abruptly turning in the margins of the several plies which necessitate a sharp bend being produced in the material and even a considerable puckering and fluting of the turned margins at certain parts as at the heel and toe portions in endeavoring to bring them in contact with the adjacent plies of the sole portion. It will thus be seen that after the various parts have been built into the boot by the operator the tendency is for the parts to slightly recover from their forced distorted shapes and to thereby loosen up the structure. Furthermore the operator in assembling the parts employs a small hand-roll and it is practically impossible for him within reasonable time limits, to roll over the entire surface of each piece to insure perfect and continuous contact, and obviously where the roll does not pass there will in many instances be ply separation. This condition is materially aggravated on account of the roll being cylindrical and therefore only making tangential contact with the curved surface of the last. When the article has been finally built it therefore does not possess the compactness and solidification of structure necessary for service conditions. The structure presents numerous blisters or air filled spaces, indicating ply separation, which are of various sizes, some resembling lines often extending nearly the length of the boot, and others appearing as bubbles or blisters.

The boot as thus unsatisfactorily built up is finally placed in the vulcanizer and is there subjected to the vulcanizing process. If the boot is vulcanized and thereby permanently fixed in this condition of porosity and ply separation an inferior article will of course be produced. The solidification and compaction of the wall will not be present but instead the plies will be loosely held together and the structure will be filled with blisters so that the numerous reinforcing pieces cannot properly function when the boot is in service, the result being that the boot will soon wear out. The heat of

vulcanization furthermore tends to materially aggravate these conditions, as it expands all the entrapped fluids and the rubber stock being also softened by the heat permits the expanded fluids to increase the porous condition of the structure.

Rubber boots and shoes were for a long time vulcanized in open heat, that is to say, they were simply placed in a room containing air heated by steam coils to the required temperature to produce vulcanization. This of course produced an inferior article for this method of vulcanizing resulted in producing the porous honey-combed structure above described to the highest degree. Attempts were made to improve upon this by placing the boot in a mold and forcing the boot out against the mold walls and then vulcanizing. This, however, was too costly and was never successful for in forcing the boot out against the mold walls it tended to open up the seams, especially at the narrow margins where the upper was joined to the lower, and thereby materially weakened the article. It therefore soon became evident that wherever pressure was resorted to it must be in the direction of the last and not away from it, in order to produce the desired compaction of the seams. Therefore it became the practice to vulcanize rubber boots and overshoes in a pressure vulcanizer in which a fluid was present under pressure during the vulcanization. This was an improvement over the other methods and was the most successful method previously employed, and for convenience of comparison it will be referred to as the straight pressure method. In the practice of this straight pressure method if a sufficient pressure were employed it would result in holding the fluids that were entrapped in the wall of the article under a sufficient force to counteract the tendency of the heat of vulcanization to expand them and would have some tendency to compress the entrapped fluids into smaller volume. It has, however, no other effect upon the boot for the entrapped fluids being still in the wall of the boot when vulcanized they will and do actually produce porosity, ply separation, etc.

The open cure method does not decrease the porosity and ply separation at all but tends to aggravate it, and the straight pressure method, while an improvement over the previous methods, does nothing more than to possibly somewhat decrease the size of the spaces produced by the porosity and ply separation. My invention is an improvement upon these prior methods and especially the straight pressure method, and may for distinction be termed the differential pressure method. It differs from all other methods by actually removing the entrapped fluids, and closing the spaces so there will be substantially no porosity and ply separation in the finally vulcanized article but instead the wall will be compacted and solidified, thereby greatly improving the wearing properties and life of the article.

My method results in actually removing the entrapped fluids from the structure composing the wall of the rubber boot or shoe, and closing the spaces or gaps thus produced thereby bringing all adjacent surfaces into intimate contact thereby unifying, compacting, and solidifying the wall which is finally permanently fixed in this condition by vulcanization.

It will be observed that a rubber boot or shoe is composed of a plied up sole and a plied up upper, the plies of the upper in general meeting the plies of the sole by means of lapped joints; or what is the same thing as far as the present invention is concerned, the adjoining surfaces of the plies of the sole and the adjoining surfaces of the plies of the upper are directed toward each other and in general meet where the lapped joints are formed between the upper and sole. Moreover it will be observed that the fabric or fibrous component, which is highly porous, is well interspersed between the rubber parts of both the upper and sole. The rubber boot or shoe is therefore constructed to provide a very satisfactory drainage system for the entrapped fluids, for with the various plies meeting and overlapping as above described thereby affording communication between the adjoining surfaces of the plies of the upper and the adjoining surfaces of the plies of the sole, and the fact that the highly porous fibrous component is so generally interspersed throughout the rubber component it results that substantially all the entrapped fluids are brought into communication or at least such a condition is made easily possible when my method is employed.

In the practice of my invention the rubber boot or shoe is built up to conform to the shape of the last and in this respect the article is completed by the operator, for the subsequent pressure steps are not intended to shape the article but rather to solidify and compact the already built up and shaped wall constituting the boot or shoe. The boot or shoe is then subjected to the exteriorly applied pressure and the interior of the wall of the boot or shoe is placed in communication with a lesser pressure. The boot or shoe as ordinarily constructed has an inner fabric or fibrous lining and an outer cover of rubber. This is admirably adopted for the practising of my invention according to the preferred manner for the rubber cover prevents the fluid which is applied under considerable pressure to the outer surface from entering the wall of the boot or shoe, and the inner surface which is

composed of fibrous material is supported by the rigid last and is thereby separated from the fluid applied to the outer surface. The lining being porous affords a "fluid" communication to all parts of the inner surface of the boot and therefore all the entrapped fluids, which must pass either directly through the porous fibrous plies or between the various plies as previously described, when being removed, will ultimately reach the fibrous lining, and accordingly if any part of this lining is placed in communication with a space which is intended to serve as the exit for the entrapped fluids this space will be in "fluid" communication with the entire inner surface of the boot, and consequently with substantially all the fluid filled spaces within the wall of the boot. The last in effect coöperates with the interstices and pores of the fibrous lining of the article to form an inclosed space separated from the outer surface of the boot so that if any part of this space is brought into communication with the lesser pressure the desired results of the removal of the fluids will be made possible.

In the preferred method of practising my invention I employ a hollow last and perforate the wall thereof at one or more places to bring the interior of the last into communication with the fabric lining of the boot, the perforations being preferably formed in the sole portion of the last. The interior of the last may further be placed in communication with the atmosphere or with a space of controllable pressure and I have produced very good results by using a reduced pressure, that is to say, a partial vacuum. For further details of an apparatus adapted for the practice of my invention reference is made to my co-pending application Serial No. 669,209. I prefer that the last be perforated at the sole for it is here that most of the trouble exists and it is preferable that the fluids move down the boot toward the sole to one or more points of exit as this will effect a substantially complete drainage of the fluids from the wall. Moreover, the porosity which exists near the top of the boot or shoe is not so serious and the entrapped fluids at these portions will easily find their way to the fibrous lining and gradually descend toward the points of exit. The boot or shoe is built to snugly fit the last, and being continuous in certain directions as for instance at the upper or leg portion, it is self-supportive thereon, and the effect of the differential upon the boot or shoe when applied as above described is to cause the upper part to more closely hug the last and to automatically seal the inner surface from the outer. It is, however, desirable in most cases to seal the top of the boot to the last to prevent any possible leakage.

The operator produces, of the numerous parts, a built-up boot or shoe complete and self-retainable as to shape but incomplete as to solidity and compactness. The tendency of the pressure applied to the outer surface of the article to change its shape is overcome by the supporting last which is shaped to closely fit the inner surface of the boot or shoe, and the pressure is therefore left free to exert its whole force upon the article. The entrapped fluids, being under the influence of the differential of pressures, follow the path of least resistance and are forced by the greater pressure in the direction of the lesser, and finally make their exit from the boot and enter the space of lesser pressure. As the entrapped fluids are being removed the spaces previously occupied by them are, of course, free to be closed and accordingly compaction of the wall gradually takes place due to the pressure on the exterior of the boot or shoe, and this pressure in coöperation with the lesser pressure which is in communication with the interior of the structure causes the article to give off its entrapped fluids which results in a compaction and solidification of the walls of the article.

While I have described the preferred manner of practising my invention it will be understood that my invention is capable of considerable modification as I claim to be the first to have compacted and solidified the walls of a rubber boot or shoe by actually removing the entrapped fluids.

As before remarked the interior of the wall may be brought into communication with atmosphere, a partial vacuum, or with a positive pressure, and any convenient medium may be employed as the pressure conveying medium applied to the outer surface of the article.

Thus, I may employ air, saturated or superheated steam, or any other form of gas, inert or otherwise, or I may employ any form of fluid medium, such as water, or any desired solution, or even a fusible metal medium. Also the application of the differential pressure may be varied as desired both as to degree of pressures and period of duration, as may also both the exterior and interior pressures. Furthermore the exterior pressure may be applied at any stage independent of the interior pressure and the interior pressure may likewise be applied at any stage independent of the exterior pressure. Also heat may be applied during any stage of the method and in the preferred practice of my invention I subject the rubber boots or shoes to the pressure treatments while they are in the vulcanizer where the heat and pressure regulations are always under the control of the operator, as more clearly appears in my beforementioned co-pending application. The pressure applied to the interior of the ar-

ticle may be controlled in any manner and this control may be exerted before the article is subjected to the final treatment as well as during the period of its subjection, an important point being that the condition of the interior as well as the exterior of the boot or shoe as to its pressure is at all times before and during the vulcanizing operation under the control of the operator and this pressure or partial vacuum may be cut off before the vulcanizing operation is begun or may continue during any part of the said operation.

I wish it to be understood that I contemplate any method of applying the heat to the article, that is to say, the heat may be applied through the external medium in which the article is placed, or may be applied to the retort or vulcanizer by means of steam pipes, either internal or external, or both, or said heat may be supplied by a furnace operating in connection with the retort or vulcanizer.

Under certain conditions it may be desirable to initially establish a pressure upon the exterior of the article, and during the vulcanizing or setting operation to either reduce, increase or discontinue said pressure. And this is equally true of the vacuum to be created upon the interior of the article, as the same may be increased, reduced or discontinued at any time during the vulcanizing or setting operation. In fact, it has been found sufficient in some cases to apply an initial vacuum to the interior of the article prior to treatment and then to seal the article and subject it to the setting operation.

I have also obtained good results, in the vulcanization of rubber boots, by applying a vacuum to the interior of the boot, and subjecting the outside thereof to that pressure only which is created by the expansion of the air in the vulcanizer under the vulcanizing temperature, and which has been found to amount to as much as 8 lbs., thus making a differential of pressure of over 20 lbs. This pressure from the heat expansion may also be increased by the vaporization of alcohol, ammonia, and the like, which expand more rapidly than air.

I also contemplate the application of heat to the articles to be set through electrical means, or through conduction from a source of heat. Thus, an aluminum last or form may readily be heated by means of an electric current, or it may be heated by heat transmitted thereto through a metallic conductor from a suitable source of heat. This source of heat may be independent, or may be associated with heat applied through an external gas or fluid.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. Vulcanizing a rubber article upon a pervious form by first applying an internal vacuum, and then vulcanizing under external heat and pressure, the vacuum being continued during that portion of the application of the vulcanizing temperature during which vapors or gases are given off by the rubber.

2. The process of making a vulcanized article which consists in applying a vulcanizable gum to a form mounted on a support, providing a margin of gum extending beyond the form and on to said support to make a tight joint or seal therewith, then applying a vacuum to the interior of the form, and then vulcanizing under external heat and pressure, the vacuum being continued during that portion of the application of the vulcanizing temperature during which vapors or gases are given off by the rubber.

3. Vulcanizing a rubber article upon a pervious form by applying a differential of pressures the greater pressure being applied to the exterior of the article and the lesser pressure to the interior and vulcanizing under external heat and pressure the differential being continued during that portion of the vulcanizing process during which vapors or gases are given off by the article.

4. A method which comprises, assembling a plurality of plies of rubber and fibrous material upon a pervious form to form a vulcanizable laminated boot or shoe built up complete and self-retaining as to shape but incomplete as to solidity and compactness, removing entrapped fluids from and solidifying and compacting the laminated structure by applying a differential of pressures the greater pressure being applied to the exterior of the article and the lesser pressure to the interior and vulcanizing under external heat and pressure the differential being continued during that portion of the vulcanizing process during which vapors or gases are given off by the article.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

RAYMOND B. PRICE.

Witnesses:
A. M. DISCH,
GEO. A. COLSON.