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PUNCTURE-SEALING COMPOUNDS FOR PNEUMATIC TIRES

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ABSTRACT

This circular was prepared as an answer to the numerous requests which the bureau receives for information concerning various puncture-sealing compounds for pneumatic tires. The different methods which are employed to render tires "puncture proof" or self-sealing against punctures, are described and a discussion is given of the type which is the most common. Arguments for and against the use of such puncture-sealing compounds are given as well as answers to the usual questions which are asked concerning them.

The history of methods designed to prevent the escape of air from pneumatic tires is almost as old as the pneumatic-tire industry. Previous to the year 1900, when the bicycle was at the height of its popularity, at least eight patents had been issued covering ways for making a pneumatic tire "puncture proof." With the later development of the automobile tire and continuing up to the present time it seems to be the goal of inventors to produce a "puncture-proof" tire.

The use of the words "puncture proof" are in a way a misnomer, as the majority of the ways devised for puncture-proofing tires are rather ways of sealing punctures and not preventing them. However, the words "puncture proof" are commonly used in connection with any means to prevent or to seal punctures. At least five different methods have been, or are being, used to accomplish these purposes.

(1) By the use of some kind of "filler" in the casing instead of a pneumatic tube. This gives a real puncture-proof tire, but departs from the pneumatic principle. The tire is no longer pneumatic, but is equivalent to a solid or cushion tire.

(2) By the use of a compression inner tube. If the rubber in the inner tube can be put under sufficient compression it will automatically tend to seal itself when punctured. This is done in practice by making a tube with a very heavy wall and of a larger periphery than the inside of the casing. This is accomplished by molding the tube with large longitudinal corrugations or wrinkles in it, which are straightened out when the tire is inflated, thus compressing the rubber. The tube must be very thick to prevent folding instead of compressing. The disadvantage of such a tube is its weight, and consequent high first cost. It also seems logical to think that the rubber in the tube will eventually take a permanent set and be no longer under compression. In this event, however, if not punctured, the tube would still

hold the air pressure and on account of its thickness would not be as easily punctured as an ordinary tube.

3. By molding substances (usually metal) in the tread portion of the casing to prevent an object, such as a nail, from piercing the casing. Satisfactory tires that are at least comparatively puncture proof have been made in this manner for several years. It is the general opinion that if the tire is not kept properly inflated, there is more chance for "separation" to develop in a tire of this kind than in one of standard construction.

4. By the use of a plastic material in the tube or inserted between laminations in the tube wall. In case of a puncture this plastic material is intended to flow slightly and produce a seal.

5. By the use of mixtures of liquid and solid materials which can be forced through the valve stem of a standard inner tube. Such mixtures, probably because of their simplicity of composition and the ease with which they can be used in standard tire equipment, seem to have met with the largest degree of success. Following is a discussion of such mixtures and a description of their action as puncture-sealing materials.

During the last 30 years at least 65 patents have been granted for compounds to be placed in inner tubes to render them self-sealing when punctured. Although some few of these mixtures are soft plastic materials which contain rubber or rubberlike substances, by far the greater number of them are essentially suspensions of fibrous or flaky materials in water or an aqueous solution. Although the simplest are composed of only fiber and water [1] nearly all contain:[2]

1. A finely ground fiber.
2. Water.
3. A material to aid in holding the fibers in suspension.
4. A material to lower the freezing point of the liquid.
5. A preservative.

In addition, dyes and odorous materials are often added to disguise the other ingredients.

The following solid materials arranged roughly in the order of their popularity have been used: Asbestos, mica, cork, wood fiber, paper pulp, bran, bark of special types, ground linseed, moss, leaves, grass, seeds, and oatmeal.

To aid in holding the fibers in suspension the following have been employed: Flour, starch, dextrin, gelatin, glue, sugar, glucose, caramel, gum arabic, soap, and water glass.

As materials designed to lower the freezing point, alcohol, glycerin, salt, and calcium chloride have been employed.

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[1] U. S. Pat. Nos. 699083 and 1561332, for example.

[2] U. S. Pat. Nos. 1070596 and 1062535, for example.

As preservatives, formaldehyde, carbolic acid, boric acid, chloroform, and certain asphaltic materials have been used.

In addition to patented products, there are many others, but all which the bureau has had occasion to examine fall under the foregoing general classification. Various proportions and combinations are used and in many cases other materials are added, as, for instance, whiting, clay, and graphite, which probably aid the fiber in the sealing process, and other organic liquids, such as "cactus sap," which may add desirable properties.

In using these compounds there must be enough to coat the inner surface of the tube with the fibrous or flaky material as well as a surplus to flow to the point where the puncture occurs.

Most persons are familiar with the old method of repairing a hole in a teakettle by inserting a small piece of cotton cloth. The sealing of an inner tube by these fibrous compounds works in a similar manner. An examination of a hole in a tube which has been sealed will show it filled with a plug of fiber which is not in any way cemented to the rubber. In other words, the fibrous mixture flows around inside the tube and in case of a puncture the fiber is crowded into the opening by the pressure of the air in the tube. It is claimed for some compounds that they harden on coming in contact with the air. This hardening process takes place slowly and in the meantime the fiber plug alone must act as the seal. Punctures in the nature of a cut or tear are difficult or impossible to seal.

If a material consisting, for instance, of ground asbestos fiber and water glass, or leather fiber and glycerin, is placed in an inner tube with a quantity of water and the tube is inflated in a casing, the puncture-sealing properties may be demonstrated in a very surprising way. A 6-penny nail can be driven through the casing, the tire revolved so that the portion of the nail inside the casing becomes coated with fiber, and the nail removed without allowing an appreciable amount of air to escape. It is sometimes necessary to turn the tire so that the puncture is on the downside in order that the surplus compound will cover it. If larger holes are made in the tube they may or may not seal, depending on their shape and size. Seals can often be obtained with a hole made by a 30-penny nail, but as a rule the compound can not be depended upon to seal large holes.

The fact that the puncture-sealing properties can be shown in such a surprising way as by deliberately driving nails into tires, has led to demonstrations of this kind being used very effectively in sales promotion. From the foregoing it will be apparent that such a demonstration proves very little concerning the value of any particular product as a tire-sealing material, as the test can be duplicated with the simplest type of compound. Materials such as those described above are often used in boilers and heating systems to repair small leaks, and work very satisfactorily where the parts are stationary. In a tire, however, which is subject to continuous flexing while running, the question of a permanent seal is the important thing. In this respect some of the compounds are doubtless much superior to others.

Assuming that satisfactory puncture-sealing materials of the class mentioned can be obtained, the arguments which have been advanced for and against their use should be given consideration.

Arguments for their use:

(1) They will prevent delays due to punctures. (This refers only to relatively small punctures and not to large ones, cuts, blowouts, or "pinched" tubes.)[3]

(2) They stop holes in porous tubes.

(3) They are said to prevent the escape of air through leaky valves. (This is open to question.)

(4) They keep tires cooler. (The use of a small amount of water in tires, particularly truck tires, to keep them cooler has sometimes been advocated and a liquid puncture-sealing compound would act in the same way as water. It is questionable whether any great advantage would result.)

(5) They preserve the rubber. (Any appreciable effect is questionable.)

Arguments against their use:

(1) It is not worth the cost and trouble because, with the good roads of to-day, tires receive comparatively few punctures of the class that would be sealed.

(2) In case of blowouts or large punctures they make considerable mess.

(3) They may freeze in winter. (This can be prevented by proper nonfreezing agents.)[3]

(4) They cause patches on tubes to loosen. (There is no reason for this with properly vulcanized patches. One maker states that "cold" cemented patches may loosen.)

(5) One maker of puncture-sealing material states that a tire containing his compound should always be inflated with the valve at the top. This would apply as well to other compounds of the same type and if strictly adhered to would cause some inconvenience. (The reason for this precaution is probably to avoid the chance of any material being forced back through the valve.)

(6) In case of a nail in a tire the motorist should know it and remove it before it damages the casing.

(7) At high speeds the wheel may be thrown off balance because of the bulk of the material being collected at one place. (It is noted that the advertisements of one prominent manufacturer of automobiles state that particular attention is paid to wheel balance. No data are available as to whether or not a wheel might be thrown off balance by the puncture-sealing material, but it would appear that centrifugal force would distribute the material uniformly around the casing.)

Following are a list of questions that are frequently asked, together with an answer to each:

(1) Is the material injurious to the casing or tube? This, of course, depends upon the particular composition; usually, however, compounds of the class described are not injurious.

(2) Does the compound make a permanent seal? It does not make a permanent seal in the sense of cementing the rubber together. If the punctured

[3] The comments in parentheses are the bureau's.

tube is removed from the casing and inflated it will leak the same as though it contained no puncture-sealing compound. When put back in the casing the puncture must be resealed with new fiber. Whether a puncture remains sealed depends upon the particular compound used in the tube and upon the size of the puncture. Seals in small holes are probably fairly permanent. With large holes, laboratory tests have shown that running the tire will sometimes produce a better seal, but in other cases will cause a sealed puncture to leak.

(3) Will any damage result from the material getting between the tube and the casing? When a puncture occurs some water passes through the opening and some may get between the tube and the casing. In the case of a puncture which does not seal immediately, considerable water may get into the tire. If this gets as far as the rim it may increase rusting. If the hole seals, the amount of fiber leaking through and accumulating between the tube and casing would probably cause no trouble. If the hole does not seal, the complete contents of the tube may be forced through a comparatively small hole into the casing.

(4) Does the compound interfere with the functioning of the valve? It does not appear to seriously interfere. However, the valve should not be directly at the bottom when inflating or applying a gauge, as some of the compound may be blown out.

(5) Does the compound corrode metal parts? Valves are made of brass so that water does not cause them to rust. Rusting of the rim has been referred to in (3). The majority of the compounds do not contain materials which will corrode the parts of the valve.

(6) Will the material cause the tube to stick to the casing? This condition has not been observed in compounds examined at the bureau, and, in general, it is not believed that trouble would result from this source.

(7) Does it affect the resiliency of the tire? As a general thing the puncture-sealing fluid does not occupy more than 5 or 6 per cent of the air space of the tire. It is not believed that this would seriously affect the resiliency of the tire.

(8) If a compound is put in a tube how long will it remain effective? The bureau has no specific data as to the length of time which compounds will retain their puncture-sealing qualities. Letters have been received, however, from individuals stating that a particular compound will remain effective only for a certain time, or that a compound will gradually dry up when in use. It does not appear from the usual ingredients of puncture-sealing compounds that there should be any great change in their character with age aside from a possible loss of the liquid portions. While such a loss might occur due to punctures, it is also possible that there would be a loss due to the air which permeates through tubes being saturated with water or other vapors derived from the compound. This would gradually reduce the amount of liquid in the tube and leave the solid portion. Such a process would be expected to take place slowly. If it did occur it would necessitate replacing the liquids lost in order that the compound retain its puncture-sealing properties.

The foregoing statements are made for the benefit of any one desiring to use puncture-proof compounds. No recommendations are made as to their desirability, and a person contemplating their use should weigh carefully the arguments for and against them.

It may be significant that in spite of the large number of compounds which have been produced in the past 30 years, none has come into very general use.

WASHINGTON, October 18, 1926.