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METHOD AND APPARATUS FOR BONDING AN ACTIVE TAG TO A PATCH AND A TIRE

A method and apparatus for bonding an active tag to a patch and assembling the patch to a tire is set forth. A patch assembly and a method for securing an electronic monitoring device having electronic and mechanical components for monitoring at least one engineering condition within a tire, comprising an rigid tag assembly encapsulating the electronic monitoring device, bonded to a vulcanized rubber patch which is secured to the inner cavity of a tire utilizing a layer of dual cure bonding rubber.

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METHOD AND APPARATUS FOR BONDING AN ACTIVE TAG TO A PATCH AND TIRE

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The following statement is a full description of this invention, including the best method of performing it known to applicant(s):

METHOD AND APPARATUS FOR BONDING AN ACTIVE TAG TO A PATCH AND A TIRE

FIELD OF THE INVENTION

This invention relates generally to monitoring engineering conditions of tires. More particularly, this invention provides a method for mounting an electronic monitoring device to a tire, and a tire incorporating such a device.

BACKGROUND OF THE INVENTION

It is desirable to monitor engineering conditions of tires, such as wear, internal pressure and internal temperature in order to reduce tire costs and maximize vehicle efficiency. Of course, it is advantageous to perform such monitoring in large truck tires, which are expensive.

Prior art methods of monitoring large truck tires have included passive integrated circuits embedded in the body of the tire, or self-powered circuits which are positioned external to the tire. The passive integrated circuits rely on inductive magnetic coupling or capacitative coupling to energize the circuit, thus providing power to the circuit from a source remote from the tire. Self-powered circuits positioned external to the tire are exposed to damage from the environment such as weather, road hazards and even vandalism.

Recent engineering advances have permitted the installation of monitoring devices having active integrated circuits within tires. One such device is described in U.S. Patent No. 5,562,787 to Koch et al. entitled "Method of Monitoring Conditions of Vehicle Tires", incorporated herein by reference, and assigned to the assignee of the present invention. These devices include an active circuit powered by a dedicated long life, miniature battery and at least one sensor for detecting, optionally storing and transmitting real time engineering conditions within the tire. Such devices are capable of being programmed to remain in an active, but dormant condition, but will switch automatically to an “awakened’ condition in response to an external signal or a condition which exceeds preset limits.

One of the problems faced with such active devices is that they are delicate electronic devices that must operate in the harsh environment of a tire. Thus it is important to secure these devices in the tires to minimize the effect of the harsh tire environment on them, while still permitting them to be exposed to this environment to allow accurate monitoring of the engineering conditions for the life of the tire. These active devices have previously been mounted in tires by first encapsulating the device or power-containing circuit in a material which forms a rigid or semi-rigid encasement about the device, thereby inhibiting straining of the device as a result of applied stresses. Such materials have included non-foam compounds such as urethanes, epoxies, polyester-styrene resins, hard rubber compositions, and the like. The encapsulated device is then placed into a green rubber material which forms a housing or is placed in a green rubber pocket or pouch that becomes part of the tire. The encapsulated device is then permanently set within the rubber material during a subsequent vulcanizing operation. The green rubber material containing the encapsulated device may be assembled to the green tire and then vulcanized with the tire. Alternatively, the green patch containing the encapsulated device may be separately vulcanized and then affixed to a cured tire with a suitable adhesive. In either event, the delicate electronic components of the active tag are exposed to high vulcanizing temperatures which may adversely affect their performance or shorten their life. Additionally, certain components of the device, such as the pressure sensor or a thermistor must remain open to the pressurized tire cavity. The flow of rubber occurring during the vulcanization process can effect the openings to the tire cavity. As set forth in U.S. Patent No. 5,562,787, the opening to the tire cavity can remain open during the curing operations by placement of a dowel into the opening.

While the methods and apparatus of U.S. Patent No. 5,562,787 provide an acceptable method of assembling an active chip into a tire cavity, an improved arrangement which increases the life of the active chip in the tire is desirable.

The above discussion of background art is included to explain the context of the present invention. It is not to be taken as an admission that any of the documents or other material referred to was published, known or part of the common general knowledge in Australia at the priority date of any of the claims of this specification.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention there is provided in combination: a pneumatic tire having an innerliner; an electronic monitoring device for monitoring at least one engineering condition of the tire; and, an attachment patch mounted to the innerliner of the tire; the electronic monitoring device mounted on the attachment patch; whereby the attachment patch is disposed between the tire and the monitoring device.

In accordance with another aspect of the present invention there is provided a method for mounting an electronic monitoring device to a tire having an innerliner, the method including the steps of: providing an electronic monitoring device for monitoring at least one engineering condition of a tire; providing an attachment patch; mounting at least part of the electronic monitoring device to the attachment patch; and mounting the attachment patch to the tire; whereby the attachment patch is disposed between the tire and the monitoring device.

In accordance with a further aspect of the present invention there is provided a tire having an active electronic monitoring device for monitoring at least one engineering condition mounted within the tire, including: a vulcanized tire having an innerliner, a rigid tag assembly including a rigid potting material encapsulating an active electronic monitoring device, the rigid tag assembly having an upper surface, a lower surface and an outer periphery; a vulcanized rubber patch of preselected configuration having edges, a first side for interfacing with a face of an encapsulated tag assembly and a second opposite side approximating the contour of an innerliner of a tire, the first side including a recessed cavity surrounded by a raised ridge of material of sufficient height surrounding a portion of the outer periphery of the rigid tag assembly; an adhesive layer securing at least the lower surface of the rigid tag assembly within the recessed cavity of the vulcanized rubber patch; and a layer of dual cure bonding rubber having a first surface and a second surface, the first surface being permanently cured to the second side of the vulcanized rubber patch and the second surface being permanently cured to the innerliner of the tire.

In accordance with a still further aspect of the present invention there is provided a method for securing within a tire an electronic monitoring device for monitoring at least one engineering condition of a tire, in such a manner and in such a location so as to minimize stress, strain, cyclic fatigue, impact and vibration, including the steps of: encapsulating an electronic monitoring device by placing the electronic monitoring device into a mold having a preselected configuration, filling the mold with an epoxy potting material, and curing the epoxy potting material to form a rigid tag assembly having the preselected configuration in such a manner so as allow the electronic components to remain free from internal tire contamination but to remain open to the tire atmosphere as necessary; manufacturing a rubber patch having a preselected configuration, the rubber patch having edges, a first side for interfacing with at least one surface of the encapsulated rigid tag, the first side including a recessed cavity surrounded by a ridge of material of sufficient height to capture the encapsulated rigid tag assembly, and a second opposite side, the second side approximating the contour of the innerliner of the tire, the patch being tapered from the ridge toward the edges; vulcanizing the rubber patch at a preselected temperature and for a time sufficient for vulcanization; applying a layer of dual cure bonding rubber to the second side of the vulcanized rubber patch; applying a fluid epoxy adhesive to an interface between the encapsulated tag assembly and the rubber patch; assembling the encapsulated tag assembly into the recessed cavity on the first side of the rubber patch so that fluid epoxy adhesive flows from an interface between the surface of the encapsulated tag assembly and the rubber patch; curing the assembly to form a patch assembly; assembling the patch assembly to the innerliner of a vulcanized tire by applying an activating cement between the dual cure bonding layer and the innerliner of the tire; then, stitching the patch assembly to the innerliner of the vulcanized tire; and curing the patch/tire assembly at a temperature and for a time sufficient to form a strong bond.

The present invention increases the life of the electronic monitoring device by minimizing the stress, strain, cyclic fatigue, impact and vibration to which the electronic monitoring device is subjected when properly assembled into a tire. While the location of the device is an important factor in determining the life of an electronic monitoring device located within a tire, so too is the manner in which the device is installed into the tire.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of the tire patch of the present invention.

Fig. 2 is a cross-sectional view of the rigid tag assembly, showing the encapsulated electronic monitoring device.

Fig. 3 is a cross-sectional view of the mold used to encapsulate the electronic monitoring device, producing the rigid tag assembly.

Fig. 4 is a perspective view of the patch assembly of the present invention.

Fig. 5 is a cross-sectional view of the patch assembled to the inner liner of a tire.

Fig. 6 is a perspective view of an alternative configuration of the tire patch of the present invention.

Fig. 7 is a cross-sectional view of the rigid tag assembly of Fig. 6, showing the encapsulated electronic monitoring device.

Fig. 8 is a perspective view of the patch assembly of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will be described below with reference to the drawings.

Fig, 1 shows a tire patch 10 of the present invention. The tire patch is of a preselected configuration, which as shown, is rectangular in shape. The patch may be of any other convenient configuration, but is shown as rectangular, and therefore has four edges 11. The tire patch 10 has a first side 12 for interfacing with a face of an encapsulated tag assembly 30, shown in Fig. 2. The patch has a second opposite side 14 approximating the contour of an inner liner of a tire. The contour of the second side 14 preferably is radiused to have about the same radius as the tire to which it is assembled, the radius being larger for larger tires. For very large tires, such as for off-the-road tires, the radius may be eliminated altogether, so that there is no contour and the opposite side is flat, having no contour.

The rubber patch is vulcanized at a preselected temperature and for a time sufficient to vulcanize the patch. The patch may be rubber selected from the group consisting of Ethylene Propylene Diene Monomer (EPDM) rubber, butyl rubber, natural rubber, neoprene and mixtures thereof. One preferred embodiment is a mixture of chlorobutyl rubber and natural rubber. Another preferred embodiment is a mixture of Styrene-Butadiene rubber (SBR) and natural rubber. Typically, patches made of these rubber compositions may be cured by heating to a temperature of about 150°C and holding at this temperature for about 30 minutes. The time and temperature may be modified as necessary to achieve sufficient curing of the patch for further assembly.

The first side 12 includes a recessed cavity 16 which is surrounded by a raised ridge 18 of rubbery polymer material. The recessed cavity optionally may have a roughened bottom surface to increase its surface area. The ridge 18 preferably is of the same material as the remainder of the patch. The ridge of material should be of sufficient height to capture the encapsulated rigid tag 30. In a preferred embodiment, the ridge is about one eighth (1/8") inch. The patch is gradually tapered from the ridge 18 of material of the first side of the patch 12, outwardly toward the edges of the patch.

Affixed to the second side 14 of the vulcanized tire patch is a dual cure bonding layer 20, which has a first side (not shown) and a second side 22. This dual cure bonding layer may be assembled to the patch at any time following vulcanization of the patch and prior to assembly of the patch assembly to the tire innerliner. The dual cure bonding layer is permanently assembled to the patch. A non-curing cement (not shown) is applied to side 14 of the patch in order to hold the dual cure bonding layer 20 onto the patch. The non-curing cement and the dual cure bonding layer are products of

Patch Rubber Company. The important feature of the dual cure bonding layer is that it can be chemically activated and cured, without the need for heating to an elevated temperature. The process is diffusion controlled, however, and some minimal heating will speed the curing process. The dual cure bonding layer may be any material which can be activated and cured to the vulcanized rubber of the tire inner liner and the vulcanized patch. Preferably, however, the dual cure bonding rubber is natural rubber. The dual cure bonding rubber, after application of the activating cement, may cure at room temperature over a period of seventy two (72) hours. However, if more rapid curing is desired. this may be accomplished by heating to 45°C for at least twenty four hours.

Fig. 2 shows a cross-sectional view of the rigid tag assembly 30, showing the encapsulated electronic monitoring device 32. Monitoring device may be a circuit board 34 which includes electronic memory as well as a variety of sensors for monitoring engineering conditions such as, for example, pressure, temperature and distance traveled. The monitoring device is discussed in detail in U.S. Patent No. 5,562,787, incorporated herein by reference. Mounted to the board is a power source 36, such a battery, which permits the active monitoring of the engineering conditions, which may be stored in the electronic memory for later use. The power source provides a bulge 38 to the rigid tag assembly, although this feature is expected to become less prominent or even completely eliminated as advances in battery technology produce smaller yet more powerful batteries. The rigid tag assembly may also house an antenna, or may provide for assembly of an antenna which protrudes from the tag assembly so that the circuitry on the board can be activated for transmittal at will.

The circuit board including sensors, battery and optional antenna, hereinafter referred to as the electronic monitoring device, are encapsulated in a potting material 40 which solidifies into a rigid material. Referring to Fig. 3, the electronic monitoring device is placed within a mold 40 having a first half 52 and a second half 54. At least one of the mold halves has a face with increased surface area, shown as surface 56 in the second half 54 of mold

40. The mold is then filled with the potting material 40 in fluid form, which fills the mold and flows around the electronic monitoring device and allowed to cure, resulting in a rigid tag assembly. Any potting material having a Young's Modulus of at least 30,000 psi and which is capable of being molded around the electronic monitoring device without damaging any of the components of the device. Preferably, the potting material has a Young's Modulus of at least about 100,000 psi. Two preferred potting materials include epoxy and urethane. If desired, the curing of the potting material around the electronic device may be accelerated by preheating the mold to an elevated temperature which is above ambient, but below the temperature at which damage to the electronic monitoring device will occur. A preferred temperature is about 80°C. After the epoxy has been cured, the mold halves 52, 54 are separated, yielding a rigid, encapsulated tag assembly 30. Tag assembly 30 has a bottom surface 42 having increased surface finish which is simply the impression of surface 56 from mold half 54.

Rigid tag assembly 30 is assembled into the recessed cavity 16 on the first side 12 of tire patch 10 either after vulcanization of the patch or after assembly of the dual bond curing layer 20 to the patch. In order to permanently adhere tag assembly 30 to patch 10, a fluid adhesive is applied to the interface between tag assembly 30 and recess 16. This adhesive, preferably an epoxy adhesive, may be applied conveniently to surface 42 of tag assembly or to the base of recess 16. As tag assembly 30 is pressed into recessed cavity 16, the epoxy adhesive flows evenly along the interface between surface 42 and the base of recess 16. The increased surface area between the base of recessed cavity 16 and surface 52 provides for additional bonding area and a stronger bond. Because the ridges around the recess are closely dimensioned to correspond to the dimensions of tag assembly 30, excess epoxy will flow between tag assembly 30 and ridge 18, and some epoxy may even flow out from this region. Of course, the flow of epoxy in this region will add to the strength of the assembly as the epoxy cures. While the epoxy can be allowed to cure at room temperature, the curing process can be accelerated by heating the assembly at an elevated temperature, for example a temperature of from about 75-90°C for at least about 30 minutes. If the dual cure bonding layer has not already been assembled to the second side 14 of tire patch 10, it may be added at this time to form patch assembly 60.

Referring now to Fig. 5, Patch assembly 60 was then assembled to the inner liner 75 of tire 70. Activating cement was first applied to second side 22 of dual cure bonding layer 20. The patch assembly was then stitched to the inner liner of the vulcanized tire and the patch assembly/tire assembly was allowed to cure for a sufficient time and temperature to form a strong bond between the tire and the patch assembly. The times and temperatures utilized for this curing may be basically the same times and temperatures as previously discussed. To ensure a strong bond, the patch assembly optionally may be clamped to the tire inner liner 75, until the curing cycle is completed.

Fig. 6 shows an alternative configuration of a tire patch 110 of the present invention. The tire patch 110 is of a preselected configuration, which as shown, is round in shape. The tire patch 110 has a first side 112 for interfacing with a face of an encapsulated tag assembly 130, shown in cross-section in Fig. 7. First side 112 includes a recessed cavity 116 , which in this alternative configuration is formed by a cylindrical rigid insert 117 molded into the rubber patch. Preferably cylindrical insert 117 is a rigid plastic material, such as nylon, epoxy or a rigid composite material such as glass-filled polyimide or glass-filled epoxy, but also may be a metal, as long as the metal does not interfere with the electronic functions and operation of tag assembly 130. Cylindrical rigid insert 117 is surrounded by a ridge 118 of rubbery material. The ridge preferably is of the same material as the remainder of the patch and should be of sufficient height to permanently hold cylindrical insert 117 in place following curing. In a preferred embodiment shown in Figs. 6 and 7, the ridge 118 is the same height as cylindrical insert 117. The patch is gradually tapered from the ridge 118 of material of the first side of the patch outwardly toward the edges of the patch. Recessed cavity 116 may have a roughened bottom surface to increase its surface area, as previously described, or alternatively may be smooth and made from the same material as the cylindrical insert. The patch has a second opposite side 114 which may approximate the contour of an inner liner of a tire. The contour of the second side 114 preferably is radiused to have about the same radius as the tire to which it is assembled, the radius being larger for larger tires. For very large tires, such as for off-the-road tires, the radius may be eliminated altogether, so that there is no contour and the opposite side 114 is flat, having no contour. Tire patch 110 including cylindrical rigid insert 117 is cured prior to insertion of rigid tag assembly 130 to form a round patch assembly.

Rigid tag assembly 130, which includes the encapsulated electronic monitoring device and has the same components as previously described, is essentially identical to rigid tag assembly 30 except for its profile, being round or circular instead of rectangular. Round rigid tag assembly 130 is permanently bonded to the round patch assembly by inserting rigid tag assembly 130 into cylindrical insert 117, as shown in Fig. 8, after applying an epoxy adhesive such as a Fusor system manufactured by Lord Corp. of Erie PA. to the interface between the rigid tag assembly 130 and the cylindrical insert 117. Of course, the epoxy adhesive also may conveniently be applied to the interface between the bottom of cavity 116, whether it is a roughened surface or made of the same or similar material as cylindrical insert 117. As the rigid tag assembly 130 is inserted into cylindrical insert 117, excess epoxy flows out from the interface, which must be removed before it cures. Cylindrical insert 117 only must be of sufficient height so that after curing of the epoxy, there is sufficient bonding strength between the insert 117 and tag assembly 130 to assure no separation. Although the rigid tag assembly 130 may be of the same height as cylindrical insert 117, as shown in the preferred embodiment, it also may be lower or higher than cylindrical insert 117 upon assembly. If tag assembly 130 is higher than the cylindrical insert 117, then insert 117 has a lower profile than the rigid tag assembly 130 so that the outer periphery of the rigid tag assembly 130 extends above the outer periphery of the cylindrical insert 117, thereby reducing the overall amount of material required for tire patch 110.

Patch assembly 160 formed by assembling rigid tag assembly 130 into tire patch 110 is bonded to a tire using the same materials and methods described above for Patch assembly 60.

Patch assemblies manufactured and assembled to a tire inner liner in the manner described above have run through tests equivalent to 100,000 miles, and have remained fully bonded to the tire.

While in accordance with the patent statutes, the best mode and preferred embodiment has been set forth above, the scope of the invention is not limited thereto, but rather by the scope of the attached claims.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. In combination:

a pneumatic tire having an innerliner;

an electronic monitoring device for monitoring at least one engineering condition of the tire; and,

an attachment patch mounted to the innerliner of the tire;

the electronic monitoring device mounted on the attachment patch;

whereby the attachment patch is disposed between the tire and the monitoring device.

2. A combination as claimed in claim 1, wherein the electronic monitoring device is an active electronic monitoring device.

3. A combination as claimed in claim 1 or 2, wherein the attachment patch includes a first side and a second side; the second side of the attachment patch being connected to the innerliner; and the monitoring device being mounted to the first side of the patch.

4. A combination as claimed in claim 3, wherein the first side of the patch includes a recessed cavity, and the monitoring device is disposed at least partially in the recessed cavity.

5. A combination as claimed in claim 4, wherein the patch includes a ridge surrounding the recessed cavity.

6. A combination as claimed in claim 5, wherein the attachment patch has an outer edge, and the attachment patch is tapered from the ridge to the outer edge.

7. A combination as claimed in claim 5 or 6, wherein the ridge is integral to the attachment patch, and the attachment patch and the ridge are fabricated from rubber.

8. A combination as claimed in claim 3 or any claim appended thereto, wherein the second side of the patch approximates the contour of the innerliner at the location where the attachment patch is mounted to the innerliner.

9. A combination as claimed in any preceding claim, wherein the attachment patch includes a layer of uncured rubber that has been cured to connect the attachment patch to the innerliner.

10. A combination as claimed in claim 9, wherein the layer of uncured rubber is dual cure rubber.

11. A combination as claimed in any preceding claim, wherein the monitoring device is connected to the attachment patch with an adhesive.

12. A combination as claimed in any preceding claim, wherein the monitoring device is encapsulated with a rigid potting material.

13. A combination as claimed in claim 12, wherein one side of the encapsulated monitoring device has an alternating raised and recessed pattern.

14. A combination as claimed in any preceding claim, wherein the attachment patch is comprised of rubber selected from the group consisting of EPDM, butyl rubber, natural rubber, neoprene, and mixtures thereof.

15. A combination as claimed in any one of claims 1 to 13, wherein the attachment patch is comprised of a mixture of chlorobutyl rubber and natural rubber.

16. A combination as claimed in any one of claims 1 to 13, wherein the attachment patch is comprised of a mixture of SBR and natural rubber.

17. A combination as claimed in any preceding claim and further including a rigid insert connected to the attachment patch, the monitoring device being disposed inside the insert.

18. In combination:

a pneumatic tire having an innerliner;

an electronic monitoring device for monitoring at least one engineering condition of the tire; and

an attachment patch mounted to the innerliner of the tire;

the attachment patch having a first side and a second side; the first side of the attachment patch having a recessed cavity; the second side of the attachment patch approximating the contour of the innerliner at the location where the attachment patch is mounted to the innerliner;

the electronic monitoring device mounted at least partially in the recessed cavity of the attachment patch;

the attachment patch being disposed between the tire and the monitoring device.

19. In combination:

a pneumatic tire having an innerliner;

an electronic monitoring device for monitoring at least one engineering condition of the tire;

an attachment patch mounted to the innerliner of the tire;

the electronic monitoring device mounted on the attachment patch; and

a layer of rubber cured to the innerliner of the tire and connected to the attachment patch to mount the attachment patch to the innerliner of the tire between the tire and the monitoring device.

20. A combination as claimed in claim 19, wherein the layer of rubber cured to the innerliner is a layer of dual cure rubber.

21. A method for mounting an electronic monitoring device to a tire having an innerliner, the method including the steps of:

providing an electronic monitoring device for monitoring at least one engineering condition of a tire;

providing an attachment patch;

mounting at least part of the electronic monitoring device to the attachment patch;

mounting the attachment patch to the tire; and

whereby the attachment patch is disposed between the tire and the monitoring device.

22. A method as claimed in claim 21, and further including the step of encapsulating the electronic monitoring device before the step of mounting the monitoring device to the attachment patch.

23. A method as claimed in claim 21 or 22, and further including the step of mounting the attachment patch to the innerliner of the tire.

24. A method as claimed in any one of claims 21 to 23, and further including the step of providing a layer of uncured rubber to one side of the attachment patch.

25. A method as claimed in claim 24, wherein the step of mounting the attachment patch to the tire includes the step of curing the layer of uncured rubber.

26. A method as claimed in claim 25, wherein the step of providing a layer of uncured rubber includes the step of providing a layer of dual cure bonding rubber, an wherein the step of curing the layer includes the step of applying an activator fluid to the layer of dual cure bonding rubber.

27. A method as claimed in any one of claims 21 to 26, wherein the step of providing an attachment patch includes the step of vulcanizing a rubber patch.

28. A method as claimed in any one of claims 21 to 27, wherein the step of providing an attachment patch includes the step of providing a recessed cavity on one side of the attachment patch.

29. A method as claimed in claim 28, wherein the step of mounting at least part of the electronic monitoring device to the attachment patch includes the

step of seating at least a portion of the electronic monitoring device in the recessed cavity.

30. A method as claimed in claim 28 or 29, and further including the steps of providing the attachment patch with a textured surface and locating the textured surface in the recessed cavity.

31. A method as claimed in claim 29, or claim 30 when appended to claim 29, and further including the step of placing an adhesive in the recessed cavity prior to performing the step of seating at least a portion of the electronic monitoring device in the recessed cavity.

32. A method as claimed in claim 27 or any claim appended thereto, wherein the step of providing the attachment patch includes the step of forming the rubber patch from a mixture of chlorobutyl rubber and natural rubber.

33. A method as claimed in claim 27 or any one of claims 28 to 31 when appended thereto, wherein the step of providing the attachment patch includes the step of forming the rubber patch from a mixture of SBR and natural rubber.

34. A method as claimed in claim 27 or any one of claims 28 to 31 when appended thereto, wherein the step of providing the attachment patch includes the step of forming the rubber patch from a material selected from the group consisting of EPDM rubber, butyl rubber, natural rubber, neoprene, and mixtures thereof.

35. A method as claimed in claim 27 or any claim appended thereto, wherein the step of vulcanizing a rubber patch includes the step of heating the rubber patch at a temperature of about 150 degrees Celsius for about 30 minutes.

36. A method as claimed in any one of claims 21 to 35, wherein the step of mounting the attachment patch to the tire includes the step of clamping the patch to the tire to provide pressure between the patch and the tire.

37. A tire having an active electronic monitoring device for monitoring at least one engineering condition mounted within the tire, including:

a vulcanized tire having an innerliner,

a rigid tag assembly including a rigid potting material encapsulating an active electronic monitoring device, the rigid tag assembly having an upper surface, a lower surface and an outer periphery;

a vulcanized rubber patch of preselected configuration having edges, a first side for interfacing with a face of an encapsulated tag assembly and a second opposite side approximating the contour of an innerliner of a tire, the first side including a recessed cavity surrounded by a raised ridge of material of sufficient height surrounding a portion of the outer periphery of the rigid tag assembly;

an adhesive layer securing at least the lower surface of the rigid tag assembly within the recessed cavity of the vulcanized rubber patch; and

a layer of dual cure bonding rubber having a first surface and a second surface, the first surface being permanently cured to the second side of the vulcanized rubber patch and the second surface being permanently cured to the innerliner of the tire.

38. A tire as claimed in claim 37, wherein the dual cure bonding rubber includes rubbers capable of bonding the vulcanized rubber of the rubber patch to the vulcanized rubber of the innerliner of the tire.

39. A tire as claimed in claim 37 or 38, wherein the dual cure bonding rubber is natural rubber.

40. A method for securing within a tire an electronic monitoring device for monitoring at least one engineering condition of a tire, in such a manner and in such a location so as to minimize stress, strain, cyclic fatigue, impact and vibration, including the steps of:

encapsulating an electronic monitoring device by placing the electronic monitoring device into a mold having a preselected configuration, filling the mold with an epoxy potting material, and curing the epoxy potting material to form a rigid tag assembly having the preselected configuration in such a manner so as allow the electronic components to remain free from internal tire contamination but to remain open to the tire atmosphere as necessary;

manufacturing a rubber patch having a preselected configuration, the rubber patch having edges, a first side for interfacing with at least one surface of the encapsulated rigid tag, the first side including a recessed cavity surrounded by a ridge of material of sufficient height to capture the encapsulated rigid tag assembly, and a second opposite side, the second side approximating the contour of the innerliner of the tire, the patch being tapered from the ridge toward the edges;

vulcanizing the rubber patch at a preselected temperature and for a time sufficient for vulcanization;

applying a layer of dual cure bonding rubber to the second side of the vulcanized rubber patch;

applying a fluid epoxy adhesive to an interface between the encapsulated tag assembly and the rubber patch;

assembling the encapsulated tag assembly into the recessed cavity on the first side of the rubber patch so that fluid epoxy adhesive flows from an interface between the surface of the encapsulated tag assembly and the rubber patch;

curing the assembly to form a patch assembly;

assembling the patch assembly to the innerliner of a vulcanized tire by applying an activating cement between the dual cure bonding layer and the innerliner of the tire; then,

stitching the patch assembly to the innerliner of the vulcanized tire; and

curing the patch/tire assembly at a temperature and for a time sufficient to form a strong bond.

41. A method as claimed in claim 40, and further including, prior to the step of curing the patch/tire assembly, the step of applying a clamping device to apply sufficient pressure to the patch assembly and the innerliner to assure intimate contact at the interface during curing.

42. A method as claimed in claim 40 or 41, wherein the step of curing the patch/tire assembly includes curing at a temperature of about 45°C for at least 24 hours.

43. A method as claimed in claim 40 or 41, wherein the step of curing the patch/tire assembly includes curing at ambient temperature for at least 72 hours.

44. A combination substantially as hereinbefore described with reference to any one of the embodiments shown in the accompanying drawings.

45. A method for mounting an electric monitoring device to a tire having an innerliner, substantially as hereinbefore described with reference to any one of the embodiments shown in the accompanying drawings.

DATED: 29 January 2002
BRIDGESTONE/FIRESTONE, INC.
By its Patent Attorneys:
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By:

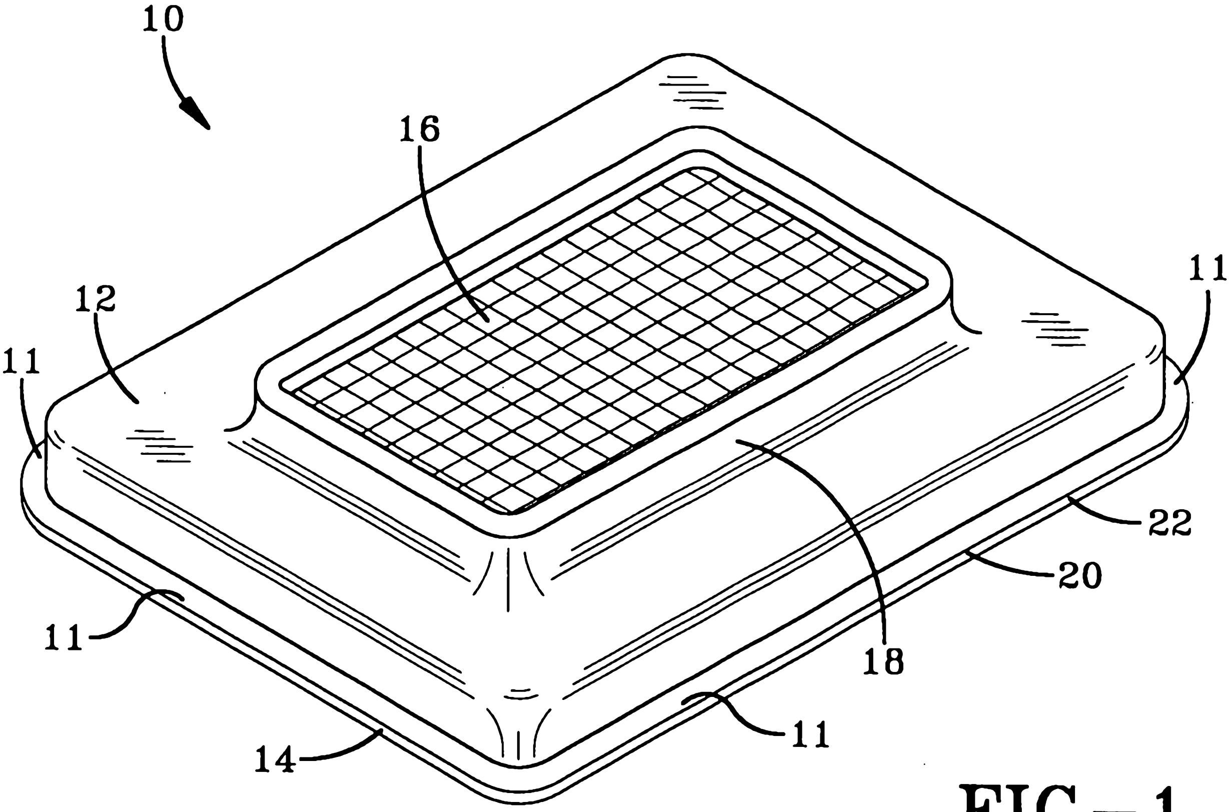


FIG-1

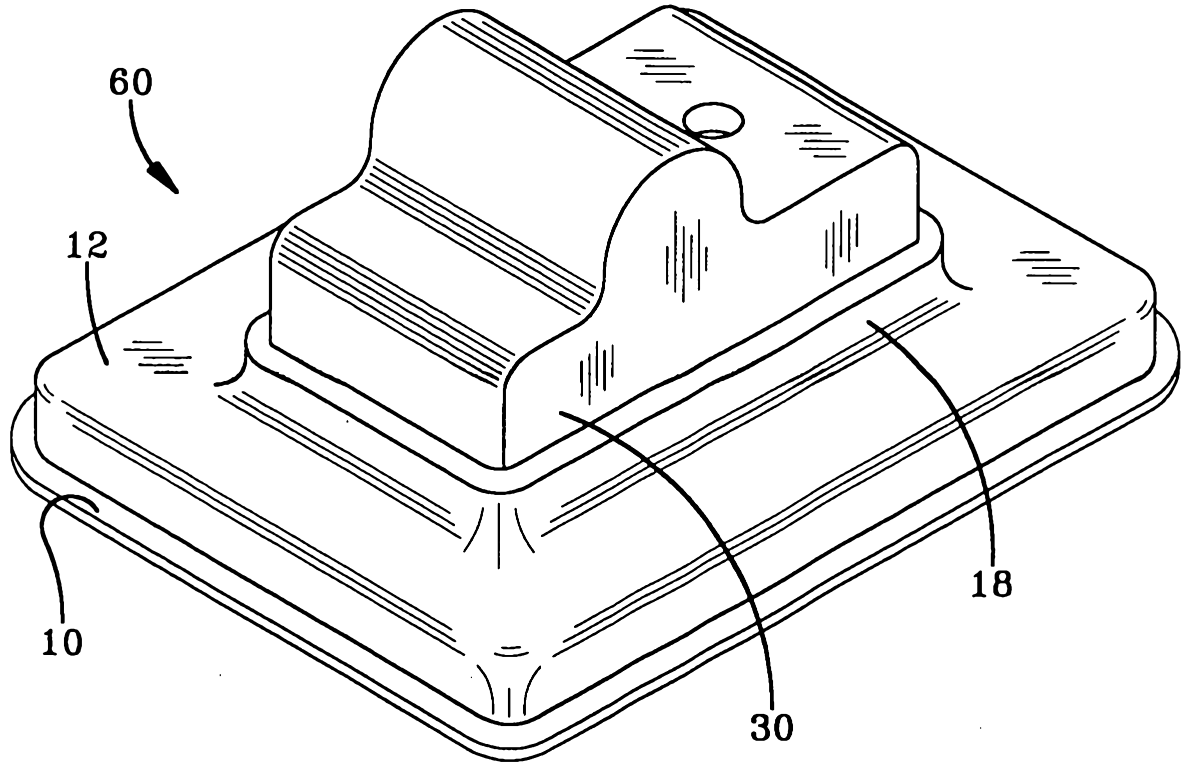
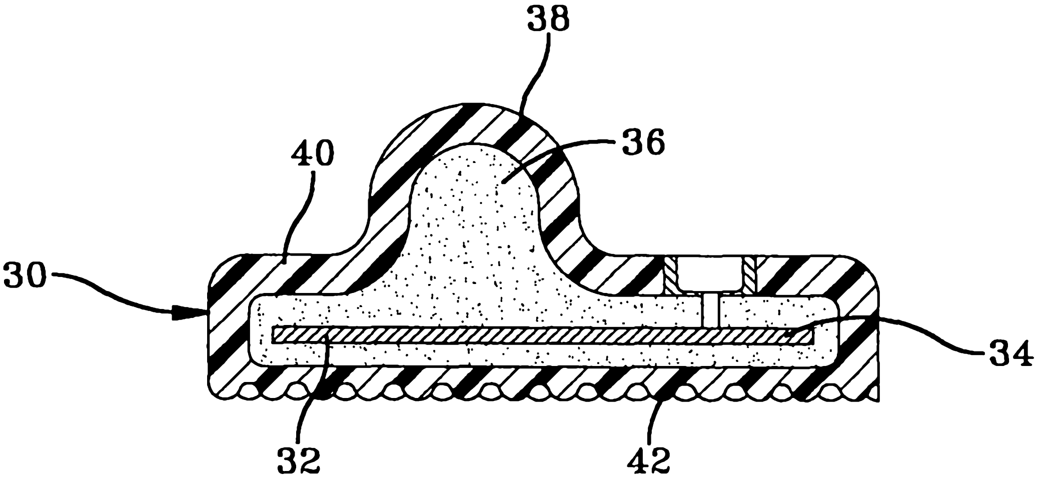
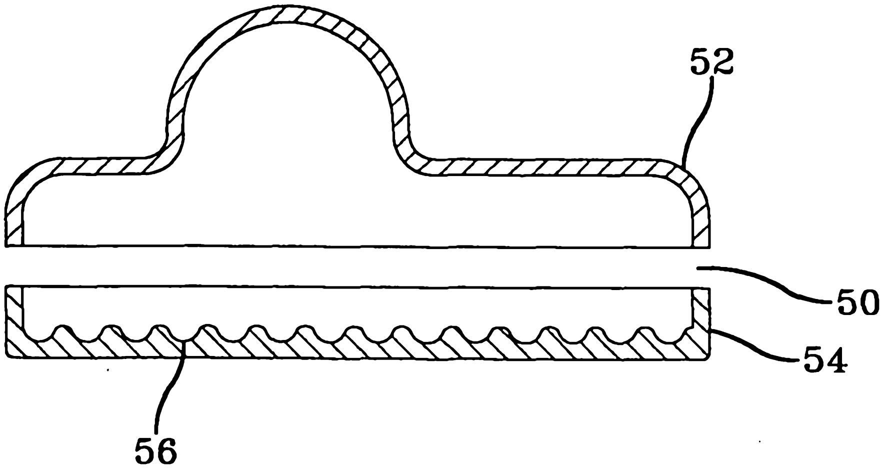


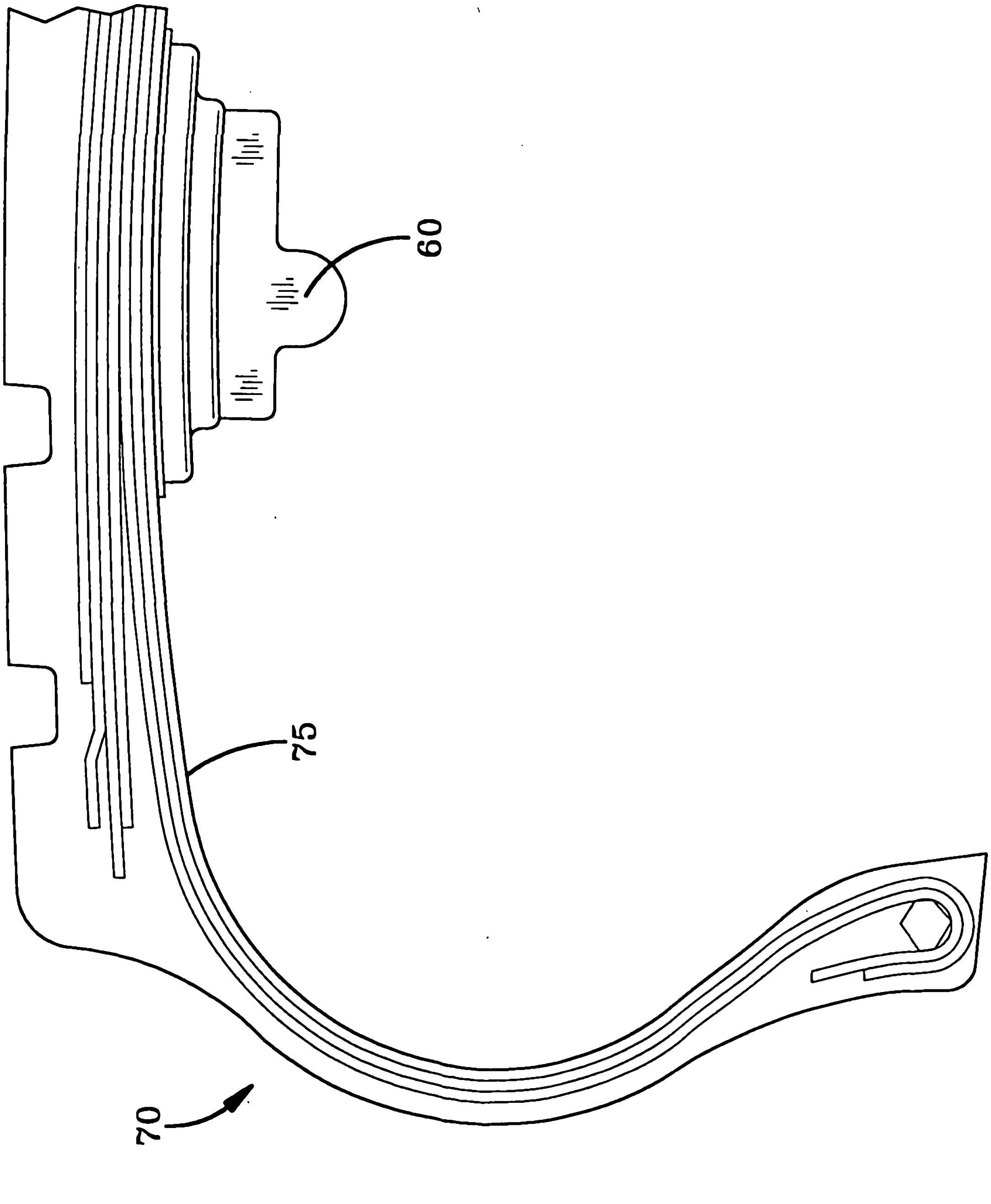
FIG-4



FIG–2



FIG–3



FIG–5

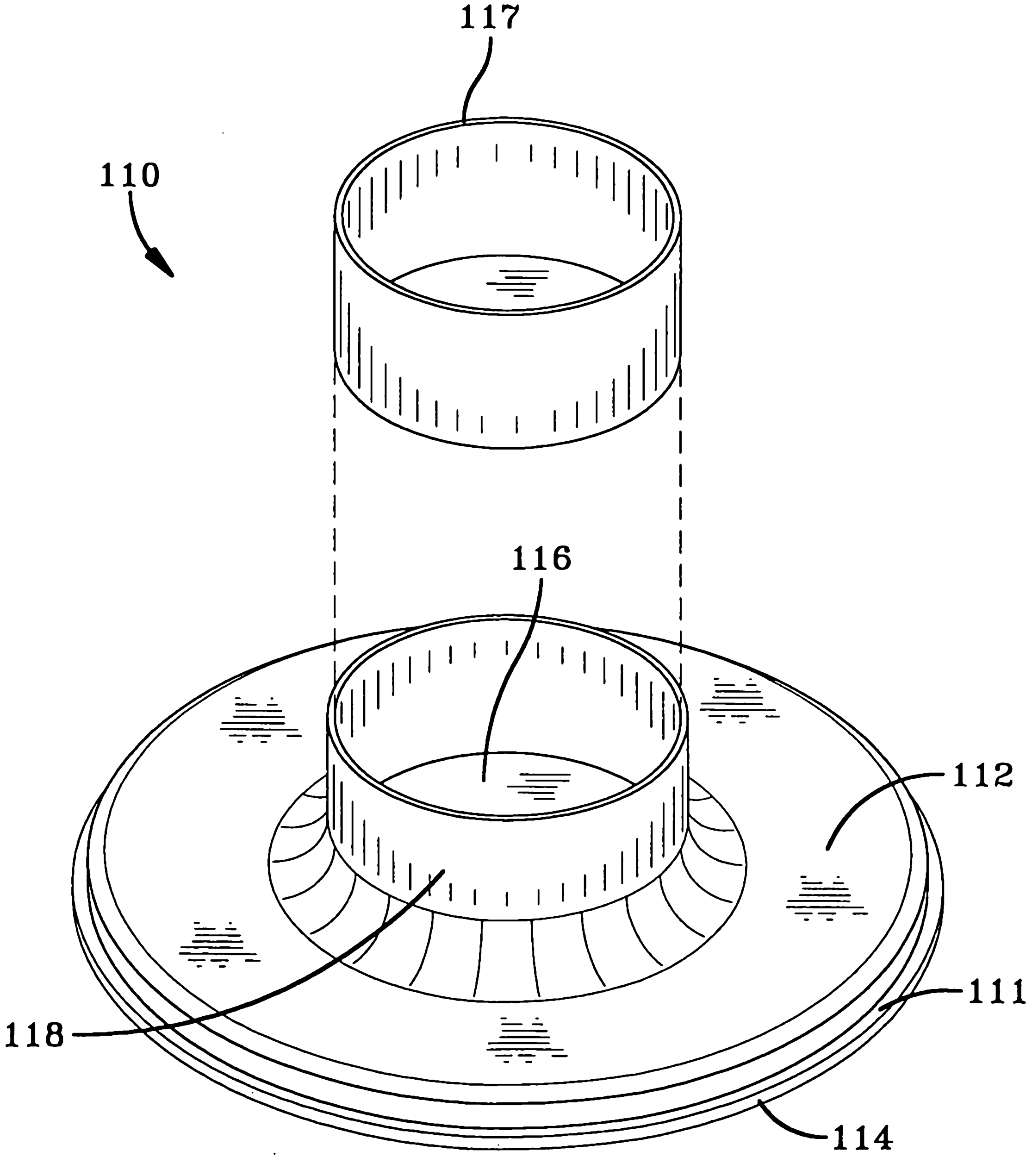


FIG-6

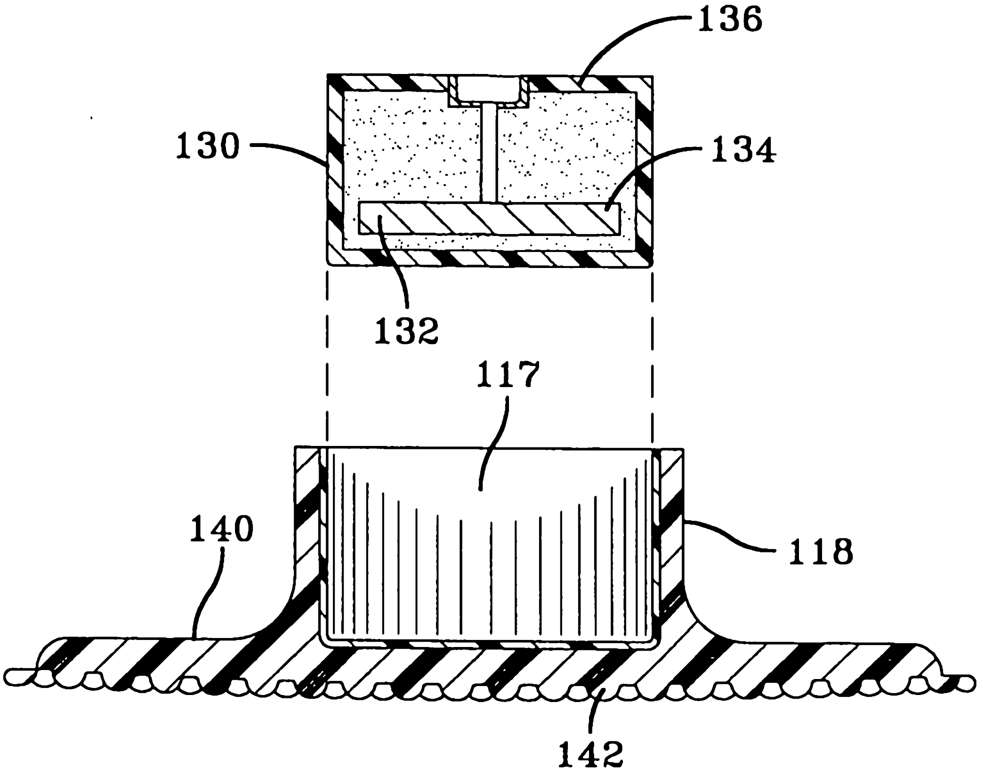


FIG-7

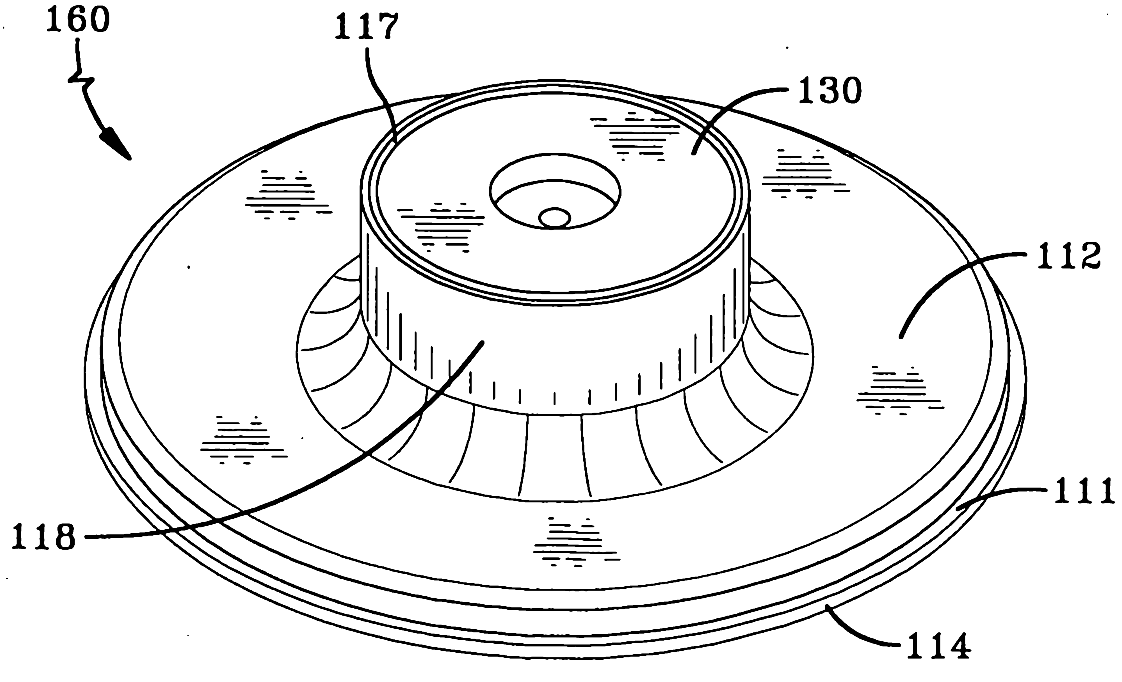


FIG-8