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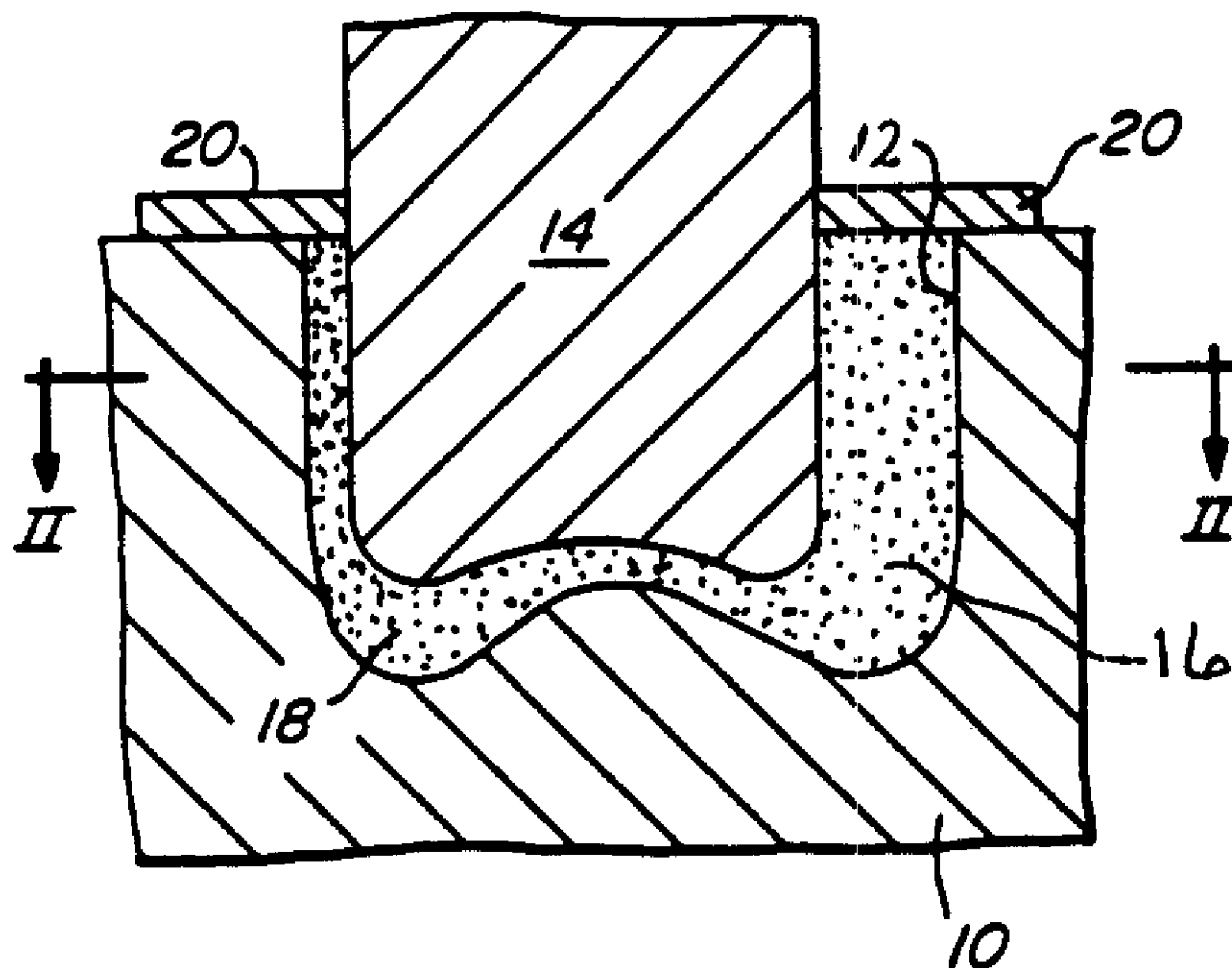
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(54) **USINAGE ORBITAL ET/OU ALTERNATIF A L'AIDE D'UN
PRODUIT VISCO-PLASTIQUE**

(54) **ORBITAL AND/OR RECIPROCAL MACHINING WITH A
VISCOUS PLASTIC MEDIUM**



(57) A method of honing, polishing, reducing, or otherwise abrading, workpiece surfaces utilizing a visco-elastic abrasive medium in situ between the workpiece and a displacer. Said displacer member having surfaces in a facing spaced relationship to the surfaces of said workpiece to be abraded to thereby form a media chamber between the surfaces of said workpiece to be machined and said displacer member. The visco-elastic abrasive medium is deposited within said media chamber. Thereafter, one or more forms of relative motion between the workpiece and displacer forces flow of the medium across the workpiece surface to be abraded thereby effecting the abrasion as desired.

ABSTRACT

A method of honing, polishing, reducing, or otherwise abrading, workpiece surfaces utilizing a visco-elastic abrasive medium in situ between the workpiece and a displacer. Said
5 displacer member having surfaces in a facing spaced relationship to the surfaces of said workpiece to be abraded to thereby form a media chamber between the surfaces of said workpiece to be machined and said displacer member. The visco-elastic abrasive medium is deposited within said media chamber.
10 Thereafter, one or more forms of relative motion between the workpiece and displacer forces flow of the medium across the workpiece surface to be abraded thereby effecting the abrasion as desired.

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ORBITAL AND/OR RECIPROCAL MACHINING
WITH A VISCOUS PLASTIC MEDIUM

TECHNICAL FIELD

5 This invention relates generally to a new and improved
method of honing, polishing, reducing, or otherwise abrading,
workpiece surfaces, and more particularly relates to a unique
new process for working the surfaces of a workpiece utilizing a
visco-elastic abrasive medium in situ between the workpiece and
10 a displacer. One or more forms of relative motion between the
workpiece and displacer then forces flow of the medium across
the workpiece surface to be worked thereby effecting the
abrasion as desired.

BACKGROUND ART

15 Abrasive flow machining is a well known nontraditional
machining process whereby a visco-elastic medium, permeated
with an abrasive grit, is extruded through or past a workpiece
surface to effect an abrasive working of that surface. The
abrasive action in abrasive flow machining can be thought of as
20 analogous to a filing, grinding, lapping or honing operation
where the extruded visco-elastic abrasive medium passes through
or past the workpiece as a "plug." The plug then becomes a
self forming file, grinding stone or lap as it is extruded
under pressure through the confined passageway restricting its
25 flow, thereby working the selected surfaces of the workpiece.

While abrasive flow machining is somewhat similar to other
abrasion techniques wherein fluids are used as a medium to
carry an abrasive grit in suspension for similar abrasion
treatments, such as hydrodynamic machining, there are
30 considerable differences. In applications where fluids are

used, i.e. liquids or gases, very high velocities must be used in order to effect any abrasive action, because high speed impingement of the grit particles against the surface to be abraded is the essential force in such processes. In the present invention, as in other abrasive flow machining processes, the visco-elastic abrasive medium is a semi-solid plastic, forced through the restrictive passageway under considerable pressure but with a relatively low velocity. The semi-solid plastic medium must not only maintain the abrasive particles in a uniform suspension, but it must further provide a relatively firm backing for the abrasive grit to hold the grit firmly against the passageway surfaces while the semi-solid, visco-elastic medium and grit are extruded therethrough. Hence, rather than impinging at high speeds on the surface to be abraded, the grit is slowly and actively worked against the surface to be abraded.

The prior art apparatus utilized in abrasive flow machining, consists of a frame member holding two directly opposed media chambers with the workpiece insertable therebetween. The media chambers are plastic extruding, positive displacement, expandable chambers which can hydraulically or mechanically extrude abrading media therefrom through the passageway of the workpiece and then into the other media chamber. A removable workpiece fixture, designed to hold the workpiece, is secured between the two media chambers. The workpiece fixture must be designed to securely hold the workpiece such that the workpiece surface to be worked is exposed within the passageway between the two media chambers.

If a surface to be abraded is merely a bore through the workpiece, the fixture must serve to merely seal each end of the bore to a media chamber so that the bore itself becomes a sealed passageway between one media chamber to the other. On the other hand, if the workpiece surface to be abraded is an external surface, the fixture is usually more complex and must be designed so that the workpiece and fixture together define the essential restricted passageway so that the surface to be abraded forms a portion of the passageway, and the medium will abrade that surface as it is extruded through the passageway.

The extruding medium, consisting of a semisolid, difficulty flowable, visco-elastic material permeated with a abrasive grit, is contained in one of the media chambers, while the other chamber is empty. To perform the process, the medium is then extruded, hydraulically or mechanically, from the filled chamber to the empty chamber via the restricted passageway through or past the workpiece surface to be abraded, thereby working the surface as desired. Typically, the extruding medium is then extruded back and forth between the chambers to the extent necessary to effect the degree of abrasion desired. Counterbores, recessed areas and even blind cavities can be abraded by using restrictors or mandrils to direct the medium flow along the surfaces to be abraded. A more detailed description of the basic prior art on abrasive flow machining can be found in United States Patent Numbers 3,521,412 - McCarty, 3,634,973 - McCarty, 3,802,128 - Minear, Jr., and 3,819,343 - Rhoades.

Subsequent to the development the basic abrasive flow machining process, numerous modifications have been developed which renders the process applicable to particular applications. While such prior art techniques of abrasive flow machining are very effective, particularly in the machining of surfaces within confined passageways or surfaces which can be incorporated within a confined passageway with a proper fixture, they do have their limitations, particularly in the machining of large complex surfaces such as the internal surfaces of large mold cavities, and the outer surfaces of gear wheels and the like. In these applications, it has usually been necessary to utilize rather large and complex fixtures, restrictors or mandrils to define a restricted passageway along the surface to be machined. If large surface areas are involved, the volume of the visco-elastic abrasive medium becomes rather excessive, requiring larger equipment with the attendant larger expense and considerable difficulty is setting-up the workpiece in a fixture to be so machined or otherwise abraded.

DISCLOSURE OF THE INVENTION

An aspect of the invention is as follows:

A method of treating a workpiece to abrade selected surfaces thereof, comprising the steps of: providing a displacer member adjacent to said workpiece, said displacer member having surfaces in a facing spaced relationship to the surfaces of said workpiece to be abraded to thereby form a media chamber between the surfaces of said workpiece to be machined and said displacer member; introducing a visco-elastic abrasive medium into said media chamber; imparting a

relative motion between said workpiece and said displacer member sufficient to cause said visco-elastic abrasive medium to be extruded from one part of said media chamber to another thereby causing a positive displacement of said visco-elastic abrasive medium across the surfaces of said workpiece to thereby abrade said workpiece surfaces; continuing said motion until said workpiece surfaces are abraded to the extent desired.

By way of added explanation, this invention is predicated upon the development of a new and inexpensive method for the working of workpiece surfaces with a visco-elastic abrasive medium which does not involve the direct extrusion thereof, and is particularly useful in the working of large complex surfaces such as mold cavities, gear wheels and the like. In this inventive process, a medium displacement chamber is formed between the workpiece surface to be machined and a displacer, which may be similar to a mandril

or restrictor as utilized in the prior art. The displacer member is shaped to have surfaces in a facing spaced relationship to the surfaces of said workpiece to be abraded to thereby form a media chamber between the surfaces of said workpiece to be machined and said displacer member. Instead of extruding the visco-elastic abrasive medium through the chamber however, the chamber is filled with a mass of the medium and is preferable sealed therein. Then the displacer and/or workpiece are put into relative motion so that the medium is forced to move about within the medium chamber, i.e. extruded from one area of the chamber to another, and its motion against the surface of the workpiece will machine or otherwise abrade the workpiece as it moves therepast.

As in conventional abrasive flow machining, the visco-elastic abrasive medium is ideally a rheopectic material having the consistency of putty at room temperature with no pressure applied. In the context of this invention, "rheopectic" defines the property of a composition in which the viscosity increases with time under shear or a suddenly applied stress. Stated another way, this property of the abrasive media is exactly the opposite of "thixotropy". A typical example of such a material is silicone bouncing putty (borosiloxane). Accordingly, the visco-elastic abrasive medium is displaced positively against and across a portion of a workpiece which is utilized as the displacement chamber or as the displacer, or as both. In this context, the abrasive medium acts as a positively displaced abrading tool. There is no need for engagement, such as meshing, between the opposed surfaces, nor

is there a need for mating of these surfaces although, in practice, it may be desirable to use such an arrangement.

Accordingly, it is an object of an aspect of this invention to provide a new and inexpensive process for honing, polishing, reducing or otherwise abrading a workpiece surface utilizing a viscoelastic abrading medium.

An object of an aspect of this invention to provide a new and inexpensive process for honing, polishing, reducing or otherwise abrading a workpiece surface utilizing a visco-elastic abrading medium which does not involve the direct extrusion of the medium.

An object of an aspect of this invention to provide a new and inexpensive process for honing, polishing, reducing or otherwise abrading a workpiece surface which is ideally suited to the working of large surface area not easily worked by conventional abrasive flow machining.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional side view illustrating one embodiment of this invention which involves orbital or horizontal reciprocal relative motion or combinations thereof between the displacer and workpiece.

Figure 2 is a cross-sectional top view of the embodiment shown in Figure 1 shown with the section taken at line II-II, and depicts an embodiment utilizing orbital relative movement, with or without rotational movement.

Figure 3 is identical to Figure 2 except that it depicts an embodiment utilizing a lateral reciprocal motion in several planes of movement, again with or without rotational motion.

Figure 4 is cross-sectional top views of another application of this invention, in this case where the workpiece is a gear, and utilizing the embodiment shown in Figures 1 and 2 incorporating both rotational and orbital relative movement between the workpiece and displacer.

Figure 5 is a cross-sectional top view illustrating another embodiment of this invention which involves only a triangular orbital relative movement between the displacer and workpiece.

Figure 6 is a cross-sectional side view illustrating another embodiment of this invention which involves a vertical relative reciprocal motion between the workpiece and displacer. As illustrated, the displacer is in the fully withdrawn position.

Figure 7 is identical to Figure 6 except that it illustrates the displacer in the fully inserted position.

Figure 8 is a cross-sectional side view illustrating another embodiment of this invention involving a vertical relative reciprocal motion as utilized effect a more even abrasion of the workpiece.

Figure 9 is a cross-sectional side view illustrating another embodiment of this invention involving a vertical relative reciprocal motion as utilized effect an uneven abrasion of the workpiece.

BEST MODES OF CARRYING OUT THE INVENTION

Throughout the description of the invention, the term "relative" motion or movement between the opposed surfaces is used to indicate that either or both the workpiece and

displacer may be in motion to accomplish positive displacement of the viscous abrasive medium. Further, this movement may be gyratory, orbital, reciprocatory, or any combination of thereof with or without the combination of rotary motion therewith, so long as the motion effects a positive displacement of the abrasive medium across the workpiece surface to be treated.

Reference to Figures 1 and 2 will illustrate one embodiment of this invention in its simplest form utilizing only orbital relative motion, wherein workpiece 10 could be a die casting mold or the like having a mold cavity 12 therein to be abraded. A displacer 14, having a profile smaller than cavity 12, is adapted to be insertable within cavity 12 to provide a medium chamber 16 formed between the entire surface of cavity 12 and displacer 14. A visco-elastic abrasive medium 18 is deposited within medium chamber 16, and is sealed therein by sealing ring 20, securely attached around displacer 14, when displacer 14 is suitable inserted within cavity 12, as shown. With displacer 14 and sealing ring 20 biased against the visco-elastic abrasive medium 18, a relative orbital motion is effected between workpiece 10 and displacer 14. This relative orbital motion will then cause a relative translational motion between the medium 18 and the contacting surfaces of workpiece 10 and displacer 14, thereby causing the surface of the cavity 12 to be abraded as desired. The relative orbital motion is continued until the workpiece 10 is abraded to the extent desired.

With reference to Figure 2, the circular arrows passing over displacer 14 represents the orbital path of the axis

thereof. In this embodiment, the motion of the visco-elastic abrasive medium 18a is caused by the relative orbital motion between the workpiece 10 and displacer 14 which tends to push or extrude the medium 18 around the cavity 12 as it is squeezed from an area of the chamber of diminishing section into an area of expanding section. In this embodiment, the relative orbital motion can be combined with a relative rotational motion so that in essence, with respect to the workpiece 10, the displacer 14 revolves on its axis as it orbits within cavity 12.

In the embodiment described above, it should be apparent that the visco-elastic abrasive medium 18 will serve to abrade the outer surface of displacer 14 as well as the workpiece surface of cavity 12. Accordingly, either piece could be representative of the workpiece as well as the displacer. It follows therefore, that Figures 1 and 2 could be representative of an application whereby the outer and lower surfaces of a cylindrical workpiece are abraded by utilizing a cavity containing body as the displacer.

In a more practical application of the above described embodiment the efficiency of the operation can be improved and wear of the displacer surface minimized if the surface of the displacer 14 is such that it resist flow of the visco-elastic abrasive medium 18 therepast. This can readily be done by any of several ways. For example, fin-like protrusions can be incorporated on the surface of the displacer which will project into the body of medium so that the medium is more or less carried along with the motion of the displacer and the relative

displacement between the displacer and the medium is reduced while enhancing the relative motion between the medium and the workpiece. It is also known that the medium will tend to adhere to porous or roughened surfaces as well as surfaces coated with polyurethane, silicon rubber or like materials. Accordingly, if the surface of the displacer 14 is made porous or roughened, or is coated with polyurethane or silicon rubber, the medium will tend to adhere thereto, so that when there is relative movement between such a displacer and a workpiece surface, the motion between the workpiece and medium is enhanced at the expense of motion between the displacer and the medium.

The embodiment depicted in Figure 3 is substantially like that depicted in Figure 2 described above, except that there is a relative lateral oscillatory motion between the displacer 12a and the workpiece 10a, here again with or without rotational motion. In this embodiment, the visco-elastic abrasive medium 18a is forced to flow back and forth within the chamber 16a by the relative lateral oscillatory motion, which can be in two or more planes as represented by the arrows imposed over the displacer 14a.

In the two embodiments described above, it should be apparent that the form of relative movement between the displacer and the workpiece is not particularly critical, particularly where the surface of the workpiece is uniform and continuous as shown. Indeed, the orbital or reciprocal motions as depicted in these two embodiments will have comparable abrading effects on the workpiece.

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In the embodiment shown in Figure 4 the principal of the application is the same except that a more complex workpiece surface is to be worked. As shown in Figure 4, the workpiece 20 may be a gear or the like having
5 uniformly spaced gear-teeth 22 around the cylindrical periphery thereof. The displacer 24 is an annular shaped form which is positioned to encircle workpiece 20, providing a chamber 26 therebetween. Displacer 24 is preferably provided with a plurality of protrusions 25
10 extending inwardly, and having a size and spacing as can be insertable between gear-teeth 22. When a visco-elastic abrasive medium 28 is sealed within chamber 26, a relative motion is imparted between workpiece 20 and displacer 24. In this embodiment, the relative motion
15 between the workpiece 20 and displacer 24 is a combination of rotational and orbital motion so that the gear-teeth 22 will come close to meshing with protrusions 25 as workpiece 20 rotates and orbits, i.e. "rolls" along the inner surface of displacer 24, but leaving a small
20 gap so that the two components do not in fact come into contact. Accordingly, when the chamber 26 is filled with a visco-elastic abrasive medium 28, and workpiece 20 and displacer 24 put into relative motion as described, the medium 28 will not only be forced to revolve about
25 chamber 26 in a manner similar to that described above, but the near meshing of gear-teeth 22 into protrusions 25 will cause the medium to flow into and out of the spaces between the gear teeth 22 so that it will flow along the surface of gear-teeth 22 to abrade the surface thereof as
30 desired. While a smooth surface on displacer 24 could be provided, it should be readily apparent

that medium 28 would not be squeezed from the recesses between gear-teeth 22, so that the abrasion would be concentrated on the outer periphery of gear teeth 22, with little abrasion on the inner surfaces thereof.

5 In the embodiment illustrated in Figure 5, a three dimensional machining action is exemplified. Here, the workpiece 30 has a triangular opening therethrough to be machined. A mating but substantially smaller triangular-sided displacer 32 is positioned within the triangular opening in
10 workpiece 30, having sufficiently smaller dimensions so that there is sufficient space between the triangular opening and the displacer 32 to form a medium chamber 34 therearound. The workpiece 30 and/or the displacer 32 are mounted to a suitable means (not shown) as will impart a relative triangular
15 translational motion between the workpiece 30 and displacer 32 as depicted by the arrow over displacer 32 so that the corners of the displacer 32 will move into the corners of the workpiece 30. As already described, a visco-elastic abrasive medium is deposited within the medium chamber 34 and sealed therein
20 before the triangular orbital motion is started. When the motion is started, the medium is forced to flow within the three-sided medium chamber as it is squeezed and extruded from from between two opposing surfaces which are coming together and into the space between two opposing surfaces that are
25 moving apart.

 In the embodiment illustrated in Figures 7 and 8, the principle of the abrasion action is substantially the same, except that there is a vertical reciprocal relative motion

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between the workpiece 40 and the displacer 42, such that the visco-elastic abrasive medium is virtually squeezed out of the media chamber 44 with each downward movement of the displacer 42. In the embodiment as illustrated, 5 an elastic sleeve member 46, such as a length of heavy rubber pipe, is secured around the upper periphery of workpiece 40 and the lower periphery of displacer 42, and there held by clamps 48. As shown in Figure 7, the arrangement is set up in its starting position with the 10 displacer 42 in its fully upward position with the visco-elastic abrasive medium disposed within the media chamber 44 such that the sides of media chamber are closed by the resilient sleeve member 46. As the displacer 42 commences its downward relative motion into the cavity of 15 workpiece 40, the visco-elastic abrasive medium is squeezed or extruded from the cavity or media chamber 44 moving upward between the vertical surfaces of workpiece 40 and displacer 42 thereby abrading the vertical surfaces of workpiece 40. Since the visco-elastic 20 abrasive medium has no place to go as the media chamber 44 becomes progressively smaller, the pressure of the medium forces the sides of elastic sleeve member 46 to be stretched outward to take up the excess volume of the visco-elastic abrasive medium, as illustrated in Figure 25 7. Subsequently, when the displacer 42 starts its upward relative motion, elastic sleeve member 46 will force the visco-elastic abrasive medium back into the expanding media chamber, with the system eventually returning to that as illustrated in Figure 6. This cycle is repeated 30 each time the displacer 42 reciprocates.

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In the vertically reciprocating embodiment described above, it should be apparent that there will be some degree of uneven abrasive action on the workpiece 40 and the displacer 42, since there will be progressively more visco-elastic abrasive medium movement along the upper vertical surfaces of the workpiece 40, and lower vertical surfaces of the displacer 42, than there will be at the opposite surfaces thereof or along the horizontal surfaces. This result should be obvious because the upper portion of the vertical cavity walls will be abraded as soon as the displacer moves downward adjacent thereto and will continue to be abraded as the displacer continues to move downward. The lower portion of those cavity walls, however, will not be significantly abraded until the displacer moves adjacent thereto. Such an uneven abrasive action can be utilized to an advantage in some applications, such as the finishing of mold cavities and other workpieces, where some degree of taper is essential. This characteristic can be either minimized or enhanced by the proper design of the displacer to workpiece interface. As an example thereof, Figure 8 represents a displacer design as will minimize uneven abrasion, while Figure 9 illustrates a design as utilized to maximize uneven abrasion to the extent of radiusing the upper corner of the cavity in the workpiece. With reference to Figure 8, it can be seen that displacer 52 is provided with heavy collar or flange portion 54 around the lower extremity thereof. Accordingly, as displacer 52 moves downward within workpiece 50 and extrudes the visco-elastic abrasive medium upward along the side wall of workpiece 50, the velocity of the medium will be greatest in the narrowed volume adjacent to the flange

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54. Behind the flange 54, where the spacing between workpiece 50 and displacer 52 is considerably increased, the upward velocity of the medium is greatly reduced, and the abrasive action on the workpiece side wall is similarly greatly reduced. In this situation, the concentration of heavy abrasion adjacent to the flange 54 is uniform throughout the full travel length of the flange 54.

Figure 9 illustrates a reverse situation where the displacer 62 is designed to maximize abrasion at the upper edge of the cavity surface in workpiece 60 to effect a radiusing thereof. Because the entire side surface of displacer 62 is angled with respect to the side surface of the cavity within workpiece 60, the abrasive action of the visco-elastic abrasive medium will be concentrated at that area where its passage is most restricted, in this case the upper edge of the cavity. The solid line is representative of the starting surface of the cavity side wall, while the dotted line is representative of the form of the finished cavity side wall.

In addition to the above discussed variations in the design of the workpiece-displacer interface, there are numerous other concepts that could be utilized to effect differing abrasion requirements. Here too, differing forms of motion in combination with vertical reciprocal motion could be utilized to effect differing abrasion requirements. In addition to combining an orbital, or horizontal reciprocal motion with the vertical reciprocal motion, the angle of the vertical reciprocal motion can be varies so that it moves downward at an

angle into the workpiece to be abraded, or the angle can be slowly rotated so that displacer moves downward into the workpiece at a constantly changing angle. Accordingly, the variations seem almost countless, and are limited only by ones
5 imagination to formulate new variations of motion and displacer design to satisfy a great variety of abrading requirements.

Typical parameter ranges for the embodiments illustrated would include grit sizes of 6 microns to 16 mesh, gap distance of 0.005-1.5 centimeters (0.002-0.500 inches), time treatments
10 of 5-60 minutes, revolutions, orbits or vibrations of 20 to 20,000, and amplitudes of vibration of 0.06-1.5 centimeters (0.025-0.500 inches). Specifically, after substantially filling the gap with a visco-elastic abrasive medium the displacer of Figure 6 could be operated at 500 vibrations per
15 minute with an amplitude of 0.13 centimeters (0.05 inches) for 5 minutes and a gap of 0.013 centimeters (0.005 inches) would be sufficient of a grit size of 10 microns.

It is preferable that the plastic carrier matrix have a sufficient body at moderate pressure and low velocity to press
20 the abrasive particles against the work surface with sufficient force to produce the results desired. One mixture successfully used in the invention is MV70 Extrude-Hone media, comprising 50% by volume of silicon carbide abrasive grit and 50% by volume of silicon bouncing putty (borosiloxane) carrier
25 (matrix) having a ratio of approximately 2:1 by weight.

By definition, silicone bouncing putty (borosiloxane) exhibits many of the characteristics of a fluid. Under pressure it becomes less flowable and more like a solid. It

conforms exactly to the shape of whatever confines it and this helps in abrading intricate shapes and details. It should be noted that silicone bouncing putty (borosiloxane) is particularly useful in the invention as it is well known that this material becomes harder when subjected to sudden shear force such as when squeezed in the gap between the opposed surfaces as they are moved relative to one another. This increased stiffness enhances abrasion of the workpiece by holding the abrasive particles more firmly in place and transferring the driving force of the working member to the abrasive grains at the work surface.

A non-rheopectic abrasive medium suitable for use in some situations is that described in U.S. Patent No. 3,819,343 - Rhoades.

This invention may be utilized to hone or abrade machined parts, die castings, forgings, sand castings, investment castings and extruded shapes. It is applicable to all materials such as steel, aluminum, brass, bronze, plastics, glass and other compositions and materials as needed.

Obviously, the abrasive used in the carrier matrix will be varied to suit the job. A satisfactory abrasive to use in working on steel is boron carbide (BC) which is readily obtained from the Norton Company in standard grit sizes. Another abrasive which is useful for many applications is aluminum oxide. Other abrasives might include diamond dust silicon carbide, rouge, corundum, garnet, aluminum, glass or, in some unusual operations, softer material such as fiber or shell material. Commonly, the abrasive will vary from about 2

to 4 grams of abrasive particles per gram of the matrix material.

5 The above-mentioned visco-elastic honing media act as a surface abrading tool and are unique for the reason that the abrasive grit is held or contained in a random repositioning arrangement in a plastic matrix. The grain particles in use in the process of this invention are sharp until the sum of all points or edges have been exposed many times, as opposed to the traditional concept of an abrasive "stone" or lap wherein the grain particle is fixed and presents one cutting point or edge which is maintained until dulling causes removal by means of a dressing operation.

10 The fastest cutting action, which is also consistent with the most uniform results, occurs when the medium exhibits an oily nonadhering contact with the work surface. It would appear that when in this condition the medium has the greatest opportunity to pass through the gap at a constant cross-sectional pace. This is contrary to a fluid flow which is greatest through the center and supposedly "zero" along the wall.

20 It should be apparent from the above described embodiments of this invention that there are many possible variations that could be utilized to effect many differing abrading requirements. Accordingly, the present invention is not limited to the preferred embodiments disclosed herein, and that many modifications in construction, arrangement, use and operation are possible within the true spirit of the invention. Accordingly, the present invention is to be considered as

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including all such modifications and variations coming within
the scope of the appended claims.

CLAIMS

1. A method of treating a workpiece to abrade selected surfaces thereof, comprising the steps of:

5 providing a displacer member adjacent to said workpiece, said displacer member having surfaces in a facing spaced relationship to the surfaces of said workpiece to be abraded to thereby form a media chamber between the surfaces of said workpiece to be machined and said displacer member;

10 introducing a visco-elastic abrasive medium into said media chamber;

15 imparting a relative motion between said workpiece and said displacer member sufficient to cause said visco-elastic abrasive medium to be extruded from one part of said media chamber to another thereby causing a positive displacement of said visco-elastic abrasive medium across the surfaces of said workpiece to thereby abrade said workpiece surfaces;

20 continuing said motion until said workpiece surfaces are abraded to the extent desired.

2. The method of claim 1 wherein said visco-elastic abrasive medium is sealed wilthin said media cavity.

3. The method of claim 1 wherein said relative motion is an orbital motion.

25 4. The method of claim 1 wherein said relative motion is an oscillatory motion.

5. The method of claim 1 wherein said relative motion is a reciprocal motion.

6. The method of claim 1 wherein said relative motion is a combination of motions.

7. The method of claim 1 wherein said relative motion is a gyratory motion.

5 8. The method of claim 1 wherein said displacer is provided with a surface resistant to the flow of said visco-elastic abrasive medium therepast.

10 9. The method of claim 8 wherein said surface resistant to the flow of said visco-elastic medium is effected by providing a plurality of protrusions thereon.

10. The method of claim 8 wherein said surface resistant to the flow of said visco-elastic medium is provided by making said surface porous.

15 11. The method of claim 8 wherein said surface resistant to the flow of said visco-elastic medium is provided by applying a coating of polyurethane.

12. The method of claim 8 wherein said surface resistant to the flow of said visco-elastic medium is provided by applying a coating of silicon rubber.

FIG. 1

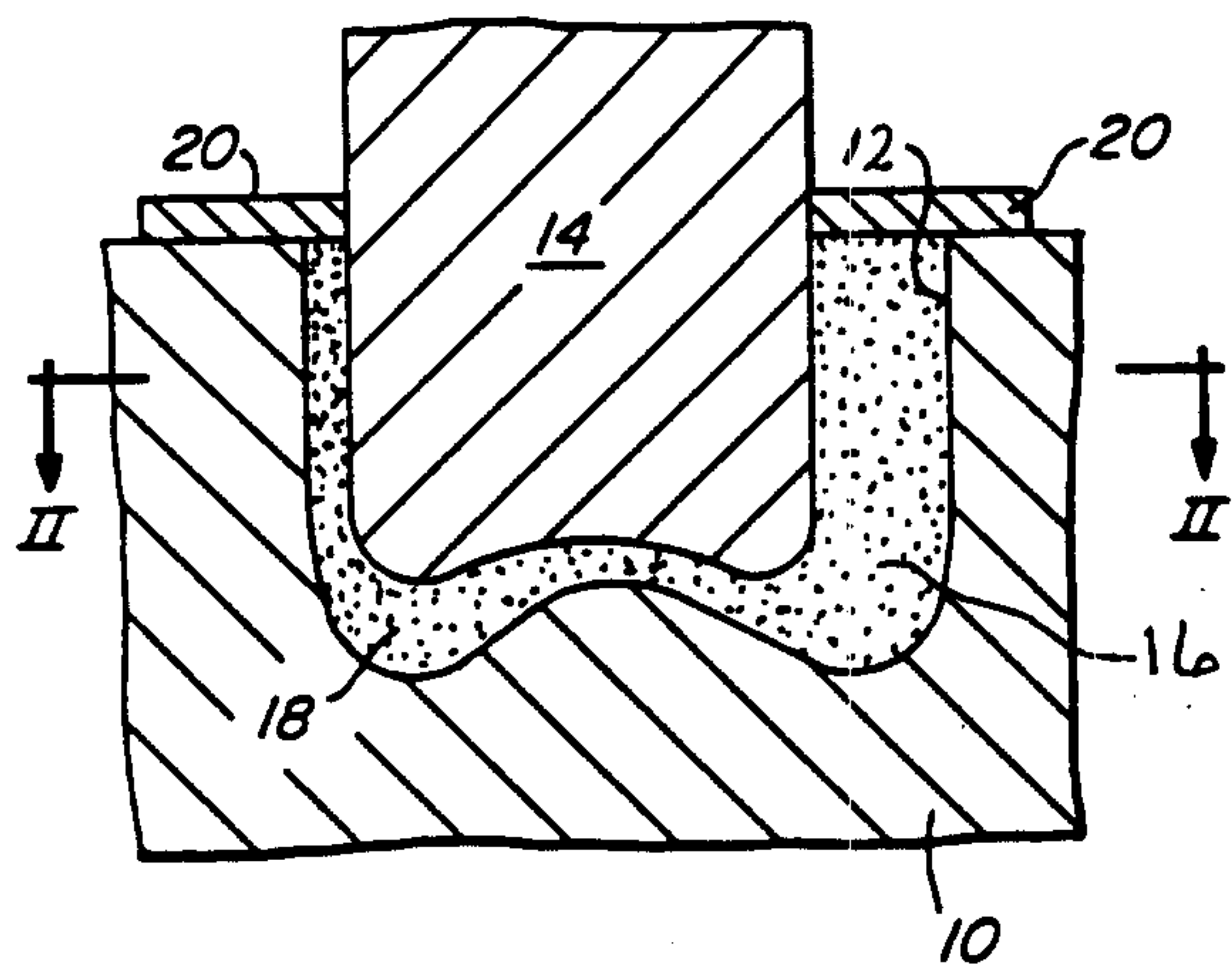


FIG. 2

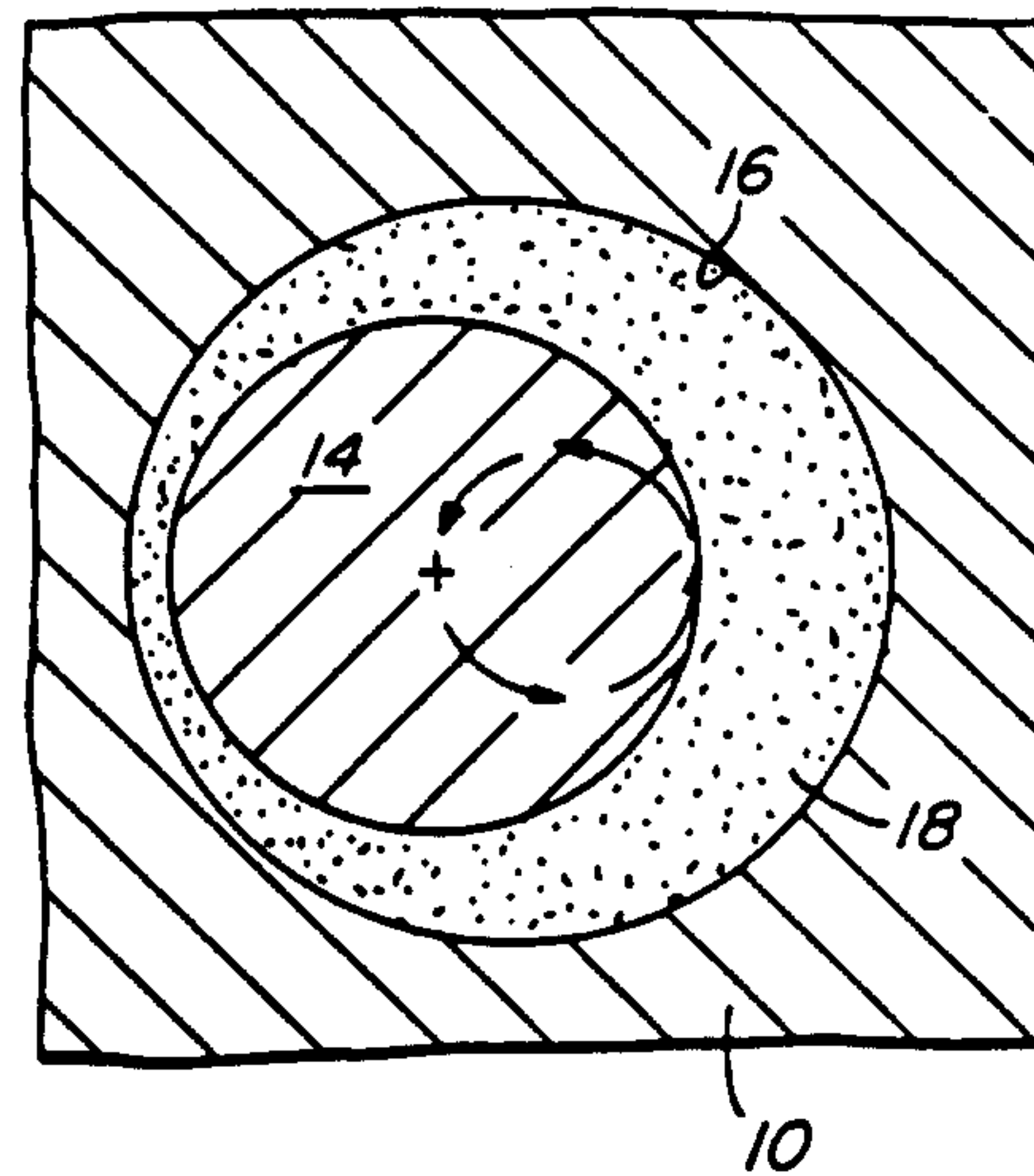
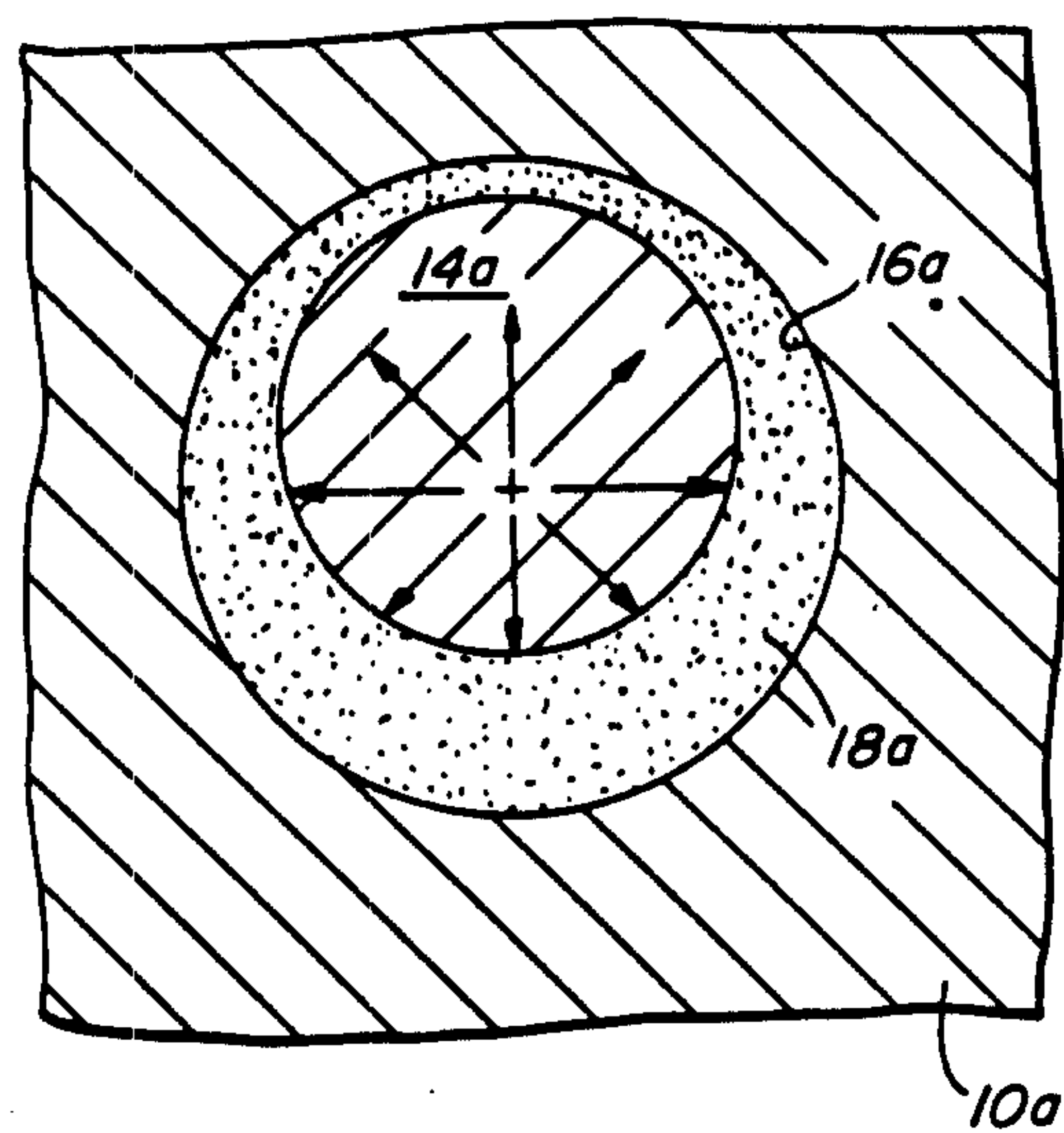


FIG. 3



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FIG. 5

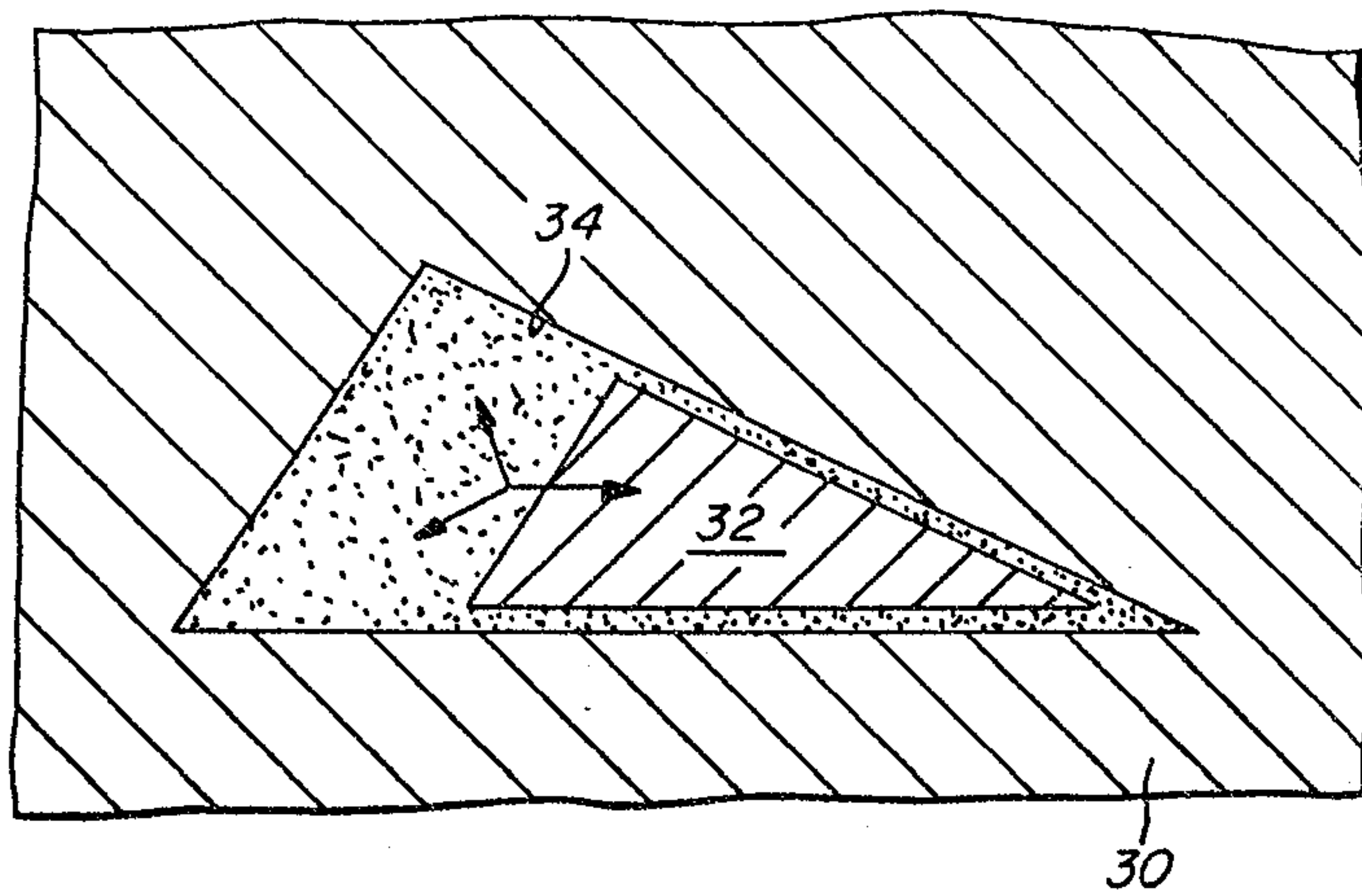
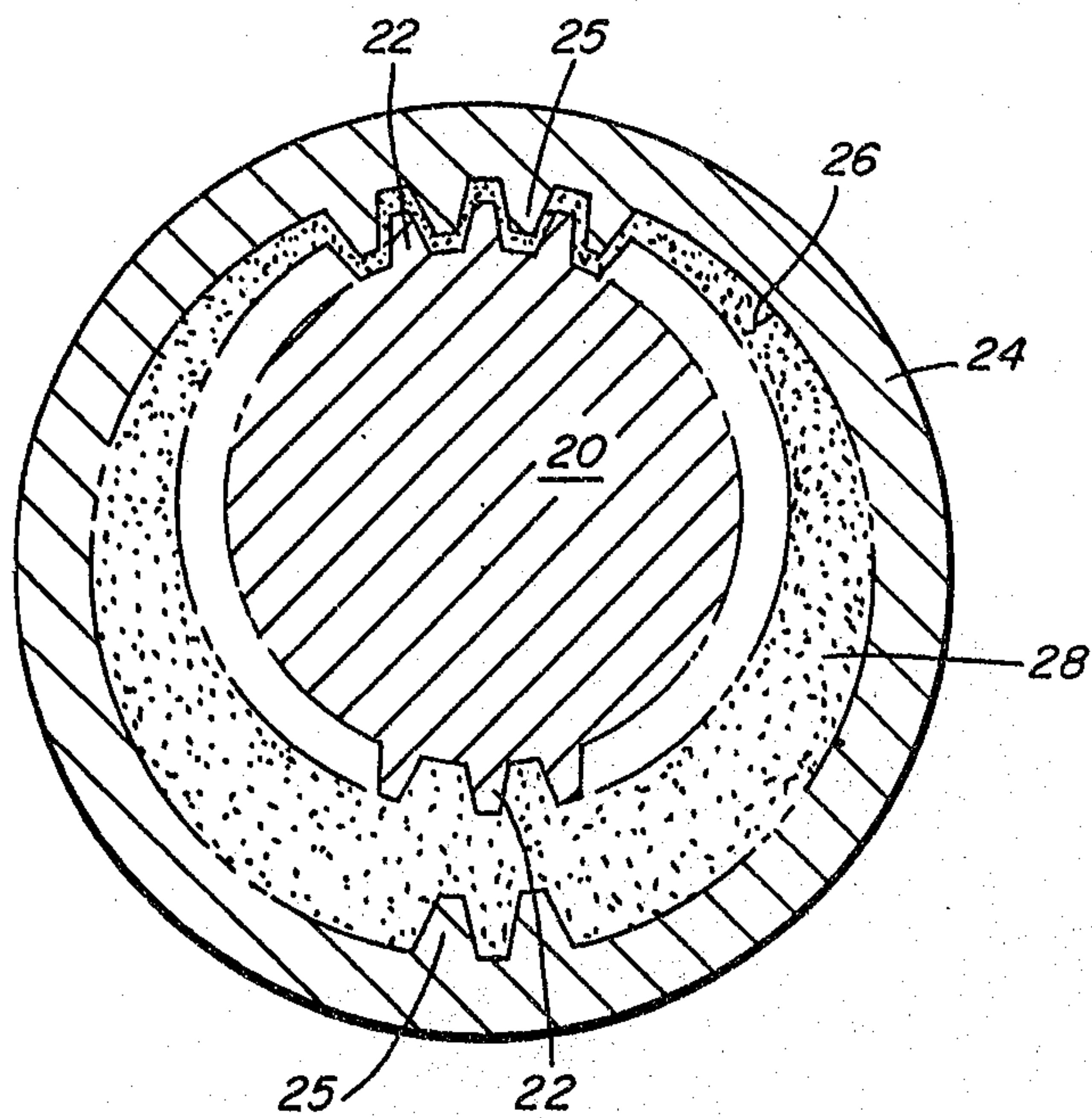


FIG. 4



Sim. J. Mc. Bunnell

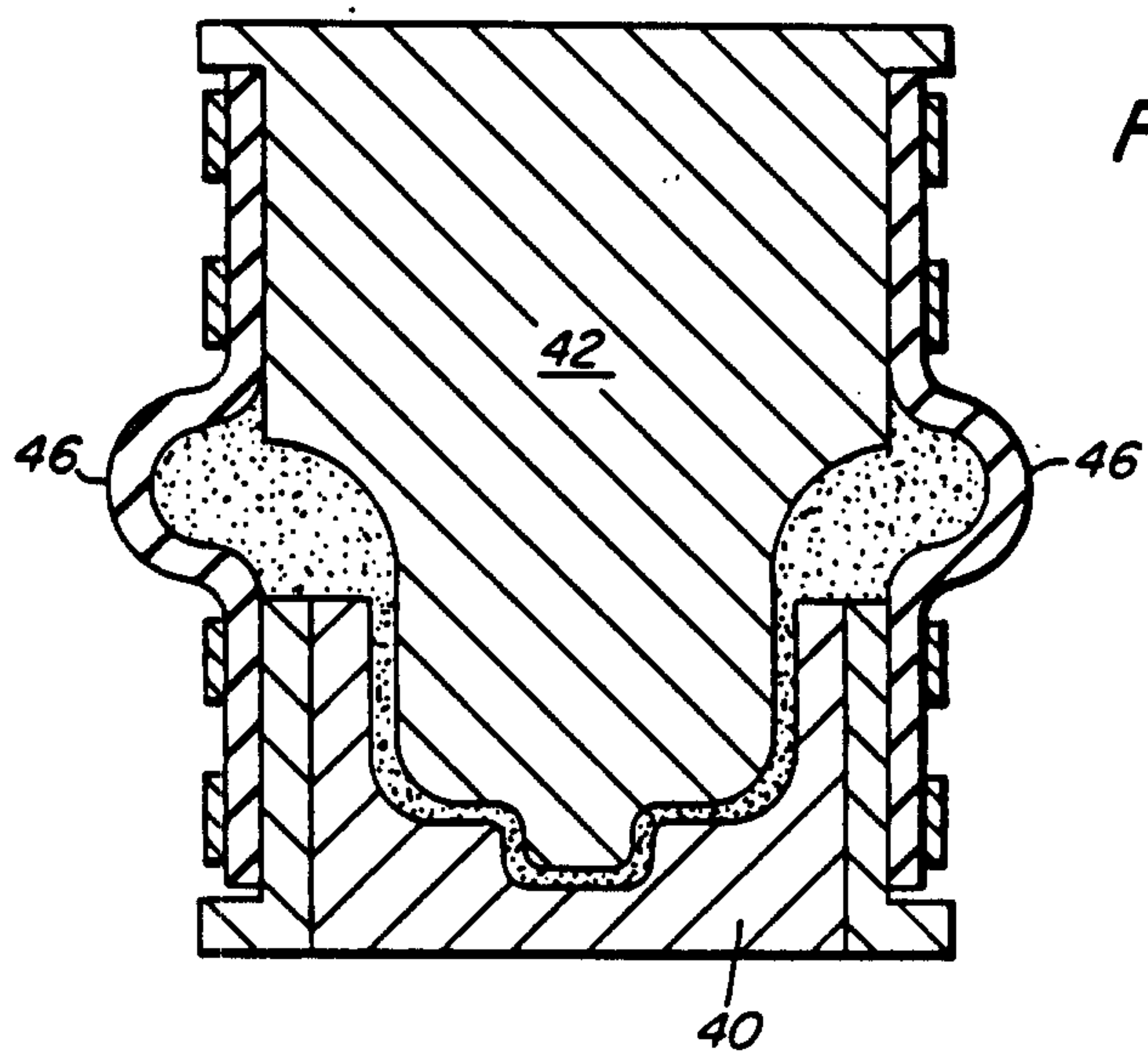
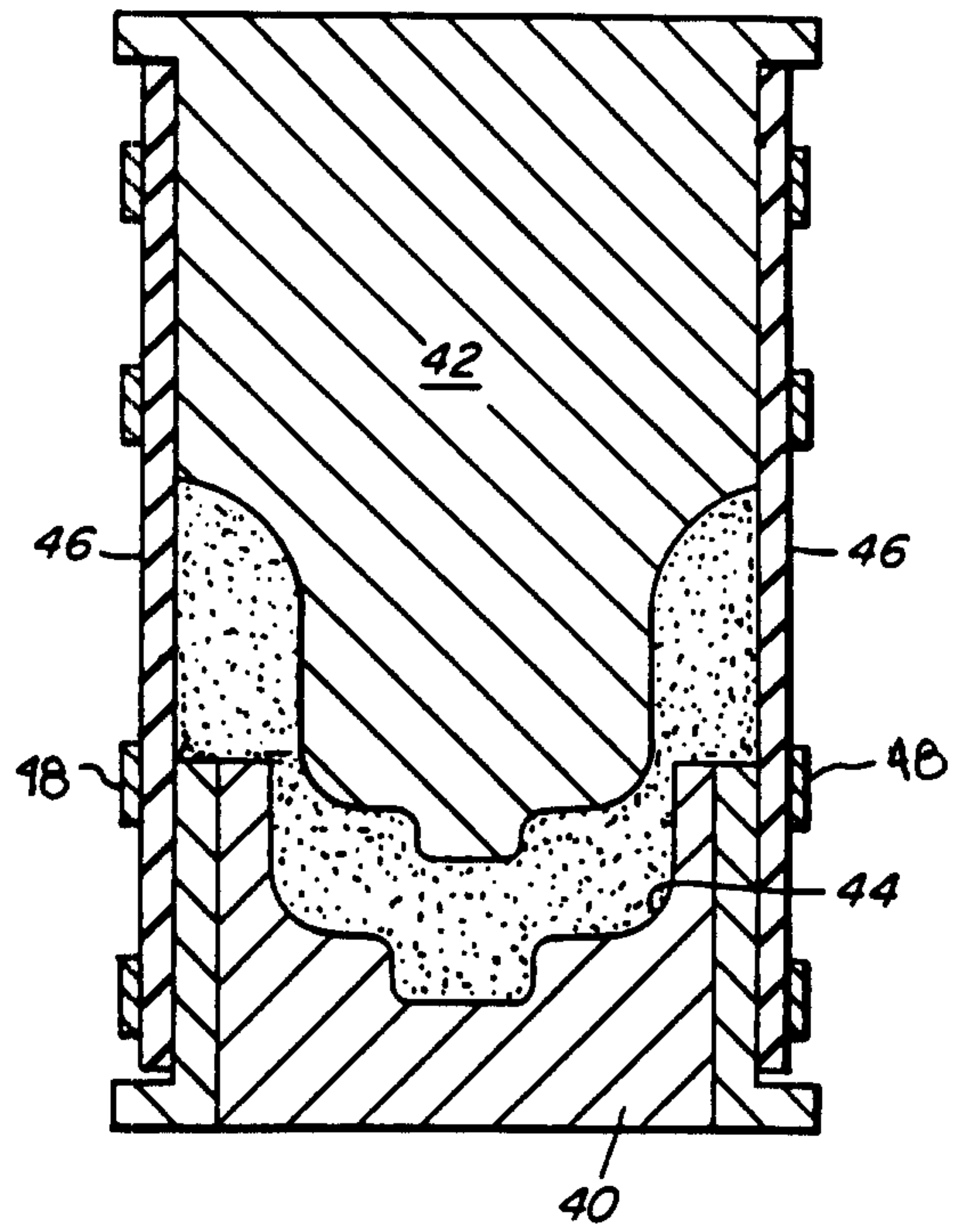


FIG. 8

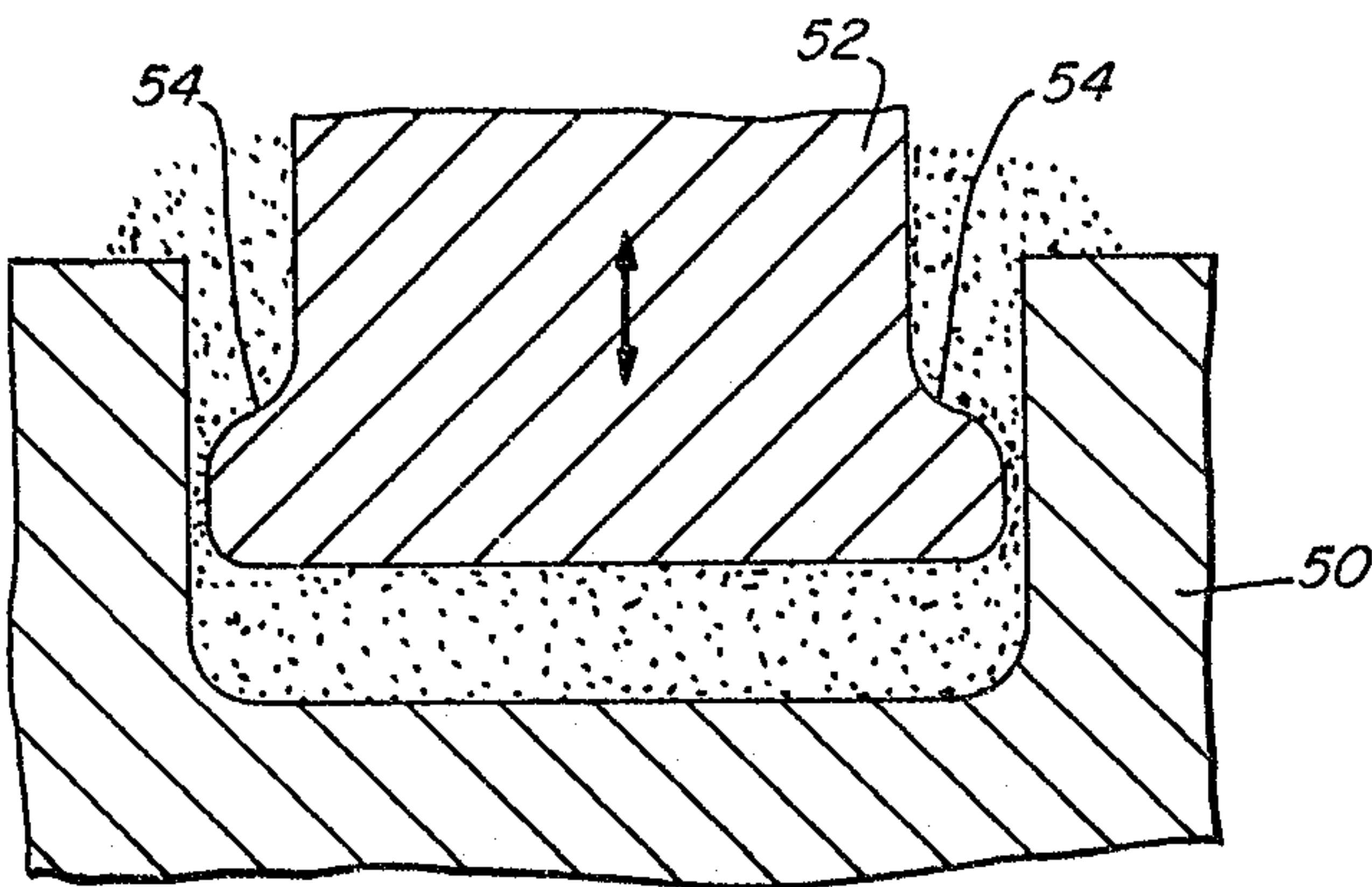
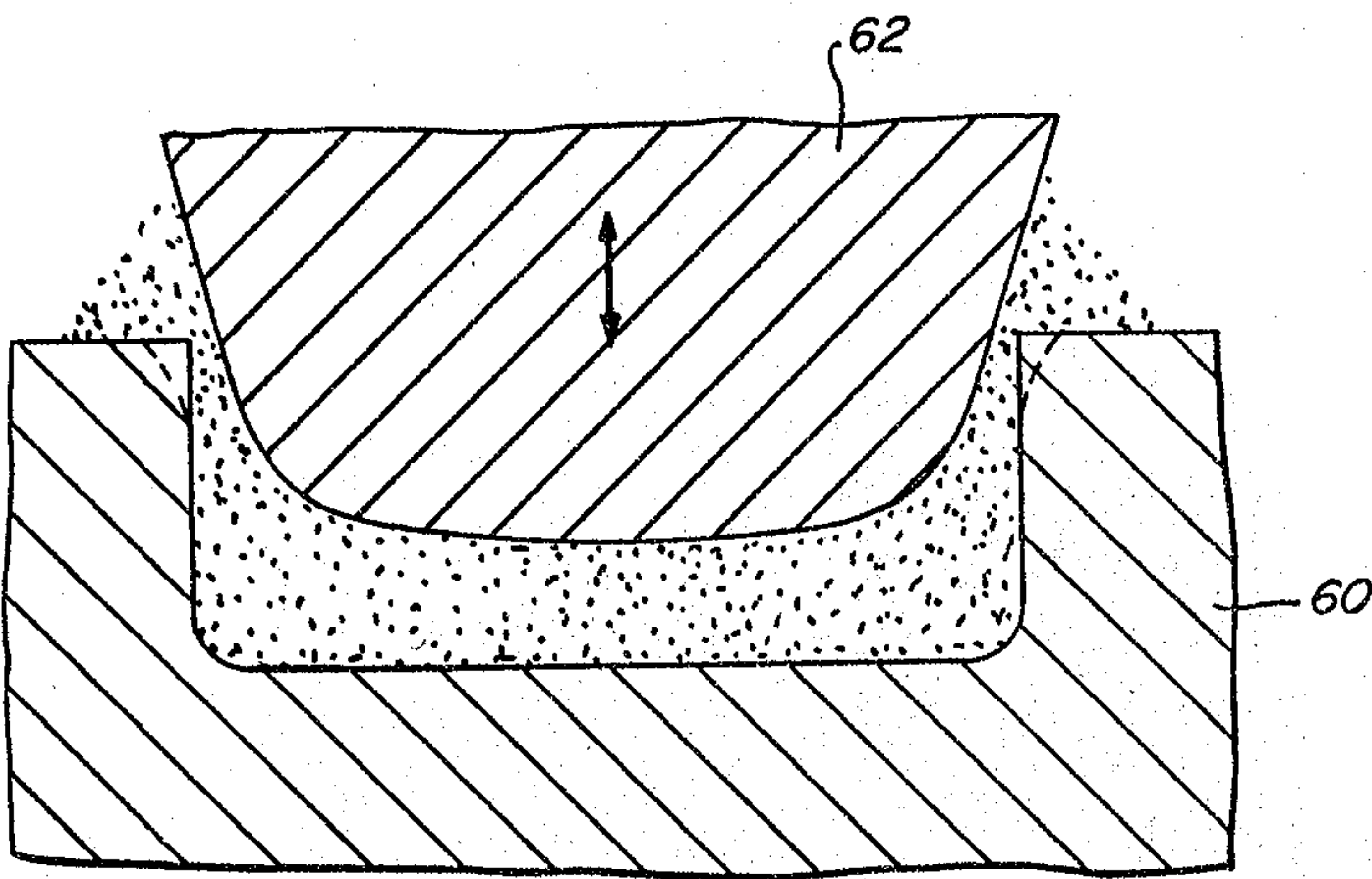


FIG. 9



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