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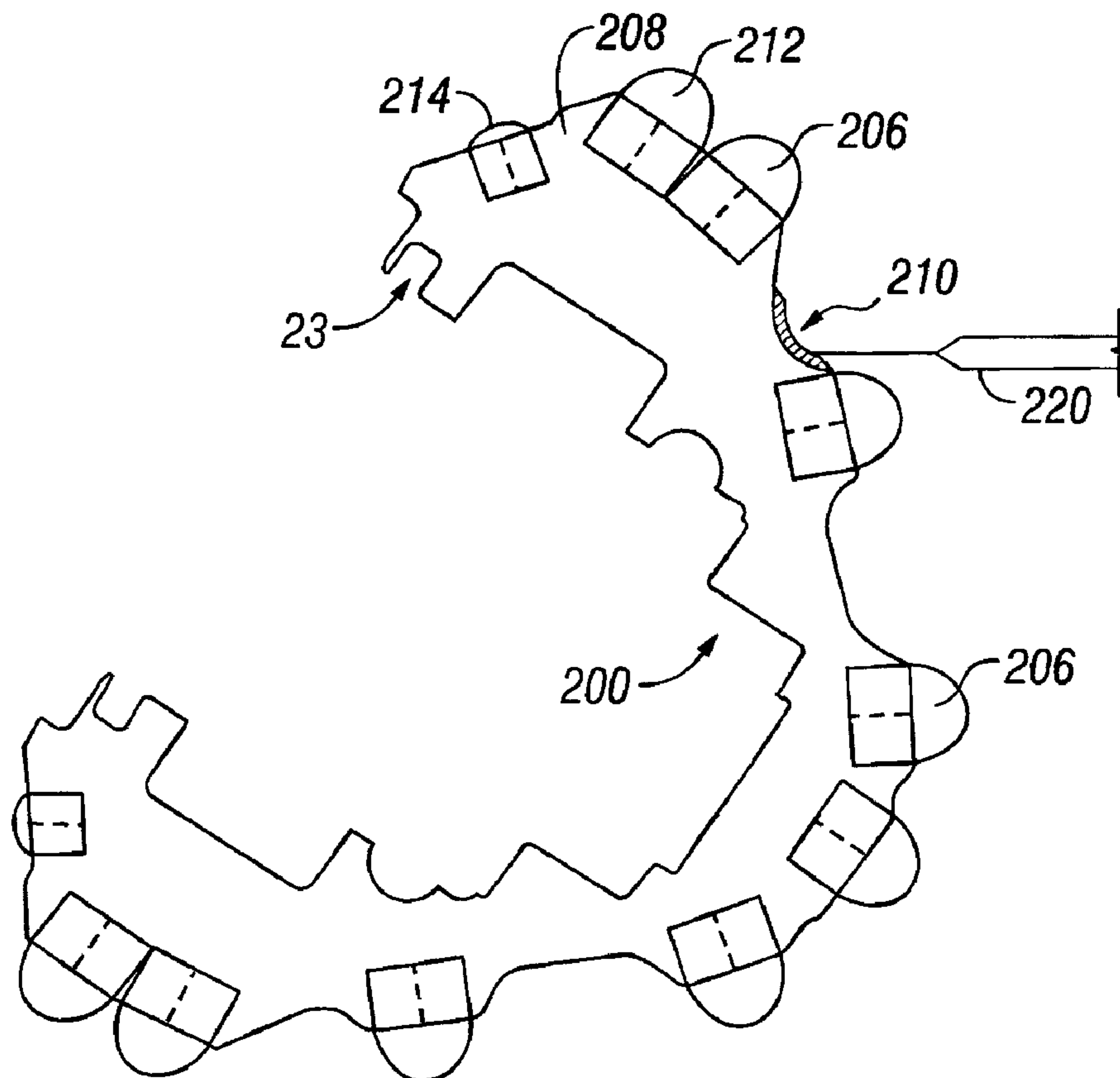
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(54) Titre : DISPOSITIF ET METHODE DE PLACAGE SELECTIF APPLIQUE PAR LASER

(54) Title: APPARATUS AND METHOD FOR SELECTIVE LASER-APPLIED CLADDING



(57) Abrégé/Abstract:

A method for applying a wear-resistant material to a rock bit is disclosed that includes depositing a coating on a selected area of the rock bit, applying a heated wear-resistant material using a laser assisted cladding apparatus to a selected portion of the rock bit, wherein the coating is selected to have material properties to prevent significant bonding between the heated wear-resistant material and the coated area of the rock bit.

Abstract

A method for applying a wear-resistant material to a rock bit is disclosed that includes depositing a coating on a selected area of the rock bit, applying a heated wear-resistant material using a laser assisted cladding apparatus to a selected portion of the rock bit, wherein the coating is selected to have material properties to prevent significant bonding between the heated wear-resistant material and the coated area of the rock bit.

Apparatus and Method for Selective Laser-Applied Cladding

Background of Invention

Field of the Invention

[0001] The invention relates generally to methods and apparatus for depositing a material on a substrate. More specifically, the invention relates to methods and apparatus for depositing a wear resistant layer on a substrate.

Background Art

[0002] Drilling in the earth is commonly accomplished by using a drill bit having a plurality of rock bit roller cones (“cutter cones”) that are set at angles relative to the drill string axis. The bit essentially crushes the formations through which it drills. The roller cones rotate on their axes and are, in turn, rotated about the main axis of the drill string. In drilling boreholes for oil and gas wells, blast holes, and raise holes, rock bit roller cones constantly operate in a highly abrasive environment. This abrasive condition exists during drilling operations even with the use of a medium for cooling, circulating, and flushing the borehole. Such a cooling medium may be either drilling mud, air, or another liquid or gas.

[0003] When drilling a hard formation, a bit with tungsten carbide inserts projecting from the body of a rolling cone generally is utilized due to the inserts' relative hardness. However, the carbide inserts are mounted in a relatively soft

metal (e.g. steel) that forms the body of the rolling cone. This relatively soft body may be abraded or eroded away when subjected to the high abrasive drilling environment. This abrasion or erosion occurs primarily due to the presence of relatively fine cuttings and chips from the formation that are in the borehole.

[0004] Additional causes include the direct blasting effect of the drilling fluid used in the drilling process, and the rolling or sliding contact of the cone body with the formation. When the material supporting the inserts is substantially eroded or abraded away, the drilling forces either may break the inserts or may force them out of the rolling cone body. As a result, the bit is no longer effective in cutting the formation. Moreover, the inserts that break off from the rolling cone may further damage other inserts, the rolling cones, or other parts of the bit, eventually leading to a catastrophic failure.

[0005] Erosion of the rolling cone body usually is most pronounced on the inner and outer edges of the lands of the cone surface. This area is immediately adjacent to the insert and the groove between two rows of inserts. The heaviest wear on the rolling cone surface lands is usually on the inner edges of the outer rows and on the outer edges of the inner rows. When drilling relatively soft but abrasive formations, the bit is able to penetrate at an extremely high rate. This can result in individual cutting inserts penetrating entirely into the abrasive formation, causing the formation to come into contact with the cone shell body.

[0006] When such abrasive contact occurs, the relatively soft cone shell material will wear away at the edges of the surface lands until the interior portion of the insert becomes exposed. The retention ability of the cone body is reduced, thereby ultimately resulting in the potential loss of the inserts and reduction of bit life. Because the penetration rate is related to the condition of the bit, the drill bit life and efficiency are of paramount importance in the drilling of boreholes.

Accordingly, various methods of hardfacing rock bit cones for erosion or abrasion protection have been attempted.

[0007] For example, thermal spraying has been used to coat the entire exposed surfaces, including the inserts, of a rolling cone with a hardfacing material. Another method involves placing small, flat-top compacts of hard material in the vulnerable cutter shell areas to prevent cone erosion. Since erosion of groove surface can be the main cause of insert loss, methods have been developed to apply hardfacing material to both the lands and the grooves of a roller cone.

[0008] It should be noted that inserts are typically retained in a roller cone by the interfacial tension generated when the insert is press-fitted into a drilled hole in the rolling cone body. Accordingly, any method used to alleviate the erosion of the rolling cone must take into consideration that the interfacial tension holding the insert must be retained.

[0009] FIG. 1 illustrates a typical prior art rock bit for drilling boreholes. The rock bit 10 has a steel body 20 with threads 14 formed at an upper end and three legs 22 at a lower end. Each of the three rolling cones 16 are rotatably mounted on a leg 22 at the lower end of the body 20. A plurality of cemented tungsten carbide inserts 18 are press-fitted or interference fitted into insert sockets formed in the cones 16.

[0010] When in use, the rock bit is threaded onto the lower end of a drill string (not shown) and lowered into a well or borehole. The drill string is rotated by a rig rotary table with the carbide inserts in the cones engaging the bottom and side of the borehole 25 as shown in FIG. 2. As the bit rotates, the cones 16 rotate on the bearing journals 19 and essentially roll around the bottom of the borehole 25. The weight on the bit is applied to the rock formation by the inserts 18 and the rock is crushed and chipped by the inserts. A drilling fluid is pumped through the drill string to the bit and is ejected through nozzles 26 (shown in FIG. 1). The drilling

fluid then travels up the annulus formed between the exterior of the drill pipe and the borehole 25 wall, carrying with it most of the cuttings and chips. In addition, the drilling fluid serves to cool and clean the cutting end of the bit as it works in the borehole 25.

[0011] FIG. 2 shows the lower portion of the leg 22 which supports a journal bearing 19. A plurality of cone retention balls ("locking balls") 21 and roller bearings 12a and 12b surround the journal 19. An O-ring 28, located within an O-ring groove 23, seals the bearing assembly.

[0012] The cone includes multiple rows of inserts, and has a heel portion 17 located between the gage row inserts 15 and the O-ring groove 23. A plurality of protruding heel row inserts 30 are about equally spaced around the heel 17. The heel row inserts 30 and the gage row inserts 15 act together to cut the gage diameter of the borehole 25. The inner row inserts 18 generally are arranged in concentric rows and they serve to crush and chip the earthen formation.

[0013] As used herein, the term "erosion" will refer to both erosion and other abrasive wear. Much of the erosion of the cone body typically occurs between the gage row inserts 15 and heel row inserts 30. Furthermore, erosion also may occur at the lands 27 between the gage row inserts 15 and inner row inserts 18. Generally, a "land" refers to a surface on a rolling cone where insert holes are drilled on the cone. It is also possible that erosion may occur in the grooves 24 between successive inner row inserts 18. These areas on a rolling cone surface are collectively referred to as "areas susceptible to erosion." Erosion in these areas may result in damage to the cone and/or loss of the inserts. In highly erosive environments, the whole cone body may be subjected to severe erosion and corrosion.

[0014] As noted above, a number of methods have been proposed for applying a hardfacing layer to the surfaces of the cones. In particular, laser cladding is a

material deposition technique where the energy of a laser is used to deposit a well-bonded hardfacing layer onto a substrate. For wear resistant applications, this layer tends to be formed of composite materials containing one or more hard phases dispersed in a relatively softer matrix. Many such hardfacing materials are known in the art, for example, U.S. Patent No. 6,196,338, assigned to the assignee of the present invention.

[0015] Typical prior art techniques involving laser cladding involve depositing a cladding material using a first, non-laser technique, and then laser fusing the cladding material to the substrate. U.S. Patent No. 4,781,770 discloses one typical prior art technique. That patent discloses, with reference to Figure 3, that a plurality of insert retention holes 146 are drilled in the exterior shell 128. Typically, the insert holes are drilled to be approximately 0.003 inch smaller in diameter than the hard cutter inserts 142, which are to be press fitted into the holes 146.

[0016] A force of approximately several thousand pounds may be required to press the cutter inserts 142 into place in the insert holes 146. In the '770 patent, the finished cone 120 is sprayed with cladding material 154 in the form of powder through a nozzle 160 (referencing Figure 4). The powder may be a mixture of carbides in a matrix, which may be blended with an organic mixture, such as cellulose acetate, to facilitate adhesion to the cone surface 128 during spraying. Alternatively, a high velocity plasma spray may be used to spray the powder 154, as shown in Figure 3. The powder spray unit is not shown. The powder is then densified and fused with a laser source 150 (see Figure 3). Further, the '770 patent discloses that the entire exterior shell 128 of the intermediate steel body 144 is treated with the laser beam 152 in a raster pattern by using a mechanical scanner.

[0017] However, laser cladding the entire cone surface is problematic in that if cracks develop in the cladding, they will invariably lead to cracks in the inserts, leading to early bit failure. What is needed, therefore, are apparatus and methods for depositing a hardfacing layer on a cone, without damaging either the surface of the cone, or the inserts affixed thereto.

Summary of Invention

[0018] In one aspect, the present invention relates to a method for applying a wear-resistant material to a rock bit that includes depositing a coating on a selected area of the rock bit, and applying a heated wear-resistant material using a laser assisted cladding apparatus to a selected portion of the rock bit, wherein the coating is selected to have material properties to prevent significant bonding between the heated wear-resistant material and the coated area of the rock bit.

[0019] In one aspect, the present invention relates to a coated insert for use in cladding applications that includes a substrate, and a coating deposited on at least one portion of said substrate in an amount sufficient to reduce bonding of a wear resistant material to said substrate, wherein the coating is a carbide, a boride, or a nitride of a metal selected from group IVA, VA, VIA transition metal.

[0020] In one aspect, the present invention relates to a method of fabricating a drill bit that includes forming a body of the drill bit, forming a plurality of holes in portions of the body to receive coated inserts, inserting a plurality of coated inserts into said plurality of holes, and cladding at least one selected area of said body with a wear resistant material, wherein the cladding comprises using a laser-assisted cladding apparatus to deposit the wear resistant material in a single step.

[0021] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

Brief Description of Drawings

- [0022] Figure 1 shows a prior art drill bit;
- [0023] Figure 2 shows a cross-section of a single leg and cone of the prior art drill bit of Figure 1;
- [0024] Figure 3 illustrates a prior art laser cladding technique;
- [0025] Figure 4 illustrates a prior art laser cladding technique;
- [0026] Figure 5a illustrates a cone in accordance with one embodiment of the present invention;
- [0027] Figure 5b illustrates one embodiment of a laser assisted cladding apparatus in accordance with the present invention;
- [0028] Figure 6 illustrates a coated insert in accordance with an embodiment of the present invention;
- [0029] Figure 7 illustrates an automated system including a computer, in accordance with an embodiment of the present invention;
- [0030] Figures 8a and 8b illustrate an apparatus for laser cladding in accordance with an embodiment of the present invention.

Detailed Description

- [0031] The present invention relates to apparatus and methods for laser-applied cladding. In particular, embodiments of the present invention provide methods and apparatus for applying cladding to selected cone surfaces and/or leg surfaces in rotary mining bits. As used herein, the term "cladding" refers to the wear resistant material that may be applied to a substrate, or to the act of depositing the material. "Cladding process" is an alternative term given to the process of depositing cladding to form a "cladding layer" on the surface of the substrate.

“Coating” is used to refer to a protective coating which may be applied to selected surfaces of the substrate, to prevent significant bonding between the cladding and the substrate, it is also used to refer to the process of applying a coating. As used herein, the term insert is not intended to be limited to an insert for a roller cone bit but is generally used to refer to any cutting element to be inserted into a cutting tool, such as a cutter inserted into a fixed cutter bit. Further, embodiments of the present invention relate to inserts for use in rock bit applications. As used herein, the term **“rock bit”** expressly includes roller cone bits, fixed cutter bits, or any other type of bit for cutting through earth formations.

[0032] Thus, instead of applying cladding only to the desired portions of the drill bit, as is typical in the prior art, cladding may be applied to the entire bit with a special coating on those sections where it is not desired to have cladding. The coating prevents the cladding from bonding to the substrate, leaving cladding on the desired portion only.

[0033] By **“selected”** the inventors mean the selective placement of cladding or selectively bonding the cladding to a substrate. Selective placement means that the cladding is applied to selected areas, while selective bonding involves pre-coating the substrate with a material that prevents the cladding from bonding to selected areas. Thus, some embodiments of the present invention provide techniques for providing cladding with a significant difference in bond strength of the cladding in an uncoated region and a coated region.

[0034] In accordance with embodiments of the invention, a coating is used that significantly decreases the bond strength of the cladding to the coated region as compared to an uncoated region. Afterwards, cladding may be deposited over an entire surface. The cladding will not significantly bond to the coated regions, and can easily be removed or allowed to fall off.

[0035] It should be noted that, while the description provided below references “insert bits,” it is expressly within the scope of the present invention that the methods and apparatus described herein may be used more generally to deposit cladding on a substrate. In general, techniques and apparatus disclosed by the present invention may be used wherever the selected application of a wear resistant compound to a substrate is desired.

[0036] One of the primary considerations when applying cladding to a drill bit or a roller cone is to avoid damaging the inserts. As noted above, prior art laser cladding techniques first apply the cladding material using some other technique and later fuse the cladding material onto the roller cone using laser beams. With this approach, a significant amount of energy is imparted to the bit. This often leads to cracks in the cladding. If cracks develop, the inserts may also crack, leading to premature failure of the bits. In order to avoid inadvertently cracking the inserts, prior art techniques generally do not apply cladding to the areas immediately adjacent to the insert. However, this approach is problematic because relatively large areas of the cone surface are left unprotected.

[0037] Embodiments of the present invention, however, allow cladding to be deposited over the entire surface of the cone in a one step process. The cladding does not bond to the coated regions of the cone (which, in one embodiment, comprises the inserts), but rather only substantially bonds to the uncoated regions.

[0038] Figure 5a illustrates an embodiment of the invention in accordance with one aspect of the invention. In Figure 5a, cone (200) includes multiple rows of inserts (206), and has a heel portion (208) located between gage row inserts (212) and an O-ring groove (23). A plurality of protruding heel row inserts (214) are spaced around the heel portion (208). As shown in Figure 5a, a laser-assisted cladding apparatus (220) is shown depositing wear resistant layer (210) on a

surface of cone (200). In particular, the laser-assisted cladding apparatus (220) is shown depositing the wear resistant layer (210) between two rows of teeth (206).

[0039] The laser-assisted cladding apparatus (220) is now discussed in more detail with reference to Figure 5b. In general, the laser-assisted cladding apparatus (220) comprises a cladding feed line and a laser (230). In one embodiment, the cladding feed line comprises a wear resistant powder (such as tungsten carbide) feed line (240). Also, in a particular embodiment, a portion of the powder feed line (240) and the laser (230) are arranged so as to be "in line." That is, the powder feed line (240) and laser (230) are disposed parallel to one another so that the laser energy heats the powder (and in some cases, melts a portion of the powder) as it is transmitted through the powder feed line into the laser path.

[0040] Although one embodiment uses a single laser source for pre-heating the wear resistant material and for laser cladding, one of ordinary skill in the art would appreciate that separate laser sources may be used for pre-heating and cladding.

[0041] Some of the laser beam energy also heats the substrate (namely a surface of the cone and/or leg). The heated or partially melted wear resistant powder is directed (referred to as the "entrained powder") towards the surface of the slightly heated substrate. As a result, the heated or partially melted wear resistant powder is deposited on the surface of the cone. The present inventors have discovered that a novel coating may be applied to selected surfaces of a cone to prevent bonding of the cladding (wear resistant powder). In a particular embodiment, the coating is applied to at least one insert to reduce damage to the insert during the cladding process and to prevent bonding of cladding to the insert.

[0042] A typical wear resistant powder comprises a tungsten carbide-cobalt powder. In one embodiment, the wear resistant powder may comprise a cobalt content of about 7 to 20 weight percent, a carbon content of about 0.5 to about 6 weight percent, and a tungsten content from about 74 to 92.5 weight percent.

However, depending on the particular application, the relative weight percents of the various chemical components may be varied. In addition, it should be understood that any wear resistant material capable of being applied by a laser cladding process is within the scope of the present invention.

[0043] As shown in Figure 6, a coating 604 in accordance with embodiments of the present invention, may be applied over the top and side surfaces of the insert 602, over the entire insert 602, or over selected portions of the insert. Those having ordinary skill in the art will recognize that a number of coatings may be suitable, so long as they provide an improved resistance to bonding between the cladding and the substrate.

[0044] In some embodiments, the coating is a boride, nitride, or carbide of a group IVA, VA, or VI transition metal (Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W), or mixtures thereof. In a particular embodiment, the coating is TiN. The coating 604 has been discovered to prevent the bonding of an applied wear resistant layer to the insert 602.

[0045] By using the coating 604, it has been discovered that cladding inadvertently applied to the insert may simply be brushed off. Thus, cladding can be applied to the entire surface of the cone, without attempting to avoid the inserts. Accordingly, a significant time reduction in applying a cladding layer to the cone surface may be realized. This is due to the fact that by using coated inserts, wear resistant material may be deposited without regard to whether the material is being deposited over an insert or over the cone. As previously noted, without such a coating, laser cladding of cone surfaces often causes the inserts to prematurely fail.

[0046] It should be noted that while reference is made to a cone surface and inserts disposed in the cone, the coatings of the present invention have a broader application. In particular, it is expressly within the scope of the present invention

that coatings in accordance with the present invention may be used generally to prevent the deposition of cladding to selected portions of a substrate.

[0047] Some embodiments of the invention relate to systems for performing the cladding process described above. A system in accordance with the invention typically includes a processor and a memory operatively coupled to the laser-cladding apparatus. In some embodiments, a system may be implemented on a general-purpose computer having a processor, a memory, and may optionally include other hardware. For example, as shown in FIG. 7, a typical computer (750) includes a processor (752), a random access memory (754), and a storage device (e.g., permanent memory or hard disk) (756). The computer (750) may also include input means, such as a keyboard (758) and a mouse (760), and output means, such as a monitor (762). Note that the general purpose computer is only for illustration and embodiments of the invention may take other forms.

[0048] In a system in accordance with the invention, the memory stores a program readable by the processor. The program may comprise a computer-aided design (CAD) rendering of a drill bit on which a cladding layer is to be deposited. The CAD rendering may include geometric information such as the location of the teeth, journal angle, and other such information as required. This information may then be transmitted to the laser-assisted cladding apparatus (shown as 220 in Figure 5a), so that the wear resistant layer may be deposited in the areas surrounding the inserts (206, 212, and/or 214) shown in Figure 5a, without contacting the inserts. In this fashion, the process can be automated, wherein a user can select a stored drill bit configuration, and allow the laser-assisted cladding apparatus (220) to deposit the cladding layer without further operator intervention.

[0049] Figures 8a and 8b illustrate an apparatus for applying cladding as described above. In Figure 8a, a cone (800) is shown mounted on a fixture (802). A portion

of the fixture (802) may be rotated or translated to expose various surfaces of the cone to a laser (806). The laser (806) may similarly be rotated or translated to apply wear resistant material, which arrives to the laser head through powder inlet (810). Additionally, a moveable air flow outlet (804) may be provided to cool the cone (800) during the cladding process.

[0050] Further, Figure 8a shows coated inserts (812), which have been previously inserted into the cone, prior to cladding. Figure 8b shows the apparatus of Figure 8a during the actual cladding process. As can be seen in Figure 8b, the air flow outlet (804) may be moved to provide a cooling stream of air over the cone (800) surface. This apparatus allows a relatively large amount of wear resistant material to be deposited in a short amount of time.

[0051] As noted above, this apparatus and the techniques associated with the apparatus provide two different types of selectivity. These are referred to herein as positional selectivity and bonding selectivity. By positional selectivity, the present inventors mean that cladding may be deposited (in a one step process) in a selected region on a cone, for example, without contacting inserts (or plugs) on that cone.

[0052] By bonding selectivity, the present inventors mean that the inserts (or selected portions of a substrate) may be treated with a coating that creates a difference in the bonding strength between the inserts and the cone with respect to the cladding.

[0053] Advantageously, therefore, one or more embodiments of the present invention are capable of producing highly erosion-resistant hardfacing coatings on rock bit cone surfaces to prevent cone shell erosion during operation. In addition, one or more embodiments of the present invention provide a cost effective way to reduce insert cracking often associated with the cladding process.

[0054] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

CLAIMS:

1. A method for applying a wear-resistant material to a rock bit, comprising:
depositing a coating on a selected area of the rock bit; and
following the depositing, applying a heated wear-resistant material to the rock bit, by coaxially feeding the wear-resistant material with a laser path, wherein the coating is selected to have material properties to prevent significant bonding between the heated wear-resistant material and the coated selected area of the rock bit.
2. The method of claim 1, wherein the selected areas of the rock bit comprises at least one insert.
3. The method of claim 1, wherein the coating comprises at least one selected from the group consisting of a metal carbide, a metal boride, and a metal nitride, wherein the metal of each of the metal carbide, metal boride, and metal nitride comprises a metal selected from group IVB, VB, and VIB transition metals.
4. The method of claim 1, further comprising removing the heated wear-resistant material from the selected area of the rock bit.
5. The method of claim 1, wherein the applying the heated wear resistant material comprises cladding with a laser assisted cladding apparatus.
6. The method of claim 5, wherein the laser-assisted cladding apparatus comprises a feed line and a laser.
7. The method of claim 6, wherein the feed line comprises the wear-resistant material.
8. The method of claim 7, further comprising disposing the feed line in parallel with the laser.
9. The method of claim 1, further comprising cooling the rock bit.

10. The method of claim 2, further comprising removing the wear-resistant material from the coated inserts.
11. The method of claim 1, wherein the wear-resistant material is deposited in a single step.
12. The method of claim 2, wherein the insert comprises a substrate and the selected area of the rock bit comprises at least a portion of the substrate.
13. A method for selectively applying cladding to a rock bit, the rock bit comprising a plurality of inserts disposed on a roller cone, and the method comprising:
 - selecting a region on said cone for cladding; and
 - depositing, in a one step process, a cladding material, wherein the one step process provides coaxially feeding the cladding material with a laser path on the selected region of a cone, without contacting inserts on that cone with the cladding material.
14. The method of claim 13, wherein the depositing, in the one step process comprises cladding with a laser assisted cladding apparatus.

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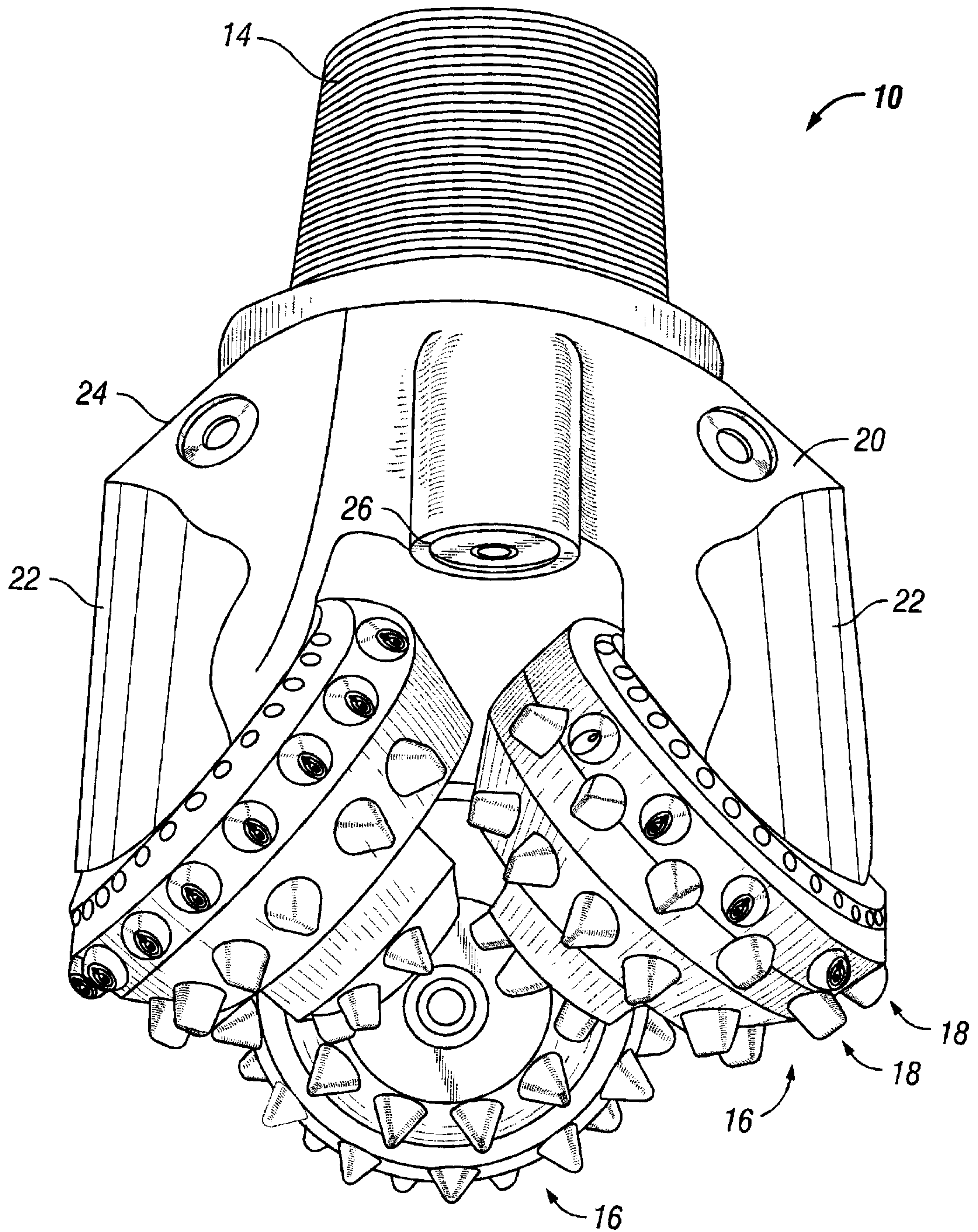


FIG. 1
(Prior Art)

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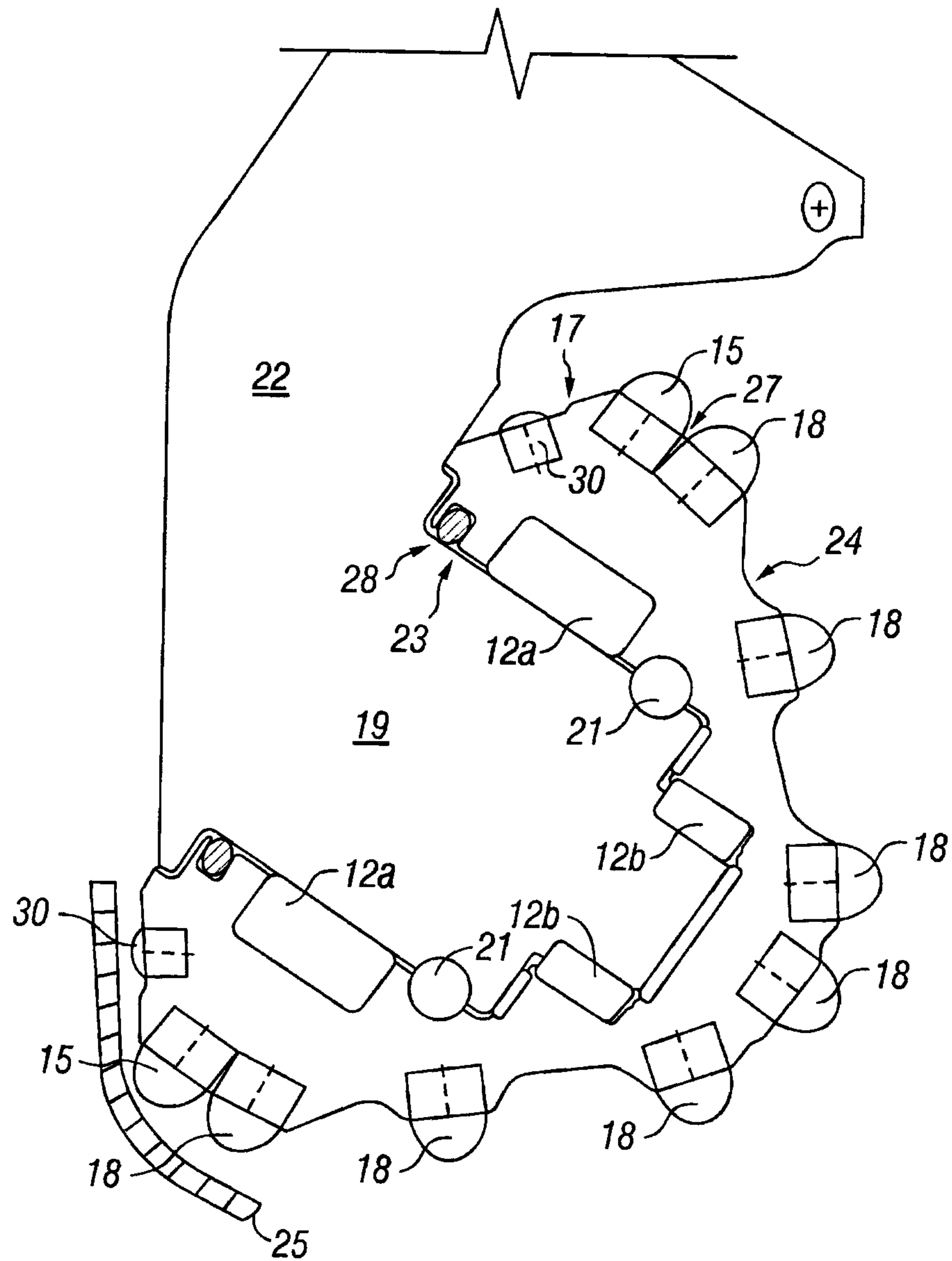


FIG. 2
(Prior Art)

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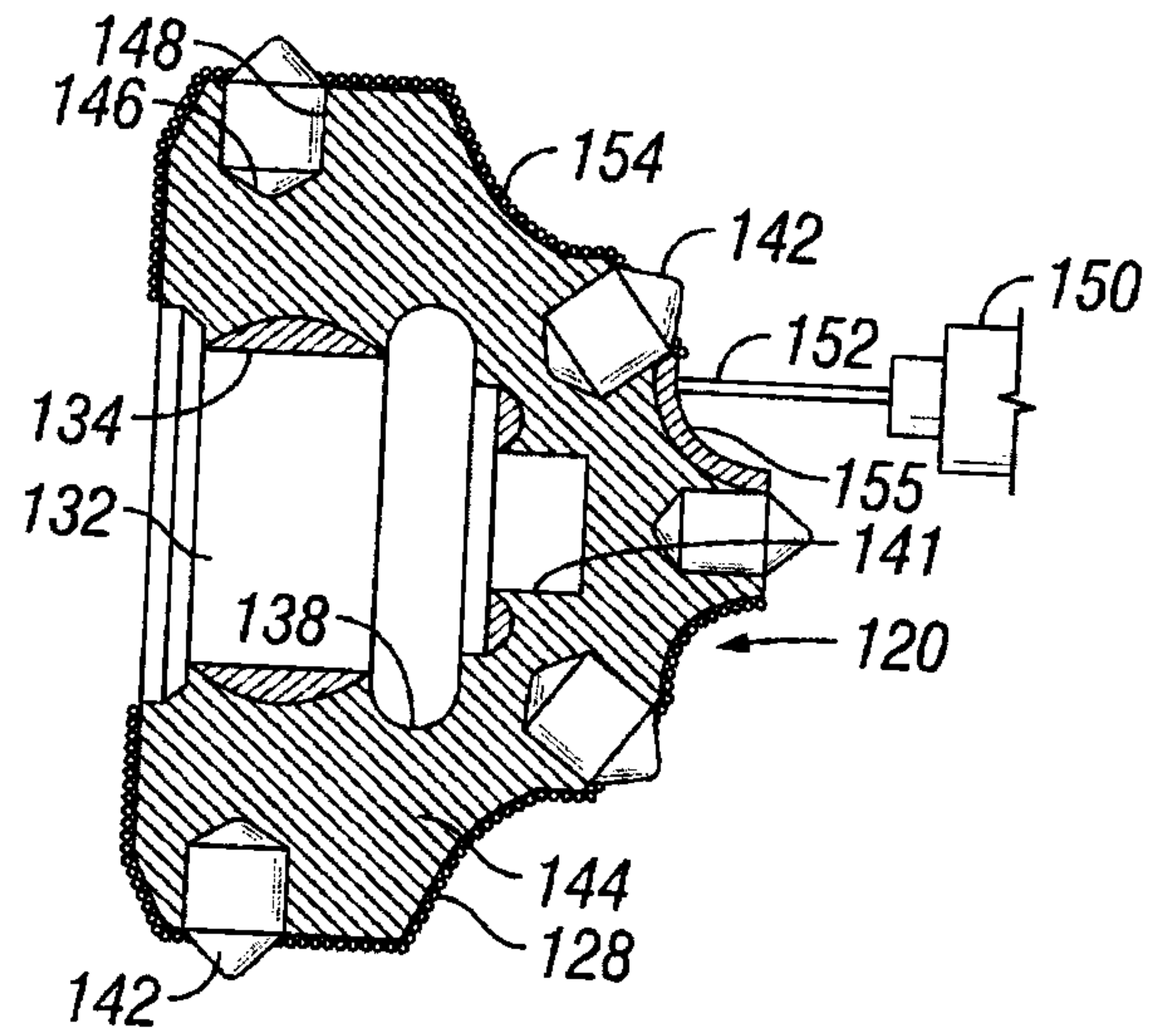


FIG. 3

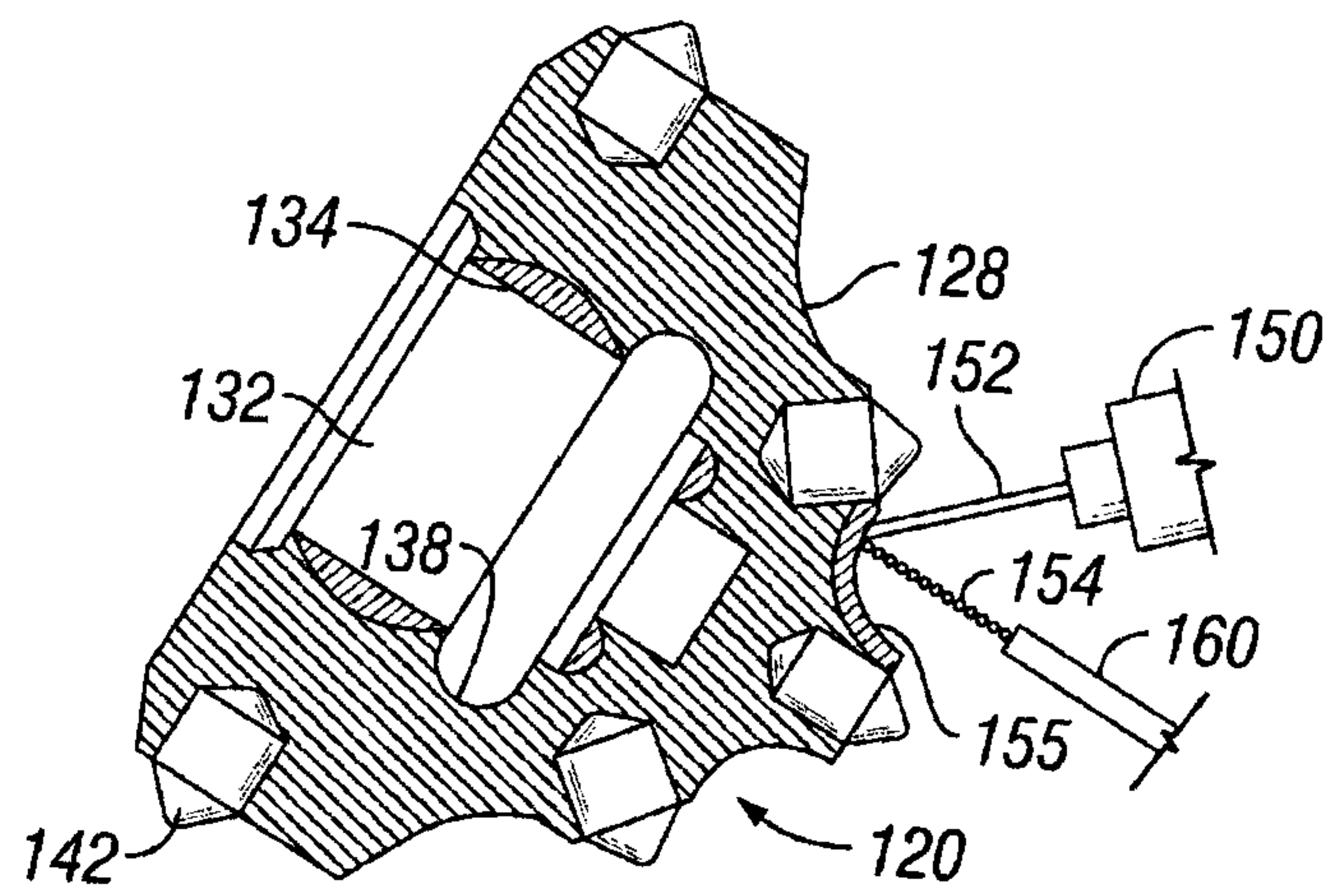


FIG. 4

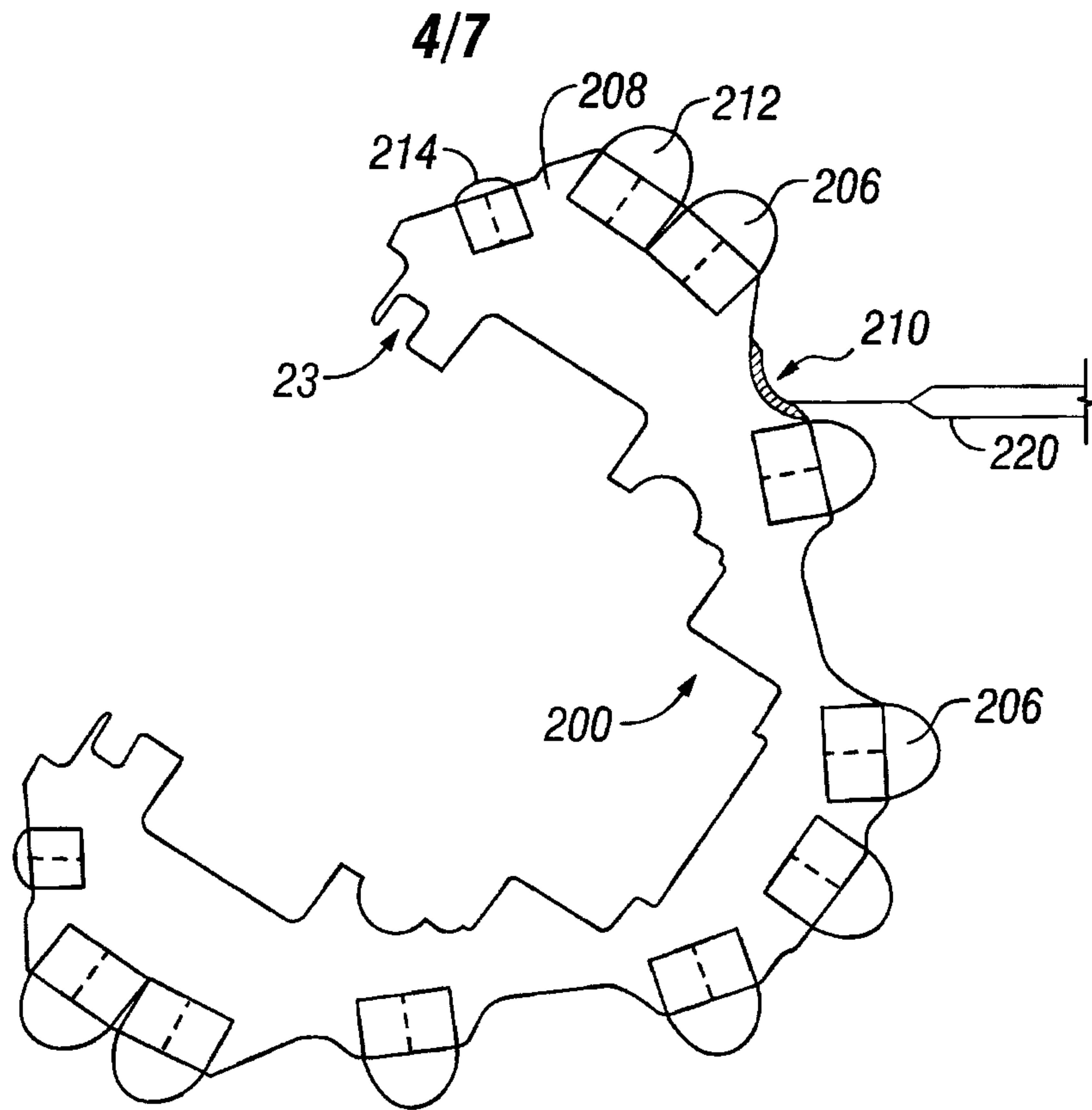


FIG. 5A

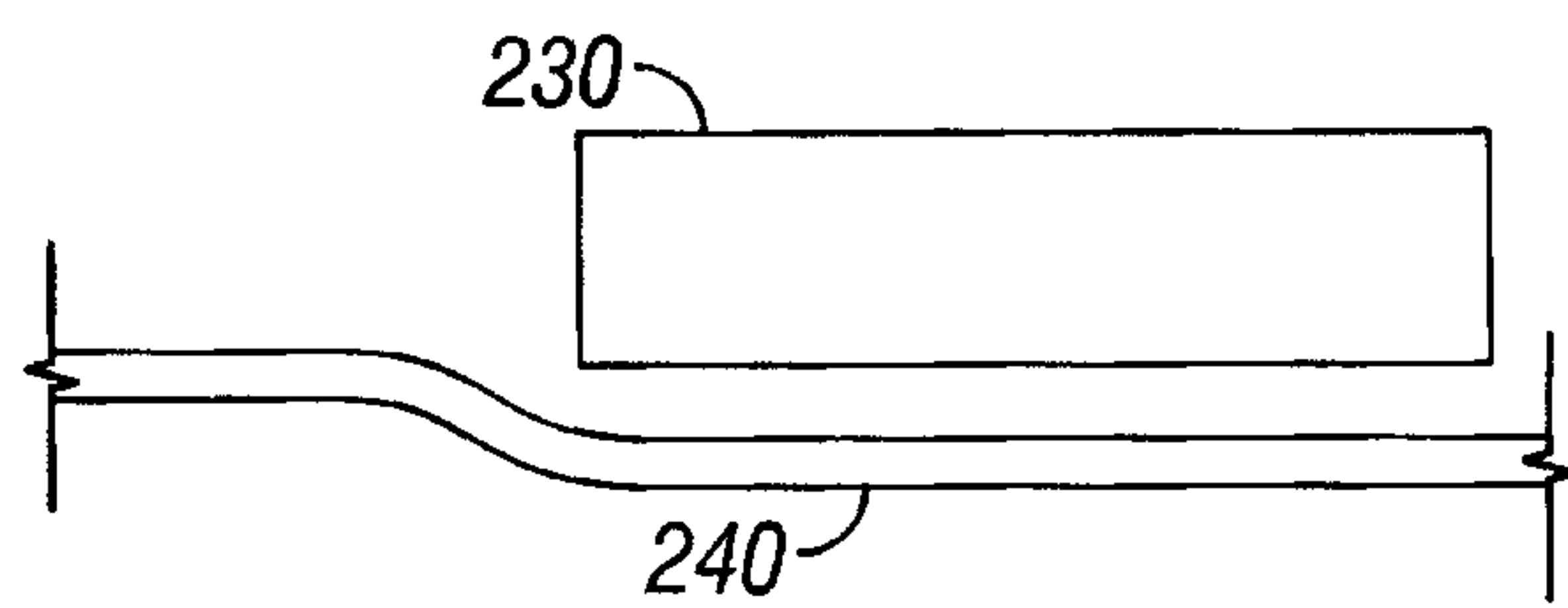


FIG. 5B

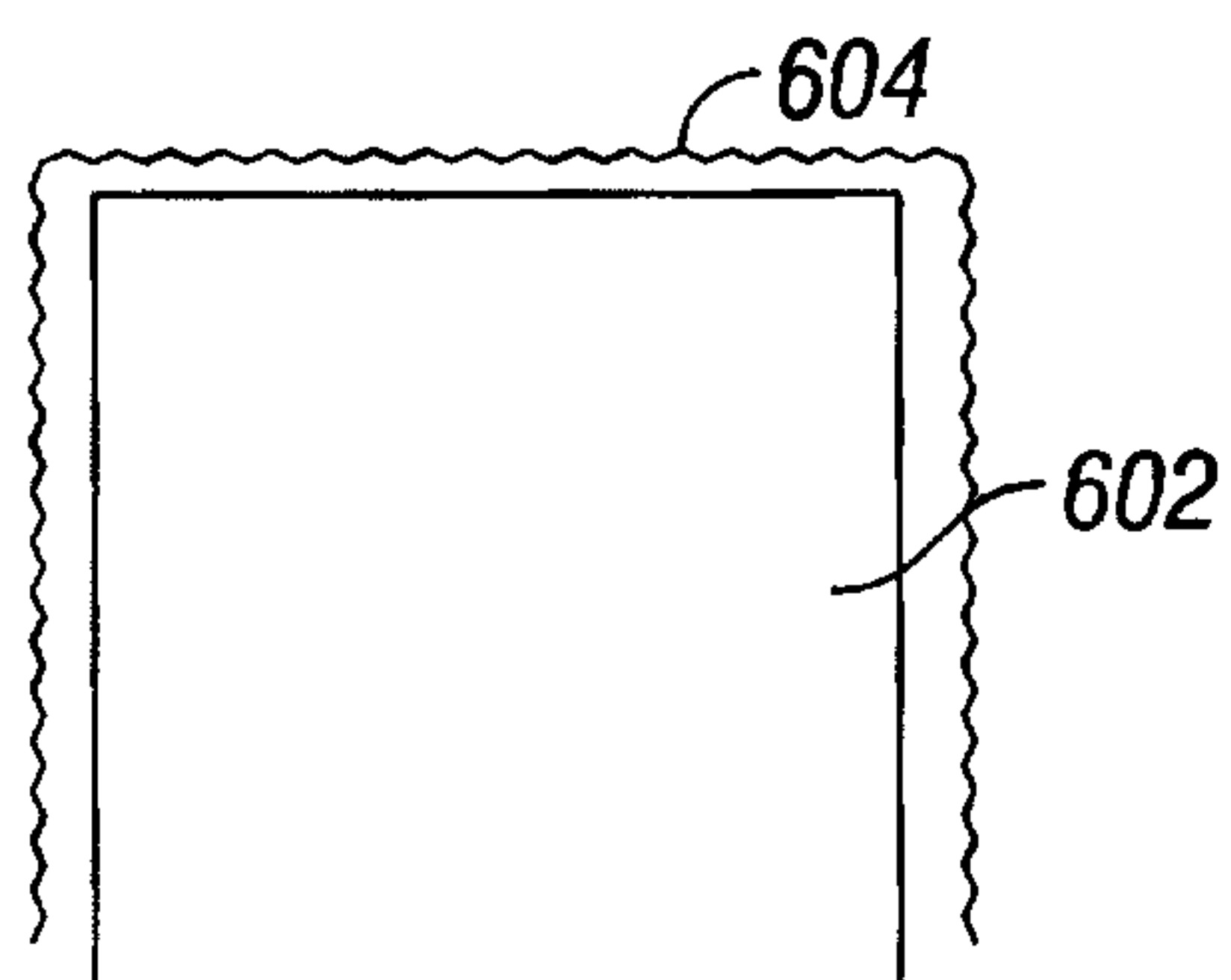


FIG. 6

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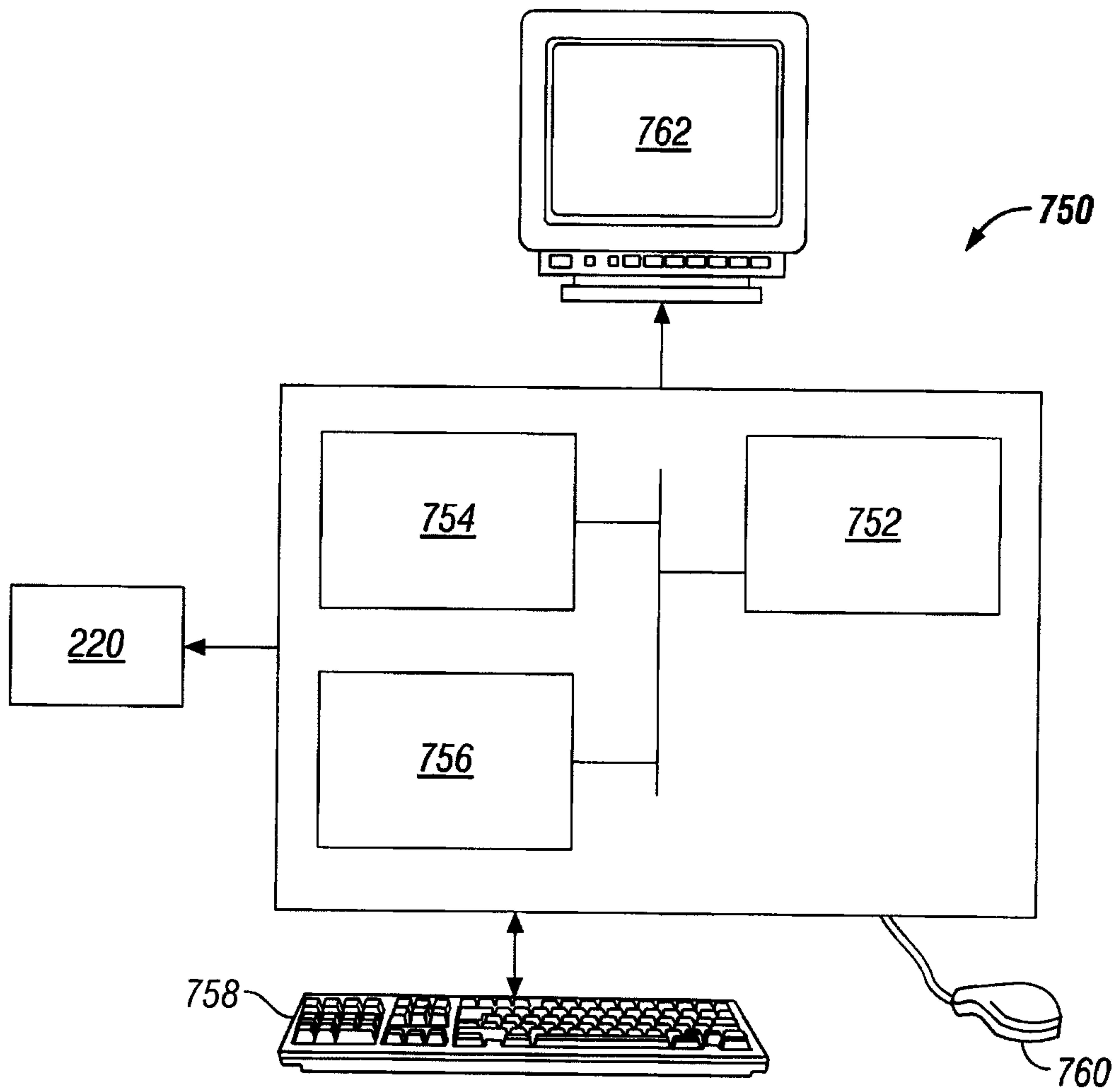


FIG. 7

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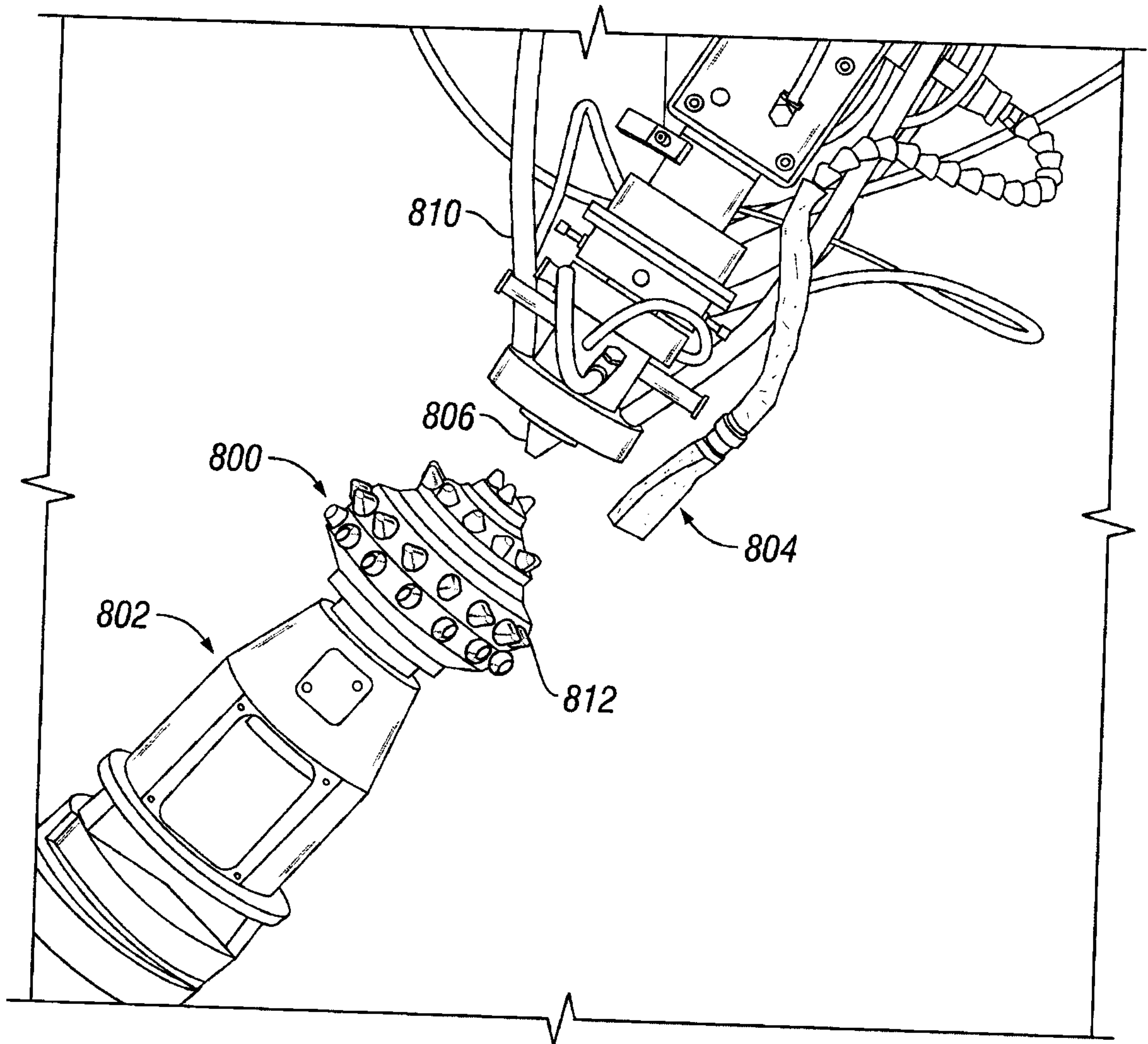


FIG. 8A

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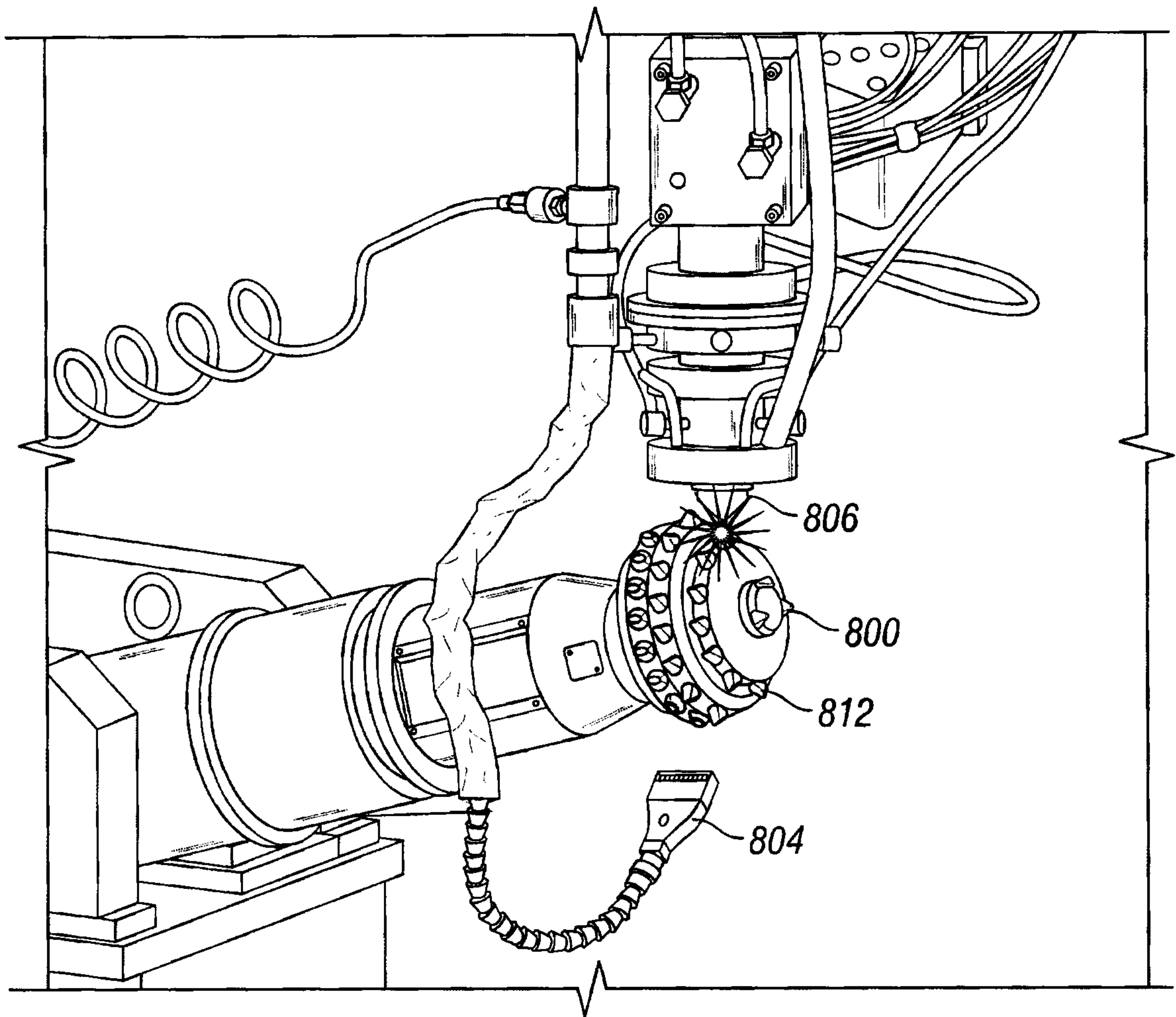


FIG. 8B

