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Description

CROSS-REFERENCE CLAIMS OF PRIORITY

[0001] This claims priority benefits of United States of America provisional patent application Nos. 60/452,704 filed March 7, 2003 A.D., and 60/463,922 filed April 18, 2003 A.D.

FIELD AND PURVIEW OF THE INVENTION

[0002] This invention concerns a method of manufacture of a ceramic body. In a particular field, the ceramic body embraces a bodily implant, especially a load-bearing joint implant. For example, the implant may be a femoral knee component in its primary or revisional form, which can be a ceramic posterior stabilized femoral component for a knee implant, and, in another exemplary embodiment, can be an artificial knee implant component made to include ceramic having a rotation device for restraining a femoral component in relation to a corresponding tibial component that can have natural load transfer. Additional ceramic manufactures can be provided.

BACKGROUND TO THE INVENTION

[0003] The quest for stronger, more versatile ceramic products is an ongoing, very important concern. Difficulties exist, for instance, in providing sufficiently strong, finished ceramic bodies that would conform to precise and intricate geometries. In light of this, many ceramic products, which would be highly desirable, remain unavailalble.

[0004] For example, although an alumina femoral knee component is known from Japan, it is made in a manner only to address the most basic of femoral implant designs, and problems with it include its great expense, as it may be made by machining a fired block. Attempts to provide ceramic advanced femoral knee components apparently have met with failure, and such more intricate ceramic implants that require great strength are lacking in the art. As an example of such an implant is a posterior stabilized femoral component for a knee implant. In fact, experts in the art are skeptical that such can be made. Note, too, Amino et al., U.S. patent No. 5,549,684.

[0005] It would be desirable to overcome such difficulties. It would be desirable, moreover, to provide an efficient and cost effective method to do the same.

[0006] EP-A-0 580 565 discloses a method of manufacturing a tooth crown wherein powder is compressed by a cold isostatic technique to form a green body which subsequently is sintered to full density.

[0007] In a particularly notable implant provision, Goodman et al., U.S. patent No. 5,766,257, discloses an artificial joint having natural load transfer. In a particular embodiment, the joint is a knee. Although it is disclosed that a ceramic substance may be employed, preferably the joint is of metal construction. For example, its femoral component frame is a cast of forged cobalt-chromium alloy, and its tibial component frame is a titanium alloy, with a Co-Cr alloy rotation device and bearings of ultra high molecular weight of polyethylene (UHMWPE). See also Zimmer, Inc., NexGen (Reg.U.S. Pat. &Tm.Off.) System Rotating Hinge Knee Design Rotionale, 2002.

[0008] Additional modularity may be provided in such a knee implant. See, Serafin, Jr., U.S. patent No. 6,629,999.

[0009] Employment of ceramic in bodily implants, to include a posterior stabilized femoral component and the knee implants of the '257 and '999 patents as well as other implants could be of benefit. For example, certain patients are allergic to slight amounts of Nickel found in Co-Cralloys, and ceramic may provide for a hard articulating surface.

[0010] However, for such complex knee implant components as noted above in particular, a more practical application of the basic concept of employing ceramics is needed.

GENERALIZED SUMMARY OF THE INVENTION

[0011] The invention is more particularly defined in the appended claims which are hereby incorporated into this description.

[0012] In general, the present invention provides, in one aspect, a method for making a ceramic body, which comprises providing an initial green body of ceramic; and machining the initial green body to provide a machined green ceramic body. The machined green ceramic body may be fired and/or further processed to provide a more finished ceramic body. Other aspects are the machined green ceramic and more finished ceramic bodies, which may be prepared by the noted method and/or made of certain, particular ceramics. For one illustration of the many possible, the ceramic body can be a femoral component for a posterior stabilized knee implant.

[0013] In another particular illustrative embodiment, in general, in one aspect the present invention provides a method for making a component body for an artificial rotation device containing knee prosthesis having a component frame, wherein the rotation device includes a swingable, depending male-type part; the knee prosthesis has a femoral component with condylar articular surfaces, plus the rotation device, and has a tibial component with meniscal articular surfaces

that mate with the condylar articular surfaces of the femoral component, plus a rotation device receptacle that includes a female-type part, so that the femoral component is matable to the tibial component through male-female cooperation of the rotation device and the rotation device receptacle, and the knee prosthesis generally has natural load transfer capability by anatomical gliding contact of the condylar and meniscal articular surfaces against one another during anatomical rotation in addition to anatomical flexion and extension, which method comprises providing an initial green body of ceramic; and machining the initial green body to provide a machined green ceramic component body for said knee prosthesis. As noted generally above, the machined green ceramic component body may be fired and/or further processed to provide a more finished ceramic component body for said knee prosthesis, and other aspects are the machined green component body, and the more finished ceramic component body prepared by the noted method and/or made of certain, particular ceramics.

[0014] The invention is useful for providing ceramic bodies.

[0015] Significantly, by the invention, the art of ceramics manufacture is advanced in kind by a unique and highly efficient method. In particular, strong, finished ceramic bodies which conform to precise and intricate geometries are now available. For example, a ceramic posterior stabilized femoral knee component with great strength, heretofore unknown to those skilled in the art, is provided. Provision is made for other ceramic bodily implants or implant components, both complex and simple, including other types of femoral knee implant components, single- and multi-piece unicompartmental joint aligning devices, ankle joint condyle-containing components, femoral head balls, humeral shoulder hemispheres, and so forth. Thus, a more practical application of the basic concept of employing ceramics in complex implants such as the knee as generally noted above is provided. In a particular aspect, strong, finished components in rotating device containing knees, which conform to precise, intricate geometries, are made available, and component bodies for an artificial rotation device containing knee prostheses made of zirconia ceramics are hereby advantageously provided, for femoral and/or tibial components. Also, other types of ceramic bodies are made available such as gears, flow-control fittings, and so forth. Zirconia ceramic bodies are advantageously provided.

[0016] Numerous further advantages attend the invention.

DEPICTION OF SEVERAL EMBODIMENTS OF THE INVENTION

[0017] The drawings form part of the specification hereof. With respect to the drawings, which are not necessarily drawn to scale, the following is briefly noted:

FIG. 1 shows a graph illustrating general phases of zirconia ceramics.
FIG. 2 shows a scheme of manufacture with the invention.
FIG. 3 shows top view of a finished ceramic body of the invention, embodied as a posterior stabilized femoral knee implant component.
FIG. 4 shows a medial to lateral side view of the component of FIG. 3.
FIG. 5 shows a front view of the component of FIG. 3.
FIG. 6 shows a rear view of the component of FIG. 3.
FIG. 7 is a sectional view of the component of FIG. 3, taken along 7S-7S of FIG. 3.
FIG. 8 is a rear, top perspective view of the component of FIG. 3.
FIGS. 9-15 show some other finished ceramic bodies hereof, embodied as follows:

FIG. 9. A modular ceramic knee implant with a metal intramedular femoral post and metal securing washer, with a metal screw fastener, also with a metal or ceramic peg for a posterior stabilizing stop, shown from one side in partial section.
FIGS. 10-11. A one-piece unicompartmental knee joint spacer as a plan view (FIG. 10) and side view (FIG. 11).
FIGS. 12-14. A two-piece unicompartmental knee joint aligning device, shown as a side sectional view (FIG. 12); a side sectional view (FIG. 13) taken perpendicularly to the view of FIG. 12, and a top view (FIG. 14) in a sliding engagement mode.
FIG. 15. A temporal mandibular joint implant cap.

FIGS. 16-19 show other finished ceramic bodies, embodied as industrial apparatus, components, or devices, as follows:

FIG. 16. An industrial bearing, shown in perspective.
FIG. 17. Flow control apparatus, shown in plan.
FIG. 18. A set of gears, shown in elevation.
FIG. 19. A set of pulleys, shown in elevation.

FIG. 20 shows a scheme of manufacture with the invention to make another ceramic body, here a finished base component for an artificial prosthetic knee joint implant, which will contain a rotation device. Compare, FIG. 2.
FIG. 21 is a front (anterior to posterior direction) of an artificial, prosthetic knee joint that may have at least a ceramic component body among its femoral and tibial components such as the base femoral component body shown in FIG. 20, which contains a rotation device.
FIG. 22 is an exploded view of the joint of FIG. 21.
FIG. 23 is a left side view (lateral to medial direction) of the femoral component to the joint of FIGS. 21 and 22.
FIG. 24 is a rear view (posterior to anterior direction) of the femoral component of FIG. 23.
FIG. 25 is a left side view of the rotation device member of the femoral component in FIGS. 22-24.
FIG. 26 is a side view of the rotation device femoral-tibial taper pin of the joint as seen in FIG. 22.
FIG. 27 is an exploded, perspective view of a femoral component of another artificial, prosthetic knee joint of the invention containing a rotation device and having a ceramic body.
FIG. 28 is an exploded, side view of the prosthetic knee joint having the femoral component of FIG. 27.
FIG. 29 is a front, perspective view of the joint of FIG. 28, assembled and having several augments to accommodate bone loss in place in its femoral component.
FIG. 30 shows perspective and side views illustrating various femoral augments, some of which can be seen within FIG. 29.
FIG. 31 is a side view of the tibial base plate found within the joint of FIG. 28.
FIG. 32 is a top, perspective view of the tibial base plate of FIG. 31.
FIG. 33 is a perspective view of some partial tibial augments that may be employed with the tibial base plate of FIG. 31.
FIG. 34 is a perspective view of a ceramic provisional femoral component having a modular rotation device employed for fitting the patient to a femoral component such as that of FIG. 27 with a properly sized rotation device.
FIG. 35 is a perspective view of a ceramic provisional femoral component having snap-in augments employed for fitting the patient to a femoral component such as that of FIG. 27 with augments as may be necessary to make up for a lack of bone. The augment provisional components snap into the femoral provisional component.
FIGS. 36-37 show side views of a ceramic femoral provisional cutting guide for implantation of a femoral component such as that of FIG. 27 with drilling, as follows:

FIG. 36. In a proximal direction into resected femur.
FIG. 37. In a posterior direction into resected femur.

FIG. 38 is a saggital sectional view of a modular ceramic human knee joint of the invention.
FIG. 39 is a rear, section view of the joint of FIG. 38.
FIG. 40 is an exploded, rear sectional view of a modular ceramic knee joint of the invention, similar to that of FIGS. 38 and 39, employing pin type attaching of its axial (taper) pin.
FIG. 41-43 show exploded, saggital sectional views of ceramic femoral knee components with modularity, as follows:

FIG. 41. Module-in-module.
FIG. 42. Top-insert stem.
FIG. 43. One-piece rotation device with stem.

FIG. 44 is a rear sectional view of the femoral component frame of FIGS. 41-43.
FIG. 45 is a saggital sectional view of the insertable rotation device with a swingable, depending male type part of the modular joint of FIGS. 38 and 39.
FIG. 46 is a rear sectional view of the insertable rotation device of FIG. 45.
FIG. 47 is an exploded side view of another embodiment of a modular ceramic tibial tray of the invention.
FIG. 48 is an exploded rear view of the tray of FIG. 47.
FIG. 49 is an exploded rear view of another embodiment of a modular ceramic tibial tray of the invention.
FIGS. 50-51 show views of a zirconia ceramic cruciate-retaining femoral component implant for a left human knee implant, as follows:

FIG. 50. Left, front, perspective plan view.
FIG. 51. Bottom view.

FIG. 52 is a rear, perspective view of a ceramic, unicompartmental femoral component condylar implant.
FIGS. 53-54 show views of a ceramic patellofemoral joint implant for a left human knee, as follows:

FIG. 53. Top, rear perspective.

FIG. 54. Front perspective.

FIGS. 55-58 show views of inter-spinal vertabra ensembles for implantation in adjacent, facing vertebral bodies for replacement of a disc, embodied as follows:

FIGS 55-56. Cap or cup mounting style, shown as a side, exploded view, with one component in section (FIG. 55); and a top view taken along arrow 41A (FIG. 56).
FIGS. 57-58. Peg or post mounting style, shown as a side, exploded view, with one component in section (FIG. 57); and a top view taken along arrow 42A (FIG. 58).

FIGS. 59-64 show views of an ankle implant ensemble, with FIGS. 59-62 a talus cap, which may be a hemi-implant, shown in top (FIG. 59) bottom (FIG. 60); side (FIG. 61); and front (FIG. 62) views -- and with FIGS. 63-64 a tibial tray, shown in side (FIG. 63) and front (FIG. 64) view.

DETAIL FURTHER ILLUSTRATING THE INVENTION

[0018] The invention can be further understood by additional detail, especially to include that which is set forth below, which may be read in view of the drawings. Such is to be taken in an illustrative and not necessarily limiting sense.

[0019] In general, in accordance with the practice of the present invention, a ceramic body can be made by providing an initial green body of ceramic, and machining the initial green body to provide a machined green ceramic body. The machined green ceramic body may be fired and/or further processed to provide a more finished ceramic body.

[0020] In certain embodiments of the present invention, one or more parts to one or more components of the knee joint implant is made of ceramic. Preferably, at least the basic femoral component with its condylar articulating surfaces is made of ceramic. Typically the ceramic condylar articulating surfaces articulate with a corresponding tibial tray liner made of ultra high molecular weight polyethylene (UHMWPE). Other parts of the femoral and tibial components may be made of, or to include, ceramic.

[0021] In certain other embodiments hereof, various additional articles of manufacture may be made. These include ceramic.

[0022] The ceramic may be any suitable type. Among these may be mentioned ceramics from "A" to "Z," to include alumina to zirconia, and mixtures thereof. A representative ceramic may be a boride, carbide, nitride, oxide, silicate and so forth of Al, Si, Sc, Y, La, the lanthanide series elements, Ac, the actinide series elements, Ti, Zr, Hf, V, Nb and/or Ta and so forth and the like. A ceramic may be toughened; thus, for example, an alumina may be a toughened alumina as known in the art. Preferably, the ceramic is a zirconia ceramic. The ceramic may be stabilized, and any stabilizer may be present in any suitable amount. For example, the zirconia ceramic may generally be a partially stabilized zirconia (PSZ) which is a zirconia ceramic stabilized, for example, with about three to three and one half percent by weight magnesium oxide, or with about from four to five percent by weight yttrium oxide, and which exists in a phase that may in essence span or be selected from tetragonal and/or cubic phases; and, from among the PSZ ceramics, a magnesium oxide stabilized transformation toughened zirconia (Mg-TTZ), which is a zirconia ceramic stabilized with approximately three to three and one half percent by weight magnesium oxide and which exists in a tetragonal phase; or a yttrium oxide tetragonal zirconia polycrystalline (Y-TZP), which is a zirconia ceramic stabilized with approximately three mole percent yttrium oxide and existing in a tetragonal phase. Compare, FIG. 1.

[0023] The finished ceramic may contain other substances. For example, zirconia ceramics typically contain a small amount of hafnia ceramic substances, say, about two percent by weight, owing to the fact that Hf is found with Zr in nature and is difficult to remove from Zr. This, however, need not be, and frequently is not, detrimental.

[0024] Beneficially, the ceramic is the Mg-TTZ, to include for reasons of its good hardness and excellent resistance to heat- and/or water-induced reversion toward a monoclinic phase. For example, a general comparison of alumina, Y-TZP and Mg-TTZ can be made as follows:

Strength after firing: Y-TZP > Mg-TTZ > alumina.
Strength after autoclaving: Mg-TTZ > alumina > Y-TZP.

Assigning arbitrary strength numbers to these ceramics for purposes of further illustration may yield the following values:

After firing: Y-TZP (150); Mg-TTZ (125); alumina (100).
Post-autoclave: Mg-TTZ (125); alumina (95); Y-TZP (50).

Thus, it may be said that Mg-TTZ does not revert to a monoclinic phase through the in vitro action of hot water, or it is not degraded or attacked by water. With in vivo use, the following has been generally observed with respect to wear for

alumina and Y-TZP implanted femoral hip balls:

At 1-4 years retrieval: Y-TZP better than alumina.
At 5-8 years retrieval: Y-TZP and alumina nearly same.
At 9-10, or more years: Alumina better than Y-TZP.

Accordingly, in vivo, Mg-TTZ, known, for example, to have been implanted as femoral hip balls (with bores drilled after firing), should be observed to provide better short and/or long term wear than alumina and better long term wear than Y-TZP.

[0025] Desirable, the ceramic body initially is made from a micropowder and/or nanopowder. For instance, a zirconia ceramic may be made from monoclinic zirconia powder with an about from 0.5-micron (um) to 10-um cross-section, as a micropowder, or with an about from 1-nanometer (nm) to 500-nm cross-section, as a nanopowder, which micropowder or nanopowder may contain about from two to five percent by weight magnesium oxide as a stabilizer. Preferably, the zirconia powder has an about from 1-um to 2-um cross-section, as the micropowder, or an about from 15-nm to 450-nm cross-section, as the nanopowder, and contains about from 3.1 to 3.4 percent by weight magnesium oxide.

[0026] The initial green body of ceramic can be provided by any suitable method or process. Pressure molding is preferred to make the initial green body, especially by a cold isostatic press (CIP) technique. Thus, a powdered ceramic material is fed into a cavity of a high-pressure press, and formed under pressure into the initial green body. A binder may be employed if needed or desired. Typically, a binder is employed with the ceramic powder if it is a micropowder or larger size. It may be the case that a binder is not required for the initial green body of nanopowder. The initial green body of ceramic is made to have a suitable density. Generally, the density of the initial green body is at least about twenty percent of the theoretical density for that ceramic. Preferably, the density of the initial green body is at least about thirty percent of theoretical, and more preferably at least about fifty percent of theoretical. Some may consider that higher theoretical densities of the initial green bodies may be provided by the employment of the smaller powders, others not, which may depend on the material. (Nanopowders, however, may sinter better than larger powders.) Higher theoretical densities may be provided by higher pressure, and so forth.

[0027] The initial green body may be provided in any suitable shape. Convenient shapes can include cylinders, tetrahedra, triangular prisms, rectangular or cubic blocks, regular pentagonal prisms, and so forth. Advantageously, the initial green body of ceramic is provided as a rectangular or cubic block.

[0028] For machining, certain initial green bodies may be left raw and pressed, and others may require heating to provide a bisque, which is considered to be a form of an initial green body. Thus, certain ceramic powders such as a zirconia nanopowder may be machined in a raw, pressed state. Certain other ceramic powders such as a micropowder for conversion into Mg-TTZ are bisqued. The heating required to form a bisque generally is considered mild. For example, a zirconia micropowder may be bisqued at temperatures about from one hundred to one thousand or eleven hundred or more degrees C, for about from one to ten hours.

[0029] In the practice of the invention, the initial green body is machined to provide the machined green ceramic body. Machining can be by any suitable method, to include by hand, by lathe, by drilling, cutting, and so forth, but preferably is carried out with a multi-axis precision cutting or tooling machine, for example, a computerized numerical control (CNC) machine. Generally, temperatures during the machining can be ambient temperatures. The machined green ceramic body may have any suitable shape, but preferably has a shape which is a precursor shape, analogous in most essential aspects, to the shape of any finished ceramic body. In light of this, the present method has a significant advantage that the machined green body may be provided with a complex shape so that if a finished ceramic would be made from it, minimal transformation to the essential shape of the body occurs. Thus, such asymmetrical, complex geometries as those of femoral components for a knee, to particularly include revisional femoral knee implant components, are readily gained. Other complex geometries, as illustrations of the versatility of the invention, in the field of surgical implants may include knee joint implant tibial components, unicompartmental knee joint aligning devices of one or more pieces, ankle joint implant components, spinal components, temporal mandibular joint implants, and so forth. Of course, other bodies can be made as the machined green body, including surgical implants such as hip femoral heads, shoulder humeral hemispheres, and so forth, which can advantageously include any trunnion receiving bores provided in precursor form so that the machined green body has less symmetry than an uninterrupted ball or generally planarly truncated ball (uninterrupted hemisphere), i.e., symmetry of a C-infinity point group, to include hip femoral and shoulder humeral heads with trunnion-receiving, tapered, truncated frustoconical bores, or a shape more asymmetric than C-infinity. And so, for additional examples, complex geometries of the femoral component and/or its rotation device and/or an insertable spike, and the tibial component tray and/or an insertable spike are readily gained.

[0030] The machined green ceramic body, as a precursor to a finished ceramic body, is provided suitably larger than the finished ceramic body. Thus, typically depending on the density of the machined green ceramic body and the density of the finished ceramic body, the machined green ceramic body may be about from one half to eighty percent larger than the corresponding finished ceramic body, in many cases about from ten to thirty percent larger. With the zirconia

ceramics and Mg-TTZ in particular, typical undersizes of the more finished ceramic in relation to the machined green body made from micropowder run about from fifteen to twenty-five percent, to include about from sixteen to twenty-three percent, less than the size of the finished ceramic body. In other words, an eighteen percent undersized more finished ceramic based on the controlling size of the machined green body may be considered to be equivalent to an about one hundred twenty-two percent oversized machined green body in relation to the controlling size of the more finished ceramic body. Thus, the relationship (I) generally obtains:

$$\text{I.}\quad \text{Oversize \%} = (100\%/(100\% - \text{undersize \%}))(100\%).$$

[0031] For example, a more finished ceramic body which is twenty percent undersized from a machined green body, is made from the machined green body which is 1.25 times as large (125%) as the more finished ceramic body.

[0032] Preferably, the more finished ceramic body is provided. This can be accomplished through at least one heating step.

[0033] The more finished ceramic body can be provided through firing of the machined green body. The firing may be conducted at any suitable temperature, for instance, within ranges about from one thousand to three thousand degrees C, for any suitable time. A temperature gradient leading to the firing temperature in the ceramic body is preferred, to include as may be conducted within ranges of about from one half to twenty degrees per minute. Annealing of the fired piece may immediately follow the firing, which may be carried out at any suitable temperature, for instance, within ranges about from seven hundred to one thousand eight hundred degrees C, for any suitable time. Further ceramic processing can include hot isostatic press (HIP) action, as may be desired or pertinent to certain ceramics. The fundamentals and practice of such procedures in general are known to those skilled in the art. Of course, details may vary for any ceramic.

[0034] For example, a Mg-TTZ more finished ceramic body may be made by firing a correspondingly larger machined green body in an oven at about from one thousand six hundred to one thousand nine hundred degrees C, preferably about from one thousand seven hundred to one thousand eight hundred degrees C, for about from one to four hours, say, about from two to three hours, with ramping temperatures leading to the firing temperature increasing from room temperature to the firing temperature at a suitable rate, say, about from one to two degrees C per minute. After such firing, annealing is desirably carried out by gradually cooling the body from the firing temperature, keeping it in a heated condition, for example, by gradually reducing the temperature of the hot, fired body about from two hundred to five hundred degrees C, say, about three hundred fifty degrees C, below the firing temperature of the body, and holding the body at the annealing temperature for about from one to three hours, say, about two hours. Cooling from the annealing temperature may be carried out at any suitable rate, say, at a rate similar to, but the reverse of, the ramping rate, until the annealed ceramic body is about room temperature. Such generally provides the more finished Mg-TTZ ceramic body, which typically has a density which approaches or attains theoretical density. Advantageously thus, no further heat processing such as by HIP action on the fired and annealed Mg-TTZ ceramic body is typically required.

[0035] A Y-TZP more finished ceramic body may be made by firing the correspondingly larger machined green body in an oven about from one thousand three hundred to one thousand five hundred degrees C for a body made from micropowder, or about one thousand one hundred to one thousand three hundred degrees C for a body made from nanopowder. Ramping, annealing and cooling procedures can be, in general terms, analogous to those for the Mg-TTZ ceramic. However, cooling at about from seven to ten degrees C per minute, down to heat treating temperature, may be advantageously employed. Finally, HIP action under Argon or Nitrogen, say, Argon, at about from one thousand to three thousand pounds per square inch (psi) pressure (converted to about from 70.36958 to 211.10874 kg/sq. cm), at a temperature about from one thousand to two thousand degrees C, for a cycle time about from four to twenty-four hours, with final cooling to room temperature. Thus, the finished ceramic body may be relieved of inorganic and organic substances, and approach or attain theoretical density.

[0036] Appropriate kiln furniture can be employed. Such furniture is beneficially placed in non-critical parts of the body. For example, the femoral knee joint implant component may be placed upside down in the kiln on kiln furniture that touches portions of the prosthesis that form a bone-implant interface rather than being placed right side up to have its articulating condylar surfaces touched during firing.

[0037] The finished ceramic parts and components can be dense materials. Generally, the finished ceramic should be at least about ninety percent of theoretical density, or it may be at least about ninety-five, ninety-six, ninety-seven, ninety-eight, or ninety-nine percent of theoretical density. Desirably, the density of the finished ceramic approaches, and especially attains, theoretical density.

[0038] The more finished ceramic knee body may be further processed as desired or required. Typically, any further processing is of a minor nature, particularly when compared to what would otherwise be required to provide the final shape from machining a fired ceramic block. Thus, polishing and/or minor amounts of grinding are typically some of the only mechanical finishing operation(s) carried out on the more finished ceramic body. A tantalum-vapor deposition or a

hydroxyapatite coating may be applied to bone-interfacing surfaces to engender ingrowth of bone. Various finished ceramic bodies to include those intended for implantation into human or animal subjects are cleaned and sterilized by known methods.

[0039] Such practice may be consolidated for illustration of preferences with reference to FIGS. 2 and 20, as follows:

Step 1: Monoclinic powder 10 is added to rubber ball cavity mold 18.
Step 2: The filled mold 18 is placed in CIP press 19.
Step 3: The press 19 is activated to provide an initial green body, for example, green block 520.
Step 4: The green block 520 is subject to bisquing if needed to provide bisqued green block 521.
Step 5: The green block 521 (or 520 if bisquing is not carried out) is machined, say, by CNC machine, to provide machined green ceramic body 530.
Step 6: The machined green ceramic body 530 is placed on suitable kiln furniture 38 in kiln 39.
Step 7: The kiln 39 is heated to fire the precursor ceramic body 530 to provide more finished ceramic body 540.
Step 8: The more finished ceramic body 540 may be processed further, for example, by polishing an articulating or bearing surface and/or by preparing for insertion such inserts as ultra high molecular weight polyethylene (UHMWPE) bushings, liners or other inserts as may be desired, and/or by sterilization, for instance, if it is for implantation as a prosthesis, to provide finally finished ceramic body 550.

[0040] The finished ceramics can be strong, tough materials. The finished ceramic preferably embraces a surgical implant which has as a feature thereof, a smooth, articulating ceramic surface.

[0041] The finished ceramics may be light-transmissive. In turn, certain ceramic knee implant components of the invention can provide for a more rapid setting of surgical cement by use of illumination, say, with blue light, through such an implant to the cement that is in contact with both the bone stock and the implant reverse. Thus, cure and surgical times can be decreased, and a more stable bone to implant interface may be provided.

[0042] The finished ceramic knee implant parts and components can be made to be of sizes which are the same as or similar to those of corresponding parts and components made of metal. In certain cases, they may be made to be slightly larger as may be desired.

[0043] In light of the foregoing and with particular reference to FIGS. 2-8, the machined green ceramic body 530, and hence the more finished ceramic body 540 and the finally finished ceramic body 550 can be embodied as a femoral component 100 to a posterior stabilized knee. As a finally finished product, the femoral component 100, of one piece of ceramic, for the posterior stabilized knee can include frame 101 with side walls 102; top 103T; distal condylar flange 104, which may include recess 104R; posterior flange 105; and anterior flange 106. Interiorly facing bone-ingrowth enhancing and/or cement adhering surface 109 such as a porous or roughened surface can face in proximal and deep directions, and can include bumps 109B. Polymethylmethacrylate or other surgical cement can be advantageously employed. Ridges 109R may define and reinforce the frame 101 and flanges 104, 105, 106. Femoral condylar surface 110 of generally convex geometry, and advantageously of constant radius of curvature in the saggital plane, especially posteriorly, generally includes inferior, medial condyle 111; inferior, lateral condyle 112; posterior, medial condyle 113; posterior, lateral condyle 114, and may be considered to include anterior, medial condyle 115, and anterior, lateral condyle 116. On a superficial side of the anterior flange 106 can be provided trochlear surface 117, on which the natural or an artificial patella, i.e., knee cap, may generally ride. Typically the condylar and trochlear surfaces 110-117 are smooth and highly polished, for example, by use of diamond grit or dust. Intracondylar notch 118 is formed. Added stabilization is provided by posterior stop 135, which contacts a corresponding member upstanding from the tibial tray liner (not illustrated) as is well known in the art.

[0044] With particular reference to FIGS. 9-15 note as follows:

FIG. 9 depicts a finally finished ceramic body 550 that is embodied as a modular femoral component 100M for a knee implant, which includes one-piece ceramic frame 101 with side walls 162; top 103T, which may have hole 103TH; distal condylar flange (not illustrated); posterior flange 105; and anterior flange 106. Femoral condylar surface 110 of generally convex geometry, again, advantageously of constant radius of curvature in the saggital plane, especially posteriorly, generally includes inferior, medial condyle 111; inferior, lateral condyle (not illustrated); posterior, medial condyle 113; posterior, lateral condyle (not illustrated); and may be considered to include anterior, medial condyle 115; any anterior, lateral condyle (not illustrated). On a superficial side of the anterior flange 106 can be provided a trochlear surface, on which the natural or an artificial knee cap may generally ride.

Intracondylar notch 118 is present. Added, modular stabilization can be provided by metal or ceramic (or other suitable material) femoral bone stock insertion stem 37, which may be affixed by employment of screw 39 and/or washer 37W. Alternatively, or in addition, metal or ceramic (or other suitable material) posterior stabilization stop rod 135P may be inserted into posterior stabilization stop rod receiving hole 135H in the frame 101 so that the rod 135P traverses the notch 118. Compare, FIGS. 3-8.

FIGS. 10 and 11 depict a finally finished ceramic body 550 that is embodied as a one-piece unicompartmental knee spacer device 100U, which includes ceramic frame body 101; articular surfaces 110; anterior cusp 140A; and posterior cusp 140P. Compare, U.S. patent No. 6,206,927.

FIGS. 12, 13 and 14 depict a finally finished ceramic body 550 embodied as a two-piece unicompartmental joint aligning device 100UU, which includes lower ceramic frame body 101 L, and upper ceramic frame body 101 U; lower articular surface 110L, intermediate sliding surfaces 110S, and upper articular surface 110U; first, lower lobe 141L and first, upper lobe 141 U, which may be disposed anteriorly when implanted; second, lower lobe 142L and second, upper lobe 142U, which may be disposed posteriorly when implanted; engaging post 143P; and engaging post receiving trough 143T.

Compare, U.S. patent application No. 10/717,104.

FIG. 15 shows a ceramic temporal mandibular joint implant 100TM/550 with articular surface 110TM. The implant 100TM is in a form of a cup for mounting on a resected jaw.

[0045] FIGS. 16-19 show more or finally finished ceramic bodies 540/550 embodied as industrial components. As examples, FIG. 16 shows ceramic journal bearing 100J; FIG. 17 shows ceramic flow control apparatus 100F, including control housing 100FH, piping 100FP, and valving 100FV; control housing; FIG. 18 shows set of gears 100G; and FIG. 19 shows pulleys 100P.

[0046] FIGS. 20-49 show additional embodiments of finally finished ceramic bodies 550 for ginglymous joint implants. FIGS. 20-33 include depictions of parts or components for a rotational knee joint 1000 with natural load transfer, which includes femoral component 100 and tibial component 200; FIGS. 34, 35, 36 and 37 depict a provisional femoral component and/or a drill jig for the femoral component 100 of a knee implant such as in FIGS. 21-29 and so forth; and FIGS. 38-49 depict modular knee joint implants, which include modularity of the type that the joint or implant can be found implanted in a first configuration, and, while the joint or implant remains implanted, it can be converted to a second configuration. In consideration of these figures, the following is noted:

The femoral component 100 can include femoral component frame 101 which may be of a one-piece ceramic construction. The frame 101 can include side walls 102; front wall 103, which may have upper segment 103U, lower segment 103L, and/or hole 103H that may be tapped to receive screw 36; and top 103T, which may have hole 103TH and may have supporting flange 103F, which may accommodate inferiorly insertable intramedullary femoral spike 37, which spike 37 may be part of a boxlike module 30 that includes side walls 32, front wall 34 that may have upper portion 34U and lower portion 34L, and top 33, which mate closely with the walls 102, 103, 103U, 103L and the top 103T, and/or including hole 34H through which the screw 36 may pass on its way to the hole 103H, or which spike 37, say again, made of Cr-Co alloy, may be secured with metal washer 37W, and has screw-receiving hole 38 threaded for receiving screw 39 that also secures boxlike modular rotation device 350. The frame 101 also can include distal condylar flange 104; posterior flange 105, anterior flange 106; femoral bone stock insertion stem 107, which may be separately addable 107A to stem receptacle 107R and be secured by set screw 107S; and wall hole 108 for integral rotation device 150. Femoral bone-loss augments 104A and 105A for use together, and 104AS and 105AS for separate use, may be provided, for example, of ceramic or suitable other material such as titanium or carbon fiber,

which may be coated by tantalum vapor deposition. Interiorly facing bone-ingrowth enhancing surface 109 such as a porous or roughened surface can face in proximal and deep directions, which surface 109 may also be provided a ceramic frame 101 through coating by tantalum vapor deposition techniques, as are known in the art. Femoral condylar surface 110 of generally convex geometry, and advantageously of constant radius of curvature in the saggital plane especially posteriorly, generally includes inferior, medial condyle 111; inferior, lateral condyle 112; posterior, medial condyle 113; posterior, lateral condyle 114, and may be considered to include anterior, medial condyle 115, and anterior, lateral condyle 116. As before, on a superficial side of the anterior flange 106 can be provided trochlear surface 117, on which the natural or an artificial knee cap may generally ride. Intracondylar notch 118, or inferiorly insertable module housing 301 for insertion of a modular rotation device 350 and/or the modular spike 30/37, may be formed. Again, the condylar and trochlear surfaces 110-117, as are are articular surfaces in general, smooth and highly polished. Condyle-backing femoral spikes 127 may be provided. Rotation devices 150 and 350 are provided.

[0047] The rotation device 150, which may be substantially ceramic but preferably in general is metal such as Co-Cr alloy, may be embraced by UHMWPE box insert 150B, and includes rotation member 151 generally with rotation member hole 152; taper pin receptacle 153, advantageously formed with a Morse-taper-accommodating cup; and punch-pin hole 154. Axle 155, which may be secured by axle plug 155P, runs through the hole 152 and may run through radial bushing 156, say, of UHMWPE, which bushing has axle hole 157; insert shoulder 158, which fits snugly in the wall hole 108; and member-spacing shoulder 159. The rotation device 150 has highly polished taper pin 160, which can include cylindrical shaft 161; and may include extraction groove 162 to extract the pin 160 from the receptacle 153, say, with a prying tool

during surgical implantation of the prosthesis 1000; extraction-restriction punch-pin locking groove 163; and taper lock tip 164, which can be made with a Morse-taper to fix the pin 160 in the cup 153. When the pin 160 is so fixed, it may be set by insertion and fit of an extraction-restriction and/or rotation-restriction punch-pin 165 through hole 154 and into groove 163. Threads 166 may be present, preferably in conjunction with Morse-taper 164, as an alternative for fastening the modular taper pin 160.

[0048] The rotation device 350 is completely modular and inferiorly insertable into the insertable modular housing 301, preferably adapted for such with its walls 102 having a Browne & Sharpe taper, say, with an about 1.5 to 2.0 degree taper 2X, or similar housing such as provided by the boxlike module with the spike 37, as an embodiment of the addable component 30, which beneficially is made of Co-Cr alloy, and can include swingable, depending male type part in housing 31 with side walls 32, preferably with a restraining Browne & Sharpe taper 32X about 1.6 to 2.1 degrees; optional top wall 33, which may have top hole 33TH; and front wall 34. Holes 52 in the side walls 52 accommodate hinge pin (axle) 55. Pivot block (rotation member) 51 can have hole 52A, which continues along the direction of the holes 52; taper pin cup 53, which may be smooth walled, tapered, say, with a Morse-taper, and/or provided with threads 56; and punch pin hole 54. The taper pin 61 is inserted in the cup 53, and may be secured through punch pin 65 and/or threads 66. The rotation device 350 may be made with a one-piece depending male type part as by having components 51 and 61 of one, integral piece.

[0049] A ceramic femoral knee component 100 may have a strength against a posterior condyle when tested in accordance with United States Food and Drug Administration (FDA) protocol of at least about 1500 pounds (lbs.) (about 0.68038856 metric tons); at least about 2000 pounds (about 0.90718475 metric tons); at least about 2500 pounds (about 1.1339809 metric tons). Note, FIG. 4, test arrow 105T; EXAMPLE 1.

[0050] Provisional or trial femoral component 100T and/or drill jig 100DJ for the femoral component 100 may be made of ceramic according to the practice of the present invention. Sizing components 100S ("hinge") and augment provisional or trial components 100AT may be used with the component 100T.

[0051] The tibial component 200 can include tibial component frame 201, which can have tibial tray 202; dovetail liner-insertion rails 203; liner-stopping ramp or rotation safety stop 204, and, central stop 204C, particularly if part of double-capture locking mechanism 204X; screw holes 205 through which can be inserted bone-fastening screws 206; stem 207 - which may be insertable inferiorly into receiving cup 207C that may be threaded, by provision of separate stem 207Q that may be threaded also; or which may be insertable superiorly, even after implantation of the component frame 201, through hole 207H that may be threaded, by provision of the separate stem 207Q that has a superior screwing head with superior threads - and which may have distal taper 207T, a number of, say, three, distal ribbed grooves 208 and/or a number, say, two, underside flanges 208F; and interiorly facing bone-ingrowth enhancing surface 209. The tibial articular surface 210 is of concave geometry in suitable complimentarity to the convex geometry of the condylar surface 110, and generally includes superior, medial articular surface 211 and superior, lateral articular surface 212 on medial lobe 213 and lateral lobe 214, respectively. On the underside of each lobe may be dovetail grooves 215 for sliding along any rails 203; lobe-spanning portion 216; notch 217 for locking in cooperation with the stop(s) 204, 204C; and inter-condylar notch 218 analogous to the notch 118. Ramp 219 may make for an easier installment over the stop 204. Such features 200-219 may be provided on a separable tibial tray liner 220 of suitable material, for example, UHMWPE. Rotation device receptacle 250 may be in a form of an essentially cylindrical cup 251, which may have top shoulder recess 252. Rotation device receptacle liner 260, for example, UHMWPE, may be inserted into the receptacle 250 and its cup 251 so as to itself receive the taper pin 60, 160. The liner 260 can include taper pin accommodating cup 261; shoulder 262, which can fit in the recess 252; a number of, say, two to four, inside, axially directed grooves 263 to permit exit of entrained body fluids during extension and flexion of the implanted joint 1000 and consequent up and down motion of the taper pin 60, 160, which fits quite closely although movable within the liner cup 261; and outside axially directed fluid-escape feature 264, say, groove, or possible hole, to permit escape of liquids and/or gasses during insertion of the liner 260 into the receptacle 250, between which there is a close, essentially immovable-in-use fit. Shoulder bevel angles A9a and A9b may be, respectively, for example, ninety degrees and one hundred eighteen degrees.

[0052] Tibial block augments may be provided, for example, as full augment 200F or partial augment 200P. The table, which follows, lists some augments available from Zimmer, Inc.

Tibial Size	M/L x AP (mm)	RHK Full Augments	NexGen Partial Augments
1	58 x 41	Size 1	Size 1
2	62 x 41	Size 2	Size 2
3	67 x 46	Size 3	Size 4
4	70 x 46	Size 4	Size 4
5	74 x 50	Size 5	Size.6
6	77 x 50	Size 6	Size 6

As skilled artisans would appreciate, RHK full tibial block augments 200A can only be used with RHK tibial base plates.

[0053] Beneficially, the knee implant 1000 has natural load transfer. As such, in addition to noted articular motions, the knee may carry a substantial amount, say, about ninety percent or more or about ninety-five percent or more of the load through the condyles.

[0054] Compare, U.S. patent Nos. 5,766,257 and 6,629,999.

[0055] In FIGS. 50-51 are seen a zirconia ceramic, for example, Mg-TTZ ceramic, cruciate-retaining femoral component implant 100CR/550. Other ceramics such as alumina, although not as preferred, may be employed. Note as in FIGS. 2-8 the waffle bump pattern on the bone-interfacing side of the component. This can, as with the other implants having them, provide a grip for surgical cement in addition to any rough surface on the bone-interfacing side of the component. Note, too, the ridges on the bone-interfacing side of the component, which, in addition to providing for a better cement bond, also help strengthen the implant. The implant 100CR includes smooth articular condyles 110 but has no box or other structure between the lateral and medial inferior and posterior condyles. Smooth, patella-tracking articular surface 117 is present between the condyles, especially as found between the lateral and medial anterior condyles.

[0056] In FIG. 52 is depicted a ceramic, for instance, a zirconia ceramic, say, Mg-TTZ ceramic, unicompartmental femoral knee component implant 100UK/550. Note as in FIGS. 2-8, 50 and 51 the waffle bump pattern and ridges. The implant 100UK also includes a smooth articular condyle 110.

[0057] In FIGS. 53 and 54 are depicted a ceramic, for instance, a zirconia ceramic, again, for an example, Mg-TTZ ceramic, patellofemoral joint implant 100PF/550. It includes smooth articular surface 110 and smooth, patella-tracking articular surface 117. Note the interior ridges. A rough surface can be provided on the interior surfaces as well. Posts are provided on the bone-interfacing, interior surface in the anterior inferior position for mounting in cement on resected femoral bone stock.

[0058] FIGS. 55-58 depict ceramic, for instance, a zirconia ceramic, vertebra cap ensembles 100VC/550 for mounting between adjacent, facing vertebrae of the spine, which include smooth, spherical section articular surfaces 110. These may be implanted in the cervical, thoracic or lumbar regions, for example, in the thoracic region, say, between the ninth and tenth vertebrae essentially covering their vertebral bodies, in lieu of bone fusion when disc failure is presented. This may keep spinal flexibility an option with disc failure. In one embodiment, the vertebra cap ensemble components are mounted through a cup device in the bone-interfacing surface of the cap over resected bone. In another embodiment, the components are mounted with the assistance of posts into resected bone. Surgical cement may be employed. Of course, another material such as a suitable metal may be employed to make these vertebra cap ensembles.

[0059] FIGS. 59-64 depict ceramic, for instance, a zirconia ceramic, for example, Mg-TTZ ceramic, ankle joint ensemble having talus cap implant 100AJ and tibial tray implant 200AJ (UHMWPE tray liner not illustrated). The talus cap 100AJ has articular surface 110 to articulate with natural tissue in hemi-arthroplasty or with the tray liner in total joint replacement arthroplasty, and is in a form of a cup for mounting over a stump of resected bone as with the temporal mandibular joint 100TMJ (FIG. 15), the vertebra cap ensemble 100VC (FIGS. 55-56); and so forth and the like. The tibial tray implant 200AJ may be a suitable metal or even ceramic, and includes an intramedullary spike and a cup for receiving and retaining the liner having an articulating surface.

[0060] Numerous further embodiments can be effected in the practice of the invention. Thus, for example, hand and foot digit joint implants can be provided in ceramic hereby, and among these may be mentioned those of the fingers, thumb, and toes, notably, among the latter the great toe. Such an implant may have, for example, in the case of the great toe, a suitable metal tray and intramedullary spike with an attachable ceramic tray liner having an articular surface, in lieu of the all-metal construction well known in the art.

[0061] The following examples further illustrate the invention.

EXAMPLE 1

[0062] A finished body of a Mg-TTZ posterior stabilized femoral knee joint implant component was begun through CIP action on an about 3-percent magnesium oxide zirconia monoclinic 1~2 um micropowder with a binder, which was bisqued to provide a right angled 3-1/2 - inch x 4-inch x 4-inch block. Then CNC machining of the block provided a green machined body 121.95% of the size of the projected more finished ceramic, as a precursor to a posterior stabilized femoral knee component with standard sized condyles. The precursor was placed with its condyles up on fired Mg-TTZ kiln furniture in an oven, which was ramped at an about 1~2-degree C per minute rate from room temperature to a firing temperature of some 1725~1775 degrees C. Firing was carried out for some 2~3 hours. Then the temperature was reduced at an about 5-degree C per minute rate to an about 1340-degree C annealing temperature. Annealing was carried out for an about 2-hour time. The annealed ceramic was cooled to room temperature at an about 5-degree C per minute rate to make a more finished posterior stabilized implant with great strength. See, FIGS. 2-8.

[0063] The more finished ceramic knee femoral component can have its reverse side roughened up by grinding with a diamond bit. Its articulating surfaces can be polished with diamond dust. The ceramic knee implant can be cleaned by immersion into an aqueous bath having a surfactant, with sonic agitation of the bath. Sterilization can be by radiation

and/or ethylene oxide.

[0064] A fired, finished ceramic posterior stabilized knee femoral component 100 (FIGS. 2-8) made as above was designated as a demonstration model. In a demonstration, the component 100 was deliberately thrown across a room onto a hard floor to impact against a wall. The audience cringed for they had seen another ceramic knee implant shatter upon being merely dropped onto the floor, but were awed as the demonstration component 100 remained intact.

[0065] Fired, finished ceramic posterior stabilized knee femoral components 100 (FIGS. 2-8) made as above were tested by placing them separately in a jig and then applying stress to a posterior flange 105 along the direction of test arrow 105T (FIG. 4) to correspond to the direction that the FDA would require testing of a corresponding metal component. A first ceramic component with an about 1.7-mm thickness for the walls/top 102/103 did not break when an about 1000-pound (convert to about 0.4535924 metric ton) force was applied, and so the component was subjected to 15-Hz fatigue stress for 200,000 cycles with a 650-pound to 550-pound (about 0.2948531 to about 0.2494758 metric ton) and 650-pound to 750-pound (about 0.2948531 to abut 0.3401943 metric ton) cycle without breaking. The component was broken with an about 2250-pound (about 1.0205829 metric ton) load, failing about its box (a wall 102 and top 103), but not the condyle flange 105. A second component with an about 1.7-mm thickness for the walls 102 was broken with an about 2300-pound (about 1.0432625 metric ton) load, again failing about its wall 102 and top 103 box, but not the condyle flange 105. This is generally about three times the minimum FDA value for Co-Cr.

[0066] A wall/top 102/103 of about 2~3 mm thickness is desired.

[0067] Finite element analysis for the Mg-TTZ knee (FIGS. 2-8) with a 3-mm wall/top 102/103 thickness was carried out for stress along the arrow 105T (FIG. 4). After 88,000,000 cycles the estimated strength was a 2800-pound value (approximately 1.270059 metric tons).

EXAMPLE 2

[0068] A block for a machined green body of for a Y-TZP posterior stabilized femoral knee joint component was made through pressure upon a monoclinic nanopowder, without binder. The block can be CNC-machined to provide a machined green ceramic body, fired and annealed, and further processed with a 1200-degree C, 20,000-psi (approximately 1406.138 kilograms per square centimeter) HIP to provide a theoretically dense, posterior stabilized component.

EXAMPLE 3

[0069] Further ceramic products can be made by the foregoing methods. See, e.g., FIGS. 9-64.

EPILOGUE

[0070] The present invention is thus provided. Various features, parts, subcombinations or combinations may be employed with or without reference to other features, parts, subcombinations and combinations in its practice, and numerous adaptations and modifications can be effected within its spirit, the literal claim scope of which is particularly pointed out as follows:

Claims

1. A method for making a ceramic body prosthetic implant or prosthetic implant component of Mg-TTZ ceramic from a powder that is a monoclinic zirconia having magnesium oxide for a stabilizer, which method comprises:

   providing a bisqued initial green body of ceramic by providing a powdered ceramic material (10), which is a monoclinic zirconia having magnesium oxide for a stabilizer, compressing the material in its powder form through a cold isostatic press operation (1, 2, 3, 18, 19) to form a raw, pressed initial green body (520), and then heating the raw, pressed initial green body to a bisque stage (4) to provide the bisqued initial green body (521); and, after the foregoing steps are carried out without employing a binder additional to the powdered ceramic material, carrying out the following further steps:

   machining the bisqued initial green body (521) to provide a machined bisqued green ceramic body (530) such that the machined bisqued green ceramic body has a shape which is a precursor shape essentially analogous to, being of the same proportions as, the shape of, but larger than, the ceramic portion of a fired predetermined finished ceramic body prosthetic implant or prosthetic implant component (540, 550); and then firing the machined bisqued green ceramic body (6, 38, 39) to provide a fired Mg-TTZ ceramic body product, which is the same size and shape or essentially the same size and shape of the ceramic portion

of the fired predetermined finished ceramic body prosthetic implant or prosthetic implant component.

2. The method of Claim 1, wherein the ceramic material (10) is the monoclinic zirconia powder with an about from 0.5-micron (um) to 10-um cross-section, as a micropowder, or with an about from 1-nanometer (nm) to 500-nm cross-section, as a nanopowder, which micropowder or nanopowder may contain from two to five percent by weight magnesium oxide as a stabilizer.

3. The method of Claim 1 or Claim 2, wherein the machined bisqued green ceramic body (6, 38, 39) is fired in an oven at about from 1600 to 1900 °C.

4. The method of any one of Claims 1 to 3, wherein the ceramic body prosthetic implant or prosthetic implant component of Mg-TTZ is for or of a load-bearing intricate prosthetic implant or implant component (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 1007A, 150, 160, 200, 200AJ, 207Q, 350, 550, 1000), optionally which is a femoral component for a posterior stabilized knee implant (135, 550), a femoral component for a rotating knee implant (100, 100M, 150, 160, 350, 550, 1000), or a femoral component for a cruciate-retaining knee implant which includes medial and lateral condylar articular surfaces (100CR, 110, 550); and optionally wherein:

polishing (8) is the sole mechanical finishing operation to the fired ceramic body (540).

5. The method of any one of Claims 1 to 3 used for the manufacture of an article of manufacture comprising a prosthetic implant or prosthetic implant component of Mg-TTZ, wherein the ceramic body prosthetic implant or prosthetic implant component is an intricate prosthetic implant or component (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 107A, 150, 166, 200, 200AJ, 207Q, 350, 550, 1000).

6. The method of Claim 5, wherein the ceramic body prosthetic implant or prosthetic implant component of Mg-TTZ may be further processed after firing only by polishing (8), optionally wherein the prosthetic implant or prosthetic implant component is at least one of an article of a femoral or tibial component for a replacement knee joint (100, 100CR, 100M, 100PF, 100UK, 150, 160, 200, 350, 550, 1000), optionally in which the article is a femoral component for a posterior stabilized knee implant (100, 100M, 135, 135P, 550) optionally in which the article is a femoral frame component for a rotation device containing knee implant (100, 101, 1000), optionally in which the article is a cruciate-retaining femoral component for a knee (100CR) and optionally in which the article is a unicompartmental femoral condylar component for a knee (100UK).

7. The method of Claim 5, wherein the ceramic body prosthetic implant or prosthetic implant component of Mg-TTZ is at least one of an article of a one-piece unicompartmental knee spacer device (100U) or a multi-piece unicompartmental joint aligning device (100UU), optionally in which the article is a temporal mandibular joint cap implant (100TM), optionally in which the article is a patellofemoral joint implant (100TM), optionally in which the article is a vertebra cap (100VC), optionally in which the article is an ankle joint ensemble or component (100AJ, 200AJ).

8. The method of claim 5, wherein the ceramic body prosthetic implant or prosthetic implant component of Mg-TTZ is femoral component implant (100, 100CR, 100M, 100UK, 550) having a strength against a posterior condyle (113, 114) of at least about 1500 pounds (abut 0.68 metric tons) when tested according to United States Food and Drug Administration standards corresponding to strength testing on a posterior condyle of a metal femoral knee component in which force is applied in a posterior to anterior direction on an unsupported portion of the condyle, optionally wherein the strength is at least about 2000 pounds (about 0.91 metric tons) when so tested, optionally wherein the strength is at least about 2500 pounds (about 1.1 metric tons) when so tested, and optionally in which the implant with such strength is a femoral component to a posterior stabilized knee (100, 100M, 135, 135P, 550).

9. The method of any one of Claims 1 to 3, wherein the ceramic body prosthetic implant or prosthetic implant component of Mg-TTZ is for or of a load-bearing intricate prosthetic implant or implant component (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 1007A, 150, 160, 200, 200AJ, 207Q, 350, 550, 1000), optionally which is a femoral component for a posterior stabilized knee implant (135, 550), a femoral component for a rotating knee implant (100, 100M, 150, 160, 350, 550, 1000), or a femoral component for a cruciate-retaining knee implant which includes medial and lateral condylar articular surfaces (100CR, 110, 550); and optionally wherein:

a hot isostatic press operation is not carried out;
the powdered ceramic material (10) has an about 10-μm cross-section at most;
polishing (8) is the sole mechanical finishing operation to the fired ceramic body (540); and/or

the fired ceramic body (540, 550) is at least about 90 percent of theoretical density.

10. The method of any one of Claims 1 to 3 used for the manufacture of an article of manufacture comprising a prosthetic implant or prosthetic implant component of Mg-TTZ, wherein the ceramic body prosthetic implant or prosthetic implant component is an intricate prosthetic implant or component (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 107A, 150, 166, 200, 200AJ, 207Q, 350, 550, 1000) and thus not a ball, truncated ball, or bored ball for a hip or shoulder joint.

11. The method of Claim 5, wherein the ceramic body prosthetic implant or prosthetic implant component of Mg-TTZ may be further processed after firing only by polishing (8), optionally wherein the prosthetic implant or prosthetic implant component is at least one of an article of a femoral or tibial component for a replacement knee joint (100, 100CR, 100M, 100PF, 100UK, 150, 160, 200, 350, 550, 1000), optionally in which the article is a femoral component for a posterior stabilized knee implant (100, 100M, 135, 135P, 550) optionally embracing an Mg-TTZ ceramic mass including a frame (101) having side walls (102) and a top (103T) that bridge left and right condylar flanges (104. 25 105, 106) that have condyles (110) including anterior, inferior and posterior condyles (111, 112, 113, 114, 115, 116) which form an intracondylar notch (118), and a posterior stabilizing stop (135, 135P) within said notch, said component being of one piece, optionally in which the article is a femoral frame component for a rotation device containing knee implant (100, 101, 1000) optionally embracing a one-piece fired ceramic frame of the Mg-TTZ having side walls (102) and a front wall (103) residing in an intracondylar notch (118) between lateral and medial anterior, inferior and posterior condylar flanges (104, 105, 106) which have corresponding articular surfaces (111, 112, 113, 114, 115, 716) plus a trochlear surface (117) essentially between said anterior flanges and respective anterior condyles, said walls able to receive a depending, rotating male part (30, 61, 150, 160. 3511) that can be engaged by a receptacle (250, 260) in a corresponding tibial tray (200), optionally in which the article is a cruciate-retaining femoral component for a knee (100CR) optionally embracing an Mg-TTZ ceramic mass including a smooth, patella-tracking articular surface (117) anteriorly between left and right condylar flanges that have condyles (110) said condyles including left and right inferior and posterior condyles (111, 112, 113, 114) between which there is an empty intracondylar notch (118), said component being of one piece, and optionally in which the article is a unicompartmental femoral condylar component for a knee (100UK) optionally embracing an Mg-7TZ ceramic mass including a smooth articular condyle surface (I10) which includes anterior, inferior and posterior condyles (111/112, 113/114, 115/116), said component being of one piece.

12. The method of Claim 5, wherein the ceramic body prosthetic implant or prosthetic implant component of Mg-TTZ is at least one of an article of a one-piece unicompartmental knee spacer device (100U) or a multi-piece unicompartmental joint aligning device (100UU), optionally in which the article is a temporal mandibular joint cap implant (100TM), optionally in which the article is a patellofemoral joint implant (100TM), optionally in which the article is a vertebra cap (100VC), optionally in which the article is an ankle joint ensemble or component (100AJ, 200AJ), optionally wherein the Mg-TTZ ceramic is light-transmissive such that a more rapid setting of surgical cement can be effected by use of illumination through the implant to the cement.

Patentansprüche

1. Verfahren zur Herstellung eines prothetischen Keramikkörper-Implantats oder einer prothetischen Implantatkomponente aus Mg-TTZ-Keramik aus einem Pulver, das ein monoklinisches Zirkonium mit Magnesiumoxid als Stabilisator ist, wobei das Verfahren umfasst:

Bereitstellen eines ungebrannten Ausgangs-Biskuitkeramikkörpers durch Bereitstellen eines pulverförmigen Keramikmaterials (10), das ein monoklinisches Zirkonium mit Magnesiumoxid als Stabilisator ist, Komprimieren des pulverförmigen Materials mittels eines isostatischen Kaltpressvorgangs (1, 2, 3, 18, 19), um einen rohen gepressten ungebrannten Ausgangskörper (520) zu erhalten, und danach Erwärmen des rohen gepressten ungebrannten Ausgangskörpers in einem Biskuitstadium (4), um den ungebrannten Biskuit-Ausgangskörper (521) zu erhalten, und, nach Durchführung der vorangehenden Schritte ohne Verwendung eines zusätzlichen Bindemittels im Keramikpulvermaterial, Durchführen der folgenden zusätzlichen Schritte:

Bearbeiten des ungebrannter Biskuit-Ausgangskörpers (521), um einen bearbeiteten ungebrannten Biskuit-Keramikkörper (530) zu erhalten, so dass der bearbeitete ungebrannte Biskuit-Keramikkörper eine Form besitzt, welche eine Vorläuferform ist, die im Wesentlichen analog zu, mit denselben Proportionen, nur größer, wie das Keramikteil eines vorbestimmten fertigen gebrannten prothetischen Keramikkörper-Imp-

lantats oder einer prothetischen Implantatkomponente (540, 550) ist, danach Brennen des bearbeiteten ungebrannten BiskuitKeramikkörpers (6, 38, 39), um ein gebranntes Mg-TTZ-Keramikkörperprodukt zu erhalten, das dieselbe Größe und Form wie das Keramikteil des vorbestimmten fertigen gebrannten prothetischen Keramikkörper-Implantats oder einer prothetischen Implantatkomponente besitzt.

2. Verfahren nach Anspruch 1, wobei das Keramikmaterial (10) das monoklinische Zirkoniumpulver ist, das als Mikropulver einen Querschnitt von zirka 0,5 Mikrometer (μm) bis 10 μm hat oder als Nanopulver einen Querschnitt von zirka 1 Nanometer (nm) bis 500 nm hat, wobei das Mikropulver oder Nanopulver von zwei bis fünf Gew.-% Magnesiumoxid als Stabilisator enthalten kann.

3. Verfahren nach Anspruch 1 oder Anspruch 2, wobei der bearbeitete ungebrannte Biskuit-Keramikkörper (6, 38, 39) in einem Ofen bei zirka 1600 bis 1900 °C gebrannt wird.

4. Verfahren nach einem der Ansprüche 1 bis 3, wobei das prothetische Keramikkörper-Implantat oder die prothetischen Implantatkomponente aus Mg-TTZ für oder aus einem komplexen tragenden prothetischen Implantat oder Implantatkomponente (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 1007A, 150, 160, 200, 200AJ, 207Q, 350, 550, 1000) ist, welches / welche optional eine femorale Komponente für ein posterior-stabilisiertes Knieimplantat (135, 550), eine femorale Komponente für ein rotierendes Knieimplantat (100, 100M, 150, 160, 350, 550, 1000) oder eine femorale Komponente für ein kreuzbandkonservierendes Knieimplantat ist, das mediale und laterale kondyläre Gelenkflächen (100CR, 110, 550) umfasst und optional wobei:

eine Politur (8) der einzige mechanische Fertigstellungsvorgang des gebrannten Keramikkörpers (540) ist.

5. Verfahren nach einem der Ansprüche 1 bis 3, das für die Herstellung eines Herstellungsartikels verwendet wird, der ein prothetisches Implantat oder eine prothetische Implantatkomponente aus Mg-TTZ umfasst, wobei das prothetische Keramikkörper-Implantat oder die prothetische Implantatkomponente ein komplexes prothetisches Implantat oder eine Implantatkomponente (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 107A, 150, 166, 200, 200AJ, 207Q, 350, 550, 1000) ist.

6. Verfahren nach Anspruch 5, wobei das prothetische Keramikkörper-Implantat oder die prothetische Implantatkomponente aus Mg-TTZ nach dem Brennen ferner nur durch Politur (8) weiterbearbeitbar ist, optional wobei das prothetische Implantat oder die prothetische Implantatkomponente mindestens ein Artikel einer femoralen oder tibialen Komponente für eine Ersatzkniegelenk (100, 100CR, 100M, 100PF, 100UK, 150, 160, 200, 350, 550, 1000) ist, optional wobei der Artikel eine femorale Komponente für ein posterior-stabilisiertes Knieimplantat (100, 100M, 135, 135P, 550) ist, optional wobei der Artikel eine femorale Strukturkomponente für ein Knieimplantat ist, das eine Rotationsvorrichtung (100, 101, 1000) enthält, optional wobei der Artikel eine femorale kreuzbandkonservierende Komponente für ein Knie (100CR) ist und optional wobei der Artikel eine unikompartimentelle femorale kondyläre Komponente für ein Knie (100UK) ist.

7. Verfahren nach Anspruch 5, wobei das prothetische Keramikkörper-Implantat oder die prothetische Implantatkomponente aus Mg-TTZ mindestens eins von einem Artikel einer unikompartimentellen Monoblock-Kniebeabstandungsvorrichtung (100U) oder einer unikompartimentelle Multiblock-Gelenkausrichtungsvorrichtung (100UU) ist, optional wobei der Artikel ein Kapselimplantat des Kiefergelenks (100TM) ist, optional wobei der Artikel ein Implantat des patellofemoralen Gelenks (100TM) ist, optional wobei der Artikel eine Wirbelkapsel (100VC) ist, optional wobei der Artikel eine Einheit oder eine Komponente eines Sprunggelenks (100AJ, 200AJ) ist.

8. Verfahren nach Anspruch 5, wobei das prothetische Keramikkörper-Implantat oder die prothetische Implantatkomponente aus Mg-TTZ eine Implantat einer femoralen Komponente (100, 100CR, 100M, 100UK, 550) ist, die eine Stabilität gegenüber einem Kondylus posterior (113, 114) von mindestens zirka 1500 Pfund (zirka 0,68 metrische Tonnen) hat, wenn er gemäß den Normen der US-amerikanischen FDA (Food and Drug Administration) getestet wird, was Kondylus posterior-Stabilitätstests einer femoralen Kniekomponente aus Metall entspricht, bei denen eine Kraft in einer Richtung posterior nach anterior auf einen nicht unterstützten Teil des Kondylus angewendet wird, optional wobei die Stabilität mindestens zirka 2000 Pfund (zirka 0,91 metrische Tonnen) entspricht, wenn der Test so durchgeführt wird, optional wobei die Stabilität mindestens zirka 2500 Pfund (zirka 1,1 metrische Tonnen) entspricht, wenn der Test so durchgeführt wird, und optional wobei das Implantat, das eine derartige Stabilität besitzt, eine femorale Komponente für ein posterior-stabilisiertes Knie (100, 100M, 135, 135P, 550) ist.

9. Verfahren nach einem der Ansprüche 1 bis 3, wobei das prothetische Keramikkörper-Implantat oder die prothetische

Implantatkomponente aus Mg-TTZ für oder aus einem komplexen tragenden prothetischen Implantat oder Implantatkomponente (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 1007A, 150, 160, 200, 200AJ, 207Q, 350, 550, 1000) ist, welches / welche optional eine femorale Komponente für ein posterior-stabilisiertes Knieimplantat (135, 550), eine femorale Komponente für ein rotierendes Knieimplantat (100, 100M, 150, 160, 350, 550, 1000) oder eine femorale Komponente für ein kreuzbandkonservierendes Knieimplantat ist, das mediale und laterale kondyläre Gelenkflächen (100CR, 110, 550) umfasst und optional wobei
kein isostatischer Warmpressvorgang durchgeführt wird,
das Keramikpulvermaterial (10) einen Querschnitt von maximal zirka 10 μm hat,
eine Politur (8) der einzige mechanische Fertigstellungsvorgang des gebrannten Keramikkörpers (540) ist, und/oder der gebrannte Keramikkörpers (540, 550) eine theoretische Dichte von mindestens zirka 90 Prozent besitzt.

10. Verfahren nach einem der Ansprüche 1 bis 3, das für die Herstellung eines Herstellungsartikels verwendet wird, der ein prothetisches Implantat oder eine prothetische Implantatkomponente aus Mg-TTZ umfasst, wobei das prothetische Keramikkörper-Implantat oder die prothetische Implantatkomponente ein komplexes prothetisches Implantat oder eine Implantatkomponente (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 107A, 150, 166, 200, 200AJ, 207Q, 350, 550, 1000) und folglich keine Kugel, Kegelstumpf-Kugel oder geschmiedete Kugel für ein Hüft- oder Schultergelenk ist.

11. Verfahren nach Anspruch 5, wobei das prothetische Keramikkörper-Implantat oder die prothetische Implantatkomponente aus Mg-TTZ nach dem Brennen ferner nur durch Politur (8) bearbeitbar ist, optional wobei das prothetische Implantat oder die prothetische Implantatkomponente mindestens ein Artikel einer femoralen oder tibialen Komponente für eine Ersatzkniegelenk (100, 100CR, 100M, 100PF, 100UK, 150, 160, 200, 350, 550, 1000) ist, optional wobei der Artikel eine femorale Komponente für ein posterior-stabilisiertes Knieimplantat (100, 100M, 135, 135P, 550) ist, einschließend optional eine Keramikmasse aus Mg-TTZ, umfassend eine Struktur (101), die mit Seitenwänden (102) und einem oberen Teil (103T) ausgestattet ist, das die kondylären Flanken rechts und links (104, 25, 105, 106) verbindet, die Kondylen (110) besitzen, die Kondylen anterior, inferior und posterior (111, 112, 113, 114, 115, 116) umfassen, die eine interkondyläre Kerbe (118) bilden, und einen Stabilisationsanschlag posterior (135, 135P) im Innern der Kerbe, wobei es sich um eine Monoblock-Komponente handelt, optional wobei der Artikel eine femorale Strukturkomponente für ein Knieimplantat ist, das eine Rotationsvorrichtung (100, 101, 1000) enthält, einschließend optional eine gebrannte Monoblock-Keramikstruktur aus Mg-TTZ, ausgestattet mit Seitenwänden (102) und einer Stirnwand (103) in einer interkondylären Kerbe (118) zwischen kondylären Flanken lateral und medial anterior, inferior und posterior (104, 105, 106), die entsprechenden Gelenkflächen (111, 112, 113, 114, 115, 716) zuzüglich einer trochlearen Fläche (117) im Wesentlichen zwischen den Flanken anterior und den jeweiligen Kondylen anterior besitzen, wobei die Wände imstande sind, einen abhängigen männlichen Rotationsteil (30, 61, 150, 160, 3511) aufzunehmen, der mittels eines Behälters (250, 260) in eine entsprechende tibiale Platte (200) eingreifen kann, optional wobei der Artikel eine femorale kreuzbandkonservierende Komponente für ein Knie (100CR) ist, einschließend optional eine Keramikmasse aus Mg-TTZ, umfassend eine glatte patellaführende Gelenkfläche (117) in Position anterior zwischen den kondylären Flanken links und rechts, die Kondylen (110) besitzen, wobei die Kondylen Kondylen inferior und posterior links und rechts (111, 112, 113, 114) besitzen, zwischen denen sich eine leere interkondyläre Kerbe (118) befindet, wobei die Komponente eine Monoblock-Komponente ist, und optional wobei der Artikel eine unikompartimentelle femorale kondyläre Komponente für ein Knie (100UK) ist, einschließend optional eine Keramikmasse aus Mg-TTZ, umfassend eine glatte kondyläre Gelenkfäche (110), die Kondylen anterior, inferior und posterior (111/112, 113/114, 115/116) umfasst, wobei die Komponente eine Monoblock-Komponente ist.

12. Verfahren nach Anspruch 5, wobei das prothetische Keramikkörper-Implantat oder die prothetische Implantatkomponente aus Mg-TTZ mindestens eins von einem Artikel einer unikompartimentellen Monoblock-Kniebeabstandungsvorrichtung (100U) oder einer unikompartimentellen Multiblock-Gelenkausrichtungsvorrichtung (100UU) ist, optional wobei der Artikel ein Kapselimplantat des Kiefergelenks (100TM) ist, optional wobei der Artikel ein Implantat des patellofemoralen Gelenks (100TM) ist, optional wobei der Artikel eine Wirbelkapsel (100VC) ist, optional wobei der Artikel eine Einheit oder eine Komponente eines Sprunggelenks (100AJ, 200AJ) ist, optional wobei die Keramik aus Mg-TTZ das Licht derart überträgt, dass der chirurgische Zement durch den Einsatz einer Beleuchtung durch das Implantat bis zum Zement schneller abbindet.

Revendications

1. Procédé pour fabriquer un implant prothétique à corps de céramique ou un composant d'implant prothétique de

céramique Mg-TTZ à partir d'une poudre qui est une zircone monoclinique comportant de l'oxyde de magnésium en tant que stabilisateur, lequel procédé comprend :

la mise à disposition d'un corps de céramique vert initial sous forme de biscuit en mettant à disposition un matériau de céramique en poudre (10), qui est une zircone monoclinique comportant de l'oxyde de magnésium en tant que stabilisateur, la compression du matériau sous sa forme de poudre par une opération de pressage isostatique à froid (1, 2, 3, 18, 19) pour former un corps vert initial pressé brut (520), et ensuite le chauffage du corps vert initial pressé brut à un stade de biscuit (4) pour obtenir le corps vert initial sous forme de biscuit (521) ; et, une fois que les précédentes étapes sont réalisées sans employer d'agent liant additionnel au matériau de céramique en poudre, la réalisation des étapes supplémentaires suivantes :

l'usinage du corps vert initial sous forme de biscuit (521) pour obtenir un corps de céramique vert sous forme de biscuit usiné (530) de sorte que le corps de céramique vert sous forme de de biscuit usiné possède une forme qui est une forme précurseur essentiellement analogue à, ayant les mêmes proportions que, la forme de, mais plus grande que, la partie de céramique d'un implant prothétique à corps de céramique ou d'un composant d'implant prothétique fini, prédéterminé et cuit (540, 550) ; puis la cuisson du corps de céramique vert sous forme de biscuit usiné (6, 38, 39) afin d'obtenir un produit à corps de céramique Mg-TTZ cuit, qui possède la même taille et forme ou essentiellement la même taille et forme que la partie de céramique de l'implant prothétique à corps de céramique ou du composant d'implant prothétique fini, prédéterminé et cuit.

2. Procédé selon la revendication 1, dans lequel le matériau de céramique (10) est de la poudre de zircone monoclinique ayant une section transversale d'environ 0,5 micromètre (μm) à 10 μm, en tant que micropoudre, ou ayant une section transversale d'environ 1 nanomètre (nm) à 500 nm, en tant que nanopoudre, laquelle micropoudre ou nanopoudre peut contenir entre deux à cinq pour cent en poids d'oxyde de magnésium en tant que stabilisateur.

3. Procédé selon la revendication 1 ou la revendication 2, dans lequel le corps de céramique vert sous forme de biscuit usiné (6, 38, 39) est cuit dans un four entre environ 1600 et 1900 °C.

4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel l'implant prothétique à corps de céramique ou le composant d'implant prothétique de Mg-TTZ est pour ou composé d'un implant ou d'un composant d'implant prothétique complexe porteur (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 1007A, 150, 160, 200, 200AJ, 207Q, 350, 550, 1000), facultativement qui est un composant fémoral pour un implant de genou postéro-stabilisé (135, 550), un composant fémoral pour un implant de genou rotatoire (100, 100M, 150, 160, 350, 550, 1000), ou un composant fémoral pour un implant de genou à conservation du ligament croisé qui comprend des surfaces articulaires condyliennes médiales et latérales (100CR, 110, 550) ; et facultativement dans lequel :

un polissage (8) est la seule opération de finition mécanique du corps de céramique cuit (540).

5. Procédé selon l'une quelconque des revendications 1 à 3, utilisé pour la fabrication d'un article de fabrication comprenant un implant prothétique ou un composant d'implant prothétique de Mg-TTZ, dans lequel l'implant prothétique à corps de céramique ou le composant d'implant prothétique est un implant ou un composant prothétique complexe (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 107A, 150, 166, 200, 200AJ, 207Q, 350, 550, 1000).

6. Procédé selon la revendication 5, dans lequel l'implant prothétique à corps de céramique ou le composant d'implant prothétique de Mg-TTZ peut être en outre traité après cuisson uniquement par polissage (8), facultativement dans lequel l'implant prothétique ou le composant d'implant prothétique est au moins un d'un article d'un composant fémoral ou tibial pour une articulation de genou de remplacement (100, 100CR, 100M, 100PF, 100UK, 150, 160, 200, 350, 550, 1000), facultativement dans lequel l'article est un composant fémoral pour un implant de genou postéro-stabilisé (100, 100M, 135, 135P, 550), facultativement dans lequel l'article est un composant de structure fémorale pour un implant de genou contenant un dispositif de rotation (100, 101, 1000), facultativement dans lequel l'article est un composant fémoral à conservation du ligament croisé pour un genou (100CR) et facultativement dans lequel l'article est un composant de condyle fémoral unicompartimental pour un genou (100UK).

7. Procédé selon la revendication 5, dans lequel l'implant prothétique à corps de céramique ou le composant d'implant prothétique de Mg-TTZ est au moins un d'un article d'un dispositif d'espacement de genou unicompartimental monobloc (100U) ou d'un dispositif d'alignement articulaire unicompartimental multibloc (100UU), facultativement

dans lequel l'article est un implant de capsule de l'articulation temporomandibulaire (100TM), facultativement dans lequel l'article est un implant d'articulation fémoro-patellaire (100TM), facultativement dans lequel l'article est une capsule vertébrale (100VC), facultativement dans lequel l'article est un ensemble ou un composant d'articulation de cheville (100AJ, 200AJ).

8. Procédé selon la revendication 5, dans lequel l'implant prothétique à corps de céramique ou le composant d'implant prothétique de Mg-TTZ est un implant de composant fémoral (100, 100CR, 100M, 100UK, 550) possédant une résistance contre un condyle postérieur (113, 114) d'au moins environ 1500 livres (environ 0,68 tonne métrique) lorsqu'il est testé conformément aux normes de la FDA (Food and Drug Administration) des États-Unis, correspondant à des tests de résistance sur un condyle postérieur d' un composant de genou fémoral en métal dans lesquels une force est appliquée dans une direction postéro-antérieure sur une partie non soutenue du condyle, facultativement dans lequel la résistance est d'au moins environ 2000 livres (environ 0,91 tonne métrique) lorsqu'il est ainsi testé, facultativement dans lequel la résistance est d'au moins environ 2500 livres (environ 1,1 tonne métrique) lorsqu'il est ainsi testé, et facultativement dans lequel l'implant possédant une telle résistance est un composant fémoral pour un genou postérostabilisé (100, 100M, 135, 135P, 550).

9. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel l'implant prothétique à corps de céramique ou le composant d'implant prothétique de Mg-TTZ est pour ou composé d'un implant ou d'un composant d'implant prothétique complexe porteur (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 1007A, 150, 160, 200, 200AJ, 207Q, 350, 550, 1000), facultativement qui est un composant fémoral pour un implant de genou postéro-stabilisé (135, 550), un composant fémoral pour un implant de genou rotatoire (100, 100M, 150, 160, 350, 550, 1000), ou un composant fémoral pour un implant de genou à conservation du ligament croisé qui comprend des surfaces articulaires condyliennes médiales et latérales (100CR, 110, 550) ; et facultativement dans lequel :

une opération de pressage isostatique à chaud n'est pas réalisée ;
le matériau de céramique en poudre (10) possède une section transversale d'environ 10 μm au maximum ;
un polissage (8) est la seule opération de finition mécanique du corps de céramique cuit (540) ; et/ou
le corps de céramique cuit (540, 550) possède une densité théorique d'au moins environ 90 pour cent.

10. Procédé selon l'une quelconque des revendications 1 à 3, utilisé pour la fabrication d'un article de fabrication comprenant un implant prothétique ou un composant d'implant prothétique de Mg-TTZ, dans lequel l'implant prothétique à corps de céramique ou le composant d'implant prothétique est un implant ou un composant prothétique complexe (100, 100AJ, 100CR, 100M, 100PF, 100TM, 100U, 100UK, 100UU, 100VC, 107A, 150, 166, 200, 200AJ, 207Q, 350, 550, 1000) et par conséquent n'est pas une boule, une boule tronquée, une boule forée pour une articulation de hanche ou d'épaule.

11. Procédé selon la revendication 5, dans lequel l'implant prothétique à corps de céramique ou le composant d'implant prothétique de Mg-TTZ peut être en outre traité après cuisson uniquement par polissage (8), facultativement dans lequel l'implant prothétique ou le composant d'implant prothétique est au moins un d'un article d'un composant fémoral ou tibial pour une articulation de genou de remplacement (100, 100CR, 100M, 100PF, 100UK, 150, 160, 200, 350, 550, 1000), facultativement dans lequel l'article est un composant fémoral pour un implant de genou postéro-stabilisé (100, 100M, 135, 135P, 550), englobant facultativement une masse de céramique de Mg-TTZ comprenant une structure (101) dotée de parois latérales (102) et d'une partie supérieure (103T) qui relie les rebords condyliens gauche et droite (104, 25, 105, 106) qui possèdent des condyles (110), comprenant des condyles antérieurs, inférieurs et postérieurs (111, 112, 113, 114, 115, 116) qui forment une échancrure intercondylienne (118), et une butée de stabilisation postérieure (135, 135P) à l'intérieur de ladite échancrure, ledit composant étant monobloc, facultativement dans lequel l'article est un composant de structure fémorale pour un implant de genou contenant un dispositif de rotation (100, 101, 1000) englobant facultativement une structure de céramique cuite monobloc de Mg-TTZ dotée de parois latérales 102) et d'une paroi frontale (103) se trouvant dans une échancrure intercondylienne (118) entre des rebords condyliens latéraux et médiaux antérieurs, inférieurs et postérieurs (104, 105, 106) qui possèdent des surfaces articulaires correspondantes (111, 112, 113, 114, 115, 716) plus une surface trochléenne (117) essentiellement entre lesdits rebords antérieurs et les condyles antérieurs respectifs, lesdites parois étant capables de recevoir une partie mâle rotative dépendante (30, 61, 150, 160, 3511) qui peut être engagée par un réceptacle (250, 260) dans un plateau tibial correspondant (200), facultativement dans lequel l'article est un composant fémoral à conservation du ligament croisé pour un genou (100CR) englobant facultativement une masse de céramique de Mg-TTZ comprenant une surface articulaire lisse de suivi rotulien (117) en position antérieure entre des rebords condyliens gauche et droite qui possèdent des condyles (110), lesdits condyles comprenant des condyles inférieurs et postérieurs gauche et droite (111, 112, 113, 114) entre lesquels se trouve une échancrure

intercondylienne vide (118), ledit composant étant monobloc, et facultativement dans lequel l'article est un composant de condyle fémoral unicompartimental pour un genou (100UK) englobant facultativement une masse de céramique de Mg-TTZ comprenant une surface de condyle articulaire lisse (110) qui comprend des condyles antérieurs, inférieurs et postérieurs (111/112, 113/114, 115/116), ledit composant étant monobloc.

12. Procédé selon la revendication 5, dans lequel l'implant prothétique à corps de céramique ou le composant d'implant prothétique de Mg-TTZ est au moins un d'un article d'un dispositif d'espacement de genou unicompartimental monobloc (100U) ou d'un dispositif d'alignement articulaire unicompartimental multibloc (100UU), facultativement dans lequel l'article est un implant de capsule de l'articulation temporo-mandibulaire (100TM), facultativement dans lequel l'article est un implant d'articulation fémoro-patellaire (100TM), facultativement dans lequel l'article est une capsule vertébrale (100VC), facultativement dans lequel l'article est un ensemble ou un composant d'articulation de cheville (100AJ, 200AJ), facultativement dans lequel la céramique de Mg-TTZ transmet la lumière de sorte qu'une prise plus rapide de ciment chirurgical peut être obtenue par l'utilisation d'une illumination à travers l'implant jusqu'au ciment.

Fig. 1

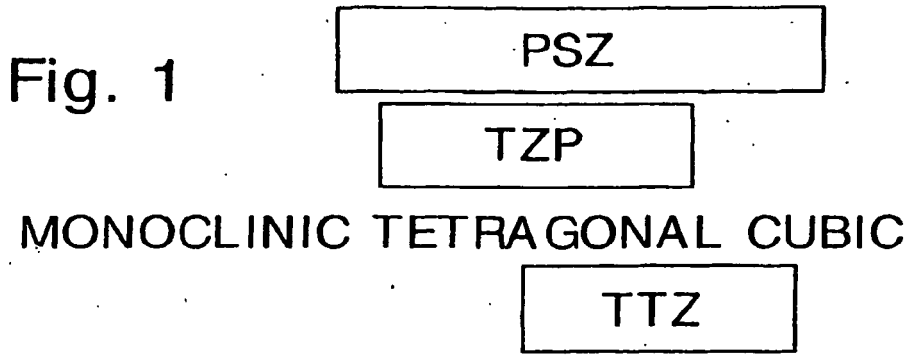
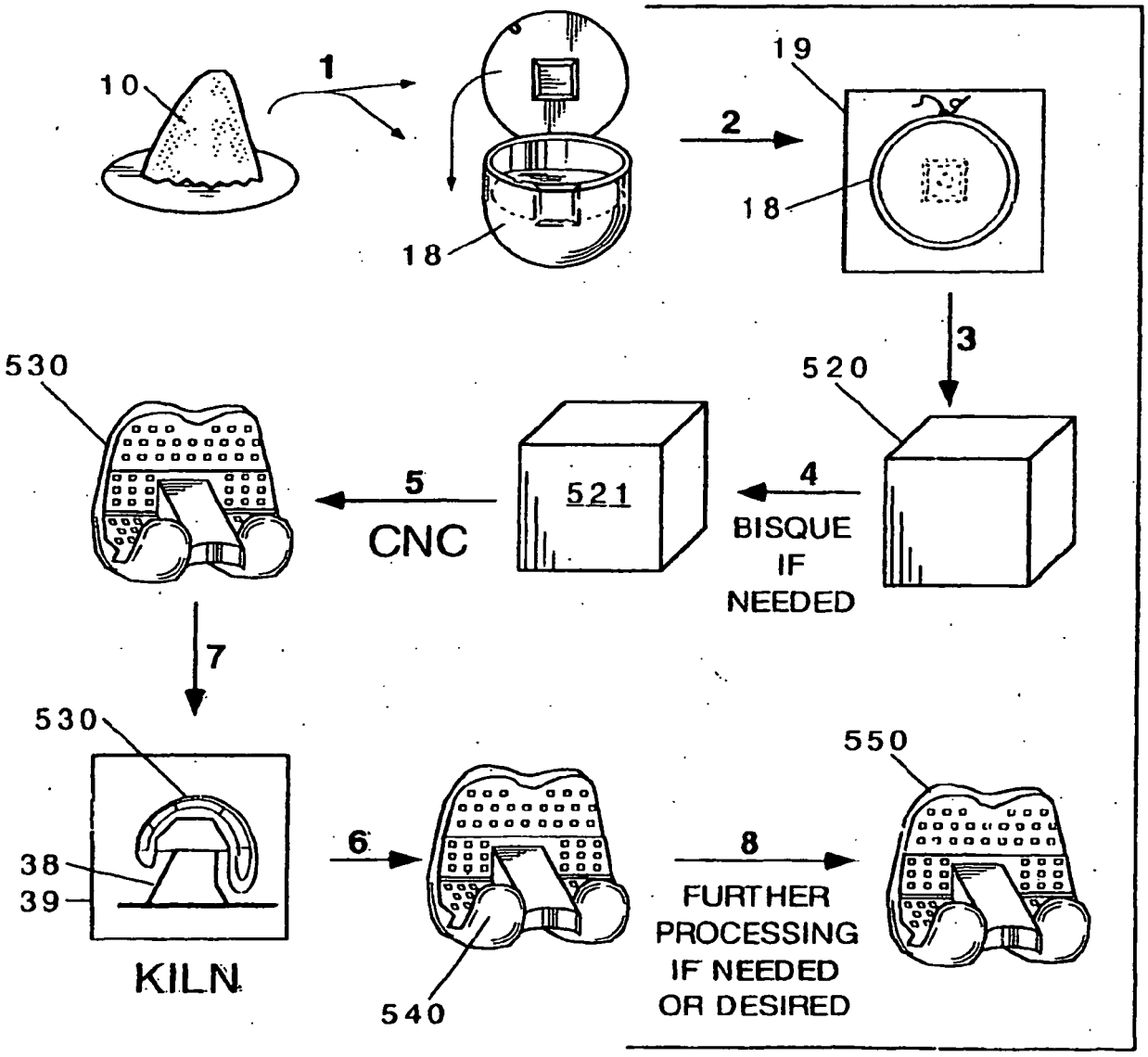

PSZ
TZP
MONOCLINIC TETRAGONAL CUBIC
TTZ

Fig. 2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IF
NEEDED
7
530
38
39
KILN
6
540
8
FURTHER
PROCESSING
IF NEEDED
OR DESIRED
550

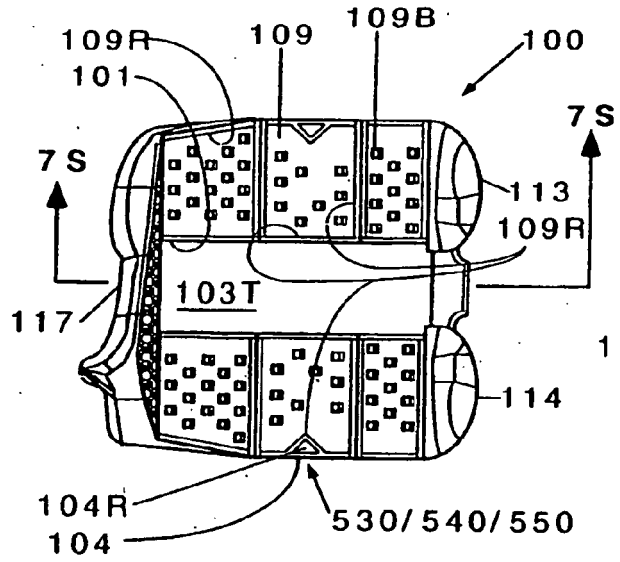


Fig. 3

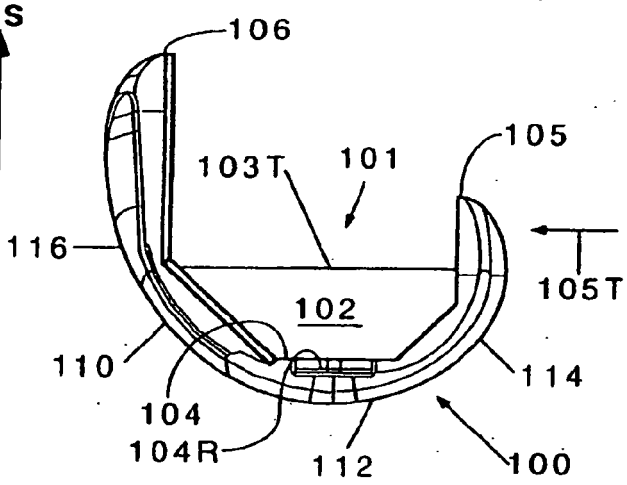


Fig. 4

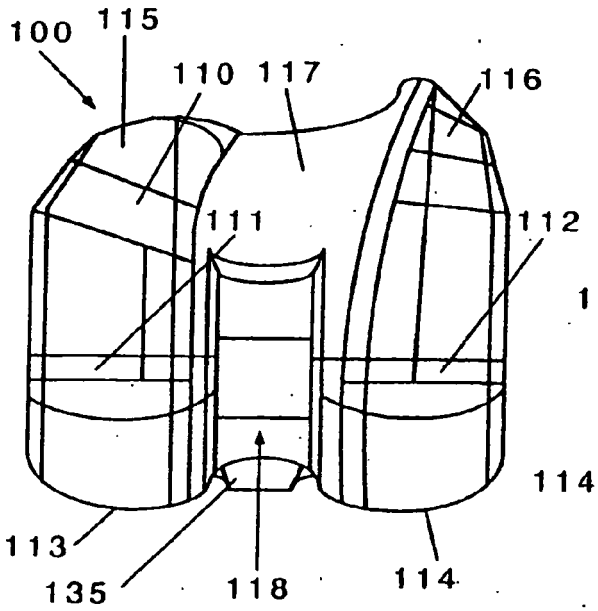


Fig. 5

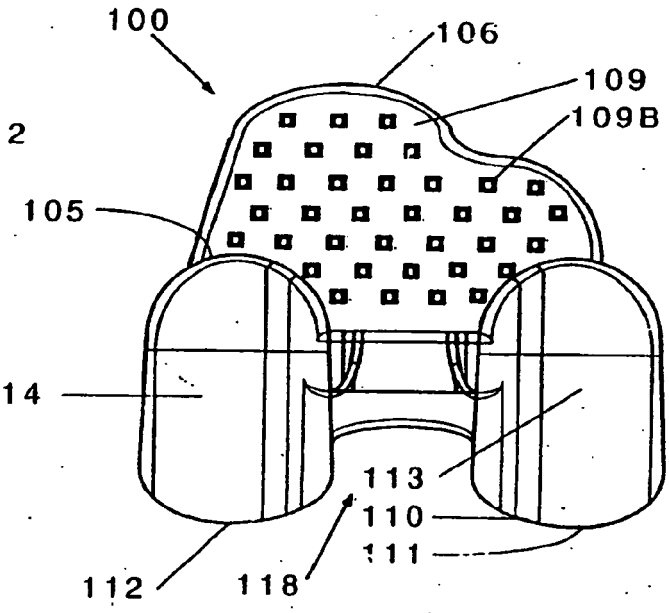


Fig. 6

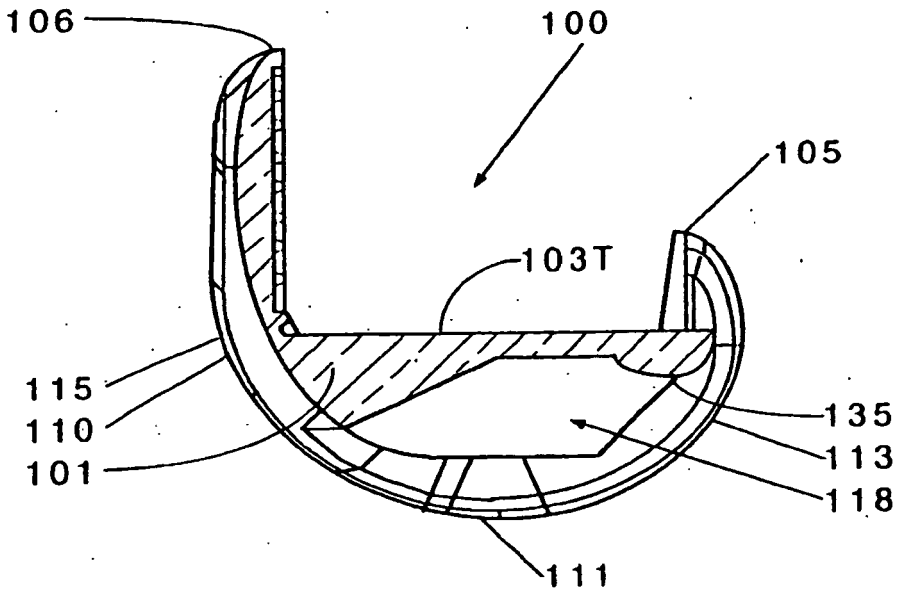

106
100
105
103T
115
110
101
135
113
118
111

Fig. 7

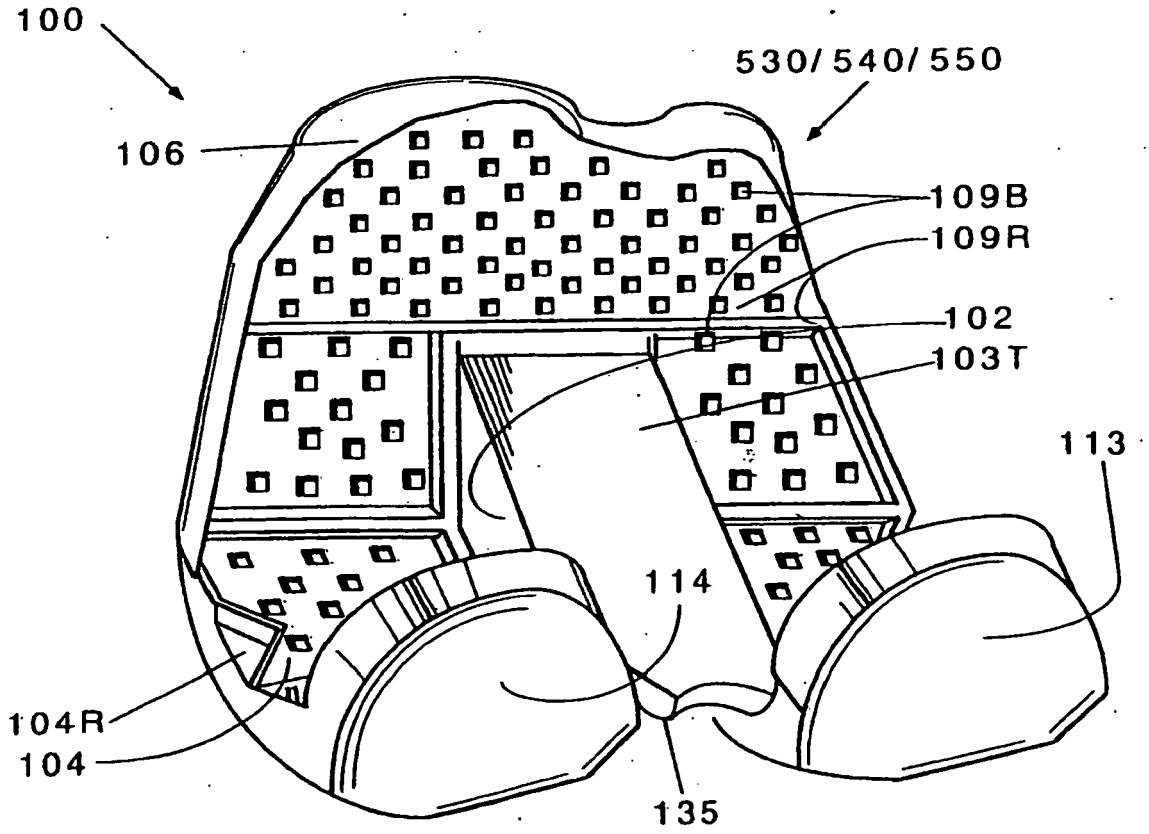

100
530/540/550
106
109B
109R
102
103T
113
114
104R
104
135

Fig. 8

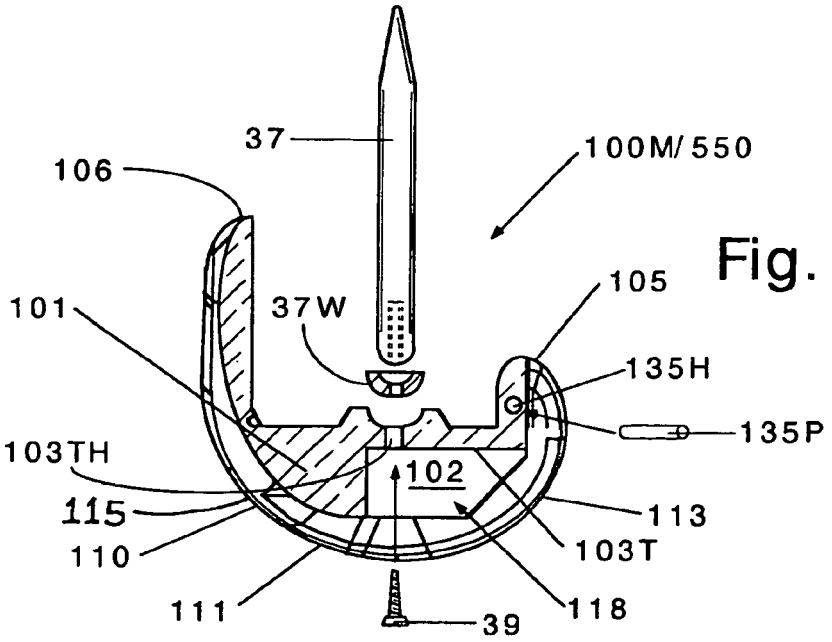


Fig. 9

Fig. 10

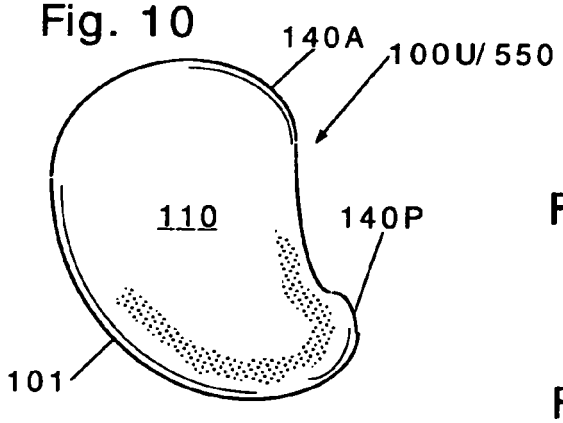


Fig. 11

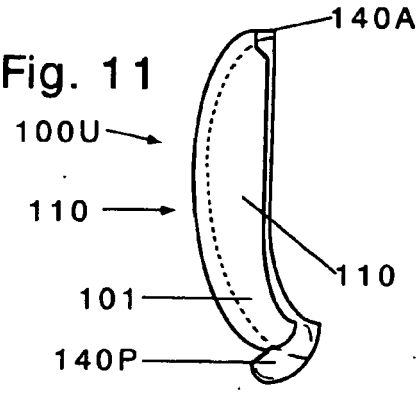


Fig. 12

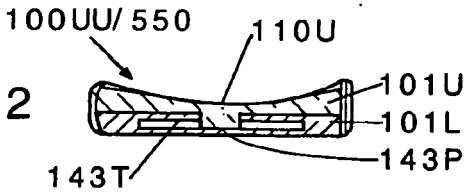


Fig. 13

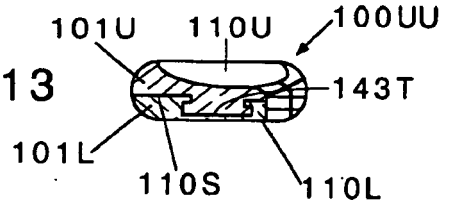


Fig. 14

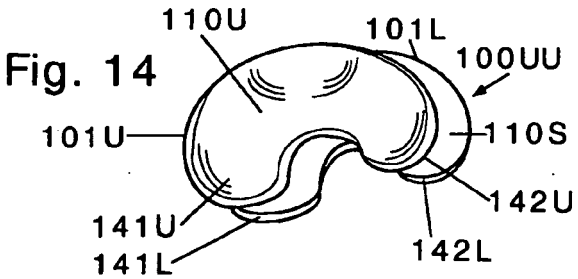


Fig. 15

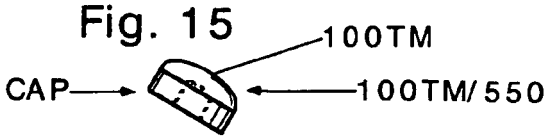


Fig. 16

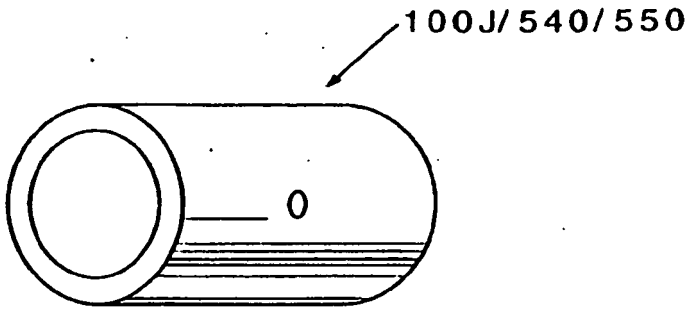


Fig. 17

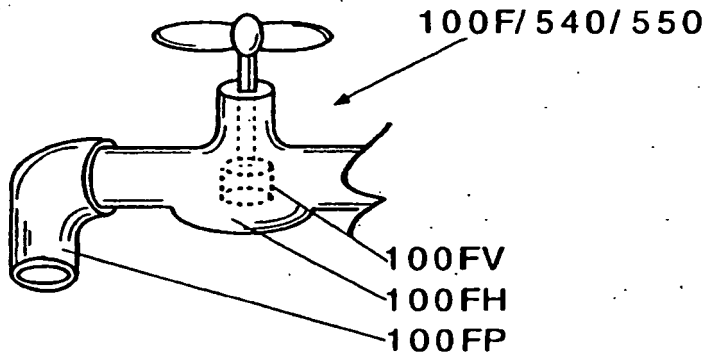


Fig. 18

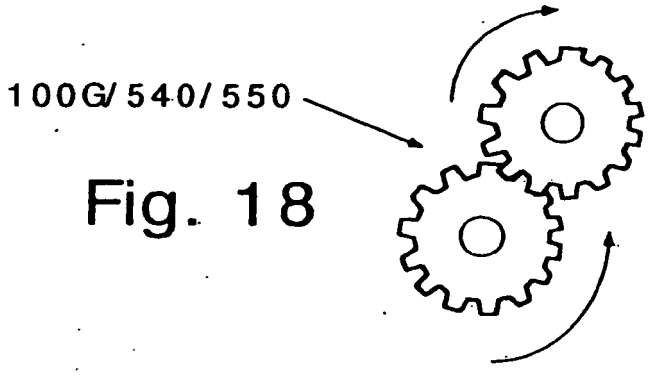


Fig. 19

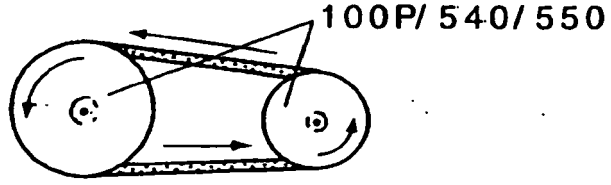


Fig. 20

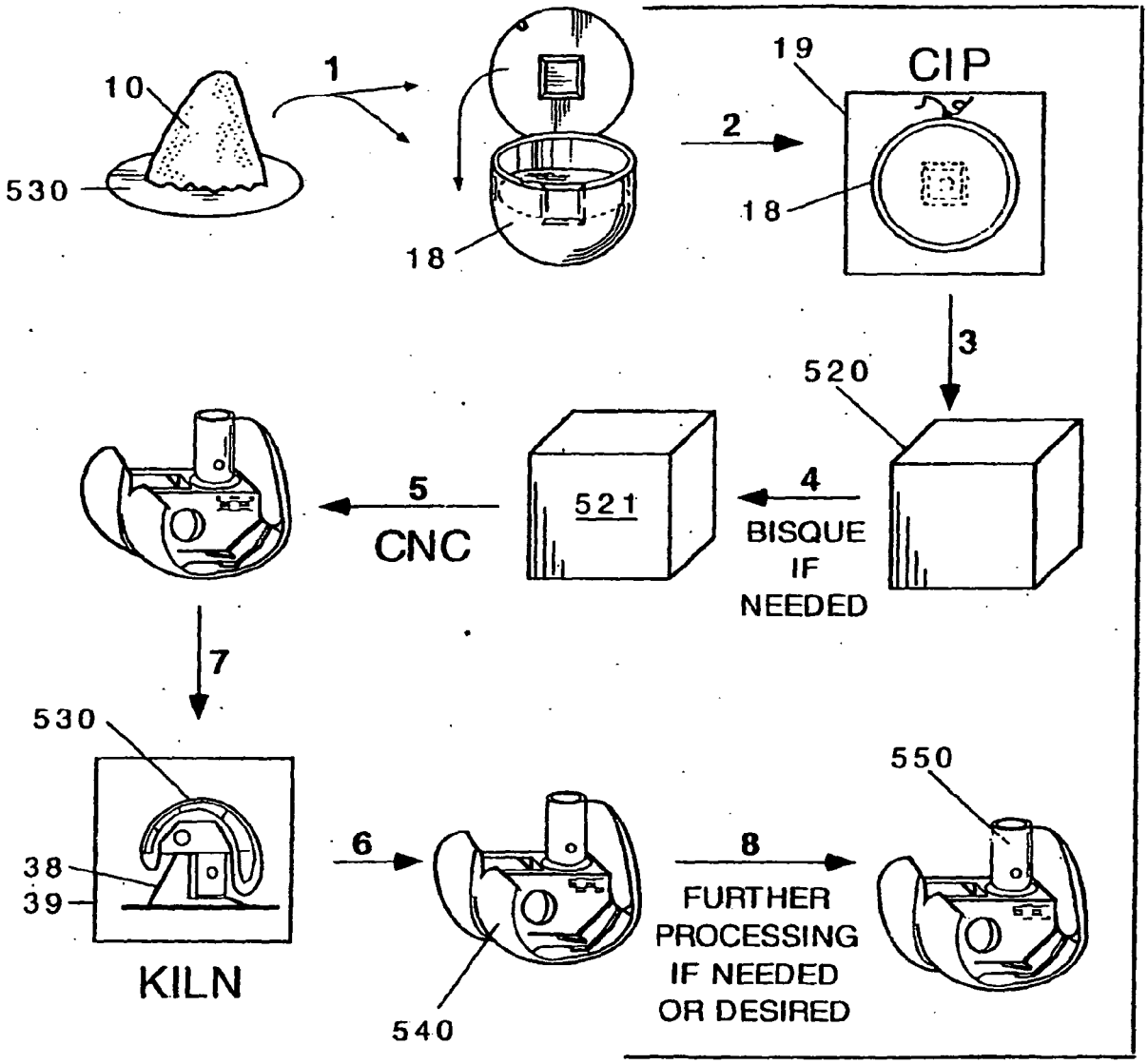

10
530
1
18
19
CIP
2
18
3
520
521
4
BISQUE IF NEEDED
5
CNC
7
530
38
39
KILN
6
540
8
FURTHER PROCESSING IF NEEDED OR DESIRED
550

Fig. 21

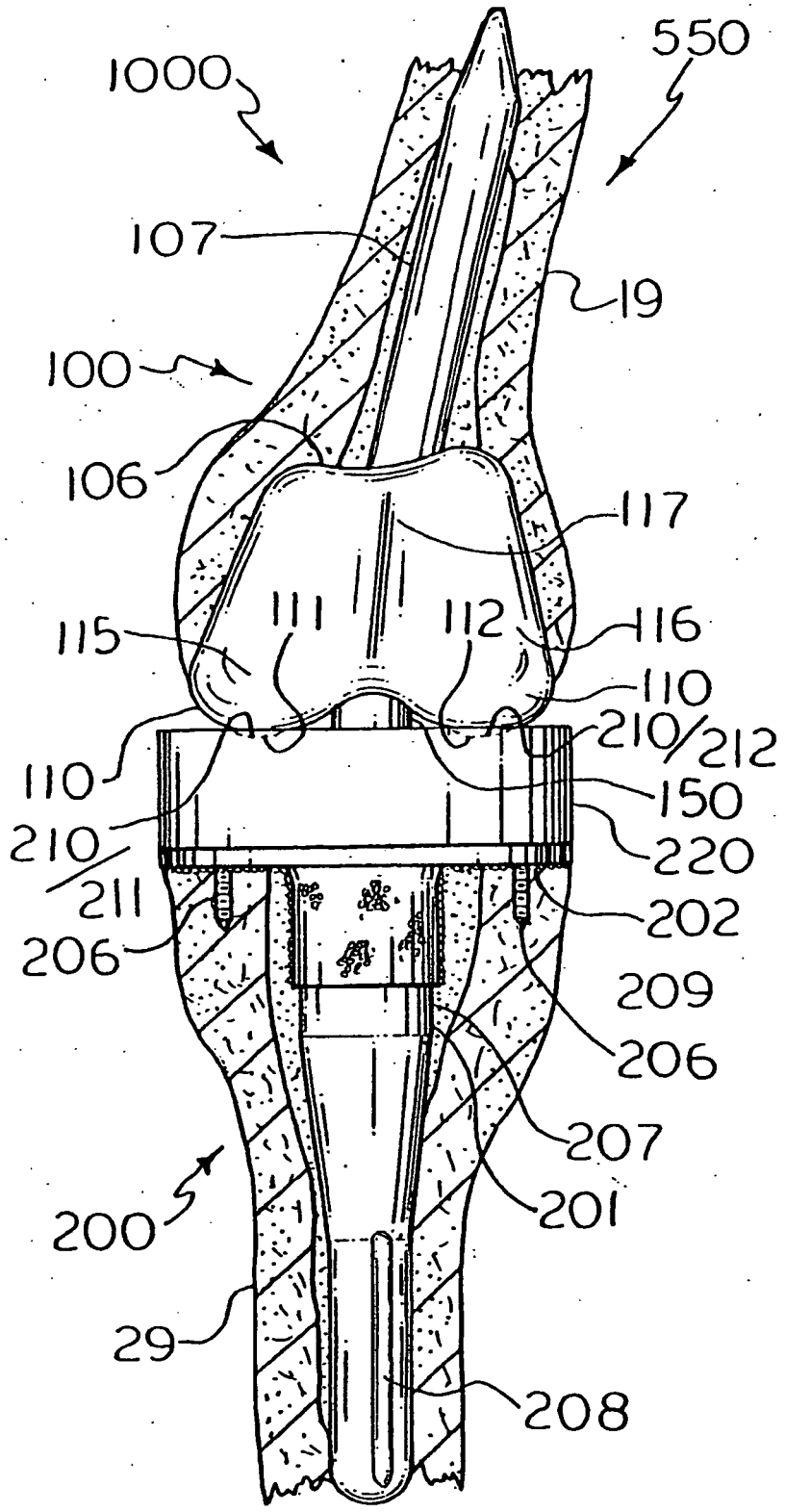
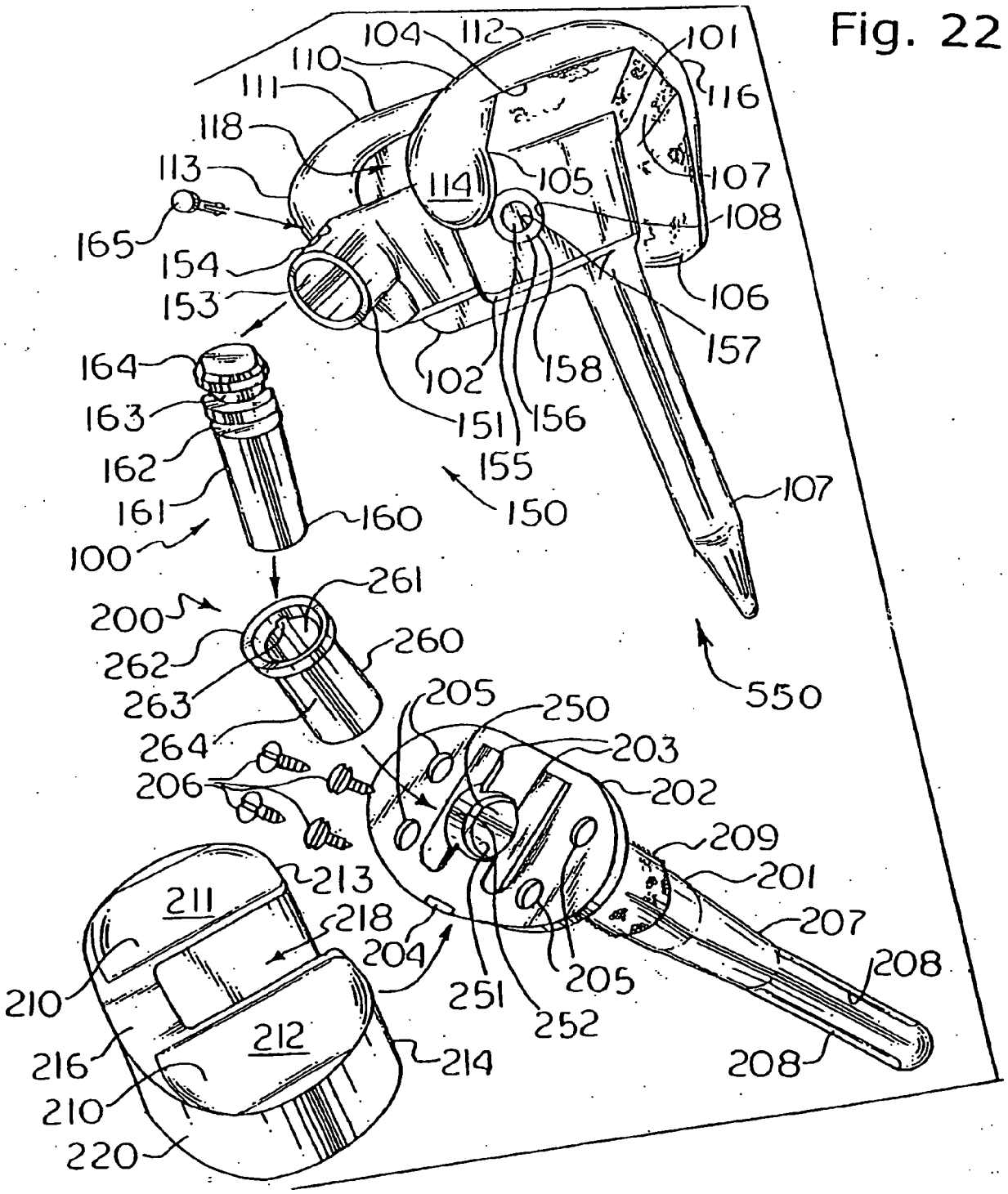

1000
550
107
19
100
106
117
115
111
112
116
110
110
210/212
150
210
220
211
202
206
209
206
207
200
201
29
208

Fig. 22


104
112
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116
111
118
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114
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107
165
108
154
153
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102
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151
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212
252
216
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208
210
220

Fig. 23

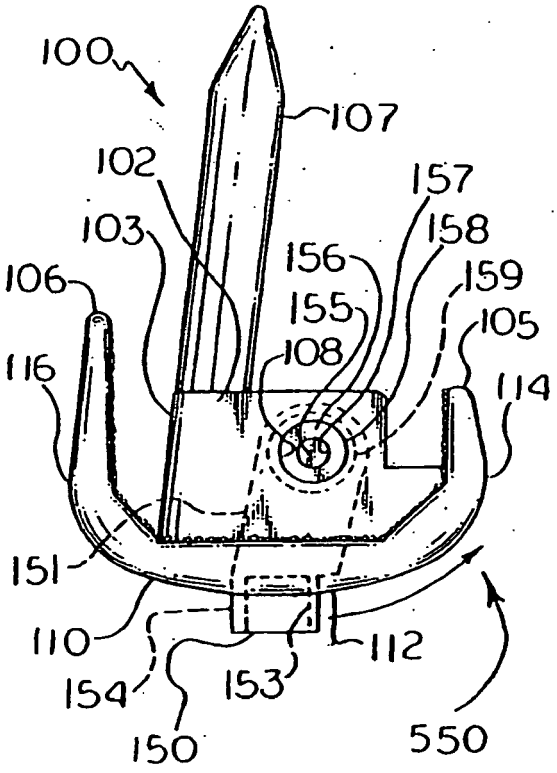


Fig. 24

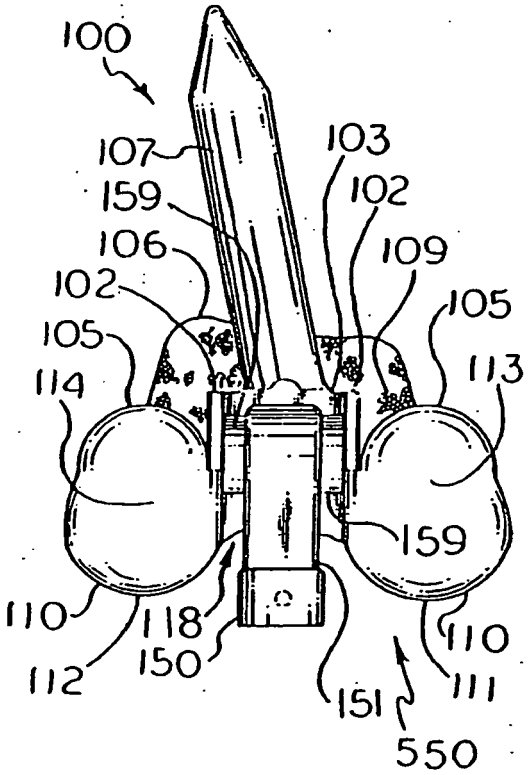


Fig. 25

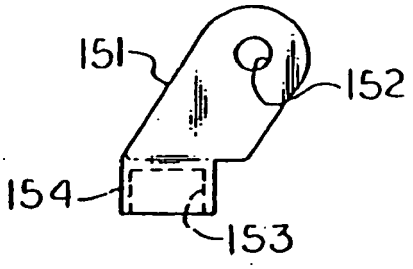


Fig. 26

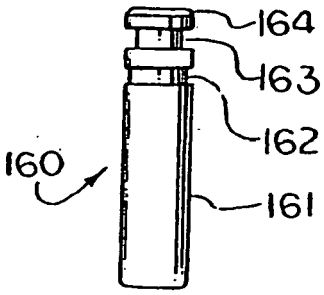
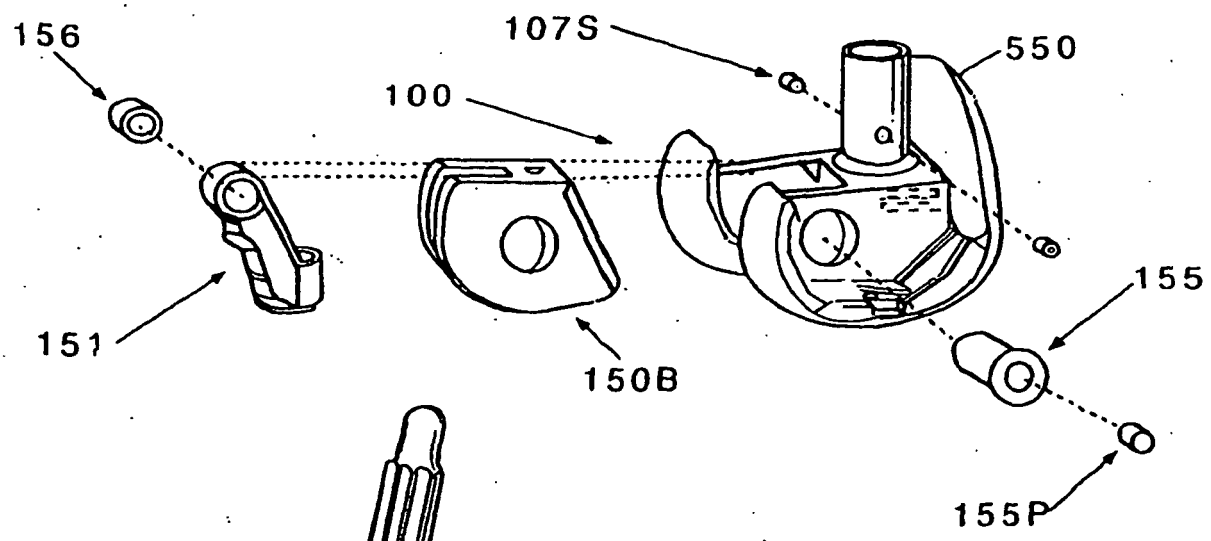


Fig. 27


156
107S
550
100
155
151
150B
155P

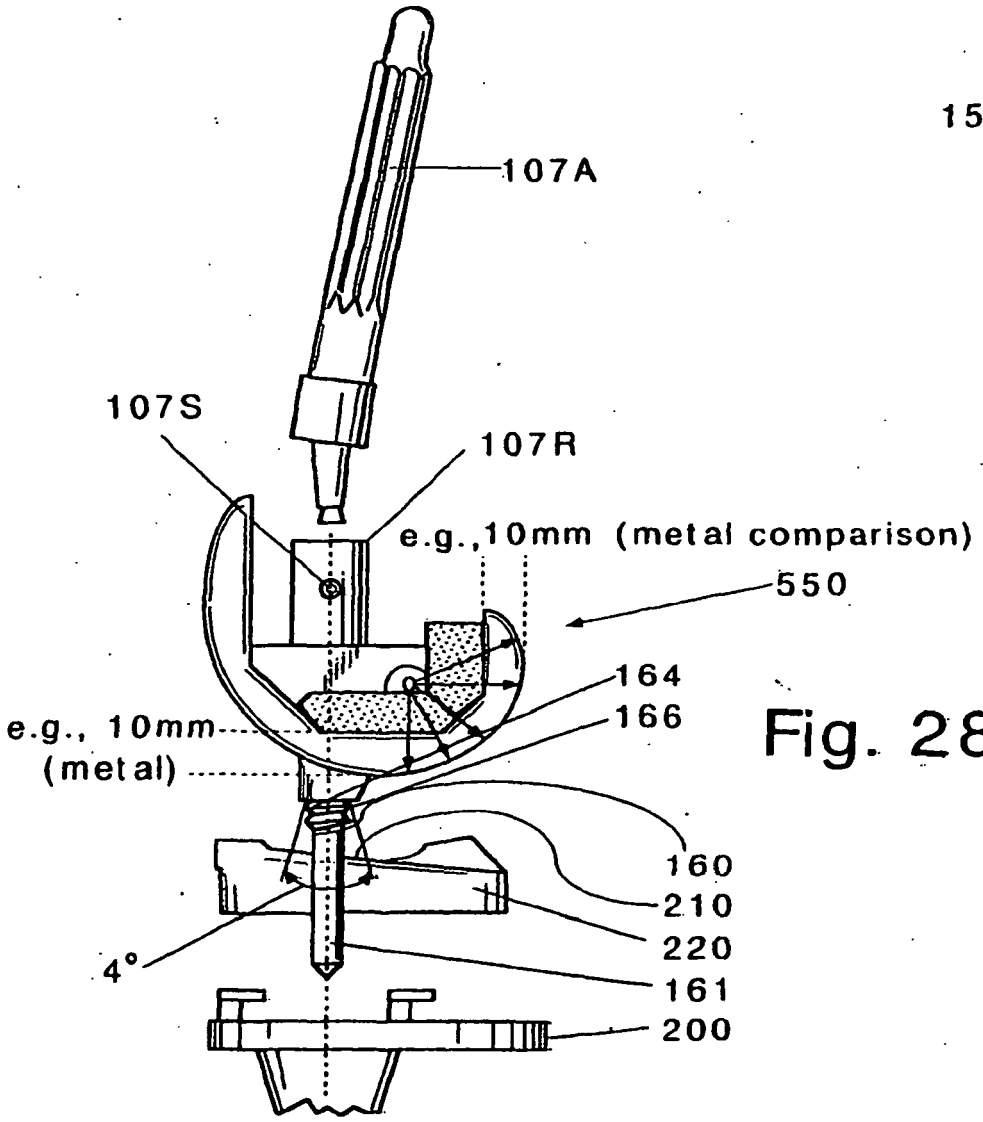

107A
107S
107R
e.g.,10mm (metal comparison)
550
164
166
e.g., 10mm
(metal)
160
210
220
4°
161
200

Fig. 28

Fig. 29

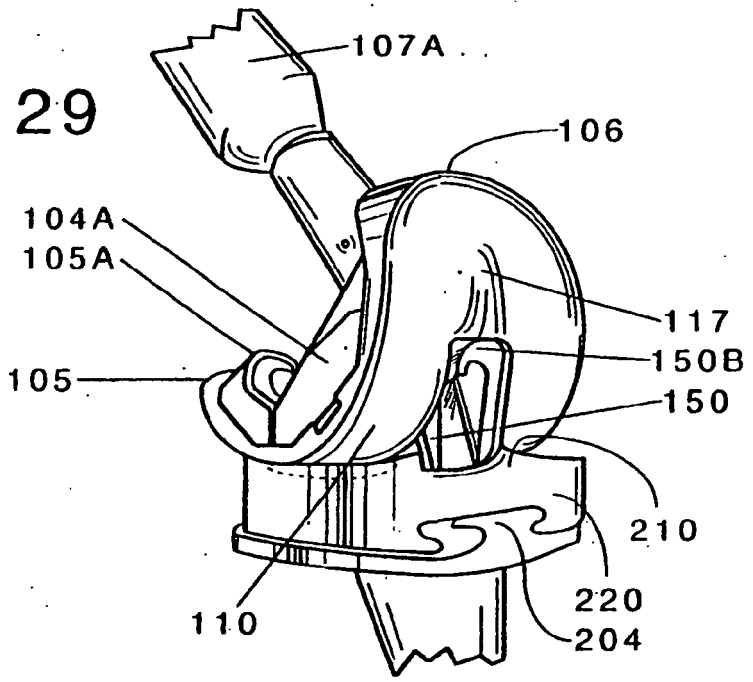

107A
106
104A
105A
117
150B
105
150
210
220
204
110

Fig. 30

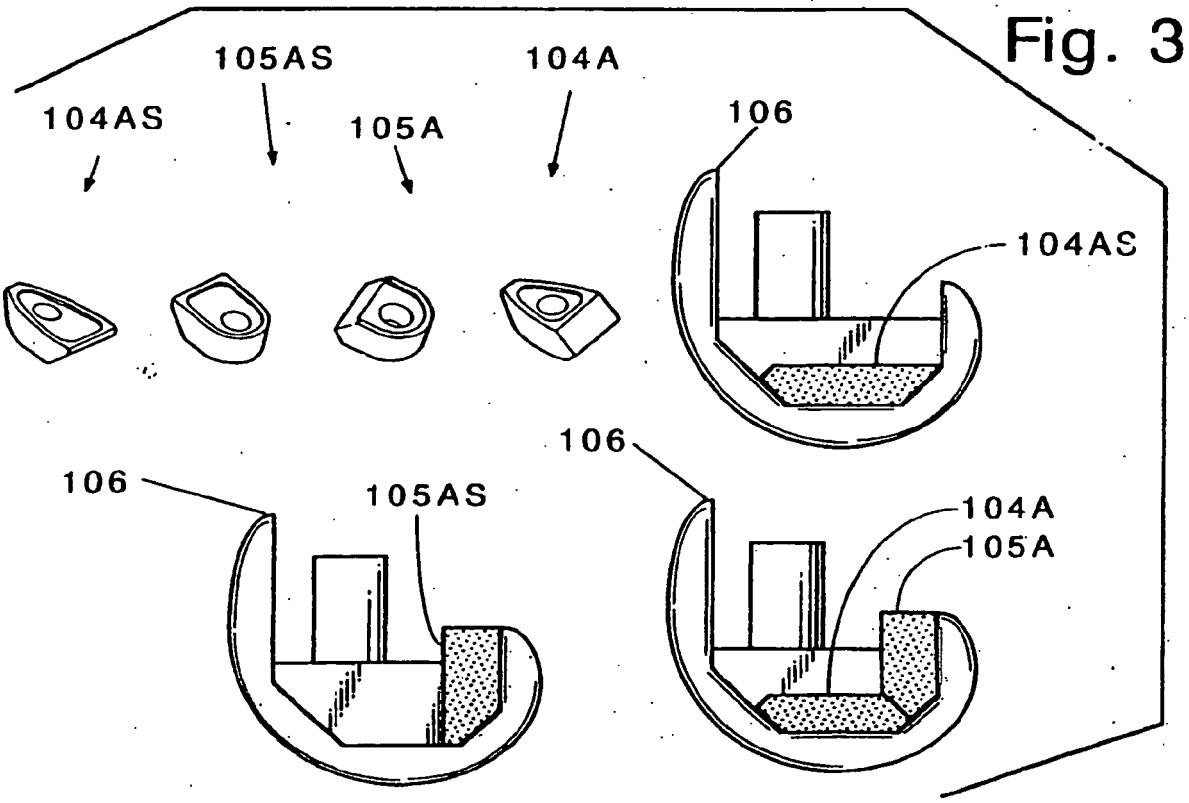

105AS
104A
104AS
105A
106
104AS
106
106
105AS
104A
105A

Fig. 31

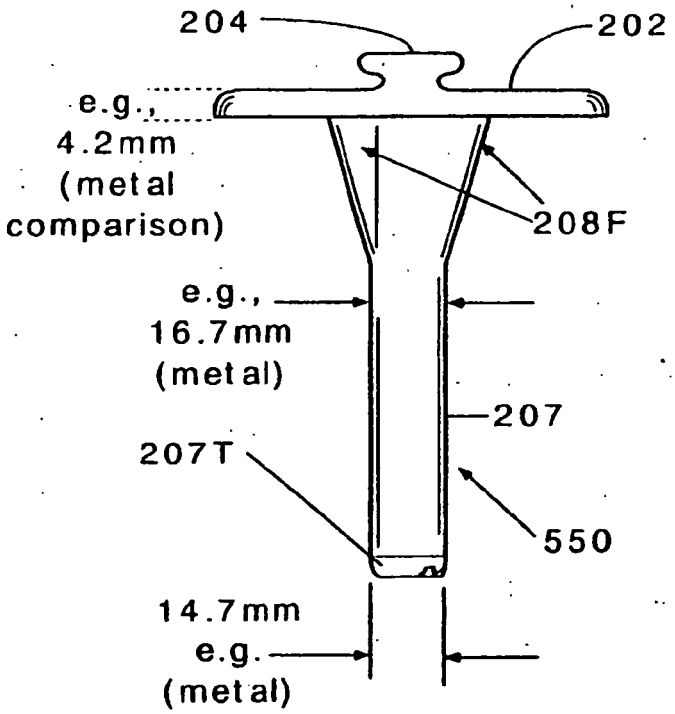


Fig. 32

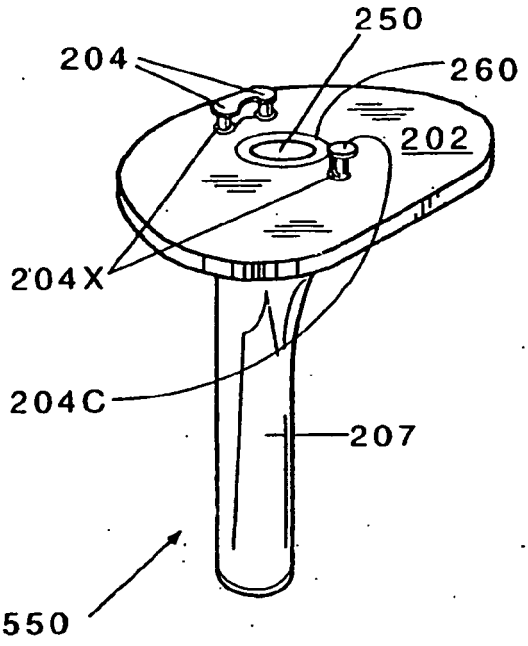


Fig. 33

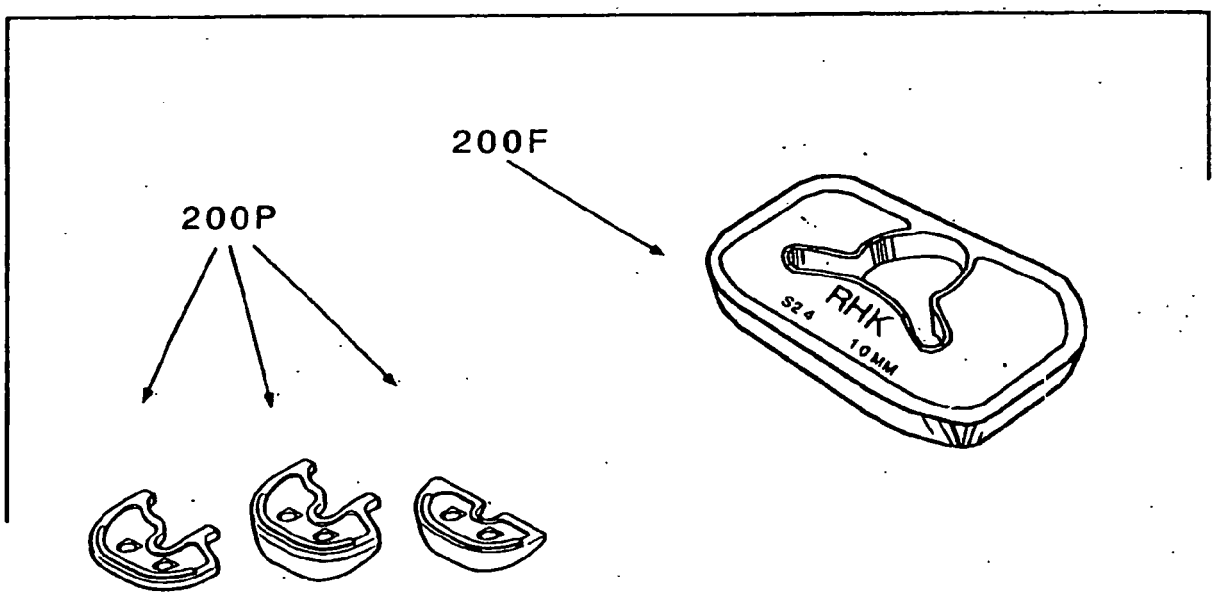


Fig. 34

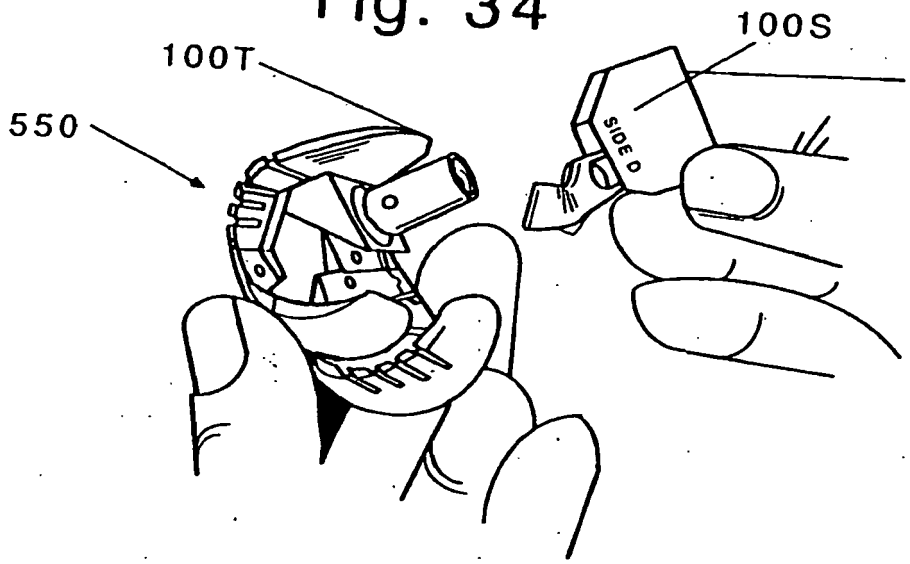


Fig. 35

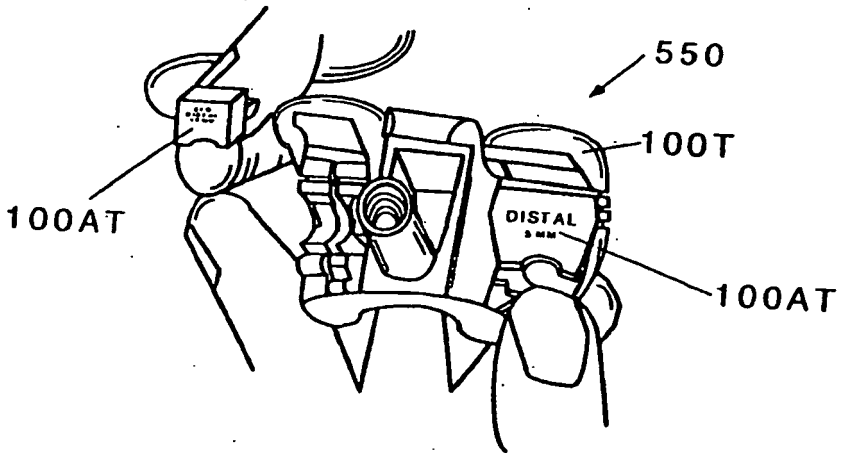


Fig. 36

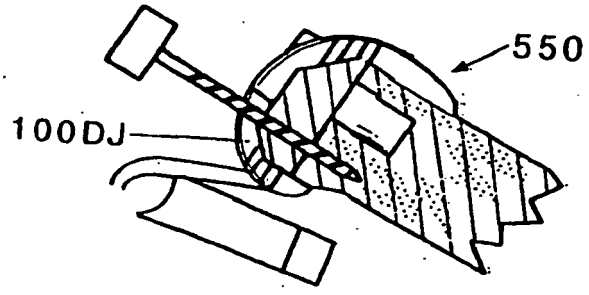
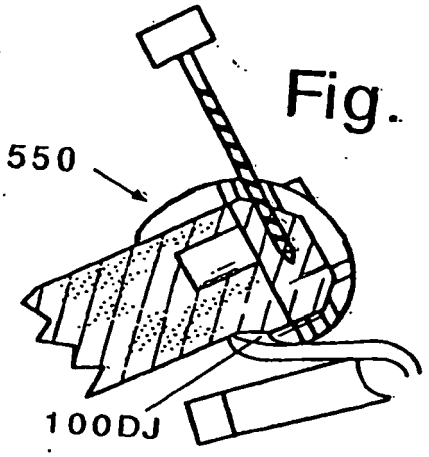


Fig. 37



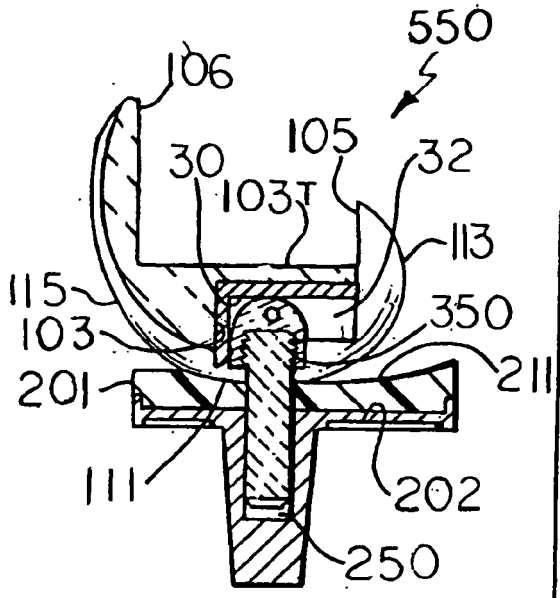


Fig. 38

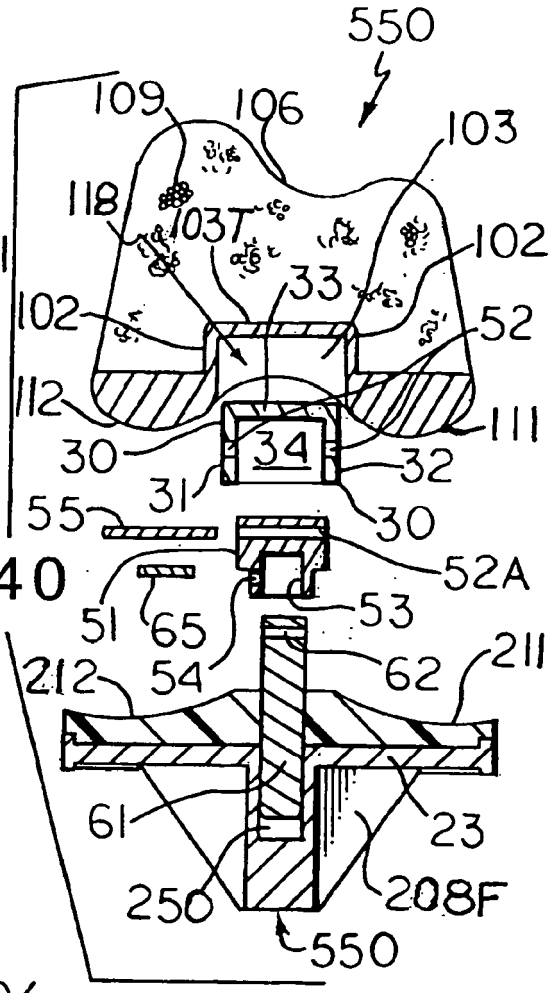


Fig. 40

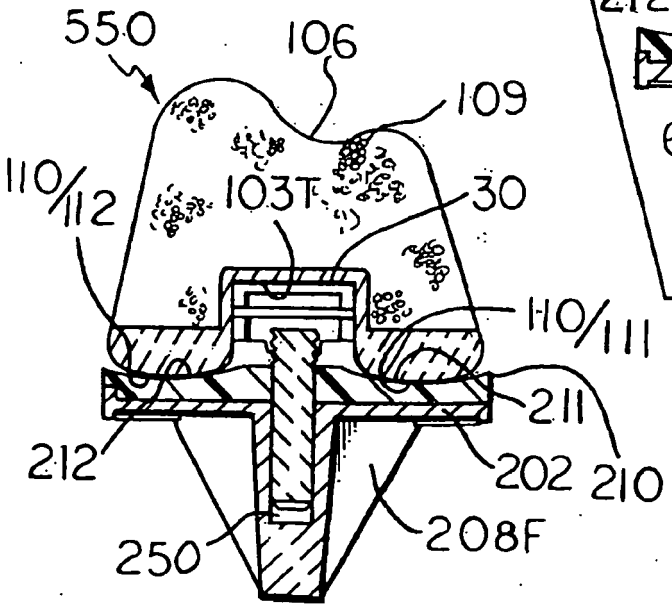
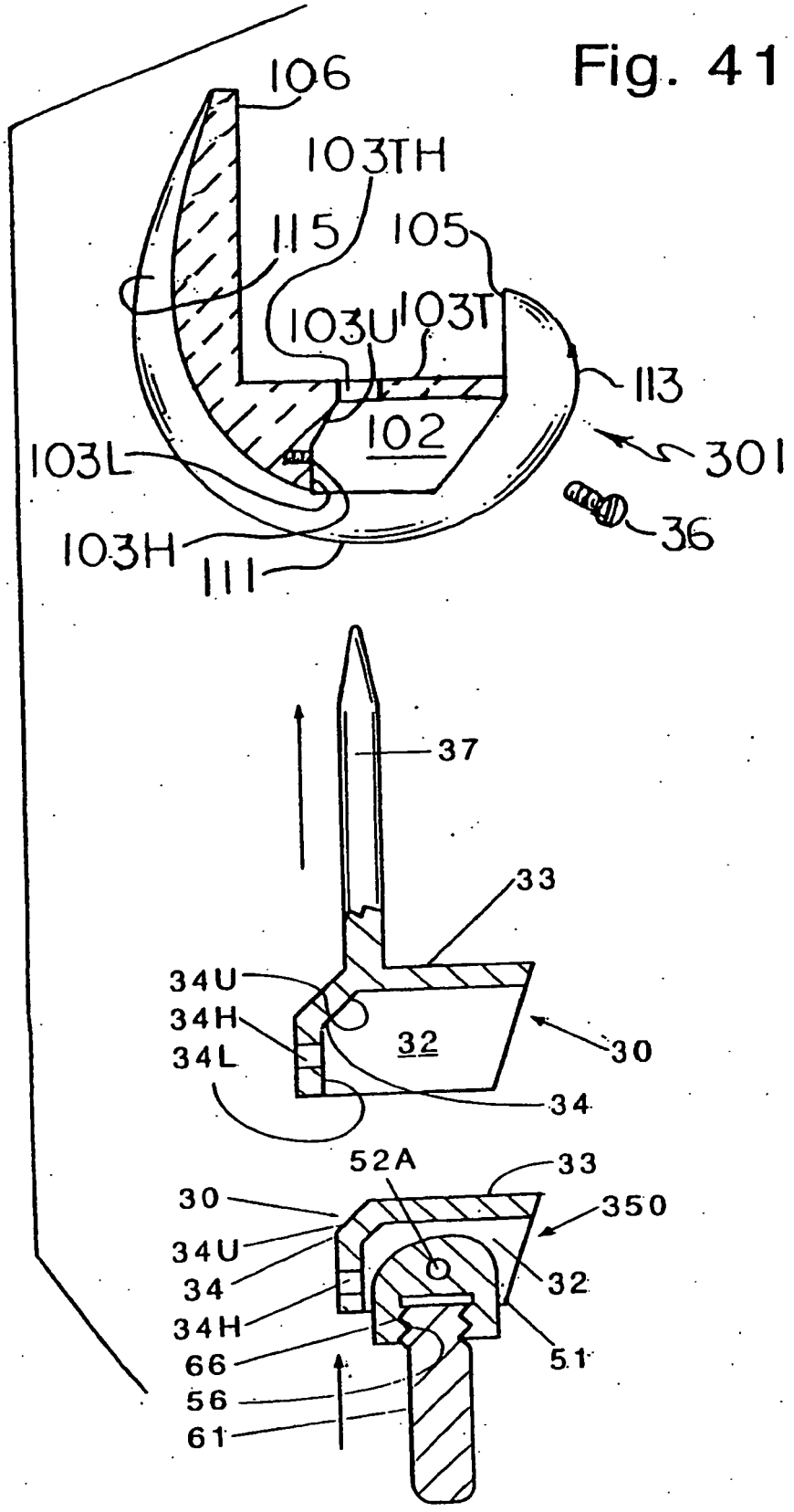


Fig. 39

Fig. 41


106
103TH
115
105
103U
103T
113
102
301
103L
36
103H
111
37
33
34U
34H
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52A
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30
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34U
34
32
34H
51
66
56
61

Fig. 42

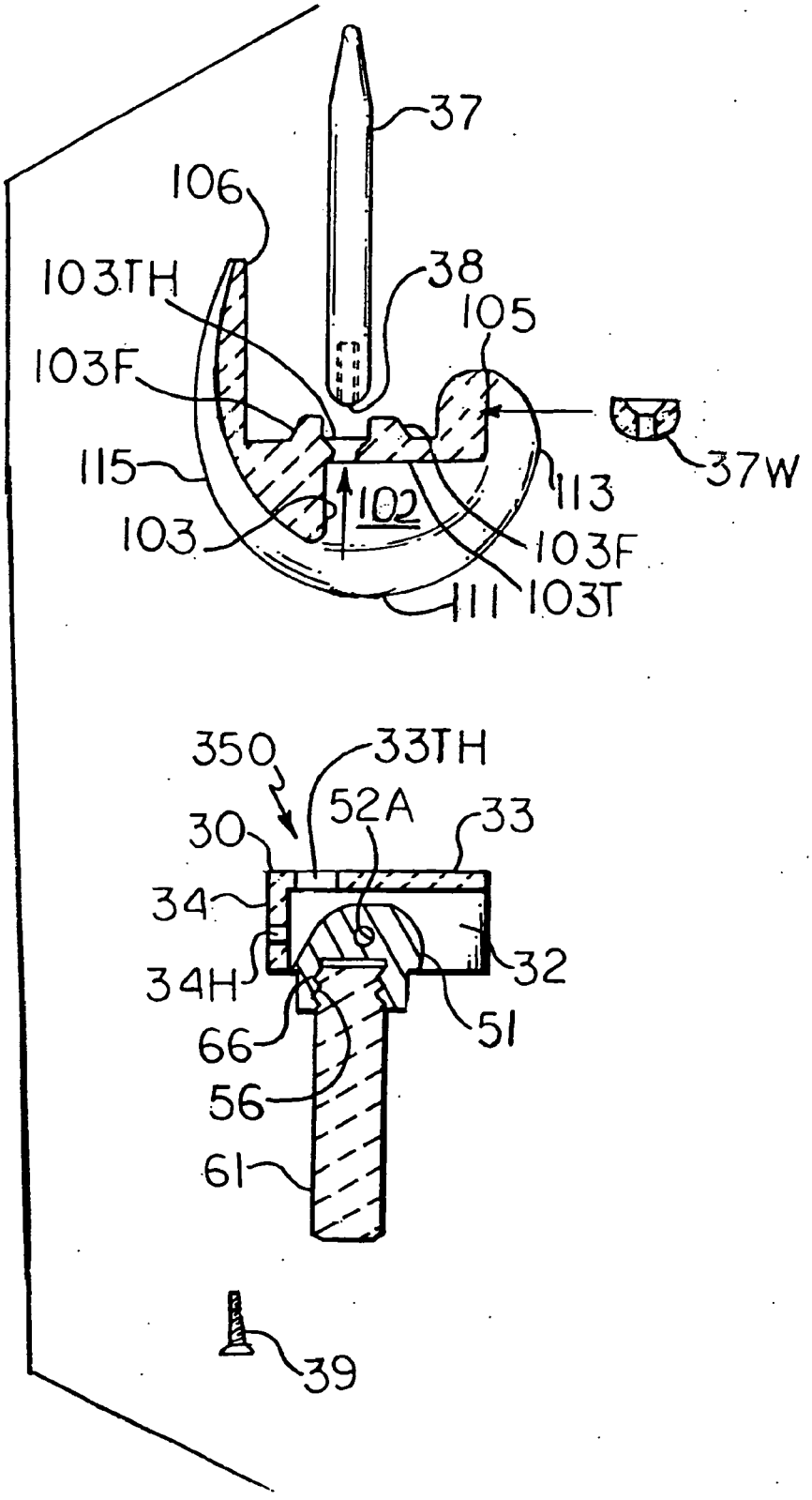
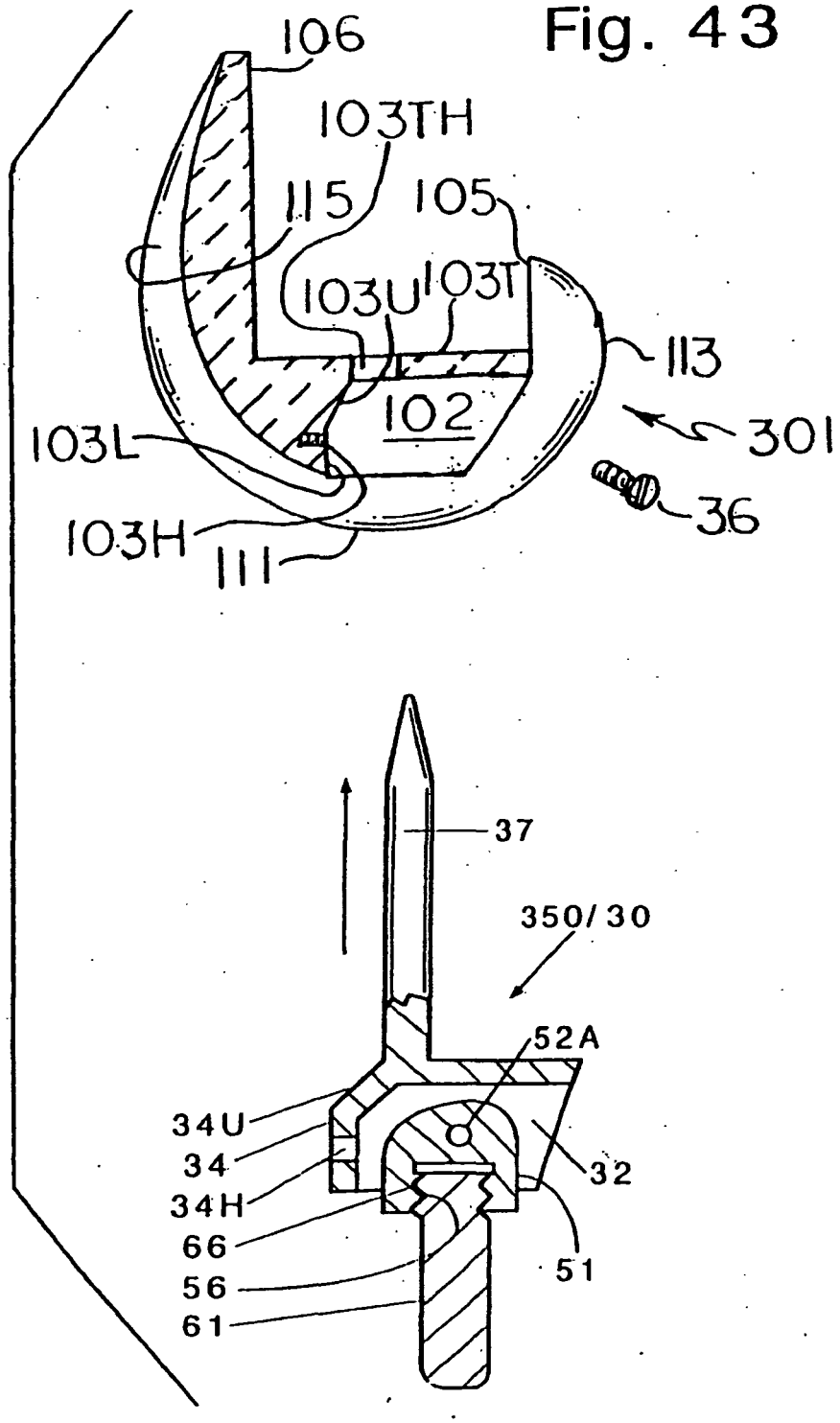

37
106
103TH
38
105
103F
37W
115
113
102
103
103F
111
103T
350
33TH
52A
33
30
34
32
34H
66
51
56
61
39

Fig. 43


106
103TH
115
105
103U
103T
113
102
301
103L
36
103H
111
37
350/30
52A
34U
34
34H
66
56
61
32
51

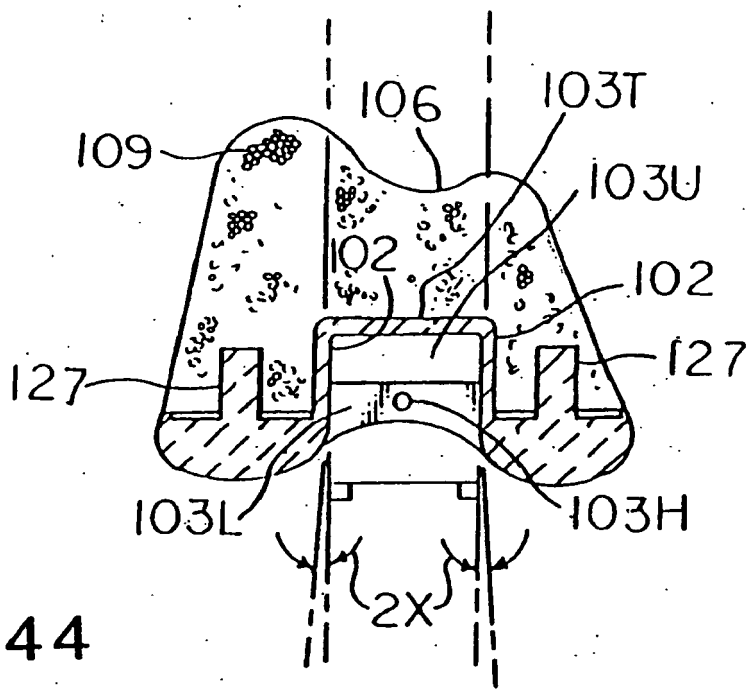


Fig. 44

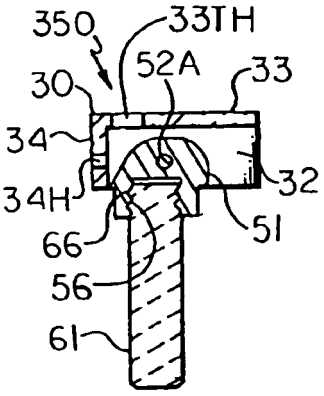


Fig. 45

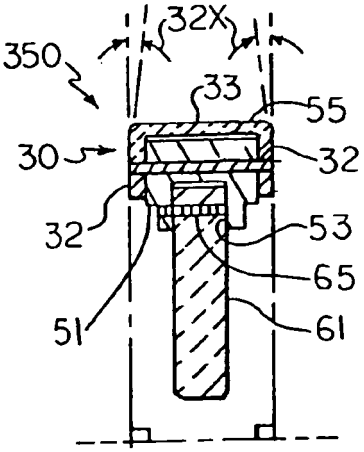


Fig. 46

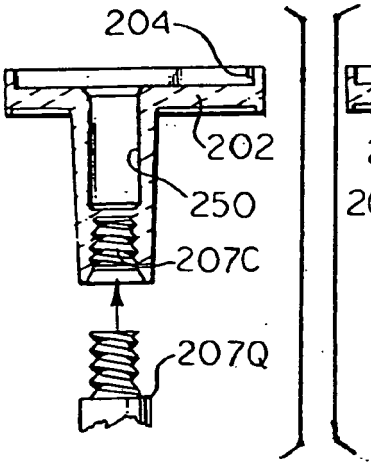


Fig. 47

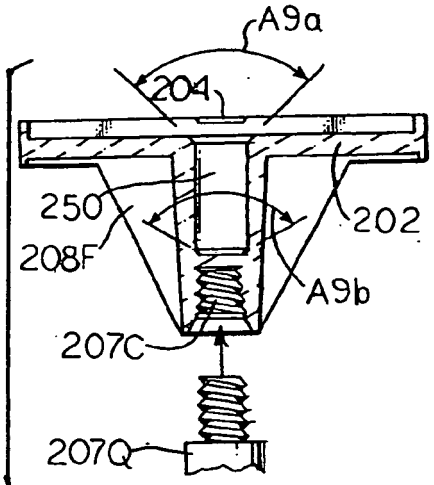


Fig. 48

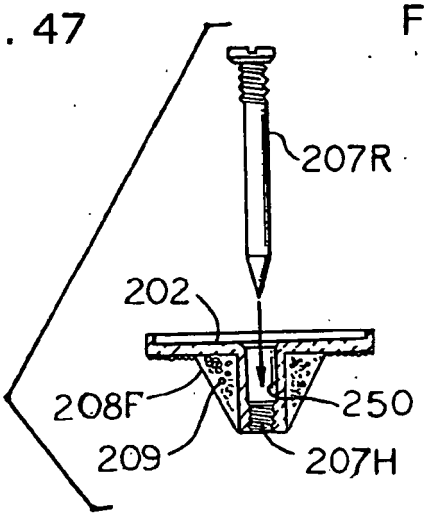


Fig. 49

Fig. 50

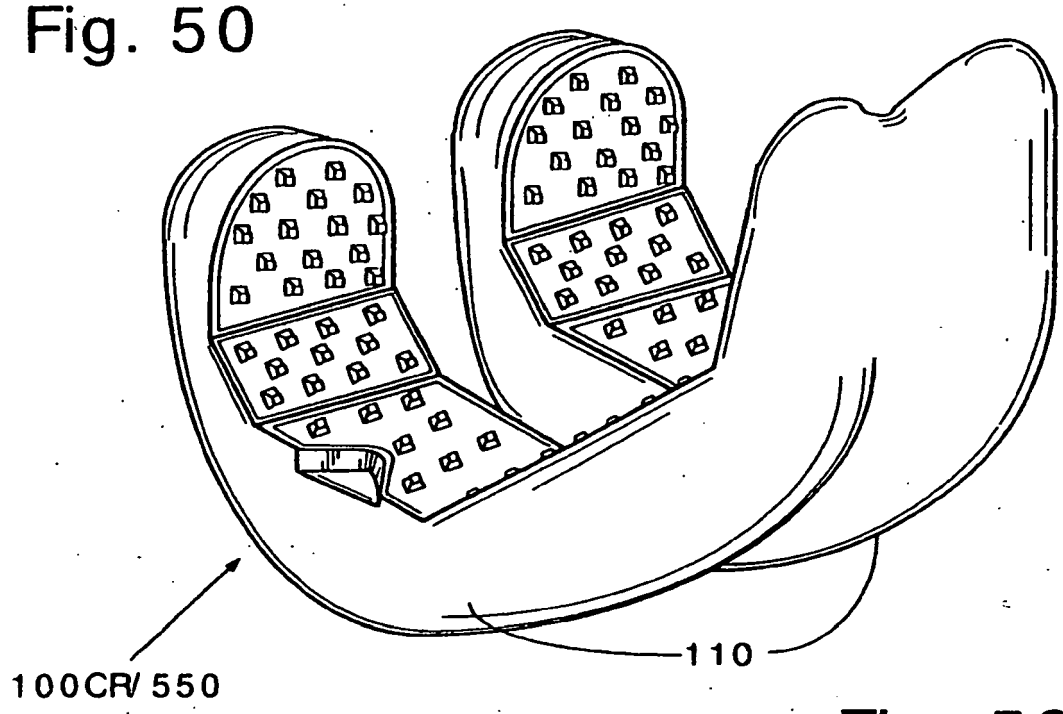


Fig. 51

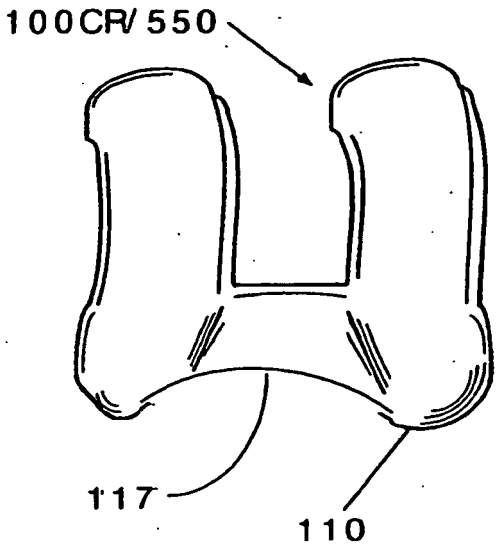


Fig. 52

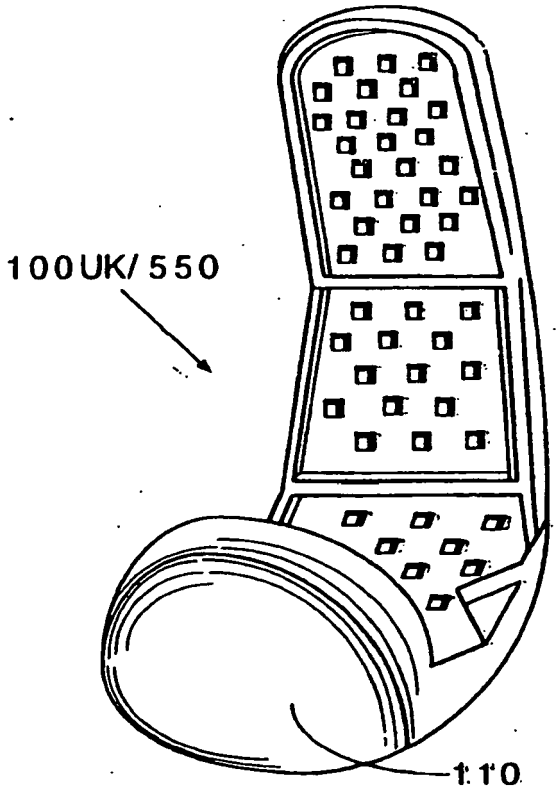


Fig. 53

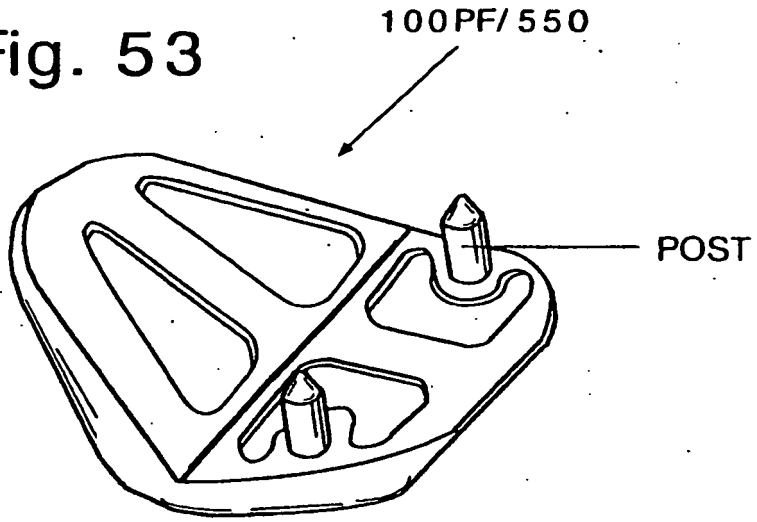
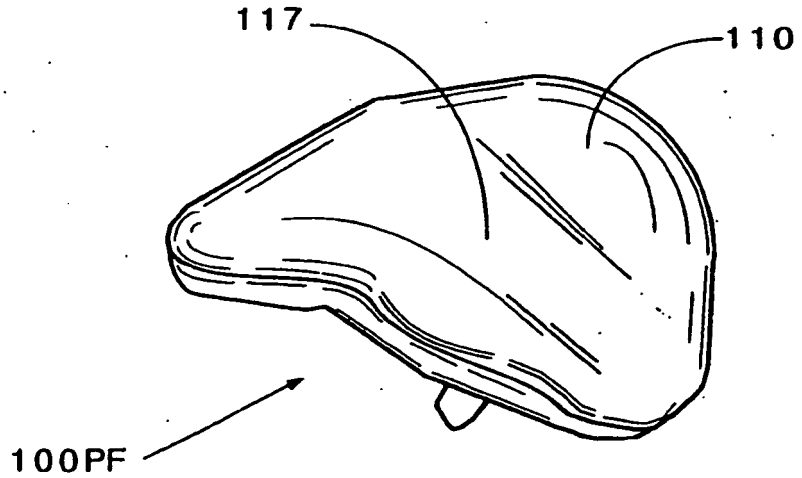


Fig. 54



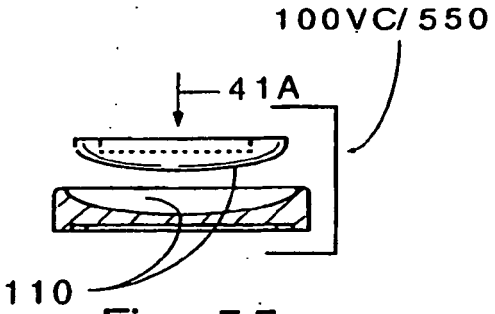


Fig. 55

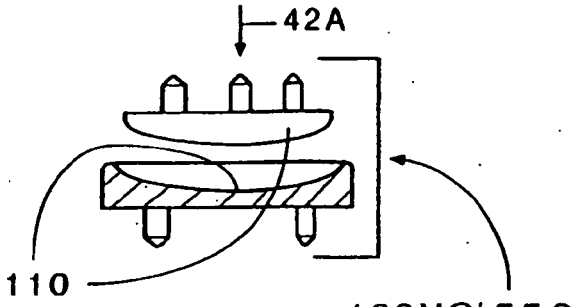


Fig. 57

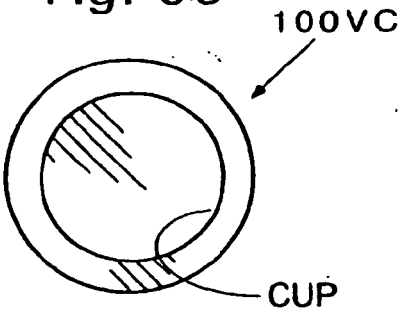


Fig. 56

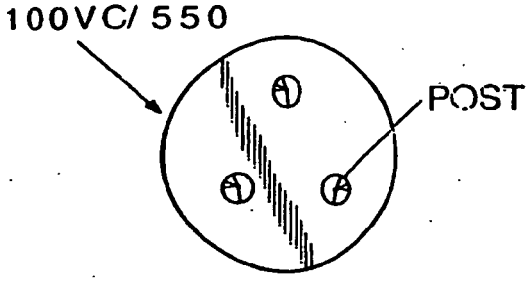


Fig. 58

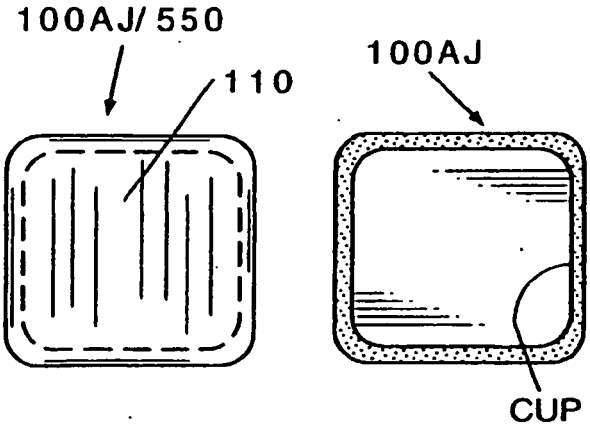


Fig. 59

Fig. 60

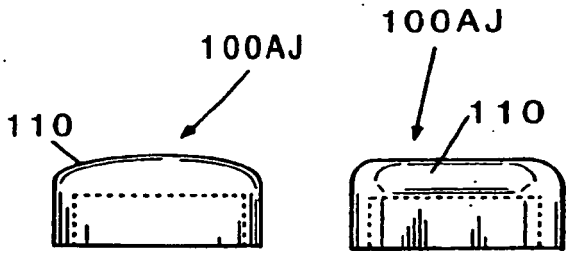


Fig. 61

Fig. 62

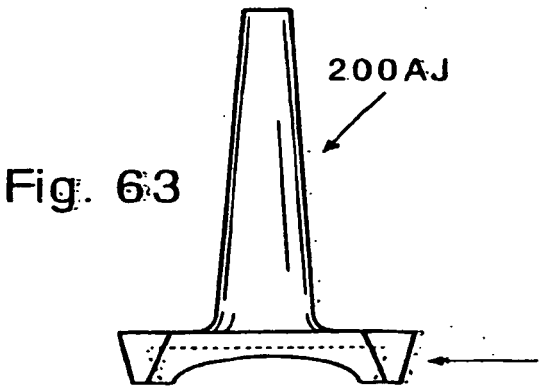


Fig. 63

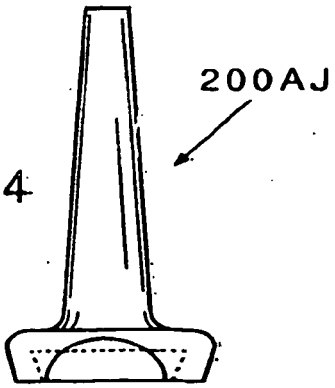


Fig. 64

REFERENCES CITED IN THE DESCRIPTION

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