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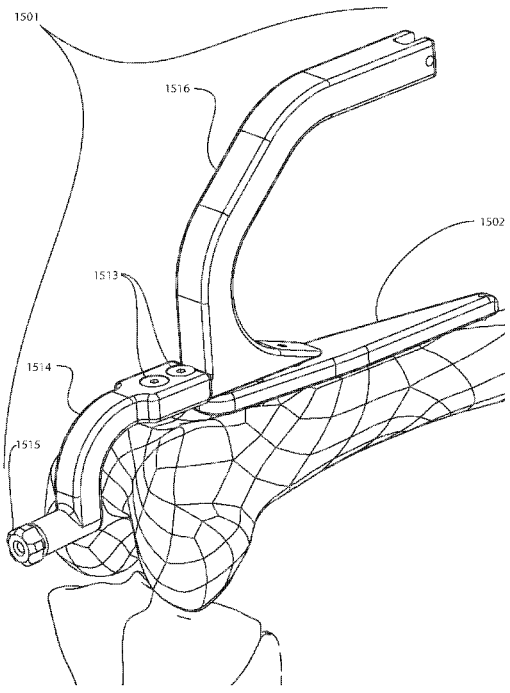

FIG. 8B

(57) Abstract: Knee arthroplasty instrument systems directly reference and align with the anterior distal femoral cortex and the mechanical axis of the leg. The anterior femoral resection is aligned in the same plane as the anterior distal femoral cortex. The center of the femoral head, the medial/lateral center of the distal femur, the medial/lateral center of the proximal tibia, and the second toe, medial/lateral center of the ankle, or anterior tibial spine are all aligned to the mechanical axis of the leg. Methods of using the instrument systems are disclosed.

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KNEE INSTRUMENTS AND METHODS

TECHNICAL FIELD

[0001] The present disclosure relates to instruments and methods to improve femoral and tibial alignment during knee arthroplasty. More specifically, the present disclosure relates to instruments and methods to reference and align with the anterior distal femoral cortex, the mechanical axis of the leg, and Whiteside's line (while intact, prior to any distal femoral resection). While this disclosure is made in the context of knee arthroplasty, the principles are applicable to alignment during other arthroplasty procedures.

BACKGROUND

[0002] Traditional total knee arthroplasty instruments utilize intramedullary instruments to determine proper distal femur saw cut alignment, and extramedullary instruments to align the saw cut for the proximal tibia. Therefore it is acceptable to prepare the distal femur separate from the proximal tibia. There exists no conjoined effort to cut the distal femur and the proximal tibia as the single lower extremity body part which constitutes the knee joint.

[0003] This contemporary instrumentation process violates the principles established by Insall in the 1970s. Popular total knee arthroplasty instruments teaches this inexact intramedullary instrument process because it is simpler to teach, understand and utilize by most surgeons.

[0004] Dr. Insall recognized the need for external rotation (ER) of the femoral component when performing a total knee arthroplasty (TKA). In 1990 Dr. Insall attributed the need for approximately 3 degrees of ER to an “abundance of soft tissue in the posteromedial corner of the knee.”

[0005] Indeed in the absence of this prescribed ER of the femoral component 1) patellar tracking will be unbalanced, related to the trochlear groove and 2) the medial compartment will be compressed significantly greater than the lateral compartment with the knee flexed beyond 40 degrees and 3) the patella would track laterally.

[0006] The reason for alteration of the normal morphology of the distal femur when performing a TKA is not well understood.

[0007] The reason for the need to externally rotate the femoral condyle approximately 3 degrees relative to the normal morphology of the femoral condyles is the clue to surgical alteration of normal morphology of the proximal tibia.

[0008] Normal Anatomy of the Proximal Tibia

[0009] As is well known, in a lateral xray of a normal proximal tibia, the plane of the medial

tibial plateau exists approximately 3 mm more distal than the lateral tibial plateau.

[0010] Evident in a CAT scan of a normal knee is the elevation difference between the planes of the two tibial plateaus.

[0011] If a saw cut is made at the proximal tibia, at a right angle to the vertical axis of the tibia, the medial tibial compartment will be elevated relative to the lateral tibial plateau. This relative elevation will, in turn, elevate the medial femoral condyle, necessitating removal of an equal amount of posterior medial femoral condyle (equal to the relative elevation of the medial tibial plateau) in order to maintain proper tracking of the patellar throughout flexion and extension of the knee. It is the external rotation of approximately 3 degrees (3 mm) that accomplishes about 3mm more removal of the condyle on the medial side than the lateral side.

[0012] The most common adjustment position for "external rotation guides" is 3 degrees. This position will remove about 3mm more off the medial femoral condyle than the lateral femoral condyle. The reality is, and therefore the error is, that condylar and plateau articular cartilage wear, and differences in plateau height between the medial and lateral plateaus, will require external rotation adjustments between 1 degree and 6 degrees in order to balance compression forces in the medial and lateral compartments for both flexion and extension.

[0013] It is only after equal compartment compression is accomplished through proper external rotation that proper ligament releases can be accomplished.

[0014] Method for Getting External Rotation Right

[0015] Equal compression of the medial and lateral compartments can only be obtained by causing the posterior femoral condylar cut to be parallel to the proximal tibial cut.

[0016] To accomplish this:

[0017] Pin the tibial cut guide in place with the tibial alignment rod centering distally over the middle of the plafond. The plafond is the ceiling of the ankle joint, that is, the articular surface of the distal end of the tibia.

[0018] After resecting the distal femur, place the 4-in-1 femoral cut guide in place over the cut surface of the distal femur. Hang the 4-in-1 cutting guide on a centrally placed pin on Whiteside's line located just below the cut slot for the anterior femoral resection. This cut slot location references the distal/anterior femoral cortex for proper anterior resection. The centrally placed pin may optionally be replaced by a protruding post located on the bone-contacting side of the 4-in-1 cut guide that fits into a corresponding hole in the femur.

[0019] Utilizing the proper sized 4-in-1 cut guide, this guide is now "rotated" until the

posterior cut slot is parallel with the cut slot on the tibial cut guide.

[0020] Appropriate fixation pins/screws secure the femoral and tibial cut guides. All cuts can now be made, assuring proper patellar tracking.

[0021] Equal and rectangular gaps can be expected in both flexion and extension. Soft tissue releases are now performed to further balance compression forces in the medial and lateral compartments.

[0022] At least the following aspects of this disclosure are believed to be novel and non-obvious contributions over the prior art of knee arthroplasty:

[0023] Reference of distal anterior femur (DAF) and exact location of femoral head to accomplish exact knowledge of 1) varus/valgus of distal femoral cut, and 2) flexion/extension of anterior and posterior femoral cuts. Both data points are contained in the position of a distal femoral pin or hole.

[0024] Determination of proper External Rotation of femur by "hanging" the upper-center portion of a 4-in-1 femoral cutting block on the distal femoral pin, which is in the center of the trochlear groove. The proximal/distal axis through the center of the block is aligned with the longitudinal axis of the tibia, which aligns the trochlear groove of the femur (Whiteside's line) with the axis of the tibia at 90 degrees flexion of the knee. The distal femoral pin may optionally be replaced by a protruding post located on the bone-contacting side of the 4-in-1 cut guide that fits into a corresponding hole in the femur.

[0025] With proper ER of the femoral component, the posterior femoral cut and the proximal tibial cut will be parallel at 90 degrees knee flexion. Therefore the 4-in-1 femoral cutting block can be extended to a 5-in-1 cutting block by adding the proximal tibial cut slot.

[0026] The 5-in-1 (effective) block is attached superiorly (proximally) at the distal femoral pin or hole and distally to the tibial alignment rod extending to the middle of the ankle. The patellar will now track properly.

[0027] With the rectangular gap at the femur and tibia, equal compression will exist between medial and lateral compartments of the knee both in flexion and extension.

[0028] Other:

[0029] Finding the femoral head.

[0030] Bar fixed to operating table over the area of the femoral head with goal post marker/target.

[0031] Ultrasound method of locating femoral head.

[0032] Guide to reference DAF and then connect to femoral head goal post/target to determine distal femoral pin location. Arthroscopic procedure contemplated.

[0033] Adjustable 4-in-1 femoral cut guide.

[0034] This disclosure teaches bony and soft tissue preparation of the knee joint utilizing instruments and techniques consistent with proven total knee arthroplasty instruments principles.

SUMMARY

[0035] The various systems and methods of the present technology have been developed in response to the present state of the art, and in particular, in response to the problems and needs in the art that have not yet been fully solved by currently available knee arthroplasty instrument systems and methods. The systems and methods of the present technology may provide more objective, repeatable alignment relative to important biomechanical features, compared to current systems and methods.

[0036] More specifically, the present disclosure relates to instruments and methods to reference and align with the anterior distal femoral cortex, the mechanical axis of the leg, and Whiteside's line (while intact, prior to any distal femoral resection). The anterior femoral resection is aligned in the same plane as the anterior distal femoral cortex. The center of the femoral head, the medial/lateral center of the distal femur, the medial/lateral center of the proximal tibia, and the second toe, medial/lateral center of the ankle, or anterior tibial spine or crest are all simultaneously aligned to the mechanical axis of the leg while the leg is in full extension and the knee joint is distracted. The distal femoral and proximal tibial resections are aligned relative to the mechanical axis of the leg. Since the distal femoral and proximal tibial resections may be made with the leg in full extension, a much smaller incision may be required, particularly in the quadriceps region. An eight to ten inch long incision, typical of the current state of the art, may be shortened to about six inches, with most of the savings occurring proximally in the quadriceps region. Whiteside's line is referenced while the distal femur is intact, before any distal femoral resection, and the anterior and posterior femoral resections and chamfer cuts are aligned to this reference using a jig.

[0037] The systems and methods disclosed herein provide a simple and fast way to objectively and precisely align the knee joint during arthroplasty procedures. This is inherently advantageous because malalignment predisposes a reconstructed knee to premature failure. This is particularly advantageous for those surgeons who must perform knee arthroplasty from

time to time, but whose knee arthroplasty procedure volume is low. Eighty percent of knee arthroplasty procedures are performed by surgeons who do no more than two knee arthroplasty procedures per month.

[0038] The systems disclosed herein provide a cost-effective mechanical alternative to surgical navigation systems, particularly because the disclosed systems include components that are readily made as disposable items. The femoral and tibial alignment components, for example, are contemplated to be disposable items.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] Exemplary embodiments of the technology will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only exemplary embodiments and are, therefore, not to be considered limiting of the scope of the technology, the exemplary embodiments will be described with additional specificity and detail through use of the accompanying drawings in which:

[0040] FIG. 1 is a perspective view of a femur, tibia, and fibula with a foot receiver and a lower bar of a foot holder assembly;

[0041] FIG. 2 is a perspective view of the femur, tibia, fibula, foot receiver, and lower bar of FIG. 1 with a femoral support arm assembly;

[0042] FIG. 3 is a perspective view of the femur, tibia, fibula, foot receiver, lower bar, and femoral support arm assembly of FIG. 2 with a femoral head finder coupled to the femoral support arm assembly;

[0043] FIG. 4 is a perspective view of the femur, tibia, fibula, foot receiver, lower bar, femoral support arm assembly, and femoral head finder of FIG. 3 with a collar coupled to the femoral support arm assembly next to the femoral head finder;

[0044] FIG. 5 is a perspective view of the femur, tibia, fibula, foot receiver, lower bar, femoral support arm assembly, and collar of FIG. 4 with a target clamp assembly coupled to the femoral support arm assembly next to the collar;

[0045] FIG. 6 is a perspective view of the femur, tibia, fibula, foot receiver, lower bar, femoral support arm assembly, collar, and target clamp assembly of FIG. 5 with a complete foot holder assembly including a bridge, target mounting block, dovetail lock, target, and thumbscrew coupled to the lower bar and the foot receiver;

[0046] FIG. 7A is a perspective view of the foot holder assembly of FIG. 6; FIG. 7B is an

exploded perspective view of the foot holder assembly of FIG. 6; and FIG. 7C is another exploded perspective view of the foot holder assembly of FIG. 6 from a different direction;

[0047] FIG. 8A is a perspective view of the femur, tibia, fibula, femoral support arm assembly, collar, target clamp assembly, and foot holder assembly of FIG. 6 with a femoral pin guide assembly coupled to the anterior distal femur; and FIG. 8B is a detail perspective view of the femur, tibia, fibula, and femoral pin guide assembly of FIG. 8A; and

[0048] FIG. 9A is a perspective view of the femoral pin guide assembly of FIG. 8A; FIG. 9B; and FIG. 9C; FIG. 9B is an exploded perspective view of the femoral pin guide assembly of FIG. 8A; and FIG. 9B is another exploded perspective view of the femoral pin guide assembly of FIG. 8A from a different direction;

[0049] FIG. 10 is a perspective view of the femur, tibia, fibula, and femoral pin guide assembly of FIG. 8B with a femoral pin inserted through the femoral pin guide assembly into the distal femur;

[0050] FIG. 11 is a perspective view of the femur, tibia, fibula, femoral pin guide assembly, and femoral pin of FIG. 10 with a pin sleeve of the femoral pin guide assembly removed;

[0051] FIG. 12 is a perspective view of the femur, tibia, fibula, and femoral pin of FIG. 11 with the rest of the femoral pin guide assembly removed;

[0052] FIG. 13 is a perspective view of the femur, tibia, fibula, and femoral pin of FIG. 12 with a tibial pin inserted into the tibial tuberosity;

[0053] FIG. 14A is a perspective view of the femur, tibia, fibula, femoral pin, and tibial pin of FIG. 13 and the foot holder assembly of FIG. 8A with a three in one cut guide assembly coupled to the femoral pin and distal femur, the tibial pin and tibia, and the foot holder assembly via a tibial extension rod assembly; and FIG. 14B is a lateral view of the femur, tibia, fibula, femoral pin, tibial pin, foot holder assembly, three in one cut guide assembly, and tibial extension rod assembly of FIG. 14A;

[0054] FIG. 15A is a perspective view of the three in one cut guide assembly and tibial extension rod assembly of FIG. 14A; FIG. 15B is an exploded perspective view of the three in one cut guide assembly of FIG. 15A; and FIG. 15C is another exploded perspective view of the three in one cut guide assembly of FIG. 15A from a different direction;

[0055] FIG. 16 is a perspective view of the femur, tibia, fibula, femoral pin, tibial pin, three in one cut guide assembly, and tibial extension rod assembly of FIG. 14A with bone pins inserted through the three in one cut guide assembly into the distal femur and proximal tibia;

[0056] FIG. 17 is a perspective view of the femur, tibia, fibula, femoral pin, tibial pin, three in one cut guide assembly, tibial extension rod assembly, and pins of FIG. 16 after making an anterior femoral resection, a posterior femoral resection, and a proximal tibial resection through the three in one cut guide assembly;

[0057] FIG. 18 is a perspective view of the femur, tibia, fibula, femoral pin, tibial pin, anterior femoral resection, posterior femoral resection, and proximal tibial resection of FIG. 17 with the three in one cut guide assembly and related bone pins removed;

[0058] FIG. 19 is a perspective view of the femur, tibia, fibula, femoral pin, and tibial pin of FIG. 18 and a portion of the femoral support arm assembly, collar, target clamp assembly, and a portion of the foot holder assembly of FIG. 8A with a distal femoral cut guide assembly coupled to the distal femur and the target clamp assembly via a femoral extension rod assembly;

[0059] FIG. 20A is a perspective view of the distal femoral cut guide assembly of FIG. 19; FIG. 20B is an exploded perspective view of the distal femoral cut guide assembly of FIG. 19; and FIG. 20C is another exploded perspective view of the distal femoral cut guide assembly of FIG. 19 from a different direction;

[0060] FIG. 21 is a perspective view of the femur, tibia, fibula, femoral pin, tibial pin, distal femoral cut guide assembly, and a portion of the femoral extension rod assembly of FIG. 19 with bone pins inserted through the distal femoral cut guide assembly into the distal femur;

[0061] FIG. 22 is a perspective view of the femur, tibia, fibula, tibial pin, distal femoral cut guide assembly, a portion of the femoral extension rod assembly, and related bone pins of FIG. 21 after removing the femoral pin and making a distal femoral resection;

[0062] FIG. 23A is a perspective view of the femur, tibia, fibula, tibial pin, distal femoral cut guide assembly, a portion of the femoral extension rod assembly, and related bone pins of FIG. 22 with a distal femoral cut block assembly of the distal femoral cut guide assembly removed; and FIG. 23B is a lateral view of the femur, distal femoral cut guide assembly, a portion of the femoral extension rod assembly, and related bone pins of FIG. 23A;

[0063] FIG. 24 is a perspective view of the femur, tibia, fibula, tibial pin, distal femoral cut guide assembly, a portion of the femoral extension rod assembly, and related bone pins of FIG. 23A with a chamfer cut guide coupled to a femoral pin block of the distal femoral cut guide assembly;

[0064] FIG. 25 is a perspective view of the chamfer cut guide of FIG. 24;

[0065] FIG. 26 is a perspective view of the femur, tibia, fibula, tibial pin, distal femoral cut

guide assembly, a portion of the femoral extension rod assembly, related bone pins, and chamfer cut guide of FIG. 24 with bone pins inserted through the chamfer cut guide into the distal femur;

[0066] FIG. 27A is a perspective view of the femur, tibia, fibula, tibial pin, distal femoral cut guide assembly, a portion of the femoral extension rod assembly, related bone pins, chamfer cut guide, and related bone pins of FIG. 26 after making an anterior chamfer cut and a posterior chamfer cut; and FIG. 27B is a lateral view of the femur, tibia, fibula, distal femoral cut guide assembly, a portion of the femoral extension rod assembly, related bone pins, chamfer cut guide, and related bone pins of FIG. 27A with an implant trial coupled to the chamfer cut guide;

[0067] FIG. 28A is a perspective view of the femur, tibia, fibula, femoral pin, tibial pin, three in one cut guide assembly, tibial extension rod assembly, and pins of FIG. 17 with a distal femoral cut guide coupled to the distal anterior femur and the three in one cut guide with bone pins; FIG. 28B is a perspective view of the distal femoral cut guide of FIG. 28A; and FIG. 28C is a side view of the distal femoral cut guide of FIG. 28A;

[0068] FIG. 29A is a perspective view of the femur, tibia, fibula, distal femoral cut guide, and pins of FIG. 28A after removing the femoral pin three in one cut guide assembly and tibial extension rod assembly and making a distal femoral resection; and FIG. 29B is a lateral view of the femur, tibia, fibula, distal femoral cut guide, and pins of FIG. 29A;

[0069] FIG. 30A is a perspective view of the femur, tibia, fibula, distal femoral cut guide, and pins of FIG. 29A with a chamfer cut guide coupled to the distal femur and the distal femoral cut guide with bone pins; and FIG. 30B is a lateral view of the femur, tibia, fibula, distal femoral cut guide, pins, and chamfer cut guide of FIG. 30A;

[0070] FIG. 31A is a perspective view of the femur, tibia, fibula, chamfer cut guide, and pins of FIG. 30A after making anterior and posterior chamfer cuts; and FIG. 31B is a lateral view of the femur, tibia, fibula, chamfer cut guide, and pins of FIG. 31A;

[0071] FIG. 32 is a perspective view of the femur, tibia, and fibula with the anterior, distal, and posterior femoral resections, the anterior and posterior femoral chamfer cuts, and the proximal tibial resection with all instruments removed;

[0072] FIG. 33 is a perspective view of a femur, tibia, and fibula with a foot receiver and a lower bar of a foot holder assembly;

[0073] FIG. 34 is a perspective view of the femur, tibia, fibula, foot receiver, and lower bar of FIG. 33 with a femoral support arm assembly;

[0074] FIG. 35A is a perspective view of the femur, tibia, fibula, foot receiver, lower bar, and femoral support arm assembly of FIG. 34 with a femoral head finder coupled to the femoral support arm assembly; and FIG. 35B is a top view of the femur, tibia, fibula, foot receiver, lower bar, femoral support arm assembly, and femoral head finder of FIG. 35A;

[0075] FIG. 36 is a perspective view of the femur, tibia, fibula, foot receiver, lower bar, femoral support arm assembly, and femoral head finder of FIG. 35A with a collar coupled to the femoral support arm assembly next to the femoral head finder;

[0076] FIG. 37 is a perspective view of the femur, tibia, fibula, foot receiver, lower bar, femoral support arm assembly, femoral head finder, and collar of FIG. 36 with a target clamp assembly coupled to the femoral support arm assembly next to the collar;

[0077] FIG. 38 is a perspective view of the femur, tibia, fibula, foot receiver, lower bar, femoral support arm assembly, collar, and target clamp assembly of FIG. 37 with a complete foot holder assembly including a bridge, target mounting block, dovetail lock, target, and thumbscrew coupled to the lower bar and the foot receiver;

[0078] FIG. 39 is a perspective view of the femur, tibia, fibula, foot holder assembly, femoral support arm assembly, collar, and target clamp assembly of FIG. 38 after making a provisional tibial resection;

[0079] FIG. 40A is a perspective view of the femur, tibia, fibula, foot holder assembly, femoral support arm assembly, collar, and target clamp assembly of FIG. 39 with a femoral pin guide assembly coupled to the anterior distal femur and the target clamp assembly via a femoral extension rod assembly; and FIG. 40B is a top view of the femur, tibia, fibula, foot holder assembly, femoral support arm assembly, collar, target clamp assembly, femoral pin guide assembly, and femoral extension rod assembly of FIG. 40A;

[0080] FIG. 41A is a perspective view of the femoral pin guide assembly of FIG. 40A; and FIG. 41B is another perspective view of the femoral pin guide assembly of FIG. 40A from a different direction;

[0081] FIG. 42 is a perspective view of the femur, tibia, fibula, femoral pin guide assembly, and a portion of the femoral extension rod assembly of FIG. 40A with femoral pins inserted through the femoral pin guide assembly into the distal femur;

[0082] FIG. 43 is a perspective view of the femur, tibia, fibula, femoral pin guide assembly, and a portion of the femoral extension rod assembly of FIG. 40A with a pin sleeve of the femoral pin guide assembly and one of the femoral pins removed;

[0083] FIG. 44 is a perspective view of the femur, tibia, fibula, and remaining femoral pin of FIG. 43 with the rest of the femoral pin guide assembly removed;

[0084] FIG. 45A is a perspective view of the femur, tibia, fibula, and femoral pin of FIG. 44 and the foot holder assembly of FIG. 38 with a knee angle guide coupled to the femoral pin; and FIG. 45B is a lateral view of the femur, tibia, fibula, femoral pin, foot holder assembly, and knee angle guide of FIG. 45A;

[0085] FIG. 46 is a perspective view of the femur, tibia, fibula, and femoral pin of FIG. 45A with the knee angle guide removed, with a distal femoral cut guide assembly coupled to the femur and the femoral pin;

[0086] FIG. 47A is an exploded perspective view of the femoral pin and distal femoral cut guide assembly of FIG. 46; and FIG. 47B is another exploded perspective view of the femoral pin and distal femoral cut guide assembly of FIG. 46 from a different direction;

[0087] FIG. 48 is a perspective view of the femur, tibia, fibula, and a portion of the distal femoral cut guide assembly of FIG. 46 after making a distal femoral resection and removing the femoral pin and an interlock and a distal plate of the distal femoral cut guide assembly;

[0088] FIG. 49A is a perspective view of the femur, tibia, and fibula of FIG. 48 and the foot holder assembly of FIG. 45A with a femoral four-in-one cut guide assembly coupled to the distal femur and a proximal tibial cut guide coupled to the proximal tibia and the foot holder assembly via a tibial extension rod assembly; FIG. 49B is an enlarged detail view of the femur, tibia, fibula, femoral four-in-one cut guide assembly, proximal tibial cut guide, and a portion of the tibial extension rod assembly of FIG. 49A; FIG. 49C is an anterior view of the femur, tibia, fibula, foot holder assembly, femoral four-in-one cut guide assembly, proximal tibial cut guide, and tibial extension rod assembly of FIG. 49A; and FIG. 49D is a lateral view of the femur, tibia, fibula, foot holder assembly, femoral four-in-one cut guide assembly, proximal tibial cut guide, and tibial extension rod assembly of FIG. 49A;

[0089] FIG. 50A is a perspective view of the femoral four-in-one cut guide assembly and the proximal tibial cut guide of FIG. 49A; FIG. 50B is another perspective view of the femoral four-in-one cut guide assembly and the proximal tibial cut guide of FIG. 49A from a different direction; FIG. 50C is an exploded perspective view of the femoral four-in-one cut guide assembly and the proximal tibial cut guide of FIG. 49A; and FIG. 50D is another exploded perspective view of the femoral four-in-one cut guide assembly and the proximal tibial cut guide of FIG. 49A from a different direction;

[0090] FIG. 51A is a front view of the femoral four in one cut guide assembly of FIG. 50A; FIG. 51B is a cross sectional view of the femoral four in one cut guide assembly of FIG. 51A, taken along section line 51B-51B of FIG. 51A; FIG. 51C is a cross sectional view of the femoral four in one cut guide assembly of FIG. 51A, taken along section line 51C-51C of FIG. 51A; FIG. 51D is an exploded perspective view of the femoral four-in-one cut guide assembly of FIG. 51A; and FIG. 51E is another exploded perspective view of the femoral four-in-one cut guide assembly of FIG. 51A from a different direction;

[0091] FIG. 52A is an exploded perspective view of a gear assembly of the femoral four in one cut guide assembly of FIG. 51A; and FIG. 52B is another exploded perspective view of the gear assembly of the femoral four in one cut guide assembly of FIG. 51A from a different direction;

[0092] FIG. 53A is a perspective view of the femur, tibia, fibula, foot holder assembly, femoral four-in-one cut guide assembly, proximal tibial cut guide, and tibial extension rod assembly of FIG. 49A with the femoral four-in-one cut guide assembly and proximal tibial cut guide adjusted to fit the femur and tibia, with bone pins inserted through the femoral four-in-one cut guide assembly into the femur, with bone pins inserted through the proximal tibial cut guide into the tibia; FIG. 53B is an enlarged detail view of the femur, tibia, fibula, foot holder assembly, femoral four-in-one cut guide assembly, proximal tibial cut guide, tibial extension rod assembly, and bone pins of FIG. 53A; FIG. 53C is an enlarged anterior detail view of the femur, tibia, fibula, foot holder assembly, femoral four-in-one cut guide assembly, proximal tibial cut guide, tibial extension rod assembly, and bone pins of FIG. 53A; and FIG. 53D is an enlarged lateral detail view of the femur, tibia, fibula, foot holder assembly, femoral four-in-one cut guide assembly, proximal tibial cut guide, tibial extension rod assembly, and bone pins of FIG. 53A;

[0093] FIG. 54 is a perspective view of the femur, tibia, fibula, femoral four-in-one cut guide assembly, proximal tibial cut guide, a portion of the tibial extension rod assembly, and bone pins of FIG. 53A after making anterior and posterior femoral resections, anterior and posterior chamfer cuts, and a proximal tibial resection;

[0094] FIG. 55 is a perspective view of the femur, tibia, and fibula with the anterior, distal, and posterior femoral resections, the anterior and posterior femoral chamfer cuts, and the proximal tibial resection with the femoral four-in-one cut guide assembly, proximal tibial cut guide, tibial extension rod assembly, and bone pins removed;

[0095] FIG. 56 is an isometric view of a knee joint with implanted femoral component, tibial component, articular insert, and patellar component, the patellar component shown exploded from the patella for clarity;

[0096] FIG. 57 is a perspective view of a femur, tibia, and fibula with another femoral pin guide assembly and another distal femoral cut guide coupled to the distal femur; and

[0097] FIG. 58A is an exploded perspective view of the femoral pin guide assembly and distal femoral cut guide of FIG. 57; and FIG. 58B is another exploded perspective view of the femoral pin guide assembly and distal femoral cut guide of FIG. 57 from a different direction.

DETAILED DESCRIPTION

[0098] Exemplary embodiments of the technology will be best understood by reference to the drawings, wherein like parts are designated by like numerals throughout. It will be readily understood that the components of the system, as generally described and illustrated in the figures herein, could be arranged and designed in a wide variety of different configurations. Thus, the following more detailed description of the embodiments of the apparatus, system, and method is not intended to limit the scope of the invention, as claimed in this or any other application claiming priority to this application, but is merely representative of exemplary embodiments of the technology.

[0099] The phrases "connected to," "coupled to" and "in communication with" refer to any form of interaction between two or more entities, including mechanical, electrical, magnetic, electromagnetic, fluid, and thermal interaction. Two components may be functionally coupled to each other even though they are not in direct contact with each other. The term "abutting" refers to items that are in direct physical contact with each other, although the items may not necessarily be attached together. The phrase "fluid communication" refers to two features that are connected such that a fluid within one feature is able to pass into the other feature.

[00100] The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. While the various aspects of the embodiments are presented in drawings, the drawings are not necessarily drawn to scale unless specifically indicated.

[00101] Standard medical planes of reference and descriptive terminology are employed in this specification. A sagittal plane divides a body into right and left portions. A mid-sagittal plane divides the body into bilaterally symmetric right and left halves. A coronal plane divides a

body into anterior and posterior portions. A transverse plane divides a body into superior and inferior portions. Anterior means toward the front of the body. Posterior means toward the back of the body. Superior means toward the head. Inferior means toward the feet. Medial means toward the midline of the body. Lateral means away from the midline of the body. Axial means toward a central axis of the body. Abaxial means away from a central axis of the body. Ipsilateral means on the same side of the body. Contralateral means on the opposite side of the body. These descriptive terms may be applied to an animate or inanimate body.

[00102] Standard terminology related to knee arthroplasty is employed in this specification. Varus means deviation of the distal part of the leg below the knee inward, resulting in a bowlegged appearance. Valgus means deviation of the distal part of the leg below the knee outward, resulting in a knock-kneed appearance.

[00103] FIGS. 1-32 illustrate an instrument system 1500.

[00104] FIG. 1 shows the step of securing a foot (not shown, the lower leg is represented by the tibia 104 and fibula 122) in a portion of a foot holder assembly 1870. The foot holder assembly 1870 includes a foot receiver 1872, a lower bar 1874, a bridge 1878, a target mounting block 1880, a dovetail lock 1881, a target 1882, and a thumbscrew 1884. The bridge 1878, target mounting block 1880, dovetail lock 1881, target 1882, and thumbscrew 1884 are shown in FIGS. 6-7C.

[00105] FIG. 2 shows the step of securing a femoral support arm assembly 1786 to an operating table (not shown) so that a portion of the femoral support arm assembly extends over the hip area. This step may be similar to or identical to the step of FIG. 69 of U.S. Patent Application No. 15/081828. The femoral support arm assembly 1786 includes a post 1788, a bar 1790, a first clamp body 1792, a second clamp body 1794, a spring 1796, a retaining ring 1798, a thumbscrew 1800, and a screw 1802. The femoral support arm assembly 1786 may be similar to or identical to the femoral support arm assembly 786 or 2786.

[00106] FIG. 3 shows the step of positioning a femoral head finder 1918 to extend over the center 120 of the head 118 of the femur 100. This alignment may be verified using imaging, for example fluoroscopy. The femoral head finder 1918 may be similar to or identical to the femoral head finder 918 or 2918.

[00107] FIG. 4 shows the step of securing a collar 1926 to the bar 1790 beside the femoral head finder 1918. The steps of FIGS. 3 and 4 may be similar to or identical to the step of FIG. 70 of U.S. Patent Application No. 15/081828. The collar 1926 may be similar to or identical to the

collar 926 or 2926. Preferably, the steps of FIGS. 1-4 may occur before sterile draping of the patient.

[00108] FIG. 5 shows the step of removing the femoral head finder 1918 and securing a target clamp assembly 1818 to the bar 1790 beside the collar 1926. This step may be similar to or identical to the step of FIG. 71 of U.S. Patent Application No. 15/081828. Preferably, this step may occur after the femoral support arm assembly 1786 has been covered with a sterile drape, such as drape 902 of FIG. 71 of U.S. Patent Application No. 15/081828. Thus the collar 1926 and the femoral support arm assembly 1786 may be nonsterile under the drape, and the target clamp assembly 1818 may be sterile above the drape. The target clamp assembly 1818 includes a target 1820, a retaining ring 1822, a first clamp body 1824, a second clamp body 1826, a lever 1828, a link 1830, and a pin 1832. The example shows two links 1830 and eight pins 1832. The target clamp assembly 1818 may be similar to or identical to the target clamp assembly 818 or 2818.

[00109] FIG. 6 shows the step of assembling the bridge 1878, target mounting block 1880, dovetail lock 1881, target 1882, and thumbscrew 1884 to the lower bar 1874 and the foot receiver 1872 to form a complete foot holder assembly 1870. FIGS. 7A-7C show the foot holder assembly 1870.

[00110] The lower bar 1874 includes bilateral sockets 1000, 1002 on either side of a concave portion 1004. The lower bar 1874 may be similar to or identical to the lower bar 874 or 2874. The bridge 1878 is a horseshoe-shaped or U-shaped part with a central bridge 1006 and two legs 1008, 1010, each leg extending from an end of the bridge 1006 and terminating in a free end. The free ends have tabs 1012, 1014, respectively. Each tab bifurcates at its tip to form a resilient snap feature. The bridge 1006 includes a through slot 1016 that extends between back to back pockets 1018, 1020. The target 1882 is a generally spoon-shaped or ladle-shaped part with an elongated stem 1022 that terminates in a bowl 1024 at one end. The stem 1022 includes an undercut rail 1026 that extends along the length of the stem. The target mounting block 1880 has a generally rectangular or square body with a rectangular or square through hole 1028. An undercut channel 1030 extends across one side of the target mounting block 1880 and across the hole 1028. The opposite side of the target mounting block 1880 includes bilateral shelves or ledges 1032, 1034 that extend transverse to, or perpendicular to, the undercut channel 1030. The dovetail lock 1881 is an elongated part that includes a generally rectangular or square body 1036 with a threaded shaft 1038 extending from one side of the

body. Bilateral shelves or ledges 1038, 1040 extend across this side of the body on opposite sides of the shaft 1038. Opposite the shaft 1038, an undercut channel 1044 extends across the body 1036 transverse to, or perpendicular to, the bilateral ledges 1038, 1040. The thumbscrew 1884 includes a mushroom-shaped body 1046 with a threaded socket 1048 opposite the enlarged mushroom "cap." The foot receiver 1872 may be similar to or identical to the foot receiver 2872.

[00111] The tab 1012 is received in the socket 1000 and the tab 1014 is received in the socket 1002. The tabs 1012, 1014 may snap into and out of engagement with the sockets 1000, 1002. The target mounting block 1880 is at least partially received in the pocket 1018 or 1020 so that the ledges 1032, 1034 rest atop the pocket walls. The target mounting block 1880 is shown in the pocket 1018. The body 1036 of the dovetail lock 1881 is at least partially received in the hole 1028 in the target mounting block 1880 so that the undercut channels 1030, 1044 face the same direction and are aligned, and so that the shaft 1038 extends through the slot 1016 of the bridge 1878 and threads into the socket 1048 of the thumbscrew 1884. The thumbscrew 1884 is partially received in the pocket 1018 or 1020, whichever one is not occupied by the target mounting block 1880. The thumbscrew 1884 is shown in the pocket 1020. The undercut rail 1026 of the target 1882 is received in the undercut channels 1030, 1044. Tightening the thumbscrew 1884 locks the undercut rail 1026 in position relative to the bridge 1878. Loosening the thumbscrew 1884 permits the target 1882 to be moved relative to the bridge 1878 in the anterior to posterior direction and in the medial to lateral direction.

[00112] FIGS. 8A and 8B show the step of coupling a femoral pin guide assembly 1501 to the anterior distal femur. This step may be similar to or identical to the step of FIG. 72 of U.S. Patent Application No. 15/081828. This step may include coupling the femoral pin guide assembly 1501 to the target 1820 of the target clamp assembly 1818 via a femoral extension rod assembly 1506 (FIG. 19). This step may include aligning the femoral pin guide assembly 1501 and/or the femoral extension rod assembly 1506 with the mechanical axis 202 of the leg as it extends through the femur 100. FIGS. 9A-9C show the femoral pin guide assembly 1501, which includes a base 1502, a handle 1516, a pin guide 1521, a screw 1513, and a pin sleeve 1515. The example shows two screws 1513. Aligning the femoral pin guide assembly 1501 and/or the femoral extension rod assembly 1506 with the mechanical axis 202 of the leg may include centering the base 1502 in the medial-lateral width of the distal femur and at the same time aligning the femoral extension rod assembly 1506 to pass over the center 120 of the

femoral head 118. This step may include positioning a distal edge of the bone contacting surface 1518 at the place on the distal anterior femur where the anterior femoral resection 214 is planned to exit the femur.

[00113] The base 1502 is an elongated plate with a bone contacting surface 1518 and an opposite top surface 1520. The base 1502 has a distal portion 1522 and a proximal portion 1524 which tapers to a proximal tip which is narrower than the distal portion. A longitudinal axis 1503 extends along the length of the base 1502 between the distal and proximal portions 1522, 1524; only a portion of the axis 1503 is shown for clarity. The base 1502 includes a hole 1526 through the distal portion 1522. A pocket 1528 is recessed into the bone contacting surface 1518 around the hole 1526. The pocket 1528 may be described as a counterbore around the hole 1526. The base 302 includes two through holes 1530, 1532 between the distal and proximal portions 1522, 1524. Each hole 1530, 1532, 1534 includes a shelf 1536 on at least one side wall. The shelves 1536 are illustrated as counterbores around the holes 1530, 1532, 1534 but may be unilaterally positioned instead. The base 1502 may include one or more frictional elements, such as spikes 1538 protruding from the bone contacting surface 1518. The spikes 1538 in this example are separate set screws with sharp leading tips inserted into corresponding holes 1539 in the base 1502.

[00114] The handle 1516 includes a base portion 1561 with a bone facing surface 1562 and an opposite top side 1564. The base portion 1561 has a distal portion 1566 and a proximal portion 1568. The base portion 1561 has a series of holes 1571, 1573, 1575, 1577 arranged from distal to proximal. An optional tab 1579 may extend from the top side between holes 1571, 1573. A stalk 1570 protrudes from the top side 1564 between the distal and proximal portions 1566, 1568. The stalk 1570 terminates in a proximal free end 1581 with a slot 1583 and through hole 1585.

[00115] The pin guide 1521 has a generally arcuate body 1523 that extends between a distal portion 1525 and a proximal portion 1527. The distal portion 1525 includes a longitudinal hole 1529 with a longitudinal slot 1531. The hole 1529 and slot 1531 extend in the distal-proximal direction. The proximal portion 1527 includes a pocket 1533 and holes 1535, 1537 which intersect the pocket. The pin sleeve 1515 includes a cylindrical shaft 1541 with an enlarged head 1543 at one end and a longitudinal through hole 1545.

[00116] The shaft 1541 of the pin sleeve 1515 is received in the hole 1529 of the pin guide 1521 so that the head 1543 is distal. The distal portion 1566 of the handle 1516 is received in

the pocket 1533 of the pin guide 1521. One of the screws 1513 extends through the holes 1535, 1571 and the other screw 1513 extends through the holes 1537, 1573 to secure the pin guide 1521 to the handle 1516. The spikes 1538 are received in the holes 1539; the spikes may optionally be integrally formed with the base 1502. A fastener (not shown) extends through the holes 1526, 1575 and a second fastener extends through the holes 1530, 1577 (for a left knee) or the holes 1532, 1577 (for a right knee) to secure the base 1502 to the handle. When the pin sleeve 1515, pin guide 1521, handle 1516, and base 1502 are coupled together as described, the hole 1545 may be aligned with the bone contacting surface 1518, or a theoretical bone contacting plane defined by the spikes 1538 where the spikes contact the distal anterior femur. Preferably, the hole 1545 may be parallel to the bone contacting surface 1518, parallel to the upcoming anterior femoral resection 214, or perpendicular to the upcoming distal femoral resection 206. The inner rod 1606 of the femoral extension rod assembly 1506 is received in the slot 1583 and the pin 1601 extends through hole 1585 and the inner rod to form a hinge about which the femoral extension rod assembly pivots in use.

[00117] FIG. 10 shows the step of placing a femoral pin 1505 into the distal femur through the pin sleeve 1515 of the femoral pin guide assembly 1501. The femoral pin 1505 is received in the hole 1545. Preferably, this step occurs while the bone contacting surface 1518 and/or the spikes 1538 of the base 1502 contact the distal anterior femur, and while the femoral pin guide assembly 1501 and/or the femoral extension rod assembly 1506 are aligned with the mechanical axis 202 of the leg. Preferably, the femoral pin 1505 is placed in strong, dense subtrochlear bone anterior to the femoral intramedullary canal and posterior to the intended location of the upcoming anterior femoral resection 214.

[00118] FIG. 11 shows the step of removing the pin sleeve 1515 after the femoral pin 1505 has been placed into the distal femur. The pin sleeve 1515 slides distally out of the hole 1529 and distally along the femoral pin 1505. This exposes the slot 1531.

[00119] FIG. 12 shows the step of removing the femoral pin guide assembly 1501 after the femoral pin 1505 has been placed into the distal femur. The femoral pin guide assembly 1501 may be lifted anteriorly so that the femoral pin 1505 exits through the slot 1531. This step may include removing the spool 1608 anteriorly from the target 1820. The femoral pin 1505 encodes information about 1) the proper varus/valgus orientation of the distal femoral resection 206, 2) the flexion/extension orientation of the anterior femoral resection 214 and the posterior femoral resection 220, and 3) the middle of the trochlear groove (Whiteside's

line). The femoral pin 1505 enables rotational adjustment of cut guides about the pin 1505, which ensures proper tracking of the patella. More specifically, femoral cut guides may be adjusted for varus-valgus rotation about the pin 1505.

[00120] FIG. 13 shows the step of placing a tibial centering pin 1507 in the tibial tuberosity to serve as a proximal tibial target. The tibial centering pin 1507 may be placed freehand or with a guide (not shown). The tibial centering pin 1507 may be centered in the medial-lateral width of the proximal tibia 106 and/or centered in the medial-lateral width of the tibial tuberosity.

[00121] FIGS. 14A and 14B show the step of coupling a three in one cut guide assembly 1321 to the femur 100, the tibia 104, and the foot holder assembly 1870. This step may include sliding a hole of the three in one cut guide assembly 1321 over the femoral pin 1505. This step may include sliding a slot of the three in one cut guide assembly 1321 over the tibial pin 1507. The three in one cut guide assembly 1321 may pivot around the femoral pin 1505 to a rotational position in which the slot accepts the tibial pin 1507. This step may include coupling the three in one cut guide assembly 1321 to a tibial extension rod assembly 1511, and coupling the tibial extension rod assembly to a target 1882 of the foot holder assembly 1870. This step may include aligning the three in one cut guide assembly 1321 and/or the tibial extension rod assembly 1511 with the mechanical axis of the leg as it extends through the tibia 104. The three in one cut guide assembly 1321 shown in FIGS. 15A-15C includes an anterior femoral cut guide 1326, a posterior femoral and tibial cut guide 1328, a tibial rail 1323, and a button assembly 1327. The three in one cut guide assembly 1321 is coupled to a tibial extension rod assembly 1511, which is coupled to the foot holder assembly 1870. FIG. 14B shows that it is preferable for the tibia 104 to be positioned so that a tibial shaft axis 201 forms a ninety degree angle 1315 with the femoral shaft axis 200 of the femur 100. The anterior femoral cut guide 1326 and the posterior femoral and tibial cut guide 1328 are pinned to the distal femur and proximal tibia, respectively, with femoral pin 1505 and tibial pin 1507. The example shows two tibial rails 1323 and two button assemblies 1327. The button assembly 1327 includes a button, a spring, and a dowel pin. The tibial extension rod assembly 1511 (FIG. 19) includes an outer rod 1605, an inner rod 1607, a sleeve 1611, a ring 1613, a pin 1601, and a ball 1617. The tibial extension rod assembly 1511 may be similar to or identical to the tibial extension rod 313, 511, 2511 or the femoral extension rod 306, 506, 1506, 2506. Aligning the three in one cut guide assembly 1321 and/or the tibial extension rod assembly 1511 with the mechanical axis of the leg may include centering the posterior femoral and tibial cut guide 1328 over the tibial pin 1507 and at

the same time aligning the tibial extension rod assembly 1511 to pass over the medial-lateral center of the ankle, the second toe, or anterior tibial spine.

[00122] The anterior femoral cut guide 1326 has a distal side 1050, an opposite proximal side 1052, and an anterior side 1054. A saw slot 1056 extends through the anterior femoral cut guide 1326 in a distal to proximal direction. A boss 1058 extends from a middle portion of the distal side 1050. A through hole 1060 extends through the boss 1058. The through hole 1060 receives the femoral pin 1505, thereby positioning the saw slot 1056 so that the anterior femoral resection 214 will exit the femur at the planned location. Bilateral through holes 1062, 1064 are located on either side of the boss 1058. The holes 1062, 1064 may include counterbores 1066, 1068 as shown in the distal side 1050. The holes 1062, 1064 may converge as they extend from distal to proximal. Bilateral rectangular or square through holes 1070, 1072 are located on either side of the boss 1058; the holes 1070, 1072 are shown outboard of the holes 1062, 1064, but could be inboard instead. The holes 1070, 1072 extend through the anterior femoral cut guide 1326 in an anterior to posterior direction passing through the anterior side 1054.

[00123] The posterior femoral and tibial cut guide 1328 has a distal side 1074, an opposite proximal side 1076, and an anterior side 1078. Saw slots 1080, 1082 extend through the posterior femoral and tibial cut guide 1328 in a distal to proximal direction. The saw slots 1080, 1082 may be parallel or there may be an acute angle between them. An arm 1084 extends distally and posteriorly from a middle portion of the distal side 1074. The free end 1085 of the arm 1084 includes a lengthwise slot 1086 and a hole 1088 that extends through the arm and across the slot. Bilateral through holes 1090, 1092 are located on either side of the arm 1084. The holes 1090, 1092 may include counterbores 1094, 1096 as shown in the distal side 1074. The holes 1062, 1064 may converge as they extend from distal to proximal. Bilateral rectangular or square bosses 1100, 1102 extend from the distal side 1074 on either side of the arm 1084. The bosses 1100, 1102 are shown outboard of the holes 1090, 1092, but could be inboard instead. Rectangular or square pockets 1104, 1106 are recessed into the distal aspect of the bosses 1100, 1102. Circular holes 1108, 1110 are recessed into the proximal ends of the pockets 1104, 1106. Rectangular or square through holes 1112, 1114 extend through the bosses 1100, 1102 in a distal to proximal direction. An anterior facing shelf 1116 is formed between anterior and posterior portions of the posterior femoral and tibial cut guide 1328. Bilateral rectangular or square through holes 1118, 1120 are located on either side of the boss

arm; the holes 1118, 1120 are shown outboard of the holes 1090, 1092, but could be inboard instead. The holes 1118, 1120 extend through the posterior femoral and tibial cut guide 1328 in an anterior to posterior direction passing through the anterior side 1078. Posterior facing shelves 1122, 1124 are formed in the proximal side of the posterior femoral and tibial cut guide 1328. The shelf 1122 rests on the proximal aspect of the tibia when the three in one cut guide 1321 is adjusted to an implant size that matches the patient's anatomy.

[00124] The tibial rail 1323 is a generally rectangular elongated part with an anterior end 1126, a posterior end 1128, and a proximal side 1130. A series of detents 1132, in this example grooves, extends along a middle portion of the proximal side 1130. Indicia 1134 may be present on the tibial rail 1323.

[00125] The button assembly 1327 includes a button body 1136, a spring 1138, and a pin 1140. The button body 1136 includes a generally rectangular shaft 1142 with an enlarged head 1144 at one end. A generally rectangular through hole 1146 extends transversely through the shaft 1142. A through hole 1148 extends transversely through the shaft 1142 and across the hole 1146.

[00126] The anterior ends 1126 of the tibial rails 1323 are received in the holes 1070, 1072 of the anterior femoral cut guide 1326 so that the posterior ends 1128 project posteriorly and the proximal sides 1052, 1130 face the same direction. The anterior ends 1126 may be fixed in the holes 1070, 1072. A spring 1138 is received in each hole 1146 of the button bodies 1136. The button bodies 1136 are received in the posterior femoral and tibial cut guide 1328 so that the shafts 1142 are in the holes 1112, 1114, the springs 1138 are in the holes 1108, 1110, the heads 1144 are in the pockets 1104, 1106, and the holes 1148 are exposed proximally to receive the pins 1140. The posterior ends 1128 of the tibial rails 1323, with attached anterior femoral cut guide 1326, are received in the anterior ends of the holes 1118, 1120 of the posterior femoral and tibial cut guide 1328 and advanced through the holes 1146 of the button bodies 1136 so that the springs 1138 are distal to the tibial rails 1323 and the pins 1140 engage the detents 1132. The inner rod 1607 of the tibial extension rod assembly 1511 is received in the slot 1086 and the pin 1601 extends through hole 1088 and the inner rod to form a hinge about which the tibial extension rod assembly pivots in use.

[00127] FIG. 16 shows the step of further securing the three in one cut guide assembly 1321 to the femur 100 and the tibia 104 by driving bone pins 1329 through the anterior femoral cut guide 1326 and the posterior femoral and tibial cut guide 1328. Preferably, this step occurs

while the three in one cut guide assembly 1321 and/or the tibial extension rod assembly 1511 are aligned with the mechanical axis 202 of the leg.

[00128] FIG. 17 shows the step of making an anterior femoral resection 214, a posterior femoral resection 220, and a proximal tibial resection 210. The anterior femoral resection 214 is made through the saw slot 1056 in the anterior femoral cut guide 1326, which is carried on the femoral pin 1505, which was positioned in the distal femur while directly referencing the distal anterior femoral cortex, notably the desired exit point for the anterior femoral resection 214. The posterior femoral resection 220 is made through the femoral saw slot 1080 in the posterior femoral and tibial cut guide 1328. The proximal tibial resection 210 is made through the tibial saw slot 1082 in the posterior femoral and tibial cut guide 1328. Note that the proximal tibial resection 210 is made while the soft tissues surrounding the knee joint are intact and loaded by the natural anatomy. Thus the conventional step of balancing soft tissues may be greatly reduced or eliminated altogether.

[00129] FIG. 18 shows the step of removing the three in one cut guide assembly 1321 after making the anterior femoral resection 214, the posterior femoral resection 220, and the proximal tibial resection 210.

[00130] FIG. 19 shows the step of coupling a distal femoral cut guide assembly 1519 to the femur 100. This step may include coupling the distal femoral cut guide assembly 1519 to the anterior distal femur and the target 1820 of the target clamp assembly 1818 via the femoral extension rod assembly 1506. This step may include aligning the distal femoral cut guide assembly 1519 and/or the femoral extension rod assembly 1506 with the mechanical axis 202 of the leg as it extends through the femur 100. The distal femoral cut guide assembly 1519 shown in FIGS. 20A-20C includes a femoral pin block 1514, a femoral riser 1504, a screw 1150, a pin 1152, and a distal femoral cut block assembly 1638. The distal femoral cut guide assembly 1519 is coupled to a femoral extension rod assembly 1506. The femoral extension rod assembly 1506 includes an outer rod 1604, an inner rod 1606, a spool 1608, a sleeve 1610, a ring 1612, a retaining ring 1614, and the pin 1601. The femoral extension rod assembly 1506 may be similar to or identical to the femoral extension rod 306, 506, 2506 or the tibial extension rod 313, 511, 1511, 2511. The distal femoral cut block assembly 1638 shown in FIGS. 20A-20C includes a distal femoral cut block 1637 and two pegs 1646. Aligning the distal femoral cut guide assembly 1519 and/or the femoral extension rod assembly 1506 with the mechanical axis 202 of the leg may include centering the femoral pin block 1514 in the medial-lateral width of the distal femur

and at the same time aligning the femoral extension rod assembly 1506 to pass over the center 120 of the femoral head 118. This step may reference four anatomical reference points: the distal margin of the medial femoral condyle, the femoral pin 1505 (which was placed by referencing the distal anterior femoral cortex and the mechanical axis of the leg), the anterior femoral resection 214, and the mechanical axis 202 of the leg (directly).

[00131] The femoral pin block 1514 is a roughly triangular plate with a bone facing surface 1154 and an opposite top surface 1156. The bone facing surface 1154 is positioned against the anterior femoral resection 214. The femoral pin block 1514 has a distal portion 1566 and a proximal portion 1568. The femoral pin block 1514 is illustrated with several through holes 1162, 1164, 1166 which receive bone pins; two mounting holes 1168 are shown as well. Two proximal holes 1162 are shown, twelve middle holes 1164 are shown, and four distal holes 1166 are shown, although any number of holes may be provided. The left and right holes 1162 may converge together as they approach the bone facing surface 1154. The left group and the right group of holes 1164 may also converge together as they approach the bone facing surface 1154. The left group and the right group of holes 1166 may include individual holes that are spaced apart widely enough in the medial-lateral direction that femoral resections may be cut while the femoral pin block 1514 remains secured to the femur 100. These widely spaced holes 1166 may be located outboard of the mounting holes 1168 so that bone pins driven through the widely spaced holes 1166 penetrate the epicondyles. The femoral pin block 1514 may be widened as shown to support the widely spaced holes 1166. The femoral pin block 514 includes a blind hole 1170 and a through hole 1172. All of the preceding holes 1162, 1164, 1166, 1168, 1170, 1172 extend at least through the top surface 1154 of the femoral pin block. The distal portion 1566 includes a transverse undercut channel 1174 with a dimple 1176 in its proximal surface.

[00132] The femoral riser 1504 is a generally curved bar with a distal portion 1178 and a proximal portion 1180. Two holes 1182, 1184 extend anteriorly into the distal portion 1178. The proximal portion 1180 includes a longitudinal slot 1186 and a transverse hole 1188 that extends across the slot 1186.

[00133] The distal femoral cut block 1637 includes a proximal mounting portion 1190 and a distal paddle 1192. The mounting portion 1190 includes a bar 1194 with a peg 1646 extending from each end of the bar. The pegs 1646 are parallel, and in this example they are separate pins which are coupled to holes 1196 in the bar 1194; the pegs 1646 may be integral with the bar

1194 instead. The bar 1194 includes a saw slot 1198 which extends in an anterior-posterior direction through the bar 1194. The paddle 1192 includes a proximal surface 1200 which is positioned against the distal medial condyle. The saw slot 1198 is offset 9 mm from the proximal surface 1200 in the example shown.

[00134] The pin 1152 is received in the hole 1170 of the femoral pin block 1514 and the hole 1182 of the femoral riser 1504. The screw 1150 extends through the holes 1172, 1184 to secure the femoral pin block 514 and the femoral riser 1504 together. The pegs 1646 are received in the holes 1196 of the distal femoral cut block 1637, and may be press fit or otherwise fixed in place. The pegs are also received in the holes 1168 of the femoral pin block 514 to couple the distal femoral cut block assembly 1638 to the femoral pin block.

[00135] FIG. 21 shows the step of further securing the distal femoral cut guide assembly 1519 to the distal femur with bone pins 1329. Preferably, this step occurs while the bone facing surface 1154 of the femoral pin block 1514 contacts the anterior femoral resection 214, and while the femoral pin guide assembly 1501 and/or the femoral extension rod assembly 1506 are aligned with the mechanical axis 202 of the leg. This improves the accuracy of the distal femoral resection 206.

[00136] FIG. 22 shows the step of removing the femoral pin 1505 and making a distal femoral resection 206. The distal femoral resection 206 is made through the saw slot 1198 in the distal femoral cut block 1637.

[00137] FIGS. 23A and 23B show the step of removing the distal femoral cut block assembly 1638 and illustrate the adjustability provided by the distal femoral cut block 1637, an optional insert 1202, and the femoral pin block 1514. The optional insert 1202 may be included in the distal femoral cut guide assembly 1519 to provide adjustability to the distal femoral cut. A cut made through the saw slot 1198 of the distal femoral cut block 1637 is in the standard or zero position. If the distal femoral cut block assembly 1638 is removed, a cut made against the distal surface 1208 of the insert 1202 is 2 mm proximal to the standard position. If the insert 1202 is removed, a cut made against the distal surface 1566 of the femoral pin block 1514 is 4 mm proximal to the standard position. The insert 1202 is an elongated bar with a longitudinal proximal undercut rail 1204 and a retention tab 1206 on the rail.

[00138]

[00139] FIG. 24 shows the step of coupling a chamfer cut guide 1751 to the femoral pin block 1514 in place of the distal femoral cut block assembly 1638. FIGS. 24-25 show views of the

chamfer cut guide 1751. The chamfer cut guide 1751 includes a generally rectangular body 1210 with a distal surface 1212, an opposite proximal surface 1214, and an anterior surface 1216. The chamfer cut guide 1751 has two saw slots 1218, 1220 which intersect at the distal surface 1212 and diverge anteriorly and posteriorly as they extend toward the proximal surface 1214. Bilateral tabs 1222, 1242 extend from the chamfer cut guide 1751 on either side of the saw slots 1218, 1220. Bilateral through holes 1226, 1228 extend through the tabs 1222, 1242, respectively, in a distal to proximal direction. An L-shaped plate 1230 extends anteriorly and proximally from the anterior surface 1216. The L-shaped plate 1230 includes an anterior plate 1231 and a proximal plate 1234. The proximal plate 1234 includes a posterior surface 1236. The proximal surface 1214 is positioned against the distal femoral resection 206 and the posterior surface 1236 is positioned against the top surface 1156 of the femoral pin block 1514 so that the tabs 1222, 1224 extend medially and laterally relative to the distal femur 100.

[00140] FIG. 26 shows the step of further securing the chamfer cut guide 1751 to the distal femur with bone pins 1329. Preferably, this step occurs while the proximal surface 1214 is in close contact with the distal femoral resection 206 and the posterior surface 1236 is in close contact with the top surface 1156.

[00141] FIG. 27A shows the step of making an anterior chamfer cut 216 and a posterior chamfer cut 218. The anterior chamfer cut 216 is made through the anterior saw slot 1218 in the chamfer cut guide 1751. The posterior chamfer cut 218 is made through the posterior saw slot 1220 in the chamfer cut guide 1751.

[00142] The chamfer cut guide 1751 may be removed so that the distal femoral resection 206 may be adjusted as illustrated in FIG. 23B. The chamfer cut guide 1751 may then be repositioned so that the anterior and posterior chamfer cuts 216, 218 can also be adjusted.

[00143] FIG. 27B shows an optional step of coupling an implant trial 1238 to the posterior femoral resection 220 and the chamfer cut guide 1751 so that the knee may be moved through a range of motion to verify that the proper flexion/extension gaps have been established. Preferably, this step occurs while the chamfer cut guide 1751 and the distal femoral cut block assembly 1638 remain secured to the femur.

[00144] FIGS. 28A-31B illustrate a group of steps for making the distal femoral resection 206 and the anterior and posterior chamfer cuts 216, 218 that may be performed as an alternative to the steps illustrated in FIGS. 18-27B.

[00145] FIG. 28A shows the step of coupling a distal femoral cut guide 1240 to the distal

anterior femur 100 and the three in one cut guide assembly 1321 of FIG. 17 with bone pins 1329. An advantage of this step is that the original alignment to the mechanical axis 202 of the leg established in FIG. 8A is maintained via the femoral pin 1505, the tibial pin 1507, the tibial extension rod assembly 1511, and the target 1882. Referring to FIGS. 28B and 28C, the distal femoral cut guide 1240 includes a distal surface 1242, a proximal surface 1244, an anterior surface 1246, and a posterior surface 1262. A saw slot 1248 and one or more holes 1250 extend through the distal femoral cut guide 1240 in an anterior to posterior direction. Five holes 1250, 1252, 1254, 1256, 1258 are shown. The holes may be counterbored at the anterior surface 1246. A tab 1260 extends distally from the distal surface 1242. The posterior surface 1262 is positioned against the anterior femoral resection 214, the tab 1242 is received in the saw slot 1056 of the anterior femoral cut guide 1326, and the distal surface 1242 is positioned against the proximal surface 1052.

[00146] FIG. 29A shows the step of removing the femoral pin 1505, three in one cut guide assembly 1321 and tibial extension rod assembly 1511 and making the distal femoral resection 206 through the saw slot 1248 of the distal femoral cut guide 1240.

[00147] FIG. 30A shows the step of coupling a chamfer cut guide 1264 to the distal femur and the distal femoral cut guide 1240 with bone pins 1329. The chamfer cut guide 1264 includes a distal surface 1266, a proximal surface 1268, and an anterior surface 1270. The chamfer cut guide 1264 has two saw slots 1272, 1274 which intersect at the distal surface 1266 and diverge anteriorly and posteriorly as they extend toward the proximal surface 1268. Bilateral tabs 1276, 1278 extend from the chamfer cut guide 1264 on either side of the saw slots 1272, 1274. Bilateral through holes 1280, 1282 extend through the tabs 1276, 1278, respectively, in a distal to proximal direction. A plate 1284 extends anteriorly from the anterior surface 1270. A slot 1286 extends through the plate 1284 in a distal to proximal direction. The proximal surface 1268 is positioned against the distal femoral resection 206, the tab 1260 of the distal femoral cut guide 1240 is received in the slot 1286 of the chamfer cut guide 1264, and the plate 1284 may be positioned against the distal surface 1242.

[00148] FIGS. 31A and 31B show the step of making anterior and posterior chamfer cuts 216, 218. The anterior chamfer cut 216 is made through the saw slot 1272 of the chamfer cut guide 1264 and the posterior chamfer cut 218 is made through the saw slot 1274.

[00149] FIG. 32 shows the femur 100, tibia 104, and fibula 122 after making the anterior femoral resection 214, the anterior chamfer cut 216, the distal femoral resection 206, the

posterior chamfer cut 218, the posterior femoral resection 220, and the proximal tibial resection 210, and after removing all instruments. FIG. 32 represents an endpoint for the steps shown in FIGS. 18-27B or for the steps shown in FIGS. 28A-31B.

[00150] FIGS. 33-58B illustrate another instrument system 2500.

[00151] FIG. 33 shows the step of securing a foot (not shown) in a portion of a foot holder assembly 2870. This step may be similar to or identical to the step of FIG. 1. The foot holder assembly 2870 includes a foot receiver 2872, a lower bar 2874, a bridge 2878, a target mounting block 2880, a dovetail lock 2881, a target 2882, and a thumbscrew 2884. The bridge 2878, target mounting block 2880, dovetail lock 2881, target 2882, and thumbscrew 2884 are shown in FIG. 38. The foot holder assembly 2870 may be similar to or identical to the foot holder assembly 870 or 1870.

[00152] FIG. 34 shows the step of securing a femoral support arm assembly 2786 to an operating table (not shown) so that a portion of the femoral support arm assembly extends over the hip area. This step may be similar to or identical to the step of FIG. 69 of U.S. Patent Application No. 15/081828 and/or FIG. 2 of this application. The femoral support arm assembly 2786 includes a post 2788, a bar 2790, a first clamp body 2792, a second clamp body 2794, a spring 2796, a retaining ring 2798, a thumbscrew 2800, and a screw 2802. The femoral support arm assembly 2786 may be similar to or identical to the femoral support arm assembly 786 or 1786.

[00153] FIGS. 35A-35B show the step of positioning a femoral head finder 2918 to extend over a center 120 of a head of the femur 100. This step may be similar to or identical to the step of FIG. 70 of U.S. Patent Application No. 15/081828 and/or FIG. 3 of this application. FIG. 35A is a perspective view and FIG. 35B is a top view. The femoral head finder 2918 may be similar to or identical to the femoral head finder 918 or 1918. Imaging, such as radiographs, fluoroscopy, a C-arm, and the like, may facilitate positioning the femoral head finder 2918 accurately over the center 120 of the femoral head.

[00154] Alternatively, the center of the femoral head may be located using ultrasound. Ultrasound equipment may already be present in the operating room for preoperative identification of the femoral nerve or other neurovascular structures. The inventors have observed that the arcs of the femoral head and acetabulum show up clearly on ultrasound. The arc of the femoral head or acetabulum may be used to determine the location of the center of the femoral head. A skin mark may be made over the center of the femoral head. The skin mark

may be made with a pen, an adhesive sticker, a clip or skin staple, a skin-piercing stud, or the like. A skin-pinching or skin-penetrating mark may be preferable in the presence of ultrasound gel. The skin mark may be transferred to the femoral support arm assembly 2786 with a plumb line, which may be supported by the femoral head finder 2918 on the bar 2790. Line 119 in FIG. 35A indicates the plumb line supported by the femoral head finder 2918 and positioned over the skin mark over the center 120 of the femoral head.

[00155] FIG. 36 shows the step of securing a collar 2926 to the bar 2790 beside the femoral head finder 2918. This step may be similar to or identical to the step of FIG. 70 of U.S. Patent Application No. 15/081828 and/or FIG. 4 of this application. The collar 2926 may be similar to or identical to the collar 926 or 1926.

[00156] The preceding steps may be performed before the patient is sterile draped. This is advantageous as it occurs before operative time begins to toll.

[00157] FIG. 37 shows the step of removing the femoral head finder 2918 and securing a target clamp assembly 2818 to the bar 2790 beside the collar 2926. This step may be similar to or identical to the step of FIG. 71 of U.S. Patent Application No. 15/081828 and/or FIG. 5 of this application. The target clamp assembly 2818 includes a target 2820, a retaining ring 2822, a first clamp body 2824, a second clamp body 2826, a lever 2828, a link 2830, and a pin 2832. The example shows two links 2830 and eight pins 2832. The target clamp assembly 2818 may be similar to or identical to the target clamp assembly 818 or 1818. The femoral support arm assembly 2786 with attached collar 2926 may be covered by a sterile drape after the femoral head finder 2918 is removed and before the target clamp assembly 2818 is coupled to the bar 2790, in a manner similar to that shown in FIG. 71 of U.S. Patent Application No. 15/081828.

[00158] FIG. 38 shows the step of assembling the bridge 2878, target mounting block 2880, dovetail lock 2881, target 2882, and thumbscrew 2884 to the lower bar 2874 and the foot receiver 2872 to form a complete foot holder assembly 2870. This step may be similar to or identical to the step of FIG. 6.

[00159] FIG. 39 shows the step of making a small provisional proximal tibial resection 209 at the base of the tibial eminence at the level of the normal lateral tibial plateau, which may optionally be referred to as a tibial sizing notch in situations where the resection 209 is limited to a small area such as the center of the lateral articular surface. The provisional proximal tibial resection 209 may involve the anterior portion of the tibial plateau as shown, or it may be less extensive or more extensive than shown. For example, the provisional proximal tibial resection

209 may involve only the tibial eminence. The provisional proximal tibial resection 209 marks the level of the unworn lateral tibial plateau and the actual joint line of the femoral-tibial joint.

[00160] FIGS. 40A-40B show the step of coupling a femoral pin block assembly 2501 to the anterior distal femur. This step may be similar to or identical to the step of FIG. 72 of U.S. Patent Application No. 15/081828 and/or FIG. 8A of this application. FIG. 40A is a perspective view and FIG. 40B is a top view. The femoral pin block assembly 2501 includes a base 2502, a handle 2516, a pin guide 2514, a screw 2513, and a pin sleeve 2515. The example shows two screws 2513. The femoral pin block assembly 2501 is coupled to a femoral extension rod assembly 2506. The femoral extension rod assembly 2506 includes an outer rod 2604, an inner rod 2606, a spool 2608, a sleeve 2610, a ring 2612, a retaining ring 2614, and a pin 2601. The femoral extension rod assembly 2506 may be similar to or identical to the femoral extension rod 306, 506, 1506 or the tibial extension rod 313, 511, 1511, 2511. The spool 2608 rests in the target 2820 so that the femoral extension rod assembly 2506 extends over the center 120 of the femoral head.

[00161] FIGS. 41A-41B show perspective views of the femoral pin block assembly 2501. The pin guide 2514 includes a first hole 2519 and a second hole 2521. The femoral pin block assembly 2501 may be similar to the femoral pin guide assembly 1501 of FIG. 9A. The first hole 2519 includes a longitudinal slot 2523. The first hole 2519 receives the pin sleeve 2515. The first hole 2519 may be parallel to the bone contacting surface 2518 of the base 2502, or a theoretical bone contacting plane defined by spikes 2538 protruding from the bone contacting surface of the base. The second hole 2521 is anteriorly spaced apart from the first hole. The second hole 2521 may be parallel to the bone contacting surface 2518 of the base 2502, or a theoretical bone contacting plane defined by spikes 2538 protruding from the bone contacting surface of the base, parallel to the first hole 2519, or aligned to correspond to the upcoming anterior femoral resection 214, in other words coplanar with the anterior femoral resection 214. The second hole 2521 may be located so that a guide wire, k-wire, pin, drill, or the like passed through the second hole is aligned with the bone contacting surface 2518 of the base 2502, or a theoretical bone contacting plane defined by spikes 2538 protruding from the bone contacting surface of the base, or the anterior femoral resection 214 (which may be at an angle to the bone contacting surface 2518 or the theoretical bone contacting plane). Preferably, the second hole 2521 is located so that the guide wire, etc. exits the anterior femoral cortex at the distal edge 2517 of the base 2502. The second hole 2521 may be used to confirm that the distal

anterior femoral resection 214, discussed below, will intersect the distal anterior femoral cortex at a satisfactory location. This ensures that the distal anterior femoral resection 214 is not too deep, so that it notches the anterior femur, and not too shallow, so that the final implant sits above the bone surface.

[00162] In an alternate arrangement, the hole 2519 may be parallel to the femoral transverse plane, or in other words, perpendicular to the upcoming distal femoral resection 206. The hole 2521 may also be parallel to the femoral transverse plane, or in other words, perpendicular to the distal femoral resection 206. Optionally, the femoral pin block assembly 2501 may enable the first and second holes to be adjusted, together or separately, with respect to the bone contacting surface 2518 and/or with respect to the mechanical axis 202 of the femur/leg. Preferably, the adjustability occurs between the distal part of pin guide 2514 and the distal part of base 2502.

[00163] FIG. 42 shows the step of placing a femoral pin 2505 into the distal femur through the pin sleeve 2515 and the first hole 2519 of the femoral pin block assembly 2501. This step may be similar to or identical to the step of FIG. 10. The femoral pin 2505 encodes information about 1) the proper varus/valgus orientation of the distal femoral resection 206, 2) the flexion/extension orientation of the distal anterior femoral resection 214 and the distal posterior femoral resection 220, 3) the middle of the trochlear groove (Whiteside's line). The femoral pin 2505 enables rotational adjustment of the femoral four-in-one cut guide assembly 3010 about the pin 2505, which ensures proper tracking of the patella. More specifically, the femoral four-in-one cut guide assembly 3010 may be adjusted for varus-valgus rotation about the femoral post 3122, which rotates within the hole 3004 created by the femoral pin 2505. The distal femoral resection 206, distal anterior femoral resection 214, distal posterior femoral resection 220, femoral four-in-one cut guide assembly 3010, femoral post 3122, and hole 3004 are discussed in greater detail below. FIG. 42 also shows the step of placing a femoral pin 2507 into the distal femur through the second hole 2521. The femoral pin 2507 may be placed into the distal femur temporarily to verify that the distal anterior femoral resection 214 will intersect the distal anterior femoral cortex at a satisfactory location, and then removed. The femoral pin 2505 is preferably a 5 mm diameter drill. The femoral pin 2507 is preferably a 3.2 mm diameter pin. Note that the femoral pin block assembly 2501 is not pinned to the anterior surface of the femur 100.

[00164] FIG. 43 shows the step of removing the pin sleeve 2515 from the first hole 2519

after the femoral pin 2505 has been placed into the distal femur. This step may be similar to or identical to the step of FIG. 11. FIG. 43 also shows the step of removing the femoral pin 2507 from the second hole 2521.

[00165] FIG. 44 shows the step of removing the femoral pin block assembly 2501 after the femoral pin 2505 has been placed into the distal femur and the pin sleeve 2515 has been removed from the first hole 2519. This step may be similar to or identical to the step of FIG. 12. The femoral pin 2505 slides laterally out of the first hole 2519 through the slot 2523 (FIG. 41B). In other words, the femoral pin block assembly 2501 slides anteriorly off of the femoral pin 2505.

[00166] FIGS. 45A-45B show the step of setting the knee angle to 90 degrees with a knee angle guide 2930. FIG. 45A is a perspective view and FIG. 45B is a side view. The knee angle guide 2930 includes a knee angle frame 2932 and a rod 2934. The knee angle frame 2932 includes a hole 2936 which receives the femoral pin 2505 and bilateral holes 2938, 2940 which receive the rod 2934. The hole 2938 is used with a right knee and the hole 2940 is used with a left knee as illustrated. The holes 2938, 2940 are parallel to each other. Referring to FIG. 45B, the femoral pin 2505 has a central longitudinal axis 2942. The rod 2934 has a central longitudinal axis 2944. The orientation of axis 2944 is set by hole 2940 which receives the rod 2934, or hole 2938 for a right knee. A 90 degree angle 2946 exists between axis 2944 and axis 2948 of the left arm 2950 of the knee angle frame 2932. A small acute angle 2952 may optionally exist between axis 2942 and 2948. The angle 2952 may be greater than or equal to zero degrees. The illustrated angle 2952 is 3 degrees. In other words, the illustrated axis 2942 is parallel to the distal anterior femoral cortex, thus parallel to the distal anterior femoral resection 214, and is at an angle of 3 degrees to the distal femoral resection 206. In other examples, the axis 2942 may be perpendicular to the distal femoral resection 206 and would thus form a small acute angle with the distal anterior femoral resection 214. The illustrated knee angle guide 2930 holds the rod 2934 (axis 2944) parallel to the distal femoral resection 206 so that when the proximal tibial resection 210 is made, its slope is accurate.

[00167] FIG. 46 shows the step of coupling a distal femoral cut guide assembly 2960 to the femur 100. The distal femoral cut guide assembly 2960 includes a distal plate 2962, a distal femoral cut guide 2964, and an interlock 2966. The distal plate 2962 slides over the femoral pin 2505. The interlock 2966 couples the distal femoral cut guide 2964 to the distal plate 2962 so that the distal femoral cut guide 2964 is free to slide in the anterior-posterior direction relative

to the distal plate 2962. Two pins 2968, 2970 are shown securing the distal femoral cut guide 2964 to the femur 100.

[00168] FIGS. 47A-47B show exploded perspective views of the distal femoral cut guide assembly 2960. The distal plate 2962 includes a medial plate portion 2972, a lateral plate portion 2974, and holes 2976, 2978, 2980, 2982, 2984. The distal femoral cut guide 2964 includes a slot 2986, holes 2988, 2990, and holes 2992, 2994, 2996. Each of the holes 2992, 2994, 2996 may optionally be a cluster of holes as shown. The interlock 2966 includes a body 2998 and two posts 3000, 3002. The femoral pin 2505 is received in hole 2976. The post 3000 is received in holes 2988 and 2978. The post 3002 is received in holes 2990 and 2980. The pin 2968 is received in hole 2992 or another hole in its cluster. The pin 2970 is received in hole 2994 or another hole in its cluster. Another pin (not shown) may optionally be received in hole 2996 or another hole in its cluster. A saw blade (not shown) is received in the slot 2986 to make a distal femoral resection 206.

[00169] FIG. 48 shows the step of removing the interlock 2966, the distal plate 2962, the femoral pin 2505, and making a distal femoral resection 206. The distal femoral resection 206 is made through the saw slot 2986 in the distal femoral cut guide 2964. Removing the femoral pin 2505 leaves a hole 3004 in the distal femur. The hole 3004 is anterior to the femoral intramedullary canal in dense strong subtrochlear bone.

[00170] FIGS. 49A-49D show the step of coupling a femoral four-in-one cut guide assembly 3010 to the femur 100 and a proximal tibial cut guide 3012 to the tibia 104. This step may be similar to the step of FIG. 14A. FIG. 49A is a perspective view. FIG. 49B is a detail view of a portion of FIG. 49A. FIG. 49C is a front view. FIG. 49D is a side view. The four-in-one cut guide assembly 3010 is an adjustable assembly. The four-in-one cut guide assembly 3010 includes an anterior cut guide 3014, an anterior chamfer guide 3016, a posterior chamfer guide 3018, a posterior cut guide 3020, a gear assembly 3022, and a screw 3024. Four screws 3024 are shown, two in the anterior chamfer guide 3016 and two in the posterior chamfer guide 3018. The four-in-one cut guide assembly 3010 and the proximal tibial cut guide 3012 are adjustably coupled together by a latch mechanism 3026. The proximal tibial cut guide 3012 is coupled to a tibial extension rod assembly 2511. The tibial extension rod assembly 2511 includes an outer rod 2605, an inner rod 2607, a sleeve 2611, a ring 2613, a pin 2601, and a ball 2617. The tibial extension rod assembly 2511 may be similar to or identical to the tibial extension rod 313, 511, 1511 or the femoral extension rod 306, 506, 1506, 2506. The ball 2617 rests in the target 2882

so that the tibial extension rod assembly 2511 extends over the center of the distal tibia 104. The femoral four-in-one cut guide assembly 3010 and the proximal tibial cut guide 3012 may be adjusted for varus-valgus rotation about the femoral post 3122 in the hole 3004 to position the ball 2617 in the target 2882.

[00171] FIGS. 50A-50D show the femoral four-in-one cut guide assembly 3010, the proximal tibial cut guide 3012, and the latch mechanism 3026. FIGS. 50A-50B are perspective views. FIGS. 50C-50D are exploded perspective views. The proximal tibial cut guide 3012 includes a body 3028 with a proximal undercut channel 3030 defined by side walls 3032, 3034, a saw slot 3036, holes 3038, 3040, 3042, a distal arm 3044 which bifurcates into arms 3046, 3048, which are separated by a slot 3050, and terminates in a compliant pin receiver 3052. The slot 3050 may receive the tibial pin 1507 in the manner shown in FIG. 14A. The pin receiver 3052 receives pin 2601 of the tibial extension rod assembly 2511. The holes 3038, 3040, 3042 may be clusters of holes as shown. The latch mechanism 3026 includes a body 3054, a lever 3056, and pins 3058, 3060. The body 3054 includes a proximal undercut rail 3062, a distal undercut rail 3064, a grip portion 3066, a recess 3068, and holes 3070, 3072. The lever 3056 includes a tooth 3074, a notch 3076, a button 3078, a hole 3080, and a spring arm 3082. The lever 3056 is received in the recess 3068 with the tooth 3074 opposite the grip portion 3066 and the button 3078 exposed. The pin 3060 is received in the hole 3070 and the notch 3076. The pin 3058 is received in the holes 3072, 3080. The distal undercut rail 3064 is received in the proximal undercut channel 3030 so that the proximal tibial cut guide 3012 may be adjusted relative to the femoral four-in-one cut guide assembly 3010 in the proximal-distal or superior-inferior direction (relative to the femur).

[00172] Optionally, for the purpose of making a provisional tibial resection 209, the proximal tibial cut guide 3012 can be positioned anterior and distal to its illustrated position in FIG. 50A, in other words distal to the posterior cut guide 3020, so that the undercut channel 3180 and the undercut channel 3030 are aligned to form a continuous undercut channel so that the proximal tibial cut guide 3012 may be adjusted relative to the femoral four-in-one cut guide assembly 3010 in the proximal-distal or superior-inferior direction (relative to the femur). The latch mechanism 3026 including body 3054 and lever 3056 would of course be reconfigured to complement this arrangement.

[00173] Optionally, the femoral four-in-one cut guide assembly 3010 and the proximal tibial cut guide 3012 may be combined together as a five-in-one cut guide assembly. In this

arrangement, the proximal tibial cut guide 3012 may be adjustable relative to the femoral four-in-one cut guide assembly 3010 in the anterior-posterior direction (relative to the femur), and may also be adjustable in the proximal-distal direction. The gear assembly 3022 would of course be reconfigured with additional gears and a rack to complement this arrangement.

[00174] FIGS. 51A-51E show the femoral four-in-one cut guide assembly 3010. FIG. 51A is a front view. FIG. 51B is a cross sectional view taken along line 51B-51B of FIG. 51A. FIG. 51C is a cross sectional view taken along line 51C-51C of FIG. 51A. FIGS. 51D-51E are exploded perspective views. The anterior cut guide 3014 includes a medial saw slot 3124, a lateral saw slot 3126, a plate 3128 with a medial rack 3130, a generally rectangular hole 3132, a round hole 3134, a boss 3136, and a femoral post 3122. The generally rectangular hole 3132 includes a medial channel 3250 and a lateral channel 3252. The femoral post 3122 is shown as a separate part coupled to the boss 3136, but the femoral post 3122 may be integrally formed with the boss 3136. The illustrated femoral post 3122 is oriented to match a femoral pin 2505 that is parallel to the bone contacting surface 2518, or theoretical bone contacting plane, however the femoral post 3122 may be oriented to match a femoral pin 2505 that is parallel to the femoral transverse plane, or in other words, perpendicular to the distal femoral resection 206. Optionally, the femoral four-in-one cut guide assembly 3010 may be designed with a through hole, similar to hole 2976 of distal plate 2962, instead of the femoral post 3122 and boss 3136. The through-hole design may affect many of the parts in the assembly 3010. The anterior chamfer guide 3016 includes a medial saw slot 3138, a lateral saw slot 3140, holes 3142, 3144, holes 3146, 3148, 3150, 3152, and a generally rectangular channel 3154. The holes 3142, 3144 receive screws 3024. The holes 3146, 3148, 3150, 3152 may receive bone screws (not shown) and may be counterbored as shown so that bone screw heads do not occlude the saw slots 3138, 3140. The generally rectangular channel 3154 includes a medial channel 3254, a lateral channel 3256, a medial lip 3262, and a lateral lip 3264. The posterior chamfer guide 3018 includes a medial saw slot 3156, a lateral saw slot 3158, holes 3160, 3162, holes 3164, 3166, 3168, 3170, and a generally rectangular channel 3172. The holes 3160, 3162 receive screws 3024. The holes 3164, 3166, 3168, 3170 may receive bone screws (not shown) and may be counterbored as shown so that bone screw heads do not occlude the saw slots 3156, 3158. By placing bone screws through some or all of holes 3146, 3148, 3150, 3152, 3164, 3166, 3168, 3170, the anterior chamfer guide 3016 and posterior chamfer guide 3018 are locked in place during the sawing process. The bone screws may serve in lieu of, and may be replaced by, a

locking mechanism in the femoral four-in-one cut guide assembly 3010. The bone screws or locking mechanism serve to isolate the gear assembly 3022 from loads generated during the sawing process. The generally rectangular channel 3172 includes a medial channel 3258, a lateral channel 3260, a medial lip 3266, and a lateral lip 3268. The plate 3128 slides against the inner surfaces of the lips 3262, 3264, 3266, 3268. The posterior cut guide 3020 includes a medial saw slot 3174, a lateral saw slot 3176, a generally rectangular socket 3178, and a distal undercut channel 3180 defined by side walls 3182, 3184. The proximal undercut rail 3062 is received in the distal undercut channel 3180 so that the proximal tibial cut guide 3012 may be adjusted relative to the femoral four-in-one cut guide assembly 3010 in the proximal-distal or superior-inferior direction (relative to the femur). The gear assembly 3022 is received in the hole 3132, channels 3154, 3172, and socket 3178.

[00175] The femoral post 3122 may optionally be included on a bone-facing side of a conventional four-in-one cut guide, integrally formed or as a separate part, for engagement with the hole 3004. Alternatively, the conventional four-in-one cut guide may optionally include a through hole that receives the femoral pin 2505. Any of these optional arrangements enable the conventional four-in-one cut guide to be rotationally adjusted in the manner described herein for the femoral four-in-one cut guide assembly 3010.

[00176] FIGS. 52A-52B are exploded perspective views of the gear assembly 3022. The gear assembly 3022 includes a housing 3084, a bolt 3086, a bolt head pin 3088, an optional second bolt head pin 3090, a saddle block 3092, an anterior rack 3094, a posterior rack 3096, a first medial gear 3098, a second medial gear 3100, a third medial gear 3102, a first lateral gear 3104, a second lateral gear 3106, a third lateral gear 3108, a fourth lateral gear 3110, a first shaft 3112, a second shaft 3114, a third shaft 3116, a fourth shaft 3118, and a fifth shaft 3120.

[00177] The housing 3084 includes holes 3188, 3190, 3192, 3194, 3196, 3198, 3200, 3202, 3204, rectangular bosses 3206, 3208, a medial rail 3210, a lateral rail 3212, and a window 3214. The hole 3188 receives the bolt 3086. The hole 3190 receives the bolt head pin 3088. The optional hole 3192 receives the optional second bolt head pin 3090. The boss 3206 surrounds the hole 3194. The boss 3208 surrounds the hole 3196. The medial rail 3210 is received in the medial channels 3250, 3254, 3258. The lateral rail 3212 is received in the lateral channels 3252, 3256, 3260. Preferably, the rails 3210, 3212 and channels 3250, 3252, 3254, 3256, 3258, 3260 are complementary undercut shapes, such as dovetails (illustrated). The undercut engagement acts to prevent the generally rectangular channels 3154, 3172 from spreading during heavy use.

[00178] The bolt 3086 includes a head 3216, a circumferential groove 3218, a shaft 3220, and a torque drive feature 3222. The groove 3218 receives the bolt head pin 3088 and the optional second bolt head pin 3090, if present. The shaft 3220 is at least partially threaded from the end opposite the head 3216.

[00179] The saddle block 3092 includes a generally rectangular body 3224, a threaded hole 3226, a boss 3228, and an indentation 3229. The body 3224 is received in the window 3214 so that the boss 3228 protrudes from the housing 3084 near the rails 3210, 3212 and the indentation 3229 faces the first medial gear 3098. The threaded hole 3226 receives the shaft 3220. The boss 3228 is received in the hole 3134.

[00180] The anterior rack 3094 includes a rack 3230, a hole 3232, and a hole 3234. The holes 3232, 3234 receive screws 3024.

[00181] The posterior rack 3096 includes a rack 3236, a hole 3238, and a hole 3240. The holes 3238, 3240 receive screws 3024.

[00182] Referring to FIGS. 51B-51C, the medial rack 3130 meshes with the first medial gear 3098, which is mounted on a hexagonal boss of the second lateral gear 3106. The second lateral gear 3106 thus rotates with the first medial gear 3098. The second lateral gear 3106 meshes with the first lateral gear 3104, which meshes with the anterior rack 3094, which is fastened to the anterior chamfer guide 3016 with screws 3024. The second lateral gear 3106 also meshes with the third lateral gear 3108. The third lateral gear 3108 meshes with the fourth lateral gear 3110, which is mounted on a hexagonal boss of the second medial gear 3100. The second medial gear 3100 thus rotates with the fourth lateral gear 3110. The second medial gear 3100 meshes with the third medial gear 3102, which meshes with the posterior rack 3096, which is fastened to the posterior chamfer guide 3018 with screws 3024.

[00183] The first shaft 3112 bears the first medial gear 3098 and the second lateral gear 3106. The first shaft 3112 is received in hole 3196. The second shaft 3114 bears the second medial gear 3100 and the fourth lateral gear 3110. The second shaft 3114 is received in hole 3198. The third shaft 3116 bears the third medial gear 3102. The third shaft 3116 is received in hole 3200 and is cantilevered in the window 3214. The fourth shaft 3118 bears the first lateral gear 3104. The fourth shaft 3118 is received in hole 3202 and is cantilevered in the window 3214. The fifth shaft 3120 bears the third lateral gear 3108. The fifth shaft 3120 is received in hole 3204 and is cantilevered in the window 3214.

[00184] The four-in-one cut guide assembly 3010 can be adjusted to position the saw slots

3138, 3140, 3156, 3158, 3174, 3176 of the guides 3016, 3018, 3020 (respectively) to correspond to the progressive arrangement of resection surfaces for the range of femoral component sizes of a knee system. The saw slots 3124, 3126 of the anterior cut guide 3014 are stationary with respect to the femur 100 because in use the femoral post 3122 is in the femoral hole 3004. In the example shown, the anterior-posterior location of each guide 3016, 3018, 3020 is independently adjustable relative to the anterior cut guide in a controlled and synchronized manner. The guides are independently adjustable because each guide may move relative to the anterior cut guide at its own rate or speed. The adjustments made to each guide are controlled and synchronized by the gear assembly 3022 so that turning the bolt 3088 clockwise and counterclockwise causes each guide to move at its own speed, and the relative speeds of the guides are selected so that when the four-in-one cut guide assembly 3010 is adjusted to a particular size, the saw slots are all positioned to correspond to that size. Note the indicia 3186 shown on the housing 3084 in FIG. 52A to indicate prosthesis sizes. An audible, visual, or tactile feedback may be provided to positively indicate that the femoral four-in-one cut guide assembly 3010 is set to a discrete implant size. Optionally, in an arrangement that lacks such positive indicators, a spacer may be used to verify that the femoral four-in-one cut guide assembly 3010 is set to a discrete implant size. As one example, a spacer may have one or more prongs, plates, or fingers that engage one or more of the gaps 3015, 3017, 3019 (FIGS. 53C-53D) that occur between the anterior cut guide 3014, the anterior chamfer guide 3016, the posterior chamfer guide 3018, and the posterior cut guide 3020 of the femoral four-in-one cut guide assembly 3010. The spacer may be removed before making any resections. The relative speeds of the guides are a matter of design choice and will change from one knee system to the next. The example shown provides proportional motion of the guides 3016, 3018, 3020 relative to the anterior cut guide 3014. It is also contemplated that non-proportional motion may be provided, so that one or more of the guides may move sometimes faster and sometimes slower, according to the design rationale of the particular knee system.

[00185] FIGS. 53A-53D show the step of adjusting the femoral four-in-one cut guide assembly 3010, adjusting the proximal tibial cut guide 3012, and pinning the femoral four-in-one cut guide assembly 3010 and the proximal tibial cut guide 3012 to the femur 100 and the tibia 104, respectively. The femoral four-in-one cut guide assembly 3010 and the proximal tibial cut guide 3012 may be adjusted for varus-valgus rotation about the femoral post 3122 in the hole 3004. The femoral four-in-one cut guide assembly 3010 may be adjusted for size by

rotating the bolt 3088 clockwise and counterclockwise to change the anterior-posterior locations of the saw slots 3138, 3140, 3156, 3158, 3174, 3176 of the guides 3016, 3018, 3020 (respectively). The proximal tibial cut guide 3012 is coupled to the femoral four-in-one cut guide assembly 3010 by the latch mechanism 3026, which fixes the saw slot 3036 a predetermined anterior-posterior distance from the saw slots 3174, 3176 and allows the proximal tibial cut guide 3012 to slide in and out over the tibial plateau. Preferably, the femoral four-in-one cut guide assembly 3010 is adjusted by first rotating the bolt 3088 until the femoral four-in-one cut guide assembly 3010 is in its closed or smallest state (shown in FIGS. 49A-51C) and then rotating the bolt 3088 in the opposite direction to move the femoral four-in-one cut guide assembly 3010 toward its fully open or largest state, until the proximal tibial cut guide 3012 contacts the provisional tibial resection 209 (shown in FIGS. 53B-54). At this point, if the femoral four-in-one cut guide assembly 3010 is between sizes, the bolt 3088 may be rotated to adjust the femoral four-in-one cut guide assembly 3010 to the next smaller size. Pins 3242, 3244, 3246, 3248 secure the femoral four-in-one cut guide assembly 3010 and the proximal tibial cut guide 3012 to the femur 100 and tibia 104, respectively. Pin 3242 is received in hole 3194, pin 3244 is received in hole 3038, pin 3246 is received in hole 3040, and pin 3248 is received in slot 3050.

[00186] FIG. 54 shows the step of making an anterior femoral resection 214, an anterior chamfer cut 216, a posterior chamfer cut 218, a posterior femoral resection 220, and a proximal tibial resection 210. The anterior femoral resection 214 is made through the saw slots 3124, 3126 in the anterior cut guide 3014. The anterior chamfer cut 216 is made through the saw slots 3138, 3140 in the anterior chamfer guide 3016. The posterior chamfer cut 218 is made through the saw slots 3156, 3158 in the posterior chamfer guide 3018. The posterior femoral resection 220 is made through the saw slots 3174, 3176 in the posterior cut guide 3020. The proximal tibial resection 210 is made through the saw slot 3036 in the proximal tibial cut guide 3012.

[00187] FIG. 55 shows the step of removing the femoral four-in-one cut guide assembly 3010, the proximal tibial cut guide 3012, the tibial extension rod assembly 2511, and related pins after making the anterior femoral resection 214, the anterior chamfer cut 216, the posterior chamfer cut 218, the posterior femoral resection 220, and the proximal tibial resection 210. This step may be similar to or identical to the step of FIG. 32.

[00188] FIG. 56 shows the step of implanting a femoral component 130, a tibial component

132, an articular insert 134, and a patellar component 136 in the prepared knee joint. This step may be similar to or identical to the step of FIG. 88 of U.S. Patent Application No. 15/081828. The femoral component 130 is fixed to the distal femur 100, the tibial component 132 is fixed to the proximal tibia 104, the articular insert 134 is coupled to the tibial component 132, and the patellar component 136 is fixed to the patella 112. The implant components shown in FIG. 56 are one example of a set of implant components for knee arthroplasty. A subset of the components shown may also be used. Unicompartmental components may also be used.

[00189] FIG. 57 shows the step of converting from an intramedullary referencing system or other conventional referencing system to the system disclosed herein by coupling another femoral pin block assembly 3270 of the present system to a distal femoral cut guide 3272 of the conventional referencing system and placing a femoral pin 2505 into the distal femur through the pin sleeve 2515. This step may take place instead of the steps of coupling the femoral pin block assembly 2501 to the anterior distal femur, as shown in FIG. 40A, and placing the femoral pin 2505 into the distal femur through the pin sleeve 2515 and the first hole 2519 of the femoral pin block assembly 2501, as shown in FIG. 42. The step of FIG. 57 may result in equivalent positioning of the femoral pin 2505 in the distal femur, as shown in FIG. 44, including formation of an equivalent hole 3004. The step of FIG. 57 may occur after a distal femoral resection 206 and a provisional proximal tibial resection 209 have been made.

[00190] FIGS. 58A-58B are exploded perspective views of the femoral pin block assembly 3270 and the distal femoral cut guide 3272. The femoral pin block assembly 3270 includes a body 3274, the pin sleeve 2515, an anterior referencing pin 3276, and a thumbscrew 3278.

[00191] The body 3274 includes a pin guide arm 3280, a distal femoral paddle 3282, and an anterior referencing arm 3284. The pin guide arm 3280 includes a first hole 3286 with a longitudinal slot 3288, equivalent to the first hole 2519 and longitudinal slot 2523. The first hole 3286 receives the pin sleeve 2515, which receives the femoral pin 2505. The slot 3288 is wider than the femoral pin 2505. The pin guide arm 3280 may include an optional second hole (not shown) equivalent to the second hole 2521. The anterior referencing arm 3284 includes a first hole 3290, a slot 3292, and a second hole 3294. The first hole 3290 receives the anterior referencing pin 3276. The slot 3292 splits the first hole 3290 longitudinally and bifurcates the free end of the arm 3284. The second hole 3294 extends through the bifurcated free ends of the arm 3284 transverse to the first hole 3290. The second hole 3294 threadedly receives the thumbscrew 3278, which can be tightened so that the first hole 3290 grips the anterior

referencing pin 3276, or loosened so that the anterior referencing pin is movable within the first hole.

[00192] The anterior referencing pin 3276 extends between a narrow distal end 3296 and a broad proximal end 3298. The distal end 3296 contacts the anterior distal femoral cortex in use, while the proximal end 3298 serves as a handle. The distal end 3296 may taper to a point as shown. The proximal end 3298 may include grip features 3300 such as grooves (shown), knurling, threads, bumps, or a rough surface texture. The anterior referencing pin 3276 may optionally include indicia 3302, best seen in the enlarged detail provided in FIG. 58B. The indicia 3302 may include reference lines, numerals, icons, or other marks.

[00193] The distal femoral cut guide 3272 includes a saw slot 3304, pin holes 3306, 3308, 3310, and holes 3312, 3314. The saw slot 3304 receives a saw blade (not shown) to make the distal femoral resection 206. The saw slot 3304 also receives the distal femoral paddle 3282 as shown in FIG. 57. The pin holes 3306, 3308, 3310 receive bone pins 3316. Each pin hole 3306, 3308, 3310 may be a cluster of holes as shown. Indicia 3318 may be present.

[00194] Any methods disclosed herein comprise one or more steps or actions for performing the described method. The method steps and/or actions may be interchanged with one another. In other words, unless a specific order of steps or actions is required for proper operation of the embodiment, the order and/or use of specific steps and/or actions may be modified.

[00195] Reference throughout this specification to "an embodiment" or "the embodiment" means that a particular feature, structure or characteristic described in connection with that embodiment is included in at least one embodiment. Thus, the quoted phrases, or variations thereof, as recited throughout this specification are not necessarily all referring to the same embodiment.

[00196] Similarly, it should be appreciated that in the above description of embodiments, various features are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure. This method of disclosure, however, is not to be interpreted as reflecting an intention that any claim in this or any application claiming priority to this application require more features than those expressly recited in that claim. Rather, as the following claims reflect, inventive aspects lie in a combination of fewer than all features of any single foregoing disclosed embodiment. Thus, the claims following this Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim

standing on its own as a separate embodiment. This disclosure includes all permutations of the independent claims with their dependent claims.

[00197] Recitation in the claims of the term "first" with respect to a feature or element does not necessarily imply the existence of a second or additional such feature or element. Elements recited in means-plus-function format are intended to be construed in accordance with 35 U.S.C. §112 Para. 6. It will be apparent to those having skill in the art that changes may be made to the details of the above-described embodiments without departing from the underlying principles of the technology.

[00198] While specific embodiments and applications of the present technology have been illustrated and described, it is to be understood that the technology is not limited to the precise configuration and components disclosed herein. Various modifications, changes, and variations which will be apparent to those skilled in the art may be made in the arrangement, operation, and details of the methods and systems of the technology disclosed herein without departing from the spirit and scope of the invention as claimed.

CLAIMS

1. A method for knee arthroplasty, comprising the steps of:

making a provisional proximal tibial resection at a base of a tibial eminence of a tibia of a knee joint;

positioning the knee joint in 90 degrees of flexion, wherein the knee joint comprises a femur and the tibia;

making a hole in a distal aspect of the femur, parallel to a mechanical axis of the femur and displaced from an intramedullary canal of the femur;

coupling a cut guide assembly to the femur and the tibia by inserting a pin or a post of the cut guide assembly into the hole parallel to the mechanical axis of the femur, wherein the cut guide assembly comprises a posterior femoral saw slot, a proximal tibial saw slot, and a tibia-contacting feature; and

contacting the provisional proximal tibial resection with the tibia-contacting feature to position the posterior femoral saw slot a predetermined first distance superior to the provisional proximal tibial resection and to position the proximal tibial saw slot a predetermined second distance inferior to the provisional proximal tibial resection.

2. The method of claim 1, wherein the provisional proximal tibial resection involves only the tibial eminence.

3. The method of claim 1,

wherein making the hole in the distal aspect of the femur comprises making the hole in subtrochlear bone anterior to an intramedullary canal of the femur.

4. The method of claim 3, wherein in a lateral view, the hole is parallel with an exterior distal anterior cortical region of the femur, wherein in an anterior view, the cortical region is centered on the mechanical axis of the femur and located adjacent to and proximal to a proximal edge of a natural articular surface of the femur.

5. The method of claim 3, wherein the cut guide assembly comprises a tibial extension rod terminating in a distal tip, the method comprising the steps of:

rotating the cut guide assembly about the post in the hole to center the distal tip of the tibial extension rod in a medial-lateral width of a distal portion of the tibia;

making a posterior femoral resection through the posterior femoral saw slot; and

making a final proximal tibial resection through the proximal tibial saw slot.

6. The method of claim 3, wherein the cut guide assembly comprises an anterior femoral saw slot that is located a fixed third distance away from the post;

wherein contacting the provisional proximal tibial resection with the tibia-contacting feature positions the posterior femoral saw slot a fourth distance inferior to the anterior femoral saw slot, wherein the cut guide assembly comprises indicia which indicate an implant size that corresponds to the fourth distance.

7. The method of claim 1,

wherein coupling the cut guide assembly to the femur comprises inserting the pin into a hole of the cut guide assembly.

8. The method of claim 7, wherein in a lateral view, the pin is parallel with an exterior distal anterior cortical region of the femur, wherein in an anterior view, the cortical region is centered on the mechanical axis of the femur and located adjacent to and proximal to a proximal edge of a natural articular surface of the femur.

9. The method of claim 7, wherein the cut guide assembly comprises a tibial extension rod terminating in a distal tip, the method comprising the steps of:

rotating the cut guide assembly about the pin in the hole to center the distal tip of the tibial extension rod in a medial-lateral width of a distal portion of the tibia;

making a posterior femoral resection through the posterior femoral saw slot; and

making a final proximal tibial resection through the proximal tibial saw slot.

10. The method of claim 7, wherein the cut guide assembly comprises an anterior femoral saw slot that is located a fixed third distance away from the post;

wherein contacting the provisional proximal tibial resection with the tibia-contacting feature positions the posterior femoral saw slot a fourth distance inferior to the anterior femoral saw slot, wherein the cut guide assembly comprises indicia which indicate an implant size that corresponds to the fourth distance.

11. A method for knee arthroplasty, comprising the steps of:

making a provisional proximal tibial resection at a base of a tibial eminence of a tibia of a knee joint, wherein the knee joint comprises the tibia and a femur;

coupling a cut guide assembly to a distal end of the tibia;

positioning the knee joint in 90 degrees of flexion;

coupling the cut guide assembly to the femur, wherein the cut guide assembly comprises a first femoral saw slot, a proximal tibial saw slot, and a tibia-contacting feature;

wherein the first femoral saw slot comprises a posterior femoral saw slot;

contacting the provisional proximal tibial resection with the tibia-contacting feature to fix the first femoral saw slot a predetermined first distance superior to the provisional proximal tibial resection and to fix the proximal tibial saw slot a predetermined second distance inferior to the provisional proximal tibial resection.

12. The method of claim 11, wherein the provisional proximal tibial resection involves only the tibial eminence.

13. The method of claim 11, comprising the step of:

making a hole in a distal aspect of the femur in subtrochlear bone anterior to an intramedullary canal of the femur;

wherein coupling the cut guide assembly to the femur comprises inserting a post of the cut guide assembly into the hole.

14. The method of claim 13, wherein in an anterior view, the hole is parallel to a mechanical axis of the femur, wherein in a lateral view, the hole is parallel with an exterior distal anterior cortical region of the femur, wherein in an anterior view, the cortical region is centered on the mechanical axis of the femur and located adjacent to and proximal to a proximal edge of a natural articular surface of the femur.

15. The method of claim 13, wherein the cut guide assembly comprises a tibial extension rod terminating in a distal tip, the method comprising the steps of:

centering the distal tip of the tibial extension rod in a medial-lateral width of a distal portion of the tibia;

making a first femoral resection through the first femoral saw slot; and

making a final proximal tibial resection through the proximal tibial saw slot.

16. The method of claim 13, wherein the cut guide assembly comprises a second femoral saw slot that is located a fixed third distance away from the post;

wherein contacting the provisional proximal tibial resection with the tibia-contacting feature positions the first femoral saw slot a fourth distance inferior to the second femoral saw slot, wherein the cut guide assembly comprises indicia which indicate an implant size that corresponds to the fourth distance.

17. The method of claim 11, comprising the step of:

inserting a pin into a distal aspect of the femur in subtrochlear bone anterior to an intramedullary canal of the femur;

wherein coupling the cut guide assembly to the femur comprises inserting the pin into a hole of the cut guide assembly.

18. The method of claim 17, wherein in an anterior view, the pin is parallel to a mechanical axis of the femur, wherein in a lateral view, the pin is parallel with an exterior distal anterior cortical region of the femur, wherein in an anterior view, the cortical region is centered on the mechanical axis of the femur and located adjacent to and proximal to a proximal edge of a natural articular surface of the femur.

19. The method of claim 17, wherein the cut guide assembly comprises a tibial extension rod terminating in a distal tip, the method comprising the steps of:

rotating the cut guide assembly about the pin in the hole to center the distal tip of the tibial extension rod in a medial-lateral width of a distal portion of the tibia;

making a first femoral resection through the first femoral saw slot; and

making a final proximal tibial resection through the proximal tibial saw slot.

20. The method of claim 17, wherein the cut guide assembly comprises a second femoral saw slot that is located a fixed third distance away from the post;

wherein contacting the provisional proximal tibial resection with the tibia-contacting feature positions the first femoral saw slot a fourth distance inferior to the second femoral saw slot, wherein the cut guide assembly comprises indicia which indicate an implant size that corresponds to the fourth distance.

21. A method for arthroplasty of a knee joint comprising a femur and a tibia, the method comprising:

making a provisional proximal tibial resection at an anterior aspect of a base of a tibial eminence of a proximal end of the tibia;

positioning the knee joint in 90 degrees of flexion;

coupling a cut guide assembly to the femur and the tibia, wherein the cut guide assembly comprises a posterior femoral saw slot, a proximal tibial saw slot, and a tibia-contacting feature located between the posterior femoral saw slot and the proximal tibial saw slot, wherein the proximal tibial saw slot is a fixed first distance from the posterior femoral saw slot along an anterior-posterior direction relative to the femur, wherein the tibia-contacting feature is a fixed second distance from the posterior femoral saw slot along the anterior-posterior direction, wherein the first distance is greater than the second distance; and

contacting only the anterior aspect of the provisional proximal tibial resection with the tibia-contacting feature.

22. The method of claim 21, comprising the step of:

making a hole in a distal aspect of the femur in subtrochlear bone anterior to an intramedullary canal of the femur;

wherein coupling the cut guide assembly to the femur comprises inserting a post of the cut guide assembly into the hole.

23. The method of claim 22, wherein in an anterior view, the hole is parallel to a mechanical axis of the femur, wherein in a lateral view, the hole is parallel with an exterior distal anterior cortical region of the femur, wherein in an anterior view, the cortical region is centered on the mechanical axis of the femur and located adjacent to and proximal to a proximal edge of a natural articular surface of the femur.

24. The method of claim 22, wherein the cut guide assembly comprises a tibial extension rod terminating in a distal tip, the method comprising the steps of:

rotating the cut guide assembly about the post in the hole to center the distal tip of the tibial extension rod in a medial-lateral width of a distal portion of the tibia;

making a posterior femoral resection through the posterior femoral saw slot; and

making a final proximal tibial resection through the proximal tibial saw slot.

25. The method of claim 22, wherein the cut guide assembly comprises an anterior femoral saw slot that is located a fixed third distance away from the post;

wherein contacting the provisional proximal tibial resection with the tibia-contacting feature positions the posterior femoral saw slot a fourth distance inferior to the anterior femoral saw slot, wherein the cut guide assembly comprises indicia which indicate an implant size that corresponds to the fourth distance.

26. The method of claim 21, comprising the step of:

inserting a pin into a distal aspect of the femur in subtrochlear bone anterior to an intramedullary canal of the femur;

wherein coupling the cut guide assembly to the femur comprises inserting the pin into a hole of the cut guide assembly.

27. The method of claim 26, wherein in an anterior view, the pin is parallel to a mechanical axis of the femur, wherein in a lateral view, the pin is parallel with an exterior distal anterior cortical region of the femur, wherein in an anterior view, the cortical region is centered on the mechanical axis of the femur and located adjacent to and proximal to a proximal edge of a natural articular surface of the femur.

28. The method of claim 26, wherein the cut guide assembly comprises a tibial extension rod terminating in a distal tip, the method comprising the steps of:

rotating the cut guide assembly about the pin in the hole to center the distal tip of the tibial extension rod in a medial-lateral width of a distal portion of the tibia;

making a posterior femoral resection through the posterior femoral saw slot; and

making a final proximal tibial resection through the proximal tibial saw slot.

29. The method of claim 26, wherein the cut guide assembly comprises an anterior femoral saw slot that is located a fixed third distance away from the post;

wherein contacting the provisional proximal tibial resection with the tibia-contacting feature positions the posterior femoral saw slot a fourth distance inferior to the anterior femoral saw slot, wherein the cut guide assembly comprises indicia which indicate an implant size that corresponds to the fourth distance.

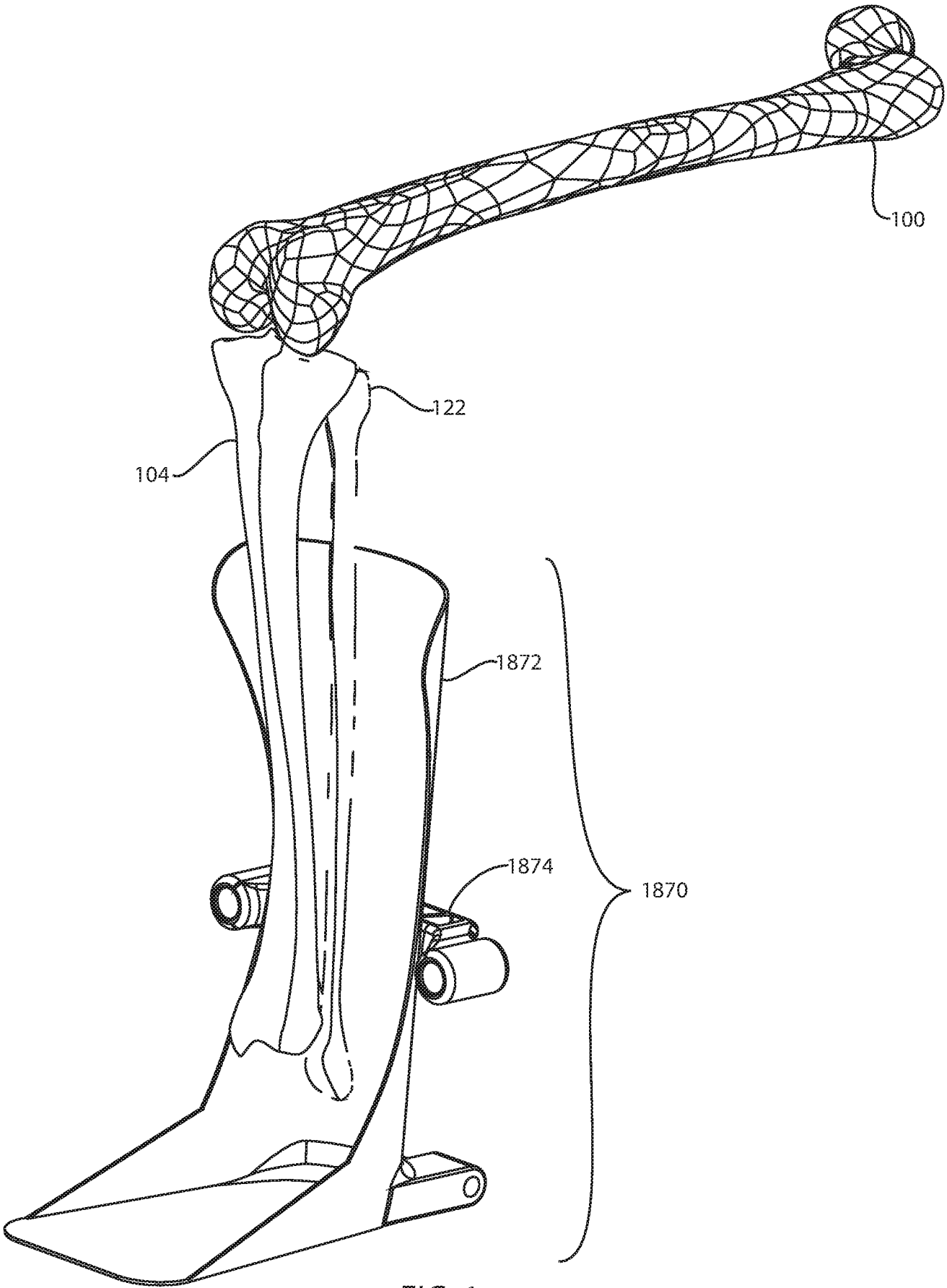

FIG. 1

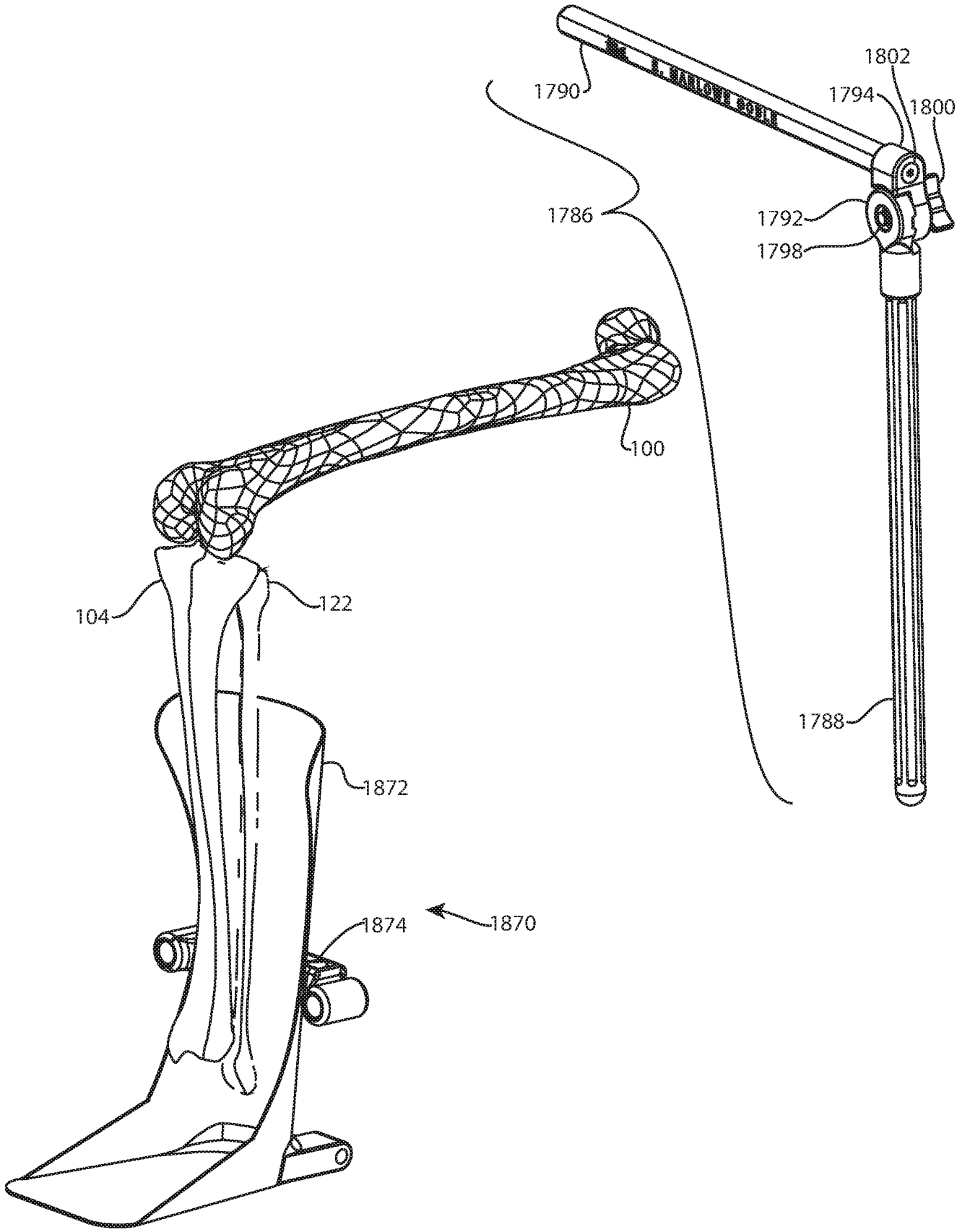
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FIG. 2

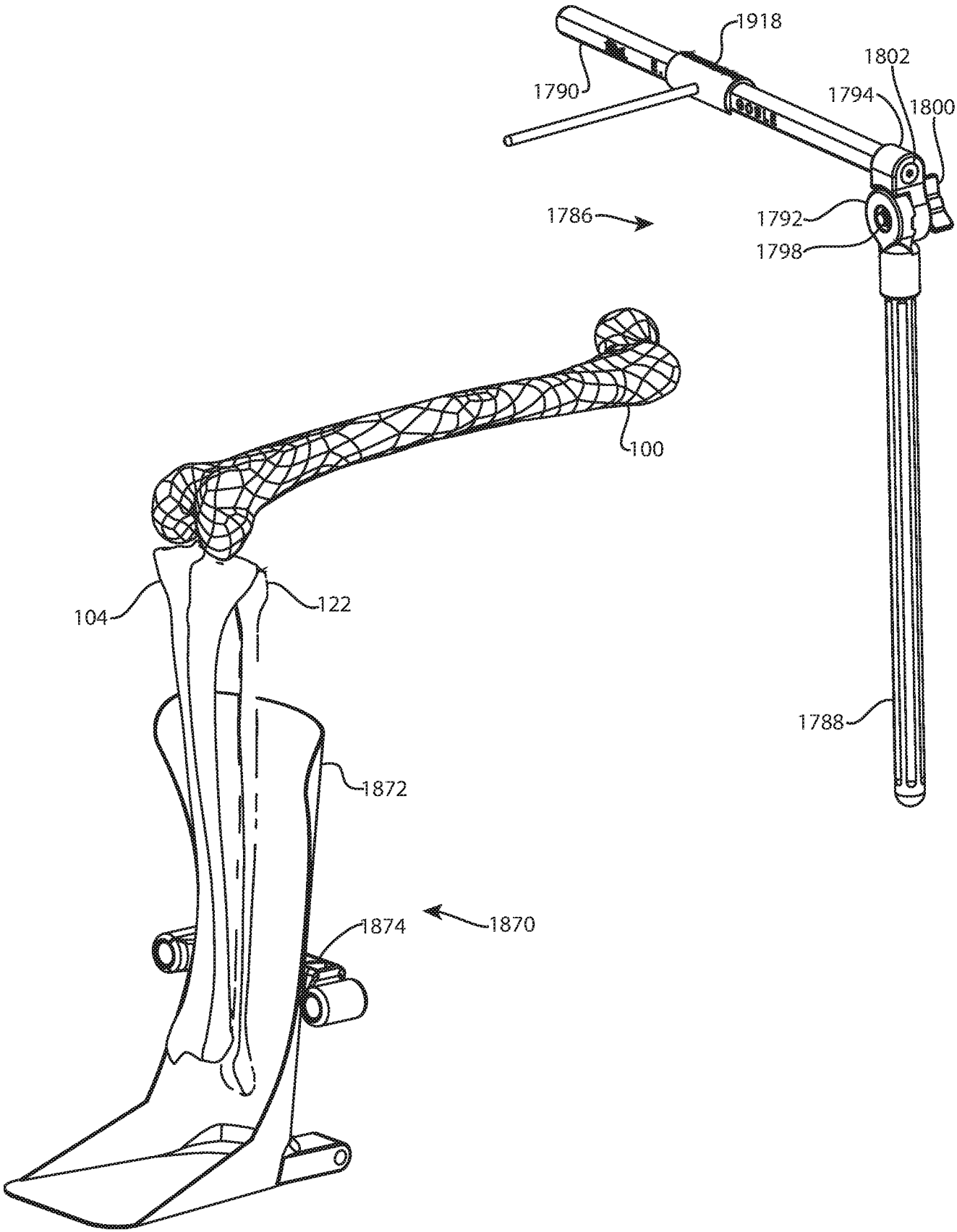
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FIG. 3

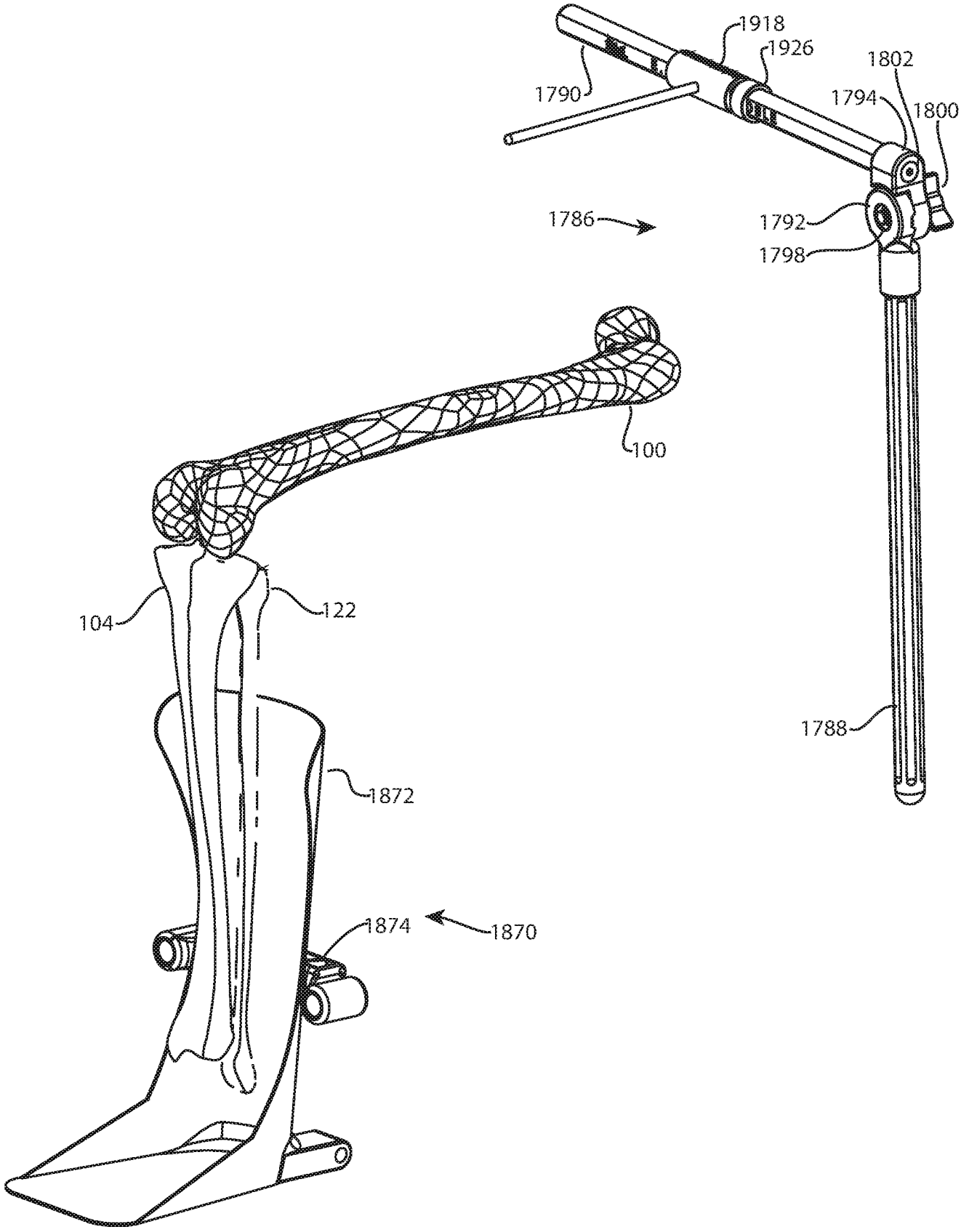
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FIG. 4

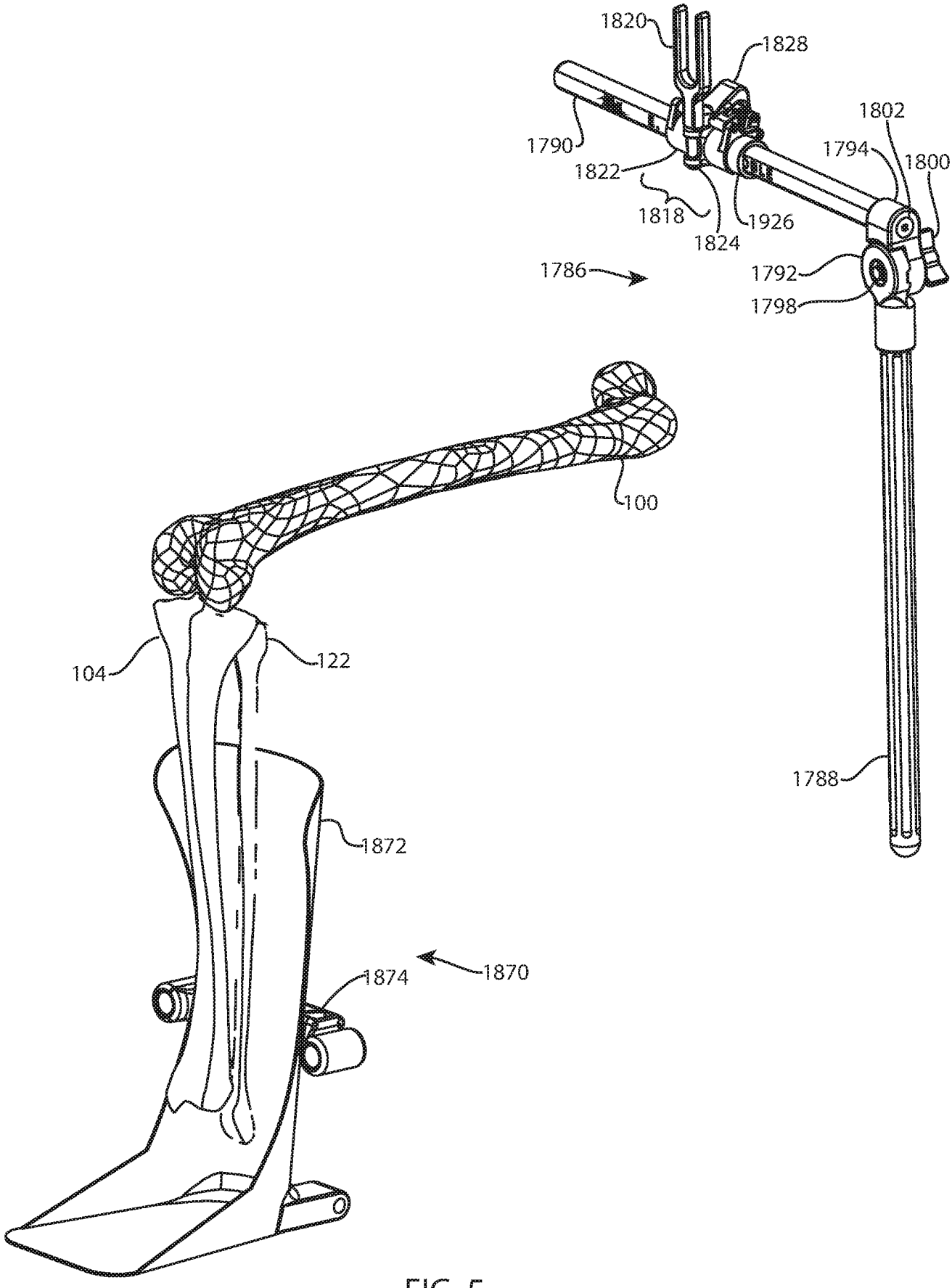
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FIG. 5

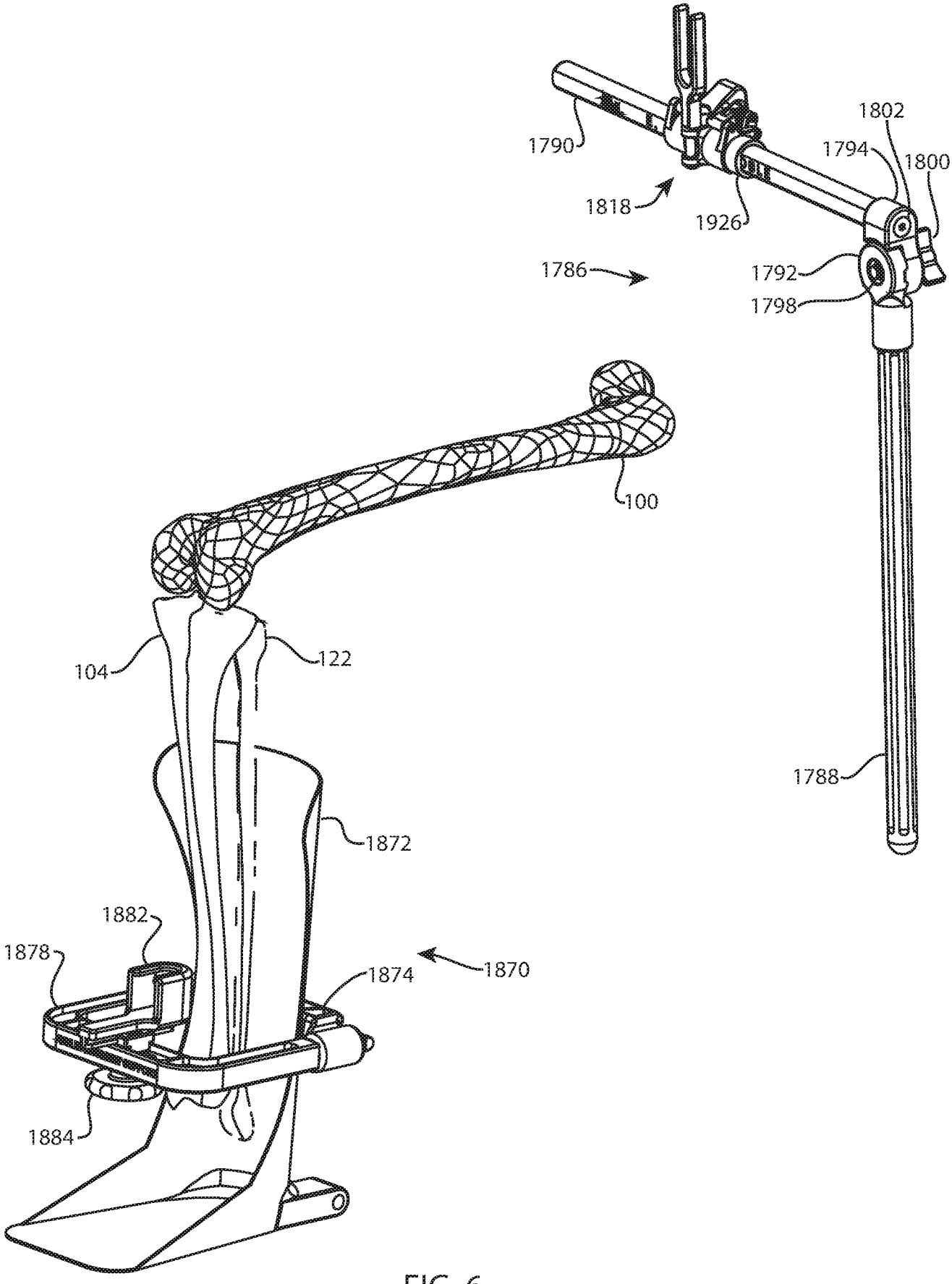
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FIG. 6

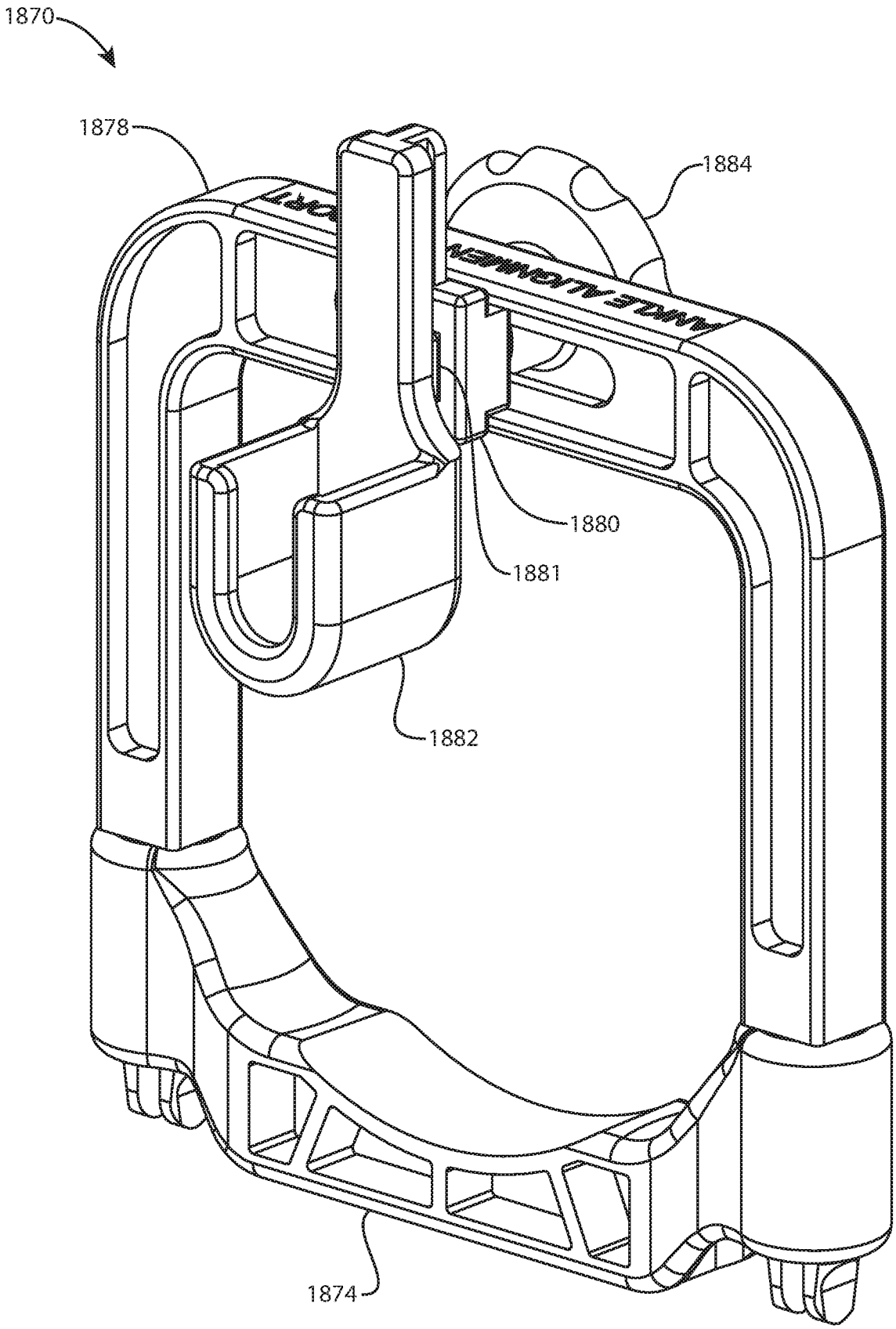

FIG. 7A

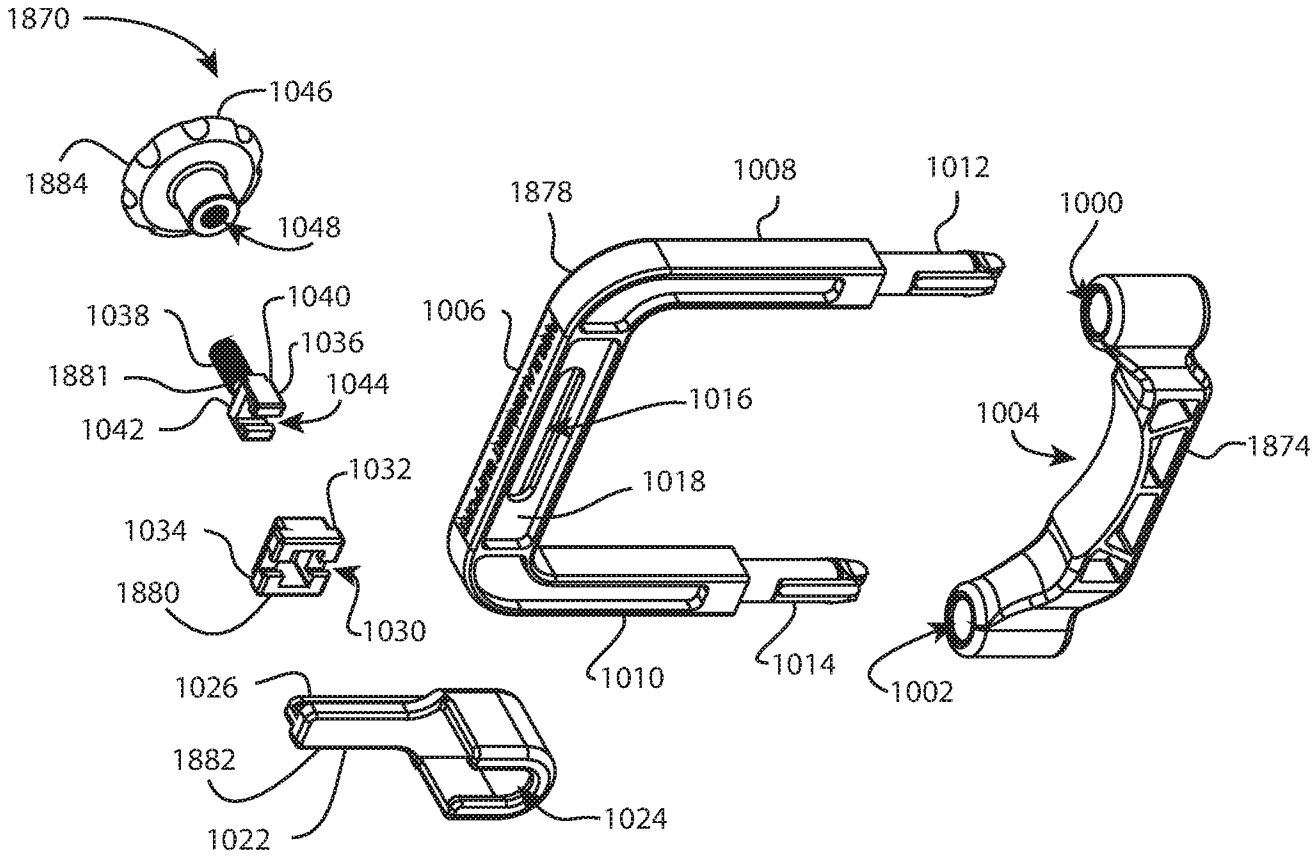
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FIG. 7B

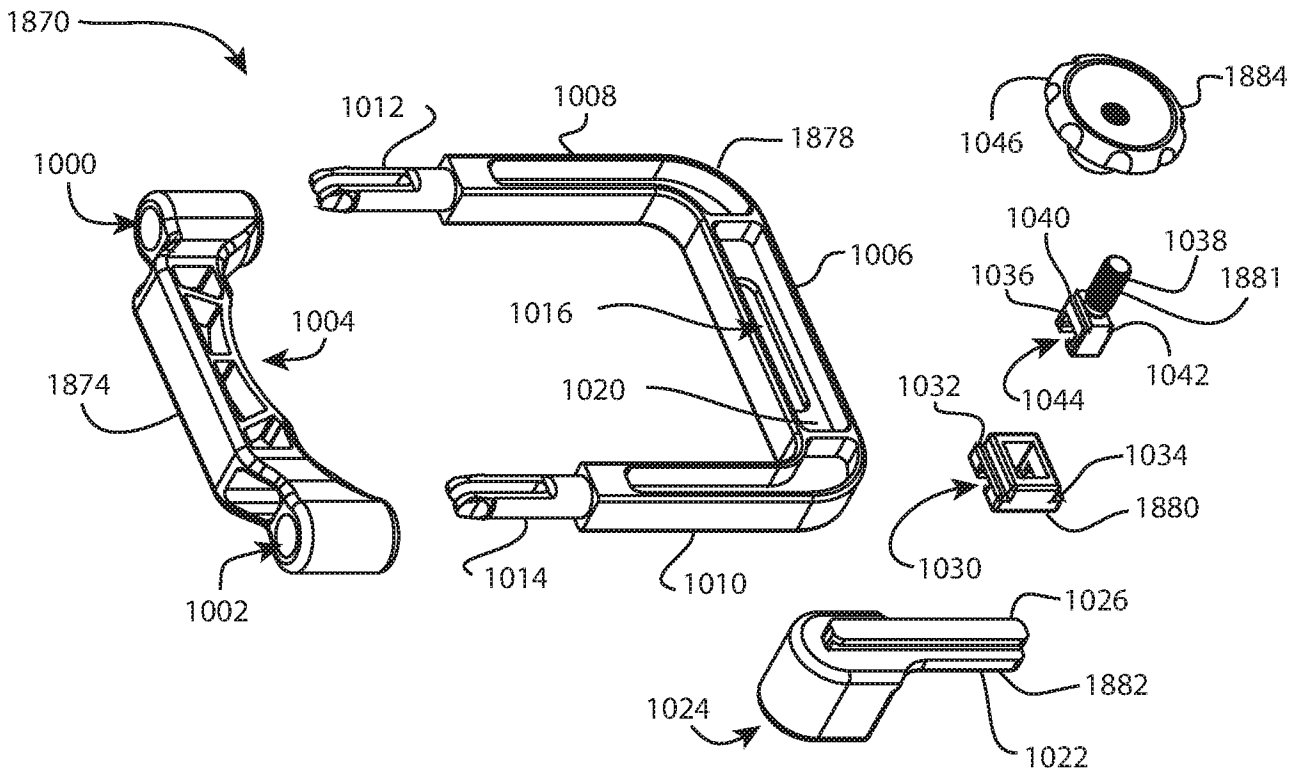
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FIG. 7C

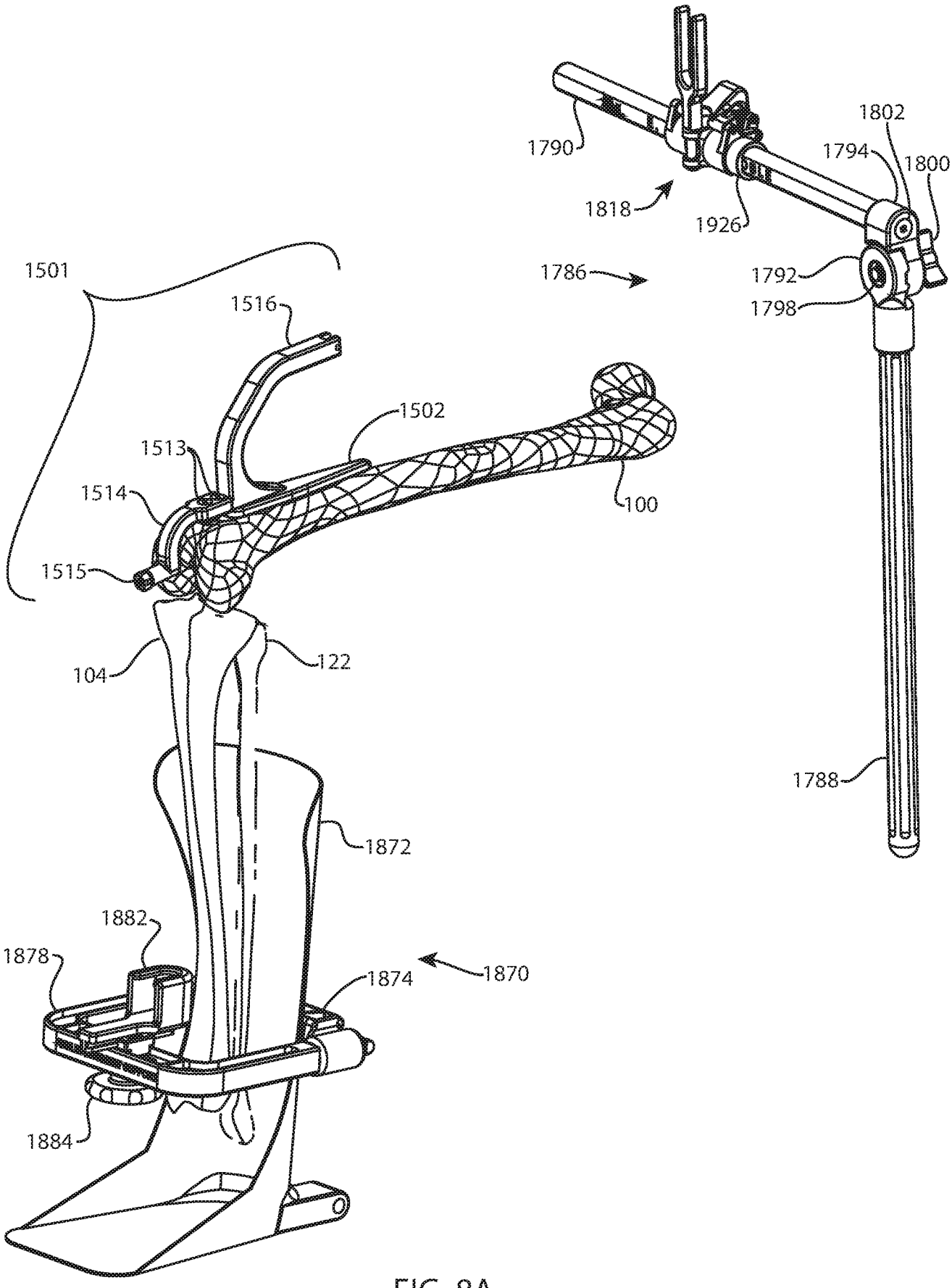
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FIG. 8A

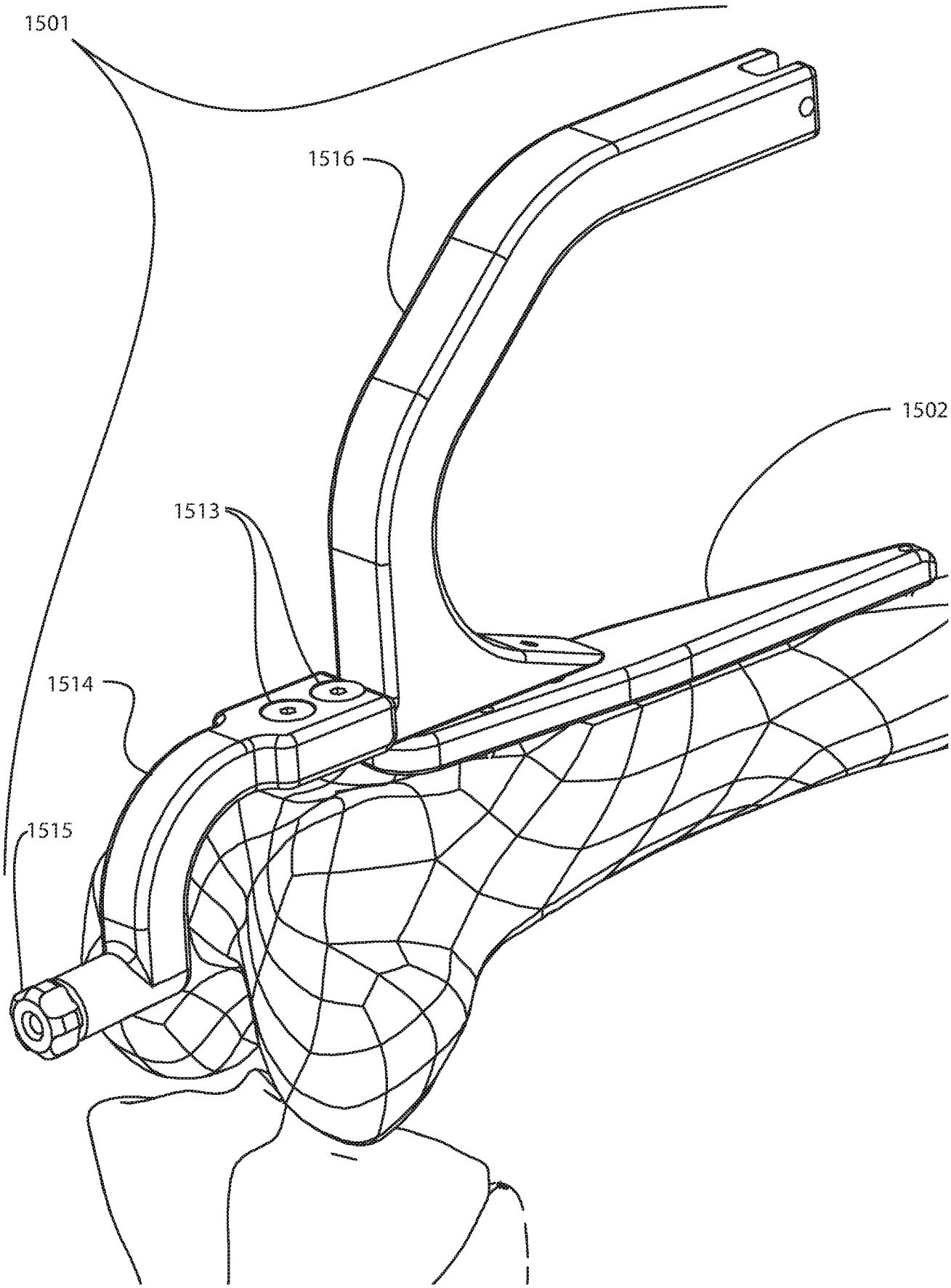

FIG. 8B

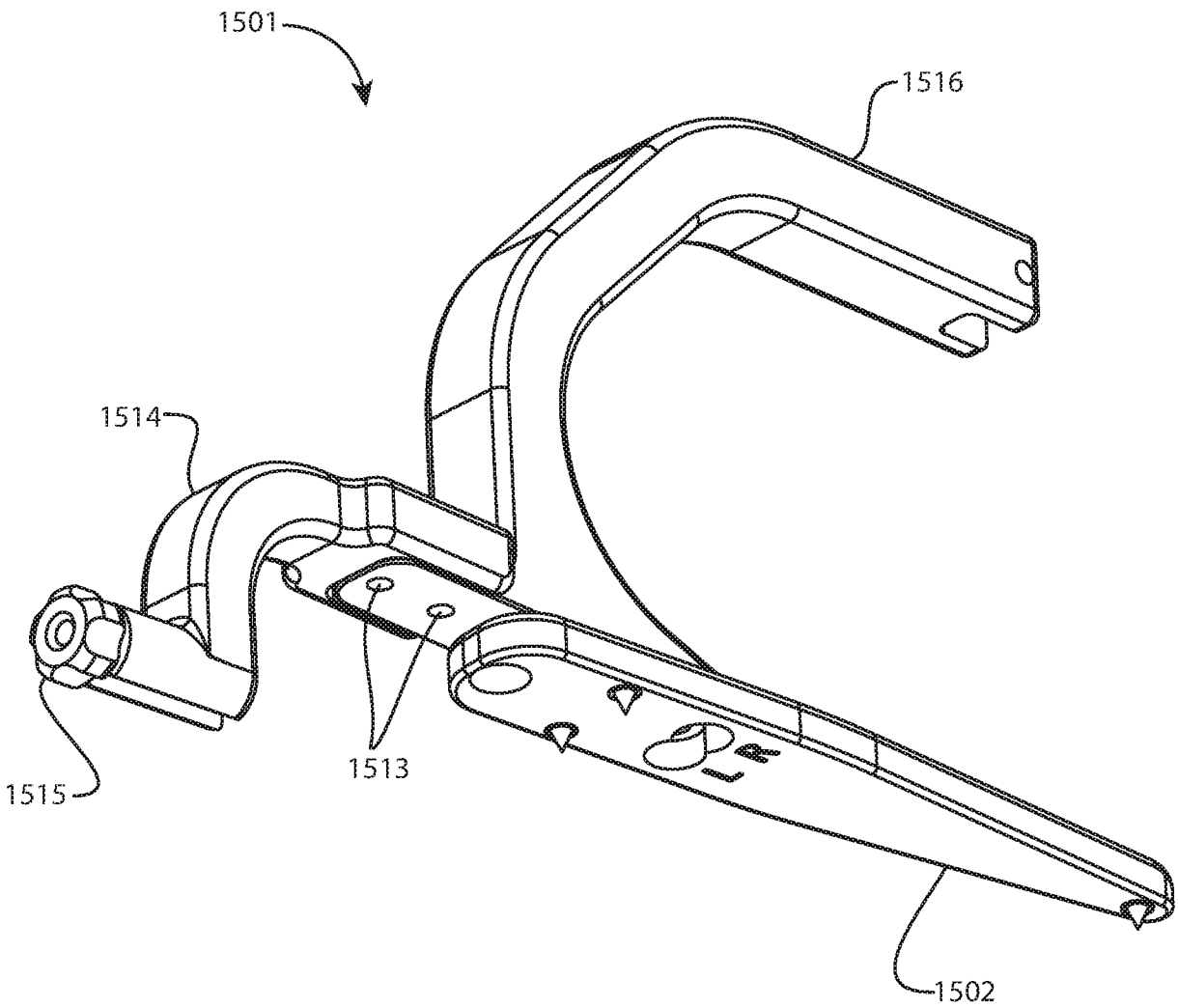

FIG. 9A

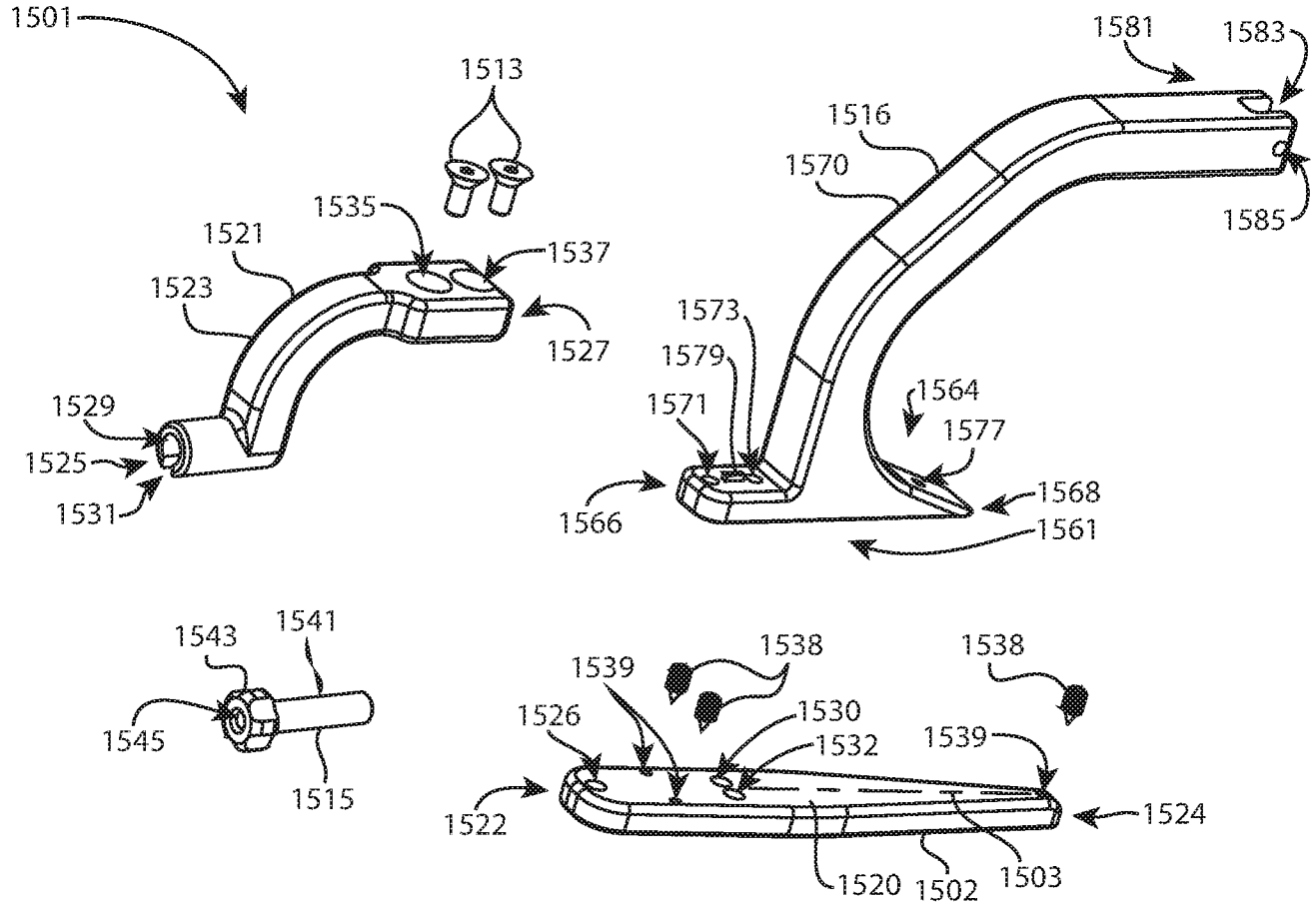
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FIG. 9B

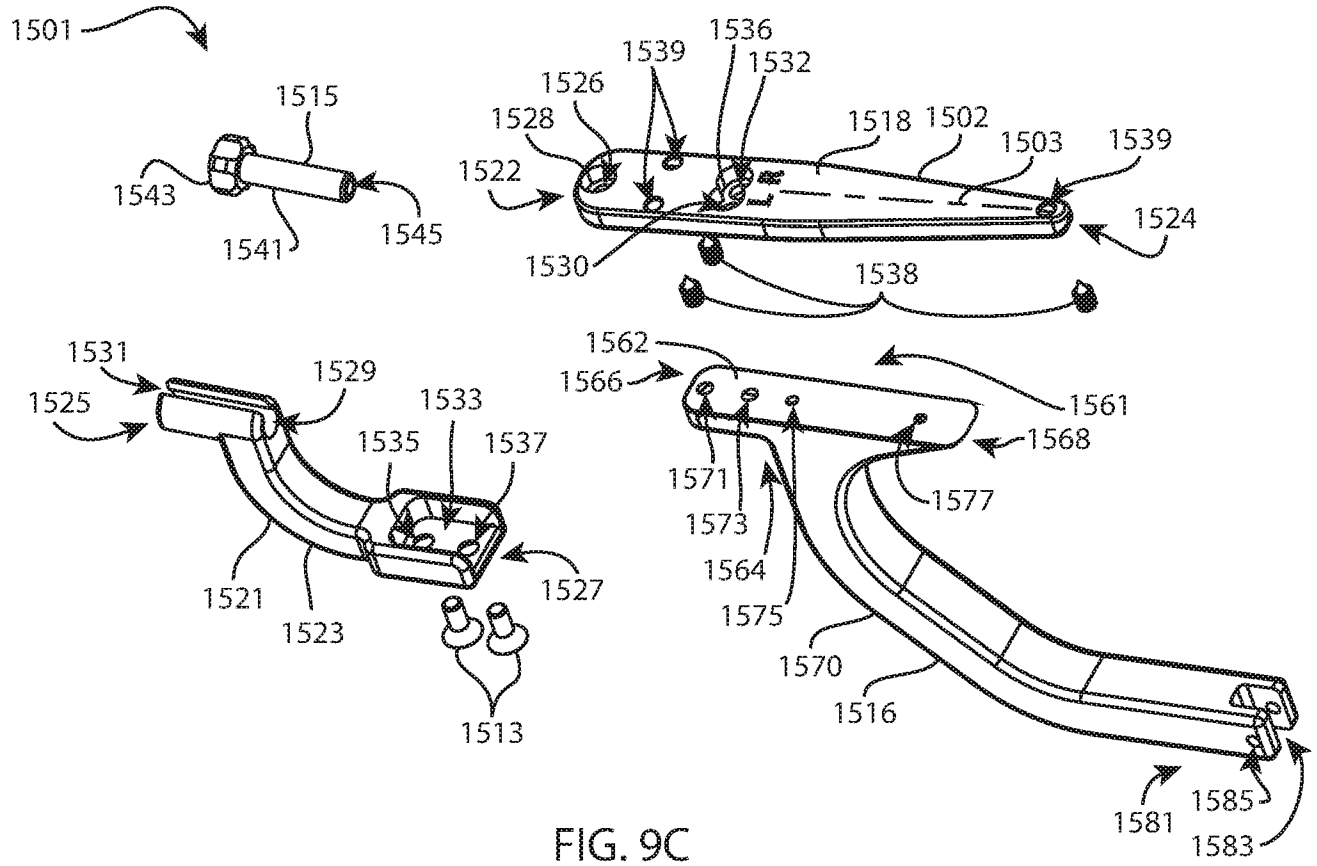
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FIG. 9C

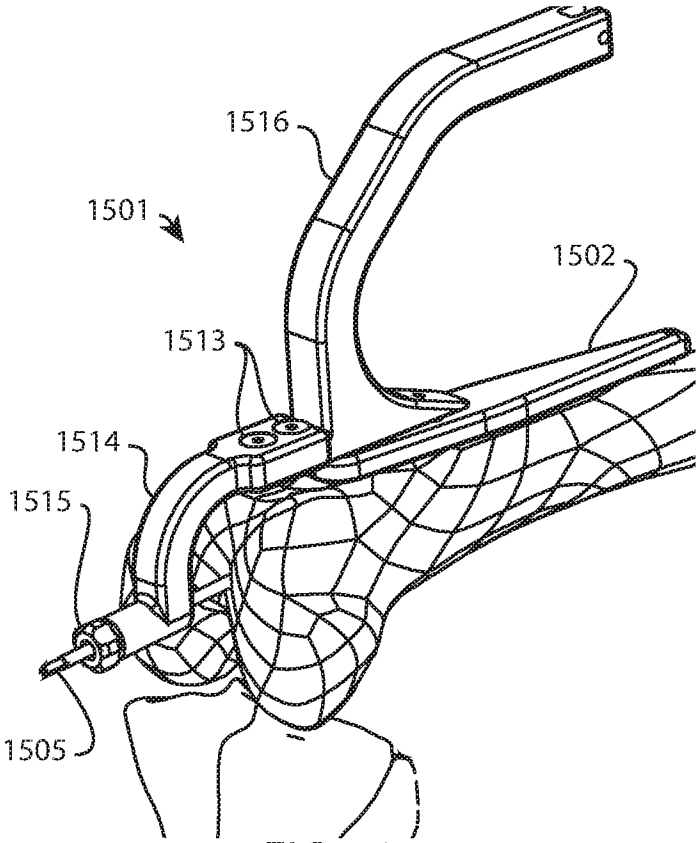
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FIG. 10

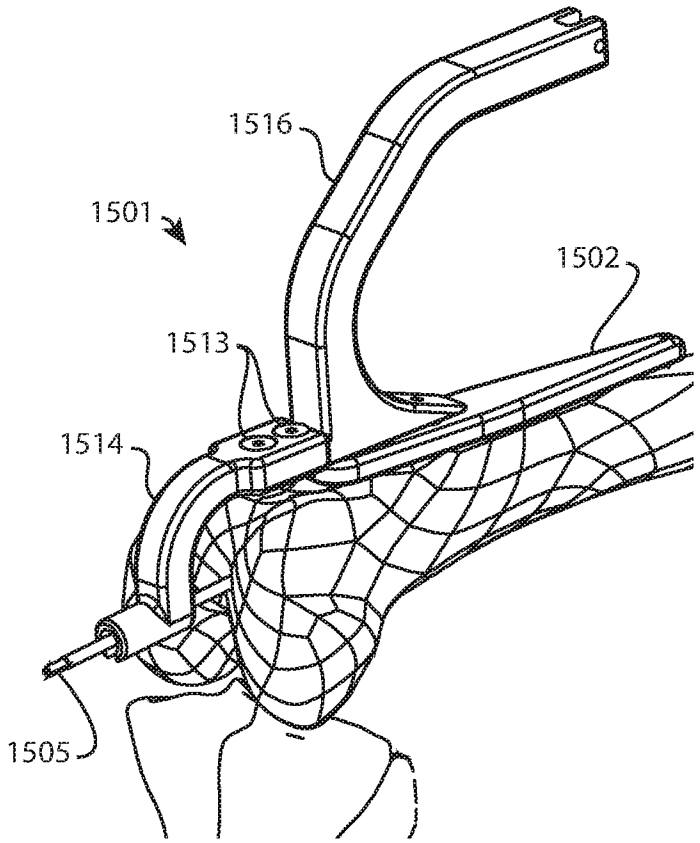
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FIG. 11

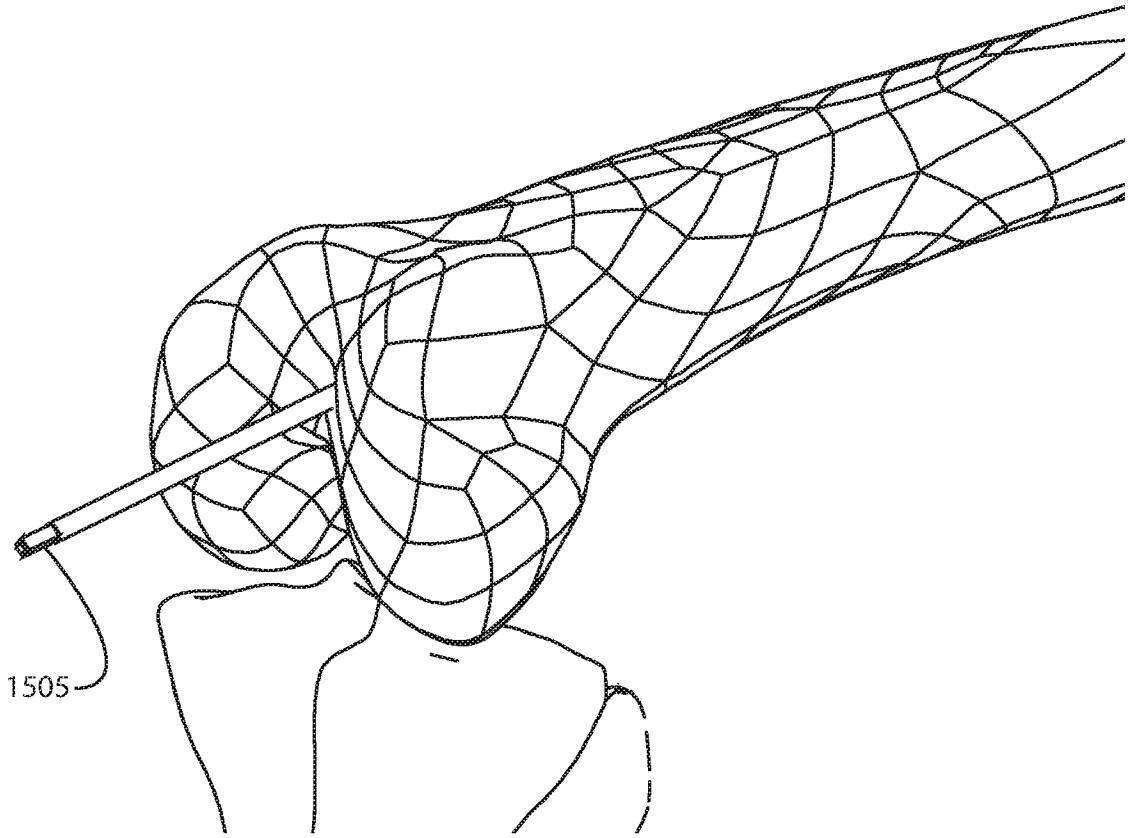

FIG. 12

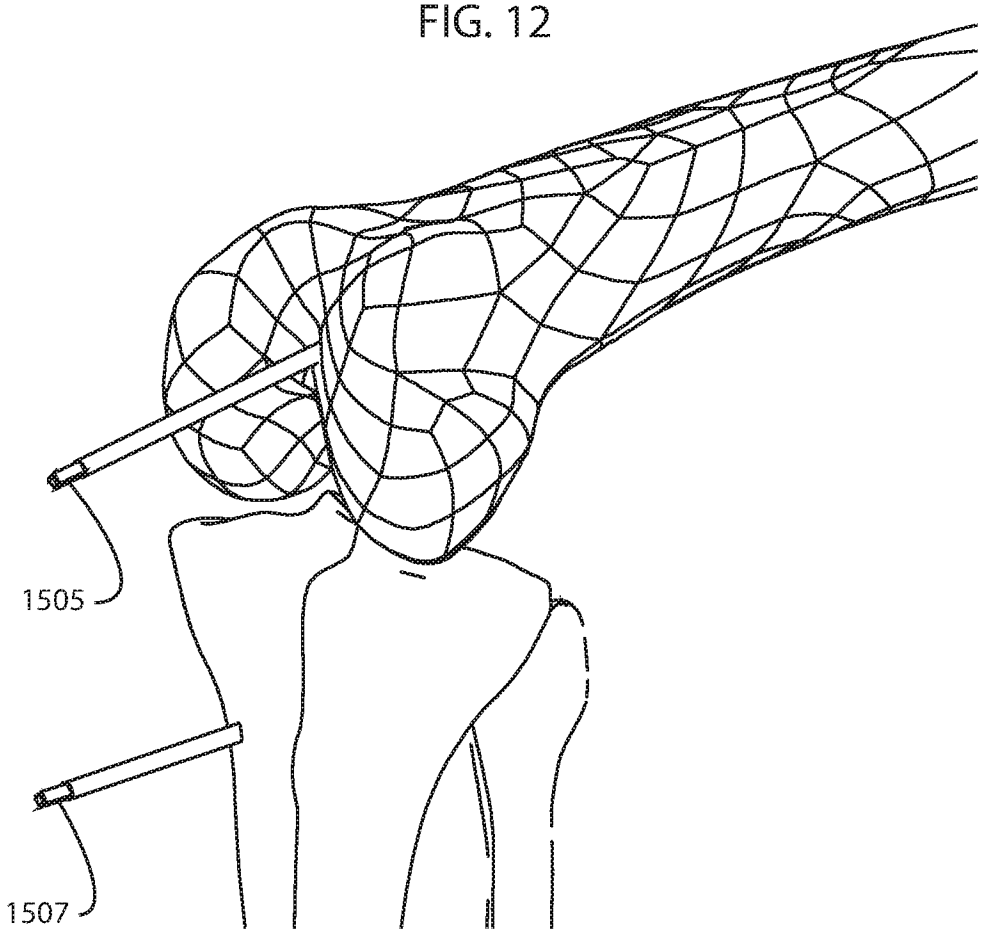

FIG. 13

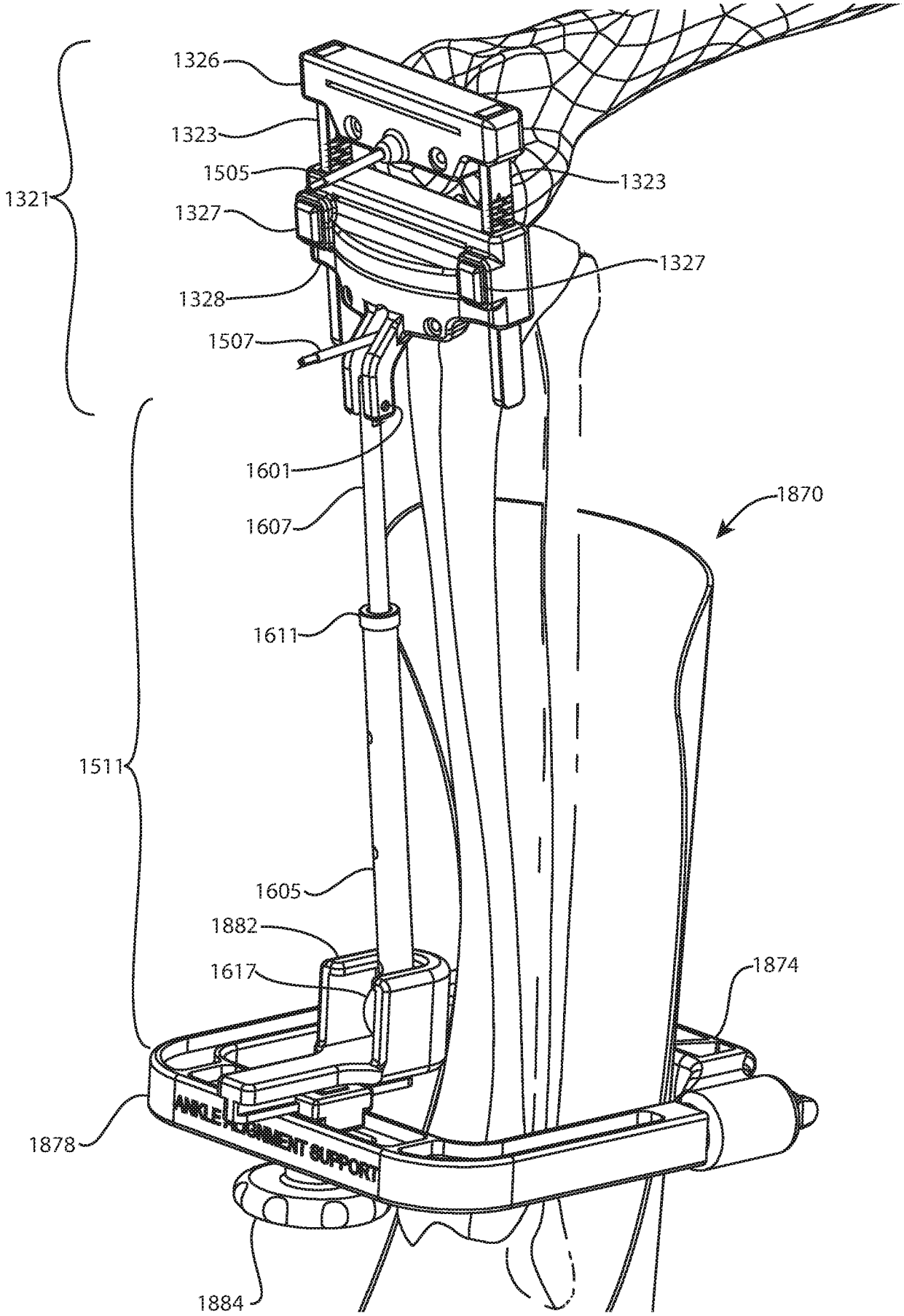
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FIG. 14A

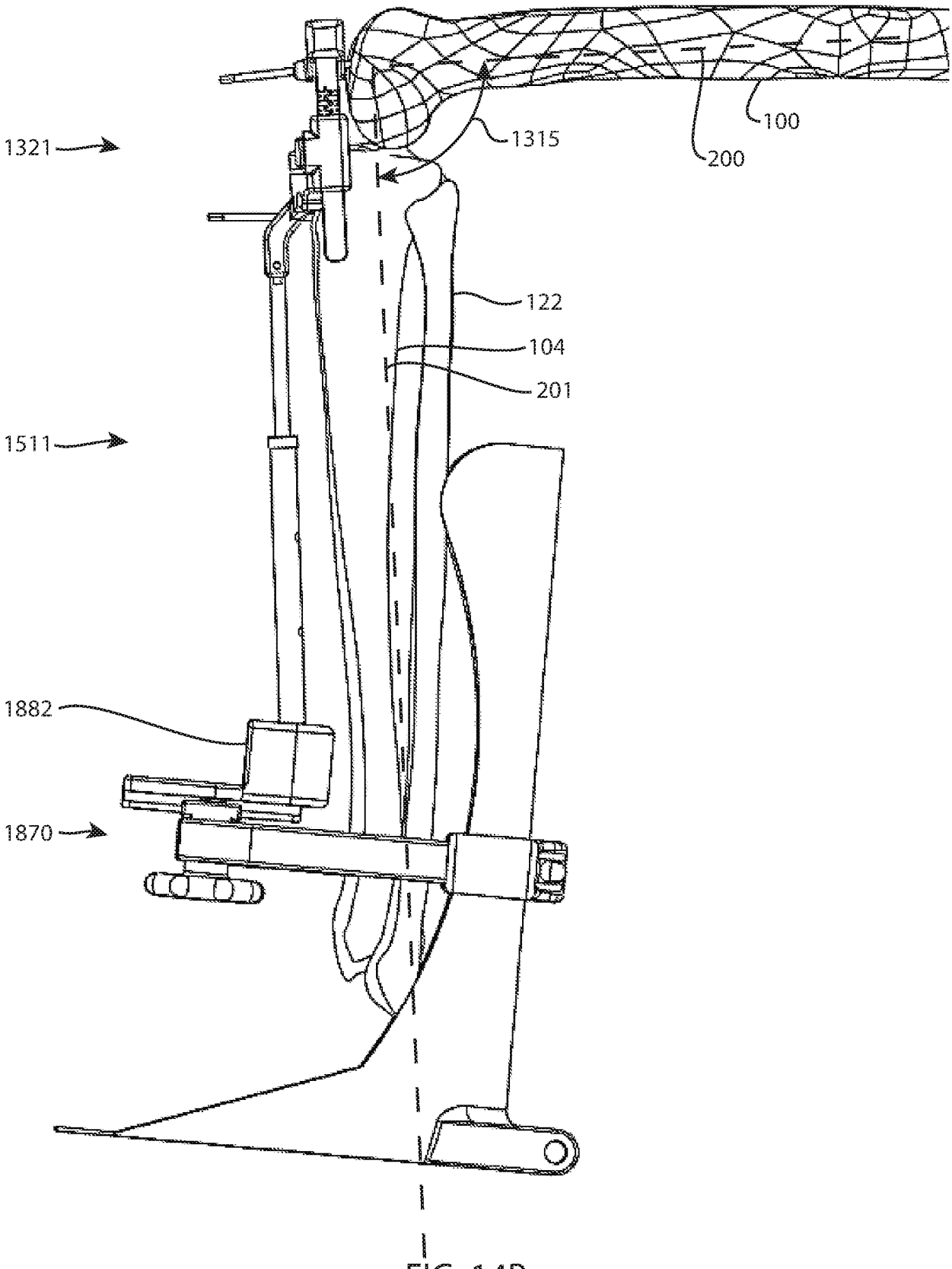

FIG. 14B

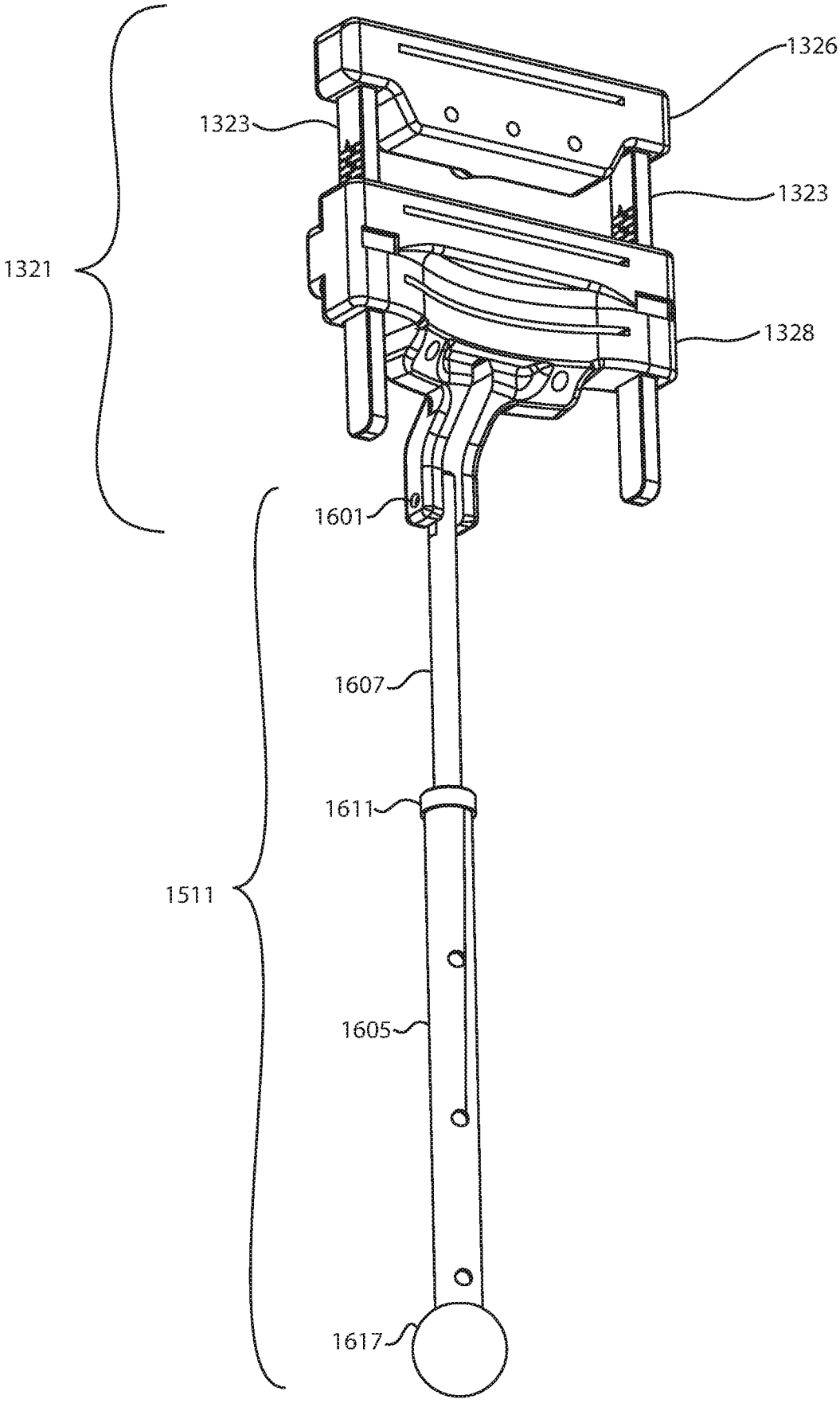

FIG. 15A

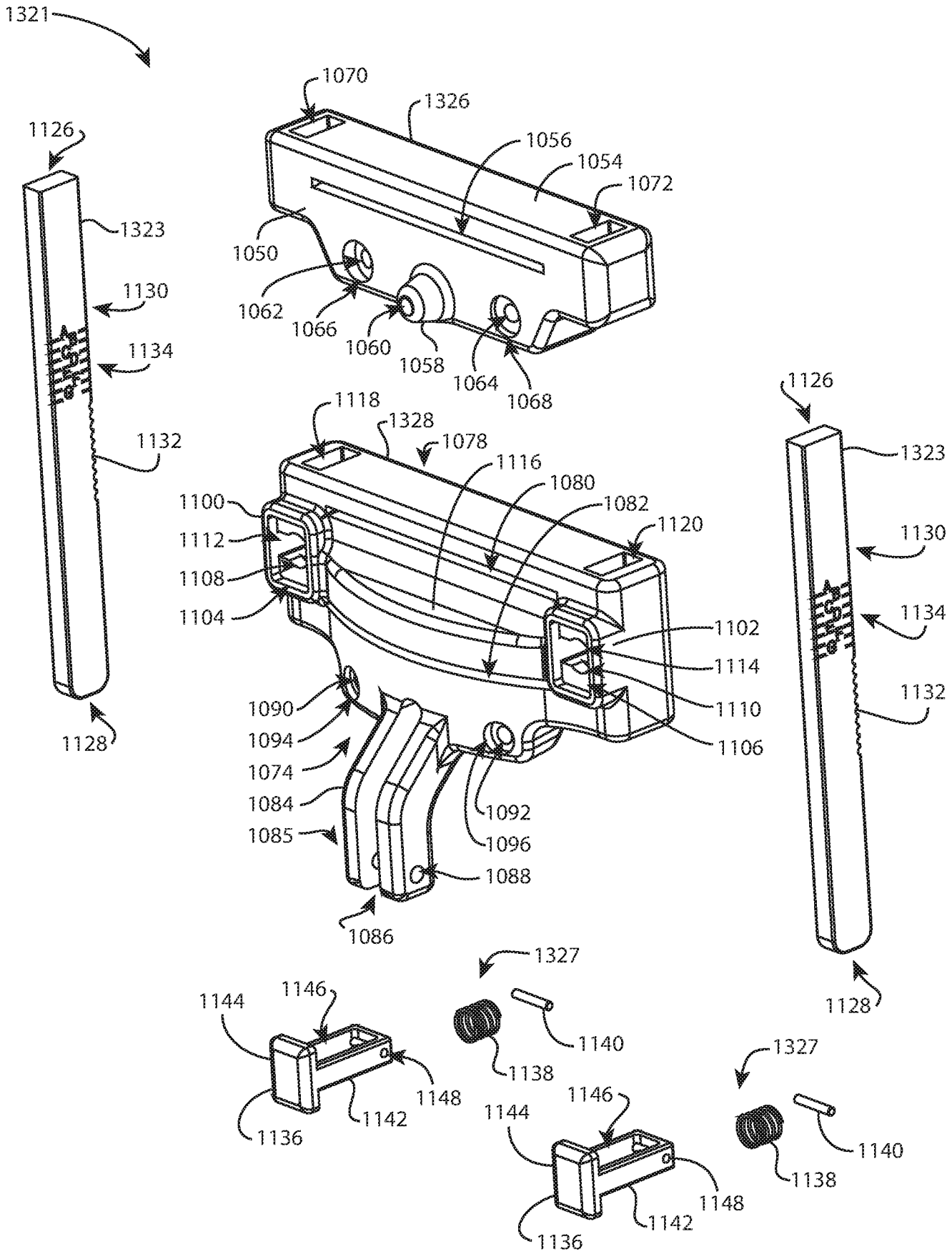
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FIG. 15B

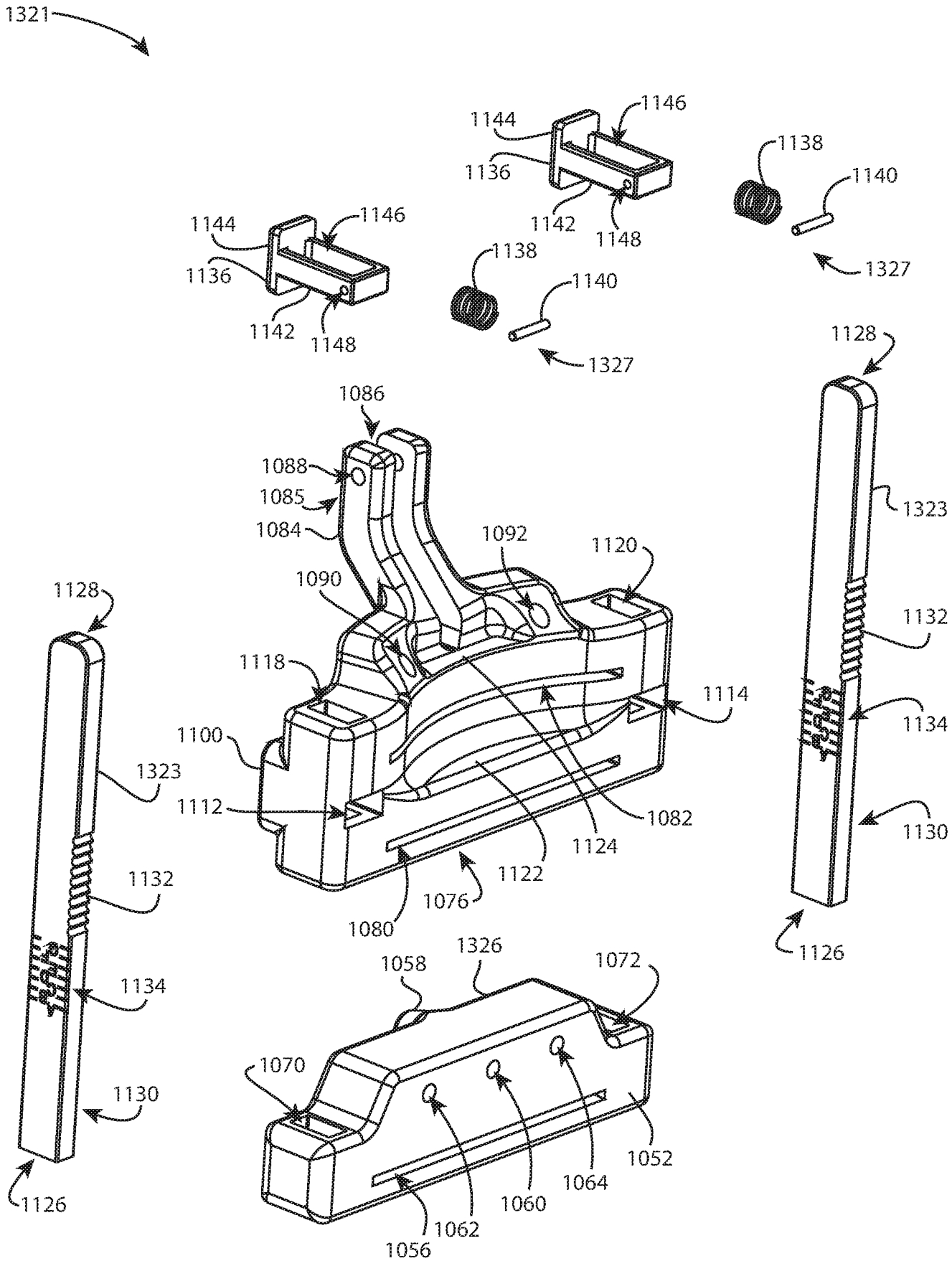
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FIG. 15C

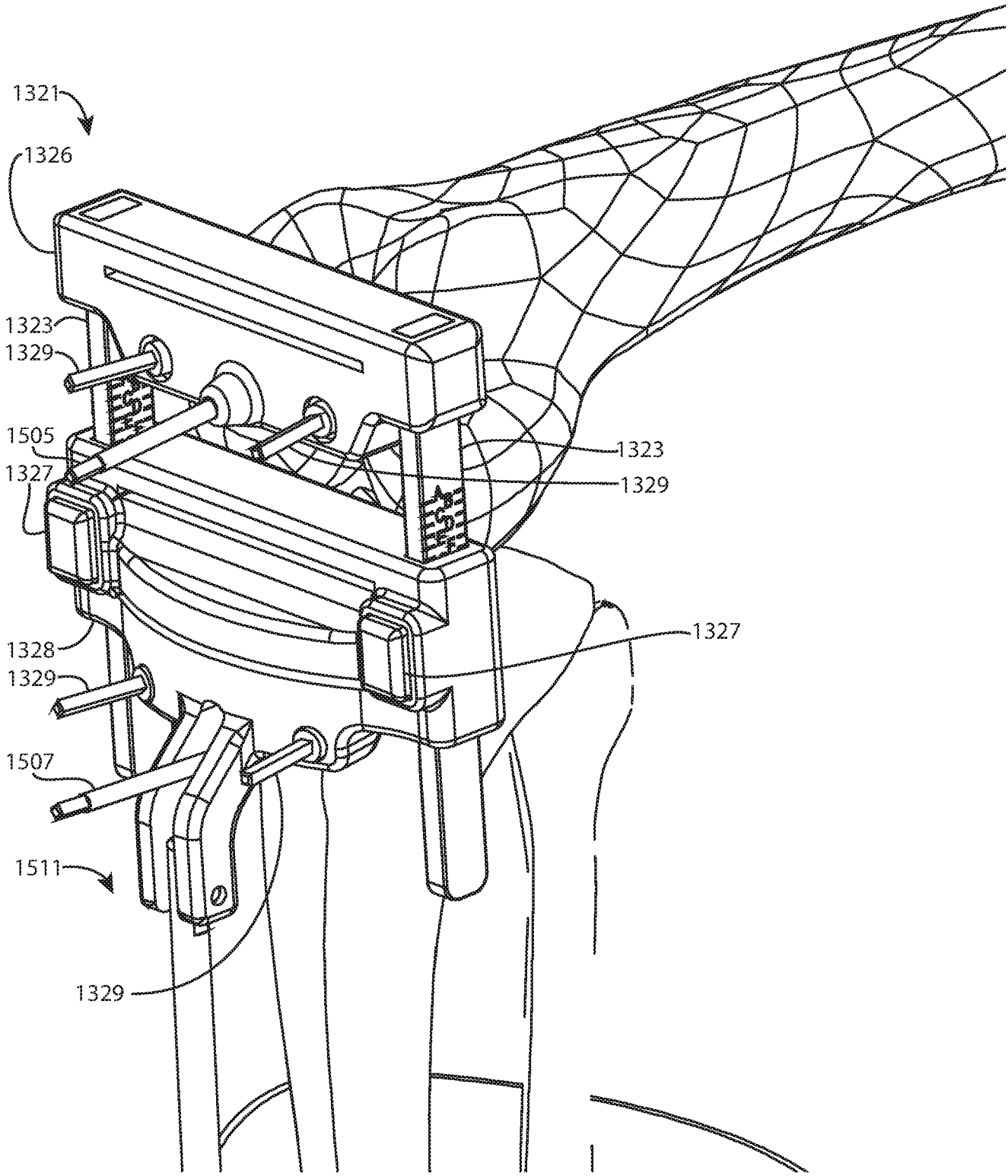
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FIG. 16

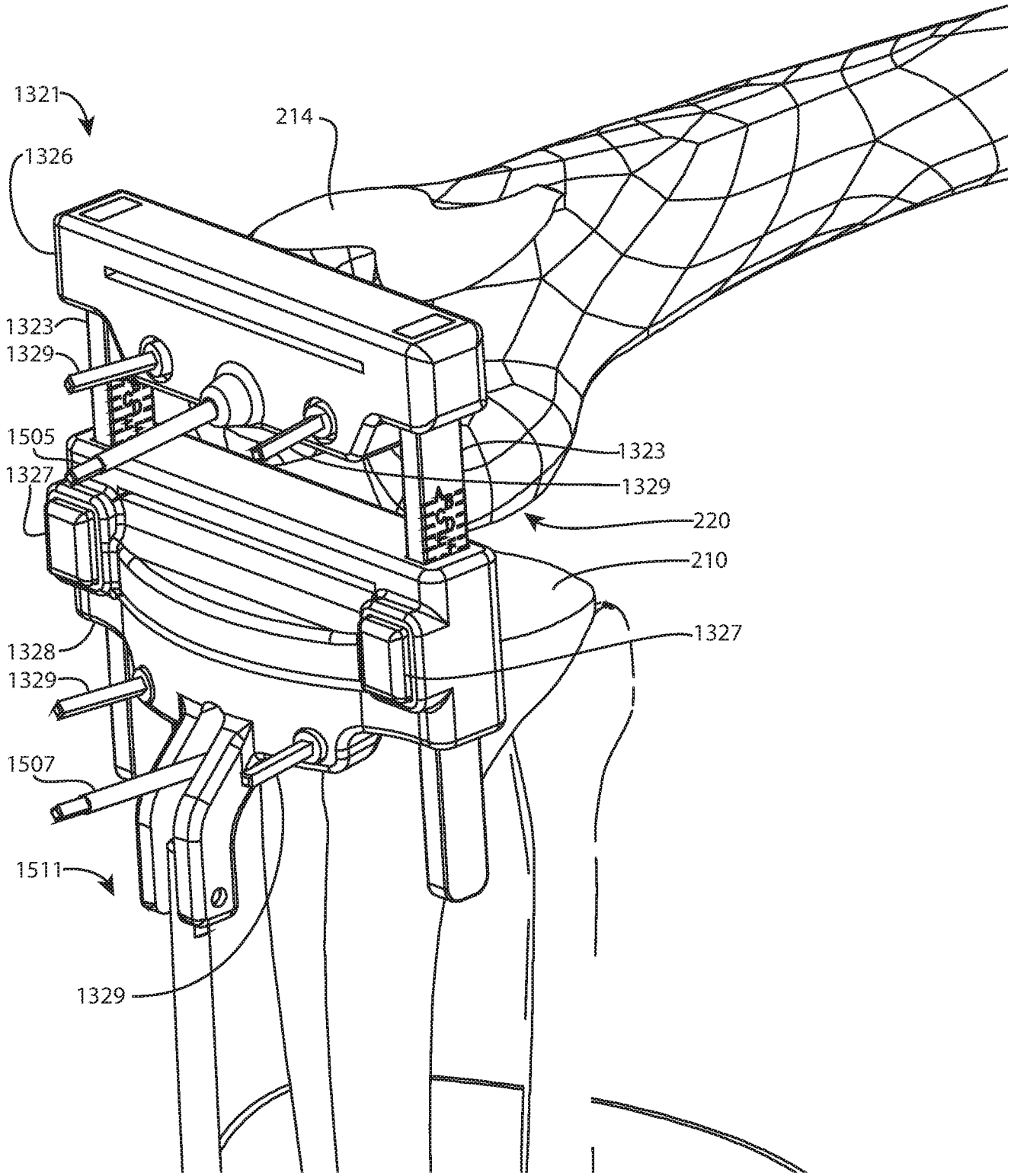
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FIG. 17

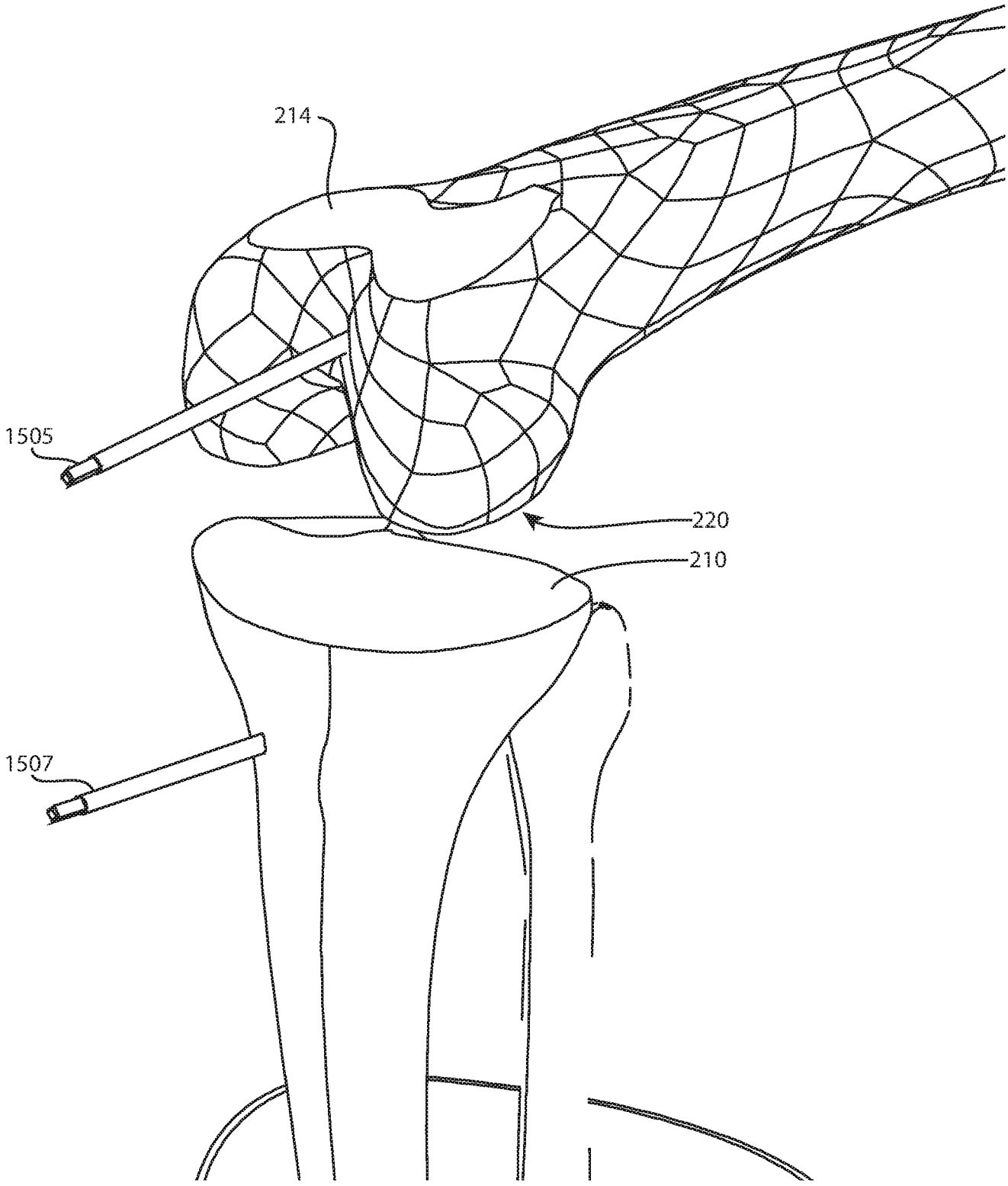

FIG. 18

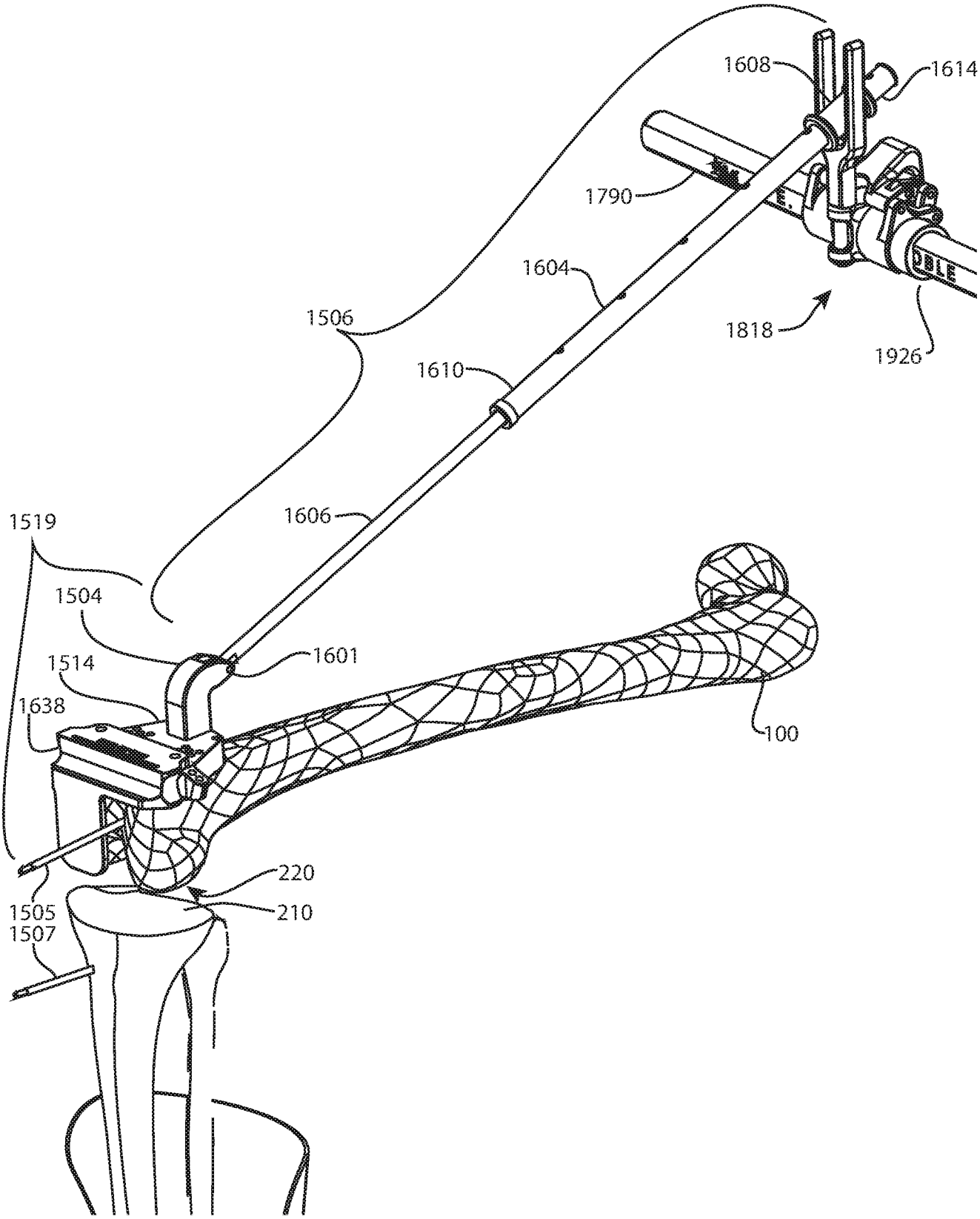
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FIG. 19

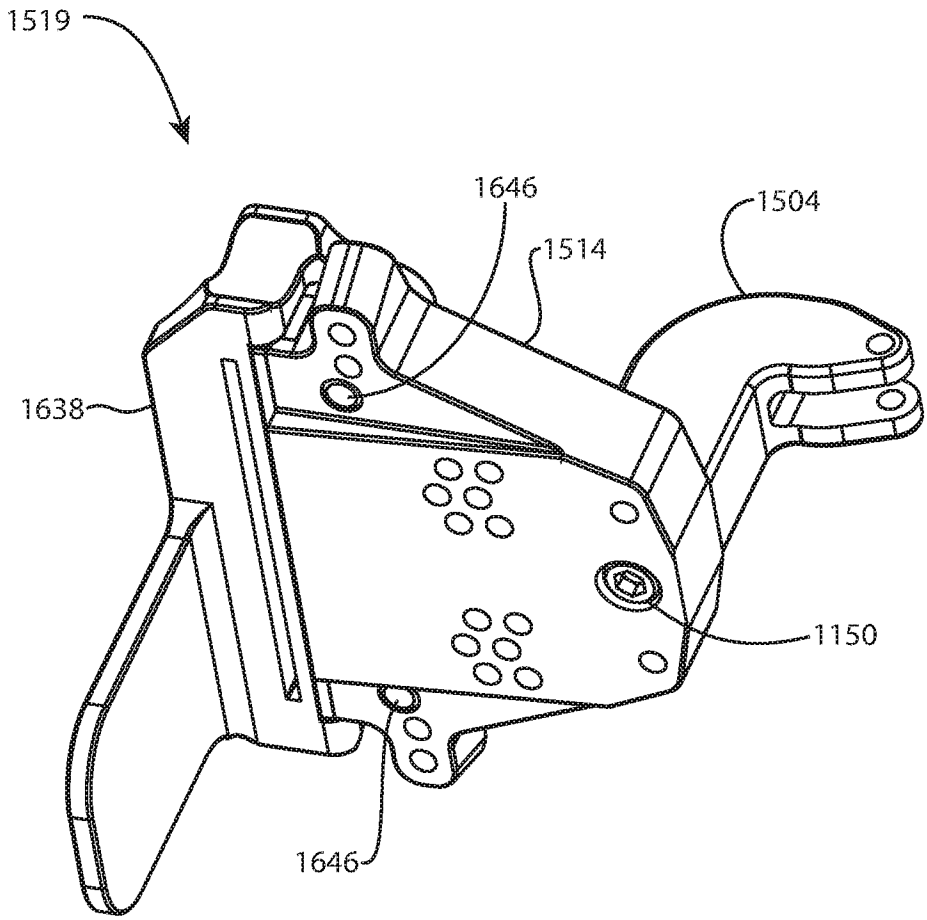

FIG. 20A

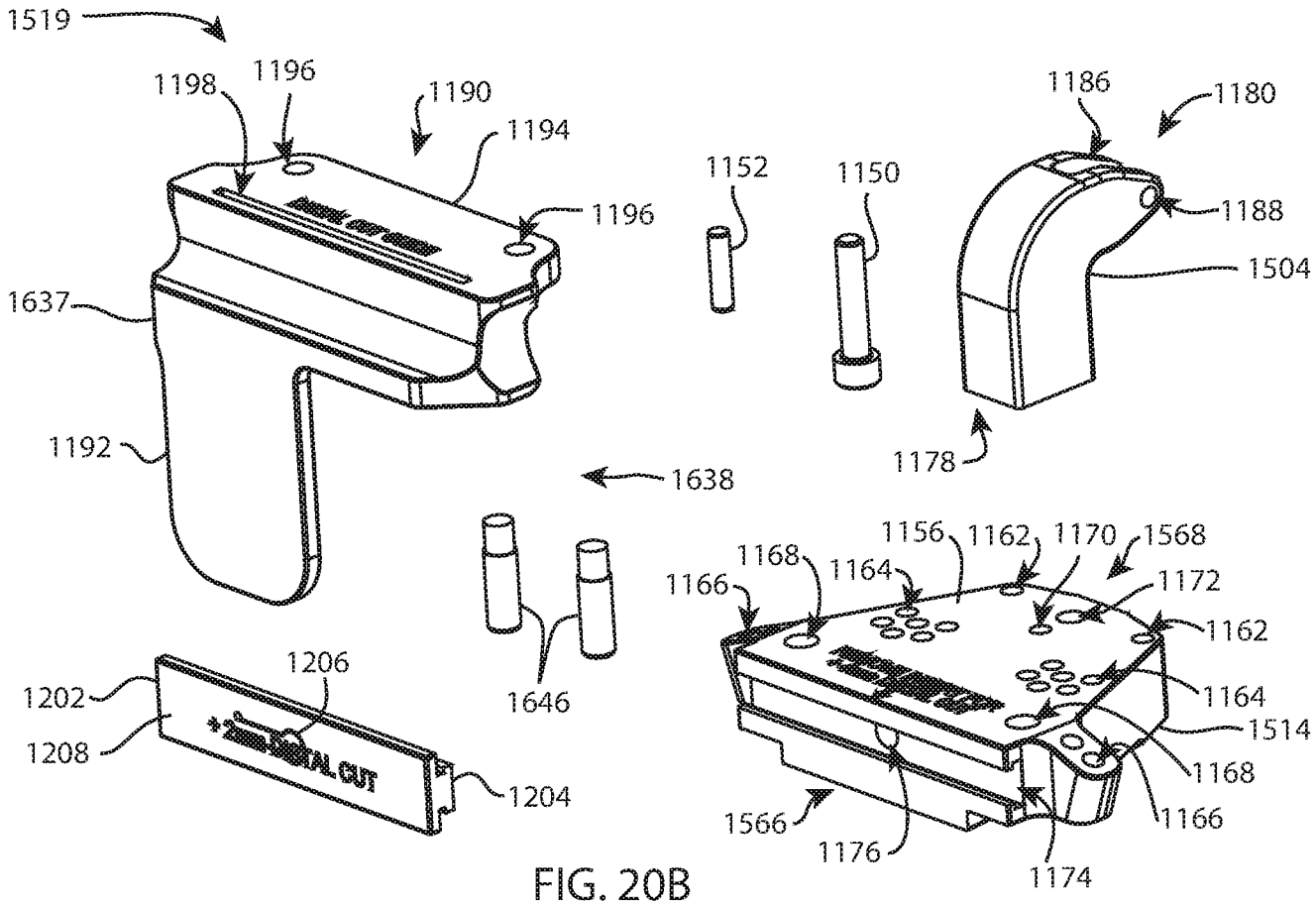

FIG. 20B

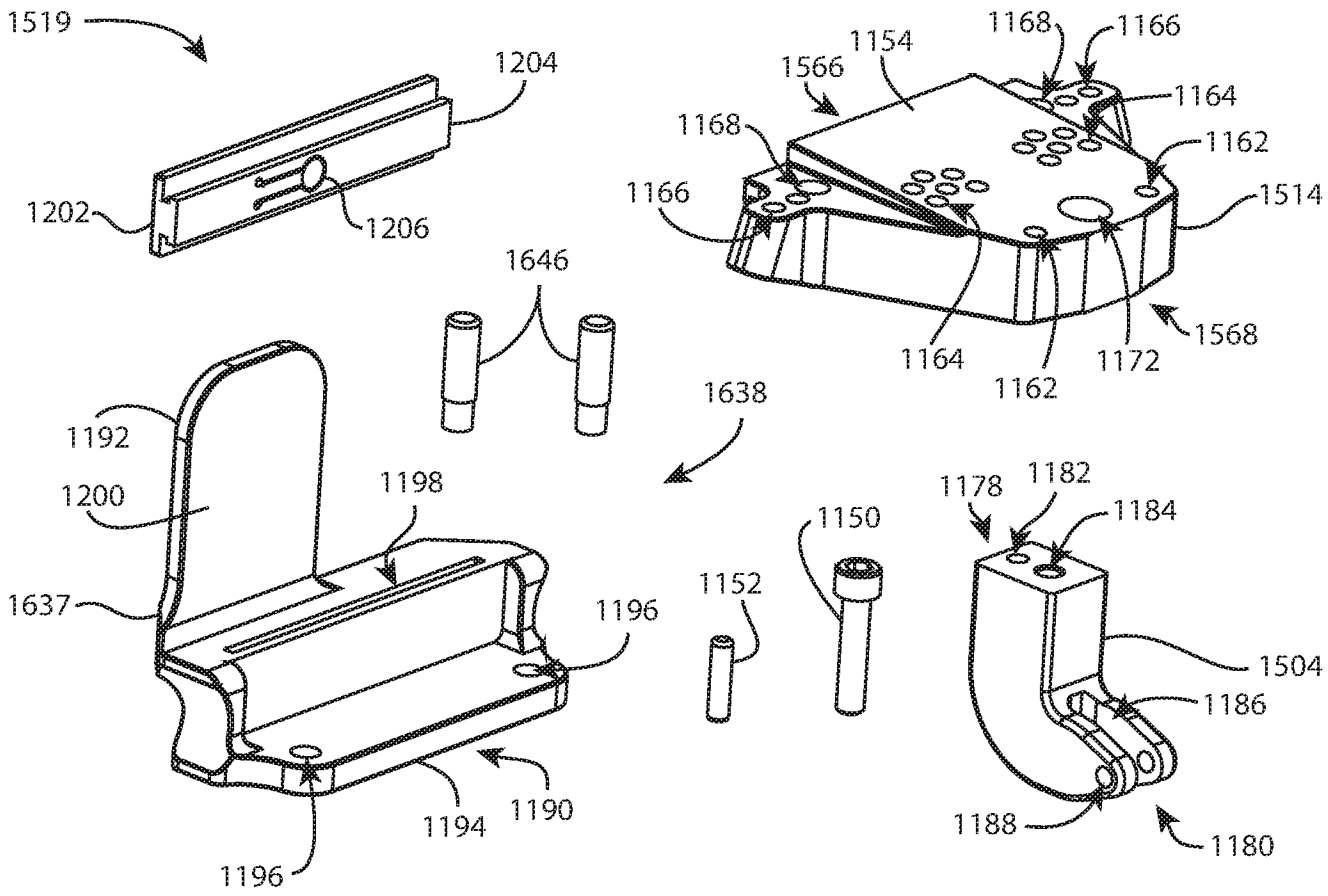

FIG. 20C

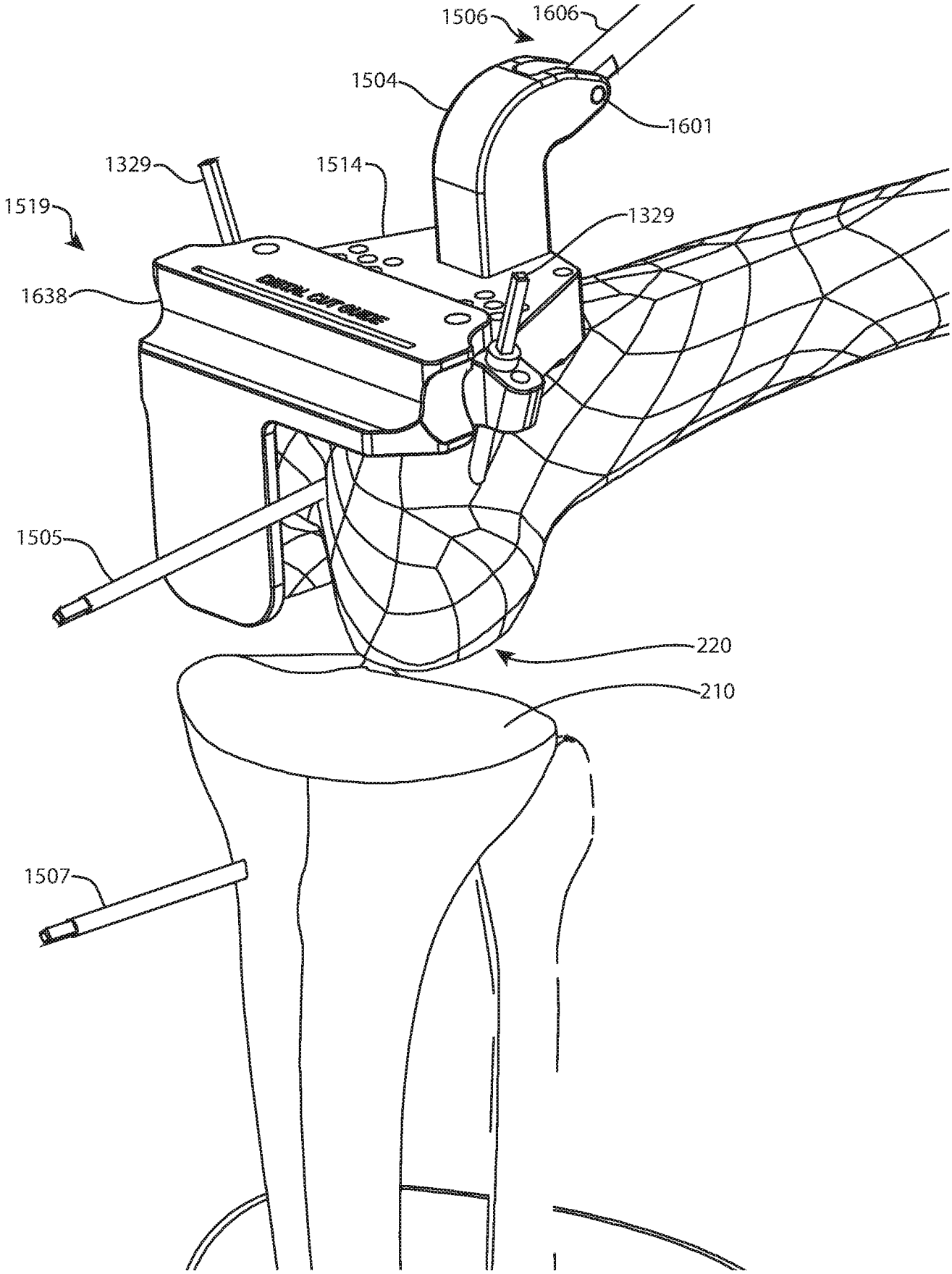
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FIG. 21

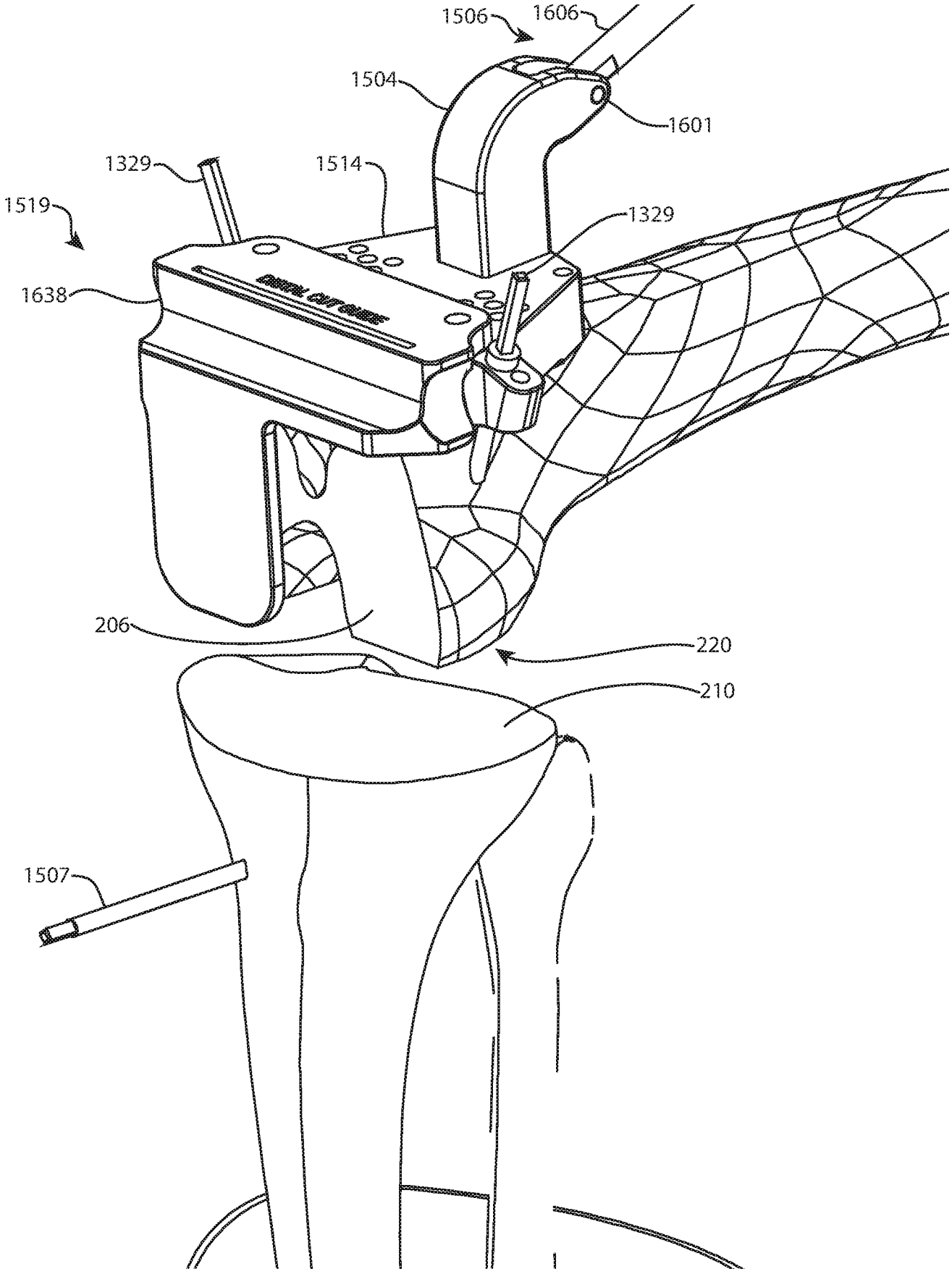

FIG. 22

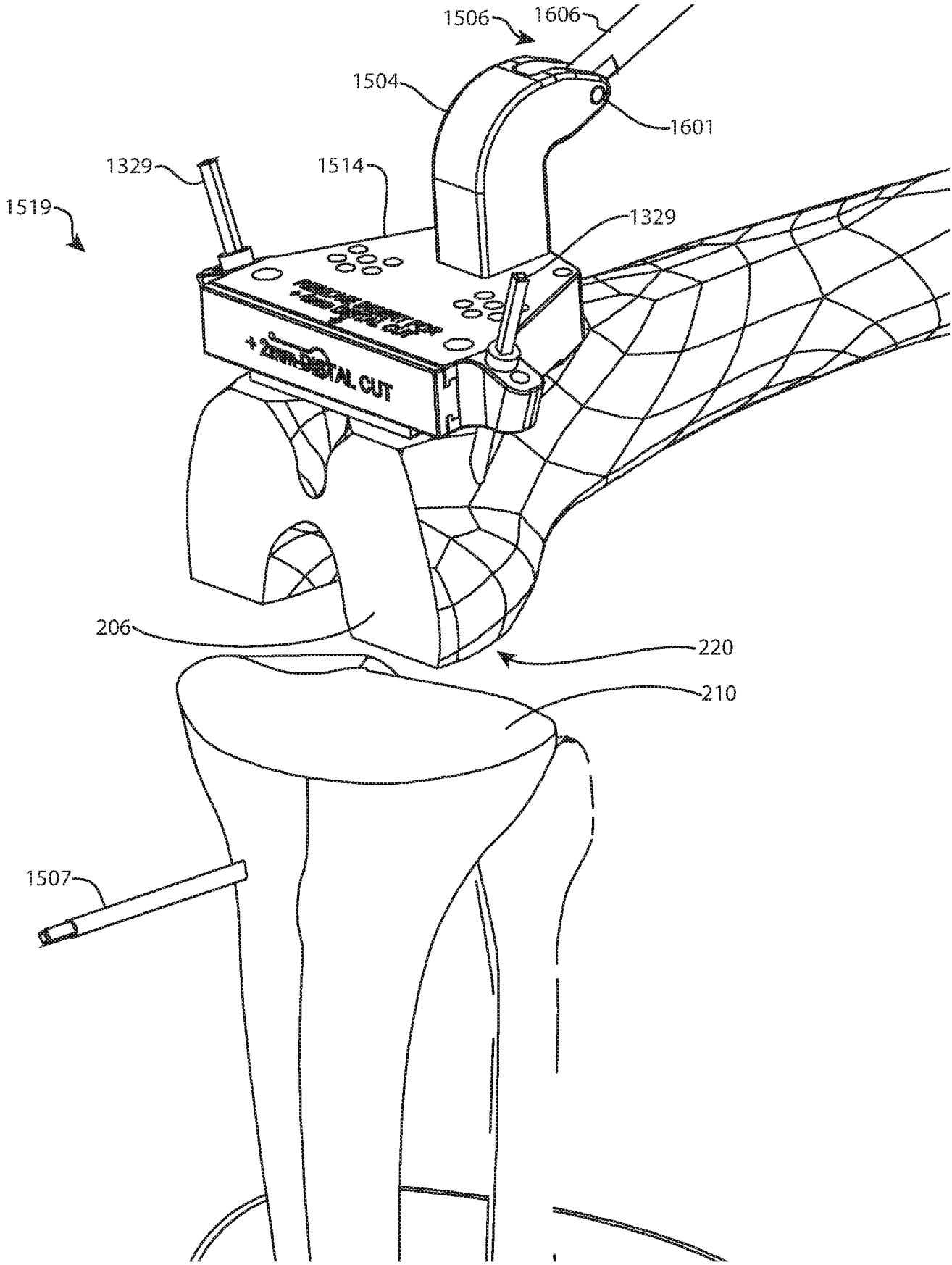

FIG. 23A

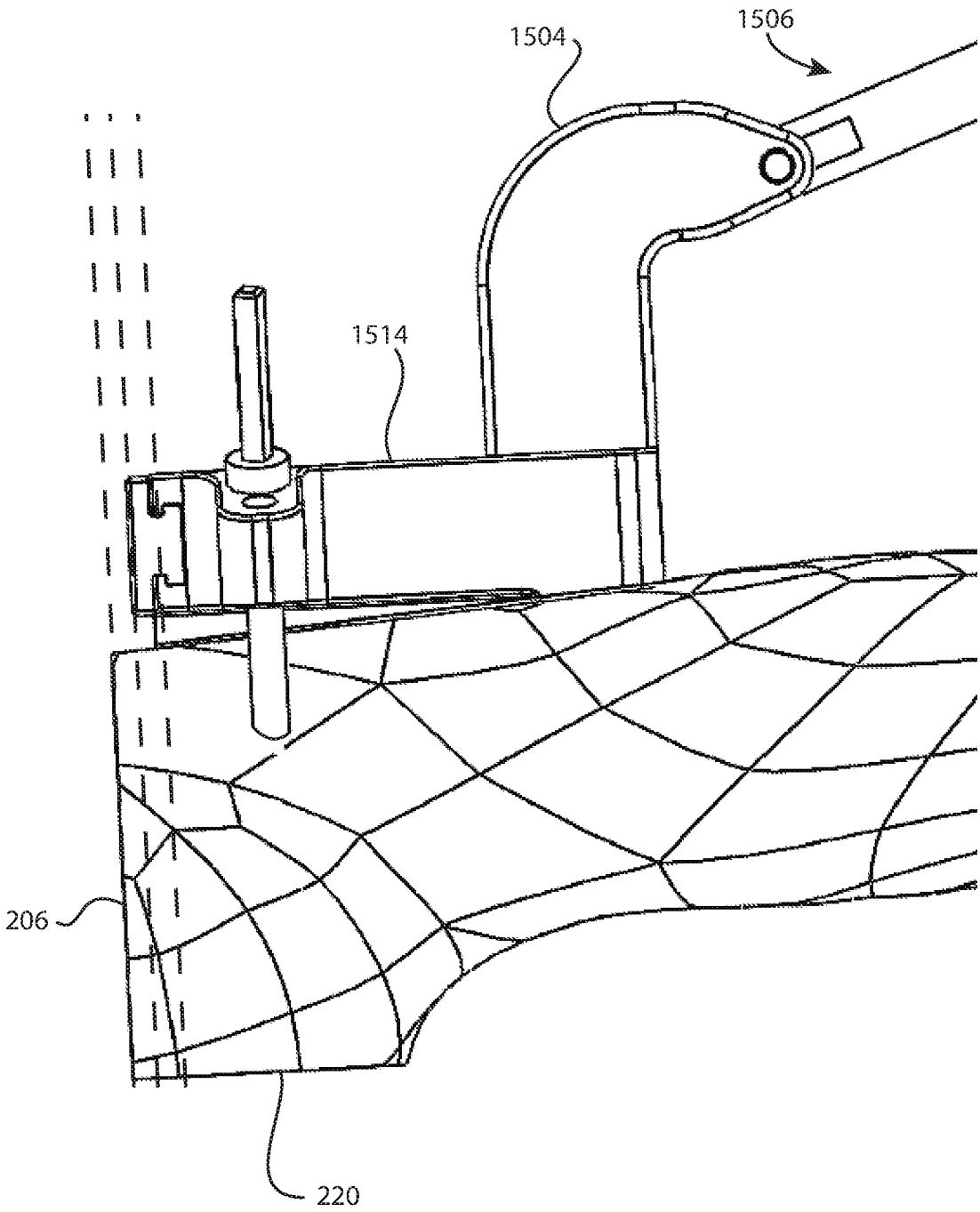

FIG. 23B

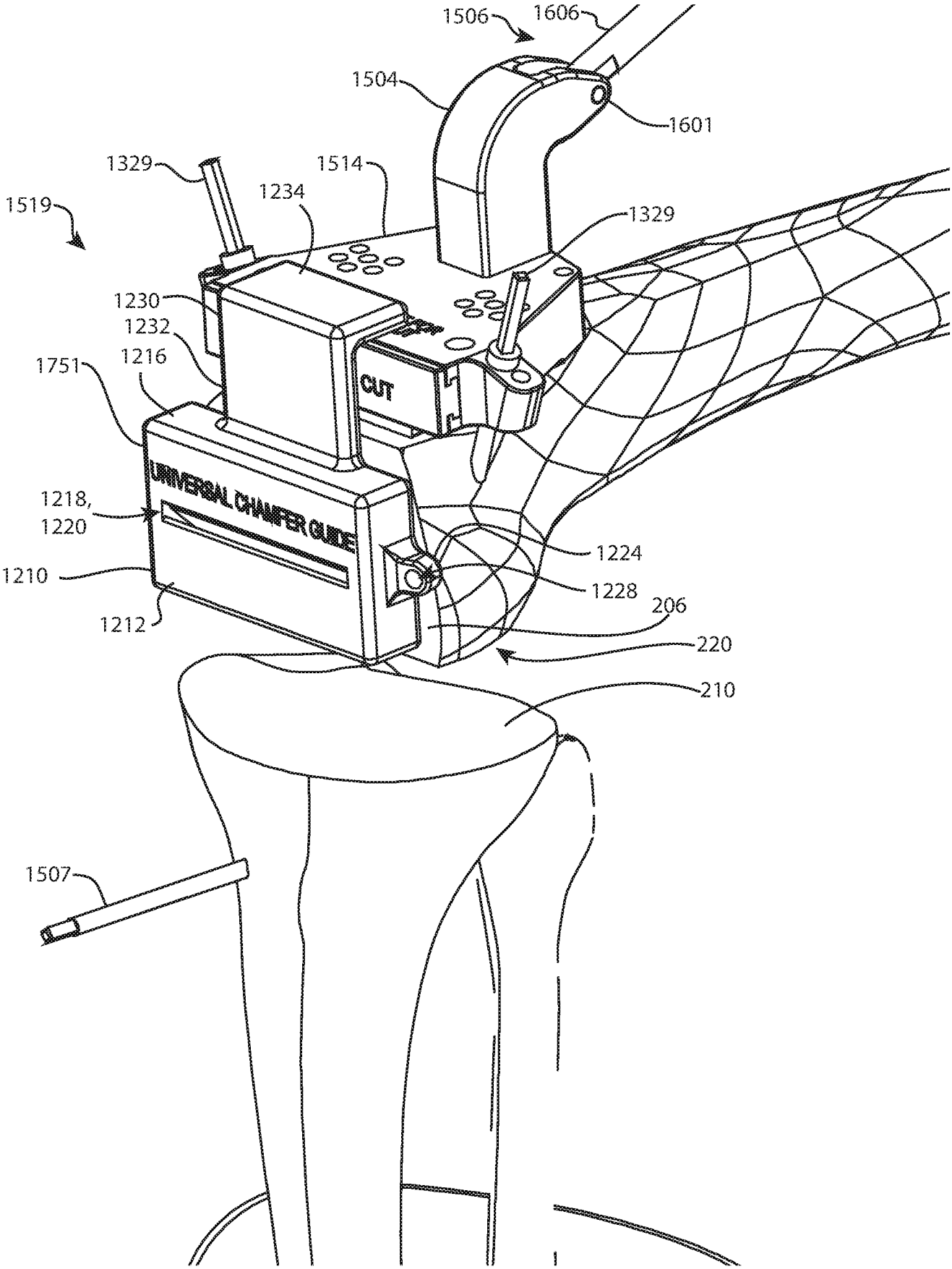
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FIG. 24

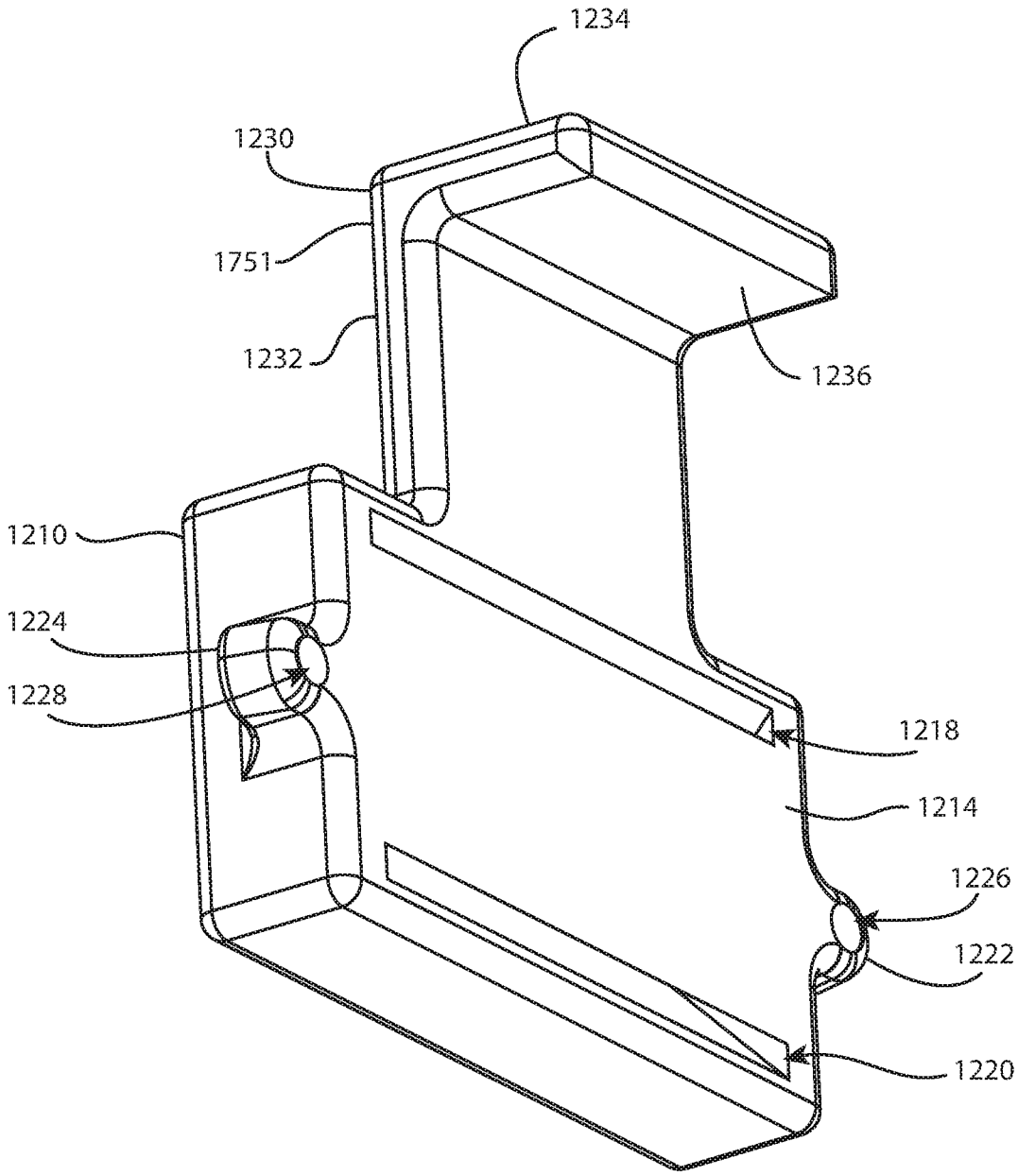
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FIG. 25

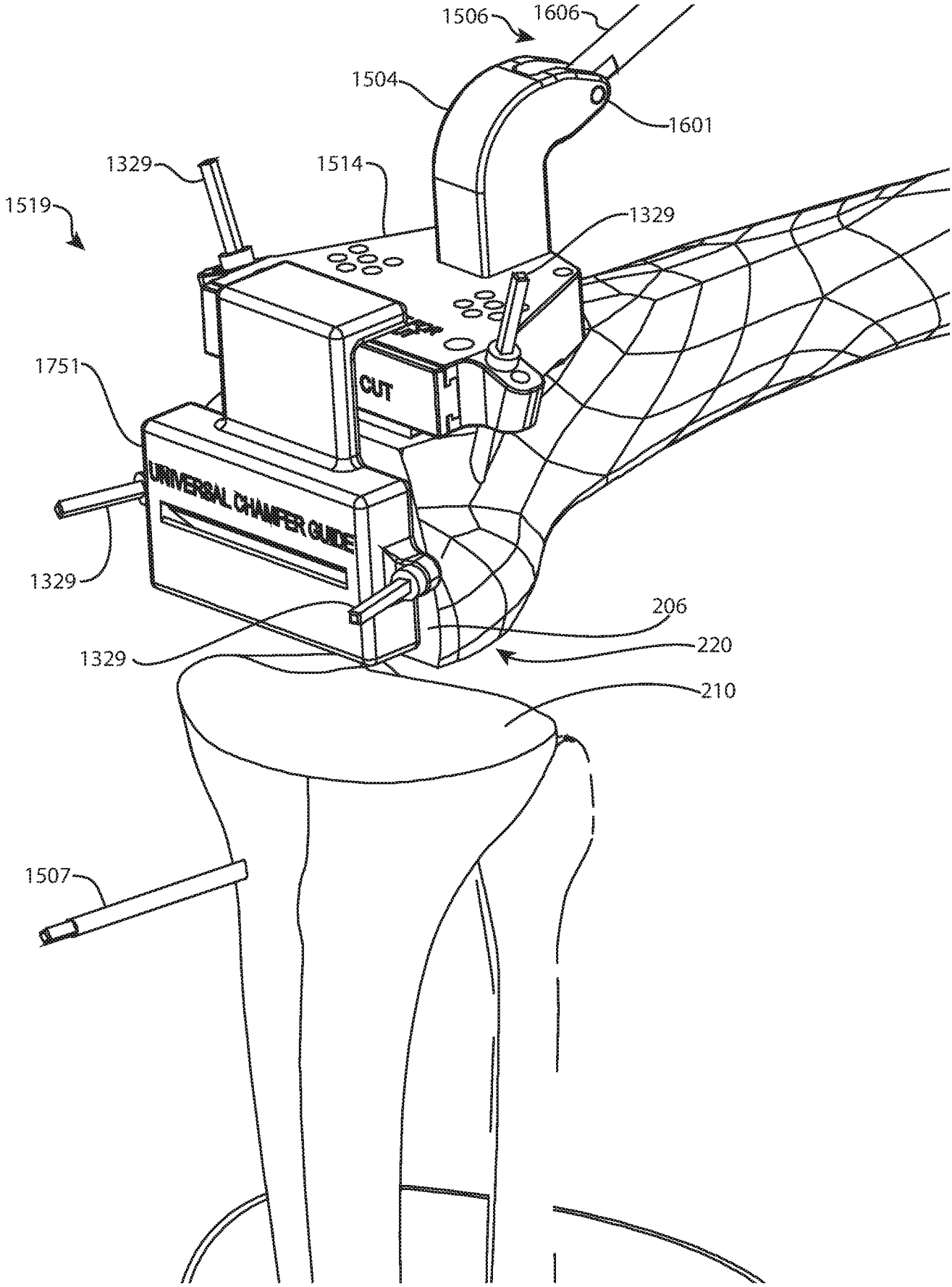
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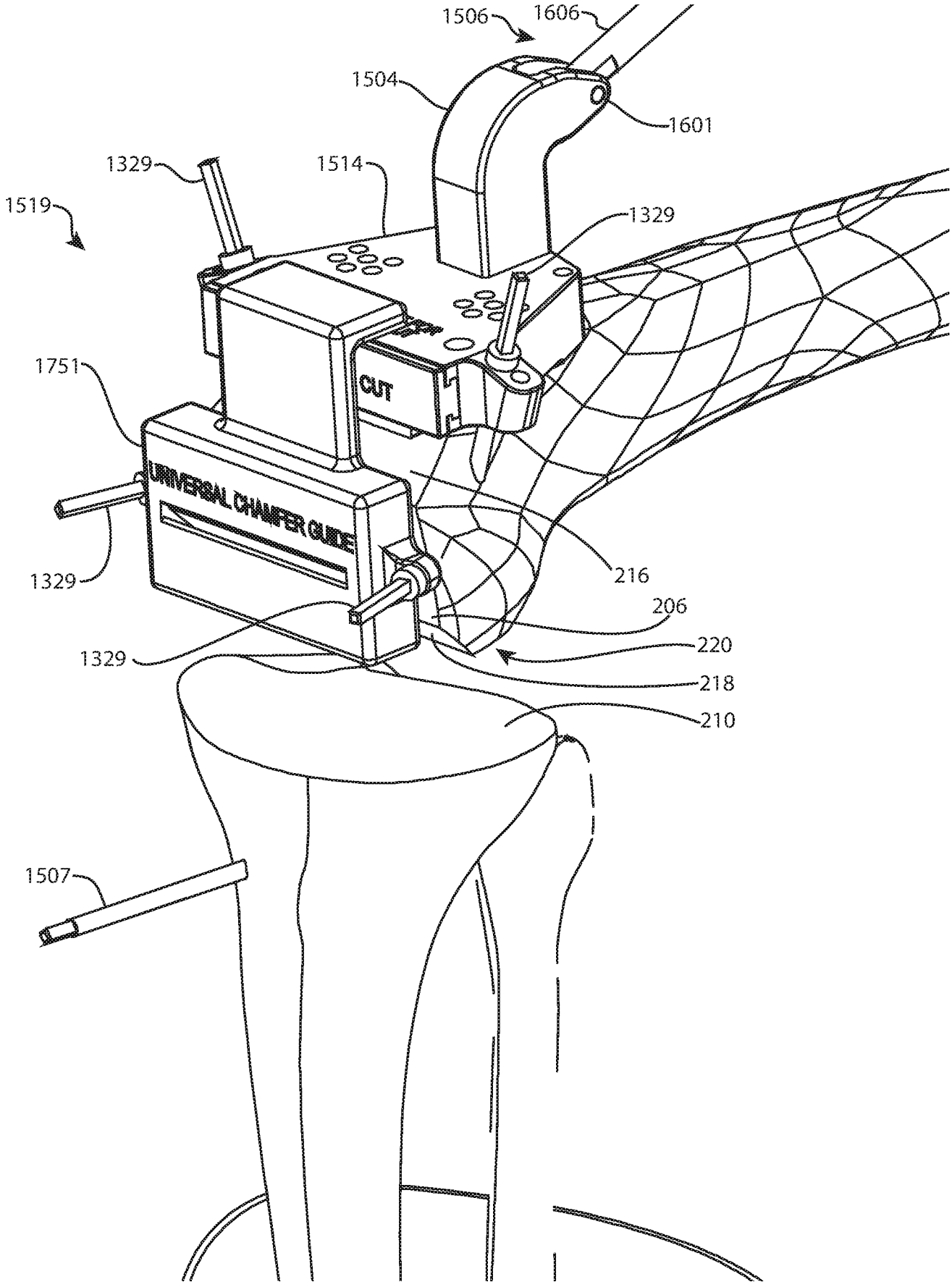
FIG. 26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1507

FIG. 27A

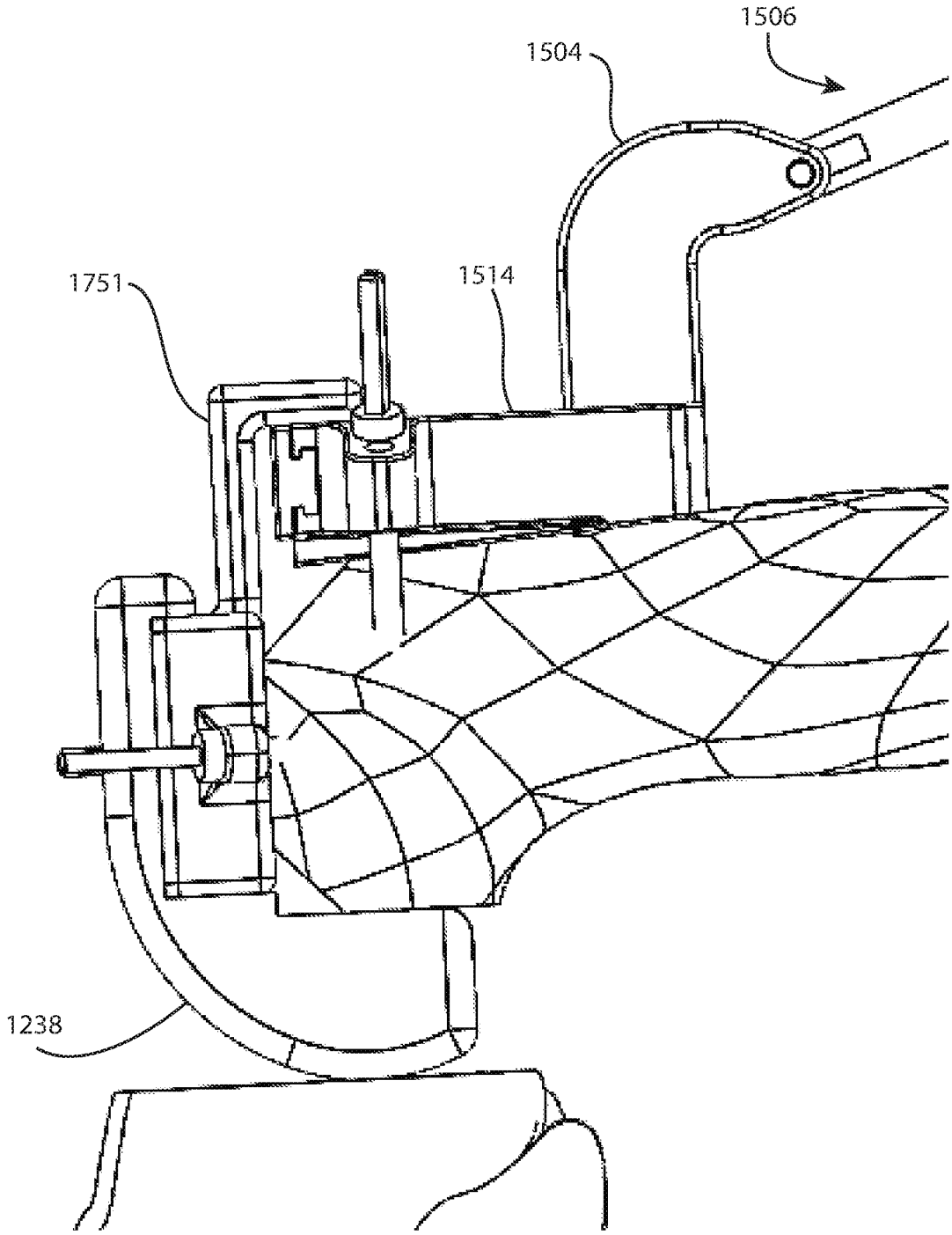

FIG. 27B

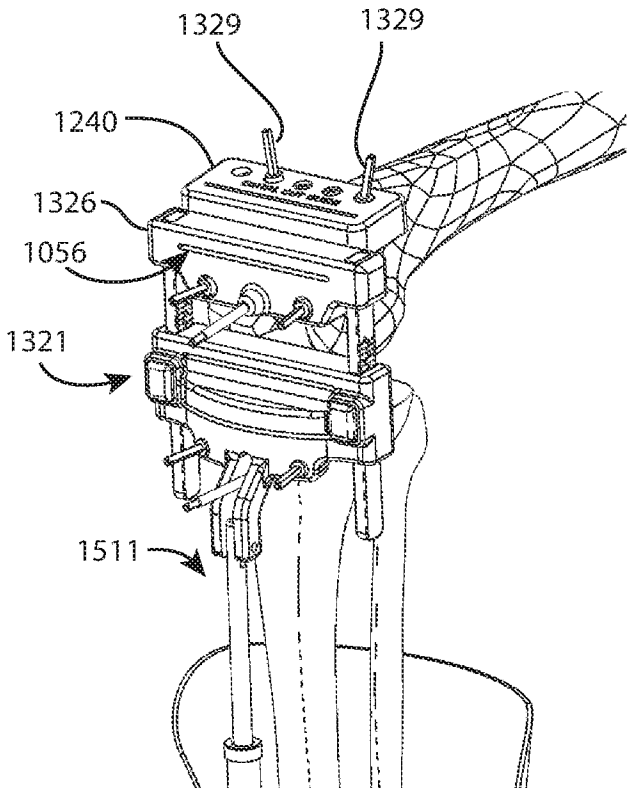

FIG. 28A

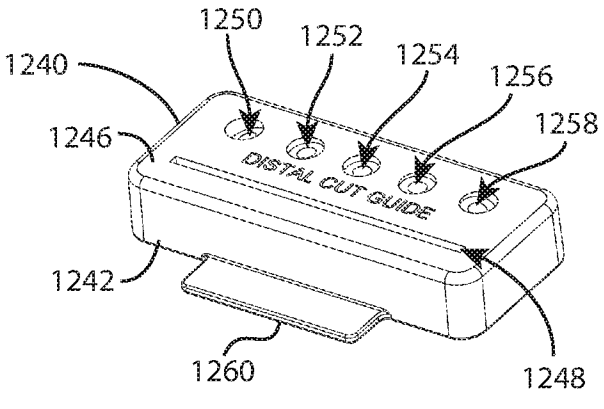

FIG. 28B

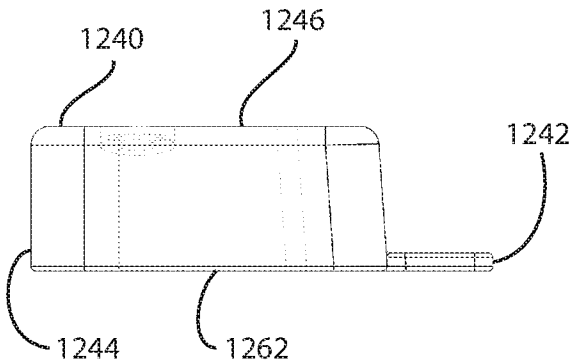

FIG. 28C

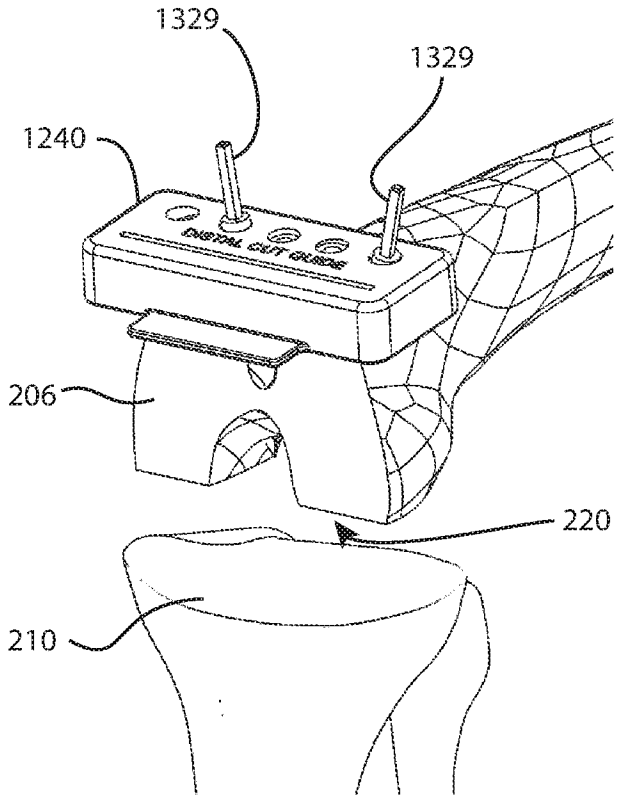

FIG. 29A

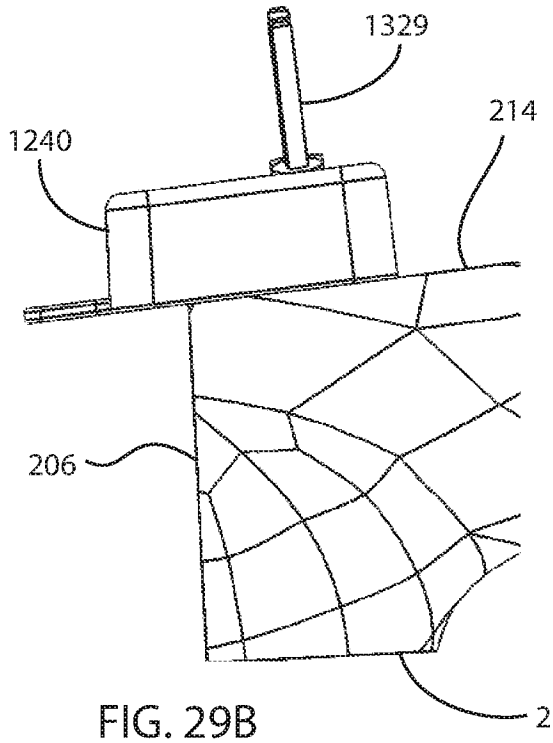

FIG. 29B

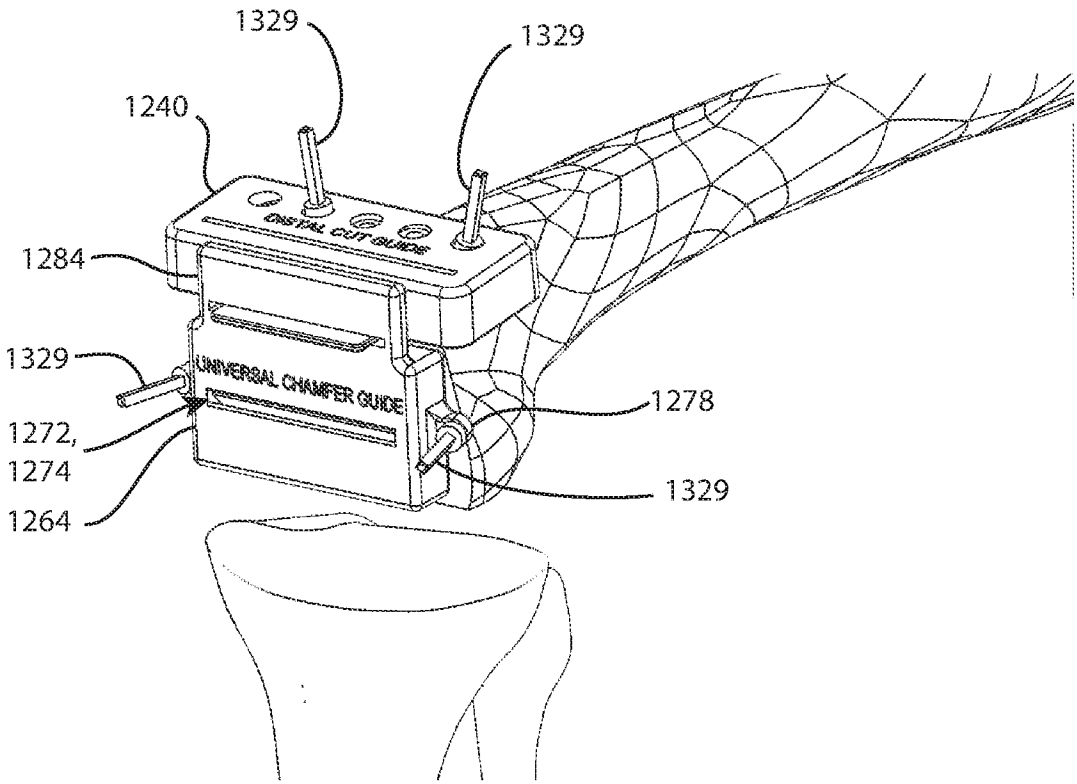

FIG. 30A

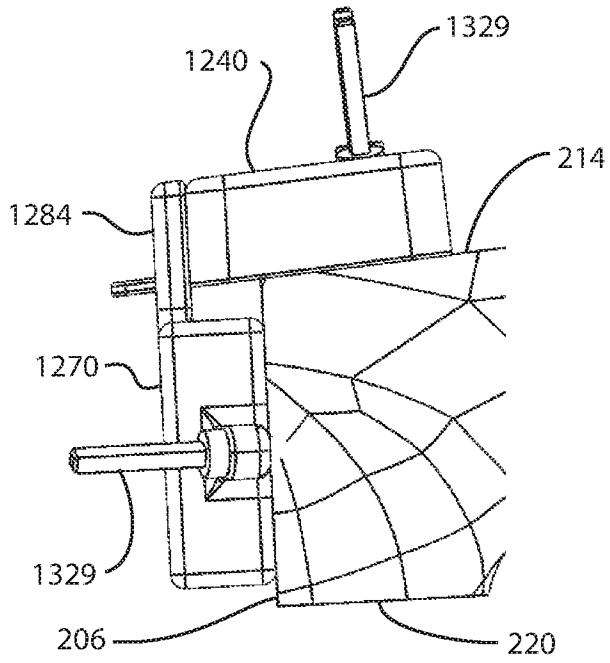

FIG. 30B

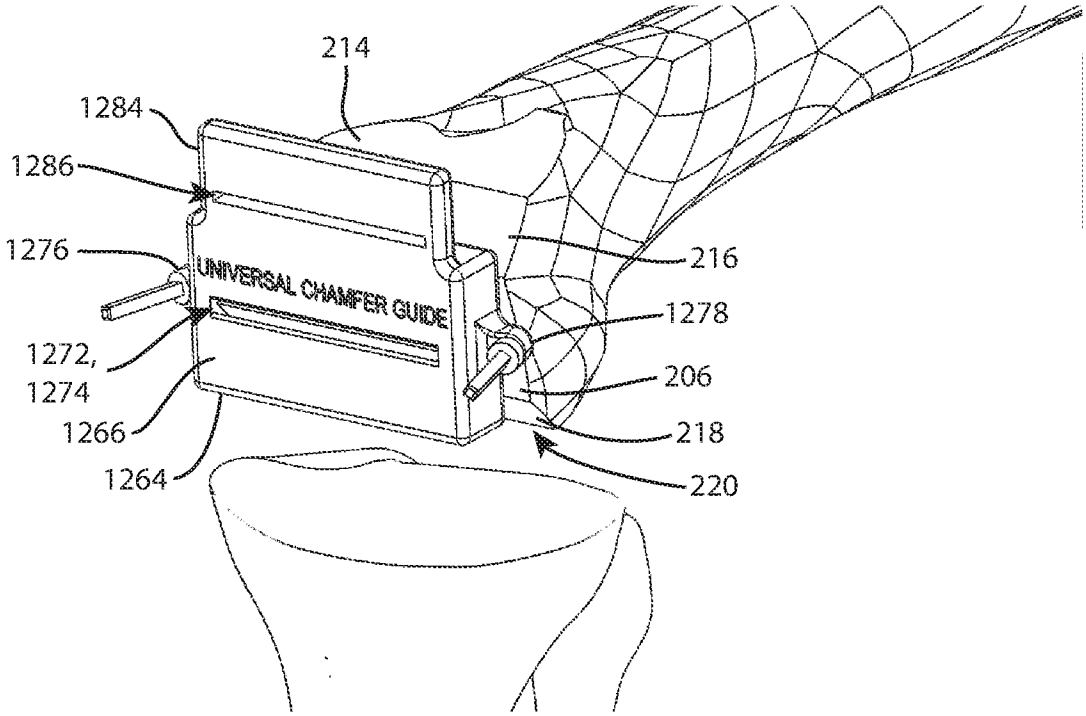

FIG. 31A

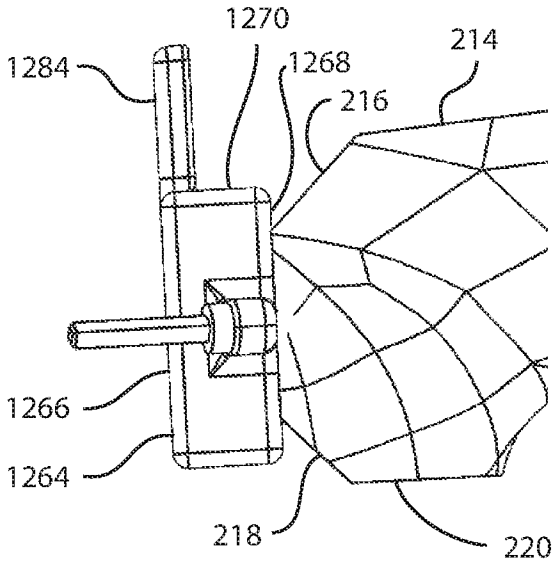

FIG. 31B

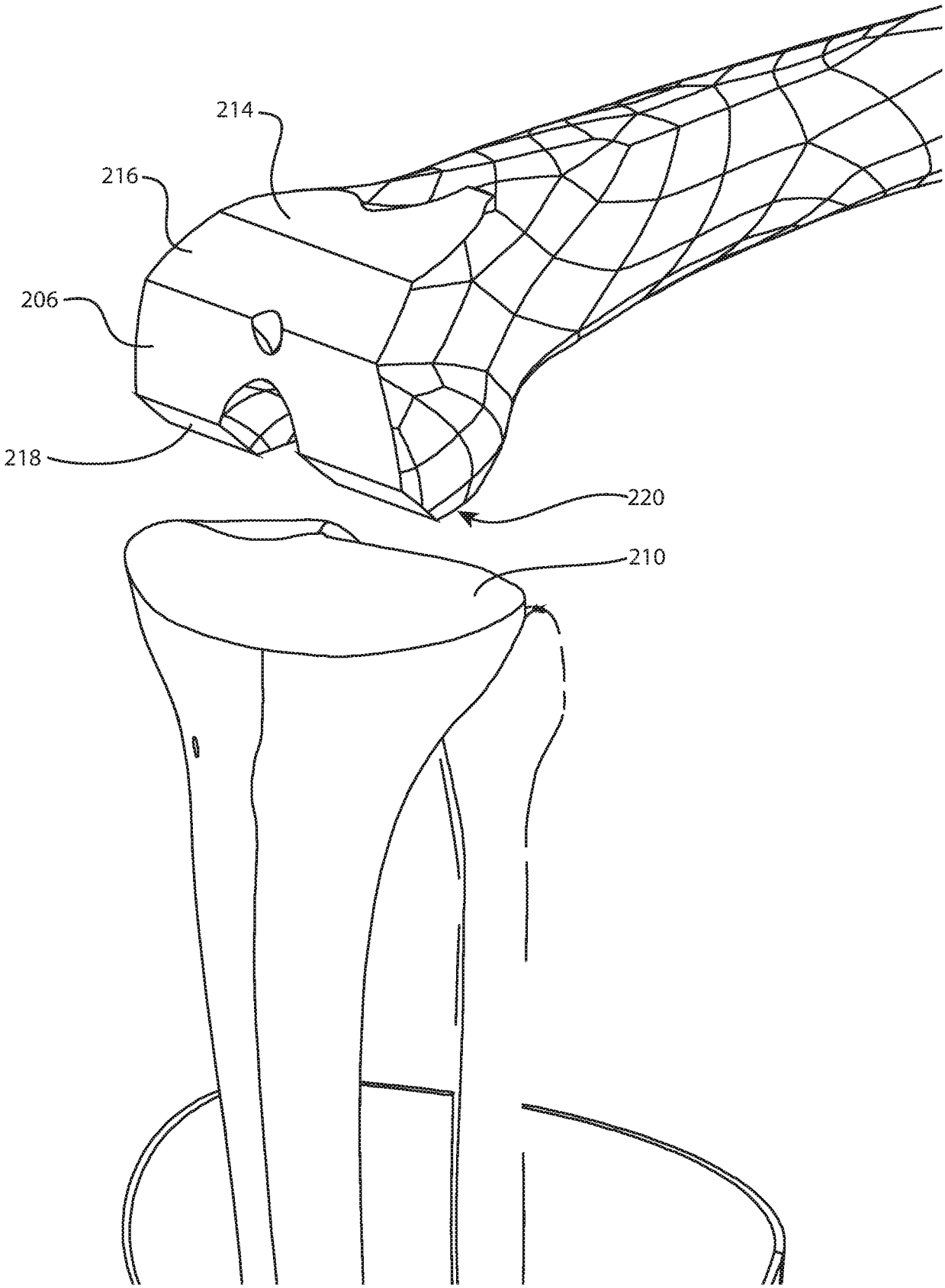

FIG. 32

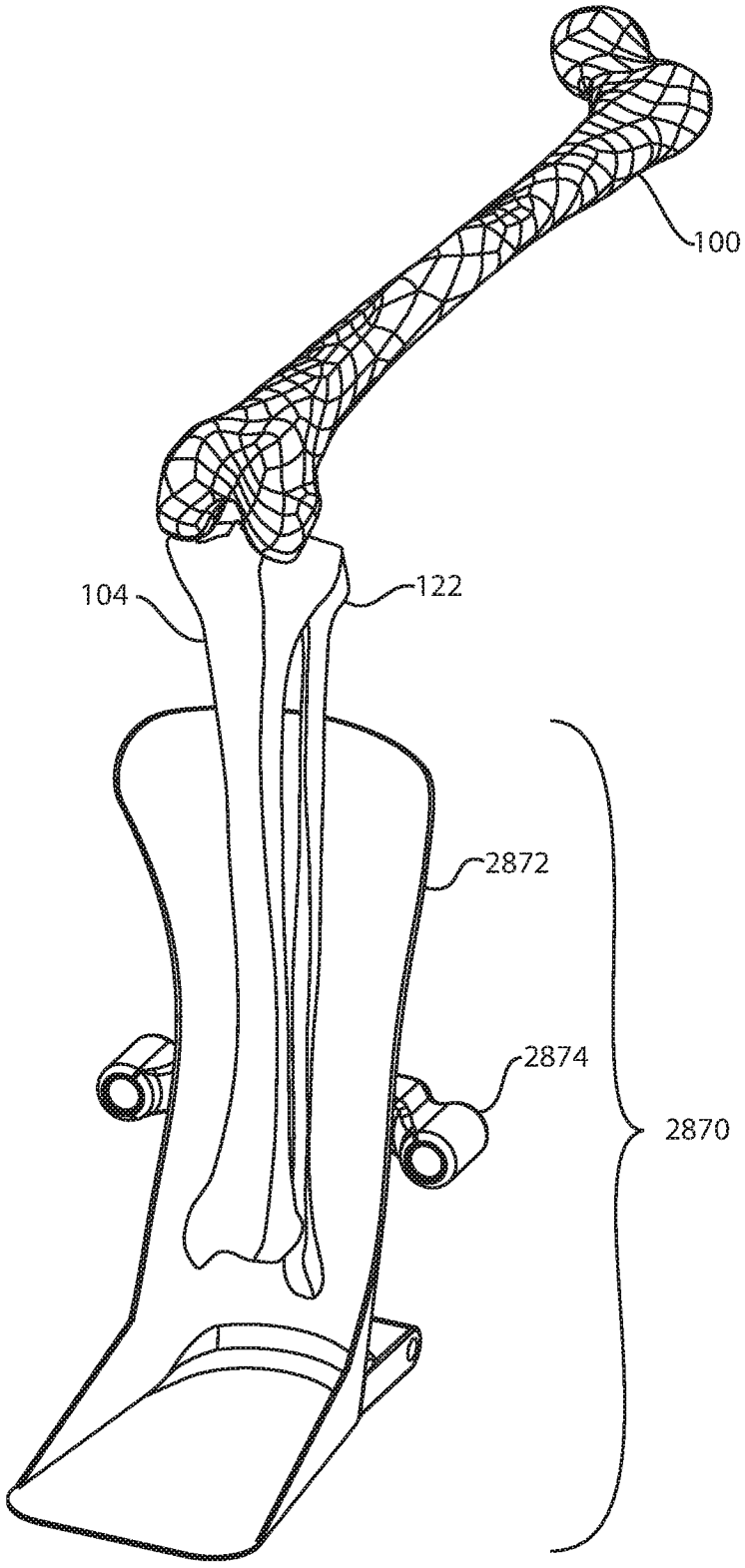

FIG. 33

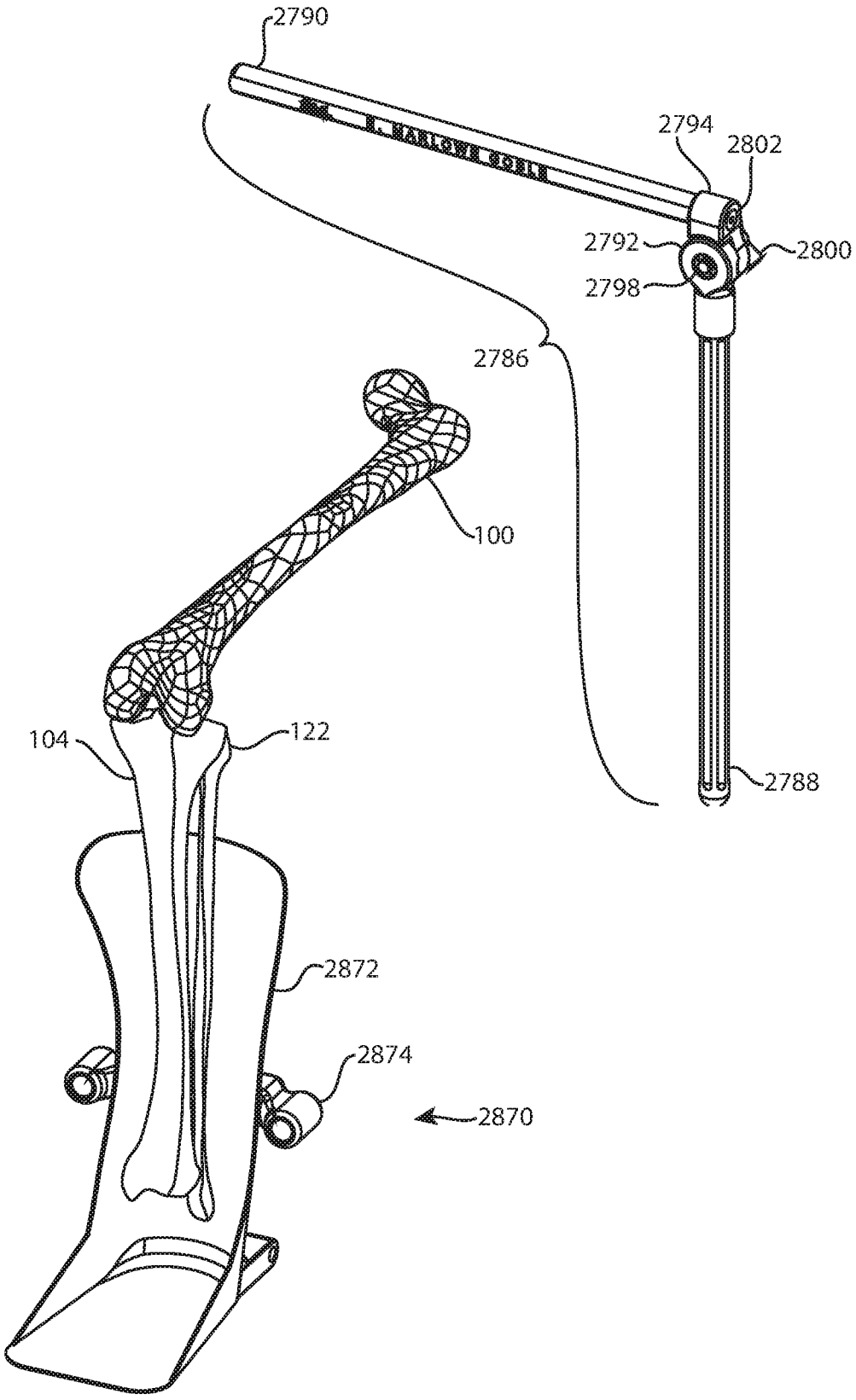
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FIG. 34

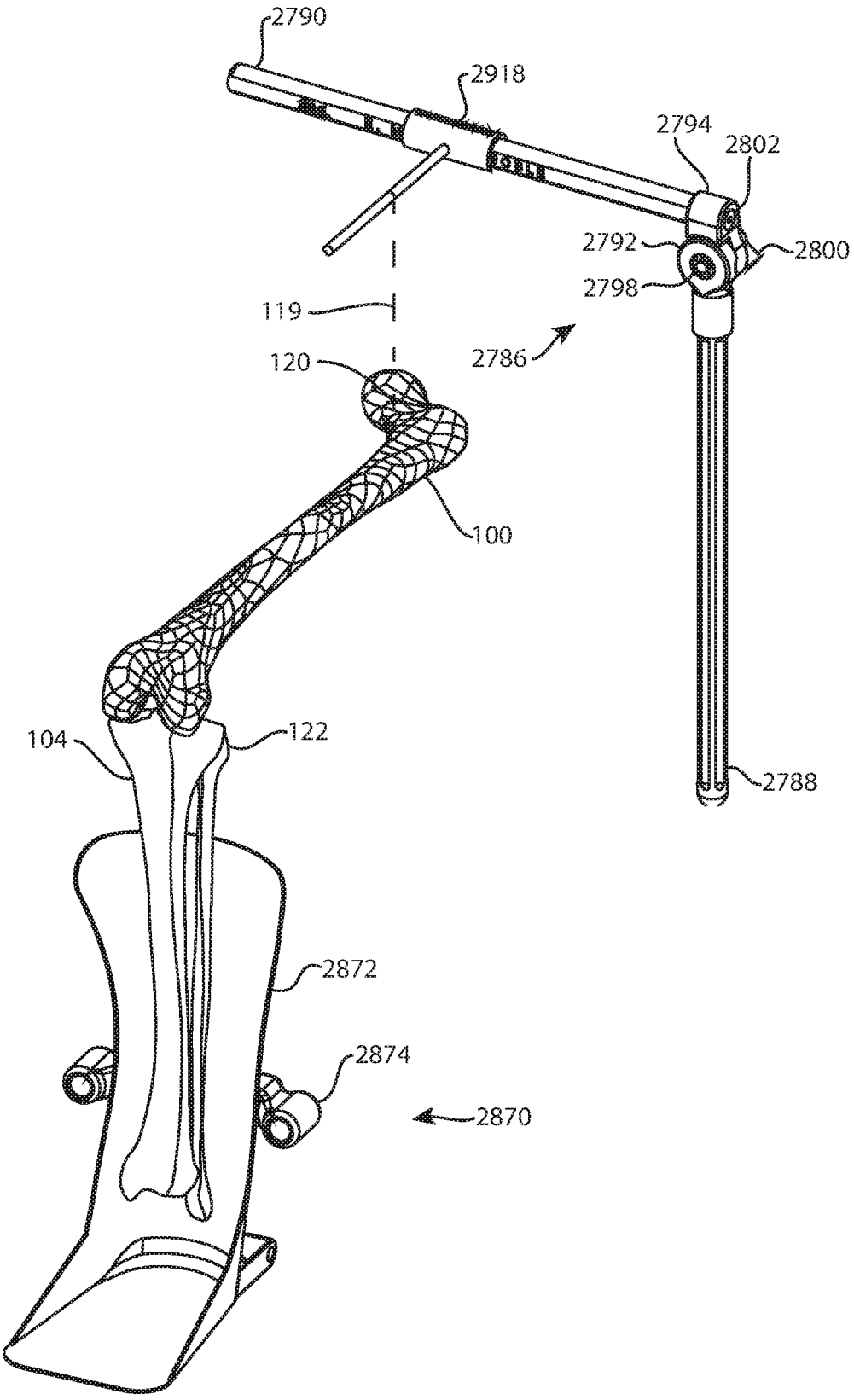
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FIG. 35A

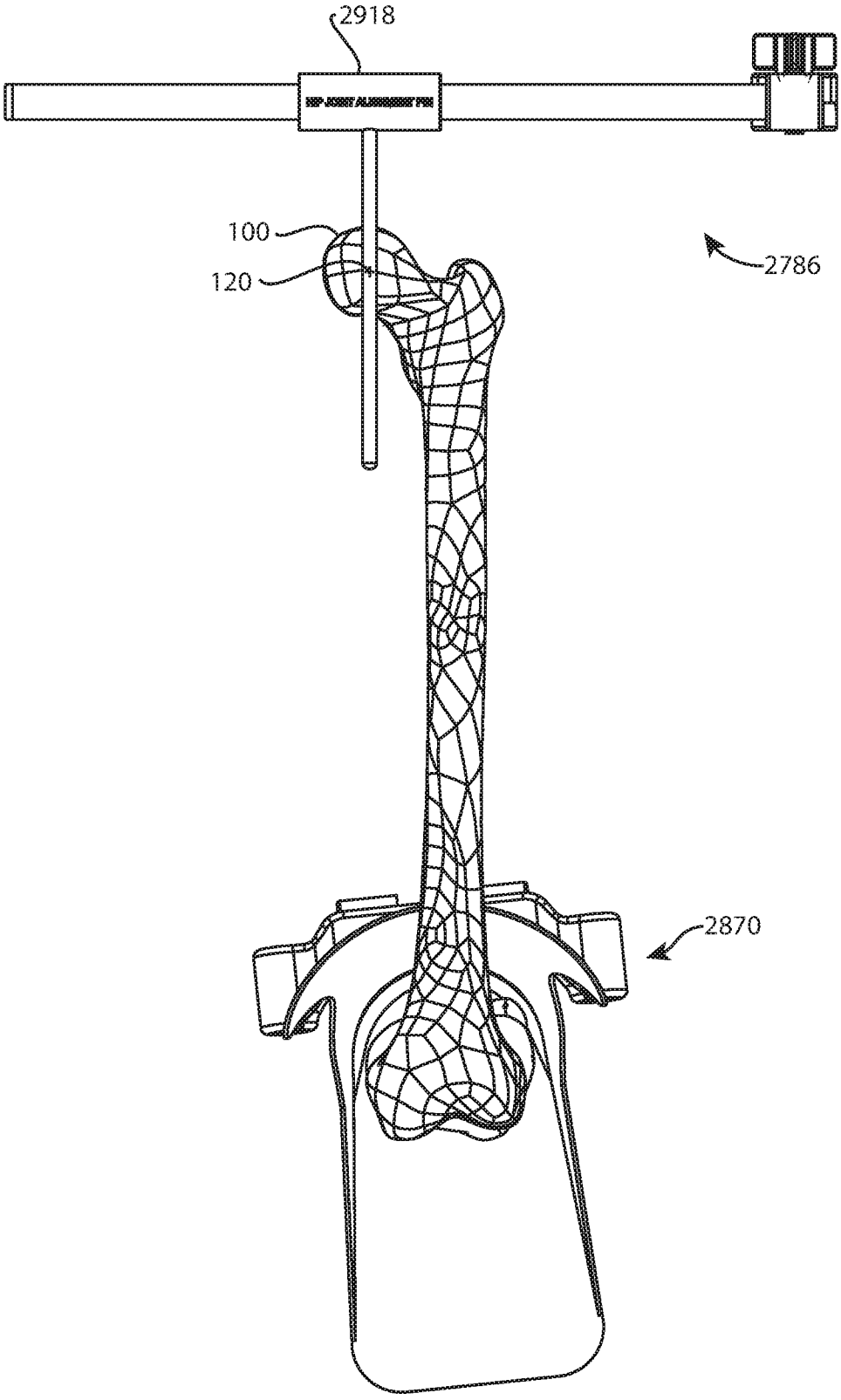

FIG. 35B

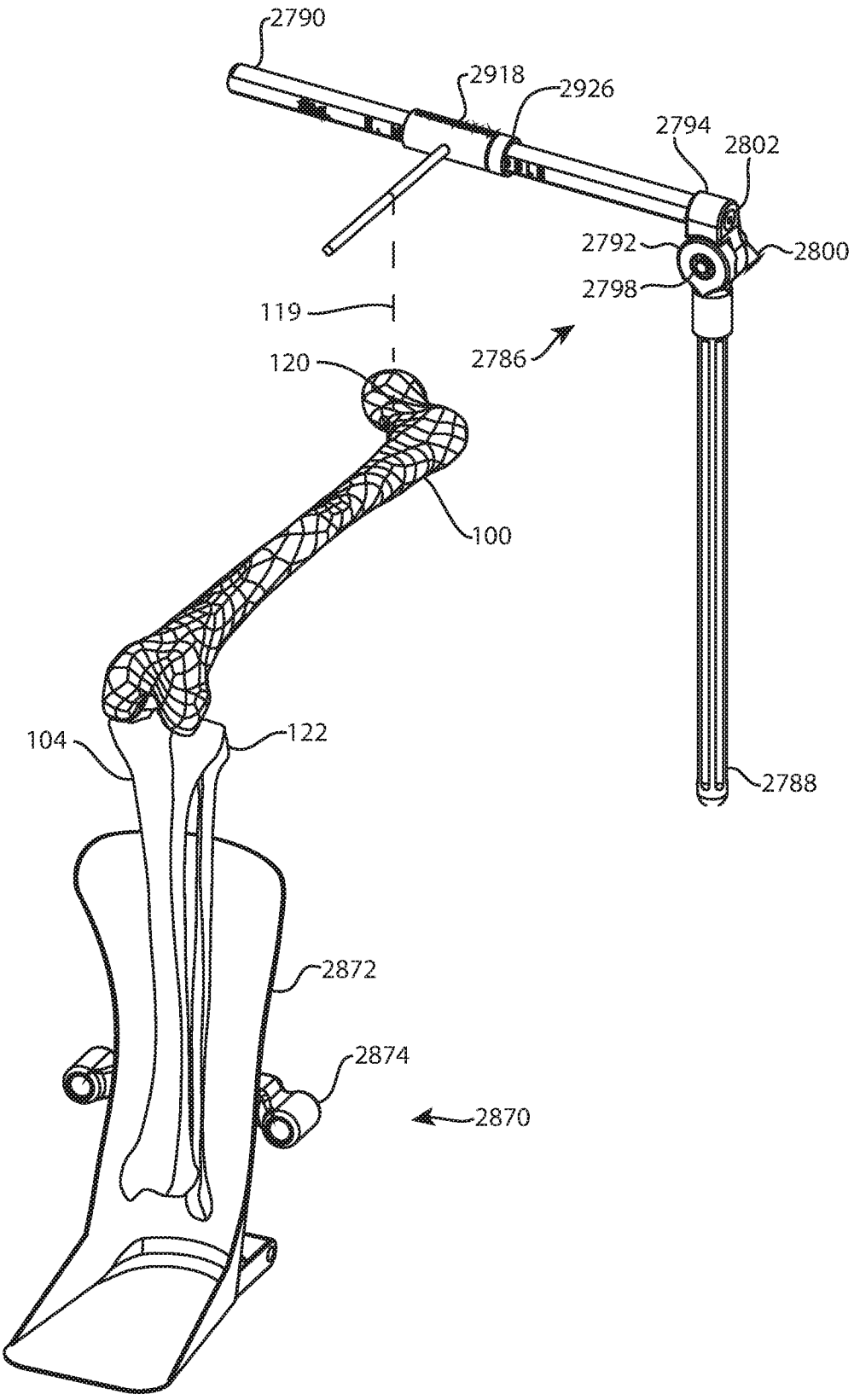
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FIG. 36

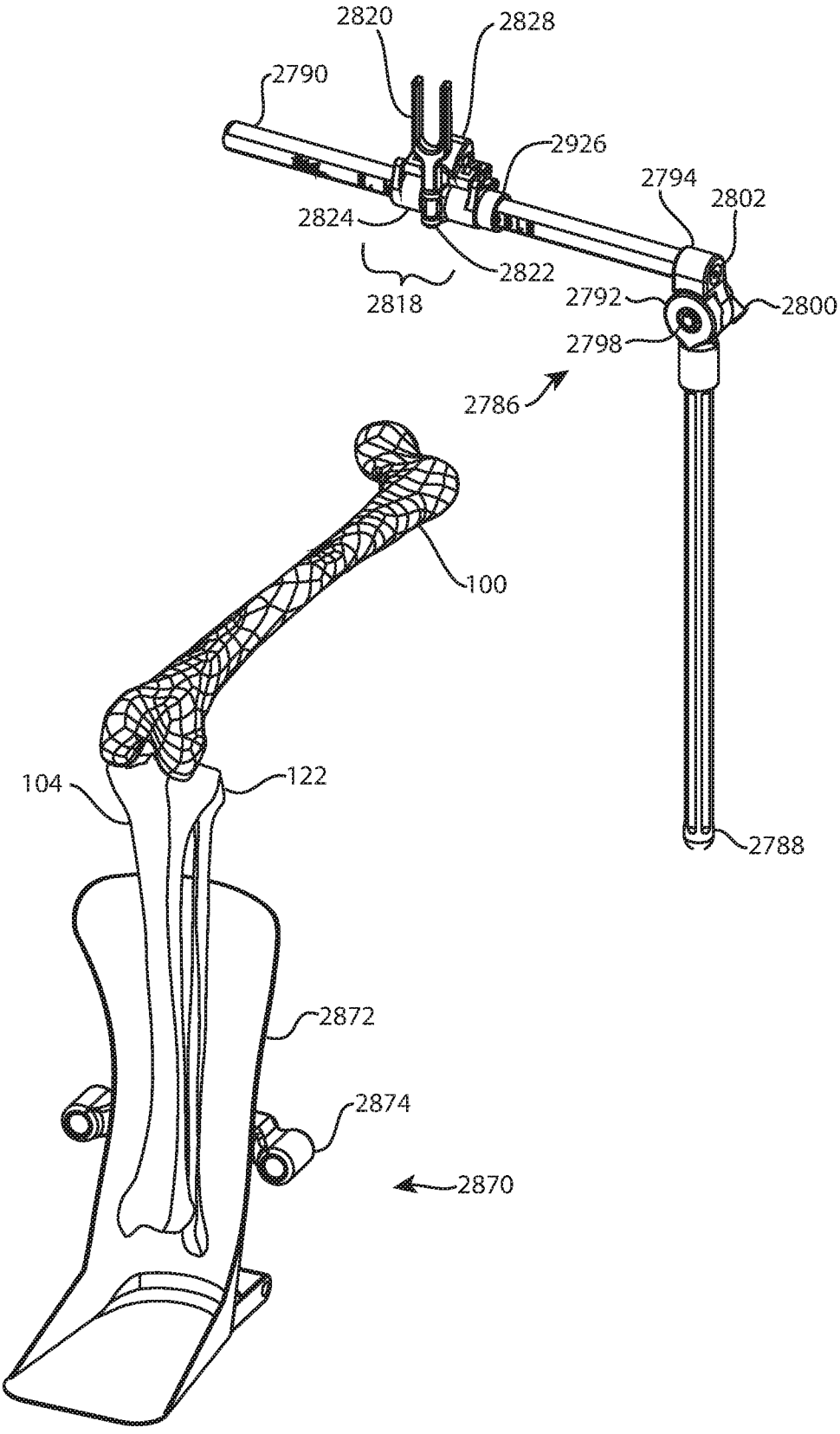
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FIG. 37

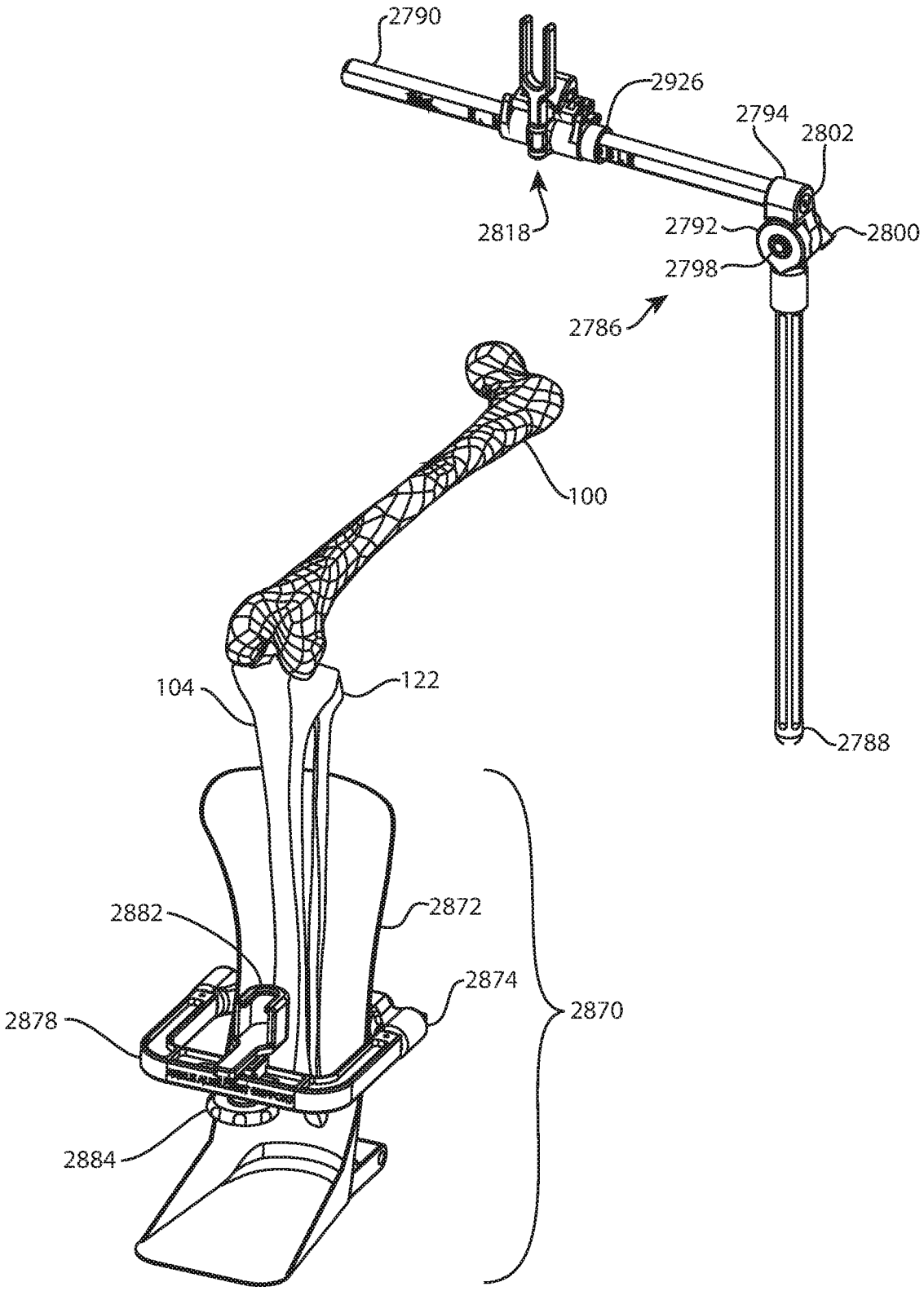
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FIG. 38

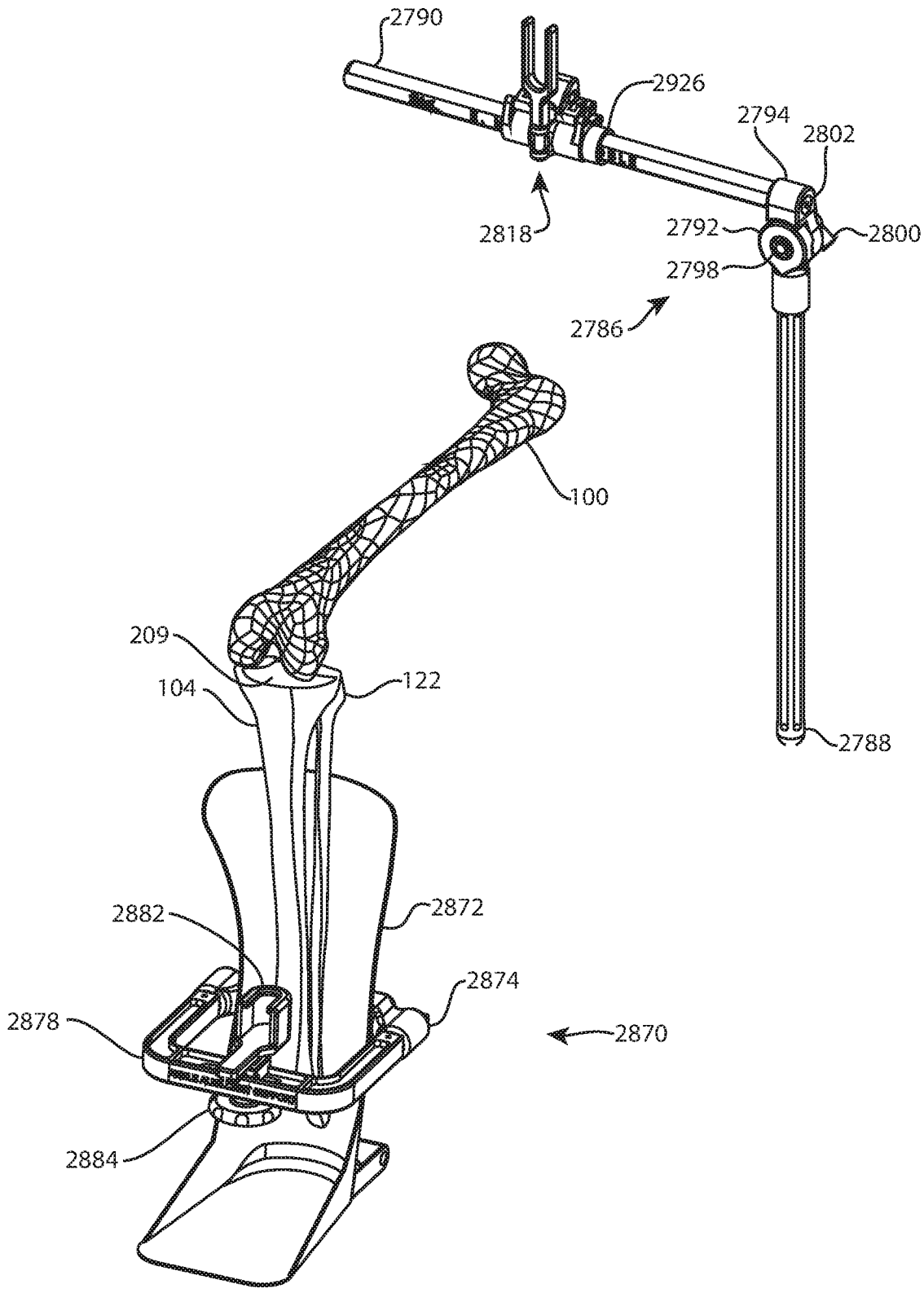
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FIG. 39

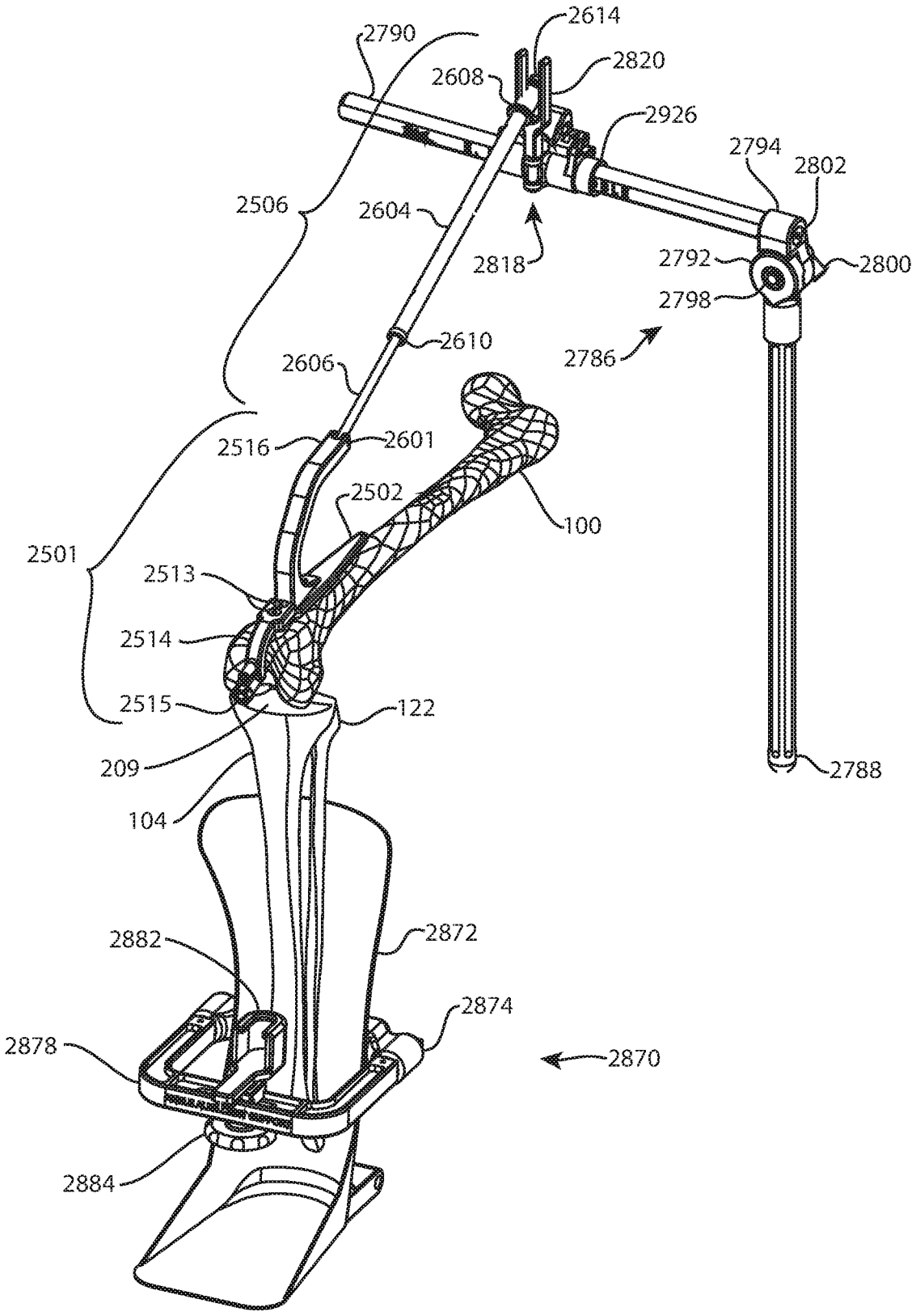
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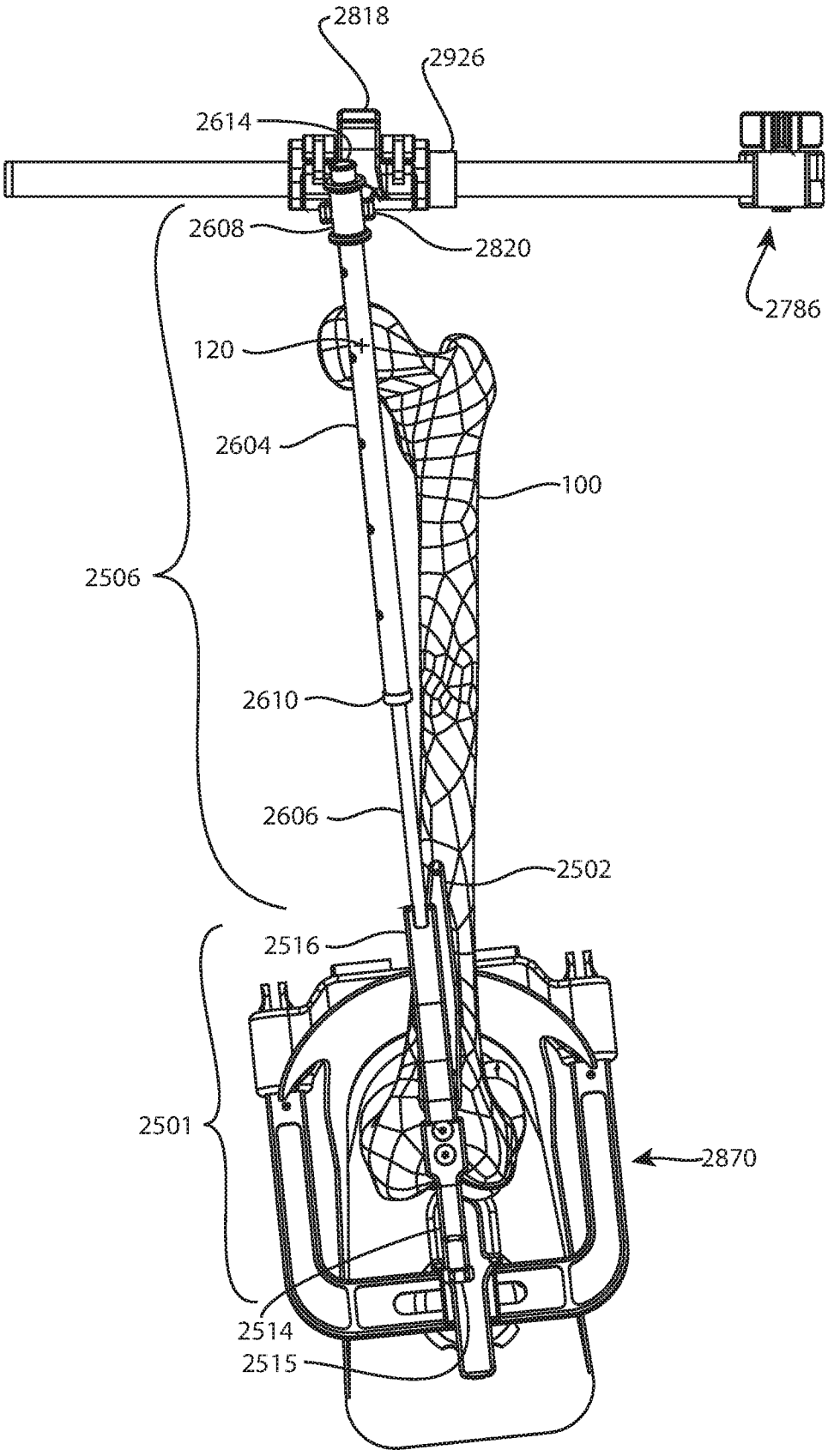
FIG. 40A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2515

FIG. 40B

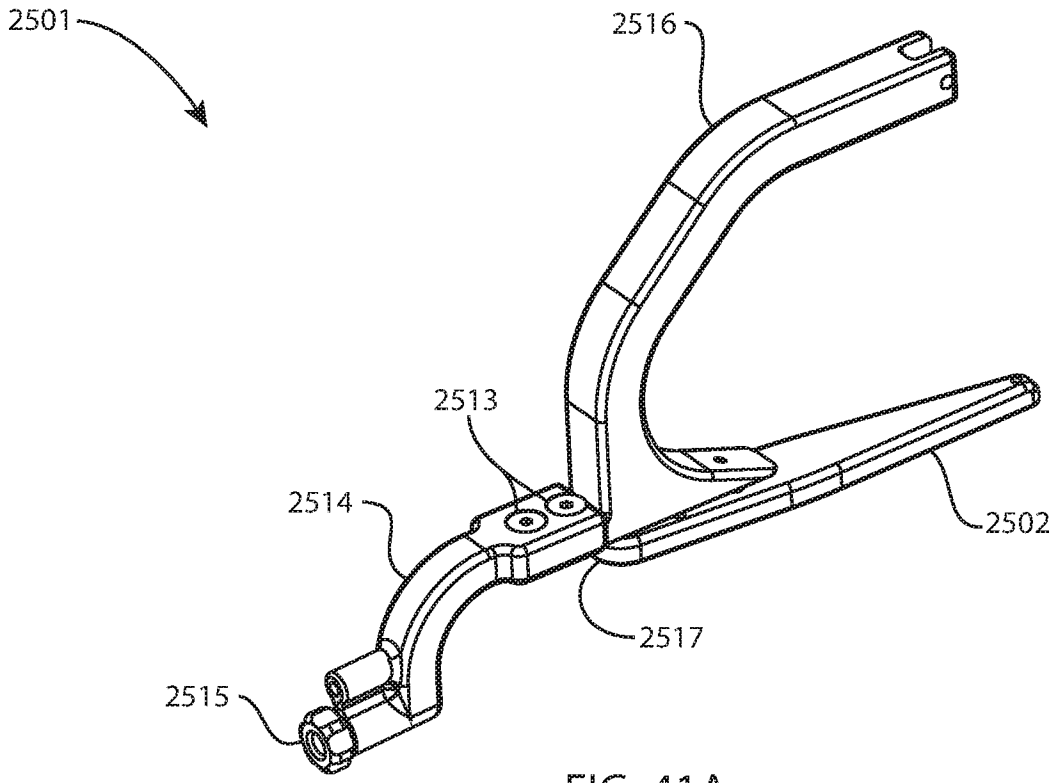


FIG. 41A

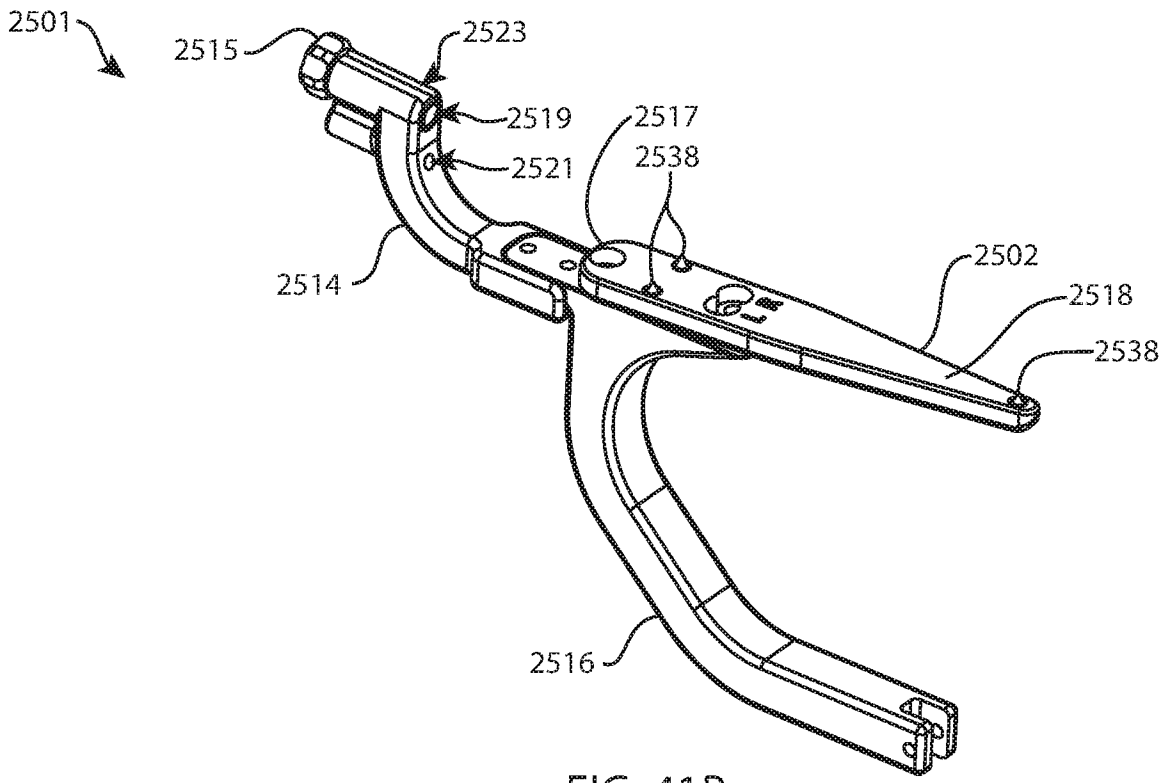


FIG. 41B

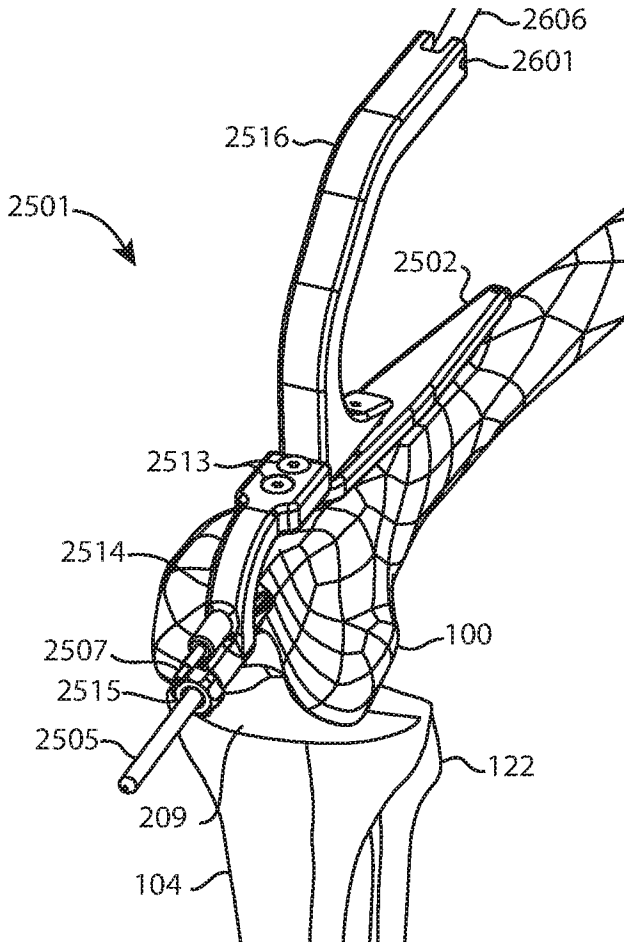


FIG. 42

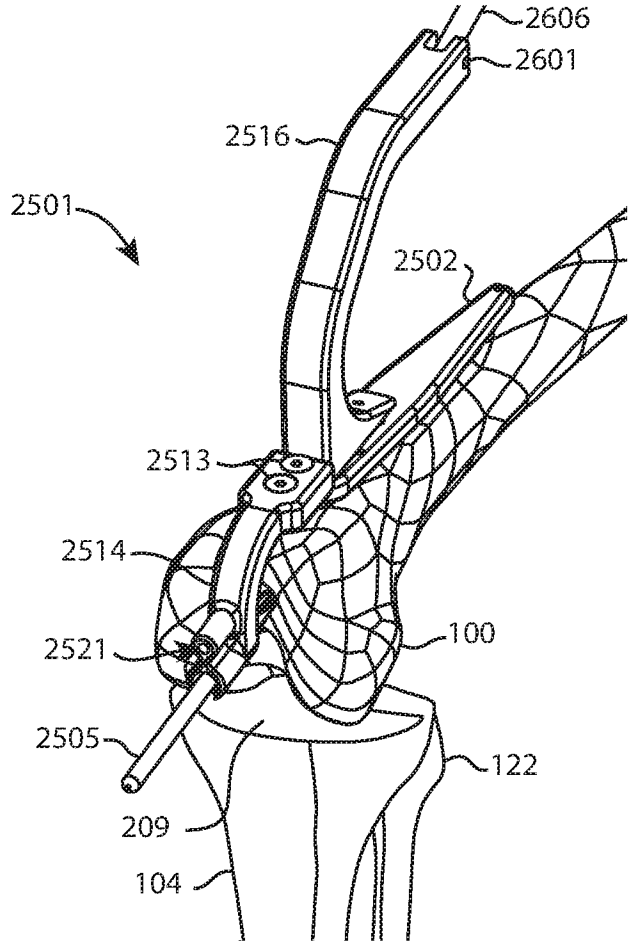


FIG. 43

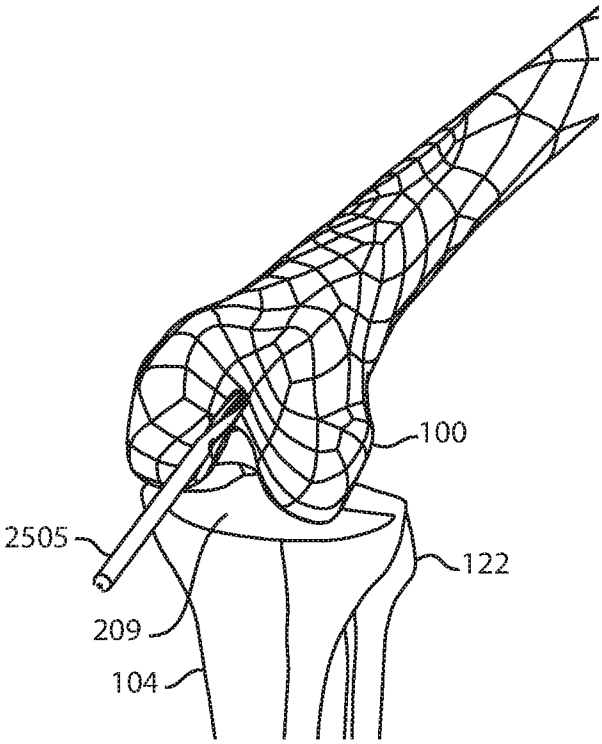


FIG. 44

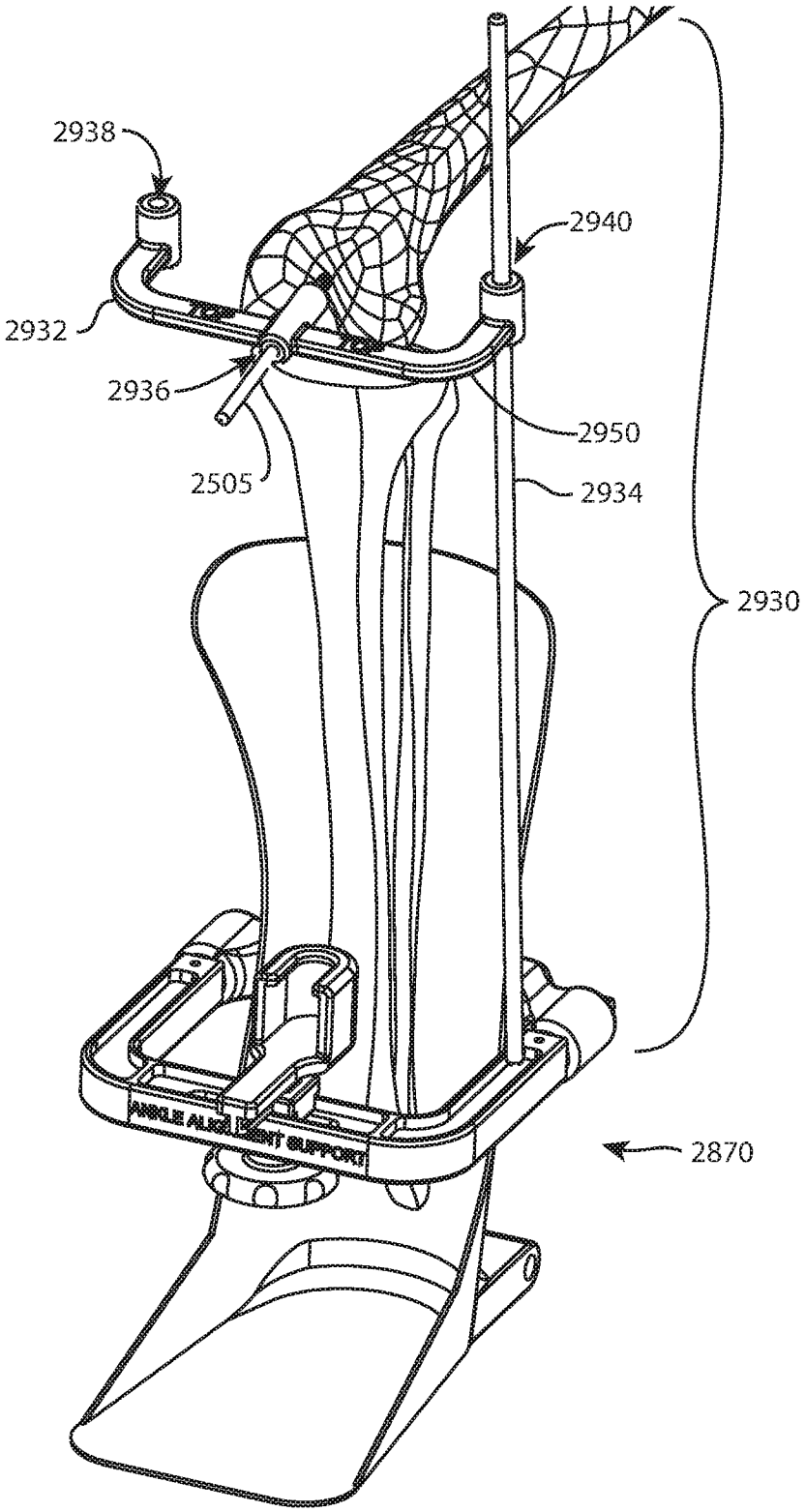


FIG. 45A

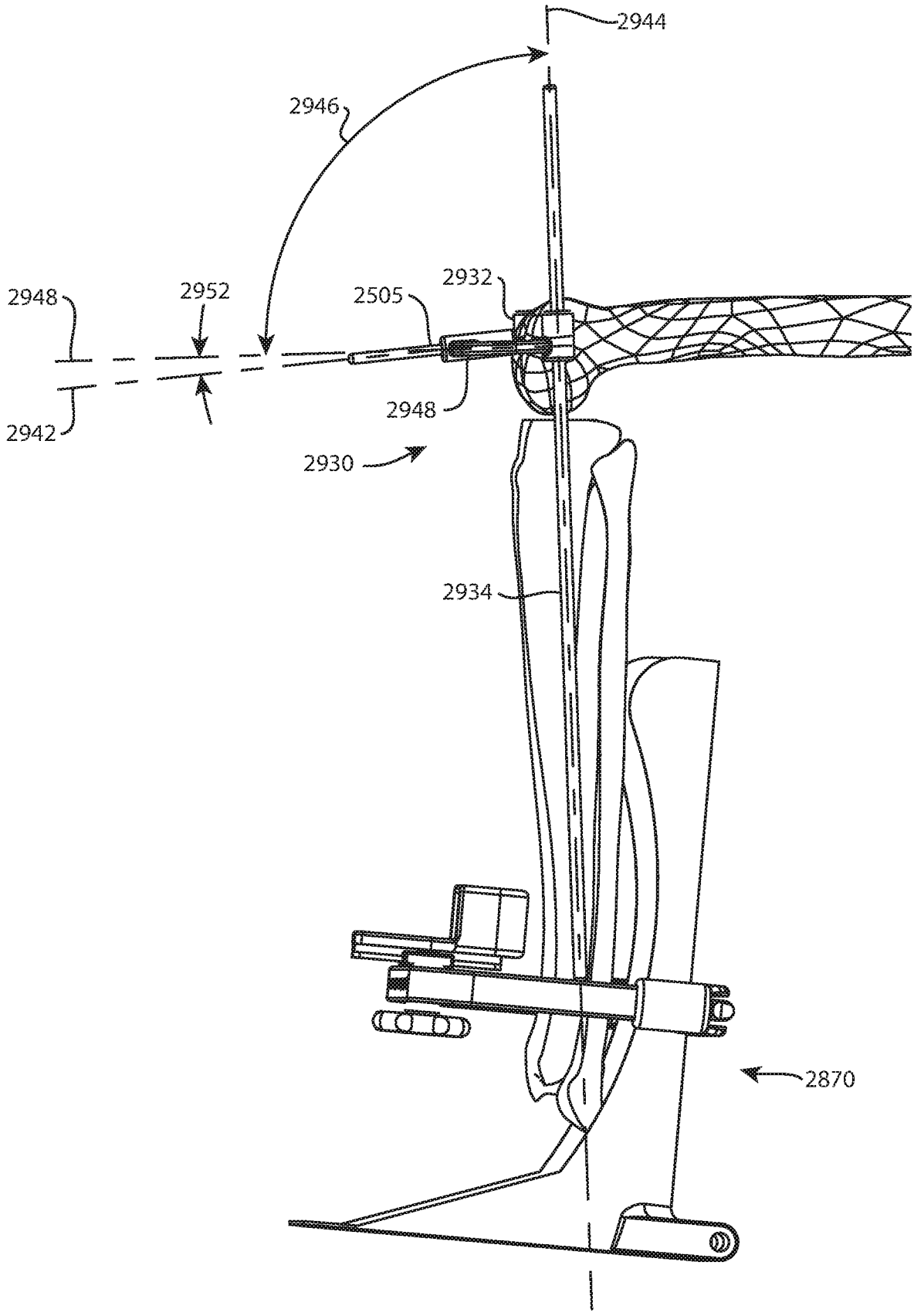


FIG. 45B

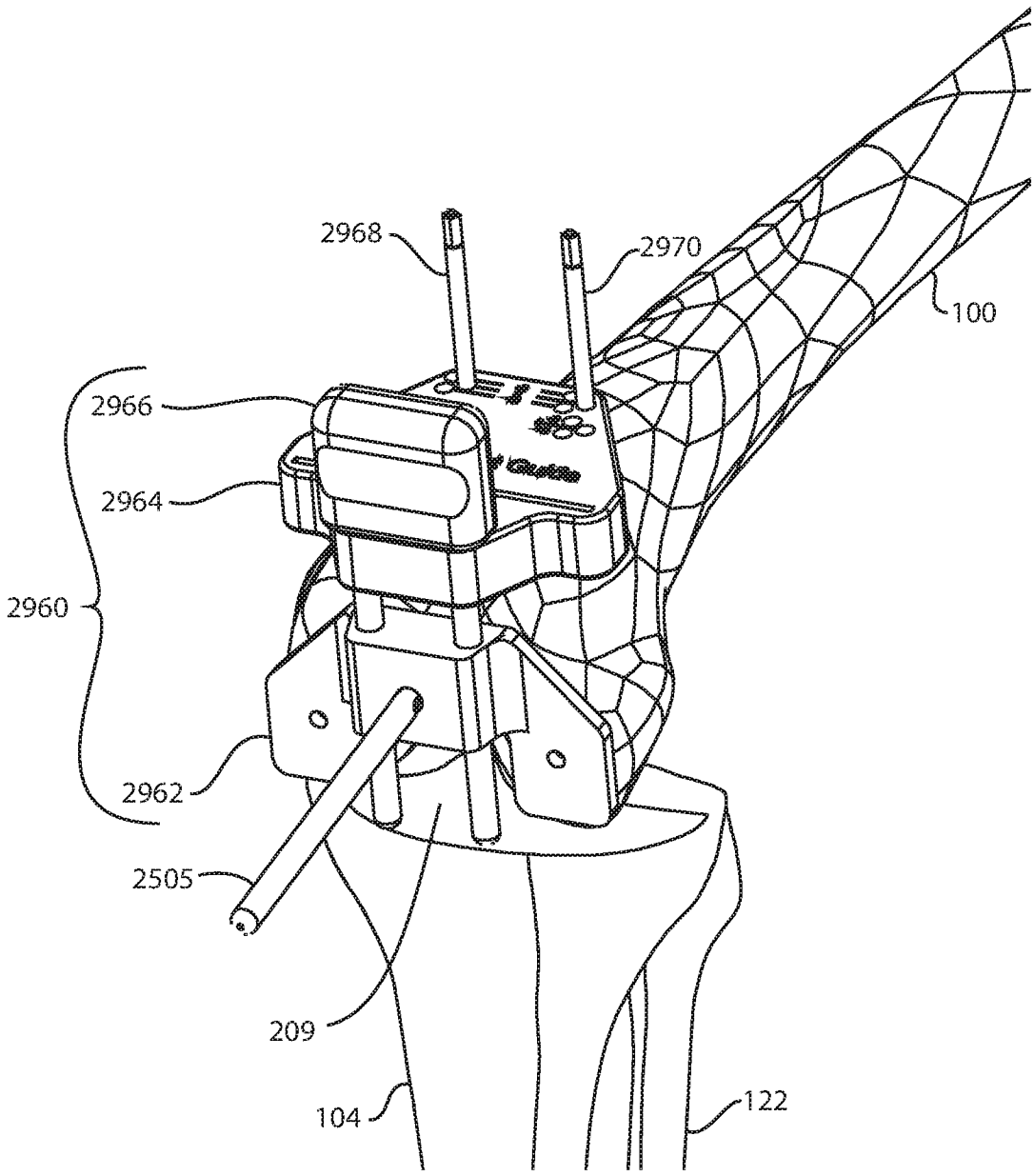


FIG. 46

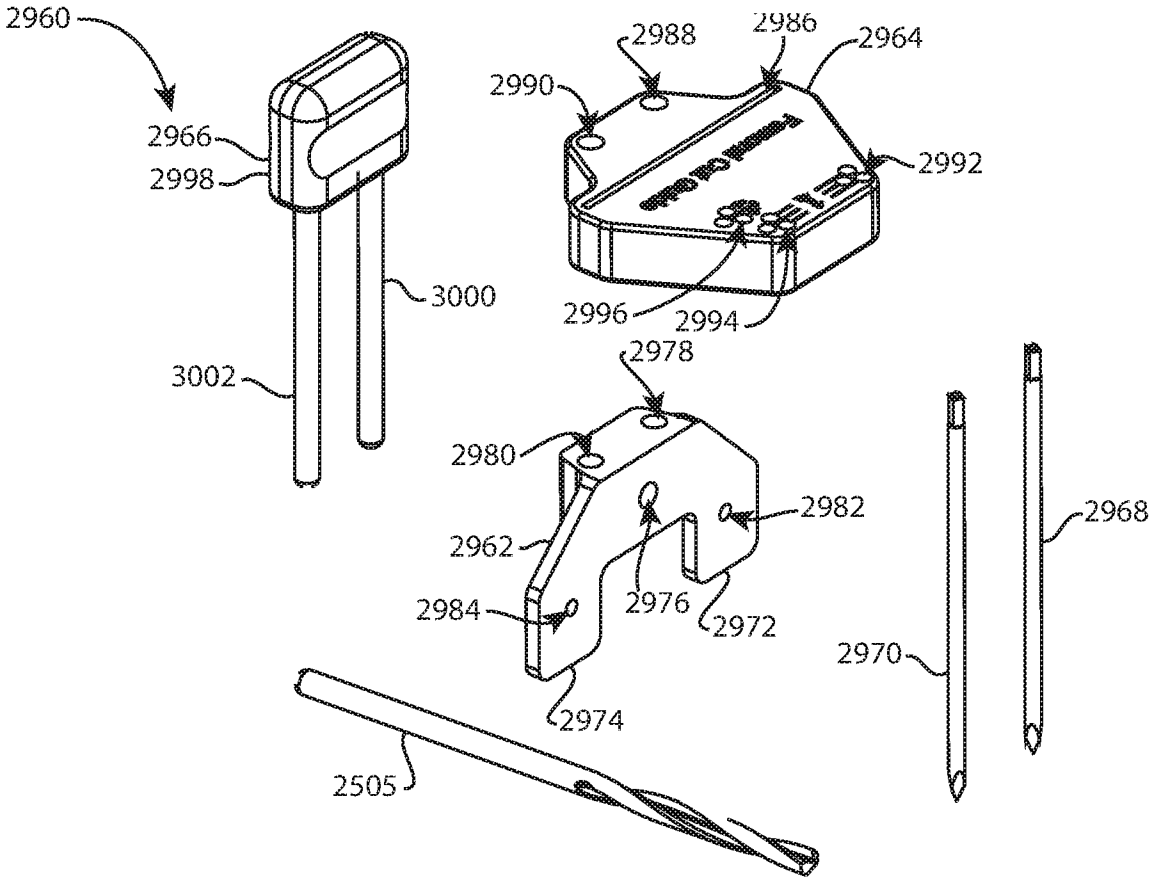


FIG. 47A

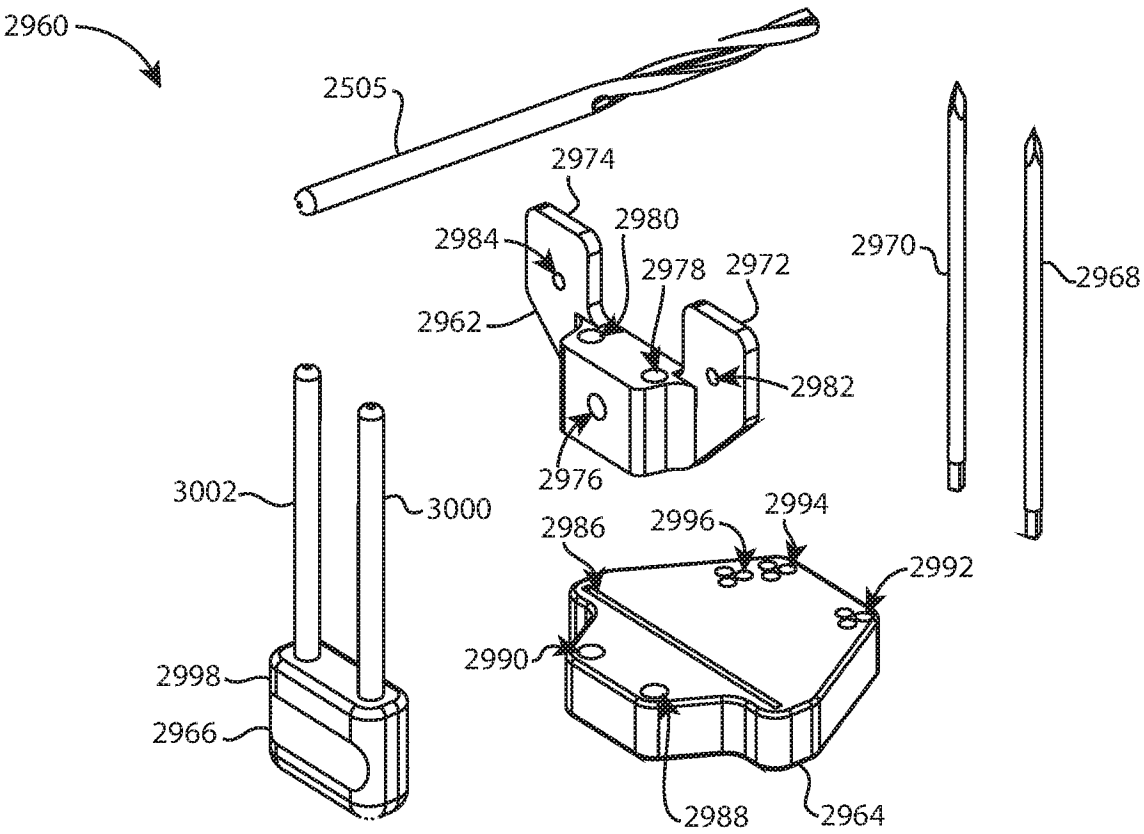


FIG. 47B

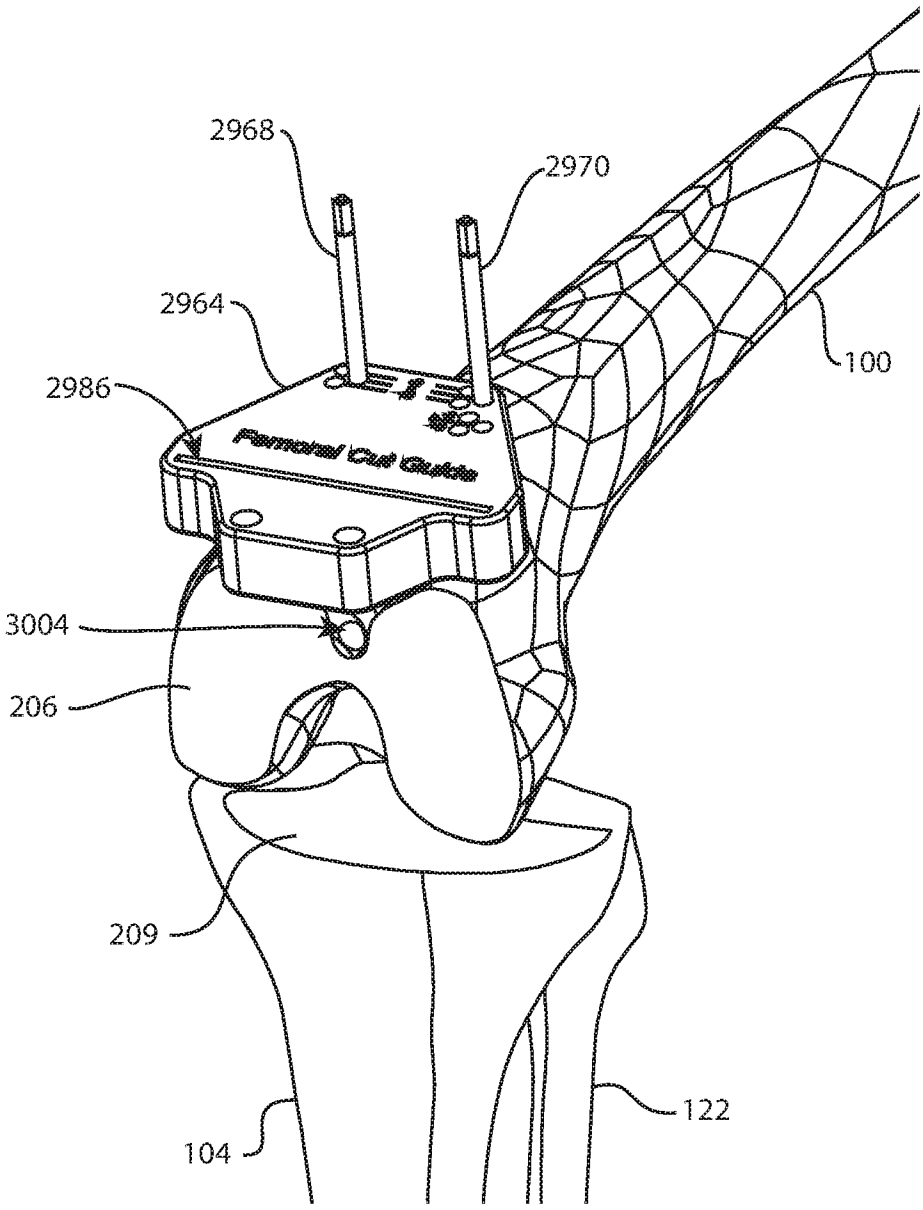
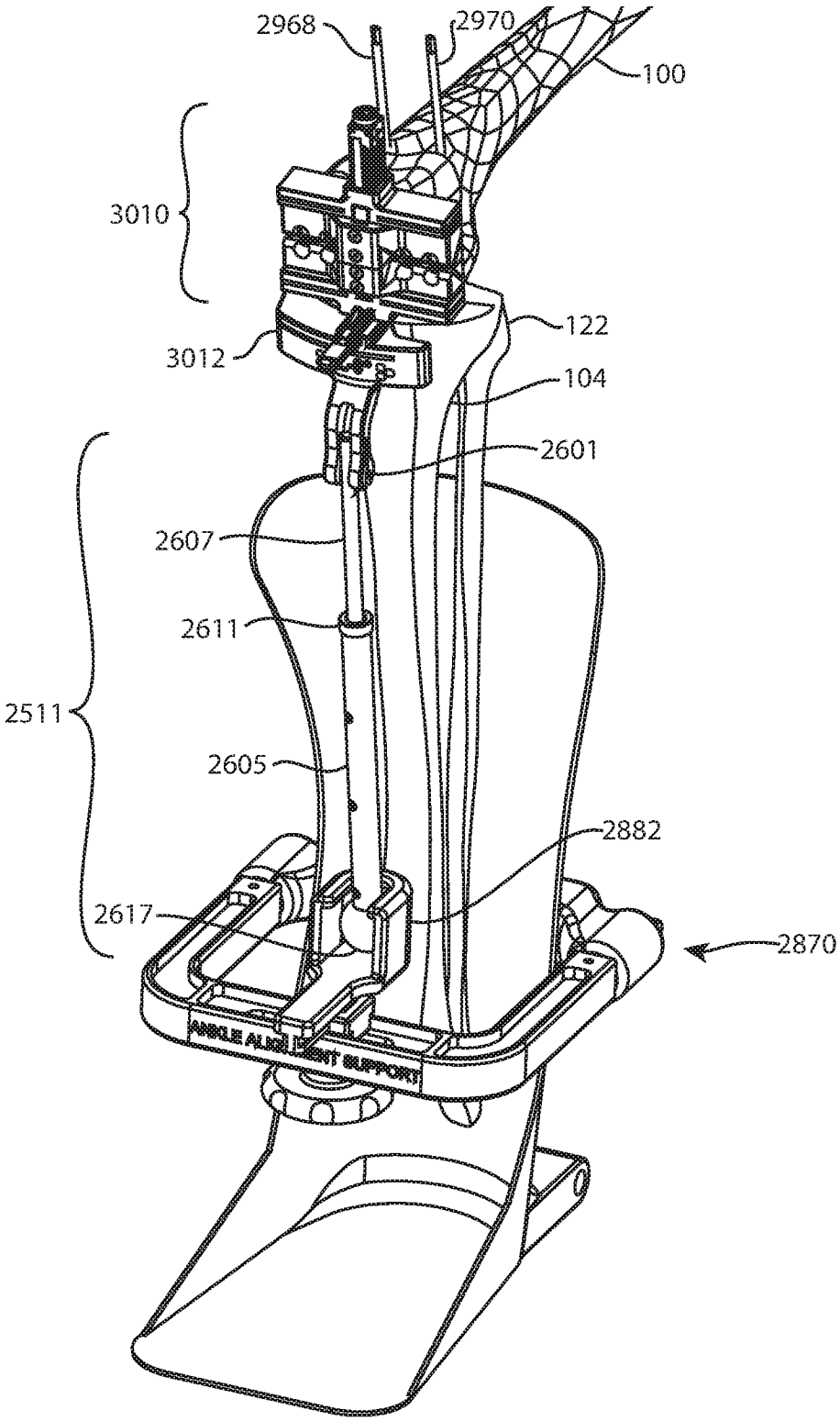


FIG. 48


2968
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2601
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2511
2605
2882
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2870

FIG. 49A

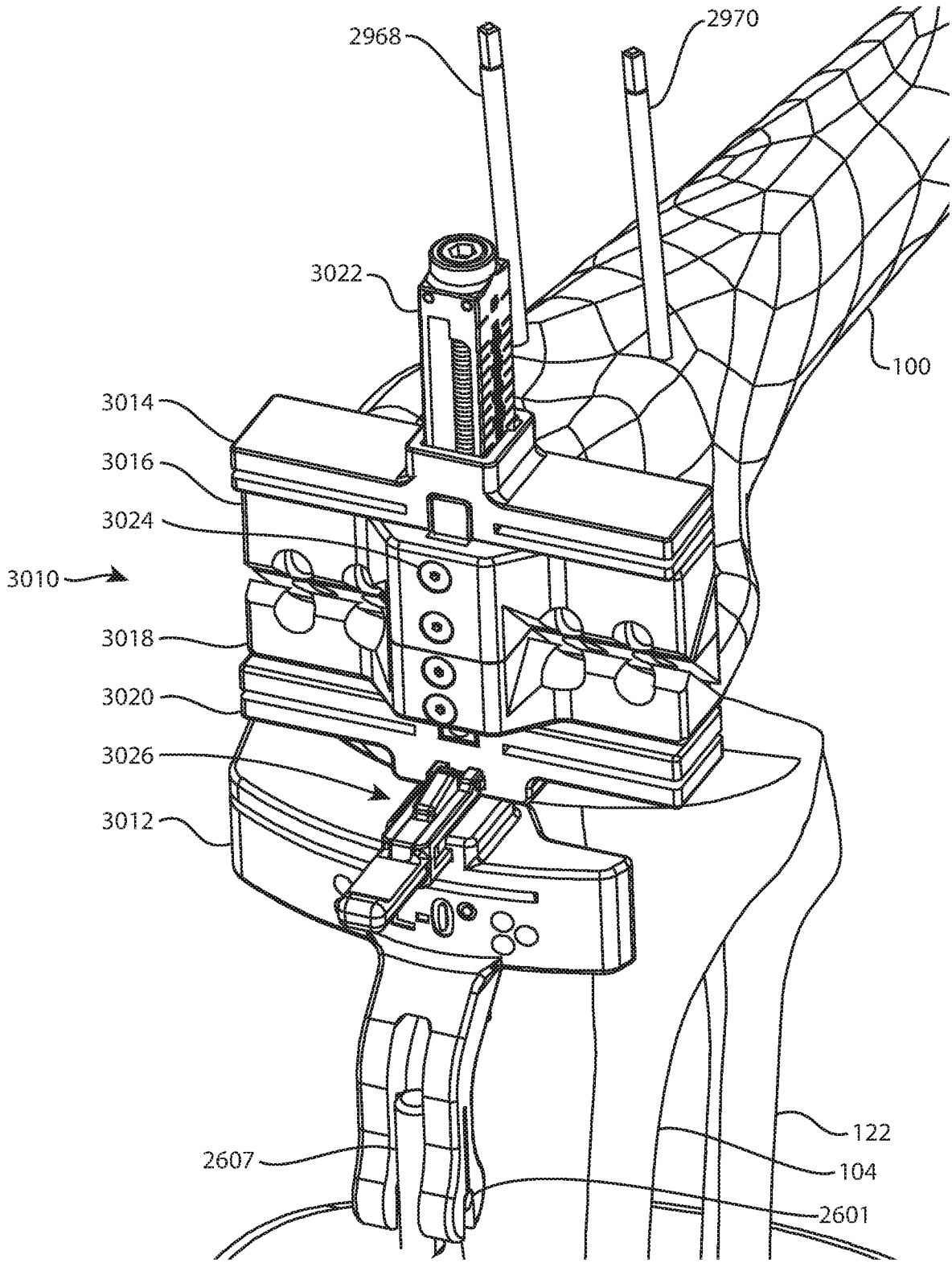
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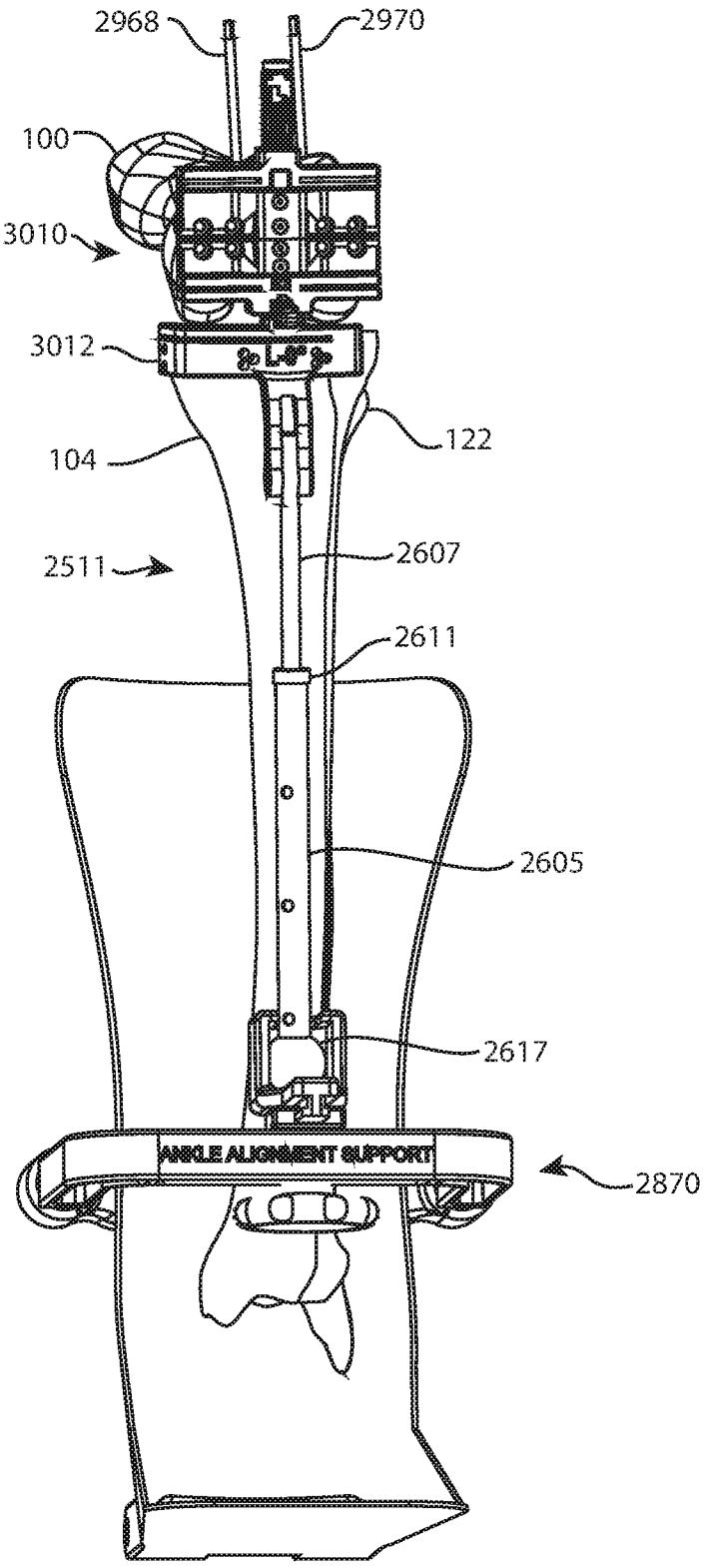
FIG. 49B


2968
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ANKLE ALIGNMENT SUPPORT
2870

FIG. 49C

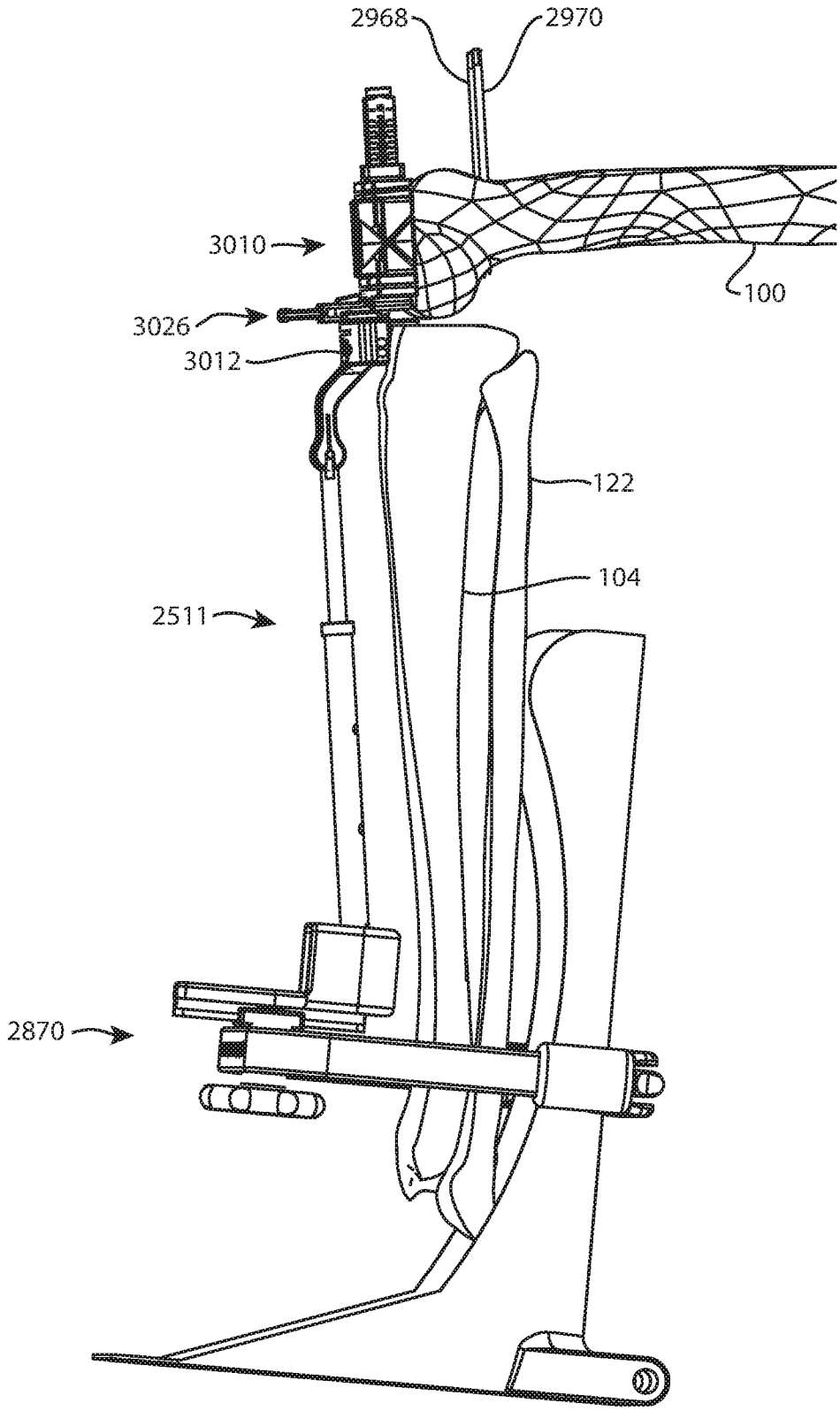


FIG. 49D

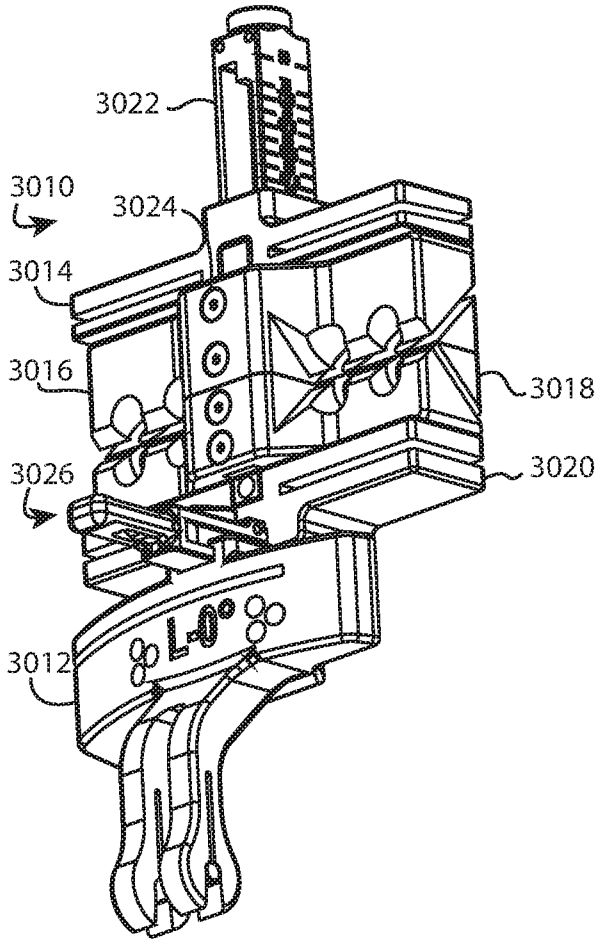


FIG. 50A

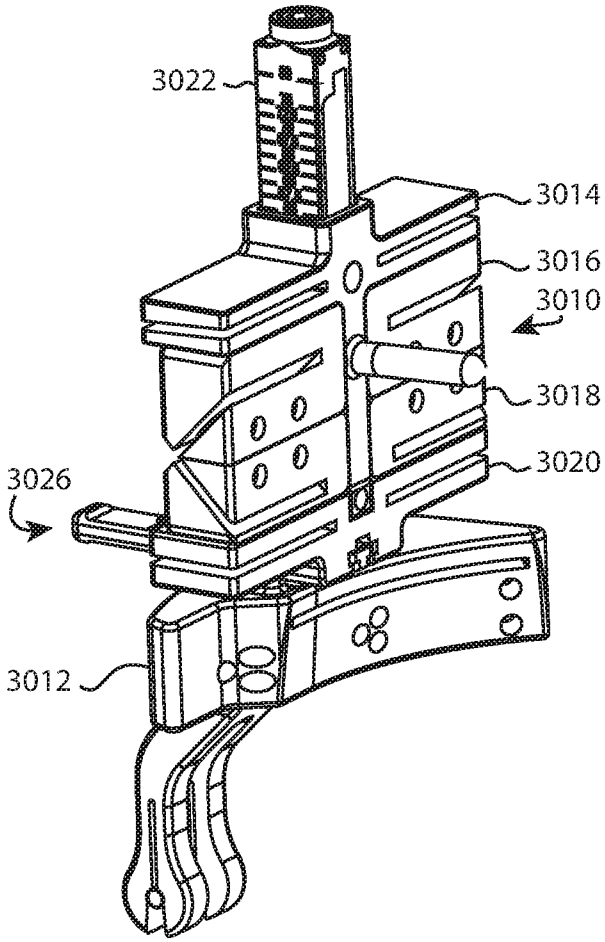


FIG. 50B

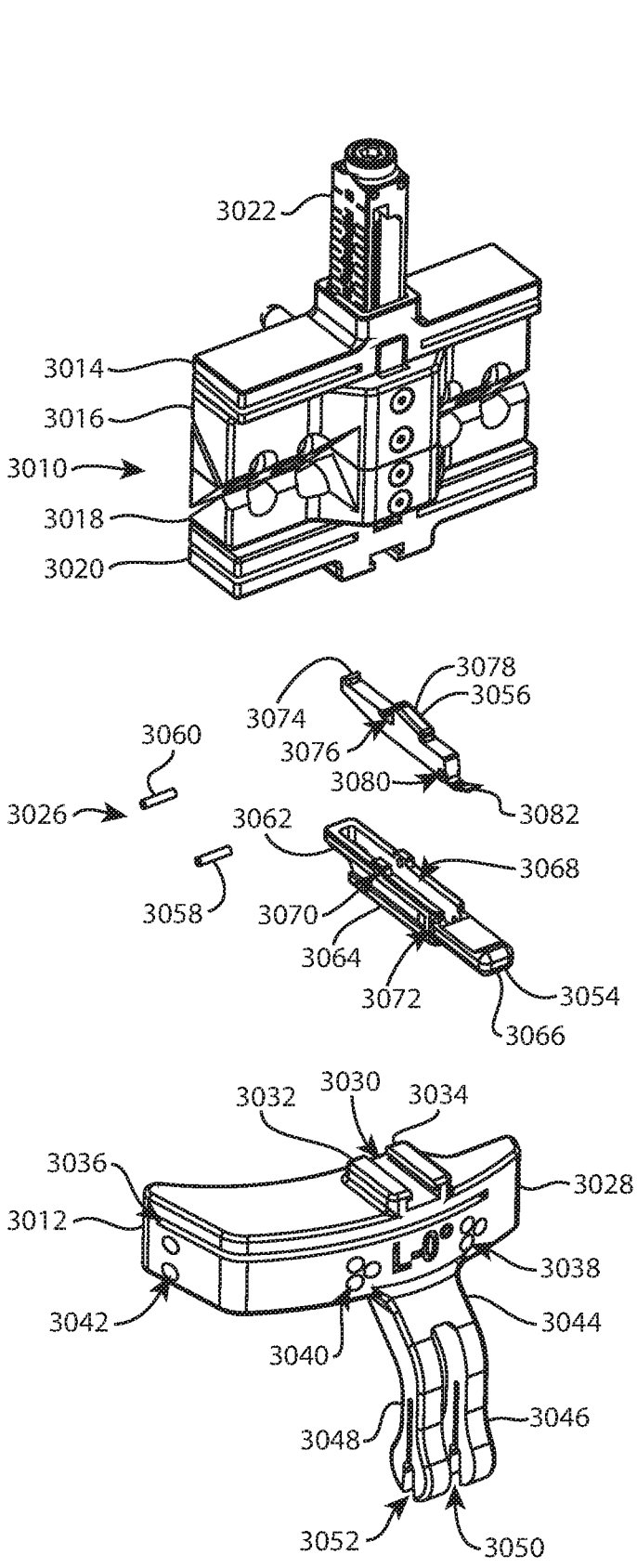


FIG. 50C

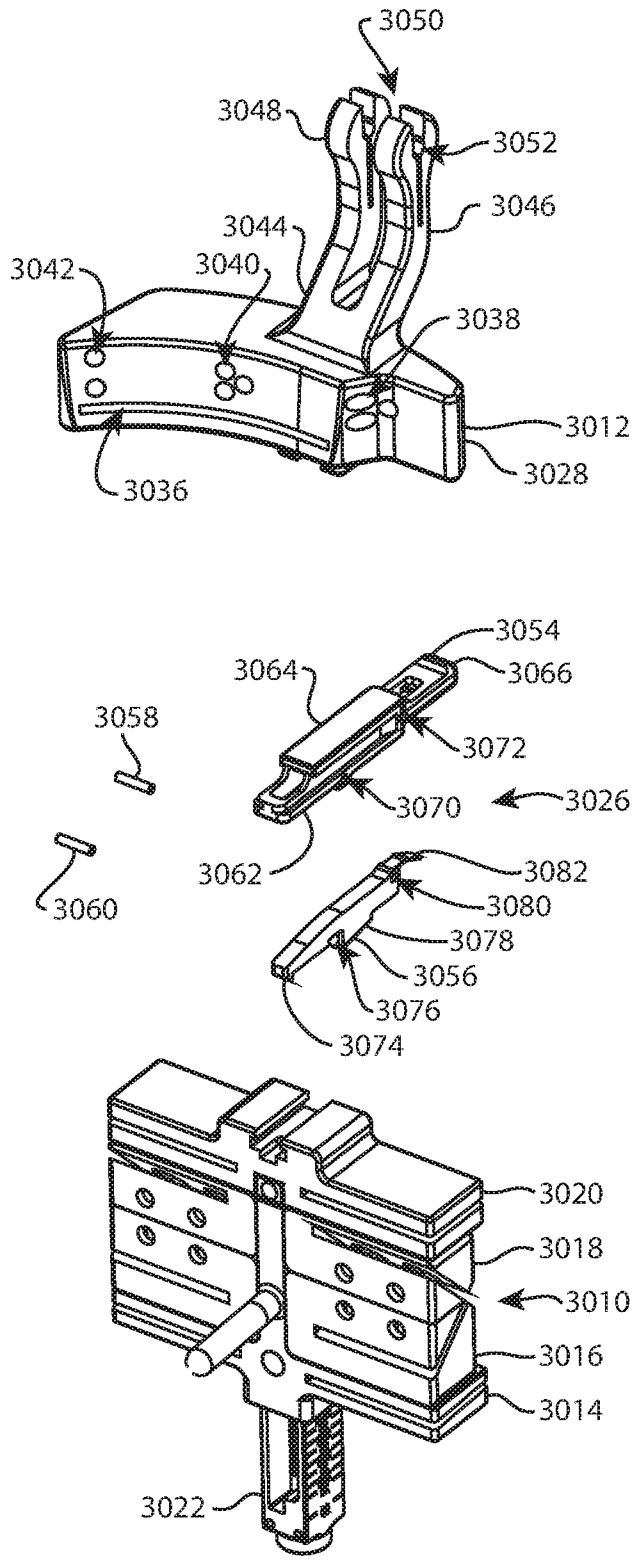


FIG. 50D

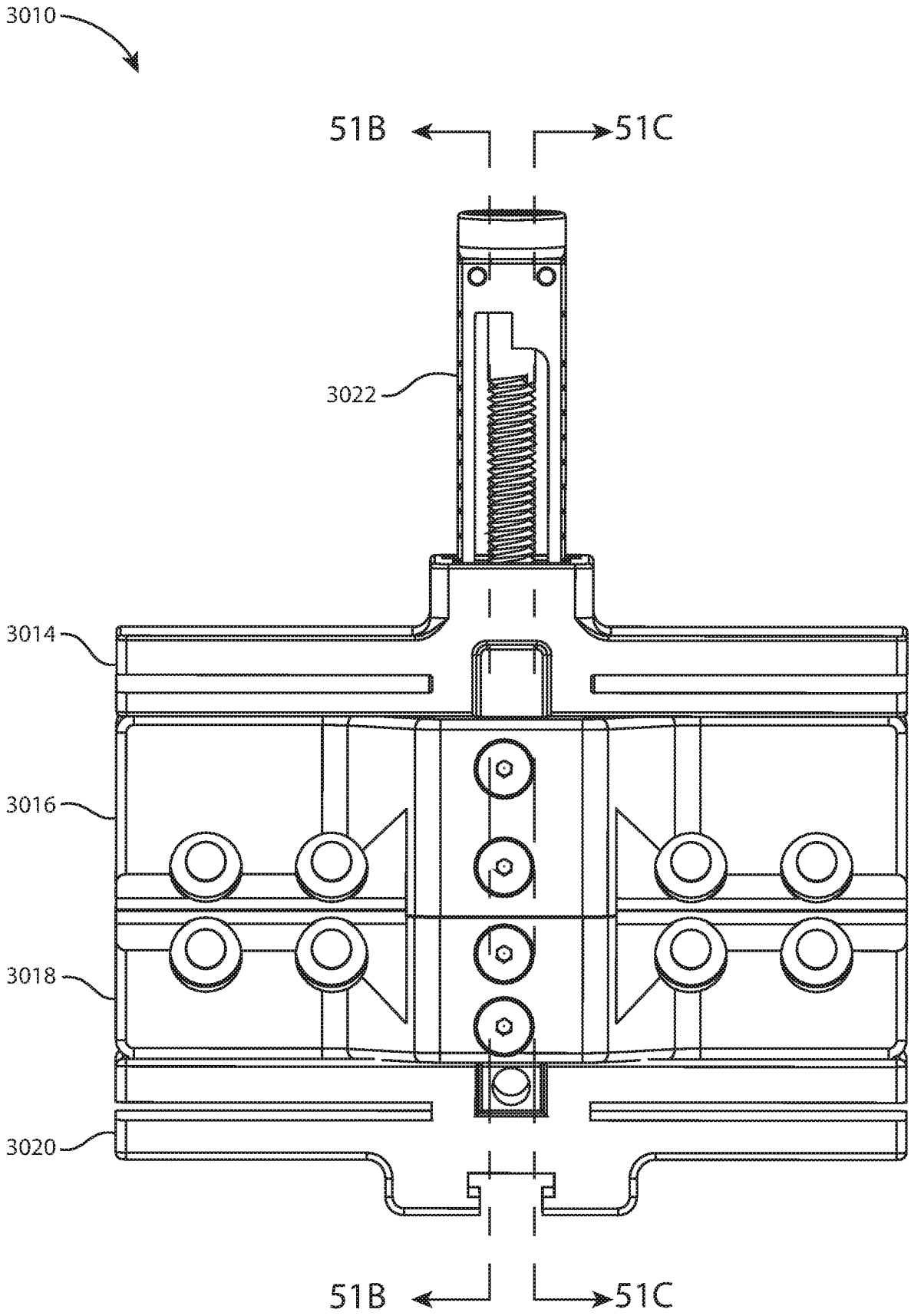


FIG. 51A

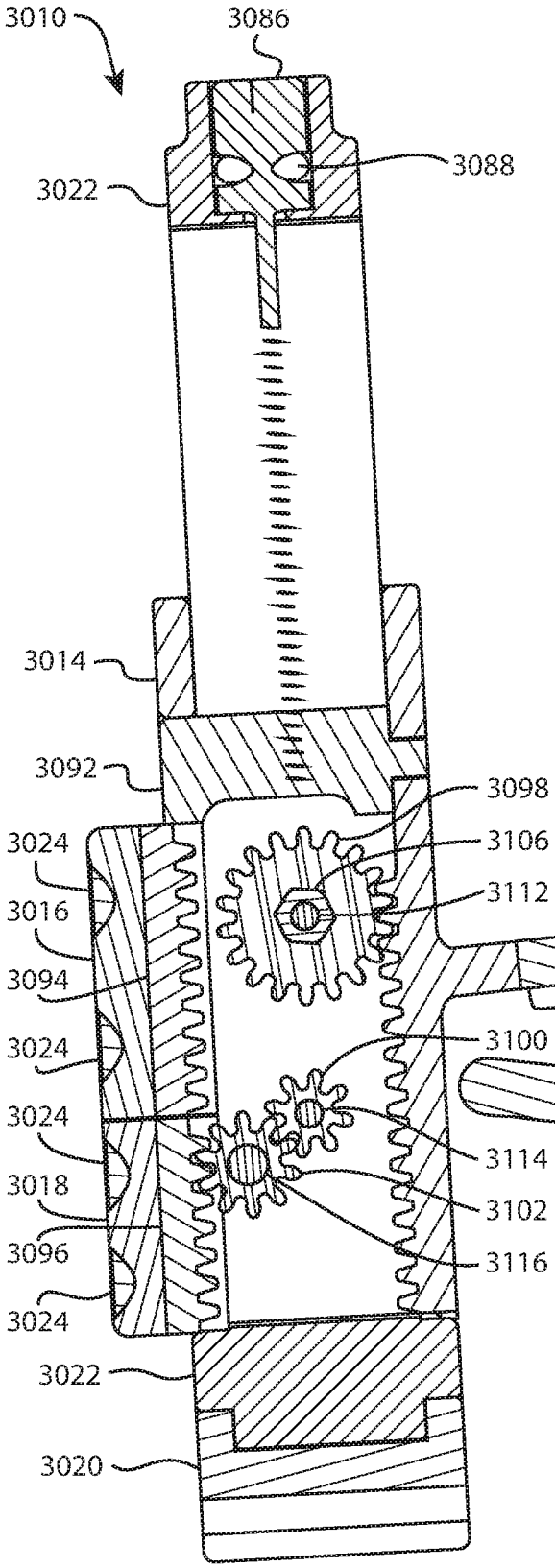


FIG. 51B

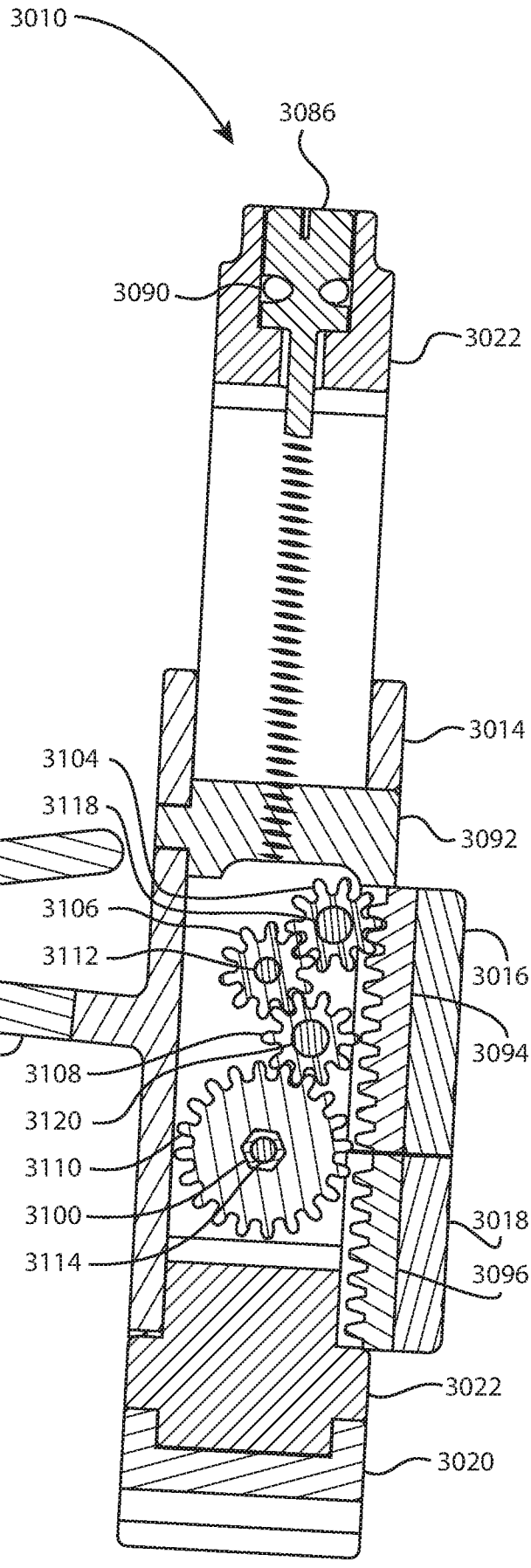
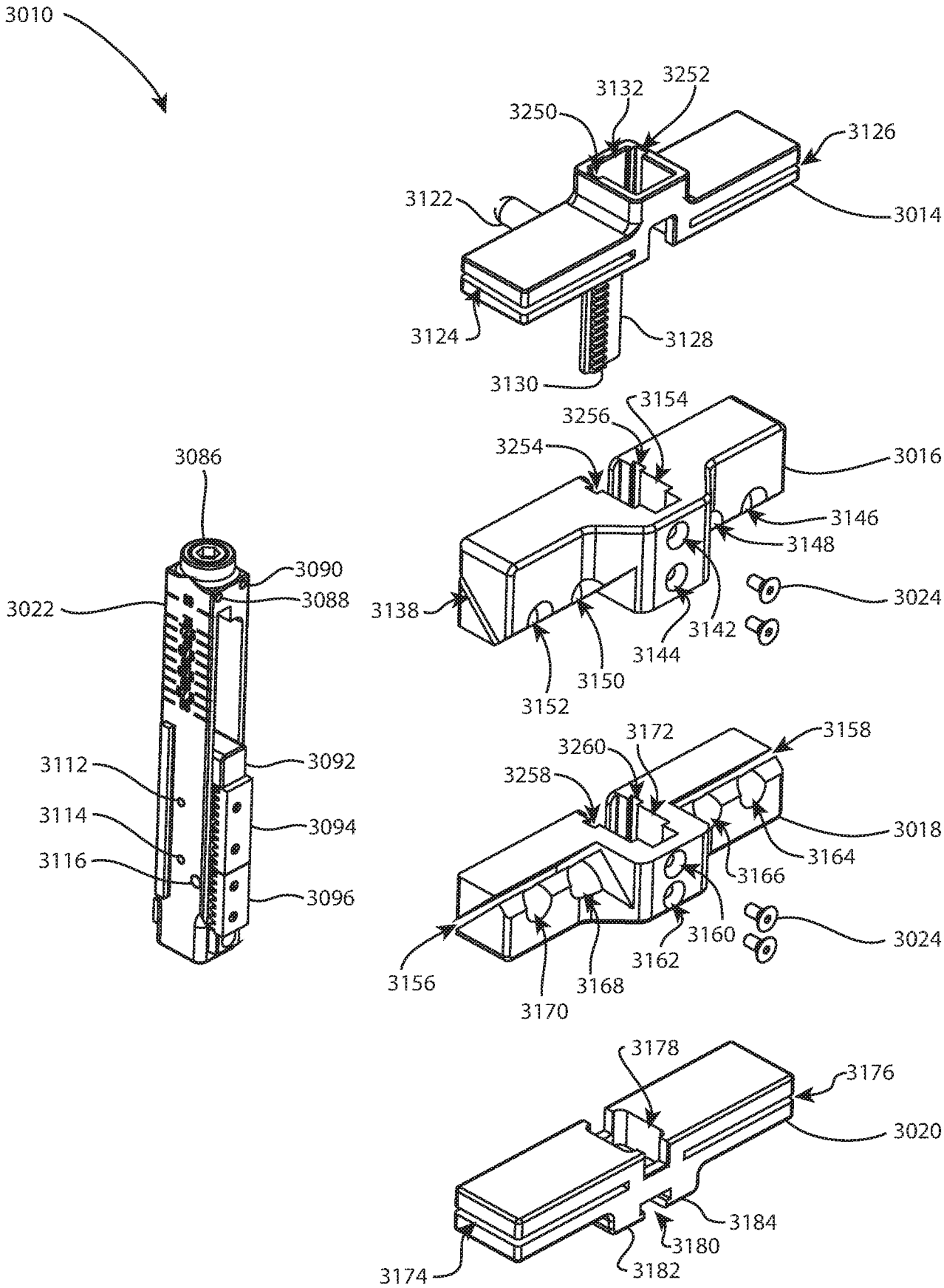


FIG. 51C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3260
3258
3018
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FIG. 51D

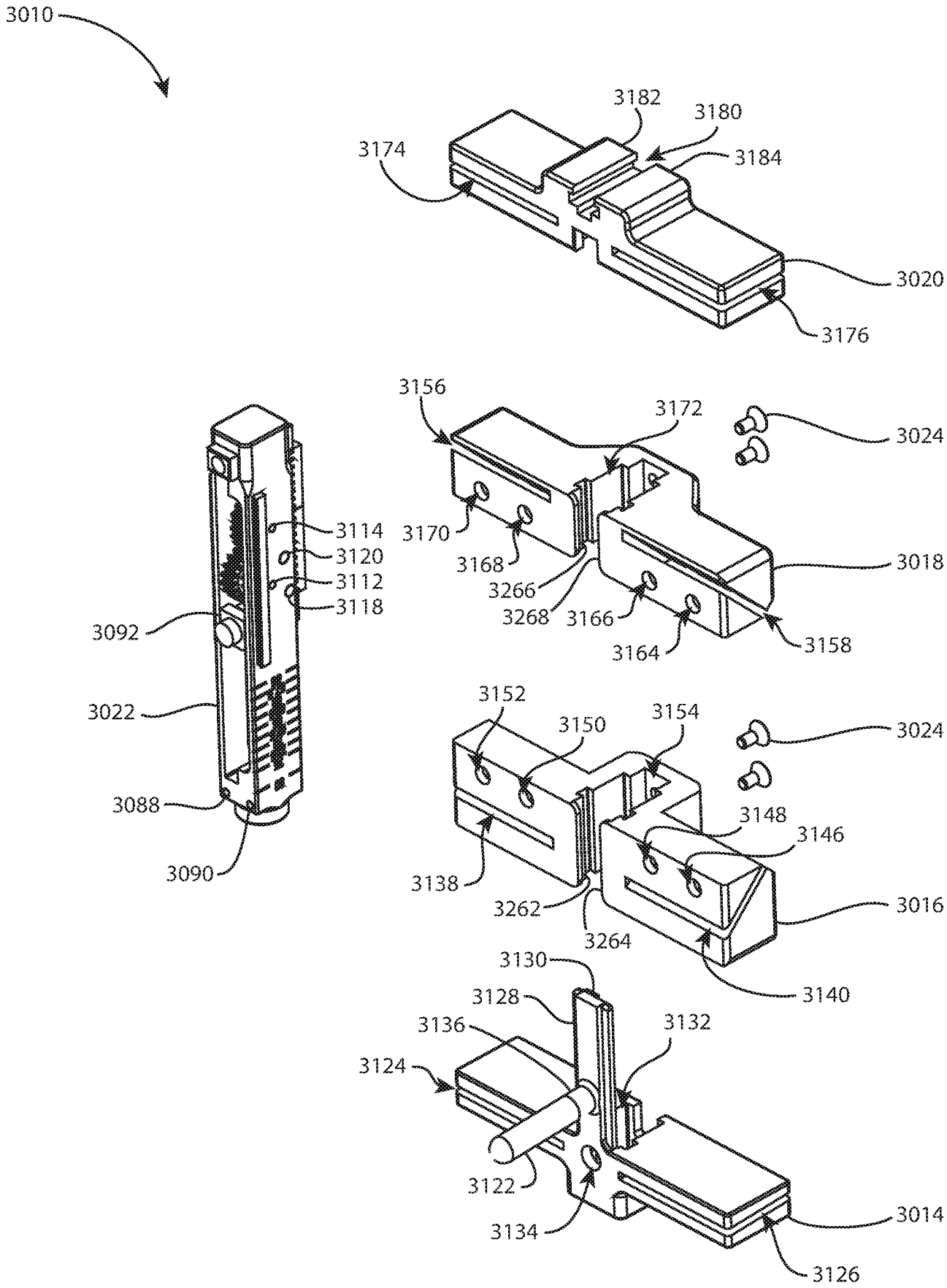
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FIG. 51E

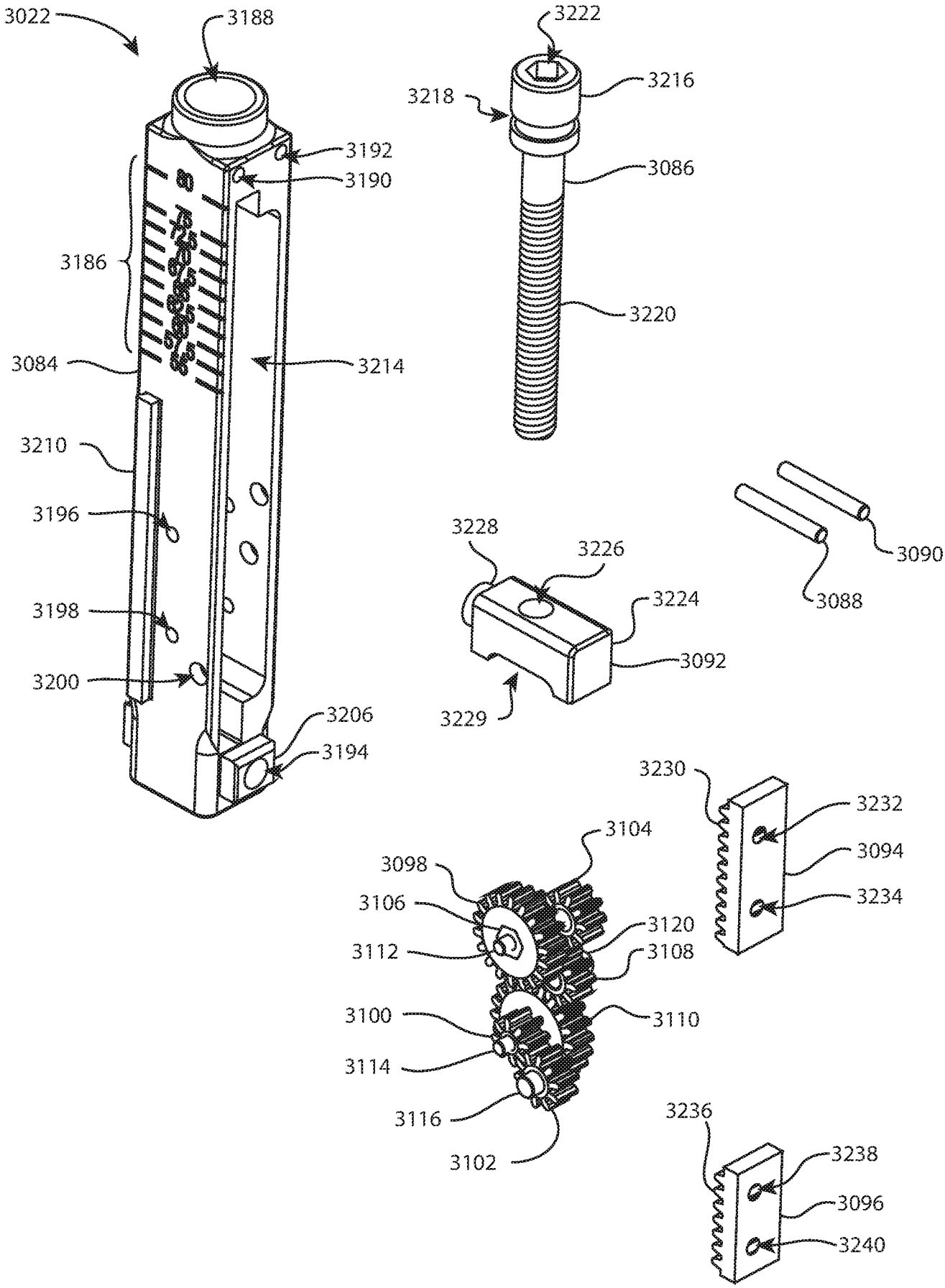
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FIG. 52A

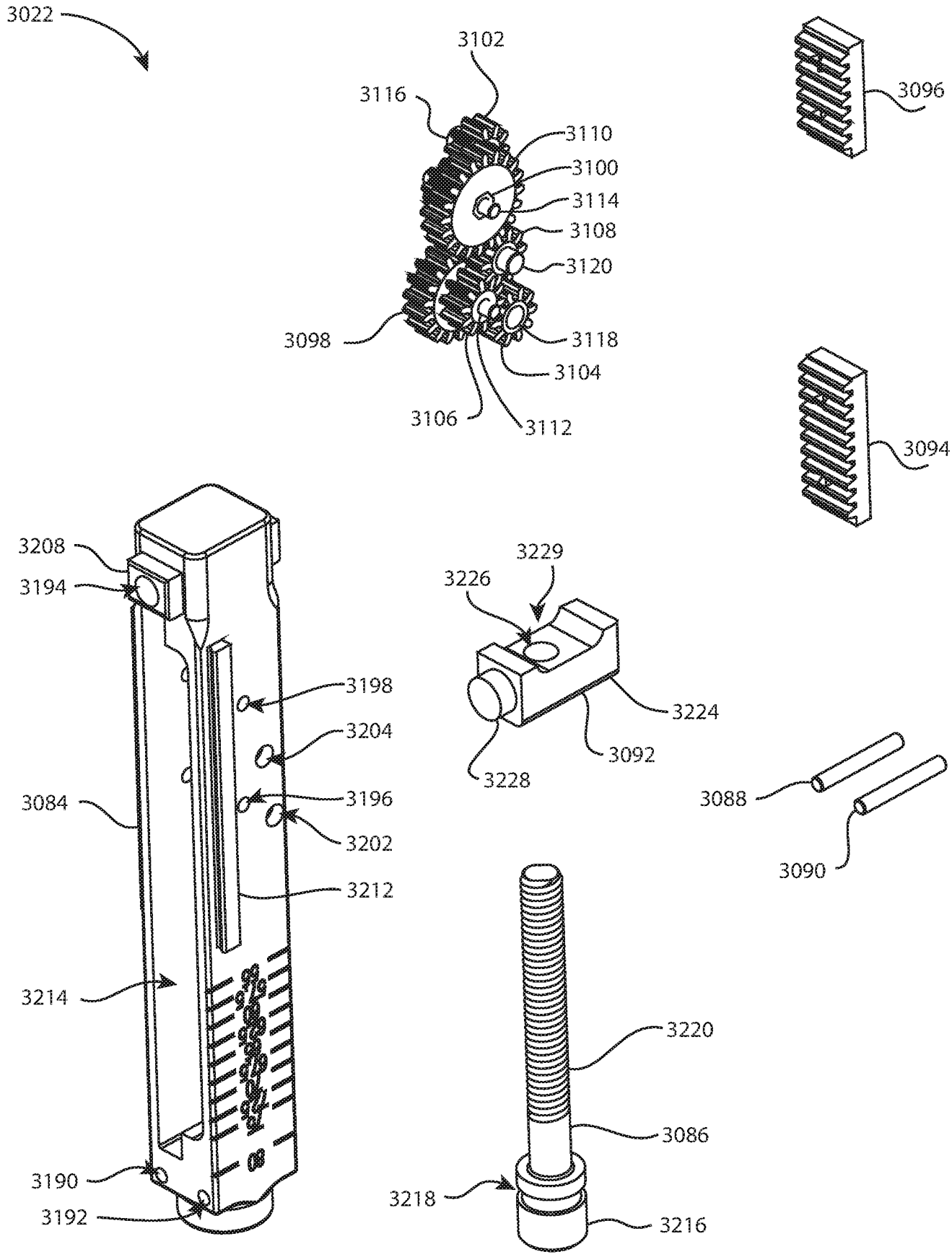
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FIG. 52B

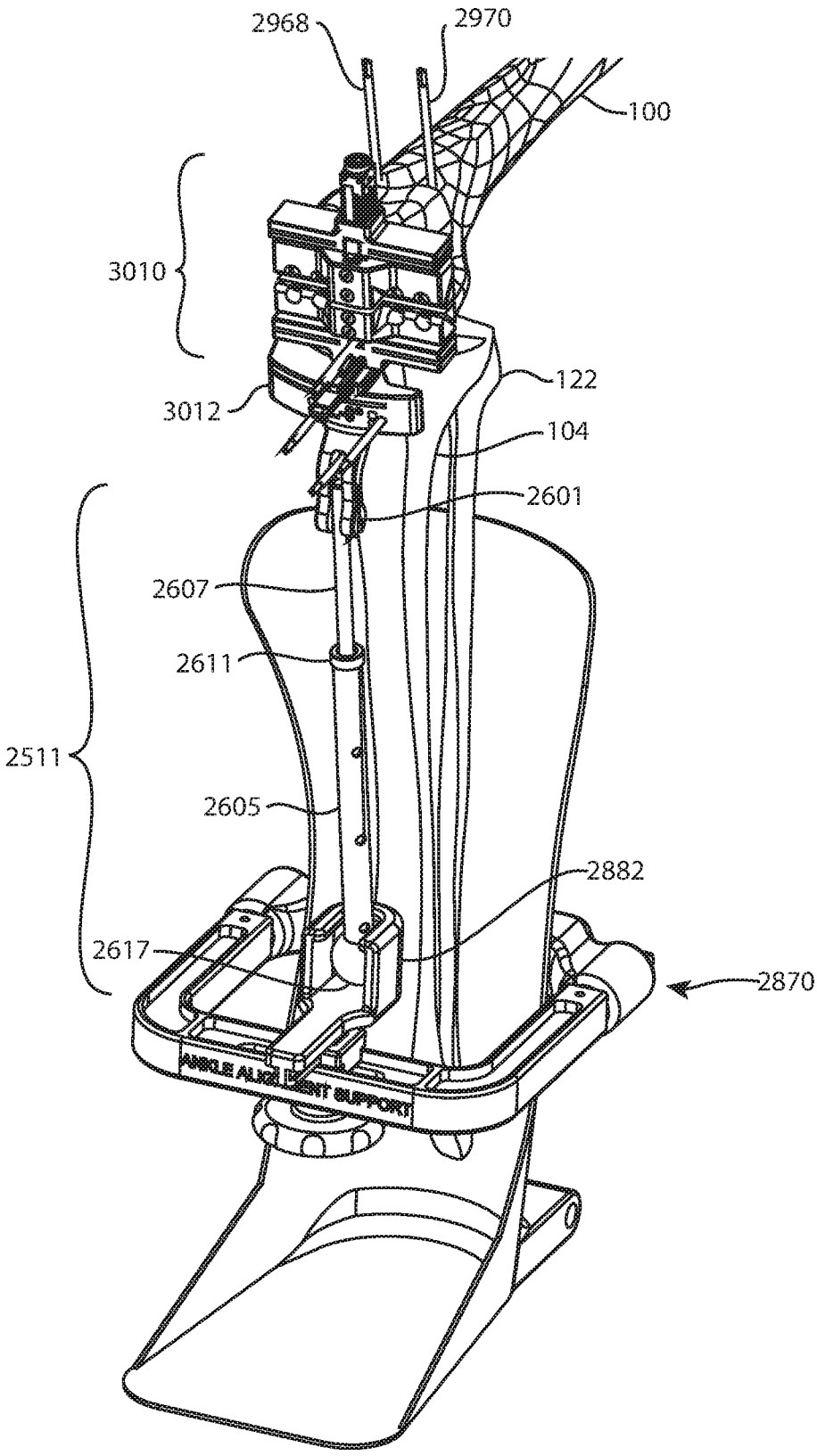
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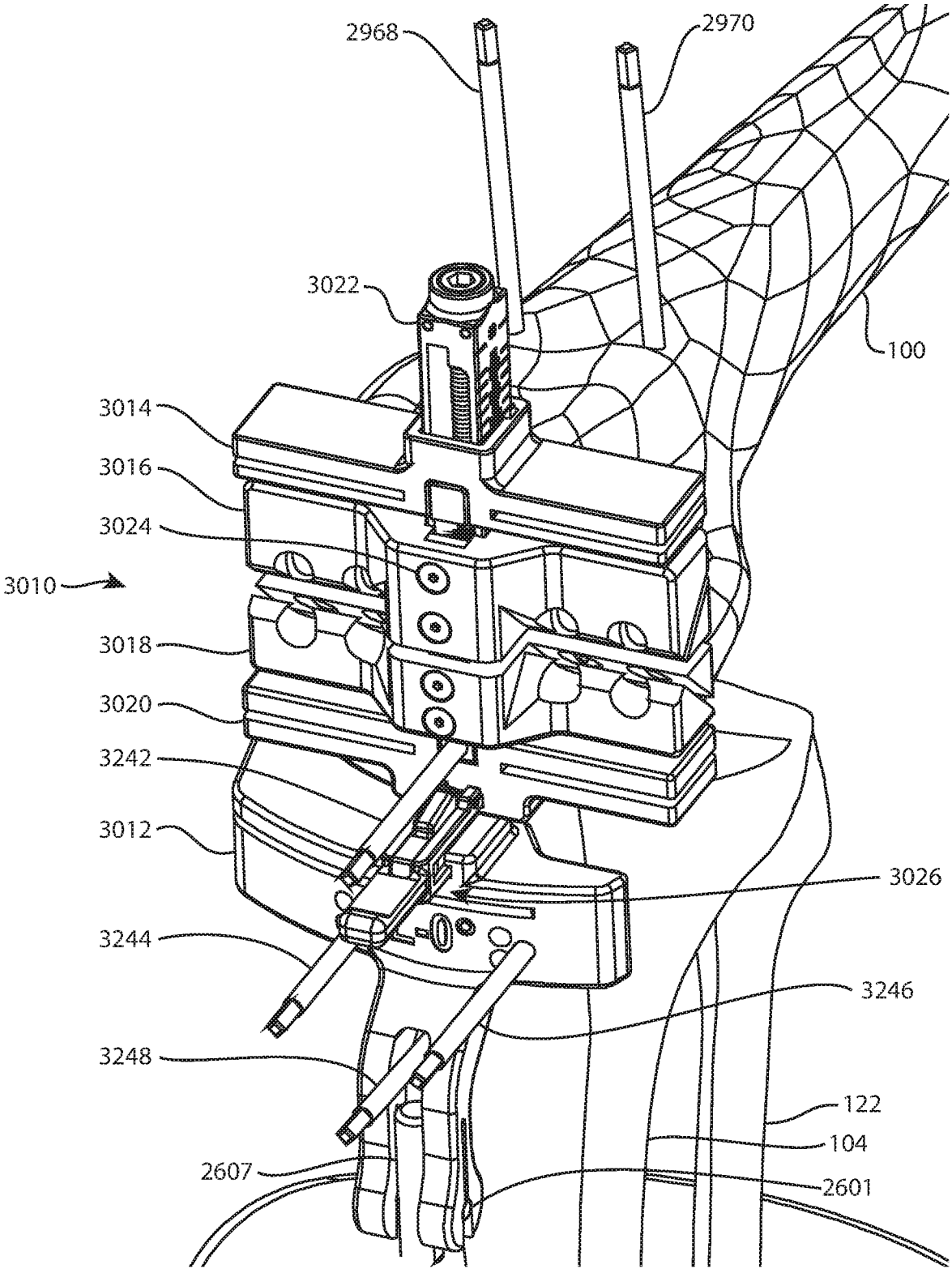
FIG. 53A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3012
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3244
3246
3248
122
104
2607
2601

FIG. 53B

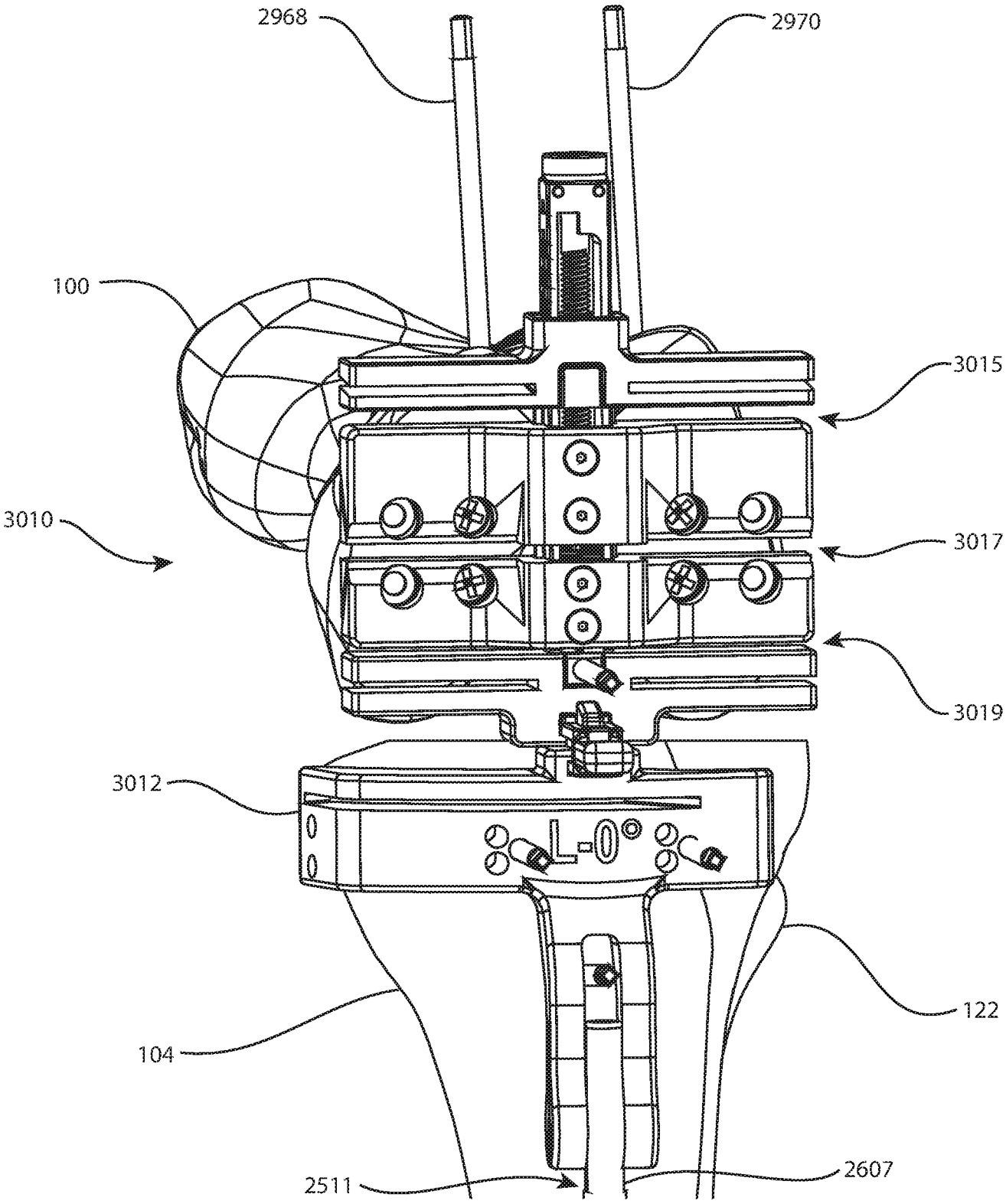


FIG. 53C

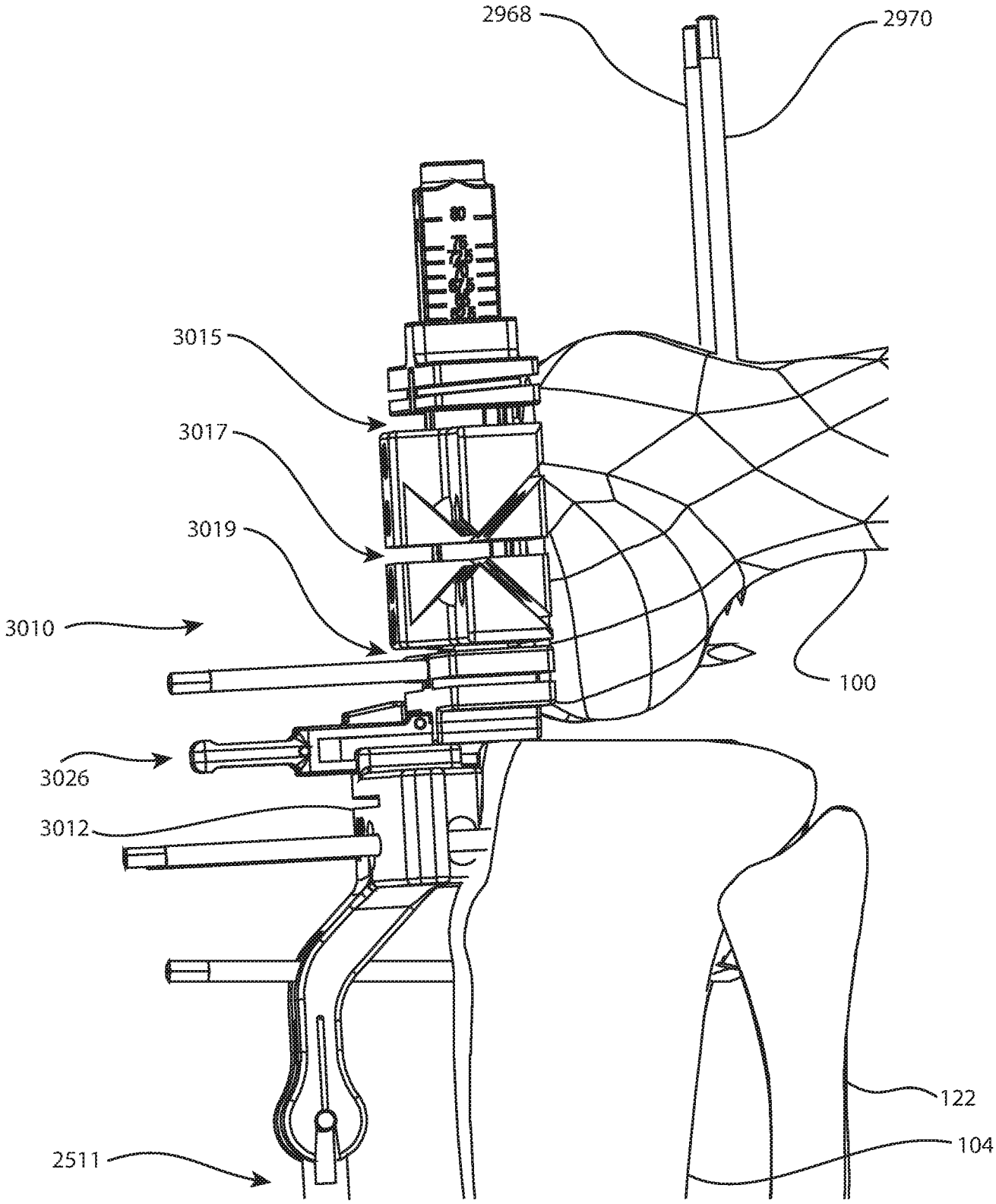
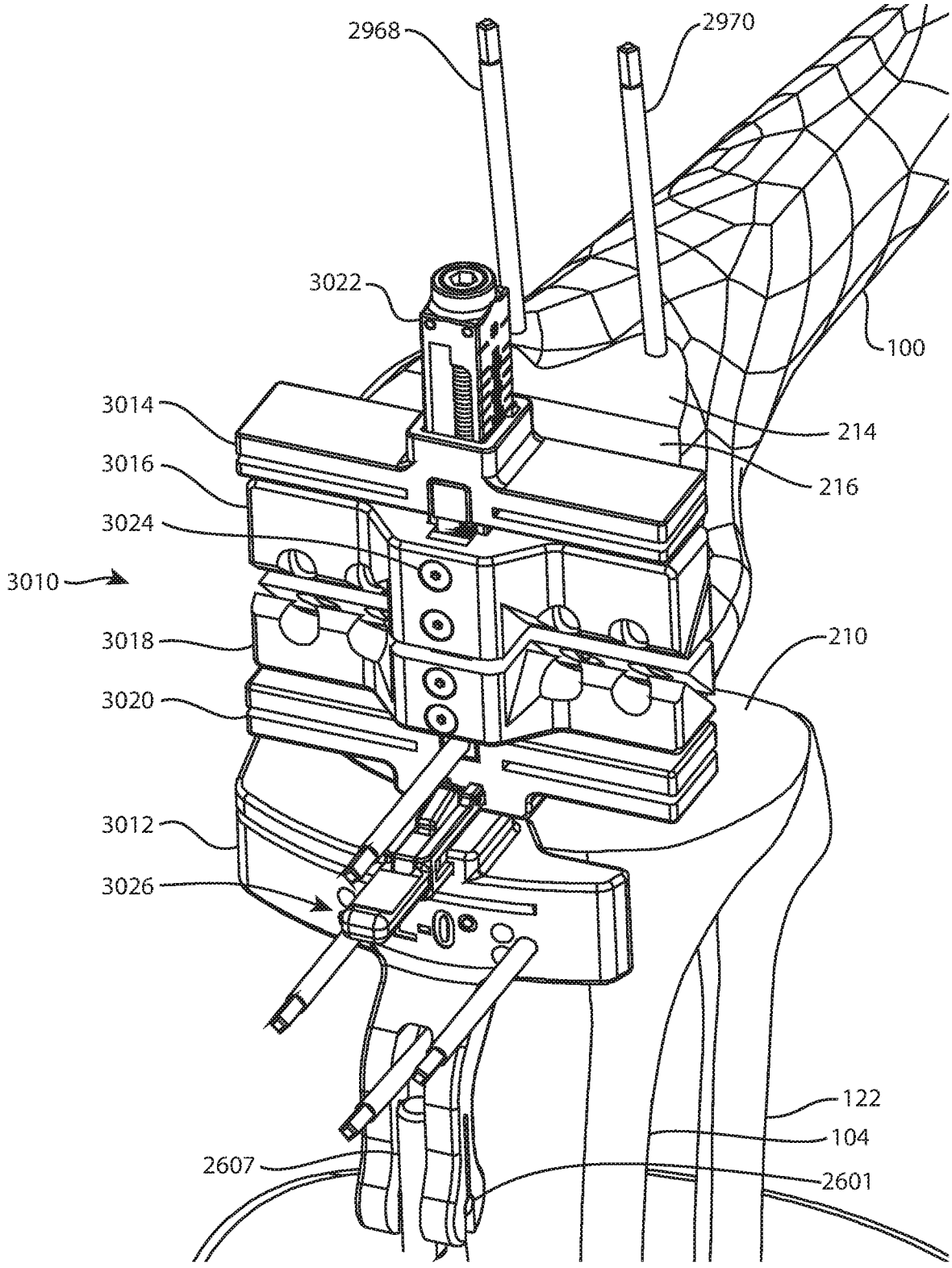


FIG. 53D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3022
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3016
216
3024
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210
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3012
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2607
2601

FIG. 54

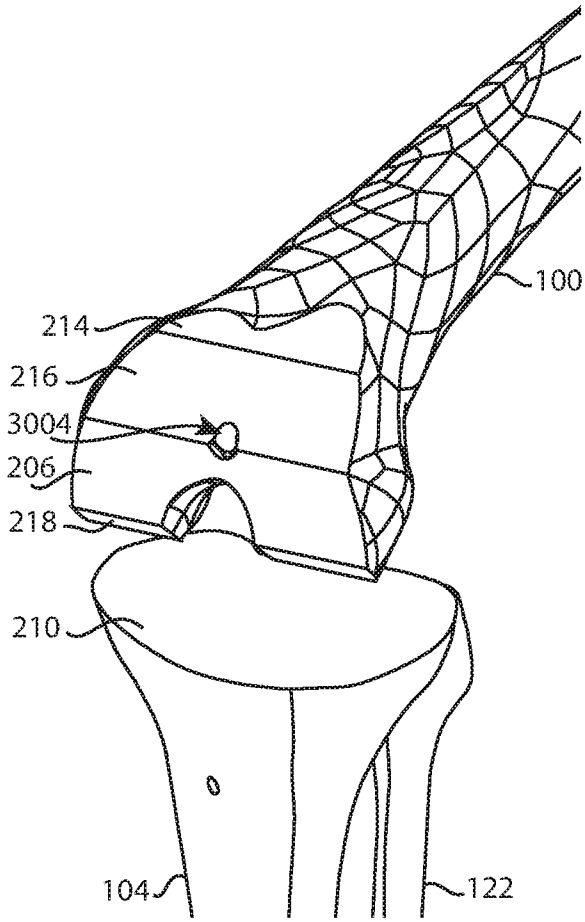


FIG. 55

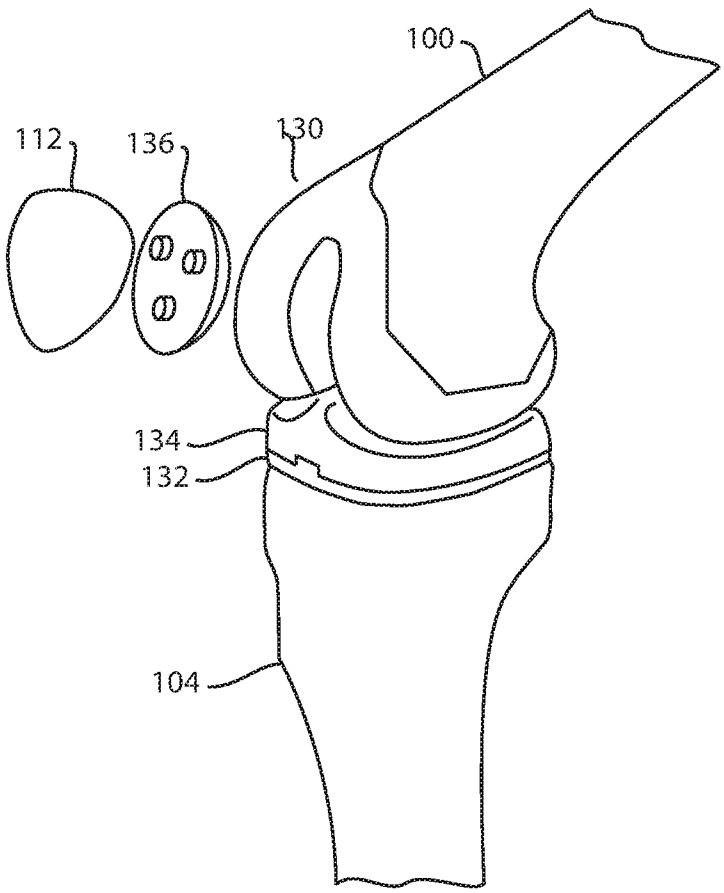
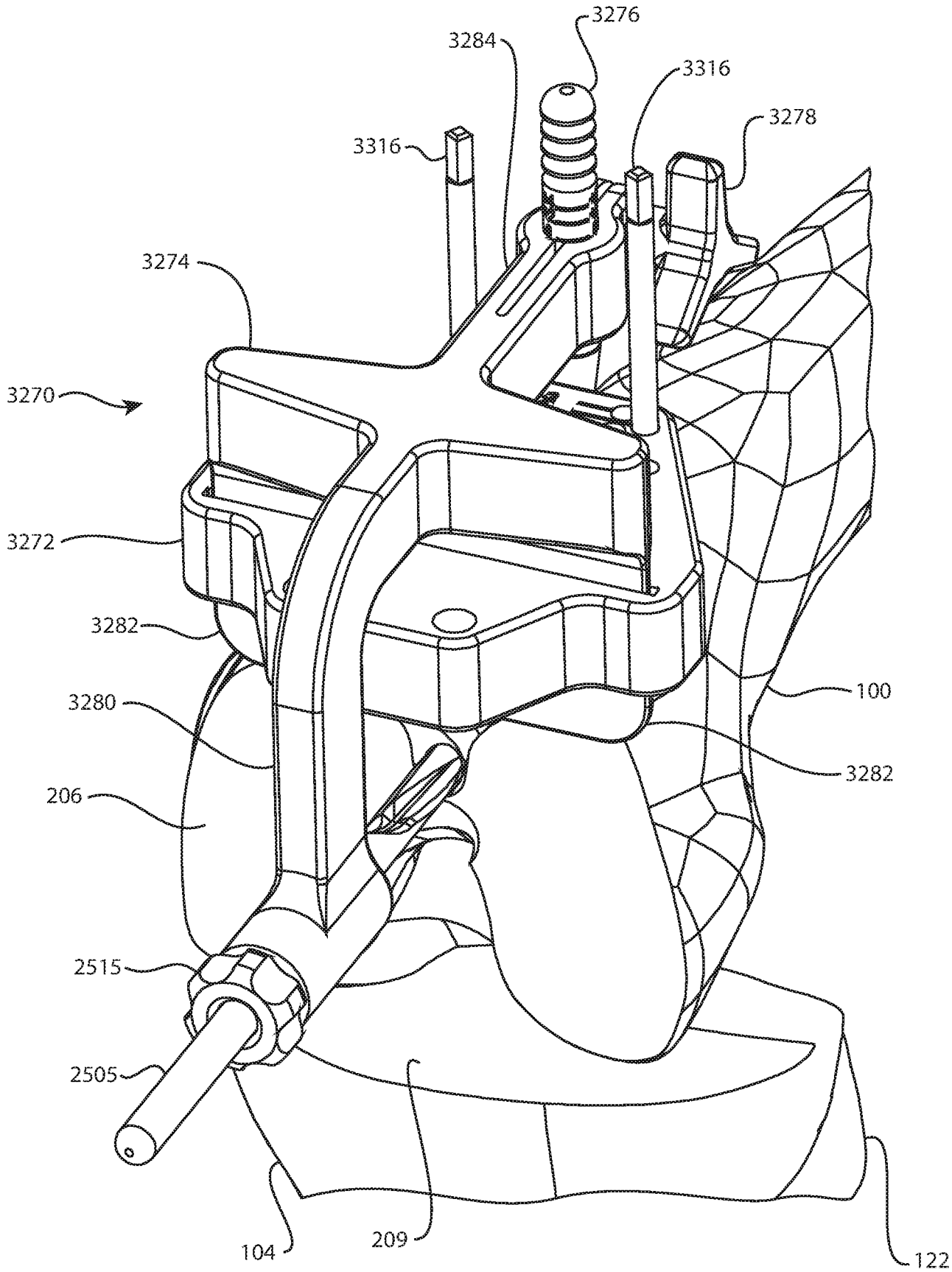


FIG. 56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3280
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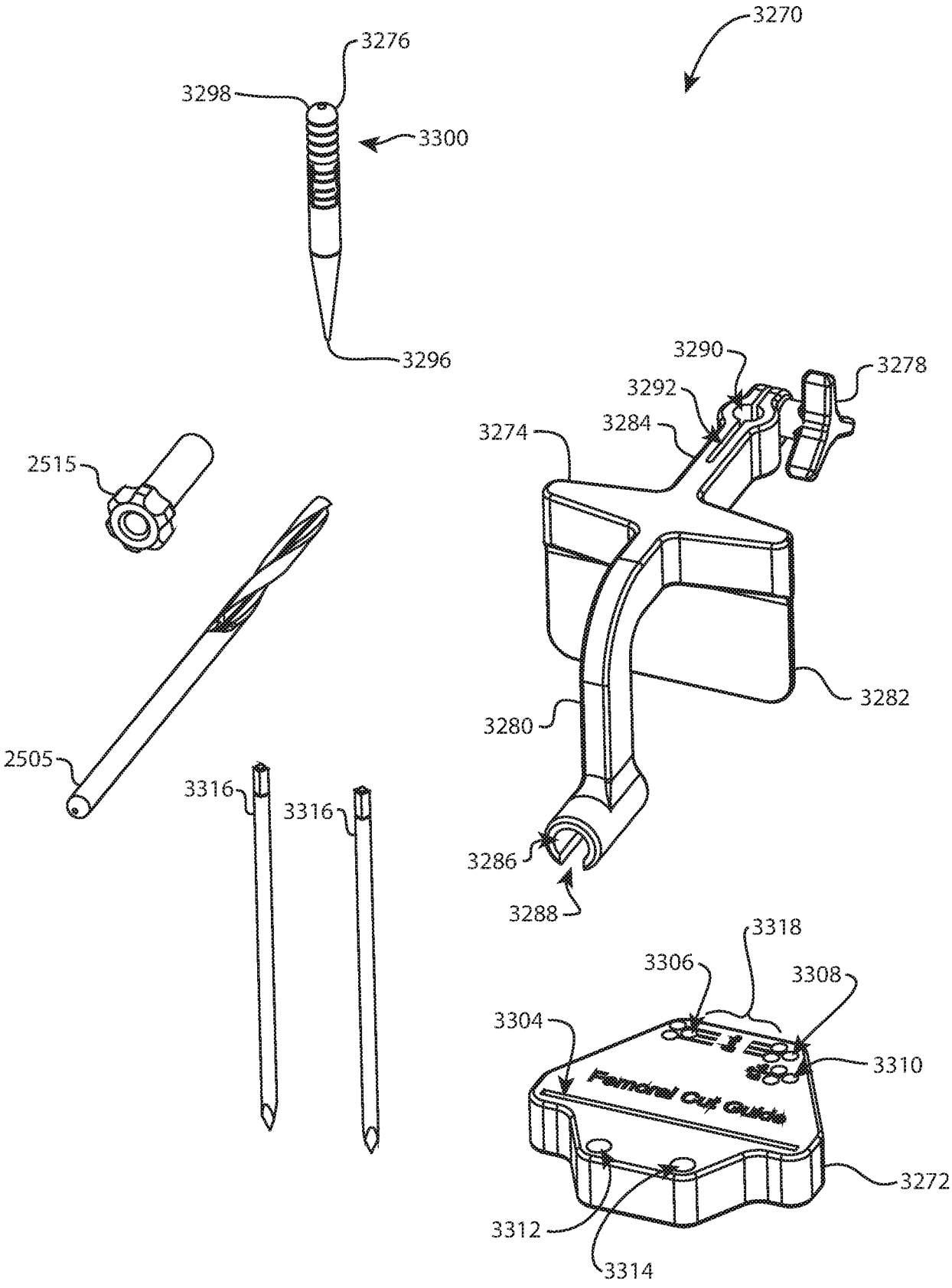
3282
206
2515
2505
104
209
122

FIG. 57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3306
3308
3304
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3272
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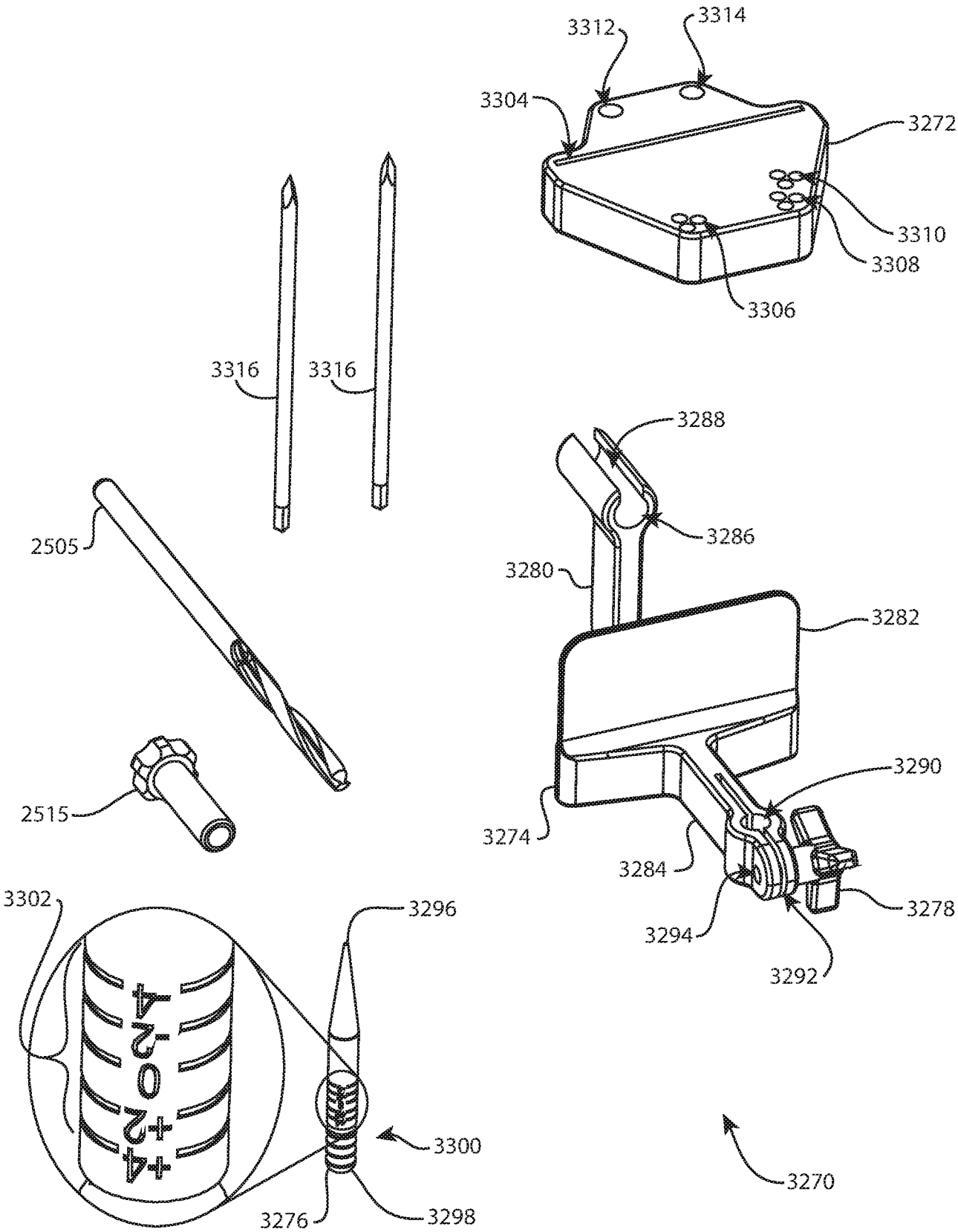
3314

FIG. 58A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2515
3274
3284
3278
3294
3292
3302
3296
+4
+2
0
-2
-4
3300
3276
3298
3270

FIG. 58B