

circumferentially-spaced planet gears radially disposed within the ring gear, and a central sun gear radially disposed within the planet gears. The sun gear of the first planetary gear set is disposed on a first sleeve rotatably mounted to the mounting shaft. The sun gear of the second planetary gear set is fixed to the mounting shaft.

[0010] These and other needs in the art are addressed in another embodiment by a clamping assembly for gripping and rotating a tubular. In an embodiment, the clamping assembly comprises a first cam gear configured to rotate about the central axis and having a radially inner surface comprising a plurality of circumferentially adjacent concave recesses defining a plurality of cam surfaces. In addition, the clamping assembly comprises a first plurality of clamp members. Each clamp member of the first plurality of clamp members is disposed in one recess of the first cam gear. Further, the clamping assembly comprises a torque gear configured to rotate about the central axis. Each clamp member is pivotally coupled to the torque gear. Each clamp member is configured to pivot between a withdraw position radially spaced apart from the tubular and a gripping position engaging the first tubular.

[0011] Embodiments described herein comprise a combination of features and advantages intended to address various shortcomings associated with certain prior devices, systems, and methods. The foregoing has outlined rather broadly the features and technical advantages of the invention in order that the detailed description of the invention that follows may be better understood. The various characteristics described above, as well as other features, will be readily apparent to those skilled in the art upon reading the following detailed description, and by referring to the accompanying drawings. It should be appreciated by those skilled in the art that the conception and the specific embodiments disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

[0011a] According to an aspect of the present invention, there is provided a clamping system for making and breaking threaded connections between a first tubular and a second tubular, the system comprising:

a clamping assembly for gripping and rotating the first tubular, wherein the clamping assembly has a central axis and includes:

a first cam gear configured to rotate about the central axis and having a radially inner surface comprising a plurality of circumferentially adjacent concave recesses defining a plurality of cam surfaces;

a first plurality of clamp members, wherein each clamp member of the first plurality of clamp members is disposed in one recess of the first cam gear;

a torque gear configured to rotate about the central axis;

wherein each clamp member is pivotally coupled to the torque gear;

wherein each clamp member is configured to pivot between a withdrawn position radially spaced apart from the tubular and a gripping position engaging the first tubular.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] For a detailed description of the disclosed embodiments of the disclosure, reference will now be made to the accompanying drawings in which:

[0013] Figure 1 is a schematic view of a drilling system in accordance with principles described herein;

[0014] Figure 2 is a partial perspective view of the clamping system of Figure 1;

[0015] Figure 3 is a partial perspective view of the clamp assembly of Figure 2;

AMENDED CLAIMS

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In the Claims

What is claimed is:

1. A clamping system for making and breaking threaded connections between a first tubular and a second tubular, the system comprising:

a clamp assembly for gripping and rotating the first tubular relative to the second tubular, the clamp assembly having a central axis and including a first cam gear, a first plurality of clamp members disposed within the first cam gear, and a torque gear;

wherein the first cam gear has a radially inner surface comprising a plurality of circumferentially adjacent concave recesses defining a plurality of circumferentially adjacent cam surfaces, wherein one clamp member of the first plurality of clamp members is disposed in each recess of the first cam gear;

wherein each clamp member is pivotally coupled to the torque gear;

wherein each clamp member is configured to pivot between a withdraw position radially spaced apart from the first tubular and a gripping position engaging the first tubular;

a clamp actuator for operating the clamp assembly, the clamp actuator having a central axis and including a mounting shaft, a first clamp drive gear rotatably coupled to the mounting shaft and a torque drive gear rotatably coupled to the mounting shaft;

wherein the first clamp drive gear engages the first cam gear and is configured to rotate the first cam gear and wherein the torque drive gear engages the torque gear and is configured to rotate the torque gear.

2. The clamping system of claim 1, wherein the rotation of the first cam gear relative to the torque gear about the central axis of the clamp assembly in a first direction is configured to transition the first plurality of clamp members from the withdrawn positions to the gripping positions;

wherein the rotation of the first cam gear relative to the torque gear about the central axis of the clamp assembly in a second direction opposite the first direction is configured to transition the first plurality of clamp members from the gripping positions to the withdrawn positions.

3. The clamping system of claim 1, wherein each cam surface has a first end and a second end circumferentially opposite the first end, wherein each cam surface curves radially outward moving from the first end to the second end.

4. The clamping system of claim 3, wherein the second end of each cam surface comprises a semi-circular concave pocket.
5. The clamping system of claim 3, wherein each clamp member has a pinned end pivotally coupled to the torque gear and a free end opposite the pinned end; and
wherein the free end is biased into engagement with the corresponding cam surface.
6. The clamping system of claim 5, wherein each clamp member has a radially inner surface extending from the pinned end to the free end and a radially outer surface extending from the pinned end to the free end;
wherein a wheel is rotatably coupled to each clamp member along the radially outer surface at the free end, wherein the wheel is configured to roll along the corresponding cam surface.
7. The clamping system of claim 1, wherein the clamp assembly further includes a second cam gear and a second plurality of clamp members disposed within the second cam gear;
wherein the second cam gear has a radially inner surface comprising a plurality of circumferentially adjacent concave recesses defining a plurality of circumferentially adjacent cam surfaces, wherein one clamp member of the second plurality of clamp members is disposed in each recess of the second cam gear.
8. The clamping system of claim 7, wherein the clamp actuator includes a second clamp drive gear that engages the second cam gear and is configured to rotate the second cam gear.
9. The clamping system of claim 7, wherein the rotation of the first cam gear relative to the torque gear about the central axis of the clamp assembly in a first direction is configured to transition the first plurality of clamp members from the withdrawn positions to the gripping positions;
wherein the rotation of the first cam gear relative to the torque gear about the central axis of the clamp assembly in a second direction opposite the first direction is configured to transition the first plurality of clamp members from the gripping positions to the withdrawn positions;

wherein the rotation of the second cam gear relative to the torque gear about the central axis of the clamp assembly in a third direction is configured to transition the second plurality of clamp members from the withdrawn positions to the gripping positions;

wherein the rotation of the second cam gear relative to the torque gear about the central axis of the clamp assembly in a fourth direction opposite the third direction is configured to transition the second plurality of clamp members from the gripping positions to the withdrawn positions;

wherein the third direction is opposite the first direction.

10. The clamping system of claim 1, wherein the mounting shaft is rotationally fixed relative to the central axis of the clamp actuator;

wherein the first clamp drive gear and the torque drive gear each comprise a planetary gear set including an annular ring gear, a plurality of circumferentially-spaced planet gears radially disposed within the ring gear, and a central sun gear radially disposed within the planet gears;

wherein the sun gear of the first clamp drive gear is disposed on a sleeve rotatably mounted to the mounting shaft;

wherein the sun gear of the torque drive gear is fixed to the mounting shaft.

11. The clamping system of claim 10, wherein the clamp actuator further comprises a plurality of circumferentially spaced pins, wherein one planet gear of the first clamp drive gear and one planet gear of the torque drive gear is rotatably coupled to each pin.

12. The clamping system of claim 10, wherein the planet gears of the first clamp drive gear and the planet gears of the torque drive gear are configured to orbit together about the central axis of the clamp actuator.

13. An actuator for operating a clamp assembly, the actuator comprising:

a mounting shaft having a central axis, wherein the mounting shaft is rotationally fixed relative to the central axis;

a first planetary gear set rotatably coupled to the mounting shaft; and

a second planetary gear set rotatably coupled to the mounting shaft;

wherein each planetary gear set includes an annular ring gear, a plurality of circumferentially-spaced planet gears radially disposed within the ring gear, and a central sun gear radially disposed within the planet gears;

wherein the sun gear of the first planetary gear set is disposed on a first sleeve rotatably mounted to the mounting shaft;

wherein the sun gear of the second planetary gear set is fixed to the mounting shaft.

14. The actuator of claim 13, wherein the first planetary gear set is configured to rotate about the central axis independent of the second planetary gear set.

15. The actuator of claim 13, further comprising:

a first motor configured to rotate the first sleeve about the central axis;

a second motor configured to rotate the ring gear of the second planetary gear set about the central axis.

16. The actuator of claim 15, further comprising a plurality of circumferentially spaced pins, wherein one planet gear of the first planetary gear set is rotatably coupled to each pin and one planet gear of the second planetary gear set is rotatably coupled to each pin.

17. The actuator of claim 16, further comprising a pin carrier including a plurality of circumferentially-spaced guide holes, wherein each pin extends through one of the guide holes.

18. The actuator of claim 13, wherein the planet gears of the first planetary gear set and the planet gears of the second planetary gear set are configured to orbit together about the central axis.

19. The actuator of claim 13, further comprising a third planetary gear set rotatably coupled to the mounting shaft, wherein the sun gear of the third planetary gear set is disposed on a second sleeve rotatably mounted to the mounting shaft.

20. The actuator of claim 19, further comprising:

a first motor configured to simultaneously rotate the first sleeve about the central axis in a first direction and rotate the second sleeve about the central axis in a second direction that is opposite the first direction;

a second motor configured to rotate the ring gear of the second planetary gear set about the central axis.

21. The actuator of claim 19, further comprising a plurality of circumferentially spaced pins, wherein one planet gear of the first planetary gear set is rotatably coupled to each pin, one planet gear of the second planetary gear set is rotatably coupled to each pin, and one planet gear of the third planetary gear set is rotatably coupled to each pin.

22. The actuator of claim 21, further comprising a pin carrier including a plurality of circumferentially-spaced guide holes, wherein each pin extends through one of the guide holes.

23. The actuator of claim 19, wherein the planet gears of the first planetary gear set, the planet gears of the second planetary gear set, and the planet gears of the third planetary gear set are configured to orbit together about the central axis.

24. A clamping assembly for gripping and rotating a tubular, the assembly having a central axis and comprising:

- a first cam gear configured to rotate about the central axis and having a radially inner surface comprising a plurality of circumferentially adjacent concave recesses defining a plurality of cam surfaces;

- a first plurality of clamp members, wherein each clamp member of the first plurality of clamp members is disposed in one recess of the first cam gear;

- a torque gear configured to rotate about the central axis;

- wherein each clamp member is pivotally coupled to the torque gear;

- wherein each clamp member is configured to pivot between a withdraw position radially spaced apart from the tubular and a gripping position engaging the first tubular.

25. The clamping assembly of claim 24, wherein the rotation of the first cam gear relative to the torque gear about the central axis in a first direction is configured to transition the first plurality of clamp members from the withdrawn positions to the gripping positions;

- wherein the rotation of the first cam gear relative to the torque gear about the central axis in a second direction opposite the first direction is configured to transition the first plurality of clamp members from the gripping positions to the withdrawn positions.

26. The clamping assembly of claim 24, wherein each cam surface has a first end and a second end circumferentially opposite the first end, wherein each cam surface curves radially outward moving from the first end to the second end.

27. The clamping assembly of claim 26, wherein each clamp member has a pinned end pivotally coupled to the torque gear and a free end opposite the pinned end; and wherein the free end is biased radially outward toward the corresponding cam surface.

28. The clamping assembly of claim 27, wherein each clamp member has a radially inner surface extending from the pinned end to the free end and a radially outer surface extending from the pinned end to the free end;

wherein a wheel is rotatably coupled to each clamp member along the radially outer surface at the free end, wherein the wheel is configured to roll along the corresponding cam surface.

29. The clamping assembly of claim 24, wherein the clamp assembly further includes a second cam gear and a second plurality of clamp members disposed within the second cam gear;

wherein the second cam gear has a radially inner surface comprising a plurality of circumferentially adjacent concave recesses defining a plurality of circumferentially adjacent cam surfaces, wherein each clamp member of the second plurality of clamp members is disposed in one recess of the second cam gear.

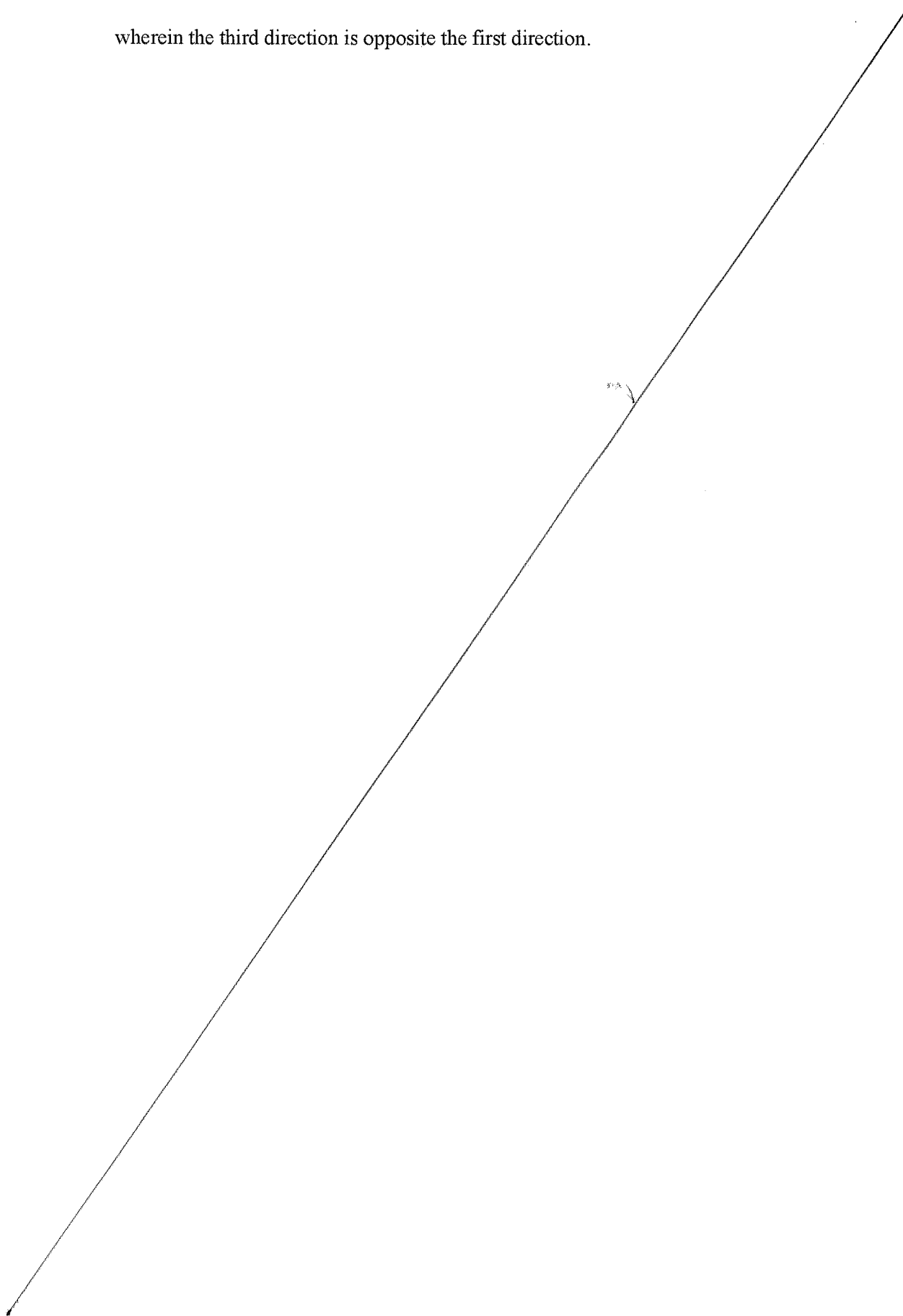
30. The clamping assembly of claim 29, wherein the rotation of the first cam gear relative to the torque gear about the central axis in a first direction is configured to transition the first plurality of clamp members from the withdrawn positions to the gripping positions;

wherein the rotation of the first cam gear relative to the torque gear about the central axis in a second direction opposite the first direction is configured to transition the first plurality of clamp members from the gripping positions to the withdrawn positions;

wherein the rotation of the second cam gear relative to the torque gear about the central axis in a third direction is configured to transition the second plurality of clamp members from the withdrawn positions to the gripping positions;

wherein the rotation of the second cam gear relative to the torque gear about the central axis in a fourth direction opposite the third direction is configured to transition the second plurality of clamp members from the gripping positions to the withdrawn positions;

wherein the third direction is opposite the first direction.



CLAIMS:

1. A clamping system for making and breaking threaded connections between a first tubular and a second tubular, the system comprising:

a clamping assembly for gripping and rotating the first tubular, wherein the clamping assembly has a central axis and includes:

a first cam gear configured to rotate about the central axis and having a radially inner surface comprising a plurality of circumferentially adjacent concave recesses defining a plurality of cam surfaces;

a first plurality of clamp members, wherein each clamp member of the first plurality of clamp members is disposed in one recess of the first cam gear;

a torque gear configured to rotate about the central axis;

wherein each clamp member is pivotally coupled to the torque gear;

wherein each clamp member is configured to pivot between a withdrawn position radially spaced apart from the tubular and a gripping position engaging the first tubular.

2. The clamping system of claim 1, wherein the rotation of the first cam gear relative to the torque gear about the central axis in a first direction is configured to transition the first plurality of clamp members from the withdrawn positions to the gripping positions;

wherein the rotation of the first cam gear relative to the torque gear about the central axis in a second direction opposite the first direction is configured to transition the first plurality of clamp members from the gripping positions to the withdrawn positions.

3. The clamping system of claim 1, wherein each cam surface has a first end and a second end circumferentially opposite the first end, wherein each cam surface curves radially outward moving from the first end to the second end.

4. The clamping system of claim 3, wherein each clamp member has a pinned end pivotally coupled to the torque gear and a free end opposite the pinned end; and

wherein the free end is biased radially outward toward the corresponding cam surface.

5. The clamping system of claim 4, wherein each clamp member has a radially inner surface extending from the pinned end to the free end and a radially outer surface extending from the pinned end to the free end;

wherein a wheel is rotatably coupled to each clamp member along the radially outer surface at the free end, wherein the wheel is configured to roll along the corresponding cam surface.

6. The clamping system of claim 1, wherein the clamp assembly further includes a second cam gear and a second plurality of clamp members disposed within the second cam gear;

wherein the second cam gear has a radially inner surface comprising a plurality of circumferentially adjacent concave recesses defining a plurality of circumferentially adjacent cam surfaces, wherein each clamp member of the second plurality of clamp members is disposed in one recess of the second cam gear.

7. The clamping system of claim 6, wherein the rotation of the first cam gear relative to the torque gear about the central axis in a first direction is configured to transition the first plurality of clamp members from the withdrawn positions to the gripping positions;

wherein the rotation of the first cam gear relative to the torque gear about the central axis in a second direction opposite the first direction is configured to transition the first plurality of clamp members from the gripping positions to the withdrawn positions;

wherein the rotation of the second cam gear relative to the torque gear about the central axis in a third direction is configured to transition the second plurality of clamp members from the withdrawn positions to the gripping positions;

wherein the rotation of the second cam gear relative to the torque gear about the central axis in a fourth direction opposite the third direction is configured to transition the second plurality of clamp members from the gripping positions to the withdrawn positions;

wherein the third direction is opposite the first direction.

8. The clamping system of claim 1, further comprising:

a clamp actuator for operating the clamp assembly, the clamp actuator having a central axis and including a mounting shaft, a first clamp drive gear rotatably coupled to the mounting shaft and a torque drive gear rotatably coupled to the mounting shaft;

wherein the first clamp drive gear engages the first cam gear and is configured to rotate the first cam gear and wherein the torque drive gear engages the torque gear and is configured to rotate the torque gear;

wherein the first cam gear has a radially inner surface comprising a plurality of circumferentially adjacent concave recesses defining a plurality of circumferentially adjacent

cam surfaces, wherein one clamp member of the first plurality of clamp members is disposed in each recess of the first cam gear;

9. The clamping system of claim 8, wherein the rotation of the first cam gear relative to the torque gear about the central axis of the clamp assembly in a first direction is configured to transition the first plurality of clamp members from the withdrawn positions to the gripping positions;

wherein the rotation of the first cam gear relative to the torque gear about the central axis of the clamp assembly in a second direction opposite the first direction is configured to transition the first plurality of clamp members from the gripping positions to the withdrawn positions.

10. The clamping system of claim 8, wherein each cam surface has a first end and a second end circumferentially opposite the first end, wherein each cam surface curves radially outward moving from the first end to the second end.

11. The clamping system of claim 10, wherein the second end of each cam surface comprises a semi-circular concave pocket.

12. The clamping system of claim 10, wherein each clamp member has a pinned end pivotally coupled to the torque gear and a free end opposite the pinned end; and

wherein the free end is biased into engagement with the corresponding cam surface.

13. The clamping system of claim 12, wherein each clamp member has a radially inner surface extending from the pinned end to the free end and a radially outer surface extending from the pinned end to the free end;

wherein a wheel is rotatably coupled to each clamp member along the radially outer surface at the free end, wherein the wheel is configured to roll along the corresponding cam surface.

14. The clamping system of claim 8, wherein the clamp assembly further includes a second cam gear and a second plurality of clamp members disposed within the second cam gear; wherein the second cam gear has a radially inner surface comprising a plurality of circumferentially adjacent concave recesses defining a plurality of circumferentially adjacent

cam surfaces, wherein one clamp member of the second plurality of clamp members is disposed in each recess of the second cam gear.

15. The clamping system of claim 14, wherein the clamp actuator includes a second clamp drive gear that engages the second cam gear and is configured to rotate the second cam gear.

16. The clamping system of claim 14, wherein the rotation of the first cam gear relative to the torque gear about the central axis of the clamp assembly in a first direction is configured to transition the first plurality of clamp members from the withdrawn positions to the gripping positions;

wherein the rotation of the first cam gear relative to the torque gear about the central axis of the clamp assembly in a second direction opposite the first direction is configured to transition the first plurality of clamp members from the gripping positions to the withdrawn positions;

wherein the rotation of the second cam gear relative to the torque gear about the central axis of the clamp assembly in a third direction is configured to transition the second plurality of clamp members from the withdrawn positions to the gripping positions;

wherein the rotation of the second cam gear relative to the torque gear about the central axis of the clamp assembly in a fourth direction opposite the third direction is configured to transition the second plurality of clamp members from the gripping positions to the withdrawn positions;

wherein the third direction is opposite the first direction.

17. The clamping system of claim 8, wherein the mounting shaft is rotationally fixed relative to the central axis of the clamp actuator;

wherein the first clamp drive gear and the torque drive gear each comprise a planetary gear set including an annular ring gear, a plurality of circumferentially-spaced planet gears radially disposed within the ring gear, and a central sun gear radially disposed within the planet gears;

wherein the sun gear of the first clamp drive gear is disposed on a sleeve rotatably mounted to the mounting shaft;

wherein the sun gear of the torque drive gear is fixed to the mounting shaft.

18. The clamping system of claim 17, wherein the clamp actuator further comprises a plurality of circumferentially spaced pins, wherein one planet gear of the first clamp drive gear and one planet gear of the torque drive gear is rotatably coupled to each pin.

19. The clamping system of claim 17, wherein the planet gears of the first clamp drive gear and the planet gears of the torque drive gear are configured to orbit together about the central axis of the clamp actuator.