

What is claimed is:

1. A device for forming a circumferential groove in a pipe element, said device comprising:

5 a pinion fixed against rotation about a pinion axis arranged coaxially with said pinion;

10 an expanding die positioned adjacent to said pinion and concentric with said pinion axis, said expanding die having a plurality of die segments movable radially toward and away from said pinion axis, each said die segment having a die face facing away from said pinion axis and engageable with an inner surface of said pipe element when moved away therefrom;

 an actuator coupled to said expanding die for moving said die segments toward and away from said pinion axis;

15 a carriage surrounding said expanding die, said carriage being rotatable about said pinion axis, said carriage defining an opening arranged coaxially with said pinion axis for receiving said pipe element;

 a plurality of gears mounted on said carriage, each said gear being rotatable relatively to said carriage about a respective gear axis, each said gear engaging with said pinion;

20 a plurality of cam bodies, each said cam body mounted on a respective one of said gears;

 a plurality of first cam surfaces, each one of said first cam surfaces extending around a respective one of said cam bodies, each one of said first cam surfaces comprising a region of increasing radius and a discontinuity; wherein

25 said pipe element is positioned between said die faces and said first cam surfaces when said pipe element is received within said opening.

2. The device according to claim 1, wherein said actuator comprises:

a draw bar positioned coaxially with said expanding die and movable along said pinion axis, motion of said draw bar moving said die segments toward and away from said pinion axis;

5 a cylinder having a piston coupled to said draw bar for moving said draw bar along said pinion axis.

3. The device according to claim 1 wherein each said gear has a same pitch circle diameter.

4. The device according to claim 1, further comprising at least one traction surface
10 extending around one of said cam bodies, said at least one traction surface being engageable with said pipe element.

5. The device according to claim 1, wherein said pinion has a pitch circle diameter equal to an outer diameter of said pipe element.

6. The device according to claim 5, further comprising at least one traction surface
15 extending around one of said cam bodies, said at least one traction surface being engageable with said pipe element, said at least one traction surface having a pitch circle diameter equal to a pitch circle diameter of one of said gears.

7. The device according to claim 1, wherein each one of said first cam surfaces
20 further comprises a region of constant radius positioned adjacent to a respective one of said discontinuities.

8. The device according to claim 4, wherein said at least one traction surface has a gap therein, said gap being aligned axially with said discontinuity of said first cam surface surrounding said one cam body.

9. The device according to claim 6, wherein said at least one traction surface has a gap therein, said gap being aligned axially with said discontinuity of said first cam surface surrounding said one cam body.

5 10. The device according to claim 4, further comprising a plurality of said traction surfaces, each one of said traction surfaces extending around a respective one of said cam bodies, each one of said traction surfaces having a gap therein, each said gap being aligned axially with a respective one of said discontinuities of said first cam surfaces on each one of said cam bodies.

10 11. The device according to claim 6, further comprising a plurality of said traction surfaces, each one of said traction surfaces extending around a respective one of said cam bodies, each one of said traction surfaces having a gap therein, each said gap being aligned axially with a respective one of said discontinuities of said first cam surfaces on each one of said cam bodies.

15 12. The device according to claim 4, wherein said at least one traction surface is positioned on said one cam body in spaced relation to said first cam surface extending around said one cam body.

13. The device according to claim 6, wherein said at least one traction surface is positioned on said one cam body in spaced relation to said first cam surface extending around said one cam body.

20 14. The device according to claim 1, comprising, at least three said gears.

15. The device according to claim 1, comprising, at least four said gears.

16. The device according to claim 4, wherein one of said first cam surfaces is positioned between said gear and said at least one traction surface.

25 17. The device according to claim 6, wherein one of said first cam surfaces is positioned between said gear and said at least one traction surface.

18. The device according to claim 4, wherein one of said first cam surfaces is positioned proximate to said at least one traction surface.

19. The device according to claim 6, wherein one of said first cam surfaces is positioned proximate to said at least one traction surface.

5 20. The device according to claim 4, wherein said at least one traction surface comprises a plurality of projections extending outwardly therefrom.

21. The device according to claim 6, wherein said at least one traction surface comprises a plurality of projections extending outwardly therefrom.

10 22. The device according to claim 1, further comprising a plurality of second cam surfaces, each one of said second cam surfaces extending around a respective one of said cam bodies and positioned in spaced relation to a respective one of said first cam surfaces.

15 23. The device according to claim 22, wherein each one of said second cam surfaces comprising a region of increasing radius and a discontinuity, each said discontinuity of said second cam surfaces being aligned with a respective one of said discontinuities of said first cam surfaces.

24. The device according to claim 23, wherein each one of said second cam surfaces comprises a region of constant radius positioned adjacent to a respective one of said discontinuities of said second cam surfaces.

20 25. The device according to claim 22, wherein each one of said second cam surfaces has a constant radius.

26. The device according to claim 22, further comprising at least one traction surface extending around one of said cam bodies, said at least one traction surface having a gap therein, said gap being aligned axially with said discontinuity of said first cam surface surrounding said one cam body.

27. The device according to claim 26, wherein said at least one traction surface comprises a plurality of projections extending outwardly therefrom.

28. The device according to claim 26, wherein said first cam surface surrounding said one cam body is positioned between said at least one traction surface and said second
5 cam surface surrounding said one cam body.

29. The device according to claim 26, wherein said first and said second cam surfaces surrounding said one cam body are positioned between said at least one traction surface and one of said gears on which said one cam body is mounted.

30. The device according to claim 26, wherein said first cam surface surrounding
10 said first cam body is positioned proximate to said at least one traction surface.

31. The device according to claim 26, wherein said at least one traction surface has a pitch circle diameter equal to a pitch circle diameter of one of said gears.

32. The device according to claim 22, further comprising a plurality of traction surfaces, each one of said traction surfaces extending around a respective one of said cam
15 bodies, each one of said traction surfaces having a gap therein, each said gap being aligned axially with a respective one of said discontinuities of said first cam surfaces on each one of said cam bodies.

33. The device according to claim 32, wherein each one of said traction surfaces comprising a plurality of projections extending outwardly therefrom.

20 34. The device according to claim 32, wherein each one of said first cam surfaces is positioned between a respective one of said traction surfaces and a respective one of said second cam surfaces on each said cam body.

35. The device according to claim 32, wherein said first and second cam surfaces are positioned between said traction surface and said gear on each said cam body.

36. The device according to claim 32, wherein said first cam surface is positioned proximate to said traction surface on each said cam body.

37. A device for forming a circumferential groove in a pipe element, said device comprising:

5 a pinion fixed against rotation about a pinion axis arranged coaxially with said pinion;

 a carriage surrounding said pinion, said carriage being rotatable about said pinion axis and defining an opening arranged coaxially with said pinion axis for receiving said pipe element;

10 a plurality of gears mounted on said carriage, each said gear being rotatable relatively to said carriage about a respective gear axis, each said gear engaging with said pinion;

 a plurality of cam bodies, each said cam body mounted on a respective one of said gears;

15 a plurality of first cam surfaces, each one of said first cam surfaces extending around a respective one of said cam bodies and engageable with said pipe element received within said opening, each one of said first cam surfaces comprising a region of increasing radius, each one of said first cam surfaces comprising a first discontinuity of said first cam surface.

20 38. The device according to claim 37, wherein each said gear has a same pitch circle diameter.

 39. The device according to claim 37, further comprising a plurality of second cam surfaces, each one of said second cam surfaces extending around a respective one of said cam bodies and positioned in spaced relation to one of said first cam surfaces.

40. The device according to claim 39, wherein each one of said second cam surfaces comprising a second region of increasing radius, each one of said second cam surfaces comprising a second discontinuity of said second cam surface, said second discontinuity being aligned with said first discontinuity on each said cam body.

5 41. The device according to claim 37, wherein each one of said first cam surfaces comprises a region of constant radius positioned adjacent to a respective one of said first discontinuities.

 42. The device according to claim 40, wherein each one of said second cam surfaces comprises a region of constant radius positioned adjacent to a respective one of said second
10 discontinuities.

 43. The device according to claim 39, wherein each one of said second cam surfaces has a constant radius.

 44. The device according to claim 37, further comprising at least one traction surface extending around one of said cam bodies, said at least one traction surface having a gap
15 therein, said gap being aligned axially with said first discontinuity of said first cam surface surrounding said one cam body.

 45. The device according to claim 44, wherein said at least one traction surface comprises a plurality of projections extending outwardly therefrom.

 46. The device according to claim 44, wherein said at least one traction surface is
20 positioned proximate to said first cam surface surrounding said one cam body.

 47. The device according to claim 44, wherein said pinion has a pitch circle diameter equal to an outer diameter of said pipe element.

 48. The device according to claim 47, wherein said at least one traction surface has a pitch circle diameter equal to a pitch circle diameter of one of said gears.

49. The device according to claim 47, further comprising a plurality of said traction surfaces, each one of said traction surfaces extending around a respective one of said cam bodies, each one of said traction surfaces having a gap therein, each said gap being aligned axially with a respective one of said discontinuities of said first cam surfaces on each one of
5 said cam bodies, each one of said traction surfaces having a pitch circle diameter equal to said pitch circle diameters of said gears.

50. The device according to claim 39, further comprising at least one traction surface extending around one of said cam bodies, said at least one traction surface having a gap therein, said gap being aligned axially with said first discontinuity of said first cam surface
10 surrounding said one cam body.

51. The device according to claim 50, wherein said pinion has a pitch circle diameter equal to an outer diameter of said pipe element.

52. The device according to claim 51, wherein said at least one traction surface has a pitch circle diameter equal to a pitch circle diameter of one of said gears.

15 53. The device according to claim 50, wherein said first cam surface is positioned between said at least one traction surface and said second cam surface surrounding said one cam body.

54. The device according to claim 50, wherein said first and second cam surfaces are positioned between said at least one traction surface and said gear on which said one cam
20 body is mounted.

55. The device according to claim 51, further comprising a plurality of said traction surfaces, each one of said traction surfaces extending around a respective one of said cam bodies, each one of said traction surfaces having a gap therein, each said gap being aligned axially with a respective one of said discontinuities of said first cam surfaces on each one of
25 said cam bodies, each one of said traction surfaces having a pitch circle diameter equal to said pitch circle diameters of said gears.

56. The device according to claim 55, wherein each one of said first cam surfaces is positioned between a respective one of said traction surfaces and a respective one of said second cam surfaces on each said cam body.

57. The device according to claim 55, wherein each one of said first and second cam surfaces is positioned between said respective one of said traction surface and a respective one of said gears on each said cam body.

58. The device according to claim 55, wherein each one of said first cam surfaces is positioned proximate to a respective one of said traction surfaces on each said cam body.

59. The device according to claim 37, comprising at least three said gears.

60. The device according to claim 37, comprising at least four said gears.

61. The device according to claim 37, further comprising a cup positioned adjacent to said pinion and facing said opening, said pipe element abutting said cup.

62. A plurality of cams for cold working a pipe element, said cams being rotated circumferentially about said pipe element, each said cam comprising:

a cam body having an axis of rotation;

a first cam surface extending around said cam body, said first cam surface comprising a first region of increasing radius and a first discontinuity of said first cam surface;

a second cam surface extending around said cam body and positioned in spaced relation along said axis of rotation to said first cam surface.

63. The cam according to claim 62, wherein said second cam surface comprises a second region of increasing radius and a second discontinuity of said second cam surface, said second discontinuity being aligned with said first discontinuity.

64. The cam according to claim 62, wherein said first cam surface has a region of constant radius positioned adjacent to said first discontinuity.

65. The cam according to claim 63, wherein said second cam surface has a region of constant radius positioned adjacent to said second discontinuity.

5 66. The cam according to claim 62, wherein said second cam surface has a constant radius.

67. The cam according to claim 62, further comprising a traction surface extending around said cam body, said traction surface having a gap therein, said gap being aligned axially with said first discontinuity.

10 68. The cam according to claim 67, wherein said traction surface comprising a plurality of projections extending outwardly therefrom.

69. The cam according to claim 62, wherein said first cam surface is positioned between said traction surface and said second cam surface.

15 70. The cam according to claim 69, further comprising a gear mounted on said cam body, said gear being arranged coaxially with said axis of rotation.

71. The cam according to claim 70, wherein said first and second cam surfaces are positioned between said traction surface and said gear.

72. The cam according to claim 62, further comprising a gear mounted on said cam body, said gear being arranged coaxially with said axis of rotation.

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