forcing the rollers into engagement with the pipe element and the need for the operator to adjust the roller travel to achieve the desired groove radius. Additionally, prior art roll grooving machines apply significant torque to the pipe element and have low production rates, often requiring many revolutions of the pipe element to achieve a finished circumferential groove. There is clearly a need for devices, for example, those using cams, to accurately cold work pipe elements which are simple yet produce faster results with less operator involvement.

Summary

~~The invention concerns~~ There is provided a device for forming a circumferential groove in a pipe element. In one example embodiment the device comprises a pinion fixed against rotation about a pinion axis arranged coaxially with the pinion. An expanding die is positioned adjacent to the pinion and concentric with the pinion axis. The expanding die has a plurality of die segments movable radially toward and away from the pinion axis. Each die segment has a die face facing away from the pinion axis and engageable with an inner surface of the pipe element when moved away therefrom. An actuator is coupled to the expanding die for moving the die segments toward and away from the pinion axis. A carriage surrounds the expanding die. The carriage is rotatable about the pinion axis. The carriage defines an opening arranged coaxially with the pinion axis for receiving the pipe element. A plurality of gears are mounted on the carriage. Each gear is rotatable relatively to the carriage about a respective gear axis. Each gear engages with the pinion. One of a plurality of cam bodies are each mounted on a respective one of the gears. One of a plurality of first cam surfaces extend around a respective one of the cam bodies. Each one of the first cam surfaces comprises a region of increasing radius and a discontinuity. The pipe element is positioned between the die faces and the first cam surfaces when the pipe element is received within the opening.

In an example embodiment the actuator comprises a draw bar positioned coaxially with the expanding die and movable along the pinion axis. Motion of the draw bar moves the die segments toward and away from the pinion axis. A cylinder has a piston coupled to the draw bar for moving the draw bar along the pinion axis.

traction surface and the gear on each the cam body. The first cam surface may be positioned proximate to the traction surface on each cam body.

~~The invention encompasses another example~~ According to an aspect of the present invention, there is provided a device for forming a circumferential groove in a pipe element. In this example the device comprises a pinion fixed against rotation about a pinion axis arranged coaxially with the pinion. A carriage surrounds the pinion. The carriage is rotatable about the pinion axis and defines an opening arranged coaxially with the pinion axis for receiving the pipe element. A plurality of gears are mounted on the carriage. Each gear is rotatable relatively to the carriage about a respective gear axis. Each gear engages with the pinion. A plurality of cam bodies, of which each cam body is mounted on a respective one of the gears, include a plurality of first cam surfaces. Each one of the first cam surfaces extend around a respective one of the cam bodies and is engageable with the pipe element received within the opening. Each one of the first cam surfaces comprises a region of increasing radius. Each one of the first cam surfaces comprises a first discontinuity of the first cam surface. In an example, each gear has a same pitch circle diameter. An example embodiment may further comprise a plurality of second cam surfaces. Each one of the second cam surfaces extends around a respective one of the cam bodies and is positioned in spaced relation to one of the first cam surfaces.

In an example embodiment, each one of the second cam surfaces comprises a second region of increasing radius. Each one of the second cam surfaces comprises a second discontinuity of the second cam surface. The second discontinuity is aligned with the first discontinuity on each cam body. By way of example, each one of the first cam surfaces comprises a region of constant radius positioned adjacent to a respective one of the first discontinuities. In a further example, each one of the second cam surfaces comprises a region of constant radius positioned adjacent to a respective one of the second discontinuities. Each one of the second cam surfaces may have a constant radius. An example embodiment further comprises at least one traction surface extending around one of the cam bodies. The at least one traction surface has a gap therein. The gap is aligned axially with the first discontinuity of the first cam surface surrounding the one cam body.

gears on each the cam body. Also by way of example, each one of the first cam surfaces may positioned proximate to a respective one of the traction surfaces on each the cam body.

An example embodiment may comprise at least three gears. An example embodiment may comprise at least four gears. An example embodiment may further comprise a cup positioned adjacent to the pinion and facing the opening. The pipe element abuts the cup.

~~The invention also encompasses~~ There is also disclosed a plurality of cams for cold working a pipe element. The cams are rotated circumferentially about the pipe element. By way of example, each cam comprises a cam body having an axis of rotation. A first cam surface extends around the cam body. The first cam surface comprises a first region of increasing radius and a first discontinuity of the first cam surface. A second cam surface extends around the cam body and is positioned in spaced relation along the axis of rotation to the first cam surface. By way of example, the second cam surface may comprise a second region of increasing radius and a second discontinuity of the second cam surface. The second discontinuity is aligned with the first discontinuity. The first cam surface may have a region of constant radius positioned adjacent to the first discontinuity. The second cam surface may have a region of constant radius positioned adjacent to the second discontinuity. In an example embodiment, the second cam surface may have a constant radius.

An example embodiment may further comprise a traction surface extending around the cam body. The traction surface has a gap therein. The gap is aligned axially with the first discontinuity. In an example, the traction surface comprises a plurality of projections extending outwardly therefrom. By way of example, the first cam surface may be positioned between the traction surface and the second cam surface. Another example embodiment comprises a gear mounted on the cam body. The gear is arranged coaxially with the axis of rotation. In an example embodiment, the first and second cam surfaces may be positioned between the traction surface and the gear.

Brief Description of the Drawings

Figure 1 is a longitudinal sectional view of an example device for forming circumferential grooves in pipe elements;

What is claimed is:

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

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

~~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;~~

~~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;~~

~~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~~

~~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;~~

~~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 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 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 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.~~

~~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.~~

~~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.~~

~~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.~~

~~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.~~

~~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.~~

~~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.~~

~~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.~~

~~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.~~

~~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 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 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 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.~~

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

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;

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;

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.

~~38~~2. The device according to claim ~~37~~1, wherein each said gear has a same pitch circle diameter.

~~39~~3. The device according to claim ~~37~~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 one of said first cam surfaces.

~~40~~4. The device according to claim ~~39~~3, 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.

~~41~~5. The device according to claim ~~37~~1, 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~~6. The device according to claim ~~40~~4, wherein each one of said second cam surfaces comprises a region of constant radius positioned adjacent to a respective one of said second discontinuities.

~~43~~7. The device according to claim ~~39~~3, wherein each one of said second cam surfaces has a constant radius.

~~44~~8. The device according to claim ~~37~~1, 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 surrounding said one cam body.

~~45~~9. The device according to claim ~~44~~8, wherein said at least one traction surface comprises a plurality of projections extending outwardly therefrom.

~~46~~10. The device according to claim ~~44~~8, wherein said at least one traction surface is positioned proximate to said first cam surface surrounding said one cam body.

~~47~~11. The device according to claim ~~44~~8, wherein said pinion has a pitch circle diameter equal to an outer diameter of said pipe element.

~~48~~12. The device according to claim ~~47~~11, wherein said at least one traction surface has a pitch circle diameter equal to a pitch circle diameter of one of said gears.

~~49~~13. The device according to claim ~~47~~11, 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, each one of said traction surfaces having a pitch circle diameter equal to said pitch circle diameters of said gears.

~~50~~14. The device according to claim ~~39~~3, 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 surrounding said one cam body.

~~51~~15. The device according to claim ~~50~~14, wherein said pinion has a pitch circle diameter equal to an outer diameter of said pipe element.

~~52~~16. The device according to claim ~~51~~15, wherein said at least one traction surface has a pitch circle diameter equal to a pitch circle diameter of one of said gears.

~~53~~17. The device according to claim ~~50~~14, 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~~18. The device according to claim ~~50~~14, wherein said first and second cam surfaces are positioned between said at least one traction surface and said gear on which said one cam body is mounted.

~~55~~19. The device according to claim ~~51~~15, 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, each one of said traction surfaces having a pitch circle diameter equal to said pitch circle diameters of said gears.

~~56~~20. The device according to claim ~~55~~19, 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~~21. The device according to claim ~~55~~19, 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~~22. The device according to claim ~~55~~19, 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~~23. The device according to claim ~~37~~1, comprising at least three said gears.

~~60~~24. The device according to claim ~~37~~1, comprising at least four said gears.

~~61~~25. The device according to claim ~~37~~1, 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.~~

~~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.~~

~~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.~~

~~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.~~