

FLOW FORMING APPARATUS

Reference to related applications

[0001] The present invention claims the priority of the US Provisional Patent Application No. 61/165,247 filed on March 31, 2009, the content of which is incorporated into the present application by reference.

Background

[0002] Various embodiments relate generally to a flow forming apparatus.

[0003] Cold rotary forming technologies, e.g., form rolling and flow forming, have been developed for forming the high precision axis-symmetrical components of several kind of metals with low cost, near net-shape and high material usage. For example, the flow forming process may have a high potential mainly for forming hollow components with a small thickness.

[0004] Various kinds of flow forming machines have been developed and commercialized for the production of automotive components, bicycle parts and components for precision engineering, etc. However, these machines are custom designed and specialized for a mass production of each particular component.

[0005] Some usual machining lathes can be used only for the flow forming of small and soft metal components, because heavy duty flow forming of components of larger size or a higher strength require high machine rigidity to cope with the large forming forces (radial and axial).

Summary

[0006] In various embodiments, a flow forming apparatus may be provided. The flow forming apparatus may include a lathe, the lathe having a base body including a machine bed and a headstock connected to the machine bed, a chuck supported by the headstock, and a mandrel configured to receive a workpiece, with the mandrel having a longitudinal axis and being supported by the headstock; a build-up system, the build-up system including: a roller head structure having at least one movably supported roller housing supporting a roller, with the roller being configured to act on the workpiece when the workpiece is received by the mandrel; an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis of the mandrel; a radial feeder configured to drive the at least one moveably supported roller housing in the radial direction of the longitudinal axis of the mandrel; and a frame, the frame supporting the roller head structure and the axial feeder; wherein the build-up system is a system separated from the lathe, wherein the machine bed supports the frame, and wherein the frame is fixed to the lathe.

[0007] In various embodiments, a flow forming apparatus may be provided including: a lathe, the lathe having a base body including a machine bed and a headstock connected to the machine bed, a chuck supported by the headstock, and a mandrel configured to receive a workpiece, with the mandrel having a longitudinal axis and being supported by the headstock; a roller head structure having at least one movably supported roller configured to act on the workpiece when the workpiece is received by the mandrel; an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis; and a frame supported by and attached to the machine bed of the lathe

at at least one first support position and at at least one second support position spaced apart from the first support position in the axial direction of the longitudinal axis of the mandrel, wherein at least a portion of the mandrel extends between the first support position and the second support position with regard to the axial direction of the longitudinal axis of the mandrel.

[0008] In various embodiments, a flow forming apparatus may be provided including: a lathe, the lathe having a base body including a machine bed and a headstock connected to the machine bed, a chuck supported by the headstock, and a mandrel configured to receive a workpiece, with the mandrel having a longitudinal axis and being supported by the headstock; a build-up system, the build-up system including: a roller head structure having at least one movably supported roller housing supporting a roller, with the roller being configured to act on the workpiece when the workpiece is received by the mandrel; an axial feeder configured to drive the at least one moveably supported roller housing in the axial direction of the longitudinal axis of the mandrel; a radial feeder configured to drive the roller head structure in the radial direction of the longitudinal axis of the mandrel; and a frame, the frame supporting the roller head structure and the axial feeder and the radial feeder; wherein the build-up system is a system separated from the lathe and wherein the frame is fixed to the lathe, wherein the machine bed supports the frame, and wherein the frame is fixed to the machine bed of the lathe at at least one first support position and at at least one second support position spaced apart from the first support position in the axial direction of the longitudinal axis of the mandrel, wherein at least a portion of the mandrel extends between the first support position and the second support position with regard to the axial direction of the longitudinal axis of the mandrel.

[0009] In various embodiments, a flow forming apparatus may be provided including a lathe, the lathe having a base body comprising a machine bed and a main drive spindle connected to the machine bed, and a build-up system, the build-up system comprising: a mandrel support connected to the main drive spindle by an axial plunge type coupling; a mandrel configured to receive a work piece, with the mandrel having a longitudinal axis and being connected to the mandrel support; a roller head structure having at least one movably supported roller housing supporting a roller, with the roller being configured to act on the workpiece when the workpiece is received by the mandrel, wherein the roller head structure further comprises a roller head structure frame supporting the at least one moveably supported roller housing; an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis of the mandrel; a radial feeder configured to drive the at least one moveably supported roller housing in the radial direction of the longitudinal axis of the mandrel; a tailstock structure; a frame, the frame supporting the mandrel support and the axial feeder and tailstock structure; and wherein the build-up system is a system separated from the lathe, wherein the machine bed supports the frame, wherein the frame is fixed to the lathe, wherein the roller head structure frame supports the radial feeder, and wherein the roller head structure frame is mounted movably in axial direction on the base body of the lathe.

[0010] In various embodiments, a flow forming apparatus may be provided including a lathe, the lathe having a base body comprising a machine bed and a main drive spindle connected to the machine bed, a mandrel support connected to the main drive spindle; a mandrel configured to receive a workpiece, with the mandrel having a longitudinal axis and being supported by mandrel support; a roller head structure having at least one

movably supported roller configured to act on the workpiece when the workpiece is received by the mandrel; an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis; a tailstock structure ; and a frame supporting the axial feeder, the mandrel support and the tailstock structure; wherein the frame is supported by and attached to the machine bed of the lathe at at least one first support position and at at least one second support position spaced apart from the first support position in the axial direction of the longitudinal axis of the mandrel, wherein at least a portion of the mandrel extends between the first support position and the second support position with regard to the axial direction of the longitudinal axis of the mandrel.

[0011] In various embodiments, a flow forming apparatus may be provided including: a lathe, the lathe having a base body comprising a machine bed and a main drive spindle connected to the machine bed, a build-up system, the build-up system comprising: a mandrel support connected to the main drive spindle; a mandrel configured to receive a workpiece, with the mandrel having a longitudinal axis and being connected to the mandrel support; a roller head structure having at least one movably supported roller housing supporting a roller, with the roller being configured to act on the workpiece when the workpiece is received by the mandrel; an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis of the mandrel; a radial feeder configured to drive the at least one moveably supported roller housing in the radial direction of the longitudinal axis of the mandrel; and a frame, the frame supporting the axial feeder and the mandrel support; wherein the build-up system is a system separated from the lathe and wherein the frame is fixed to the lathe, wherein the machine bed supports the frame, and wherein the frame is fixed to the machine bed of

the lathe at at least one first support position and at at least one second support position spaced apart from the first support position in the axial direction of the longitudinal axis of the mandrel, wherein at least a portion of the mandrel extends between the first support position and the second support position with regard to the axial direction of the longitudinal axis of the mandrel.

Brief Description of the Drawings

[0012] In the drawings, like reference characters generally refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments of the invention are described with reference to the following drawings, in which:

[0013] FIG. 1 shows a top view of a first embodiment of a flow forming apparatus according to various embodiments;

[0014] FIG. 2 shows a side view of the first embodiment of a flow forming apparatus shown in FIG. 1;

[0015] FIG. 3 shows a sectional view of the first embodiment of a flow forming apparatus along the line X-X of FIG. 2;

[0016] FIG. 4 shows a three-dimensional view of a second embodiment of a flow forming apparatus according to various embodiments;

[0017] FIG. 5 shows a top view of the second embodiment of a flow forming apparatus shown in FIG. 4;

[0018] FIG. 6 shows a side view of the second embodiment of a flow forming apparatus shown in FIG. 4;

[0019] FIG. 7 shows a front view of the second embodiment of a flow forming apparatus shown in FIG. 4.

[0020] FIG. 8 shows a top view of a third embodiment of a flow forming apparatus according to various embodiments;

[0021] FIG. 9 shows a side view of the third embodiment of a flow forming apparatus shown in FIG. 8; and

[0022] FIG. 10 shows a sectional view of the third embodiment of a flow forming apparatus along the line X-X of FIG. 9.

Description

[0023] The following detailed description refers to the accompanying drawings that show, by way of illustration, specific details and embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and electrical changes may be made without departing from the scope of the invention. The various embodiments are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments.

[0024] The word "exemplary" is used herein to mean "serving as an example, instance, or illustration". Any embodiment or design described herein as "exemplary" is

not necessarily to be construed as preferred or advantageous over other embodiments or designs.

[0025] The term "connection" is intended to include a direct "connection" as well as an indirect "connection", respectively.

[0026] The terms "upper" and "lower" or "above" and "below" refer to the vertical direction.

[0027] Referring now to a first embodiment of a flow forming apparatus 1 shown in FIGS. 1 to 3, the first exemplary flow forming apparatus 1 may include a lathe 10 having a base body 12, which base body 12 includes a machine bed 14 and a headstock 16 connected to the machine bed 14. In some embodiments, the lathe 10 may be a CNC lathe.

[0028] The connection between the machine bed 14 and the headstock 16 may be any detachable or unsolvable connection, or the machine bed 14 and the headstock 16 may be formed as one-pieced. For example, the connection may be provided by welding or by means of screws or bolts. The headstock 16 may be arranged on the upper side of the machine bed 14 or may be arranged on a front end of the machine bed 14, as shown in FIG. 2.

[0029] When seen from the ground on which the flow forming apparatus 1 may be placed when in use, the upper end or upper surface 18 of the headstock 16 may be at a higher position than the upper end or upper surface 20 of the machine bed 14. In a side view, the base body 12 may have an L-shape, which can be seen from FIG. 2, wherein the headstock 16 forms a vertical section of the L-shape and wherein the machine bed 14 forms a horizontal section of the L-shape. The length of the machine bed 14 in a

horizontal direction may be greater than the height of the headstock 16 in a vertical direction, or vice versa, or the length of the machine bed 14 in the horizontal direction may be substantially the same as the height of the headstock 16 in the vertical direction.

[0030] The lathe 10 may further include a chuck 22 supported by the headstock 16 and a mandrel 24 having a longitudinal axis 26.

[0031] The chuck 22 may be rotatably supported by the headstock 16 and may be rotatably driven by a respective driver. Furthermore, the chuck 22 may include a plurality of chuck jaws, like for example two or three or four or five chuck jaws, which are movable with regard to each other so as to enabling clamping of the mandrel 24. For example, such chuck jaws may be movable in a radial direction of the mandrel 24 to enable clamping of the mandrel 24 by the chuck 22.

[0032] The mandrel 24 may be received and/or clamped and/or held in or by the chuck 22, and thus may supported by the headstock 16. For example, the mandrel 24 may be detachably received in the mandrel 24. When the mandrel 24 is received in the chuck 22 and the exemplary flow forming apparatus 1 stands on a ground 28, which ground 28 is not part of the flow forming apparatus 1 but supports and/or contacts the base body 12, the mandrel 24 or the longitudinal axis 26 of the mandrel 24 may extend in the horizontal direction.

[0033] Upon a flow forming process that can be performed on the exemplary flow forming apparatus 1, the mandrel 24 may receive a workpiece which is to be recasted in a flow forming process. This may be performed in such a manner that the work piece which may be a hollow workpiece extends around the mandrel 24 or at least a portion of the mandrel 24 extends inside the workpiece.

[0034] The first embodiment of a flow forming apparatus shown in FIGS. 1 to 3 may further include a frame 30.

[0035] The frame 30 is supported by the machine bed 14 and/or directly contacts the machine bed 14. The frame 30 may include multiple beams 32 that are connected to each other. For example, the frame 30 may have four beams 32 or five beams 32 or six beams 32 or seven beams 32 or eight beams 32 or nine beams 32 or ten beams 32 or eleven beams 32 or twelve beams 32 or thirteen beams 32 or fourteen beams 32 or fifteen beams 32 or sixteen beams 32 or seventeen beams 32 or nineteen beams 32 or twenty beams 32 or more than twenty beams 32. In the embodiment shown in FIGS. 1 to 3, the frame 30 may include ten beams 32, namely a first beam 34 (shown in FIG. 2), a second beam (not shown), a third beam 38 (shown in FIG. 2), a fourth beam (not shown), a fifth beam 42 (shown in FIGS. 1 and 2), a sixth beam 44 (shown in FIG. 1), a seventh beam 46 (shown in FIG. 1), an eighth beam 48 (shown in FIG. 1), a ninth beam 50 (shown in FIG. 2), and a tenth beam (not shown).

[0036] The beams 32, or first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be straight beams or substantially straight beams. However, the beams 32, or first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may also be formed in another manner. The beams 32, or first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be hollow beams or beams configured in a solid manner. The beams 32, or first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam

44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be made from steel or any other suitable material. The cross-sections of the beams 32 or, first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, which cross-sections are perpendicular to the longitudinal axis of the respective beam, may be rectangular or circular or square or elliptic or polygonal, like triangular or pentagonal or hexagonal, or of any suitable shape. It should be noted that the beams 32 or, first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, may have identical or similar cross-sections and may be made from identical or similar material or may differ with regards to its cross-sections or material, wherein, in some embodiments, any combinations of the above-mentioned shapes of the cross-sections and materials can be provided. The cross-sections of the beams 32 or, first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be substantially the same along the length of the respective beam or may change along the respective length.

[0037] The longitudinal direction of the beams 32 or, first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be allocated such that each of these beams 32 or, first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, extends either in a horizontal direction or in a vertical direction, as shown in FIGS. 1 to 3. In an alternate embodiment, longitudinal direction of one or a plurality of the beams 32 may extend

inclined to the vertical direction as well as inclined to the horizontal direction. For example, one beam 32 or multiple beams 32 extending inclined to the vertical direction as well as inclined to the horizontal direction may be provided in an alternate embodiment (not shown), which beam 32 or each of which beams 32 connects a beam 32 extending in the horizontal direction and a beam 32 in the vertical direction so as to further enhance strength and/or rigidity of the frame 30.

[0038] Beams 32 or, those of the first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, that are connected to each other or directly connected to each other, may be connected via one or more screws or by welding or by bolts or in any other suitable manner. All the beams 32, or the first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, of the frame 30 may connected to each other such that none of these beams 32 or, the first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, of the frame 30 is movable with regard to another of these beams 32, or the first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, of the frame 30.

[0039] In various embodiments, which are shown in FIGS. 1 to 3, the longitudinally axes of the first beam 34, of the second beam, of the third beam 38, and of the fourth beam of the frame 30, or the first beam 34, the second beam, the third beam 38, and the fourth beam of the frame 30 extend parallel to each other. In addition the longitudinal axes of the fifth beam 42, of the sixth beam 44, of the ninth beam 50, and of the tenth

beam of the frame 30 or the fifth beam 42, the sixth beam 44, the ninth beam 50, and the tenth beam of the frame 30 extend parallel to each other in the embodiments. Further, the longitudinal axes of the seventh beam 46 and of the eighth beam 48, or the seventh and eighth beams 46, 48 extend parallel to each other in the embodiments.

[0040] In various embodiments, which is shown in FIGS. 1 to 3, the longitudinally axes of the first beam 34, of the second beam, of the third beam 38, and of the fourth beam of the frame 30, or the first beam 34, the second beam, the third beam 38, and the fourth beam of the frame 30 are arranged in the vertical direction. In addition the longitudinal axes of the fifth beam 42, of the sixth beam 44, of the ninth beam 50, and of the tenth beam of the frame 30, or the fifth beam 42, the sixth beam 44, the ninth beam 50, and the tenth beam of the frame 30 are allocated in a horizontal direction.

[0041] As mentioned above, the second beam, the fourth beam, and the tenth beam are not shown in FIGS. 1 to 3, and thus explanations on the positions there of will be given below.

[0042] In the embodiments shown in FIGS. 1 to 3, the first beam 34, the ninth beam 50, the third beam 38, and the fifth beam 42 are connected to each other such that these four beams (i.e. first beam 34, ninth beam 50, third beam 38, and fifth beam 42) form a first frame 52 (shown in FIG. 2), of which the first frame 52 is a rectangular frame 52 in this embodiment. The second beam, the tenth beam, the fourth beam, and the sixth beam 44 are connected to each other such that these four beams (i.e. second beam, tenth beam, fourth beam, and sixth beam 44) form a second frame 54 (shown in FIG. 1), of which the second frame 54 is a rectangular frame 54 in this embodiment. The seventh beam 46, the fifth beam 42, eighth beam 48, and the sixth beam 44 are connected to each other such

that these four beams (seventh beam 46, fifth beam 42, eighth beam 48, and sixth beam 44) form a third frame 56 (shown in FIG. 1), of which the third frame 56 is a rectangular frame 56 in this embodiment.

[0043] The first beam 34, the seventh beam 46, and the second beam are connected to each other such that these three beams (i.e. first beam 34, seventh beam 46, and second beam) form a first U-shape 58 (shown in FIGs. 1 and 2), of which the U-shape 58 may also be named as a fourth frame 58 of the frame 30. The third beam 38, the eighth beam 48, and the fourth beam are connected to each other such that these three beams (i.e. third beam 38, eighth beam 48, and fourth beam) form a second U-shape 60 (shown in FIGs. 1 and 2), of which the U-shape 60 may also be named as a fifth frame 60 of the frame 30.

[0044] The size and shape of the first frame 52 may substantially be the same as or may correspond to the size and shape of the second frame 54.

[0045] The size and shape of the fourth frame 58 may substantially be the same as or may correspond to the size and shape of the fifth frame 60.

[0046] The first frame 52 and the second frame 54 are arranged parallel to each other and spaced apart from each other by means of the sixth beam 44 and the seventh beam 46.

[0047] The fourth frame 58 and the fifth frame 60 are arranged parallel to each other and spaced apart from each other by means of the fifth beam 42, sixth beam 44, ninth beam 50, and tenth beam.

[0048] In the first embodiment, the first frame 52 and the second frame 54 are arranged on opposite (lateral) sides of the mandrel 24 or of a vertical plane running through the longitudinal axis 26 of the mandrel 24, respectively. These first and second

frames 52, 54 may be allocated and formed symmetrically with regard to a vertical plane running through the longitudinal axis 26 of the mandrel 24.

[0049] In the first embodiment, the fourth frame 58 and the fifth frame 60 are allocated and formed symmetrically with regard to a vertical plane running perpendicular to the longitudinal axis 26 of the mandrel 24.

[0050] The frame 30 may be supported by and attached to the machine bed 14 of the lathe 10 at least one first support position 62 (shown in FIG. 2) and at least one second support position 64 (shown in FIG. 2) spaced apart from the first support position 62 in the direction of the longitudinal axis 26 of the mandrel 24, wherein at least a portion 66 of the mandrel 24 extends between the first support position 62 and the second support position 64 with regard to the direction of the longitudinal axis 26 of the mandrel 24. A first support position 62 may be a position on the upper surface 20 of the machine bed 14 in which the first beam 34 or the second beam is supported by the machine bed 14, and a second support position 64 may be a position on the upper surface 20 of the machine bed 14 in which the third beam 38 or the fourth beam is supported by the machine bed 14. In the embodiment shown in FIGS. 1 to 3, the lower end 70 (shown in FIG. 2) of the first beam 34 and the lower end (not shown) of the second beam and the lower end 72 (shown in FIG. 2) of the third beam 38 and the lower end (not shown) of the fourth beam are supported at the first support position 62 or the second support position 64 on the upper surface 20 of the machine bed 14 and/or are in direct contact with the upper surface 20 of the machine bed 14.

[0051] The frame 30 is fixed to the machine bed 14 by means of welding or screws or any other suitable attachment means such that the frame 30 is fixed at one position and

not movable. In the embodiment of FIGS. 1 to 3, the frame 30 may be fixed to the machine bed 14, for example, by means of welding or screws or any other suitable attachment means, in the one or more first support positions 62 and in the one or more second support positions 64 such that the frame 30 is fixed at one position and not movable.

[0052] In the embodiment shown in FIGS. 1 to 3, the first exemplary flow forming apparatus 1 may further include a roller head structure 80. Details of the roller head structure 80 may be seen in FIG. 3. The roller head structure 80 may include at least one roller 82. In the embodiment shown in FIG. 3, the roller head structure 80 is provided with only two rollers 82. Each of the two rollers 82 is movably supported so that the respective roller 82 is rotatable around its longitudinal axis. However, in an alternate embodiment, the rollers 82 may be held in a manner such that the rollers 82 cannot rotate around its longitudinal axes. It should be noted that only one roller 82 or more than two roller 82 may be provided in alternate embodiments. The roller head structure 80 may include for each of these rollers 82, a separate roller housing 84. Each of these roller housings 84 receives and/or supports and/or holds one or only one roller 82. In the first embodiment, which embodiment is shown in FIG. 1 to 3, the two rollers 82 are allocated on opposite sides of the mandrel 24 with regard to a direction perpendicular to the longitudinal axis 26 of the mandrel 24. The rollers 82 may be arranged and supported such that the longitudinal or central axes of these two rollers 82 are arranged perpendicular with respect to each other. These two rollers 82 may further be arranged and supported such that the longitudinal or central axes of these two rollers 82 are arranged perpendicular with respect to the longitudinal axis 26 of the mandrel 24. In an

embodiment, the longitudinal axes of these two rollers 82 may be arranged with the longitudinal axis 26 of the mandrel 24 in the same plane, as shown in FIG. 3. The aforementioned plane may be a horizontal plane.

[0053] In the embodiment as shown in FIG. 3, the roller head structure 80 may further include a roller head structure frame 86 that supports both of the roller housings 84. Each of these roller housings 84 may be movably supported by the roller head structure frame 86. The roller head structure frame 86 and the roller housings 84 may be configured such that each of the roller housings 84 is movable in the radial direction of the mandrel 24. Each of the rollers 82 is received in one of the roller housings 84 such that the respective roller 82 is moved together with the respective roller housings 84, when the roller housing 84 is moved. Each of the rollers 82 may be detachably received and/or supported and/or held in the respective roller housings 84, so as to enable replacement of the respective roller 84 by another one of the same or different size. In addition or alternatively, the roller housings 84 may be detachably received in the roller head structure frame 86, so as to enable replacement of the respective roller 84 by another one of the same or different size.

[0054] The first exemplary flow forming apparatus 1 may further include a first feeder 88 having one or more first drive devices 90. It may be provided that the first feeder 88 includes separate first drive devices 90 for each of the roller housings 84, so that the respective roller housing 84, and thus the respective roller 82 supported and/or received and/or held by the respective roller housing 84, may be driven by the respective first drive device 90. Each first drive device 90 of the first feeder 88 may be designed as

or comprise, for example, a servo drive device or as a motor, like an electro motor or a servo motor, or a hydraulic or pneumatic drive device, or any other suitable drive device.

[0055] In the embodiment shown in FIGS. 1 to 3, the first feeder 88 has two separate first drive devices 90, which may be designed as servo drive devices 90 or servo motors 90, wherein a first of these two first drive devices 90 of the first feeder 88 are or may be connected to a first of the two roller housings 84 so as to drive the first roller housing and wherein a second of these two first drive devices 90 of the first feeder 88 are or may be connected to a second of the two roller housings 84 so as to drive the second roller housing.

[0056] The first feeder 88 may be configured and/or allocated as a radial feeder, and each of the first drive devices 90 of the feeder 88 may be designed and/or allocated such that it can move a respective roller housing 84, and thus a respective roller 82 received and/or supported and/or held by the roller housings 84, in a direction perpendicular to the axial direction of the longitudinal axis 26 of the mandrel 24. In some embodiments, the first feeder 88 may be configured and/or allocated as a radial feeder, and each of the first drive devices 90 of the feeder 88 may be designed and/or allocated such that it can move a respective roller housing 84, and thus a respective roller 82 received and/or supported and/or hold by the roller housings 84, in a radial or substantially radial direction of the mandrel 24.

[0057] Each of the two first drive devices 90 of the first feeder 88 may be configured such that it can drive the respective roller housings 84 optionally in one of two opposite directions so as to move the respective roller housings 84 towards or away from the mandrel 24. In the embodiment shown in FIGS. 1 to 3 the two roller housings 84 may be

optionally moved towards each other or away from each other by means of the two first drive devices 90.

[0058] The first drive devices 90 may be synchronized with regard to its speed and/or position such that movements of the respective roller housings 84, that are drivable by these first drive devices 90, are synchronized with regard to its speed and / or position. The synchronisation of the speed and/or position of the first drive devices 90 may be such that the movement of the first drive devices 90 are controlled such that it is ensured that the positions of the first drive devices 90 and/or the forces of the first drive devices 90, which forces acts on the mandrel 24 and/or the workpiece, are kept mirror-imaged with regard to a plane through the longitudinal axis 26 of the mandrel 24, which plane may be perpendicular to a plane through both of the axes of these two rollers 82. The first drive devices 90 may be controlled by a controller, that may be a CNC controller (not shown), and the sychronisation may be controlled by the controller.

[0059] The first feeder 88 may be supported by the frame 30.

[0060] In some embodiments, the first feeder 88 may be fixed to the frame 30. In some embodiments, the first feeder 88 may be supported by or fixed to the roller head structure frame 86, which belongs to the roller head structure 80 that is supported by the frame 30, or may belong to the roller head structure 80 that is supported by the frame 30.

[0061] The roller head structure 80 may, for example, be supported by the ninth beam 50 and by the tenth beam, wherein the roller head structure 80 is supported such that it is movable in axial direction of the longitudinal axis 26 of the mandrel 24.

[0062] The first exemplary flow forming apparatus 1 may include a tailstock structure 94 (shown in FIG. 1). The tailstock structure 94 may replace in some

embodiments an existing tailstock or tailstock structure 94 of the lathe 10, which existing tailstock or tailstock structure may be removed. The tailstock structure 94 may support the mandrel 24 at its longitudinal end opposite to the headstock 16. The tailstock structure 94 may be supported by the frame 30 in some embodiments. This support may be in some embodiments such that axial forces of the tailstock structure 94 and/or axial forces of the mandrel 24 and/or axial force induced by a flow forming process may be supported by the frame 30. The dead centre of the tailstock structure 94 may be driven by a standalone hydraulic cylinder system in some embodiments. The tailstock structure 94 may be secured by an end lead-screw mechanism support, locked by turning the lead-screw via a hand wheel in some embodiments.

[0063] The first exemplary flow forming apparatus 1 may include a second feeder 96, which may be an axial feeder 96 (shown in FIG. 2). The second feeder 96 may directly and/or indirectly drive the roller housings 84 and/or the roller head structure frame 86 and/or the roller head structure 80 in the axial direction of the longitudinal axis 26 of the mandrel 24 so that the rollers 82 are moved in the axial directions, for example optionally in one of both orientations of the longitudinal axis 26 of the mandrel 24. The second feeder 96 may include one or more second drive devices 98. In some embodiments, it may be provided that the second feeder 96 may include separate second drive devices 98 for each of the roller housings 84, so that the respective roller housing 84, and thus the respective roller 82 supported and/or received and/or held by the respective roller housing 84, may be driven by the respective second drive device 98. In some embodiments, it may be provided that the second feeder 96 may include multiple second drive devices 98 which may drive the roller head structure frame 86 and/or the roller head structure 80.

[0064] Each second drive device 98 of the second feeder 96 may be designed or include, for example, a servo drive device or a motor, like an electro motor or a servo motor, or a hydraulic or pneumatic drive device, or any other suitable drive device.

[0065] In some embodiments, the second feeder 96 has two separate second drive devices 98, which may be designed as servo drive devices 98 or servo motors 98, wherein a first of these two second drive devices 98 of the second feeder 96 are or may be connected to a first of the two roller housings 84 so as to drive the first roller housing and wherein a second of these two second drive devices 98 of the second feeder 96 are or may be connected to a second of the two roller housings 84 so as to drive the second roller housing. In some embodiments, two drive devices 98 which may be configured as mentioned above, may be connected to the roller head structure frame 86 and/or the roller head structure 80. The connection between each of the drive devices 98 and the respective roller housings 84 or the roller head structure frame 86 and/or the roller head structure 80, respectively, may be performed by means of spindels 104 in the first embodiment or, in alternate embodiments, by means of a ball screws or by means of racks or by any other suitable devices. When using spindels 104, a respective spindel nut receiving a respective spindel 104 may be provided on each of the roller housings 84 in some embodiments. When using spindels 104, respective spindel nuts (not shown) each receiving a respective spindel 104 may be provided on the roller head structure frame 86 and/or the roller head structure 80 in some embodiments. When using spindels 104, each of the spindels 104 may be rotatably driven by a respective separate second drive device 98 in some embodiments. When using ball screws, a respective ball screw nut receiving a respective ball screw may be provided on each of the roller housings 84 in some

embodiments. When using ball screws, respective ball screw nuts each receiving a respective ball screw may be provided on the roller head structure frame 86 and/or the roller head structure 80 in some embodiments. When using ball screws, each of the ball screws may be rotatably driven by a respective separate second drive device 98 in some embodiments. When using racks, a respective gear engaging the rack and rotatably driven by one of the second drive devices 98 may be provided for each of the racks in some embodiments. When using racks, each of the racks may be fixedly connected to a respective roller housing 84 in some embodiments. When using racks, each of the racks may be fixedly connected to the roller head structure frame 86 and/or the roller head structure 80 in some embodiments. When using two racks or two spindles 104 or two ball screws, the two racks or two spindles 104 or two ball screws, respectively, may be arranged parallel to each other in some embodiments. When using two racks or two spindles 104 or two ball screws, the two racks or two spindles 104 or two ball screws, respectively, may be arranged mirror-imaged with regard to a vertical plane running through the longitudinal axis 26 of the mandrel 24 in some embodiments. Although some examples using devices rotatably driven by the second drive devices 98 and axially driving the roller head structure 80 or parts thereof have been described, the roller head structure 80 or parts thereof may alternatively be axially driven by the second feeder 96 using second drive devices 98 that outputs axial forces that are transmitted by respective elements, like for example axially movable bars, in some embodiments.

[0066] The second drive devices 98 may be synchronized with regard to its speed and/or position. The second drive devices 98 may be synchronized with regard to the first drive devices 90 in some embodiments.

[0067] The second drive devices 98 may be controlled by a controller (not shown), that may be a CNC controller, and the synchronisation may be controlled by the controller.

[0068] The second feeder 96 may include the second drive devices 98 and the racks or spindels 104 or ball screws, respectively, which may be driven by the second drive devices 98.

[0069] The second feeder 96 may be supported by the frame 30. In some embodiments, the second feeder 96 may be fixed to the frame 30. In some embodiments, the second feeder 96 may be supported by or fixed to one or more or all of the third beam 38, fourth beam, and eighth beam 48.

[0070] The first exemplary flow forming apparatus 1 may include an axial support 100 including one or more main bearings (not shown), like for example roller bearing. The axial support 100 may include a main bearing housing 102 supporting the main bearing or main bearings. The at least one main bearing or the main bearing housing 102 respectively may be configured as a thrust bearing. The at least one main bearing may be configured to bear axial forces or the axial maximum force applied to the mandrel 24 from the axial feeder 96 and the tailstock structure 94.

[0071] The axial support 100 may be supported by the frame 30. In an embodiment, the main bearing housing 102 may be fixed to the frame 30. This support may be shown in some embodiments such that the axial forces of the tailstock structure 94 and/or axial forces of the mandrel 24 and/or axial force induced by a flow forming process may be supported by the axial support 100.

[0072] In an embodiment, the axial support 100 may be supported by or fixed to one or more or all of the first beam 34, second beam, and seventh beam 46.

[0073] Safety covers (not shown) may be provided. For example, safety covers may be provided such that the safety covers protect the rotating parts of the first feeder 88 and of the second feeder 96. Safety covers may be supported by the frame 30.

[0074] The roller head structure 80 may be supported by the frame 30. In some embodiments, the roller head structure 80 may be supported by the spindels 104 or by the ball screws or by the racks or by any other suitable devices, spindels 104 or ball screws or by racks or other suitable devices may be driven by the second second feeder 96, wherein the spindels 104 or ball screws or by racks or other suitable devices may be supported by frame 30. In some embodiments the roller head structure 80 may be axially movably supported by the ninth beam 50 and the tenth beam. In some embodiments the roller head structure 80 may be supported by the machine bed 14. The roller head structure 80 may be axially movably supported by the machine bed 14.

[0075] The flow forming apparatus 1 may be designed as multi-axis flow forming apparatus. In the first embodiment, the flow forming apparatus 1 may be designed as 4-axis flow forming apparatus, wherein two axes for driving radial movement and two axes for driving axial movement. Taking also the mandrel 24 into account, the flow forming apparatus 1 may be designed as 4-axis flow forming apparatus in the first embodiment. For example, an exemplary flow forming apparatus 1 may be designed as a CNC-multi-axis flow forming apparatus, apart from the axis that may be provided by the mandrel 24.

[0076] The first exemplary flow forming apparatus 1 may further include a controller (not shown), that may be designed as a CNC controller. The controller may control the movement of the four axes of the flow forming apparatus 1 or the respective driving movements of the two first drive devices 90 and the respective driving movements of the

two second drive devices 98, respectively. These four axes or driving movements, respectively, may be synchronized by the controller, or CNC controller, respectively. The controller, or CNC controller may also control the movement of the mandrel 24 in some embodiments. For example, the controller or CNC controller may also control the movement of the mandrel 24 at any fixed speed in some embodiments. The controller or CNC controller, respectively, may also control the tailstock structure 94 or movements of the tailstock structure 94, respectively, in some embodiments. The controller or CNC controller, respectively, may comprise a LCD display panel, key-pads functions and remote control, or may consist of a LCD display panel, key-pads functions and remote control. The CNC controller may be able to load and run G-code programs.

[0077] The CNC controller may be supported by the base body 12 in some examples. In some examples, the CNC controller may be supported by the frame 30.

[0078] The mandrel 24 may be supported between the chuck 22 and tailstock or tail stock structure 94 at the center position in some embodiments.

[0079] The axial load support 100 may be mounted on the frame 30 at the front of the chuck 22 of the lathe 10 and has a thrust bearing for supporting the axial load applied to mandrel 24 from the rollers in some embodiments.

[0080] The frame 30 may be configured in some embodiments such that all axial forces of the axial feeder 96 and the tailstock structure 94 and radial forces of the axial feeder 96 are supported by the frame 30.

[0081] The radial rolling loads applied to the workpiece on the mandrel 24 from two rollers may balance with each other at both sides of the mandrel 24 and may be supported only by the roller head structure frame 86 of the roller head structure 80 in some embodiments.

[0082] The structure of the flow forming apparatus 1 of some embodiments may be such that the structure enables the flow forming apparatus 1 to perform the heavy duty flow forming for various kinds of tubular metal components under a relatively high forming load and minimum deflection of flow forming apparatus 1.

[0083] In some embodiments, the flow forming apparatus 1 may have a build-up system 110 which may be integrated onto the existing lathe 10. The build-up system 110 have the following modules: frame 30, roller head structure 80, first feeder 88, tailstock structure 94, second feeder 96, axial support 100. In some embodiments, the build-up system 110 may further include the controller or CNC controller, respectively. In some embodiments, the build-up system 110 may further include the safety covers.

[0084] The machine bed 14 may support the frame 30 at positions or only at positions that are in vertical direction, below the mandrel 24. The first 62 and second 64 support positions may be, in vertical direction, below the mandrel 24.

[0085] The base body 12 may be made from metal or any other suitable material. By way of example, the base body 12 may be made from steel.

[0086] Referring now to a second embodiment of a flow forming apparatus 1 shown in FIGS. 4 to 7, the second exemplary flow forming apparatus 1 comprises a lathe 10 having a base body 12, which base body 12 includes a machine bed 14 and a headstock 16 connected to the machine bed 14. In some embodiments the lathe 10 may be a CNC lathe.

[0087] The connection between the machine bed 14 and the headstock 16 may be any detachable or unsolvable connection, or the machine bed 14 and the headstock 16 may be formed as one-pieced. For example, the connection may be provided by welding or by means of screws or bolts. The headstock 16 may be arranged on the upper surface 20

(shown in FIG. 6) of the machine bed 14, as shown in FIG. 6, or may be arranged on a front end of the machine bed 14.

[0088] When seen from the ground on which the flow forming apparatus 1 may be placed when in use, the upper end or upper surface 18 (shown in FIGs. 5 and 6) of the headstock 16 may be at a higher position than the upper end or upper surface 20 of the machine bed 14. In a side view, the base body 12 may have an L-shape, which can be seen from FIG. 6, wherein the headstock 16 forms a vertical section of the L-shape and wherein the machine bed 14 forms a horizontal section of the L-shape. The length of the machine bed 14 in a horizontal direction may be longer than the height of the headstock 16 in a vertical direction, or vice versa, or the length of the machine bed 14 in the horizontal direction may be substantially the same as the height of the headstock 16 in the vertical direction.

[0089] The lathe 10 may further include a chuck 22 supported by the headstock 16 and a mandrel 24 having a longitudinal axis (not shown).

[0090] The chuck 22 may be rotatably supported by the headstock 16 and may be rotatably driven by a respective driver. Furthermore, the chuck 22 may include a plurality of chuck jaws, like for example two or three or four or five chuck jaws, which are movable with regard to each other so as to enabling clamping of a mandrel 24. For example, such chuck jaws may be movable in a radial direction of a mandrel 24 to enable clamping of the mandrel 24 by the chuck 22.

[0091] The mandrel 24 may be received and/or clamped and/or held in or by the chuck 22, and thus may supported by the headstock 16. For example, the mandrel 24 may be detachably received in the mandrel 24. When the mandrel 24 is received in the chuck

22 and the exemplary flow forming apparatus 1 stands on a ground 28, which ground 28 is not part of the flow forming apparatus 1 but supports and/or contacts the base body 12, the mandrel 24 or the longitudinal axis 26 of the mandrel 24 may extend in the horizontal direction.

[0092] Upon a flow forming process that can be performed on the exemplary flow forming apparatus 1, the mandrel 24 may receive a workpiece which is to be recasted in a flow forming process. This may be performed in such a manner that the work piece which may be a hollow workpiece extends around the mandrel 24 or at least a portion of the mandrel 24 extends inside the workpiece.

[0093] The second embodiment of a flow forming apparatus shown in FIGS. 4 to 7 may further include a frame 30.

[0094] The frame 30 is supported by the machine bed 14 and / or directly contacts the machine bed 14. The frame 30 includes multiple beams 32 that are connected to each other. For example, the frame 30 may have four beams 32 or five beams 32 or six beams 32 or seven beams 32 or eight beams 32 or nine beams 32 or ten beams 32 or eleven beams 32 or twelve beams 32 or thirteen beams 32 or fourteen beams 32 or fifteen beams 32 or sixteen beams 32 or seventeen beams 32 or nineteen beams 32 or twenty beams 32 or more than twenty beams 32. In the embodiment shown in FIGS. 4 to 7, the frame 30 may include ten beams 32, namely a first beam 34, a second beam 36, a third beam 38, a fourth beam 40, a fifth beam 42, a sixth beam 44, a seventh beam 46, an eighth beam 48, a ninth beam 50, and a tenth beam (not shown).

[0095] The beams 32, or first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and

tenth beam may be straight beams or substantially straight beams. However, the beams 32, or first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may also be formed in another manner. The beams 32, or first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be hollow beams or beams configured in a solid manner. The beams 32, or first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be made from steel or any other suitable material. The cross-sections of the beams 32 or, first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, which cross-sections are perpendicular to the longitudinal axis of the respective beam, may be rectangular as shown in FIG. 4, but may in alternative embodiments be circular or square or elliptic or polygonal, like triangular or pentagonal or hexagonal, or of any suitable shape. It should be noted that the beams 32 or, first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, may have identical or similar cross-sections and may be made from identical or similar material or may differ with regards to its cross-sections or material, wherein, in some embodiments, any combinations of the above-mentioned shapes of the cross-sections and materials can be provided. The cross-sections of the beams 32 or, first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth

beam may be substantially the same along the length of the respective beam or may change along the respective length.

[0096] The longitudinal direction of the beams 32 or, first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be allocated such that each of these beams 32 or, first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, extends either in a horizontal direction or in a vertical direction, as shown in FIGS. 4 to 7. In an alternate embodiment longitudinal direction of one or a plurality of the beams 32 may extend inclined to the vertical direction as well as inclined to the horizontal direction. For example, one beam 32 or multiple beams 32 extending inclined to the vertical direction as well as inclined to the horizontal direction may be provided in an alternate embodiment (not shown), which beam 32 or each of which beams 32 connects a beam 32 extending in the horizontal direction and a beam 32 in the vertical direction so as to further enhance strength and / or rigidity of the frame 30.

[0097] Beams 32 or, those of the first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, that are connected to each other or directly connected to each other, may be connected via one or more screws or by welding or by bolts or in any other suitable manner. All the beams 32, or the first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, of the frame 30 may connected to each other such that none of these beams 32 or, the first beam 34, second beam 36, third beam 38, fourth beam 40,

fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, of the frame 30 is movable with regard to another of these beams 32, or the first beam 34, second beam 36, third beam 38, fourth beam 40, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, of the frame 30.

[0098] In the embodiment of the invention, which is shown in FIGS. 4 to 7, the longitudinally axes of the first beam 34, of the second beam 36, of the third beam 38, and of the fourth beam 40 of the frame 30, or the first beam 34, the second beam 36, the third beam 38, and the fourth beam 40 of the frame 30 extend parallel to each other. In addition the longitudinal axes of the fifth beam 42, of the sixth beam 44, of the ninth beam 50, and of the tenth beam of the frame 30 or the fifth beam 42, the sixth beam 44, the ninth beam 50, and the tenth beam of the frame 30 extend parallel to each other in the embodiment. Further, the longitudinal axes of the seventh beam 46 and of the eighth beam 48, or the seventh and eight beams 46, 48 extend parallel to each other in the embodiment.

[0099] In the embodiment of the invention, which is shown in FIGS. 4 to 7, the longitudinally axes of the first beam 34, of the second beam 36, of the third beam 38, and of the fourth beam 40 of the frame 30, or the first beam 34, the second beam 36, the third beam 38, and the fourth beam 40 of the frame 30 are arranged in the vertical direction. In addition, the longitudinal axes of the fifth beam 42, of the sixth beam 44, of the seventh beam 46, of the eighth beam 48, of the ninth beam 50, and of the tenth beam of the frame 30, or the fifth beam 42, the sixth beam 44, the seventh beam 46, the eighth beam 48, the ninth beam 50, and the tenth beam of the frame 30 are allocated in a horizontal direction.

[00100] As mentioned above, the tenth beam is not shown in FIGS. 4 to 7, and thus explanations on the positions thereof will be given below.

[00101] In the embodiment shown in FIGS. 4 to 7, the first beam 34, the ninth beam 50, the third beam 38, and the fifth beam 42 are connected to each other such that these four beams (i.e. first beam 34, ninth beam 50, third beam 38, and fifth beam 42) form a first frame 52, of which the first frame 52 is a rectangular frame 52 in this embodiment. The second beam 36, the tenth beam, the fourth beam 40, and the sixth beam 44 are connected to each other such that these four beams (i.e. second beam 36, tenth beam, fourth beam 40, and sixth beam 44) form a second frame 54, of which the second frame is a rectangular frame 54 in this embodiment. The seventh beam 46, the fifth beam 42, eighth beam 48, and the sixth beam 44 are connected to each other such that these four beams (i.e. seventh beam 46, fifth beam 42, eighth beam 48, and sixth beam 44) form a third frame 56, of which the third frame 56 is a rectangular frame 56 in this embodiment.

[00102] The first beam 34, the seventh beam 46, and the second beam 36 are connected to each other such that these three beams (i.e. first beam 34, seventh beam 46, and second beam 36) form a first U-shape 58, of which the U-shape 58 may also be referred to as a fourth frame 58 of the frame 30. The third beam 38, the eighth beam 48, and the fourth beam 40 are connected to each other such that these three beams (i.e. third beam, 38, eighth beam 48, fourth beam 40) form a second U-shape 60, of which the U-shape 60 may also be named a fifth frame 60 of the frame 30.

[00103] The size and shape of the first frame 52 may substantially be the same as or may correspond to the size and shape of the second frame 54.

[00104] The size and shape of the fourth frame 58 may substantially be the same as or may correspond to the size and shape of the fifth frame 60.

[00105] The first frame 52 and the second frame 54 are arranged parallel to each other and spaced apart from each other by means of the sixth beam 44 and the seventh beam 46.

[00106] The fourth frame 58 and the fifth frame 60 are arranged parallel to each other and spaced apart from each other by means of the fifth beam 42, sixth beam 44, ninth beam 50, and tenth beam.

[00107] In the second embodiment, the first frame 52 and the second frame 54 are arranged on opposite (lateral) sides of the mandrel 24 or of a vertical plane running through the longitudinal axis of the mandrel 24, respectively. These frames 52 and 54 may be allocated and formed symmetrically with regard to a vertical plane running through the longitudinal axis of the mandrel 24.

[00108] In the second embodiment, the fourth frame 58 and the fifth frame 60 are allocated and formed symmetrically with regard to a vertical plane running perpendicular to the longitudinal axis of the mandrel 24.

[00109] The frame 30 is supported by and attached to the machine bed 14 of the lathe 10 at at least one first support position 62 (shown in FIG. 6) and at at least one second support position 64 (shown in FIG. 6) spaced apart from the first support position 62 in the direction of the longitudinal axis of the mandrel 24, wherein at least a portion 66 of the mandrel 24 extends between the first support position and the second support position with regard to the direction of the longitudinal axis of the mandrel 24. The at least one first support position 62 or the first support position 62 may be a position on the upper

surface 20 of the machine bed 14 in which the first beam 34 or the second beam 36 is supported by the machine bed 14, and the at least one second support position 64 or the second support position 64 may be a position on the upper surface 20 of the machine bed 14 in which the third beam 38 or the fourth beam 40 is supported by the machine bed 14.

[00110] In the embodiment shown in FIGS. 4 to 7, the lower end 70 (shown in FIG. 6) of the first beam 34 and the lower end (not shown) of the second beam 36 and the lower end 72 (shown in FIG. 6) of the third beam 38 and the lower end (not shown) of the fourth beam 40 are supported at the first support position 62 or the second support position 64 on the upper surface 20 of the machine bed 14 and/or are in direct contact with the upper surface 20 of the machine bed 14.

[00111] The frame 30 is fixed to the machine bed 14 by means of welding or screws or any other suitable attachment means such that the frame 30 is fixed at one position and not movable. In the embodiment of FIGS. 4 to 7, the frame 30 is fixed to the machine bed 14, for example, by means of welding or screws or any other suitable attachment means, in the one or more first support positions 62 and in the one or more second support positions 64 such that the frame 30 is fixed at one position and not movable.

[00112] The second exemplary flow forming apparatus 1 further comprises a roller head structure 80. The roller head structure 80 comprises at least one roller. In the embodiment shown in FIGS. 4 to 7, the roller head structure 80 is provided with only two rollers. Each of the rollers is movably supported so that the respective roller is rotatable around its longitudinal axis. However, in an alternate embodiment the rollers may be held in a manner that the rollers cannot rotate around its longitudinal axes. It must be noted that only one roller or more than two rollers may be provided in alternate embodiments of

the invention. The roller head structure 80 comprises for each of these rollers a separate roller housing (not shown). Each of these roller housings receives and / or supports and / or holds (only) one roller. In the second embodiment, which embodiment is shown in FIGS. 4 to 7, the two rollers are allocated on opposite sides of the mandrel 24 with regard to a direction perpendicular to the longitudinal axis of the mandrel 24. The rollers may be arranged and supported such that the longitudinal or central axes of these two rollers are arranged perpendicular with respect to each other. These two rollers may further be arranged and supported such that the longitudinal or central axes of these two rollers are arranged perpendicular with respect to the longitudinal axis of the mandrel 24. In an exemplary embodiment, the longitudinal axes of these two rollers may be arranged with the longitudinal axis of the mandrel 24 in the same plane, as previously shown in FIG. 3. The afore-mentioned plane may be a horizontal plane.

[00113] The roller head structure 80 further comprises a roller head structure frame (not shown) that supports both of the roller housings. Each of these roller housings is movably supported by the roller head structure frame. The roller head structure frame and the roller housings may be configured such that each of the roller housings are movable in the radial direction of the mandrel 24. Each of the rollers is received in one of the roller housings such that the respective roller is moved together with the respective roller housings, when the roller housing is moved. Each of the rollers may be detachably received and / or supported and / or hold in the respective roller housings, so as to enable replacement the respective roller by another one of the same or different size. In addition or alternatively, the roller housings may be detachably received in the roller head

structure frame, so as to enable replacement of the respective roller by another one of the same or different size.

[00114] The rollers and the roller head structure frames of the second embodiment may be designed according to the rollers and the roller head structure frame of the first embodiment.

[00115] The second exemplary flow forming apparatus 1 further comprises a first feeder 88 having one or more first drive devices. It may be provided that the first feeder 88 comprises separate first drive devices for each of the roller housings, so that the respective roller housing, and thus the respective roller supported and/or received and/or held by the respective roller housing, may be driven by the respective first drive device. Each first drive devices of the first feeder 88 may be designed as or comprise, for example, a servo drive device or a motor, like an electro motor or a servo motor, or a hydraulic or pneumatic drive device, or any other suitable drive device.

[00116] In the embodiment shown in FIGS. 4 to 7, the first feeder 88 has two separate first drive devices 90 of the first feeder 88, which may be designed as servo drive devices 90 or servo motors 90, wherein a first of these two first drive devices 90 of the first feeder 88 are or may be connected to a first of the two roller housings so as to drive the first roller housing and wherein a second of these two first drive devices 90 of the first feeder 88 are or may be connected to a second of the two roller housings so as to drive the second roller housing.

[00117] The first feeder 88 may be configured and/or allocated as a radial feeder, and each of the first drive devices 90 of the first feeder 88 may be designed and/or allocated such that it can move a respective roller housings, and thus a respective roller received

and/or supported and/or hold by the roller housings, in direction perpendicular to the axial direction of the longitudinal axis of the mandrel 24. In some embodiments, the first feeder 88 may be configured and/or allocated as a radial feeder, and each of the first drive devices 90 of the feeder 88 may be designed and/or allocated such that it can move a respective roller housings, and thus a respective roller received and/or supported and/or hold by the roller housings, in a radial or substantially radial direction of the mandrel 24.

[00118] Each of the two first drive devices 90 of the first feeder 88 may be configured such that it can drive the respective roller housings optionally in one of two opposite directions so as to move the respective roller housings towards or away from the mandrel 24. In the embodiment shown in FIGS. 4 to 7, the two roller housings may be optionally moved towards each other or away from each other by means of the two first drive devices 90.

[00119] The first drive devices 90 may be synchronized with regard to its speed and/or position such that movements of the respective roller housings, that are drivable by these first drive devices 90, are synchronized with regard to its speed and/or position. The synchronisation of the speed and / or position of the first drive devices 90 may be such that the movement so the first drive devices 90 are controlled such that it is ensured that the positions of the first drive devices 90 and/or the forces of the first drive devices 90, which forces acts on the mandrel 24 and/or the workpiece, are kept mirror-imaged with regard to a plane through the longitudinal axis of the mandrel 24, which plane may be perpendicular to a plane through both of the axes of these two rollers. The first drive devices 90 may be controlled by a controller 92, that may be a CNC controller, and the synchronisation may be controlled by the controller 92.

[00120] The first feeder 88 may be supported by the frame 30. In some embodiments, the first feeder 88 may be fixed to the frame 30. In some embodiments, the first feeder 88 may be supported by or fixed to the roller head structure frame, which belongs to the roller head structure 80 that is supported by the frame 30, or may belong to the roller head structure 80 that is supported by the frame 30.

[00121] In the second embodiment, the roller head structure 80 may be movably supported by the fifth beam 42 and the sixth beam 44, which may each have slotted holes 116 extending in an axial direction of the longitudinal axis of the mandrel 24. One or more rods 118 supported by the roller head structure 80 may extend through both of the slotted holes 116, wherein the rod 118 or the rods 118 is/are movable in the axial direction of the longitudinal axis of the mandrel 24. The slotted holes 116 may provide relieved space movements for rod 118 in the axial direction of the longitudinal axis of the mandrel 24.

[00122] The second exemplary flow forming apparatus 1 may include a tailstock structure 94. The tailstock structure 94 may replace in some embodiments an existing tailstock or tailstock structure 94 of the lathe 10, which existing tailstock or tailstock structure 94 may be removed. The tailstock structure 94 may support the mandrel 24 at its longitudinal end opposite the headstock 16. The tailstock structure 94 may be supported by the frame 30 in some embodiments. This support may be in some embodiments such that the axial forces of the tailstock structure 94 and/or the axial forces of the mandrel 24 and/or the axial force induced by a flow forming process may be supported by the frame 30. The dead centre of the tailstock structure 94 may be driven by a standalone hydraulic cylinder system in some embodiments. The tailstock structure 94 may be secured by an

end lead-screw mechanism support, locked by turning the lead-screw via a hand wheel in some embodiments.

[00123] The second exemplary flow forming apparatus 1 may include a second feeder 96, which may be an axial feeder 96. The second feeder 96 may directly and/or indirectly drive the roller housings and/or the roller head structure frame and/or the roller head structure 80 in the the axial direction of the longitudinal axis of the mandrel 24 so that the rollers are moved in the axial directions, for example optionally in one of both orientations of the longitudinal axis of the mandrel 24. The second feeder 96 may include one or more second drive devices 98. In some embodiments, it may be provided that the second feeder 96 may include separate second drive devices 98 for each of the roller housings, so that the respective roller housing, and thus the respective roller supported and/or received and/or held by the respective roller housing, may be driven by the respective second drive device 98. In some embodiments, it may be provided that the second feeder 96 may include multiple second drive devices 98 which may drive the roller head structure frame and/or the roller head structure 80.

[00124] Each second drive devices 98 of the second feeder 96 may be designed as or include, for example, a servo drive device or a motor, like an electro motor or a servo motor, or a hydraulic or pneumatic drive device, or any other suitable drive device.

[00125] In some embodiments, the second feeder 96 has two separate second drive devices 98, which may be designed as servo drive devices 98 or servo motors 98, wherein a first of these two second drive devices 98 of the second feeder 96 are or may be connected to a first of the two roller housings so as to drive the first roller housing and wherein a second of these two second drive devices 98 of the second feeder 96 are or

may be connected to a second of the two roller housings so as to drive the second roller housing. In some embodiments, two drive devices 98, which may be configured as mentioned above, may be connected to the roller head structure frame and/or the roller head structure 80. The connection between each of the drive devices 98 and the respective roller housings or the roller head structure frame and/or the roller head structure 80, respectively, may be performed by means of spindels 104 in the second embodiment or, in alternate embodiments, by means of a ball screws or by means of a racks or by any other suitable devices. When using spindels 104, a respective spindle nut receiving a respective spindle 104 may be a provided on each of the roller housings in some embodiments. When using spindels 104, respective spindle nuts each receiving a respective spindle 104 may be a provided on the roller head structure frame and / or the roller head structure 80 in some embodiments. When using spindels 104, each of the spindels 104 may be rotatably driven by a respective separate second drive device 98 in some embodiments. When using ball screws, a respective ball screw nut receiving a respective ball screw may be a provided on each of the roller housings in some embodiments. When using ball screws, respective ball screw nuts each receiving a respective ball screw may be provided on the roller head structure frame and / or the roller head structure 80 in some embodiments. When using ball screws, each of the ball screws may be rotatably driven by a respective separate second drive device 98 in some embodiments. When using racks, a respective gear engaging the rack and rotatably driven by one of the second drive devices 98 may be provided for each of the racks in some embodiments. When using racks, each of the racks may fixedly connected to a respective roller housing in some embodiments. When using racks, each of the racks may be fixedly

connected to the roller head structure frame and / or the roller head structure 80 in some embodiments. When using two racks or two spindels 104 or two ball screws, the two racks or two spindels 104 or two ball screws, respectively, may be arranged parallelly to each other in some embodiments. When using two racks or two spindels 104 or two ball screws, the two racks or two spindels 104 or two ball screws, respectively, may be arranged mirror-immaged with regard to a vertical plane running through the longitudinal axis mandrel 24 in some embodiments. Although some examples using devices rotatably driven by the second drive devices 98 and axially driving the roller head structure 80 or parts thereof have been described, the roller head structure 80 or parts thereof may alternatively be axially driven by the second feeder 96 using second drive devices 98 that outputs axial forces that are transmitted by respective elements, like for example axially movable bars, in some embodiments.

[00126] The second drive devices 98 may be synchronized with regard to its speed and/or position. The second drive devices 98 may be synchronized with regard to the first drive devices 90 in some embodiments.

[00127] The second drive devices 98 may be controlled by a controller 92, that may be a CNC controller, and the synchronisation may be controlled by the controller 92.

[00128] The second feeder 96 may include the second drive devices 98 and the racks or spindels 104 or ball screws, respectively, which may be driven by the second drive devices 98.

[00129] The second feeder 96 may be supported by the frame 30. In some embodiments, the second feeder 96 may be fixed to the frame 30. In some embodiments,

the second feeder 96 may be supported by or fixed to one or more or all of the third beam 38, fourth beam 40, and eighth beam 48.

[00130] The second exemplary flow forming apparatus 1 may include an axial support 100 including one main bearing 114 or more main bearings 114, like for example roller bearing. The axial support 100 may include a main bearing housing 102 supporting the main bearing or main bearings 114. The at least one main bearing 114 may be configured as a thrust bearing. The at least one main bearing 114 may be configured to bear axial forces or the axial maximum force applied to the mandrel 24 from the axial feeder 96 and the tailstock structure 94.

[00131] The axial support 100 may be supported by the frame 30. In an embodiment, the main bearing housing 100 may be fixed to the frame 30. This support may be in some embodiments such that axial forces of the tailstock structure 94 and / or axial forces of the mandrel 24 and/or axial force induced by a flow forming process may be supported by the axial support 100.

[00132] In an embodiment, the axial support 100 may be supported by or fixed to one or more or all of the first beam 34, second beam 36, and seventh beam 46.

[00133] Safety covers may be provided (not shown). For example, safety covers may be provided such that the safety covers protect the rotating parts of the first feeder 88 and of the second feeder 96. Safety covers may be supported by the frame 30.

[00134] The roller head structure 80 may be supported by the frame 30. In some embodiments, the roller head structure 80 may be supported by the spindles 104 or by the ball screws or by the racks or by any other suitable devices, spindles 104 or ball screws or by racks or other suitable devices may be driven by the second feeder 96, wherein the spindles 104 or ball screws or by racks or other suitable devices may be supported by the

frame 30. In some embodiments the roller head structure 80 may be axially movably supported by the ninth beam 50 and the tenth beam. In some embodiments the roller head structure 80 may be supported by the machine bed 14. The roller head structure 80 may be axially movably supported by the machine bed 14.

[00135] The flow forming apparatus 1 may be designed as multi-axis flow forming apparatus. In the second embodiment, the flow forming apparatus 1 may be designed as 4-axis flow forming apparatus having two axes for driving radial movement and two axes for driving axial movement. Taking also the mandrel 24 into account, the flow forming apparatus 1 may be designed as 4-axis flow forming apparatus in the second embodiment. For example an exemplary flow forming apparatus 1 may be designed as CNC-multi-axis flow forming apparatus, apart from the axis that may be provided by the mandrel 24.

[00136] The second exemplary flow forming apparatus 1 may further comprise a controller 92, that may be designed as a CNC controller 92. The controller 92 may control the movement of the four axes of the flow forming apparatus 1 or the respective driving movements of the two first drive devices 90 and the respective driving movements of the two second drive devices 98, respectively. These four axes or driving movements, respectively, may be synchronized by the controller 92, or CNC controller 92, respectively. The controller 92, or CNC controller 92 may also control the movement of the mandrel 24 in some embodiments. For example, the controller 92, or CNC controller 92 may also control the movement of the mandrel 24 at any fixed speed in some embodiments. The controller 92 or CNC controller 92, respectively, may also control tailstock structure 94 or movements of the tailstock structure 94, respectively, in some embodiments. The controller 92 or CNC controller 92, respectively, may comprise a LCD display panel, key-pads functions and remote control, or may consist of a LCD display panel, key-pads

functions and remote control. The CNC controller 92 may be able to load and run G-code programs.

[00137] The CNC controller 92 may include a control panel 108.

[00138] The CNC controller 92 may be supported by the base body 12 in some examples. In some examples, the CNC controller 92 may be supported by the frame 30.

[00139] The mandrel 24 may be supported between the chuck 22 and tailstock or tailstock structure 94 at the center position in some embodiments.

[00140] The axial support 100 may be mounted on the frame 30 at the front of the chuck 22 of the lathe 10 and has a thrust bearing for supporting the axial load applied to mandrel 24 from rollers in some embodiments.

[00141] The frame 30 may be configured in some embodiments such that all axial forces of axial feeder 96 and the tailstock structure 94 and radial forces of the axial feeder 96 are supported by the frame 30.

[00142] The radial rolling loads applied to the workpiece on the mandrel 24 from two rollers may balance with each other at both side of the mandrel 24 and may be supported only by the roller head structure frame of the roller head structure 80 in some embodiments.

[00143] The structure of the flow forming apparatus 1 of some embodiments may be such that it enables the flow forming apparatus 1 to perform the heavy duty flow forming for various kinds of tubular metal components under a high forming load and minimum defection of the flow forming apparatus 1.

[00144] In some embodiments, the flow forming apparatus 1 may have a build-up system 110 which may be integrated onto the existing lathe. The build-up system 110 have the following modules: frame 30, roller head structure 80, first feeder 88, tailstock

structure 94, second feeder 96, axial support 100. In some embodiments, the build-up system 110 may further include the controller 92 or CNC controller 92, respectively.

[00145] In some embodiments, the build-up system 110 may further include the safety covers.

[00146] The flow forming apparatus 1 may further have an electrical and/or electronical compartment 112.

[00147] Each of the second drive devices 98 may be arranged at an end of the flow forming apparatus 1, which end is an end opposite to the headstock 16 in axial direction of the longitudinal axis of the mandrel 24.

[00148] The machine bed 14 may support the frame 30 at positions or only at positions that are, in vertical direction, below the mandrel 24. The first support position 62 and second support position 64 may be, in a vertical direction, below the mandrel 24.

[00149] The base body 12 may be made from metal or any other suitable material. For example, the base body 12 may be made from steel.

[00150] In the first and second embodiment, the first frame 52 and the second frame 54 have been described as rectangular frames. However, the first frame 52 and the second frame 54 may have other shapes.

[00151] For example, the first frame 52 and the second frame 54 may have a U-shaped form. Such a U-shaped form may be such that the ninth beam 50 or the tenth beam respectively, is omitted in the first and second embodiment. The first frame 52 and the second frame 54 may be shaped as a trapezoid, like a symmetrical trapezoid. For example, the first beam 34 and third beam 38 may be inclined towards each other, with the distance between the upper ends of the first beam 34 and third beam 38 being shorter than the distance between the lower ends of the first beam 34 and third beam 38.

Accordingly, the second beam 36 and third beam 38 may be inclined towards each other, with the distance between the upper ends of the second beam 36 and third beam 38 being shorter than the distance between the lower ends of the second beam 36 and the third beam 38. In another embodiment, the first frame 52 and the second frame 54 may be the afore-mentioned trapezoid shape, like a symmetrical trapezoid shape, wherein the ninth beam 50 or the tenth beam, respectively, are omitted.

[00152] As further examples, the fourth frame 58 and the fifth frame 60 may have a rectangular form, thereby correspondingly including an additional beam. The fourth frame 58 and the fifth frame 60 may be shaped as a trapezoid, like a symmetrical trapezoid. For example, the first beam 34 and second beam 36 may be inclined towards each other, with the distance between the upper ends of the first beam 34 and second beam 36 being shorter than the distance between the lower ends of the first beam 34, and second beam 36. Accordingly, the second beam 36 and third beam 38 may be inclined towards each other, with the distance between the upper ends of the second beam 36 and third beam 38 being shorter than the distance between the lower ends of the second beam 36 and third beam 38. In another embodiment the fourth frame 58 and the fifth frame 60 may be the afore-mentioned trapezoid shape, like a symmetrical trapezoid shape, wherein the lower horizontal beams, respectively, are omitted.

[00153] Referring now to a third embodiment of a flow forming apparatus 1 shown in FIGS. 8 to 10, the third exemplary flow forming apparatus 1 may include a lathe 10 having a base body 12, which base body 12 includes a machine bed 14 and a headstock 16 connected to the machine bed 14. In some embodiments, the lathe 10 may be a CNC lathe.

[00154] The connection between the machine bed 14 and the headstock 16 may be any detachable or unsolvable connection, or the machine bed 14 and the headstock 16 may be formed as one-pieced. For example, the connection may be provided by welding or by means of screws or bolts. The headstock 16 may be arranged on the upper side of the machine bed 14 or may be arranged on a front end of the machine bed 14, as shown in FIG. 9.

[00155] When seen from the ground on which the flow forming apparatus 1 may be placed when in use, the upper end or upper surface 18 of the headstock 16 may be at a higher position than the upper end or upper surface 20 of the machine bed 14. In a side view, the base body 12 may have an L-shape, which can be seen from FIG. 9, wherein the headstock 16 forms a vertical section of the L-shape and wherein the machine bed 14 forms a horizontal section of the L-shape. The length of the machine bed 14 in a horizontal direction may be greater than the height of the headstock 16 in a vertical direction, or vice versa, or the length of the machine bed 14 in the horizontal direction may be substantially the same as the height of the headstock 16 in the vertical direction.

[00156] The lathe 10 may further include a main drive spindle 120 supported by the headstock 16. The main drive spindle 120 may be rotatably supported by the headstock 16 and may be rotatably driven by a respective driver.

[00157] The third embodiment of the flow forming apparatus shown in FIGS. 8 to 10 may further include a mandrel 24 having a longitudinal axis 26. The third embodiment of the flow forming apparatus shown in FIGS. 8 to 10 may further include a mandrel support 122. The mandrel support 122 may be connected to the main drive spindle 120 by an axial plunge type coupling 124. For example, the axial plunge type coupling 124 may

be such that the axial plunge type coupling 124 provides internal teeth, wherein the mandrel support 122 is provided with external teeth engaging the internal teeth of the plunge type coupling 124, or vice versa. The axial plunge type coupling 124 may allow an axial movement of the mandrel 24 with regard to the main drive spindle 120, but may connect the mandrel 24 to the main drive spindle 120 such that rotary movement of the main drive spindle 120 causes rotary movement of the mandrel 24. The axial plunge type coupling 124 may, for example, be fixed to the main drive spindle 120. In some embodiments, the axial plunge type coupling 124 may be received and / or fixed to the main drive spindle 120 by means of a chuck 22 or by means of welding or by means of teeth, or in any other suitable manner. However, in the embodiment shown in Figs. 8 to 10, there is no chuck 22, and the axial plunge type coupling 124 may be fixed to the main drive spindle 120 by welding, or clamping, or screwing, or by means of teeth, or in any other suitable manner. The mandrel 24 may be connected to the mandrel support 122. For example, the mandrel 24 may be fixed to the mandrel support 122 by clamping or welding or by means of screws or in any other suitable manner.

[00158] When the mandrel 24 is received in the exemplary flow forming apparatus 1 and the exemplary flow forming apparatus 1 stands on a ground 28, which ground 28 is not part of the flow forming apparatus 1 but supports and/or contacts the base body 12, the mandrel 24 or the longitudinal axis 26 of the mandrel 24 may extend in the horizontal direction.

[00159] Upon a flow forming process that can be performed on the exemplary flow forming apparatus 1, the mandrel 24 may receive a workpiece which is to be recasted in a flow forming process. This may be performed in such a manner that the work piece

which may be a hollow workpiece extends around the mandrel 24 or at least a portion of the mandrel 24 extends inside the workpiece.

[00160] The third embodiment of the flow forming apparatus shown in FIGS. 8 to 10 may further include a frame 30.

[00161] The frame 30 is supported by the machine bed 14 and/or directly contacts the machine bed 14. The frame 30 may include multiple beams 32 that are connected to each other. For example, the frame 30 may have four beams 32 or five beams 32 or six beams 32 or seven beams 32 or eight beams 32 or nine beams 32 or ten beams 32 or eleven beams 32 or twelve beams 32 or thirteen beams 32 or fourteen beams 32 or fifteen beams 32 or sixteen beams 32 or seventeen beams 32 or nineteen beams 32 or twenty beams 32 or more than twenty beams 32. In the embodiment shown in FIGS. 8 to 10, the frame 30 may include ten beams 32, namely a first beam 34 (shown in FIG. 9), a second beam (not shown), a third beam 38 (shown in FIG. 9), a fourth beam (not shown), a fifth beam 42 (shown in FIGS. 8 and 9), a sixth beam 44 (shown in FIG. 8), a seventh beam 46 (shown in FIG. 8), an eighth beam 48 (shown in FIG. 8), a ninth beam 50 (shown in FIG. 9), and a tenth beam (not shown).

[00162] The beams 32, or first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be straight beams or substantially straight beams. However, the beams 32, or first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may also be formed in another manner. The beams 32, or first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50,

and tenth beam may be hollow beams or beams configured in a solid manner. The beams 32, or first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be made from steel or any other suitable material. The cross-sections of the beams 32 or, first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, which cross-sections are perpendicular to the longitudinal axis of the respective beam, may be rectangular or circular or square or elliptic or polygonal, like triangular or pentagonal or hexagonal, or of any suitable shape. It should be noted that the beams 32 or, first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, may have identical or similar cross-sections and may be made from identical or similar material or may differ with regards to its cross-sections or material, wherein, in some embodiments, any combinations of the above-mentioned shapes of the cross-sections and materials can be provided. The cross-sections of the beams 32 or, first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be substantially the same along the length of the respective beam or may change along the respective length.

[00163] The longitudinal direction of the beams 32 or, first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam may be allocated such that each of these beams 32 or, first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, extends either in a

horizontal direction or in a vertical direction, as shown in FIGS. 8 to 10. In an alternate embodiment, longitudinal direction of one or a plurality of the beams 32 may extend inclined to the vertical direction as well as inclined to the horizontal direction. For example, one beam 32 or multiple beams 32 extending inclined to the vertical direction as well as inclined to the horizontal direction may be provided in an alternate embodiment (not shown), which beam 32 or each of which beams 32 connects a beam 32 extending in the horizontal direction and a beam 32 in the vertical direction so as to further enhance strength and/or rigidity of the frame 30.

[00164] Beams 32 or, those of the first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, that are connected to each other or directly connected to each other, may be connected via one or more screws or by welding or by bolts or in any other suitable manner. All the beams 32, or the first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, of the frame 30 may connected to each other such that none of these beams 32 or, the first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, of the frame 30 is movable with regard to another of these beams 32, or the first beam 34, second beam, third beam 38, fourth beam, fifth beam 42, sixth beam 44, seventh beam 46, eighth beam 48, ninth beam 50, and tenth beam, of the frame 30.

[00165] In various embodiments, which are shown in FIGS. 8 to 10, the longitudinally axes of the first beam 34, of the second beam, of the third beam 38, and of the fourth beam of the frame 30, or the first beam 34, the second beam, the third beam 38, and the

fourth beam of the frame 30 extend parallel to each other. In addition the longitudinal axes of the fifth beam 42, of the sixth beam 44, of the ninth beam 50, and of the tenth beam of the frame 30 or the fifth beam 42, the sixth beam 44, the ninth beam 50, and the tenth beam of the frame 30 extend parallel to each other in the embodiment shown in Fig. 8 to 10. Further, the longitudinal axes of the seventh beam 46 and of the eighth beam 48, or the seventh and eighth beams 46, 48 extend parallel to each other in the embodiment shown in Fig. 8 to 10.

[00166] In various embodiments, which is shown in FIGS. 8 to 10, the longitudinally axes of the first beam 34, of the second beam, of the third beam 38, and of the fourth beam of the frame 30, or the first beam 34, the second beam, the third beam 38, and the fourth beam of the frame 30 are arranged in the vertical direction. In addition the longitudinal axes of the fifth beam 42, of the sixth beam 44, of the ninth beam 50, and of the tenth beam of the frame 30, or the fifth beam 42, the sixth beam 44, the ninth beam 50, and the tenth beam of the frame 30 are allocated in a horizontal direction.

[00167] As mentioned above, the second beam, the fourth beam, and the tenth beam are not shown in FIGS. 8 to 10, and thus explanations on the positions there of will be given below.

[00168] In the embodiments shown in FIGS. 8 to 10, the first beam 34, the ninth beam 50, the third beam 38, and the fifth beam 42 are connected to each other such that these four beams (i.e. first beam 34, ninth beam 50, third beam 38, and fifth beam 42) form a first frame 52 (shown in FIG. 9), of which the first frame 52 is a rectangular frame 52 in this embodiment. The second beam, the tenth beam, the fourth beam, and the sixth beam 44 are connected to each other such that these four beams (i.e. second beam, tenth beam,

fourth beam, and sixth beam 44) form a second frame 54 (shown in FIG. 8), of which the second frame 54 is a rectangular frame 54 in this embodiment. The seventh beam 46, the fifth beam 42, eighth beam 48, and the sixth beam 44 are connected to each other such that these four beams (seventh beam 46, fifth beam 42, eighth beam 48, and sixth beam 44) form a third frame 56 (shown in FIG. 8), of which the third frame 56 is a rectangular frame 56 in this embodiment.

[00169] The first beam 34, the seventh beam 46, and the second beam are connected to each other such that these three beams (i.e. first beam 34, seventh beam 46, and second beam) form a first U-shape 58 (shown in FIGs. 8 and 9), of which the U-shape 58 may also be named as a fourth frame 58 of the frame 30. The third beam 38, the eighth beam 48, and the fourth beam are connected to each other such that these three beams (i.e. third beam 38, eighth beam 48, and fourth beam) form a second U-shape 60 (shown in FIGs. 1 and 2), of which the U-shape 60 may also be named a fifth frame 60 of the frame 30.

[00170] The size and shape of the first frame 52 may substantially be the same as or may correspond to the size and shape of the second frame 54.

[00171] The size and shape of the fourth frame 58 may substantially be the same as or may correspond to the size and shape of the fifth frame 60.

[00172] The first frame 52 and the second frame 54 are arranged parallel to each other and spaced apart from each other by means of the sixth beam 44 and the seventh beam 46.

[00173] The fourth frame 58 and the fifth frame 60 are arranged parallel to each other and spaced apart from each other by means of the fifth beam 42, sixth beam 44, ninth beam 50, and tenth beam.

[00174] In the third embodiment, the first frame 52 and the second frame 54 are arranged on opposite (lateral) sides of the mandrel 24 or of a vertical plane running through the longitudinal axis 26 of the mandrel 24, respectively. These first and second frames 52, 54 may be allocated and formed symmetrically with regard to a vertical plane running through the longitudinal axis 26 of the mandrel 24.

[00175] In the third embodiment, the fourth frame 58 and the fifth frame 60 are allocated and formed symmetrically with regard to a vertical plane running perpendicular to the longitudinal axis 26 of the mandrel 24.

[00176] The frame 30 may be supported by and attached to the machine bed 14 of the lathe 10 at least one first support position 62 (shown in FIG. 9) and at least one second support position 64 (shown in FIG. 9) spaced apart from the first support position 62 in the direction of the longitudinal axis 26 of the mandrel 24, wherein at least a portion 66 of the mandrel 24 extends between the first support position 62 and the second support position 64 with regard to the direction of the longitudinal axis 26 of the mandrel 24. A first support position 62 may be a position on the upper surface 20 of the machine bed 14 in which the first beam 34 or the second beam is supported by the machine bed 14, and a second support position 64 may be a position on the upper surface 20 of the machine bed 14 in which the third beam 38 or the fourth beam is supported by the machine bed 14. In the embodiment shown in FIGS. 8 to 10, the lower end 70 (shown in FIG. 9) of the first beam 34 and the lower end (not shown) of the second beam and the lower end 72 (shown in FIG. 9) of the third beam 38 and the lower end (not shown) of the fourth beam are supported at the first support position 62 or the second support position 64 on the upper

surface 20 of the machine bed 14 and/or are in direct contact with the upper surface 20 of the machine bed 14.

[00177] The frame 30 is fixed to the machine bed 14 by means of welding or screws or any other suitable attachment means. In the embodiment of FIGS. 8 to 10, the frame 30 may be fixed to the machine bed 14, for example, by means of welding or screws or any other suitable attachment means, in the one or more first support positions 62 and in the one or more second support positions 64.

[00178] In the embodiment shown in FIGS. 8 to 10, the third exemplary flow forming apparatus 1 may further include a roller head structure 80. Details of the roller head structure 80 may be seen in FIG. 10. The roller head structure 80 may include at least one roller 82. In the embodiment shown in FIG. 10, the roller head structure 80 is provided with only two rollers 82. Each of the two rollers 82 is movably supported so that the respective roller 82 is rotatable around its longitudinal axis. It should be noted that only one roller 82 or more than two roller 82 may be provided in alternate embodiments. The roller head structure 80 may include for each of these rollers 82 a separate roller housing 84. Each of these roller housings 84 receives and/or supports and/or holds one or only one roller 82. In the third embodiment, which embodiment is shown in FIG. 8 to 10, the two rollers 82 are allocated on opposite sides of the mandrel 24 with regard to a direction perpendicular to the longitudinal axis 26 of the mandrel 24. The rollers 82 may be arranged and supported such that the longitudinal or central axes of these two rollers 82 are arranged perpendicular with respect to each other. These two rollers 82 may further be arranged and supported such that the longitudinal or central axes of these two rollers 82 are arranged perpendicular with respect to the longitudinal axis 26 of the mandrel 24.

In an embodiment, the longitudinal axes of these two rollers 82 may be arranged with the longitudinal axis 26 of the mandrel 24 in the same plane, as shown in FIG. 10. The aforementioned plane may be a horizontal plane.

[00179] In the embodiment as shown in FIG. 10, the roller head structure 80 may further include a roller head structure frame 86 that supports both of the roller housings 84. Each of these roller housings 84 may be movably supported by the roller head structure frame 86. The roller head structure frame 86 and the roller housings 84 may be configured such that each of the roller housings 84 is movable in the radial direction of the mandrel 24. Each of the rollers 82 is received in one of the roller housings 84 such that the respective roller 82 is moved together with the respective roller housings 84, when the roller housing 84 is moved. Each of the rollers 82 may be detachably received and/or supported and/or held in the respective roller housings 84, so as to enable replacement of the respective roller 84 by another one of the same or different size. In addition or alternatively, the roller housings 84 may be detachably received in the roller head structure frame 86, so as to enable replacement of the respective roller 84 by another one of the same or different size.

[00180] The third exemplary flow forming apparatus 1 may further include a first feeder 88 having one or more first drive devices 90. It may be provided that the first feeder 88 includes separate first drive devices 90 for each of the roller housings 84, so that the respective roller housing 84, and thus the respective roller 82 supported and/or received and/or held by the respective roller housing 84, may be driven by the respective first drive device 90. Each first drive device 90 of the first feeder 88 may be designed as

or comprise, for example, a servo drive device or as a motor, like an electro motor or a servo motor, or a hydraulic or pneumatic drive device, or any other suitable drive device.

[00181] In the embodiment shown in FIGS. 8 to 10, the first feeder 88 has two separate first drive devices 90, which may be designed as servo drive devices 90 or servo motors 90, wherein a first of these two first drive devices 90 of the first feeder 88 are or may be connected to a first of the two roller housings 84 so as to drive the first roller housing and wherein a second of these two first drive devices 90 of the first feeder 88 are or may be connected to a second of the two roller housings 84 so as to drive the second roller housing.

[00182] The first feeder 88 may be configured and/or allocated as a radial feeder, and each of the first drive devices 90 of the feeder 88 may be designed and/or allocated such that it can move a respective roller housing 84, and thus a respective roller 82 received and/or supported and/or held by the roller housings 84, in a direction perpendicular to the axial direction of the longitudinal axis 26 of the mandrel 24. In some embodiments, the first feeder 88 may be configured and/or allocated as a radial feeder, and each of the first drive devices 90 of the feeder 88 may be designed and/or allocated such that it can move a respective roller housing 84, and thus a respective roller 82 received and/or supported and/or hold by the roller housings 84, in a radial or substantially radial direction of the mandrel 24.

[00183] Each of the two first drive devices 90 of the first feeder 88 may be configured such that it can drive the respective roller housings 84 optionally in one of two opposite directions so as to move the respective roller housings 84 towards or away from the mandrel 24. In the embodiment shown in FIGS. 8 to 10 the two roller housings 84 may

be optionally moved towards each other or away from each other by means of the two first drive devices 90.

[00184] The first drive devices 90 may be synchronized with regard to its speed and/or position such that movements of the respective roller housings 84, that are drivable by these first drive devices 90, are synchronized with regard to its speed and / or position. The synchronisation of the speed and/or position of the first drive devices 90 may be such that the movements of the first drive devices 90 are controlled such that it is ensured that the positions of the first drive devices 90 and/or the forces of the first drive devices 90, which forces acts on the mandrel 24 and/or the workpiece, are kept mirror-imaged with regard to a plane through the longitudinal axis 26 of the mandrel 24, which plane may be perpendicular to a plane through both of the axes of these two rollers 82. The first drive devices 90 may be controlled by a controller, that may be a CNC controller (not shown), and the synchronisation may be controlled by the controller.

[00185] The first feeder 88 may be supported by the frame 30 and / or by the roller head structure frame 86.

[00186] In some embodiments, the first feeder 88 may be fixed to the frame 30. In some embodiments, the first feeder 88 may be supported by or fixed to the roller head structure frame 86, which belongs to the roller head structure 80 that is supported by the frame 30, or may belong to the roller head structure 80 that is supported by the frame 30.

[00187] The roller head structure 80 may, for example, be supported in some embodiments by the ninth beam 50 and by the tenth beam, wherein the roller head structure 80 is supported such that it is movable in axial direction of the longitudinal axis 26 of the mandrel 24.

[00188] In some alternate embodiments, the roller head structure 80 may, for example, be supported by the machine bed 14 (shown in Fig. 9), wherein the roller head structure 80 is supported such that it is movable in axial direction of the longitudinal axis 26 of the mandrel 24. For example, the roller head structure frame 86 of the roller head structure 80 may be supported by the machine bed 14 (shown in Fig. 9), wherein the roller head structure frame 86 may be supported such that it is movable in axial direction of the longitudinal axis 26 of the mandrel 24. The roller head structure frame 86 may be in direct contact with the machine bed 14, for example. In some embodiments the roller head structure frame 86 is not supported by the frame 30. In some embodiments the roller head structure frame 86 is not vertically supported by the frame 30 (shown in Fig. 9).

[00189] The third exemplary flow forming apparatus 1 may include a tailstock structure 94 (shown in FIG. 8). The tailstock structure 94 may replace in some embodiments an existing tailstock or tailstock structure 94 of the lathe 10, which existing tailstock or tailstock structure may be removed. The tailstock structure 94 may support the mandrel 24 at its longitudinal end opposite to the headstock 16 or opposite the mandrel support 122, respectively. The tailstock structure 94 may be supported by the frame 30 in some embodiments. This support may be in some embodiments such that axial forces of the tailstock structure 94 and/or axial forces of the mandrel 24 and/or axial force induced by a flow forming process may be supported by the frame 30. The dead centre of the tailstock structure 94 may be driven by a standalone hydraulic cylinder system in some embodiments. The tailstock structure 94 may be secured by an end lead-screw mechanism support, locked by turning the lead-screw via a hand wheel in some embodiments.

[00190] The third exemplary flow forming apparatus 1 may include a second feeder 96, which may be an axial feeder 96 (shown in FIG. 9). The second feeder 96 may directly and/or indirectly drive the roller housings 84 and/or the roller head structure frame 86 and/or the roller head structure 80 in the axial direction of the longitudinal axis 26 of the mandrel 24 so that the rollers 82 are moved in the axial directions, for example optionally in one of both orientations of the longitudinal axis 26 of the mandrel 24. The second feeder 96 may include one or more second drive devices 98. In some embodiments, it may be provided that the second feeder 96 may include separate second drive devices 98 for each of the roller housings 84, so that the respective roller housing 84, and thus the respective roller 82 supported and/or received and/or held by the respective roller housing 84, may be driven by the respective second drive device 98. In some embodiments, it may be provided that the second feeder 96 may include multiple second drive devices 98 which may drive the roller head structure frame 86 and/or the roller head structure 80.

[00191] Each second drive device 98 of the second feeder 96 may be designed or include, for example, a servo drive device or a motor, like an electro motor or a servo motor, or a hydraulic or pneumatic drive device, or any other suitable drive device.

[00192] In some embodiments, the second feeder 96 has two separate second drive devices 98, which may be designed as servo drive devices 98 or servo motors 98, wherein a first of these two second drive devices 98 of the second feeder 96 are or may be connected to a first of the two roller housings 84 so as to drive the first roller housing and wherein a second of these two second drive devices 98 of the second feeder 96 are or may be connected to a second of the two roller housings 84 so as to drive the second

roller housing. In some embodiments, two drive devices 98 which may be configured as mentioned above, may be connected to the roller head structure frame 86 and/or the roller head structure 80. The connection between each of the drive devices 98 and the respective roller housings 84 or the roller head structure frame 86 and/or the roller head structure 80, respectively, may be performed by means of spindels 104 in the third embodiment or, in alternate embodiments, by means of a ball screws or by means of racks or by any other suitable devices. When using spindels 104, a respective spindle nut receiving a respective spindle 104 may be provided on each of the roller housings 84 in some embodiments. When using spindels 104, respective spindle nuts (not shown) each receiving a respective spindle 104 may be provided on the roller head structure frame 86 and/or the roller head structure 80 in some embodiments. When using spindels 104, each of the spindels 104 may be rotatably driven by a respective separate second drive device 98 in some embodiments. When using ball screws, a respective ball screw nut receiving a respective ball screw may be provided on each of the roller housings 84 in some embodiments. When using ball screws, respective ball screw nuts each receiving a respective ball screw may be provided on the roller head structure frame 86 and/or the roller head structure 80 in some embodiments. When using ball screws, each of the ball screws may be rotatably driven by a respective separate second drive device 98 in some embodiments. When using racks, a respective gear engaging the rack and rotatably driven by one of the second drive devices 98 may be provided for each of the racks in some embodiments. When using racks, each of the racks may be fixedly connected to a respective roller housing 84 in some embodiments. When using racks, each of the racks may be fixedly connected to the roller head structure frame 86 and/or the roller head

structure 80 in some embodiments. When using two racks or two spindels 104 or two ball screws, the two racks or two spindels 104 or two ball screws, respectively, may be arranged parallel to each other in some embodiments. When using two racks or two spindels 104 or two ball screws, the two racks or two spindels 104 or two ball screws, respectively, may be arranged mirror-imaged with regard to a vertical plane running through the longitudinal axis 26 of the mandrel 24 in some embodiments. Although some examples using devices rotatably driven by the second drive devices 98 and axially driving the roller head structure 80 or parts thereof have been described, the roller head structure 80 or parts thereof may alternatively be axially driven by the second feeder 96 using second drive devices 98 that outputs axial forces that are transmitted by respective elements, like for example axially movable bars, in some embodiments.

[00193] The second drive devices 98 may be synchronized with regard to its speed and/or position. The second drive devices 98 may be synchronized with regard to the first drive devices 90 in some embodiments.

[00194] The second drive devices 98 may be controlled by a controller (not shown), that may be a CNC controller, and the synchronisation may be controlled by the controller.

[00195] The second feeder 96 may include the second drive devices 98 and the racks or spindels 104 or ball screws, respectively, which may be driven by the second drive devices 98.

[00196] The second feeder 96 may be supported by the frame 30. In some embodiments, the second feeder 96 may be fixed to the frame 30. In some embodiments, the second feeder 96 may be supported by or fixed to one or more or all of the third beam 38, fourth beam, and eighth beam 48.

[00197] The third exemplary flow forming apparatus 1 may include an axial support 100 including one or more main bearings 126, like for example roller bearing. The at least one main bearing 126 may be configured as a thrust bearing. The at least one main bearing may be configured to bear axial forces or the axial maximum force applied to the mandrel 24 from the axial feeder 96 and the tailstock structure 94. The axial support 100 may further include the mandrel support 122. It may be provided that the mandrel 24 is directly supported by the mandrel support 122 and the mandrel support 122 is directly supported by the main bearing 126.

[00198] The axial support 100 and / or the main bearing 126 may be supported by the frame 30. This support may be shown in some embodiments such that the axial forces of the tailstock structure 94 and/or axial forces of the mandrel 24 and/or axial force induced by a flow forming process may be supported by the axial support 100 or the frame 30, respectively.

[00199] In an embodiment, the axial support 100 may be supported by or fixed to one or more or all of the first beam 34, second beam, and seventh beam 46.

[00200] Safety covers (not shown) may be provided. For example, safety covers may be provided such that the safety covers protect the rotating parts of the first feeder 88 and of the second feeder 96. Safety covers may be supported by the frame 30.

[00201] The roller head structure 80 may be supported by the frame 30. In some embodiments, the roller head structure 80 may be supported by the spindles 104 or by the ball screws or by the racks or by any other suitable devices, spindles 104 or ball screws or by racks or other suitable devices may be driven by the second second feeder 96, wherein the spindles 104 or ball screws or by racks or other suitable devices may be supported by

frame 30. In some embodiments the roller head structure 80 may be axially movably supported by the ninth beam 50 and the tenth beam. In some embodiments the roller head structure 80 may be supported by the machine bed 14. The roller head structure 80 may be axially movably supported by the machine bed 14.

[00202] The flow forming apparatus 1 may be designed as multi-axis flow forming apparatus. In the third embodiment, the flow forming apparatus 1 may be designed as 4-axis flow forming apparatus, wherein two axes for driving radial movement and two axes for driving axial movement. For example, an exemplary flow forming apparatus 1 may be designed as a CNC-multi-axis flow forming apparatus, apart from the axis that may be provided by the mandrel 24.

[00203] The third exemplary flow forming apparatus 1 may further include a controller (not shown), that may be designed as a CNC controller. The controller may control the movement of the four axes of the flow forming apparatus 1 or the respective driving movements of the two first drive devices 90 and the respective driving movements of the two second drive devices 98, respectively. These four axes or driving movements, respectively, may be synchronized by the controller, or CNC controller, respectively. The controller, or CNC controller may also control the movement of the mandrel 24 in some embodiments. For example, the controller or CNC controller may also control the movement of the mandrel 24 at any fixed speed in some embodiments. The controller or CNC controller, respectively, may also control the tailstock structure 94 or movements of the tailstock structure 94, respectively, in some embodiments. The controller or CNC controller, respectively, may comprise a LCD display panel, key-pads

functions and remote control, or may consist of a LCD display panel, key-pads functions and remote control. The CNC controller may be able to load and run G-code programs.

[00204] The CNC controller may be supported by the base body 12 in some examples. In some examples, the CNC controller may be supported by the frame 30.

[00205] The mandrel 24 may be supported between the main drive spindle 120 or axial plunge type coupling, respectively, and the tailstock or tail stock structure 94, respectively, at the center position in some embodiments.

[00206] The axial load support 100 may be mounted on the frame 30 at the front of the chuck 22 (if provided) or the spindle 120 of the lathe 10 and has a thrust bearing for supporting the axial load applied to mandrel 24 from the rollers in some embodiments.

[00207] The frame 30 may be configured in some embodiments such that all axial forces of the axial feeder 96 and the tailstock structure 94 are supported by the frame 30.

[00208] The radial rolling loads applied to the workpiece on the mandrel 24 from two rollers 82 may balance with each other at both sides of the mandrel 24 and may be supported only by the roller head structure frame 86 of the roller head structure 80 in some embodiments.

[00209] The structure of the flow forming apparatus 1 of some embodiments may be such that the structure enables the flow forming apparatus 1 to perform the heavy duty flow forming for various kinds of tubular metal components under a relatively high forming load and minimum deflection of flow forming apparatus 1.

[00210] In some embodiments, the flow forming apparatus 1 may have a build-up system 110 which may be integrated onto the existing lathe 10. The build-up system 110 have the following modules: frame 30, roller head structure 80, first feeder 88, tailstock

structure 94, second feeder 96, axial support 100. In some embodiments, the build-up system 110 may further include the controller or CNC controller, respectively. In some embodiments, the build-up system 110 may further include the safety covers.

[00211] The machine bed 14 may support the frame 30 at positions or only at positions that are in vertical direction, below the mandrel 24. The first 62 and second 64 support positions may be, in vertical direction, below the mandrel 24.

[00212] The base body 12 may be made from metal or any other suitable material. By way of example, the base body 12 may be made from steel.

[00213] While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

1	flow forming apparatus
10	lathe
12	base body
14	machine bed
16	headstock
18	upper end/upper surface of 16
20	upper end/upper surface of 14
22	chuck
24	mandrel
26	longitudinal axis
28	ground
30	frame
32	beam
34	first beam
36	second beam
38	third beam
40	fourth beam
42	fifth beam
44	sixth beam
46	seventh beam
48	eighth beam
50	ninth beam
52	first rectangular frame
54	second (rectangular) frame
56	third (rectangular) frame
58	first U-shape, fourth frame
60	second U-shape, fourth frame
62	first support position
64	second support position
66	portion of mandrel 24
70	lower end of the first beam 34
72	lower end of the third beam 38
80	roller head structure
82	roller
84	roller housing
86	roller head structure frame
88	first feeder/radial feeder
90	first drive device, for example servo drive device or servo motor
92	controller
94	tailstock structure
96	second feeder/axial feeder
98	second drive device
100	axial support
102	main bearing housing
104	spindel
108	control panel

110	build-up system
112	electrical or electronical compartment
114	main bearing
116	slotted hole
118	rod
120	main drive spindel
122	mandrel support
124	axial plunge type coupling
126	main bearing

Claims

What is claimed is:

1. A flow forming apparatus, comprising:

a lathe, the lathe having

a base body comprising a machine bed and a headstock connected to the machine bed,

a chuck supported by the headstock, and

a mandrel configured to receive a workpiece, with the mandrel having a longitudinal axis and being supported by the headstock;

and

a build-up system, the build-up system comprising:

a roller head structure having at least one movably supported roller housing supporting a roller, with the roller being configured to act on the workpiece when the workpiece is received by the mandrel;

an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis of the mandrel;

a radial feeder configured to drive the at least one movably supported roller housing in the radial direction of the longitudinal axis of the mandrel; and

a frame, the frame supporting the roller head structure and the axial feeder;

wherein the build-up system is a system separated from the lathe, wherein the machine bed supports the frame, and wherein the frame is fixed to the lathe.

2. The flow forming apparatus of claim 1,
wherein the build up-system further comprises an axial support comprising a thrust bearing, wherein the axial support is configured to bear axial forces or the axial maximum force applied by the mandrel, when the axial forces are applied to the mandrel from the axial feeder, and wherein the frame supports the axial support.
3. The flow forming apparatus of claim 1,
wherein the build-up system further comprises a tailstock structure supporting the mandrel, wherein the frame supports the tailstock structure.
4. The flow forming apparatus of claim 1,
wherein the roller head structure is movable in the longitudinal direction of the longitudinal axis of the mandrel.
5. The flow forming apparatus of claim 1, further comprising:
a CNC controller, wherein the CNC controller is configured to control the axial feeder and the radial feeder.
6. The flow forming apparatus of claim 1,
wherein the frame comprises a plurality of beams extending in a horizontal direction, and a plurality of beams extending in a vertical direction.

7. The flow forming apparatus of claim 1,
wherein the frame comprises a plurality of frames.
8. The flow forming apparatus of claim 7,
wherein each of the plurality of frames comprises a plurality of beams.
9. The flow forming apparatus of claim 8,
wherein at least two of the plurality of frames are formed having a common beam.
10. The flow forming apparatus of claim 8,
wherein at least one of the plurality of frames is a rectangular frame.
11. The flow forming apparatus of claim 8,
wherein at least one of the plurality of frames is a U-shaped frame.
12. The flow forming apparatus of claim 1,
wherein the machine bed supports the frame at vertical positions that are below a
vertical position at which the mandrel extends.
13. The flow forming apparatus of claim 1,
wherein the frame further supports the radial feeder.
14. The flow forming apparatus of claim 1,

wherein the roller head structure comprises a roller head structure frame movably supporting the at least one movably supported roller housing, and wherein the roller head structure frame is configured to bear radial forces of a flow forming process for which the flow forming apparatus is to be used.

15. A flow forming apparatus comprising:

a lathe, the lathe having

a base body comprising a machine bed and a headstock connected to the machine bed,

a chuck supported by the headstock, and

a mandrel configured to receive a workpiece, with the mandrel having a longitudinal axis and being supported by the headstock;

a roller head structure having at least one movably supported roller configured to act on the workpiece when the workpiece is received by the mandrel;

an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis; and

a frame supported by and attached to the machine bed of the lathe at at least one first support position and at at least one second support position spaced apart from the at least one first support position in the axial direction of the longitudinal axis of the mandrel, wherein at least a portion of the mandrel extends between the at least one first support position and the at least one second support position with regard to the axial direction of the longitudinal axis of the mandrel.

16. The flow forming apparatus as claimed in claim 15,
wherein the roller head structure further comprises at least one roller housing, the
flow forming apparatus further comprising:

a radial feeder configured to drive the at least one roller housing in the
radial direction of the longitudinal axis of the mandrel.
17. The flow forming apparatus of claim 15, further comprising:

a CNC controller, wherein the CNC controller is configured to control the axial
feeder and the radial feeder.
18. The flow forming apparatus of claim 15,

wherein the machine bed supports the frame at vertical positions that are below a
vertical position at which the mandrel extends.
19. The flow forming apparatus of claim 15,

wherein the roller head structure comprises a roller head structure frame movably
supporting the at least one roller housing, and wherein the roller head structure
frame is configured to bear radial forces of a flow forming process for which the
flow forming apparatus is to be used.
20. A flow forming apparatus comprising:

a lathe, the lathe having

a base body comprising a machine bed and a headstock connected to the machine bed,

a chuck supported by the headstock, and

a mandrel configured to receive a workpiece, with the mandrel having a longitudinal axis and being supported by the headstock;

and

a build-up system, the build-up system comprising:

a roller head structure having at least one movably supported roller housing supporting a roller, with the roller being configured to act on the workpiece when the workpiece is received by the mandrel;

an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis of the mandrel;

a radial feeder configured to drive the at least one movably supported roller housing in the radial direction of the longitudinal axis of the mandrel; and

a frame, the frame supporting the roller head structure and the axial feeder and the radial feeder;

wherein the build-up system is a system separated from the lathe and wherein the frame is fixed to the lathe, wherein the machine bed supports the frame, and

wherein the frame is fixed to the machine bed of the lathe at at least one first support position and at at least one second support position spaced apart from the at least one first support position in the axial direction of the longitudinal axis of the mandrel, wherein at least a portion of the mandrel extends between the at least

one first support position and the at least one second support position with regard to the axial direction of the longitudinal axis of the mandrel.

21. The flow forming apparatus of claim 20,
wherein the machine bed supports the frame at vertical positions that are below a vertical position at which the mandrel extends.
22. The flow forming apparatus of claim 20,
wherein the roller head structure comprises a roller head structure frame movably supporting the at least one movably supported roller housing, and wherein the roller head structure frame is configured to bear radial forces of a flow forming process for which the flow forming apparatus is to be used.
23. A flow forming apparatus, comprising:
a lathe, the lathe having
a base body comprising a machine bed and a main drive spindle connected to the machine bed,
a build-up system, the build-up system comprising:
a mandrel support connected to the main drive spindle by an axial plunge type coupling;
a mandrel configured to receive a work piece, with the mandrel having a longitudinal axis and being connected to the mandrel support;

a roller head structure having at least one movably supported roller housing supporting a roller, with the roller being configured to act on the workpiece when the workpiece is received by the mandrel, wherein the roller head structure further comprises a roller head structure frame supporting the at least one roller housing;

an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis of the mandrel;

a radial feeder configured to drive the at least one movably supported roller housing in the radial direction of the longitudinal axis of the mandrel;

a tailstock structure; and

a frame, the frame supporting the mandrel support and the axial feeder and tailstock structure;

wherein the build-up system is a system separated from the lathe, wherein the machine bed supports the frame, wherein the frame is fixed to the lathe, wherein the roller head structure frame supports the radial feeder, and wherein the roller head structure frame is mounted movably in the axial direction on the base body of the lathe.

24. The flow forming apparatus of claim 23,

wherein the build up-system further comprises a thrust bearing, wherein the mandrel support is configured to bear axial forces or the axial maximum force applied by the mandrel, when the axial forces are applied to the mandrel from the

axial feeder through the roller head structure, and wherein the frame supports the axial mandrel support.

25. The flow forming apparatus of claim 23,
wherein the roller head structure frame is configured to bear radial forces of a flow forming process for which the flow forming apparatus is to be used.
26. The flow forming apparatus of claim 25,
wherein the roller head structure frame is supported by the machine bed.
27. The flow forming apparatus of claim 23,
wherein the base body further comprises a headstock connected to the machine bed, and wherein the main drive spindle is supported by the headstock.
28. A flow forming apparatus comprising:
a lathe, the lathe having
 a base body comprising a machine bed and a main drive spindle connected to the machine bed,
a mandrel support connected to the main drive spindle;
a mandrel configured to receive a workpiece, with the mandrel having a longitudinal axis and being supported by the mandrel support;
a roller head structure having at least one movably supported roller configured to act on the workpiece when the workpiece is received by the mandrel;

an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis;

a tailstock structure; and

a frame supporting the axial feeder, the mandrel support and the tailstock structure;

wherein the frame is supported by and attached to the machine bed of the lathe at at least one first support position and at at least one second support position spaced apart from the at least one first support position in the axial direction of the longitudinal axis of the mandrel, wherein at least a portion of the mandrel extends between the at least one first support position and the at least one second support position with regard to the axial direction of the longitudinal axis of the mandrel.

29. The flow forming apparatus of claim 28,
wherein the roller head structure is configured to bear radial forces of a flow forming process for which the flow forming apparatus is to be used.
30. The flow forming apparatus of claim 29,
wherein the roller head structure is supported by the machine bed.
31. The flow forming apparatus of claim 28,
wherein the base body further comprises a headstock connected to the machine bed, and wherein the main drive spindle is supported by the headstock.

32. A flow forming apparatus comprising:

a lathe, the lathe having

a base body comprising a machine bed and a main drive spindle connected to the machine bed,

a build-up system, the build-up system comprising:

a mandrel support connected to the main drive spindle,

a mandrel configured to receive a workpiece, with the mandrel having a longitudinal axis and being connected to the mandrel support;

a roller head structure having at least one movably supported roller housing supporting a roller, with the roller being configured to act on the workpiece when the workpiece is received by the mandrel;

an axial feeder configured to drive the roller head structure in the axial direction of the longitudinal axis of the mandrel;

a radial feeder configured to drive the at least one movably supported roller housing in the radial direction of the longitudinal axis of the mandrel; and

a frame, the frame supporting the axial feeder and the mandrel support;

wherein the build-up system is a system separated from the lathe and wherein the frame is fixed to the lathe, wherein the machine bed supports the frame, and

wherein the frame is fixed to the machine bed of the lathe at at least one first support position and at at least one second support position spaced apart from the at least one first support position in the axial direction of the longitudinal axis of

the mandrel, wherein at least a portion of the mandrel extends between the at least one first support position and the at least one second support position with regard to the axial direction of the longitudinal axis of the mandrel.

33. The flow forming apparatus of claim 32, wherein the roller head structure comprises a roller head structure frame movably supporting the at least one movably supported roller housing, wherein the roller head structure frame is configured to bear radial forces of a flow forming process for which the flow forming apparatus is to be used.
34. The flow forming apparatus of claim 32, wherein the base body further comprises a headstock connected to the machine bed, and wherein the mandrel is supported by the headstock.
35. The flow forming apparatus of claim 33, wherein the roller head structure frame is supported by the machine bed.