

12 **EUROPEAN PATENT APPLICATION**

21 Application number: **81101479.4**

51 Int. Cl.³: **B 24 B 19/02, B 24 B 41/06**

22 Date of filing: **02.03.81**

30 Priority: **05.03.80 GB 8007400**

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43 Date of publication of application: **09.09.81 Bulletin 81/36**

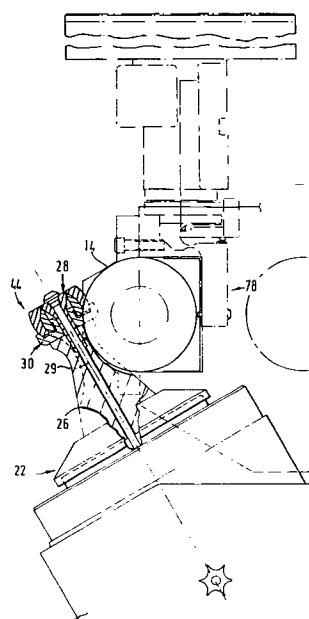
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84 Designated Contracting States: **AT DE FR GB IT SE**

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54 **An improved method of grinding, grinding machine, and mechanism for clamping a workpiece in position.**

57 The invention is concerned with the machining of longitudinal ball tracks into the inner joint members of universal joints. A workpiece for the joint member is clamped in position by clamping mechanism of a spindle mechanism (22), by which a split collet (38) is opened into interior engagement with the workpiece, pulling the workpiece onto an annular base surface (32) and into engagement with internally curved surface portions (35) provided by resilient fingers, which engage with the exterior surface (82) of the workpiece. In this position, the longitudinal axis (LA2) of the joint member coincides with the longitudinal axis (LA1) of the spindle mechanism. The spindle mechanism (22) is then moved arcuately about a further axis (LA3) relative to a rotating grinding wheel (14) so that the grinding wheel effects machining of one of the ball tracks of the member. Subsequent to retraction of the grinding wheel, the spindle mechanism (22) is rotated about its longitudinal axis (LA1) to present to the grinding wheel (14) another surface portion of the joint member, and another ball track is machined into the workpiece.



Title: An improved method of grinding, grinding machine,
and mechanism for clamping a workpiece in
position.

Description of the Invention

5 This invention is concerned with improvements
relating to grinding, in particular to the grinding of
parts for universal joints of the kind (hereinafter
referred to as being of the kind specified) comprising an
inner joint member provided on an outer surface thereof
with a number of circumferentially-spaced, longitudi-
nally extending ball tracks in the form of grooves, an
outer member provided on an inner surface thereof with a
similar number of circumferentially-spaced, longitudi-
15 nally extending ball tracks, also in the form of grooves
and torque-transmitting balls, each located in and opera-
tive between a ball track of the inner member and a
corresponding ball track of the outer member, portions at
least of the tracks of the inner member being curved in
20 the longitudinal direction.

In the provision of a universal joint of the kind
specified with constant velocity ratio characteristics,
means is provided, when the inner and outer members are
articulated, to retain the balls in a common plane which
25 bisects the longitudinal axes of the inner and outer
joint members. Such means may be afforded by a cage for
the balls which is operative between the inner surface of
the outer member and the outer surface of the inner
member, said inner and outer surfaces being curved about
30 centres which lie, when the inner and outer joint members
are aligned, equal distances on opposite sides of the
centre of the joint.

In another arrangement, such means is afforded by the tracks of the outer member being curved in the longitudinal direction, the centres of curvature of the tracks in the inner member and the tracks in the outer member lying, when the inner and outer members are aligned, on the longitudinal axis of the joint equal distances on opposite sides of the centre of the joint. In such a construction, a cage is advantageously, but not necessarily provided, but which need not be functional in the provision of the universal joint with constant velocity ratio characteristics.

The present invention has been devised primarily for the grinding of the ball tracks in the inner members of universal joints of the kind specified, but it is to be appreciated that the invention may be useful in similar fields where analogous problems arise.

In a conventional method of grinding the ball tracks in the inner joint member of a universal joint of the kind specified, the member is mounted on a spindle, with the longitudinal axis of the member extending at right angles to the spindle axis, and the centre of curvature of the ball tracks coincident with the spindle axis. The member is so mounted that it can alternately be clamped in position and indexed or rotated about its longitudinal axis. The outer surface portion of the member is presented to a rotary grinding wheel and the spindle is rotated about its longitudinal axis, thus machining two ball tracks, one each side, into the inner joint member. On completion, the grinding wheel is moved clear of the member and the member is indexed about its longitudinal axis and again clamped, and an adjacent surface portion of the member is presented to the grinding wheel for the grinding of further ball tracks. These operations are repeated until all the required ball tracks (usually six) have been machined into the inner joint member.

Conventionally in such an operation, a grinding wheel of some 600 mm in diameter is used. This allows metal to be removed quickly and smoothly from the joint member, with speedy dispersal of the heat which is generated. However, the construction and arrangement which is necessarily employed imposes limitations on the size, and hence the robustness and accuracy of the indexing mechanism. Since the accuracy of the spacing of the ball tracks in the inner joint member is necessarily dependent upon the accuracy of operation of the indexing mechanism, heretofore the tolerances to which the ball tracks have been provided in the inner joint members of universal joints of the kind specified have been greater than are in theory desirable. The large tolerance with which ball tracks in such joint members have heretofore been provided, has resulted in the universal joint having performance characteristics which have been lower than has been desired. This is particularly true in universal joints of the kind specified, having constant velocity ratio characteristics.

It is one of the various objects of this invention to provide a method of grinding the ball tracks of the inner member of a universal joint of the kind specified, by which higher accuracy in the spacing of the ball tracks around the joint member may readily be obtained.

According to this invention there is provided a method of grinding the ball tracks of an inner joint member for a universal joint of the kind specified, in which the joint member is mounted on a spindle mechanism with the longitudinal axis of the spindle mechanism coinciding with the longitudinal axis of the joint member, and the spindle mechanism is moved arcuately about a further axis relative to a rotating grinding wheel so that the grinding wheel effects machining of one of the ball tracks of the member, subsequent to which the

spindle mechanism is rotated about its longitudinal axis to present to the grinding wheel another surface portion of the joint member, for the machining of a further ball track.

5 The grinding wheel which will be used will advantageously be as large as can be accommodated without unduly detracting from the rigidity of the spindle mechanism upon which the inner member is mounted. Thus
10 the grinding wheel will usually be much smaller than has previously been used in conventional methods as hereinbefore described. Thus, preferably the diameter of the grinding wheel is less than 250 mm., and preferably less than 175 mm.

15 The invention may be utilised in the provision of ball tracks, the centre of curvature of which is spaced from the longitudinal axis of the joint member.

20 However, where the centre of curvature of the ball tracks lies on the longitudinal axis of the joint member, said further axis about which the spindle mechanism is arcuately moved passes through said centre of curvature, and extends at right angles to the longitudinal axis of the spindle mechanism.

25 Desirably the grinding wheel is initially advanced linearly into a position for engagement by the joint member, subsequent to which the spindle mechanism is moved about said further axis through an arc which is sufficient to enable the full length of a ball track to be machined into the joint member. Advantageously the grinding wheel is advanced linearly in small increments,
30 the spindle mechanism being oscillated subsequent to each advance, to cause the ball track to be machined to a progressively increasing depth.

Subsequent to completion of the machining of the ball track, the grinding wheel is disengaged from the joint member, and the spindle mechanism is rotated about its longitudinal axis to enable an adjacent surface portion of the joint member to be presented to the grinding wheel for the machining of a further ball track. Disengagement between the grinding wheel and the joint member may be effected, either by retracting the grinding wheel linearly from the joint member, or by increasing the arc of oscillation of the spindle mechanism to carry the joint member away from the grinding wheel, or both.

Subsequent to completion of machining of all the desired ball tracks, the grinding wheel can be retracted to a position separated further from the spindle mechanism, to provide clearance for the unloading and loading of another workpiece to be machined.

The invention is most advantageous in the provision of inner joint members for use in universal joints of the kind specified, having constant velocity ratio characteristics, since it is in such joints that accuracy of manufacture is most desired. Thus, where the ball tracks of the inner and outer joint members are intended to afford the universal joint with constant velocity ratio characteristics, the axis about which the spindle mechanism is moved during grinding of each ball track will be off-set from that point which, when the inner joint member is assembled with the outer joint member in the provision of a constant velocity ratio universal joint, corresponds to the centre of the joint.

It will be appreciated that the invention may be utilised in the provision of the curved portions of ball tracks which in addition comprise portions which are not curved, or which are not curved about the same centre.

This invention also provides a grinding machine for the machining of ball tracks in the inner joint members for universal joints of the kind specified and comprising:

- 5 (a) a spindle mechanism;
- (b) means to enable the inner joint member of a universal joint of the kind specified to be mounted on the spindle mechanism with the longitudinal axis of the joint member
10 coinciding with the longitudinal axis of the spindle mechanism;
- (c) the grinding wheel mounted in a position such that a grinding surface thereof is adjacent to the joint member when so mounted on the
15 spindle mechanism;
- (d) the spindle mechanism being mounted for movement about a second axis coincident with the axis of curvature of a ball track to be provided in that surface portion of the joint
20 member which is adjacent to the grinding surface of the grinding wheel;and
- (e) indexing mechanism operative intermittently to rotate the spindle mechanism about its longitudinal axis by a desired fraction of a
25 revolution.

Preferably the grinding wheel is mounted for translatory movement between a retracted position and an advanced position, and the indexing mechanism is operative to rotate the spindle mechanism only when the
30 grinding wheel is fully disengaged from the joint member being machined. Thus, with a surface portion of the joint member presented to the grinding surface of the grinding wheel, the grinding wheel may be moved to its advanced position, prior to movement of the spindle

mechanism about said second axis. Such movement of the grinding wheel into its advanced position may bring the grinding surface into grinding relationship with the joint member, machining of the ball track being completed by movement of the spindle mechanism about said second axis.

Preferably the second axis passes through the longitudinal axis of the spindle mechanism at right angles thereto, and preferably the grinding wheel is mounted for such translatable movement, in a direction in which the axis of rotation of the grinding wheel moves along a line which intersects the point of intersection of the longitudinal and said second axis of the spindle mechanism.

Preferably, the spindle mechanism comprises a clamping mechanism so constructed and arranged as to clamp an inner joint member to be operated upon by the machine, in a position in which the centre of curvature of the ball tracks coincides with the second axis. Preferably such clamping mechanism comprises a support member, providing a base surface lying in a plane extending at right angles to the longitudinal axis of the spindle mechanism, and a clamping device to clamp the back face of the joint member against the base surface.

Preferably the support member comprises means to ensure axial alignment of the joint member with the longitudinal axis of the spindle mechanism, said means advantageously comprising a surface which is internally curved, against which the exterior surface of the joint member may seat when the back face thereof is clamped against the base surface of the support member. Conveniently, said internally curved surface is conical and abuts tangentially the exterior surface of the joint member.

5 Preferably, said curved surface is interrupted at positions corresponding to those in the exterior surface of the joint member at which the ball tracks are or are intended to be provided, the support member thus affording a number of surface portions, which together afford said means to ensure axial alignment of the joint member.

10 The construction of the support member is such as to permit limited movement of said surface portions relative to the longitudinal axis of the spindle mechanism, as may be necessary to accomodate any small intolerances in the dimensional accuracy of the exterior surface of the joint member.

15 Preferably the clamping mechanism is operative to engage an interior part of the joint member, such as a surface within the interior bore of the joint member, or an upper, exterior surface of the joint member.

20 It will be appreciated that the clamping mechanism described in the last preceding five paragraphs may be used to advantage in the clamping of an inner joint member for a universal joint of the kind specified, to enable a machining operation to be carried out on the joint member, other than a machining operation of the kind hereinabove described.

25 Thus, according to another aspect of this invention there is thus provided a clamping mechanism for an inner joint member for a universal joint of the kind specified, comprising:

30 (a) a support member providing a base surface which lies in a plane disposed around, and at right angles to, a longitudinal axis of the clamping mechanism, and which comprises a plurality of

resilient fingers extending radially outwardly, each finger providing a surface portion facing generally towards said longitudinal axis;

5 (b) a clamping device mounted on said longitudinal axis and comprising:

10 (i) a clamping member mounted for limited movement along the longitudinal axis and having clamping portions capable of being moved radially outwardly of the longitudinal axis from inner to outer positions;

15 (ii) operating mechanism to effect such movement of the clamping member;

the construction and arrangement being such that with the clamping portions in their inner positions, such an inner joint member may be placed in engagement with the support member, whereby the operating mechanism may effect
20 firstly radial outward movement of the clamping portions into engagement with an interior part of the joint member, and secondly longitudinal movement of the clamping member to clamp the back face of the joint member against the base surface of the support member, engagement
25 between the surface portions of the fingers and exterior surface portions of the joint member serving to ensure substantial alignment between the longitudinal axis of the joint member and the longitudinal axis of the clamping mechanism.

30 The resilience of the fingers may be no more than is necessary to accommodate for dimensional inaccuracy in the exterior surface of the joint member, and may be such as to permit movement of said surface portions by (for example) 0.05mm.

Preferably said surface portions are curved about a centre lying on said longitudinal axis, conveniently about a point which coincides with the centre of curvature of the exterior surface of the joint member, when said exterior surface is part spherical, when said back face is clamped in position against the base surface of the supporting member.

Conveniently the clamping member is afforded by a split collet.

There will now be given a detailed description, to be read with reference to the accompanying drawings, of a method of grinding the ball tracks of the inner joint member of a universal joint of the kind specified, and a machine for carrying out the method, and clamping mechanism for clamping the joint member in position during the grinding operation, which are preferred embodiments of this invention and which have been selected to illustrate the invention by way of example.

In the accompanying drawings:-

FIGURE 1 is a sectional view of a constant velocity ratio universal joint, the ball tracks of which are machined by the use of the machine;

FIGURE 2 is a side elevation of the machine which is the preferred embodiment of the invention, spindle mechanism thereof having been omitted for the purposes of clarity;

FIGURE 3 is a front elevation of the machine;

FIGURE 4 is an enlarged side elevation, showing the relationship between the spindle mechanism and grinding mechanism of the machine;

FIGURE 5 is a plan view of a workpiece location ring of the spindle mechanism;

FIGURE 6 is an enlarged side elevation, showing clamping mechanism of the spindle mechanism;

FIGURE 7 is a view showing the clamping mechanism in a release position; and

5 FIGURE 8 is a view showing the clamping mechanism in a clamping position.

10 The machine which is the preferred embodiment of this invention is a twin-head grinding machine, and is adapted for the grinding of ball tracks in inner members of universal joints of the kind specified, specifically of the kind shown in Figure 1 of the drawings, and is particularly adapted to operate on two such joint members simultaneously. The machine comprises a bed 6 upon which grinding mechanism 8 is mounted. The grinding mechanism 15 8 comprises a drive motor 10, and a belt drive 12 for each of the two spaced grinding wheels 14, which are preferably from 75mm to 115mm in diameter. The grinding mechanism is mounted for horizontal sliding movement across the bed 6 between a retracted position (shown in dotted lines in Figure 4) and an advanced position, as 20 shown in full lines in the drawings.

25 Also mounted on the bed, spaced on either side of the grinding mechanism, are two journal bearings 16 which have a common longitudinal axis LA3 which lies in a horizontal plane in which the axes of rotation of the grinding wheels 14 also lie. Extending between journal bearings 16, for rocking movement about the common axis thereof, is a cranked arm 18. One end portion of the arm 18 is connected to driving mechanism 20, adapted to 30 effect a controlled rotation of the arm 18 about the common axis of the bearings 16.

Mounted on a central portion 19 of the arm 18 for rotation about respective longitudinal axes LA1 are two spindle mechanisms 22, each of said axes passing through the point of interception of the common axes LA3 of the journal bearings 16, and the line of movement of the centre of rotation of one of the grinding wheels 14 between its retracted and advanced positions.

Each of the spindle mechanisms 22 is carried by an indexing mechanism 66 (not shown in detail), adapted under automatic or operator control to rotate its associated spindle mechanism 22 through a portion of a revolution.

Each spindle mechanism 22 comprises a clamping device 24, adapted to clamp a workpiece in a position in which the longitudinal axis LA2 of the workpiece is coincident with the longitudinal axis of the spindle mechanism, and in which the centre of curvature C of the ball tracks to be machined is coincident with the point of interception of the common axes of the bearings 16, and the line of travel of the centre of the associated grinding wheel 14. Thus, the clamping mechanism comprises a workpiece supporting device 26, upon which the workpiece may be positioned, and a clamping device 28 adapted firmly to clamp the workpiece against the supporting device.

The workpiece supporting device 26 comprises a base portion 29, to an upper surface of which a support member 30 is secured, said support member 30 providing a flat, annular base surface 32 which lies in a plane disposed around, and at right angles to, the longitudinal axis of the clamping mechanism, and a plurality of resilient fingers 34 extending radially outwardly (see Figure 5), each finger providing a curved, inwardly facing surface 35 (see also Figure 7). The surfaces 35 lie in a cone,

and are arranged to be engaged tangentially by the outer surface 82 of the joint member, when clamped in position.

5 The clamping device 28 comprises a clamping member afforded by a split collet 38, having clamping portions 40 which are capable of limited radial outward movement from the position shown in Figure 7. The collet 38 is mounted for limited movement along the longitudinal axis of the clamping mechanism, an inner end of the collet being carried by a mounting member 42, which is urged
10 into an upper position by compression springs 44 (see Figure 6).

The base portion 29 of the workpiece supporting device 26 is secured to a cylindrical sleeve 60, which is secured in position against axial movement but which is
15 rotatable about the longitudinal axis on bearings carried by an outer casing 64.

The clamping mechanism comprises an operating mechanism 46, which comprises an operating member 48 which extends axially through the collet 38. At an outer end
20 portion, the operating member is provided with a head 50, beneath which there is provided an enlarged portion 53 which provides a frusto-conical outer surface 51, a flat annular surface 52 being provided beneath the head. At its inner end, the operating member 48 is secured to an
25 upper end of a hollow piston-like element 56, which is urged downwardly (Figure 6) by a powerful spring 58.

The machine also comprises twin dresser units 78, adapted to retain the grinding surface of the two grinding wheels in a condition with a desired surface profile.

5 The machine which is the preferred embodiment of
this invention is specifically adapted for use in the
machining of ball tracks 80 in the outer surface 82 of
the inner joint member 84 of a constant velocity
universal joint of the kind illustrated in Figure 1 of
the drawings. In such a joint, the ball tracks 80 (of
which there are six) are uniformly spaced around the
circumference of the inner member, and are curved in the
longitudinal sense about an axis which is situated on the
10 longitudinal axis of the joint member. In cross-section,
the ball tracks 80 are of "gothic arch" cross-section, so
that contact between the ball tracks and the torque
transmitting balls is linear. It will however be appreciated that the ball tracks 80 may of any desired cross-
15 section.

In the performance of the invention, with the grind-
ing mechanism in its retracted position, a workpiece for
an inner joint member 84 is mounted on the workpiece
support member 30 of each of the spindle mechanisms 22,
20 and is clamped thereon, in a position in which the
longitudinal axis LA2 of the workpiece coincident with
the longitudinal axis LA1 of the spindle mechanism in
each case.

25 This is accomplished, in the case of each spindle
mechanism, by firstly admitting fluid under pressure
beneath the hollow piston-like element 56, to cause said
element to move upwardly against the action of the com-
pression spring 58, so that the enlarged portion 53 of
the operating member 48 moves out of the collet 38,
30 allowing the clamping portions 40 of the collet to move
inwardly, by virtue of the resilience of the collet, as
is shown in Figure 7. The diameter of the outer edge 41
of the collet is in this position slightly less than the
inner diameter of the joint member 84, allowing the joint
35 member to be placed on the support device 26, into a

position in which the outer surface 82 of the joint member seats against the curved surfaces 35 of the fingers 34. In this position, the base 85 of the joint member will be separated a slight distance from the base surface 32 of the support device 26.

The fluid under pressure applied to the element 56 is then released allowing the compression spring 58 to move the element, and hence the operating member 48, downwardly. Initially, the frusto-conical surface 51 of the operating member 48 engages a complementarily-flared surface 39 of the collet 38 in an outward direction, the angle of said surfaces, and the relative strengths of the springs 44 and the spring 58 being such as to retain the collet in its upper position until the enlarged portion 53 of the operating member 48 completely enters the cavity between the clamping portions 40 of the collet as is shown in Figure 8, with the clamping portions 40 of the collet firmly engaging an inclined surface on the interior of the joint member.

Thereupon, further downward movement of the operating member 48, by virtue of the engagement of the flat annular surface 52 of the head 50 against the collet, causes the collet to be drawn downwardly against the action of the springs 44, pulling the joint member 48 towards the base surface 32 of the supporting device, causing the fingers 34 to flex open slightly until the base 85 of the joint member is seated against the base surface 32 of the support device. Thus, the position of the joint member on the longitudinal axis is determined by engagement of the base 85 with the base surface 82, whilst the position of the centre of the joint member is determined by the engagement of the outer surface 82 with the curved surfaces 35 of the fingers 34.

By the use of the arrangement described above, it has been found that the joint member may be located and retained in a desired position, to an accuracy of 0.005 or better.

5 With the arm 18, and consequently the spindle mechanisms 22 and indexing mechanisms 66, in a first position (shown in Figure 4) the grinding mechanism is advanced, from its retracted position into a contact position in which the grinding wheels which are rotating at a
10 suitable speed, engage the workpiece. The driving mechanism 20 is then operated to rotate the arm 18 about the common axis LA3 of the journal bearings 16 through an angular rotation of 80° , and is then returned, causing the grinding wheels 14 each to traverse its associated
15 workpiece. The grinding wheels are then advanced incrementally, and the 80° oscillation is repeated, until the grinding wheels reach their fully advanced positions, when the ball tracks will be machined to the required
20 depth. With the grinding mechanism in its fully advanced position, the arm 18, and consequently the workpiece, spindle mechanisms 22 and indexing mechanisms 36, are moved through a further 30° to disengage the workpieces from the grinding wheels, and the grinding mechanism is retracted to its position slightly rearwardly of its
25 contact position.

 The indexing mechanism 66 is then operated to rotate both of the spindle mechanisms through 60° , involving a rotation of the sleeves 60 and thus the element 56, and the clamping mechanism 24 about their respective longitudinal axes LA1, causing further surface portions of the
30 workpieces to be presented to the grinding wheels 14, preparatory to the grinding of further ball tracks in the two workpieces.

The support arm 18 is again oscillated about its pivotal axis, and the grinding mechanism is again incrementally advanced from its contact position to its fully advanced position, in the machining of a further ball track in each workpiece, at which point the workpieces are disengaged from the grinding wheels as before.

On completion of machining of all six ball tracks in the workpiece, and on completion of full oscillation of the support arm to carry the workpieces from engagement with the grinding wheels, the grinding mechanism is moved to its fully retracted position to provide sufficient clearance to allow the workpieces to be removed from the spindle heads, to be replaced by fresh workpieces. This is accomplished by the application of fluid under pressure to the element 56, causing it to advance against the action of the compression spring 58. Initially both the operating member 48 and the collet 38 move upwardly from within the central bore of the joint member 84, whereupon the enlarged portion 53 of the operating member 48 moves from within the clamping portions 40 of the collet 38 allowing said clamping portions 48 to move slightly together under the resilience of the collet. The machined joint member 84 may then be removed from the supporting device, and replaced by a fresh blank to be operated on by the machine.

By the construction and arrangement of the machine which is the subject of this invention, the indexing mechanism, which causes rotation of the workpiece blank through a desired portion of a revolution between each machining operation, may be constructed sturdily and robustly. In particular, by the use of the clamping mechanism above described, a joint member may be secured in position with an accuracy which has heretofore only been achieved with considerable difficulty. Further, the

smallness of the grinding wheels 14 allows the spindle mechanisms 22 not only to hold their workpieces securely during the machining operation, but additionally allows precision indexing mechanism to be utilised. In this manner, the angular spacing of the ball tracks 40 of the inner joint member may be provided to an accuracy which has hitherto been difficult to obtain in automatically operating, volume-production machinery. The accuracy of the provision of the ball tracks of the inner member allows the universal joint to be assembled with notable lack of relative movement between the inner and outer members, without the provision of undue clamping forces. In this manner, the universal joint may operate more smoothly, more silently, with less frictional forces acting on the torque transmitting balls during articulation of the joint, which affords the universal joint with a longer life.

It will be appreciated that, whilst the clamping mechanism of the machine which is the preferred embodiment of this invention is particularly adept in the securing in position of the inner member of a universal joint of the kind specified during the performance of the described grinding operation, the clamping mechanism may be utilised for the securement of the joint member in position during other machining operations, and may be used to advantage in the securing in position of similar articles, where analogous problems arise.

Additionally it is to be appreciated that whereas the illustrative machine is a twin-head machine, the principles of this invention may be utilised in a single-head machine.

CLAIMS:

1. A method of grinding the ball tracks of an inner joint member for a universal joint of the kind specified, in which the joint member is mounted on a spindle mechanism (22) with the longitudinal axis (LA1) of the spindle mechanism coinciding with the longitudinal axis (LA2) of the joint member, and the spindle mechanism (22) is moved arcuately about a further axis (LA3) relative to a rotating grinding wheel (14) so that the grinding wheel effects machining of one of the ball tracks (80) of the member (84), subsequent to which the spindle mechanism (22) is rotated about its longitudinal axis (LA1) to present to the grinding wheel (14) another surface portion of the joint member, for the machining of a further ball track.
2. A method according to claim 1 wherein the centre of curvature (C) of the ball tracks (80) lies on the longitudinal axis (LA2) of the joint member (84), and said further axis (LA3) about which the spindle mechanism (22) is arcuately moved passes through said centre of curvature (C), and extends at right angles to the longitudinal axis (LA1) of the spindle mechanism.
3. A method according to claim 1 wherein the grinding wheel (14) is initially advanced linearly relative to the joint member into a position for engagement therewith, subsequent to which the spindle mechanism (22) is moved about said further axis (LA3) through an arc which is sufficient to enable the full length of the ball track (80) to be machined into the joint member, the grinding wheel (14) being advanced linearly in small increments, and the spindle mechanism (22) being oscillated subsequent to each advance, to cause the ball track to be machined to a progressively increasing depth.

4. A method according to any one of the preceding claims wherein subsequent to completion of the machining of the ball track, the grinding wheel (14) is disengaged from the joint member (84), and the spindle mechanism (22) is rotated about its longitudinal axis (LA1) to enable an adjacent surface portion of the joint member to be presented to the grinding wheel (14) for the machining of a further ball track.

5. A method according to claim 4 wherein disengagement between the grinding wheel (14) and the joint member (84) is effected by retracting the grinding wheel (14) linearly from the joint member.

6. A method according to one of claims 4 and 5 wherein disengagement between the grinding wheel (14) and the joint member (84) is effected by increasing the arc of oscillation of the spindle mechanism (22) to carry the joint member (84) away from the grinding wheel (14).

7. A grinding machine for the machining of ball tracks in the inner joint members for universal joints of the kind specified and comprising:

- (a) a spindle mechanism (22);
- (b) means (24) to enable the inner joint member (84) of a universal joint of the kind specified to be mounted on the spindle mechanism with the longitudinal axis (LA2) of the joint member coinciding with the longitudinal axis (LA1) of the spindle mechanism;
- (c) a grinding wheel (14) mounted in a position such that a grinding surface thereof is adjacent to the joint member when so mounted on the spindle mechanism;

the spindle mechanism being so mounted for movement about a second axis (LA3) coincident with the axis of curvature

of the ball track to be provided in that surface portion of the joint member which is adjacent to the grinding surface of the grinding wheel; and

(d) indexing mechanism operative intermittently to rotate the spindle mechanism (22) about its longitudinal axis (LA1) by a desired fraction of a revolution.

8. A grinding machine according to claim 7 wherein the grinding wheel (14) is mounted for translatory movement between a retracted position and an advanced position, and the indexing mechanism is operative to rotate the spindle mechanism (22) only when the grinding wheel (14) is fully disengaged from the joint member being machined.

9. A grinding machine according to claim 8 wherein the second axis (LA3) passes through the longitudinal axis (LA1) of the spindle mechanism at right angles thereto, and the grinding wheel (14) is mounted for such translatory movement in a direction in which the axis of rotation of the grinding wheel moves along a line which intersects the point of intersection of the longitudinal axis (LA1) and said second axis (LA3) of the spindle mechanism (22).

10. A grinding machine according to any one of claims 7, 8 and 9 wherein the spindle mechanism (22) comprises a clamping mechanism (24) so constructed and arranged as to clamp an inner joint member (84) to be operated upon by the machine in a position in which the centre of curvature (C) of the ball tracks (80) coincides with the second axis (LA3).

11. A grinding machine according to claim 9 wherein said clamping mechanism (24) comprises a support member (30) providing a base surface (32) lying in a plane extending at right angles to the longitudinal axis (LA1) of the

spindle mechanism, and a clamping device (28) to clamp the back face (85) of the joint member against the base surface.

5 12. A grinding machine according to claim 11 wherein the support member (30) comprises means (34, 35) to ensure axial alignment of the joint member with the longitudinal axis (LA1) of the spindle mechanism (22), said means comprising a surface (35) curved in to locate the exterior surface (82) of the joint member, and against
10 which said exterior surface of the joint member seats, when the back face (85) thereof is clamped against the base surface (32) of the support member (30).

13. A grinding machine according to claim 12 wherein said curved surfaces (35) is interrupted at positions
15 corresponding to those in the exterior surface of the joint member at which the ball tracks (80) are or are intended to be provided.

14. A grinding machine according to claim 13 wherein the construction of the support member (30) is such as to
20 permit limited movement of said surface portions (35) relative to the longitudinal axis (LA1) of the spindle mechanism, as may be necessary to accommodate any small intolerances in the dimensional accuracy of the exterior surface (82) of the joint member.

25 15. A grinding machine according to any one of claims 10 to 14 wherein the clamping mechanism (24) is operative to engage an interior part or exterior end face of the joint member.

30 16. A clamping mechanism for an inner joint member for a universal joint of the kind specified, comprising:

- (a) a support member (30) providing a base surface (32) which lies in a plane disposed around,

5 and at right angles to, a longitudinal axis (LA1) of the clamping mechanism, and which comprises a plurality of resilient fingers (34) extending radially outwardly, each finger (34) providing a surface portion (35) facing generally towards said longitudinal axis (LA1); and

(b) a clamping device (28) mounted on said longitudinal axis (LA1) and comprising:

10 (i) a clamping member (38) mounted for limited movement along the longitudinal axis and having clamping portion (40) capable of being moved radially outwardly of the longitudinal axis from inner to outer positions; and

15

(ii) operating mechanism (48, 50, 56, 58) to effect such movement of the clamping member (38);

20 the construction and arrangement being such that with the clamping portions (40) in their inner positions, such an inner joint member (84) may be placed in engagement with the support member (30), whereby the operating mechanism may effect first radial outward movement of the clamping portions (40) into engagement with part of the joint member, and secondly longitudinal movement of the

25 clamping member (38) to clamp the back face (85) of the joint member against base surface (32) of the support member (30), engagement between the surface portions (35) of the fingers (34) and exterior surface portions of the

30 joint member serving to ensure substantial alignment between the longitudinal axis (LA2) of the joint member and the longitudinal axis (LA1) of the clamping mechanism.

17. A clamping mechanism according to claim 16 wherein the resilience of the fingers (34) is such as to permit movement of said surface portions (35) by about 0.05 mm, in the use of the mechanism.

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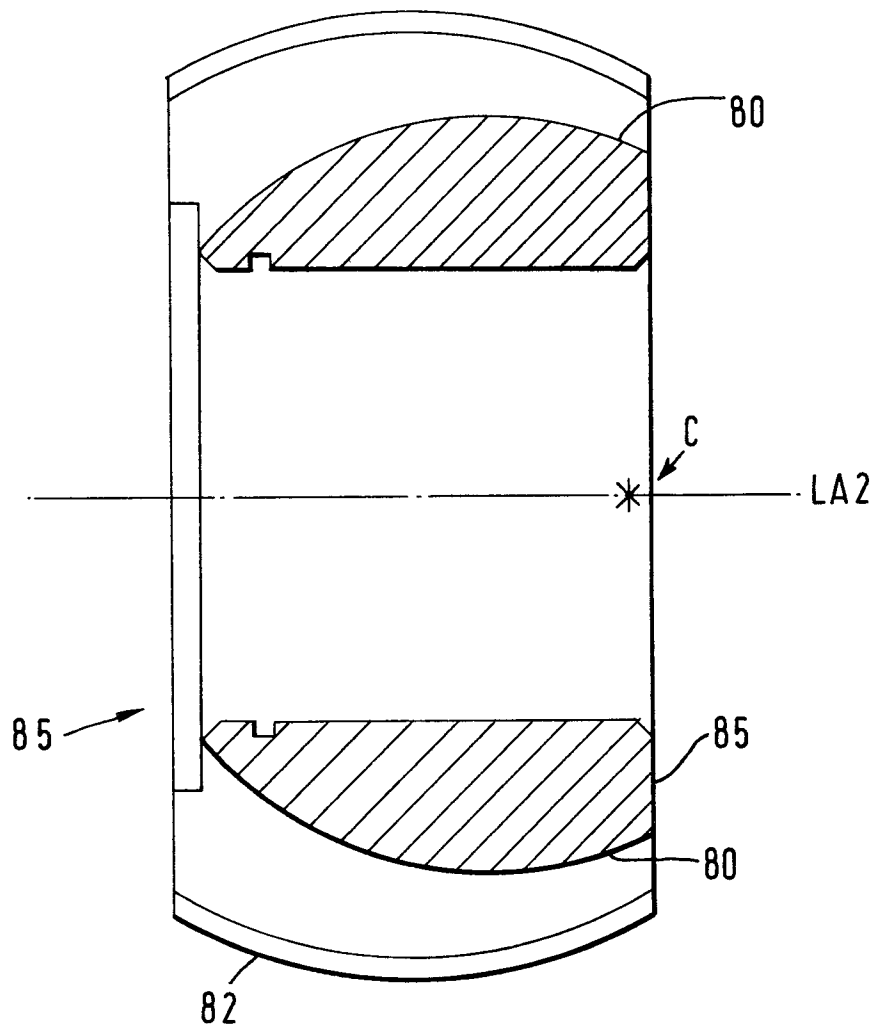


FIG. 1

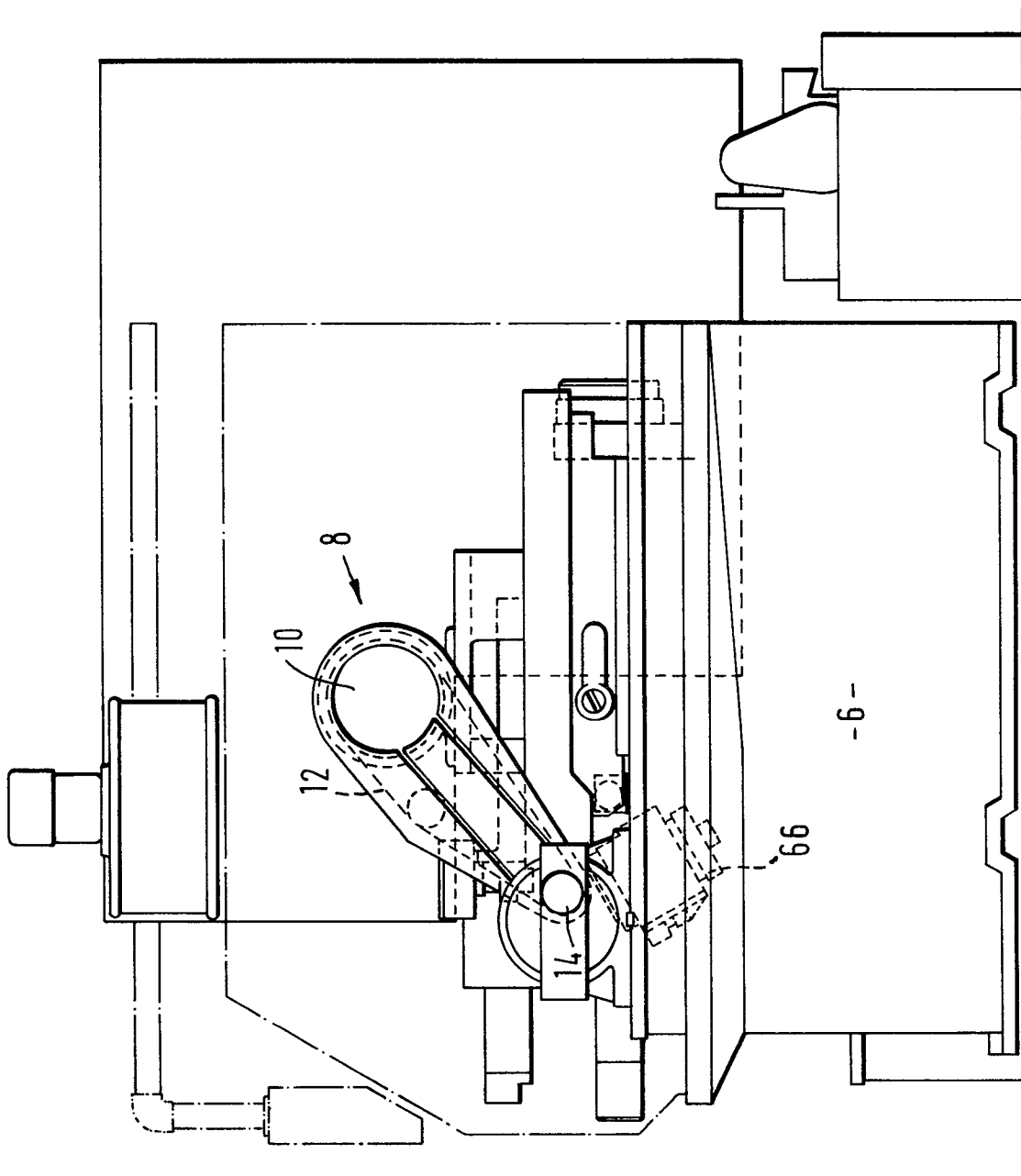


FIG. 2

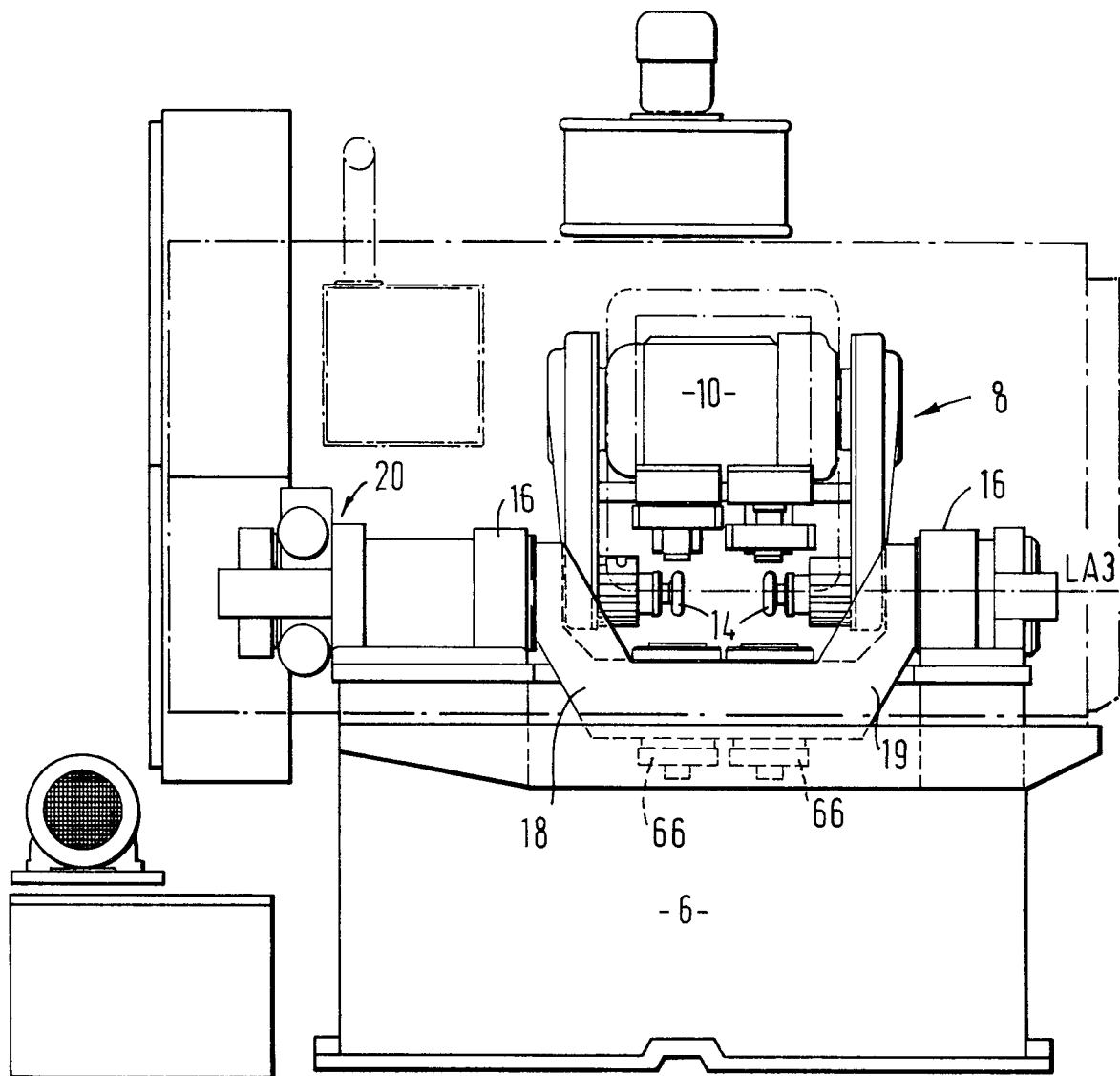


FIG. 3

