United States Patent

[11] 3,612,031

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[21] Appl. No. 741,130
[22] Filed June 28, 1968
[45] Patented Oct. 12, 1971
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[32] Priority Mar. 15, 1968
[33] Italy
[31] 807879

[54] **GRINDING WHEEL DRESSER**
7 Claims, 10 Drawing Figs.

[52] U.S. Cl. ..... 125/11 CC
[51] Int. Cl. B24b 53/00
[50] Field of Search 51/100; 125/11

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ABSTRACT: This invention relates to a machine tool for dressing a grinding wheel with a concave profile. The wheel is rotated and is reciprocated axially, and a cutting tool is moved radially relative thereto under control of an eccentric cam. The eccentric cam is rocked under control of the relative movement of the grinding wheel and the tool support by means of a linear inclined cam, which is preferably of adjustable inclination, to control the depth of the concave profile. The dressed grinding wheel may be used in an automatically cycling grinding machine for forming track surfaces of convex profile on bearing outer race rings.

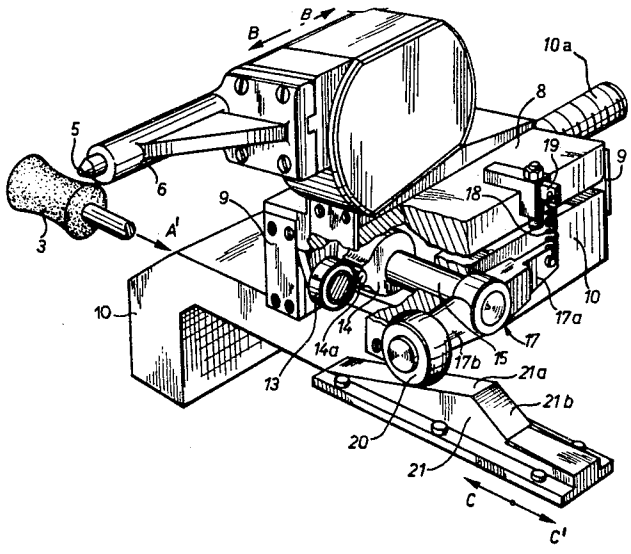


Fig_1

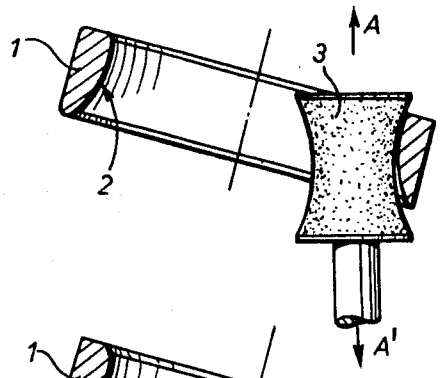


Fig_2

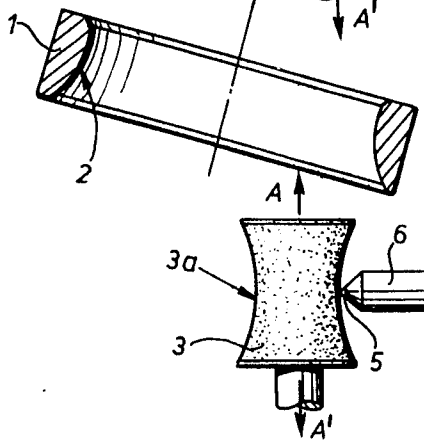


Fig_6

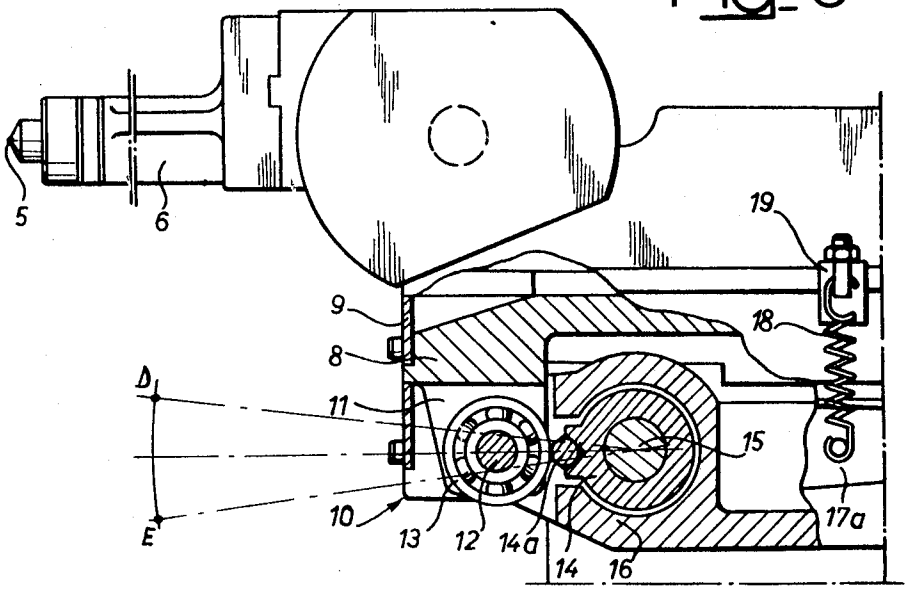


Fig.3

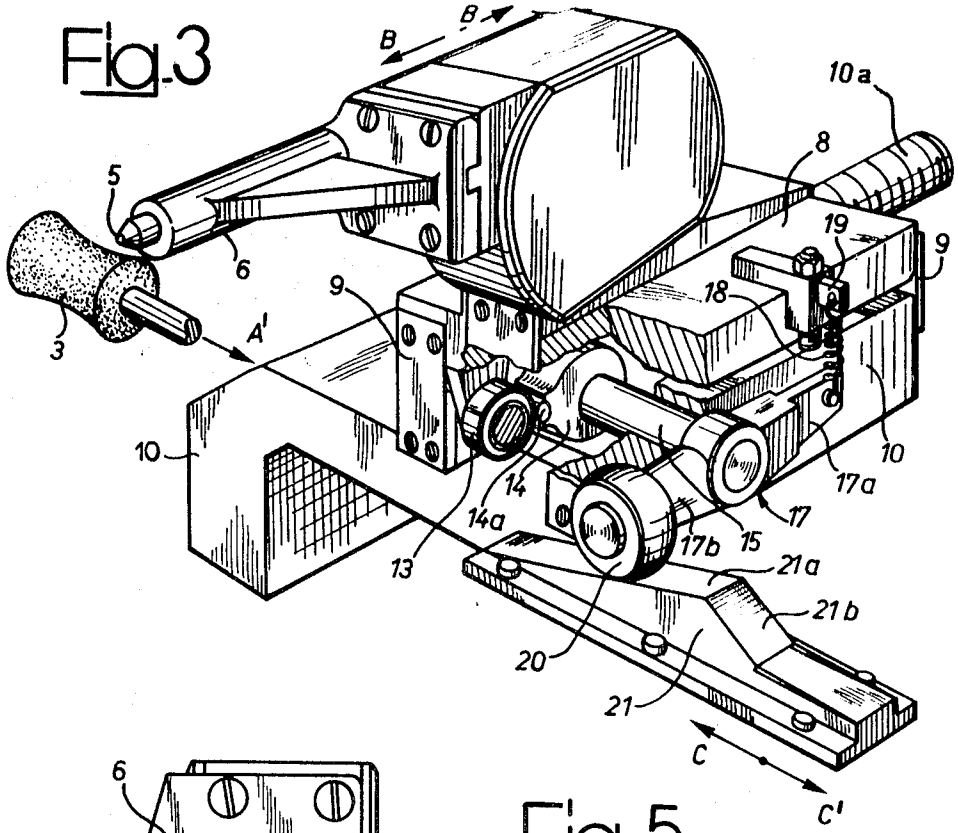

B
B
10a
8
5
6
19
9
18
9
A'
3
10
14
14a
13
17a
10
17
17b
15
21a
21b
20
21
C
C'

Fig.5

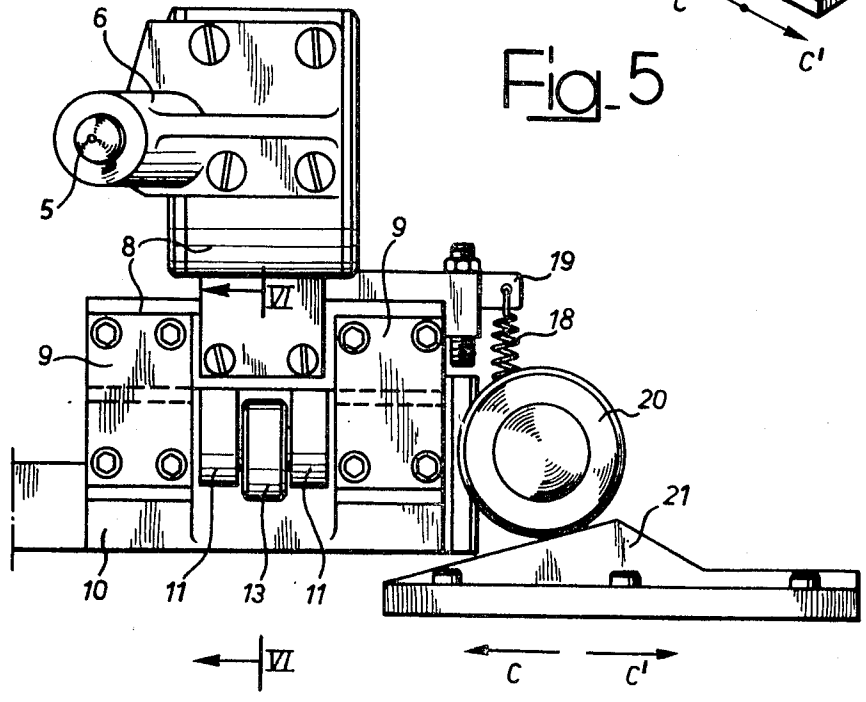

6
5
8
9
19
VI
18
9
20
21
10
11
13
11
VI
C
C'

Fig. 4

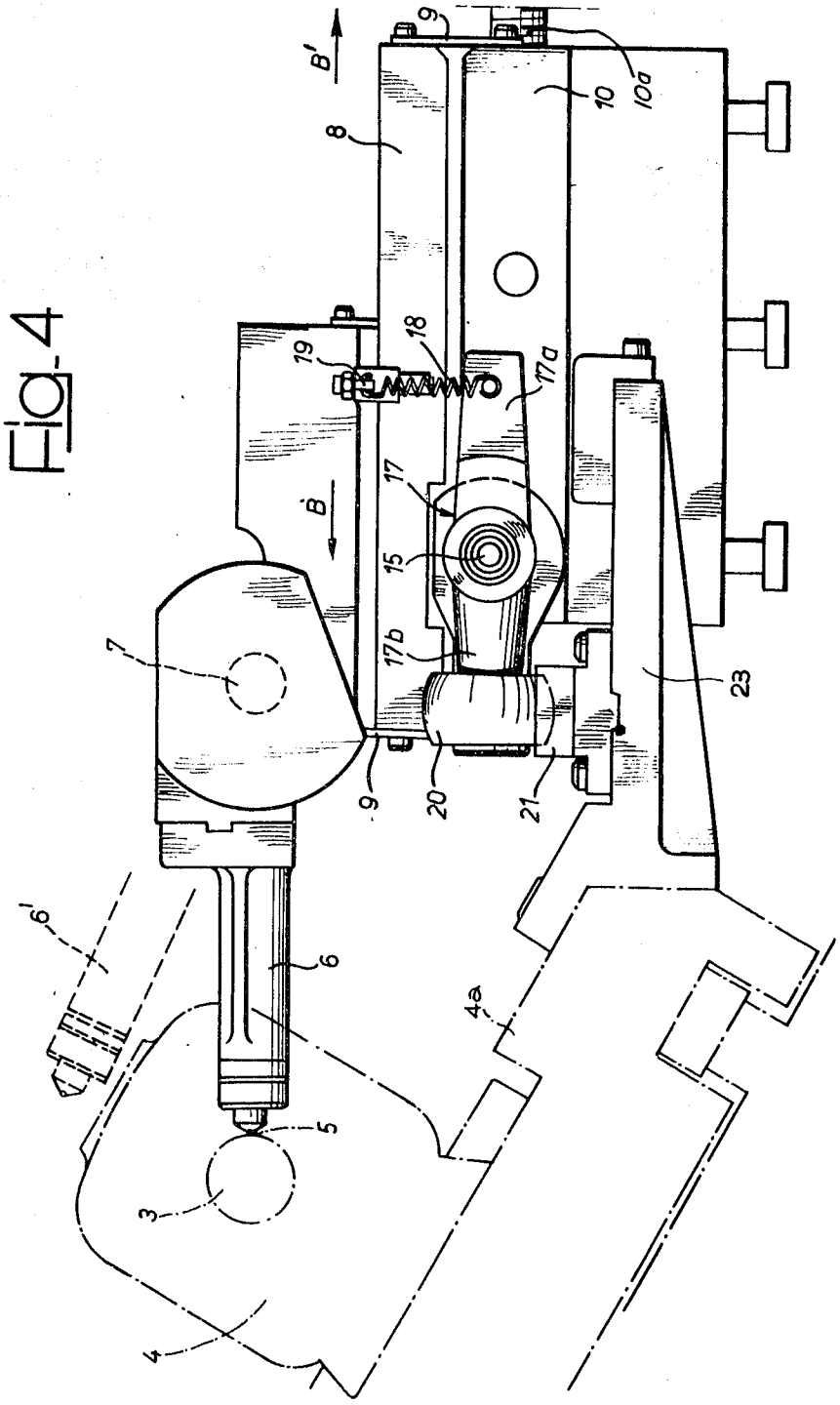


Fig. 7

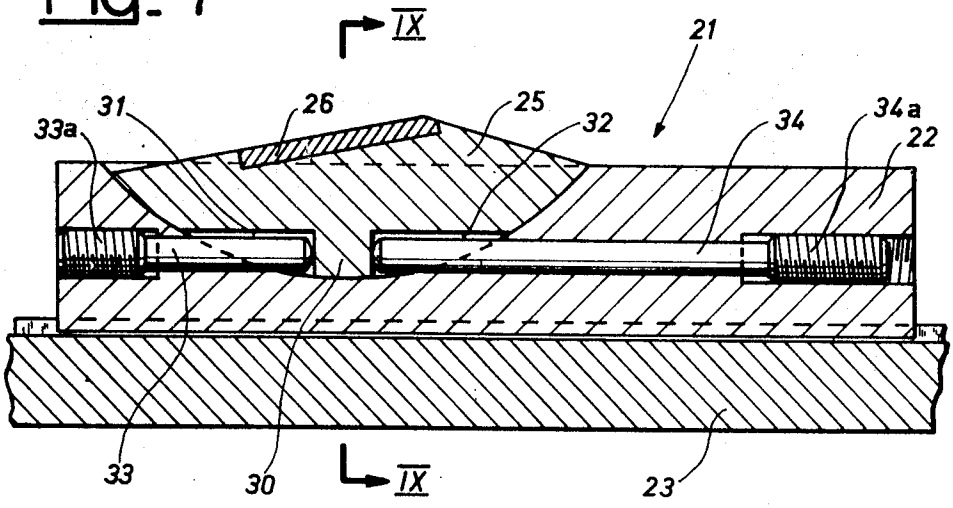

IX
21
31
26
25
32
34
34a
22
33a
33
30
IX
23

Fig. 8

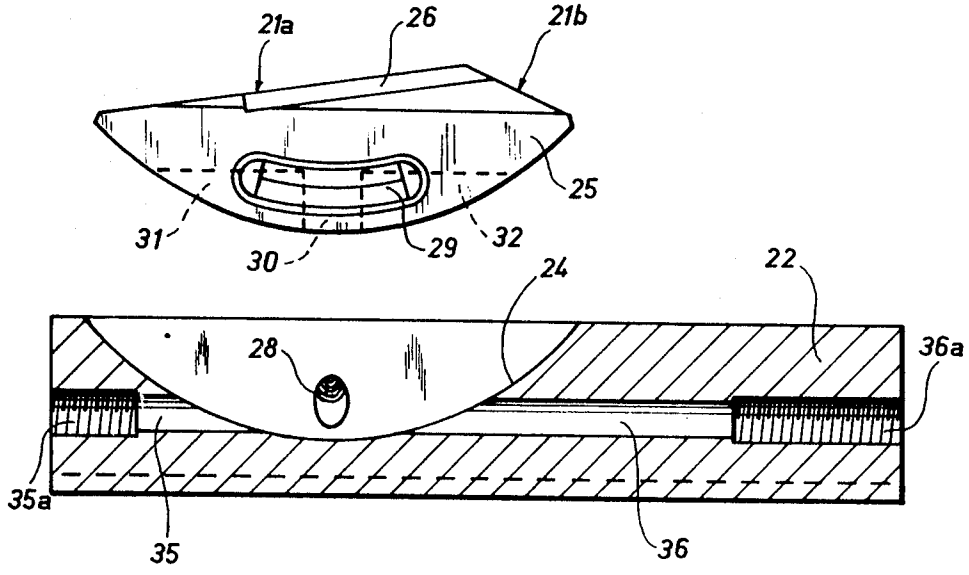

21a
26
21b
25
31
30
29
32
24
22
28
36a
35a
35
36

Fig. 9

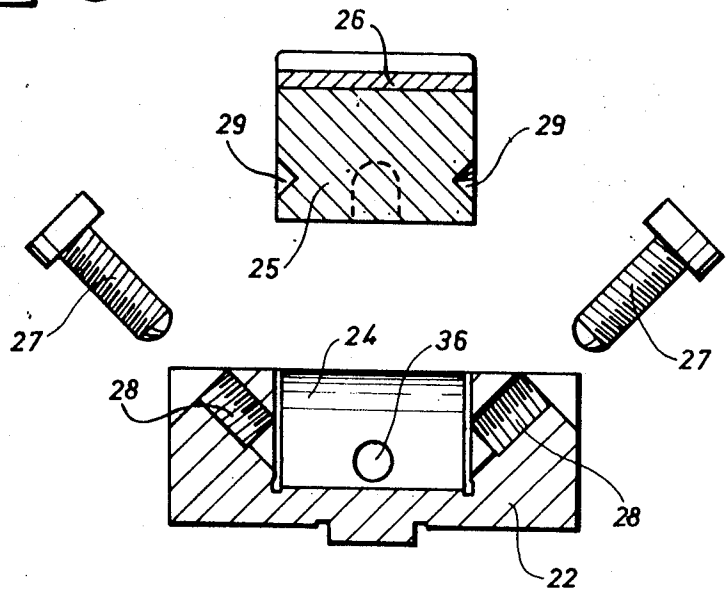
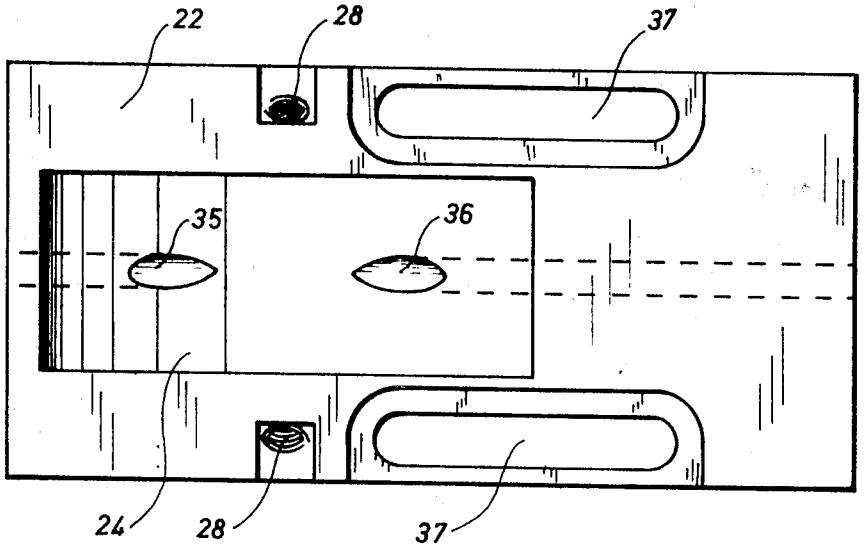


Fig. 10



GRINDING WHEEL DRESSER

This invention concerns improvements in or relating to machine tools, more particularly machine tools for dressing or trueing shaped grinding wheels.

In antifriction bearings, in particular conical or cylindrical roller bearings, it is known to make the track surfaces of the bearing outer race rings of slightly convex profile in axial cross section order to improve the efficiency and working life of the bearings and reduce the operational noise level thereof.

One method of forming such a convex profile on the track surface of an outer race ring is to grind the surface with a shaped grinding wheel having a concave profile in axial cross section, the grinding wheel being reciprocated in a direction parallel to its rotational axis or moved radially relative to the track surface, in a grinding machine operating in an automatic cycle.

For accurate machining of the convex profile of the rolling track surface to be ground the grinding wheel should be of an accurately controlled profile, which should be dressed or trued between successive cycles of the grinding machine. The present invention is particularly concerned with machine tools suitable for shaping such grinding wheels by trueing their profiles, for example, between roughing and finishing steps on a workpiece.

In general, the rolling track surface of a bearing race ring to be ground requires to have a very small convexity, the profile depth being typically of the order of a few hundredths of millimeter. The profile of the grinding wheel used to form such a surface must therefore be accurately controlled.

It is known, for example, from British Pat. No. 890,232 to employ a cam for controlling directly displacements of a cutting tool in a radial direction relative to a rotating grinding wheel, which is reciprocated along its rotational axis, the cam being fast with the grinding wheel holder. Movement of the cutting tool towards the grinding wheel is positively controlled by the cam, while movement of the tool away from the grinding wheel is controlled effectively by biassing springs which act urge a cam-follower into engagement with the cam.

Slight play between the various components of such an arrangement is unavoidable, leading to a region of discontinuity between the two sections of the resulting profile derived by movement of the tool respectively towards and away from the grinding wheel.

In general, in known arrangements, the profile of the cam is directly related to the profile required to be formed on the workpiece (i.e. the grinding wheel). Strictly accurate control of the profile of the workpiece is consequently not possible in practice owing to the difficulty of reproducing accurately on the cam the required profile, even on an enlarged scale.

With a view to avoiding these disadvantages this invention has as an object to provide a machine tool, suitable for use in trueing a shaped grinding wheel, of the type in which reciprocation of the workpiece along its rotational axis is combined with a displacement of a cutting tool along an axis perpendicular to the grinding wheel axis, in which the workpiece profile is controlled automatically with high accuracy, substantially unaffected by any play inherent in the machine tool assembly or resulting from wear of the machine tool components.

A further object of the invention is to provide a machine tool of the above-mentioned type in which any play may be taken up and in which the profile of the workpiece can be varied at will and easily by adjustment without entailing replacement of components.

According to the invention there is provided a device for dressing a generally cylindrical workpiece such as a grinding wheel to form a concave profile thereon, in which the workpiece is rotated about its axis and moved in a longitudinal direction parallel to its rotational axis, and a cutting tool is supported for movement into and out of engagement with the workpiece in a transverse direction perpendicular to said longitudinal direction, the transverse movement of the cutting tool being controlled by a linear cam, inclined to said longitudinal direction, which effects rocking movement of an eccentric cam in dependence on the movement of the workpiece, said eccentric cam in turn moving a carriage supporting said cutting tool in said transverse direction.

The invention also provides a machine tool comprising a workpiece holder for supporting a generally cylindrical workpiece for rotation about its axis, means for effecting relative linear movement of the workpiece holder and a carriage support in a longitudinal direction parallel to the axis of rotation of the workpiece, a tool-supporting carriage mounted on the carriage support for movement relative thereto in a transverse direction perpendicular to said longitudinal direction, spring means biassing the carriage relative to the support away from the path of relative movement of the workpiece holder and maintaining a cam-follower element mounted on the carriage in engagement with an eccentric cam mounted on a longitudinally extending shaft journaled in said support, a lever arm fixed to said shaft and carrying a roller which is maintained in contact with and adapted to roll upon a linear cam which is movable with the workpiece holder and inclined to said longitudinal direction, so that upon said relative linear movement of the workpiece holder and the tool support the eccentric cam is rocked through a dead center position with respect to the cam-follower element to effect controlled reciprocation of the tool-supporting carriage in said transverse direction.

The invention will be more clearly understood from the following description, given by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a diagrammatic plan view, partly in axial section, illustrating the grinding of the track surface of an outer race ring for a roller bearing, carried out on a grinding machine provided with a shaped grinding wheel dressed by means of a machine tool according to the invention;

FIG. 2 is a part-sectional diagrammatic plan view, corresponding to FIG. 1, illustrating the grinding wheel dressing step;

FIG. 3 is a partly cutaway diagrammatic perspective view of one embodiment of the machine tool according to the invention, in its preferred application as a grinding wheel dressing device;

FIG. 4 is a front view of the machine tool of FIG. 3;

FIG. 5 is a side view of said machine tool;

FIG. 6 is a cross-sectional view on an enlarged scale on line VI—VI of FIG. 5;

FIG. 7 is a longitudinal sectional view on an enlarged scale of a linear-operating cam assembly according to a modification of the embodiment of FIG. 3;

FIG. 8 is a part-sectional exploded side view of the cam assembly of FIG. 7;

FIG. 9 is an exploded cross-sectional view on line IX—IX of FIG. 7, and

FIG. 10 is a plan view of a detail of FIGS. 7, 8 and 9.

In the drawings the same reference numerals are used to indicate the same or like parts.

In FIGS. 1 & 2, an outer race ring 1 of a conical or cylindrical roller bearing has a substantially frustoconical rolling track 2 having a convex profile in axial section. In the drawing this convexity of the track profile is deliberately exaggerated for the sake of clarity; in practice the depth of the convex profile is of the order of few hundredths of a millimeter.

As shown in FIG. 1, the track 2 is ground by means of a shaped rotary grinding wheel 3 which during the grinding operation is reciprocated by a small constant extent parallel to its rotational axis in the direction A—A'. In axial cross section the profile 3a (FIG. 2) of the grinding wheel 3 is concave, being in the shape of an arc of smaller curvature than the convex profile of the track 2.

Upon completion of a roughing step before starting finishing grinding of the rolling track 2 the grinding wheel 3 is removed from engagement with the ring 1 (FIG. 2) and is dressed and checked in profile by means of a trueing tool comprising a diamond 5 which is secured to the end of a tubular toolholder 6. The diamond 5 is moved in a transverse direction B—B' perpendicular to the direction A—A' in a controlled manner as hereinafter described so that the com-

bination of the grinding wheel movement and the diamond movement causes the diamond 5 to cut the concave profile 3*a* in the grinding wheel 3.

The tubular toolholder 6 for the diamond 5 is mounted for oscillation about a horizontal pivot 7, indicated in broken lines in FIG. 4, and is movable by known means (not shown) from an inoperative position indicated by dash lines at 6' in FIG. 4 to an operative position shown in full lines, in which the diamond 5 contacts the grinding wheel 3.

The toolholder 6 and pivot 7 are mounted on a movable tool-supporting carriage 8 which is movable relative to a carriage support structure 10 in the transverse direction B—B'. The support structure 10 is mounted on the bedplate of the machine tool. The carriage 8 is supported from the support structure 10 by leaf springs 9 which bias the carriage 8 in the direction B' away from the grinding wheel 3.

A leadscrew 10*a* engages the support structure 10 for effecting transverse displacement thereof in the direction B in order to allow for wear of the grinding wheel 3.

The carriage 8 carries a fork 11 which supports stub shaft 12 extending longitudinally and carrying a cam-follower roller 13 freely rotatable thereon. The cam-follower roller 13 cooperates with an eccentric cam 14 keyed to a shaft 15 extending parallel with the longitudinal direction A—A' and journaled in a sheath 16 fast with the support structure 10.

The cam 14 has an eccentric portion 14*a* which comes into contact with the cam-follower roller 13 and which is constituted by a separately attached stud of hard material, such as tungsten carbide, having a very high wear resistance.

A transversely extending lever 17 is keyed to the free end of the cam shaft 15. The lever 17 has a first lever arm 17*a* which is engaged by a helical spring 18 attached to an anchorage 19 on the carriage frame 8, and a second, opposite, lever arm 17*b* carrying at its free end a roller 20 rotatable about a substantially transverse axis and adapted to roll on a linear-operating cam 21, the roller 20 being held in engagement with the cam 21 by the spring 18. The linear cam 21 moves with the grinding wheel 3, as indicated by arrows C—C'. The cam 21 is carried by a bracket 23 fast with a carriage 4*a* on which a holder 4 for the grinding wheel 3 is supported.

The linear cam 21 has a double ramp profile comprising a first portion 21*a* (FIG. 3) which is slightly inclined to the horizontal and a second portion 21*b* which is more steeply inclined to the horizontal in an opposite direction to the portion 21*a*.

As a result of the relative displacement of the linear cam 21 with respect to the support structure 10, the roller 20 rides over the first portion 21*a*, of the cam 21 and effects an angular displacement of the shaft 15 and therefore of the eccentric cam 14. The arrangement is such that the eccentric cam 14 rotates through an arc DE, exaggerated in FIG. 6, symmetrically disposed about the dead center position of the cam 14 relative to the cam-follower roller 13. Consequently the diamond 5 is moved in the direction B—B' towards and then away from the grinding wheel 3 as the latter moves longitudinally in the direction A—A'.

The combined transverse displacement of the diamond 5 in a direction B—B' and longitudinal displacement of the grinding wheel 3 in the direction A—A' effects shaping and dressing of the grinding wheel 3 to the desired concave profile 3*a*.

Upon completion of the dressing strokes of the diamond 5 the tool holder 6 is moved angularly about its pivot 7 to its inoperative position 6' to permit displacement of the grinding wheel holder 4 in the direction A to the working position of the grinding wheel 3 (FIG. 1).

According to a modification shown in FIGS. 7 to 10 the linear cam 21 is adjustable and comprises a plate 22 mounted on the bracket 23 fast with the carriage 4*a*, with provision for adjustment of the plate 22 in the longitudinal direction C—C' on the bracket 23. Thus the plate 22 is formed along its longitudinal edges with elongated slots 37 to permit said longitudinal adjustment of the plate 22 relative to securing bolts (not shown) on the bracket 23. In this way the position of the cam 21 relative to the roller 20 can be adjusted.

A sector-shaped member 25 is mounted for oscillation about a transverse axis in a part-cylindrical cradle 24 formed in the upper surface of the plate 22. The member 25 has a top double ramp profile comprising portions 21*a*, 21*b* as previously described. The less steep portion 21*a* of the profile is provided at its region which contacts the roller 20 with a reinforcing plate 26 of hard material. The member 25 is connected to the plate 22 by means of two inclined screws 27 (FIG. 9) which are screwed into two tapped holes 28 formed with opposite inclinations in the plate 22. The screws 27 engage at their inner ends in two respective arcuate recesses 29 (FIG. 8) of V-profile (FIG. 9) formed in the flanks of the member 25.

The curved surface of the member 25 is longitudinally milled to provide respective recesses 31, 32 separated by an intermediate wall 30 having opposite smooth faces which face in the longitudinal direction C—C' and which are acted upon by two opposite pushrods 33, 34 (FIG. 7) seated in respective longitudinal bores 35, 36 (FIG. 8) in the plate 22. The bores 35, 36 are coaxial and communicate with the respective recesses 31, 32. The rods 33, 34 are formed with screw-threaded portions 33*a*, 34*a* cooperating with corresponding tapped portions 35*a*, 36*a* of the bores 35, 36. By selectively screwing or unscrewing the rods 33, 34 in the bores 35, 36 the member 25 may be rocked about a transverse axis in the cradle 24 in order to vary the inclination of the linear cam portion 21*a* to the horizontal, and thereby vary the radius of curvature of the concave profile 3*a* formed on the grinding wheel 3.

With the above-described arrangement the dressing of the grinding wheel 3 is effected with high accuracy, since the displacement of the diamond 5 is totally unaffected by any play due to errors in assembly or wear of the components, and is controlled solely by the linear cam portion 21*a*.

Moreover, the linear cam 21 controlling the diamond displacement may be easily and accurately formed, as distinct from the shaped cams used in profile-copying arrangements.

The large effective transmission ratio of the arrangement affords, in effect, a high amplification of the profile 3*a* to be formed, that is to say, small adjustments of the profile 3*a* are effected by relatively large adjustments of the linear cam 21, permitting very fine control.

The machine tool may be used, moreover, for dressing cylindrical wheel by preventing rotation of the shaft 15 carrying the eccentric cam 14.

Finally, with the above-described machine too, the same profile 3*a* of the dressed grinding wheel 3 is repeated accurately, independently of the diameter of the wheel 3 and, therefore, independently of wear thereof.

What we claim is:

1. Machine tool comprising in combination:
   a. a workpiece holder adapted to support a generally cylindrical workpiece for rotation about its axis;
   b. a carriage support;
   c. means for effecting linear movement of the workpiece holder relatively to the carriage support in a longitudinal direction parallel to the axis of rotation of the workpiece;
   d. a tool-support carriage mounted on the carriage support for movement relative thereto in a transverse direction perpendicular to said longitudinal direction;
   e. spring means biasing the carriage relative to the support away from the path of relative movement of the workpiece holder;
   f. eccentric cam means mounted for rocking movement in the support about a longitudinally extending axis and effective to displace the tool-supporting carriage controllably relative to the support against the action of said spring means;
   g. a linear cam which is movable with the workpiece holder and inclined to the said longitudinal direction;
   h. a roller adapted to roll on said linear cam;

i. lever means supporting the roller and operatively connected to the eccentric cam to effect controlled rocking movement of the latter in dependence on the relative linear movement of the workpiece holder and the carriage support, thereby to effect controlled reciprocation of the carriage relative to the carriage support in said transverse direction, the linear cam comprising a cradle support, a sector-shaped member mounted in the cradle support for rocking movement about a transverse axis, means effective to adjust the angular position of the sector-shaped member in the cradle support to adjust the angle of inclination of the linear cam and hence the extent of reciprocation of the tool-supporting carriage, and locking means effective to lock the said member in its adjusted position relative to the cradle support.

2. Machine tool according to claim 1, wherein the means for adjusting the angular position of the sector-shaped member comprises two opposing pushrods, respective longitudinal bores in the cradle support in which said pushrods are mounted, and recesses in the curved surface of the sector-shaped member having opposite substantially longitudinally facing surfaces the rods having screw-threaded portions the bores being formed with cooperating tapped portions effecting longitudinal adjustment of the pushrods.

3. Machine tool according to claim 1, in which the locking means comprise respective screws, tapped holes in the cradle support receiving said screws on opposite sides of the sector-shaped member and respective arcuate recesses formed in said opposite sides of the sector-shaped member in which recesses respective said screws are engageable to lock the said member.

4. Machine tool according to claim 1 wherein said lever means is connected to said eccentric cam by a shaft mounted on said support for rocking movement about a longitudinal axis that is substantially parallel to said longitudinal direction.

5. Machine tool according to claim 1 wherein an eccentric cam follower element is mounted on said carriage in engagement with said eccentric cam.

6. Machine tool according to claim 1 wherein said spring means comprise a plurality of leaf springs supporting the carriage on the support.

7. Machine tool according to claim 5 in which the range of rocking movement of the eccentric cam corresponding to movement of the roller over the linear cam extends symmetrically on opposite sides of a dead center position with respect to the eccentric cam-follower element on the carriage.