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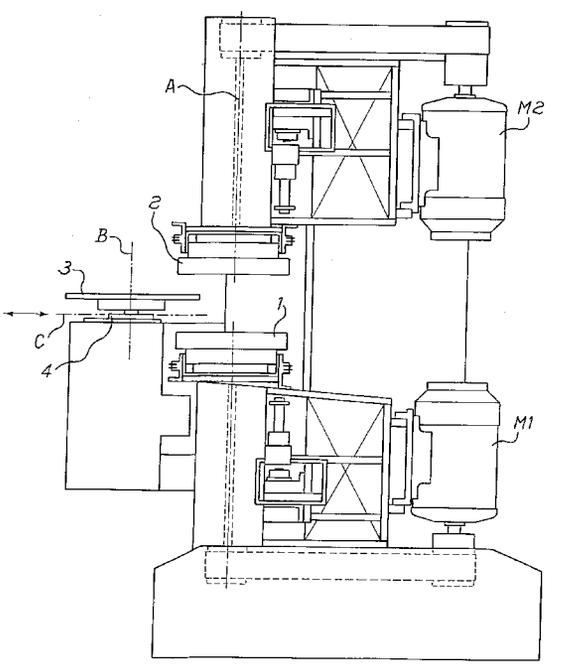
(54) Grinding machine with grinding wheels at variable distance.

(57) A grinding machine fitted with a control unit suitable to provide the displacement of one or more grinding wheels (1, 2) and with a mechanism (3, 5) for holding and feeding the workpieces (P), in which the grinding wheels (1, 2) are displaced with a feed which is interpolated, according to a programmable law, with the position of the said mechanism (3, 5) for holding and feeding the workpieces. It is consequently possible to obtain a very high precision in the machining of the workpieces, a lower and more regular wear of the grinding wheels and longer intervals between the wheel dressing cycles.

Fig.1



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The present invention is concerning the machines for grinding mechanical workpieces and specifically a grinding machine with the grinding wheels at a distance which is variable according to the position of the workpieces.

In the grinding of ferrous or ceramic workpieces and specifically for the finishing operation a so called "fine grinding" of those surfaces is needed for which a high accuracy is required.

For that purpose grinding machines are employed which remove from the workpieces a well established amount of material, usually called "stock" and provide surfaces whose tolerances in flatness, parallelism and size are within thousandths of millimeters.

There are several types of grinding machines, among which there are the well known "double head" or "duplex" grinders, fitted with two cup wheels of proper diameter and width, placed one against the other and carried by proper wheel spindles. In these machines the wheels are opposite but not necessarily coaxial, so that - in some cases - the active surfaces of the wheels are not parallel, rather usually converge in the direction the workpieces are fed through them during the grinding operation. These grinding machines are also fitted with mechanisms to hold the workpieces in proper seats and guide them in the path between the wheels, such a path and the displacement of the wheels being properly controlled.

In order to keep the wanted tolerances it is necessary to keep the geometry of the active surface (or "face") of the grinding wheels unchanged in spite of their unavoidable wear, which is done by reconditioning the wheels - by dressing the active surface - as much more frequently as the tolerance of the workpieces is small.

Particularly the known grinding machines are basically of two types and operate according to two principles known as "Diskus" and "Wendt".

The machines which operate according to the "Diskus" principle have the wheels in fixed position, with the active surfaces converging in the feed direction of the workpieces. The distance between the wheels can be set according to the thickness of the workpieces, which are usualy carried through the wheels by a rotary feed disc with proper seats.

The workpieces are guided along a fix path, which is an arc of a circle, from the point of entrance into the grinding wheels, usually wider, to a point of exit from the grinding wheels, usually narrower, the difference between the said two points usually being equal to stock to be removed.

These machines can operate with comparatively short grinding cycles and on comparatively large workpieces, but are showing large deformations of the face of the grinding wheels, due to their convergent positioning, which imposes frequent dressing cycles.

The machines which operate according to the "Wendt" principle on the opposite have parallel grinding wheels and the workpieces, placed on a holding-feed plate, are caused to oscillate with a radial displacement within or slightly outside the face of the grinding wheel whilst one or both wheels are fed and progressively grind the workpieces, basically at a constant feed rate, until the whole stock is removed.

These machines have comparatively long grinding cycles and may claim a small deformation of the face of the grinding wheels, which allows longer intervals between the dressing cycles.

The above mentioned two types of grinding machines may grind with good precision thanks to the way of handling the displacement of the grinding wheels and of the holding-feed mechanism of the workpieces.

Particularly in the second case (Wendt) wheels diplace along their axis and workpieces along an axis within the face of the wheels whereas in the first case (Diskus) the workpieces move along the periphery of the feed disc which rotates on its axis.

The present invention has the object of providing a grinding machine capable of handling high precision workpieces of any size, with short working cycles and mainly with minimum deformation of the geometrical characteristics of the wheels, which may be dressed at significantly long intervals.

The object is achieved with a grinding machine provided with a unit which controls one or more grinding wheels and with a mechanism for holding and feeding the workpieces, in which the grinding wheels are moved into a feed which is interpolated, according to a predeterminable law, with the position of the said mechanism for holding and feeding the workpieces.

In a preferred embodiment, such a grinding machine, fitted with variable-distance wheels, is of double head type and has the advantage of using parallel wheels to have a lower and more regular wear thereof.

The same machine offers the further advantage of being able to feed the workpieces according to a sosphisticated trajectory, as resulting from the interpolation of two linear motions or of a linear motion with a rotary motion, according to the way the hold-and-feed mechanism is activated. This characteristic, in conjunction with the variable feed of the grinding wheels, allows the machining by controlling the action at the same time over three axes.

It is consequently possible to effect a complex and articulated machining which is finally more precise.

These and additional advantages of a grinding machine according to the present invention will clearly appear from the following, detailed description of two preferred embodiments made with reference to the attached drawings where:

FIGURE 1 is a side view of the grinding machine

according to the present invention in a first embodiment;

FIGURE 2 is a top view of the machine according to Figure 1;

FIGURE 3 is a top view, similar to Figure 2, of the machine according to a different embodiment;

FIGURE 4 is a diagram showing the operative principle of the machine of Figures 1 and 2; and

FIGURE 5 is a diagram showing the operative principle of the machine in Figures 1 and 3.

Fig. 1 shows that the grinding machine according to the present invention substantially includes two cup wheels 1, 2 mounted on an axis A and driven by the respective motors M1 and M2 through a belt transmission. They can be reciprocally approached through known drives, preferably operated by an electronic unit (not shown) which accomplishes a numerical control.

The machine moreover includes a feed disc 3 parallel to and partly interposed between the grinding wheels 1 and 2, mounted on a slide 4. The disc may rotate on an axis B, parallel to the axis A, whereas the slide may move along a third axis C, perpendicular to the said axes A, B. The feed disc 3 is the holding fixture for the workpieces which are set in proper seats (not shown), preferably at the periphery of the disc and are fed between the wheels 1, 2 over a path resulting from the composition of the rotary motion of the feed disc 3 with the displacement of the slide 4, as better explained later on.

The rotation of feed disc 3 and the displacement of slide 4 are controlled through well known and not shown drivers, by the said numerical control unit: consequently the full operation of the machine is based on the combination of the said movements, as obtained by entering a well determined interpolation among the drive mechanisms of wheels 1, 2 of feed disc 3 and of slide 4.

Fig. 2 is a top view of the same grinding machine which is showing the rim i.e. the active surface of the cup wheel 2, overlapping the periphery of feed disc 3. It is clear that the displacement along axis C of the disc-slide assembly modifies the overlapping of the active edge of the wheels in respect of the periphery of the feed disc where the seats for the workpieces are located.

Fig. 3 is a top view of a different accomplishment of a machine according to the present invention. In this case the feed part is a plate 5 which is mounted on a slide 4', shown by dotted lines, similar to the one described in the previous case.

Such a slide may translate, driven by known systems, along two orthogonal axes D and E on a plane which is parallel to and intermediate between the wheels of the machine or, preferably, it may translate along axis D only which corresponds to axis C of the former case. The workpieces are -set in proper seats (not shown) of plate 5 in the overlapping area, feed being effected along a path resulting from the combination of two linear motions or along just one axis, as better explained later on. The displacement over one or two axes of slide 4', is effected with known drivers (not shown) by the said numerical control unit in which, also in the case, a well determined law is entered to effect the interpolation of the motions of two or three involved axes.

With reference to Fig. 4 there is seen that a workpiece P, laying into a seat over the periphery of the feed disc 3 according to Fig. 1, moves along a path which was pre-set through the combined movements of the feed disc and is guided through the wheels to be finally touched by them. The said combined movements of the feed disc originate from the interpolation of its rotary motion with the linear motion of its center over axis C. In the particular case shown, the workpiece P follows the path which is schematized by twelve subsequent positions corresponding to a full swing of the rotation center of the feed disc between the given extreme positions CR1, CR2. Obviously such a displacement is guided by the numerical control unit and its amplitude depends upon the kind of grinding desired for workpiece P, upon its size and the width of the active face of wheels 1, 2.

Fig. 4 also shows on top a diagram D1 which is schematizing (with three characteristics lines CC1, CC2 and CC3) three possible ways of feeding the cup wheels 1, 2 with the numerical control unit of the machine. Actually the grinding action of wheels 1, 2 takes place between a position X, where the contact between each wheel and the corresponding side of the workpiece P starts, and an end position Y, where the stock removal is completed. It is consequently possible to obtain a constant action of the wheels (characteristic line CC2) whereby to constant displacements of the workpiece correspond equal feeds of the grinding wheels 1, 2 and consequently constant stock removals.

It is on the opposite possible to obtain a greater feed of the wheels in the initial phase of the contact with the workpiece (characteristic line CC1), in order to remove 3/4 of stock in the first half of the feed of the wheels, or - vice versa - to impose to the wheels a greater feed in the second part of cycle (characteristic line CC3) in order to remove 3/4 of stock during the second half of the stroke of the wheels.

Obviously it is possible to enter in the numerical control unit of the machine any kind of law for the wheel feed, in accordance with the needs of the grinding operation to be performed. This flexibility in the action of the grinding machine according to the present invention may particularly be profited to remove more stock from the workpiece with the outer rim of the cup wheels than with the inner rim where the wear is higher and the wheel is more easily damaged.

With final reference to Fig. 5 it may be seen an

example of controlled feed on one axis of the machine shown by Fig. 3. Actually a workpiece P is schematically shown as being in a proper seat of plate 5, which is mounted on the slide previously described and is moving along axis C of the machine from a position ES1 to an extreme position ES2 and back to ES1. This kind of displacement is shown by seven successives positions of the workpiece which, between the second and the sixth position, travels between the grinding wheels 1, 2.

In this case the workpiece P is fed through numerical control of the motion on axis C only, whereas in the former case both axes B and C were controlled, such a feed being however interpolated with the feed of the grinding wheels 1, 2.

Clearly it is also possible to move the plate by controlling it over two axes, preferably orthogonal, along which the slide can move, thus obtaining a path of the workpiece as resulting from the combination of two linear displacements.

Fig. 5 is also showing diagram D2 which schematically makes clear again the main feature of the grinding machine according to the present invention.

Actually it is seen, for example, that the feed of the wheels 1, 2 may be programmed according to the characteristic line shown in the diagram to obtain that more than 3/4 of the stock be removed between the second and the third positions shown. Thus most of the necessary effort is observed by the outer rim of each wheel.

It is clear that, even in this case, the interpolation between the displacement of plate 5 (possibly over two axes) and the feed of grinding wheels 1, 2 (over axis A) may be entered in the numerical control unit according to the feature of the machining to perform the operation in the best manner.

It is obvious that a variable wheel feed connected with the position of the workpieces, no matter how they are fed, can be employed in any grinding machine with one or more grinding wheels, particularly in the "double head disc grinders" in which one wheel may displace on its axis and the other one may be in fix position.

All mechanical parts of the grinding machine according to the present invention may be of any known type, provided they are suitable, whereas the numerical control may be performed, for example, by a microprocessor which might handle at the same time the combined displacements along three axes. It is theoretically possible to assume that the displacements along three axes be, wholly or partially, even mechanically performed.

Claims

1. A grinding machine fitted with a unit suitable to control the displacement of one or more grinding wheels (1, 2) and of a mechanism (3, 5) for holding and feeding workpieces (P), characterized by the fact that the wheels (1, 2) are moved with a feed which is interpolated according to a preset law with the position of the said workpiece (P) hold and feed mechanism (3, 5).

2. A machine according to claim 1, characterized by the fact that it is fitted with two parallel and opposite cup wheels (1, 2) rotating on an axis (A), at least one of which may also move along the said axis (A).

3. A machine according to claim 2, characterized by the fact that the holding and feeding mechanism for the workpieces (P) is a feed disc (3) rotatable about a second axis (B) parallel to the said axis (A) and capable of moving along a third axis (C) between the wheels (1, 2) and perpendicular to the said axes (A, B).

4. A machine according to claim 2, characterized by the fact that the holding and feed mechanism for the workpieces (P) is a plate (5) suitable to move along two perpendicular axes (D, E) in a plane which is parallel to the wheels (1, 2) and is interfering with them.

5. A machine according to claim 2, characterized by the fact that the holding and feed mechanism for the workpieces (P) is a plate (5) parallel to the wheels (1, 2) capable to move along an axis (C) between the wheels and perpendicular to the said axis (A).

6. A machine according to claim 2, characterized by the fact that the holding and feed mechanism (3, 5) for the workpieces (P) is mounted on a slide (4) capable to move parallel to the wheels (1, 2) along one axis (c) or along two perpendicular axes (D, E).

7. A machine according to anyone of the preceding claims, characterized by the fact that the control unit is electronic and performs an interpolated numerical control on the mechanisms driving the grinding wheels (1, 2), and on the one (3, 5) for holding and feeding the workpieces (P).

Fig.1

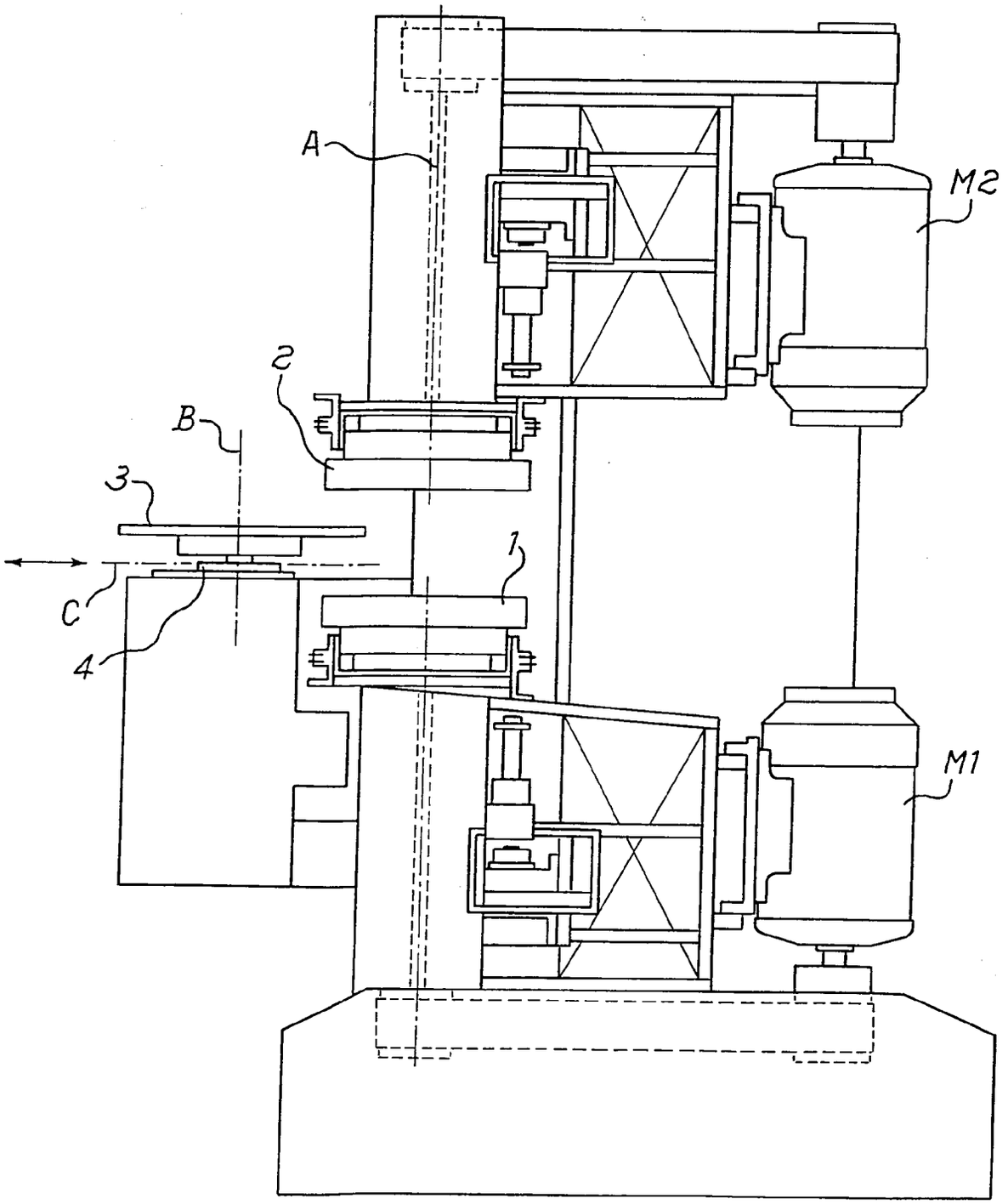


Fig.2

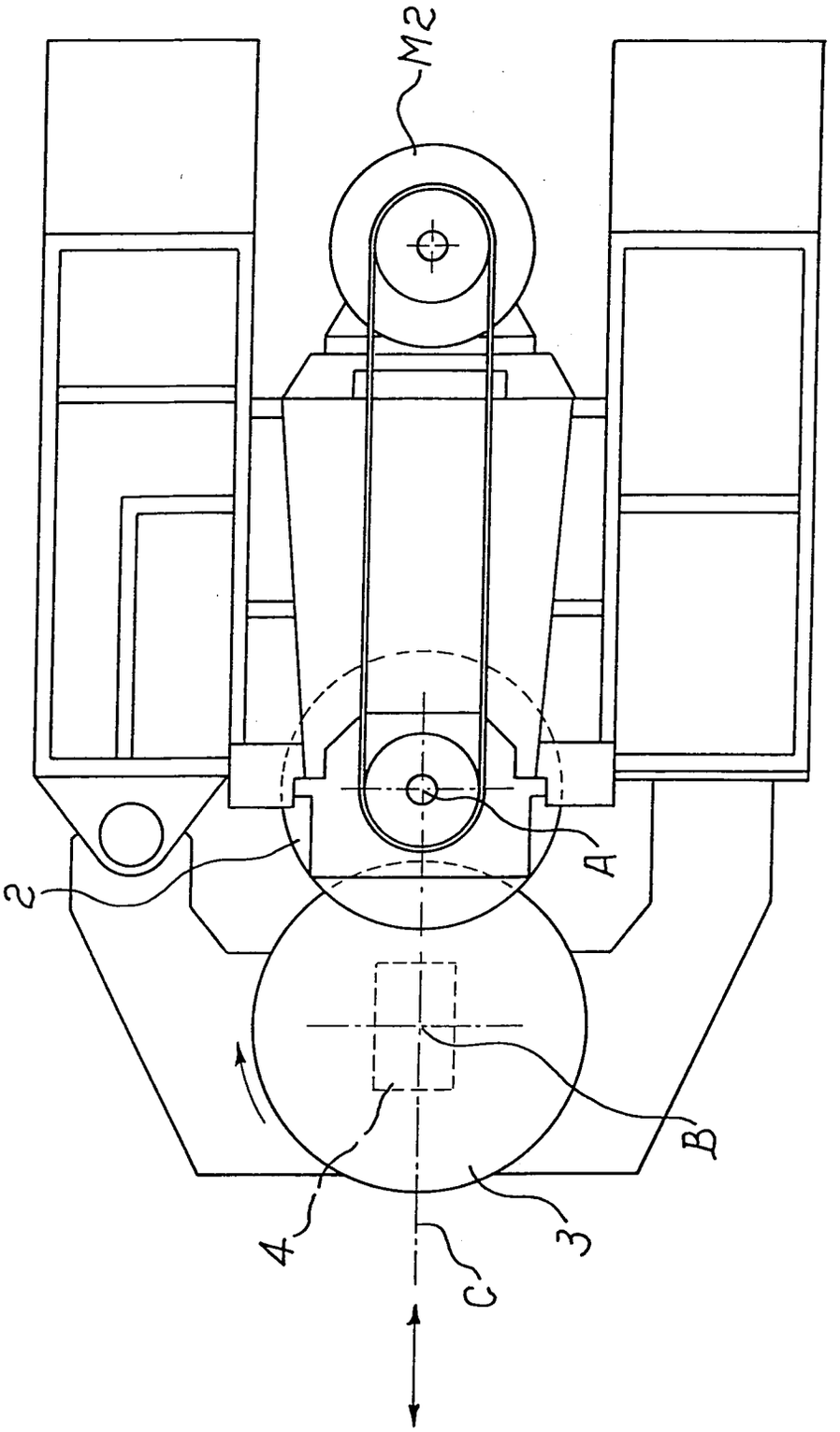


Fig.3

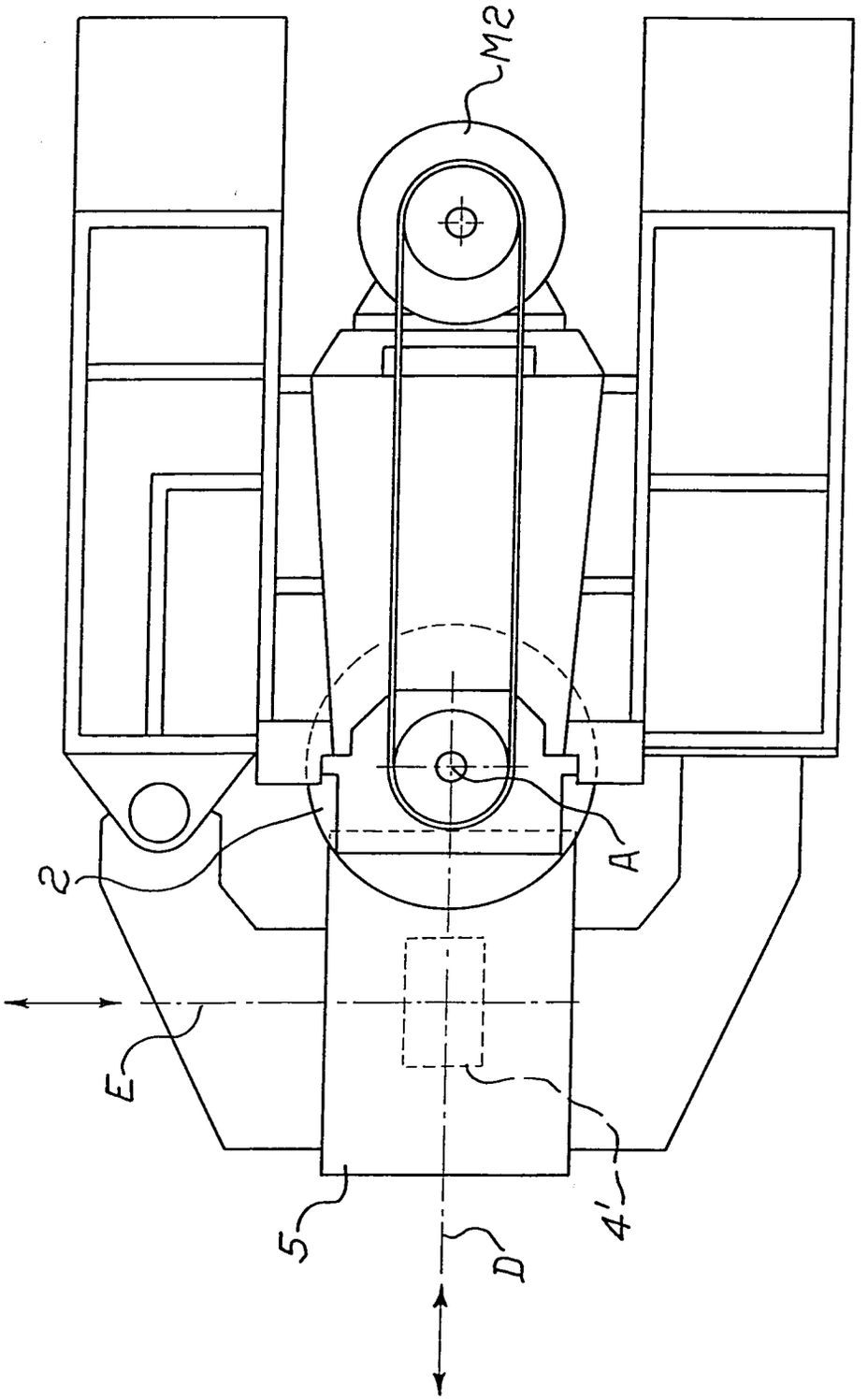


Fig.4

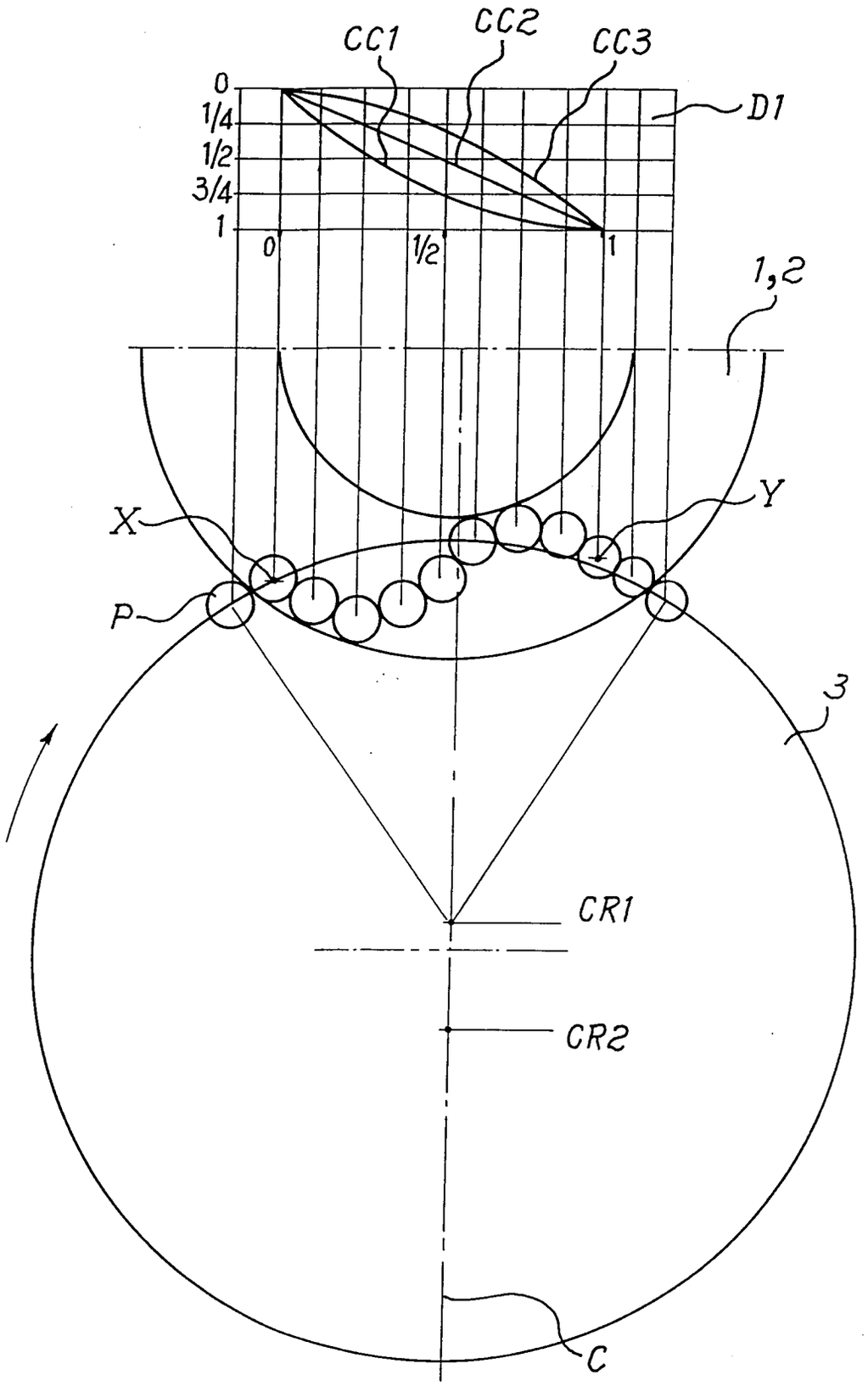
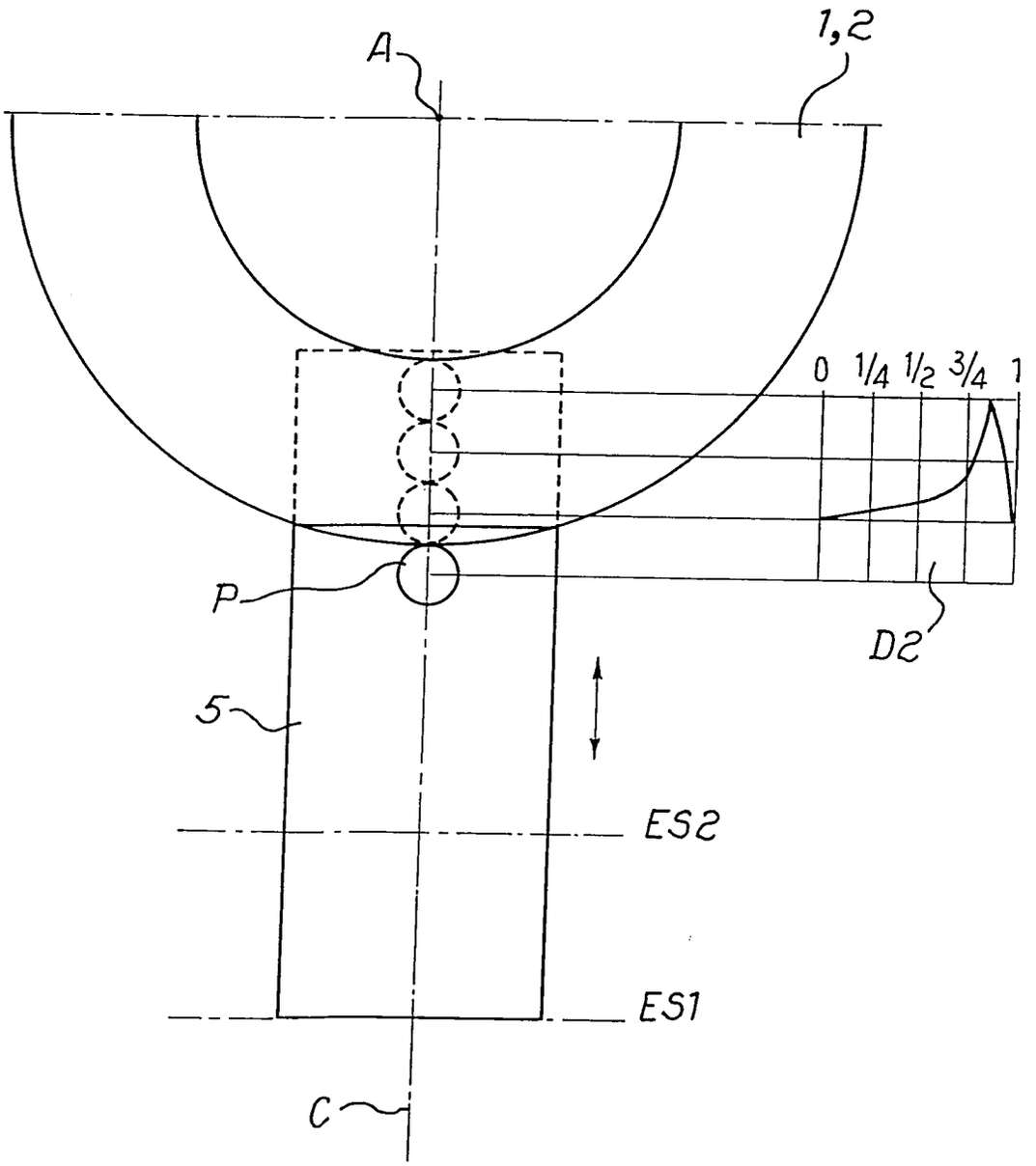


Fig.5



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EUROPEAN SEARCH REPORT

Application Number
EP 93 83 0171

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X Y	DE-A-1 752 268 (K. MENGELE & SÖHNE) * page 2, line 15 - page 3, line 10; figure 1 *	1 2,3,6	B24B7/04 B24B7/17
Y	DE-A-2 419 249 (CONE- BLANCHARD MACHINE CO.) * figures 1,2 *	3,6	
Y	EP-A-0 421 350 (ASAHI GLASS CO. LTD.) * column 3, line 39 - column 7, line 45; figures 1-8 *	2,3,6	
A	WERKSTATT UND BETRIEB vol. 121, no. 2, February 1988, MüNCHEN, DE pages 127 - 131 G.WERNER ET AL 'Steuerungskonzepte für das Schleifen' * page 128, right column, line 33 - line 37 *	7	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			B24B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	05 OCTOBER 1993	WUNDERLICH J.

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