

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 675 780 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
12.08.1998 Bulletin 1998/33

(51) Int. Cl.⁶: **B24B 19/12**, B24B 21/00,
B24B 27/00

(21) Application number: **94902880.7**

(86) International application number:
PCT/GB93/02569

(22) Date of filing: **16.12.1993**

(87) International publication number:
WO 94/14571 (07.07.1994 Gazette 1994/15)

(54) WORKPIECE GRINDING APPARATUS AND METHOD

WERKSTÜCKSCHLEIFVORRICHTUNG UND WERKSTÜCKSCHLEIFVERFAHREN

APPAREIL ET PROCEDE DE MEULAGE DE PIECES A USINER

(84) Designated Contracting States:
**AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL
PT SE**

(30) Priority: **23.12.1992 GB 9226845**
15.03.1993 GB 9305245

(43) Date of publication of application:
11.10.1995 Bulletin 1995/41

(73) Proprietor:
WESTERN ATLAS U.K. LIMITED
Aylesbury, Buckinghamshire HP20 2RQ (GB)

(72) Inventors:
• **COVERDALE, Stephen Roger,**
Spring Hill
Nr Bradford, West Yorkshire DB18 1ND (GB)

• **GRAYSTON, Granville**
r Keighley, West Yorkshire BD20 7DS (GB)

(74) Representative:
Nash, Keith Wilfrid
KEITH W. NASH & Co.
Pearl Assurance House
90-92 Regent Street
Cambridge CB2 1DP (GB)

(56) References cited:
CH-A- 666 214 **DE-A- 2 333 041**
DE-A- 4 034 146 **DE-C- 4 137 924**
GB-A- 481 722 **US-A- 3 222 822**

• **RESEARCH DISCLOSURE no. 272 , December**
1986 , NEW YORK USA page 735 'machine
controls'

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 675 780 B1

Description

Field of the Invention

This invention relates to improvements in or relating to workpiece grinding method and apparatus.

Background to the Invention

When grinding (abrasive machining) the profile of a cam lobe, as on a camshaft for an automotive engine, it is normal to use an abrasive wheel. However, when the cam profile has a re-entrant portion, the size of the abrasive wheel to grind into the re-entrant portion may be so small as to preclude this method of grinding. The grinding of small radius re-entrant portions has been performed by using an abrasive belt which passes around a guide shoe, the outboard end of which has a small known radius, which is imparted to the abrasive surface of the belt, which can therefore not only grind the re-entrant region but also, if desired can finish grind the cam profile.

Unfortunately abrasive belts tend to wear rapidly when removing large amounts of stock.

In GB-A-481 722 there is disclosed a method of grinding such a cam, in which the concave or re-entrant portion is separately ground by a grinding wheel of small diameter or by a wheel having the required profile, while the remaining portion is ground by a wheel of larger radius. A disadvantage of this method is that there may be formed discontinuities in the cam profile at each side of the re-entrant portion.

Objects of the Invention

It is one object of the present invention to provide an improved method of grinding a workpiece which includes the step of belt grinding.

It is another object of the present invention to provide an improved workpiece grinding machine which incorporates belt grinding.

Summary of the Invention

According to one aspect of the present invention there is provided a method of grinding the periphery of a workpiece having a re-entrant region of relatively small radius, characterised by the steps of:

- (1) rough grinding the whole periphery to form a modified profile, which is an approximation to the final desired profile, using an abrasive grinding wheel of a radius greater than that of the re-entrant region of the periphery, and
- (2) finish grinding the modified profile including the re-entrant region by means of an abrasive belt, without removing the workpiece from the machine.

By the term "modified profile" is meant an approximation to the final profile to be obtained by grinding, so that a minimum of stock is left on non-re-entrant parts of the profile but proportionately more stock is left in regions of re-entrant parts of the profile, since the large diameter wheel prevents its entry into the re-entrant parts. The abrasive belt is employed in accordance with the invention to remove the remaining stock from the parts of the workpiece having the modified profile including the stock in any re-entrant part of the profile which cannot be removed by the large diameter grinding wheel.

In a conventional grinding machine for grinding a workpiece such as a camshaft by a grinding wheel, the workpiece is mounted between a headstock and a footstock which define a grinding station. The headstock and/or footstock also rotate the workpiece in a conventional and controlled manner about an axis through the workpiece. The cam profile therefore does not describe a circular path. A wheelhead mounts the grinding wheel and a wheelhead feed therefor produces a reciprocating motion of the wheel to provide an action which puts the grinding wheel in the correct position during the rotation of each section of the workpiece profile being ground, to thereby generate the desired profile therearound, and finally to remove the grinding wheel therefrom. By superimposing a forward feed onto the reciprocation of the wheelhead, the profile is reduced in size in a controlled manner towards its finished size.

In a conventional abrasive belt grinding machine, the belt is similarly advanced and retracted in a reciprocal manner, with an overall feed, to finish the workpiece as required.

In accordance with another aspect of the present invention, there is provided apparatus for performing the aforesaid method comprising a grinding station with a grinding wheel to grind the periphery of a workpiece having a re-entrant region of relatively small radius, the grinding wheel having a radius greater than that of the final radius to be obtained in the re-entrant region, characterised in that the grinding wheel is arranged to rough grind the whole periphery to form a modified profile which is an approximation to the final profile, and in that there is associated with the grinding wheel an abrasive belt grinding facility having a guide shoe around which the belt passes and the radius of which is no greater than that of the final radius to be obtained in the re-entrant region, belt drive means and actuating means to move the belt into engagement with the workpiece to finish grind the modified profile to the final profile whilst the workpiece is still within the grinding station.

The belt grinding facility may be mounted for advance and retraction to engage and disengage the workpiece along the same axis as the grinding wheel moves to engage and disengage the workpiece at the grinding station. Alternatively it may move along a different axis from that of the grinding wheel, but which is laterally spaced from the wheel. Alternatively it may move

in the same plane as the wheel, along a line which passes through the axis of workpiece station but is angled relative to the axis along which the wheel moves.

The headstock and footstock may be mounted on a carriage which is movable relative to the grinding wheel and belt, to present different axially spaced regions of a workpiece in succession to the grinding station, so that the whole workpiece may be finished by way of a succession of separate wheel and belt grindings in the same machine.

As applied to the production of a camshaft, where the belt is mounted above or below the grinding wheel, a sequence of grinding in accordance with the invention comprises rough grinding consecutively all the cam shaft lobes on a workpiece using the grinding wheel to produce modified cam profiles at each cam position, indexing the wheelhead through the appropriate angle to present the abrasive belt to the workpiece, and finish grinding consecutively all the modified profiles along the camshaft to the required size and shape.

The finished component can be unloaded and a new workpiece put in place whilst the wheelhead indexes so as to present the grinding wheel at the start of the next workpiece grinding sequence as described above.

In an embodiment in which the abrasive belt is mounted alongside the grinding wheel, the belt and wheel are separately movable towards and away from the workpiece so that when the abrasive belt is grinding, the grinding wheel is clear of the workpiece, and when the grinding wheel is to be engaged, the abrasive belt is retracted so that it does not make contact with the workpiece.

In this embodiment the grinding sequence typically involves rough grinding a component using the grinding wheel, and then finish grinding the same part of the component using the abrasive belt, before the wheelhead assembly is moved to the next region of the component to be ground.

In a further embodiment in which belt and wheel are axially spaced apart, the abrasive belt is adapted to engage the workpiece to finish grind a modified profile whilst the grinding wheel is actively rough grinding another axially spaced region of the workpiece. In this way, a workpiece can be finish ground in virtually the same time as would be required to rough grind it prior to a finish grinding sequence.

Other features and aspects of the invention are defined in the appended claims.

Brief Description of the Drawings

The invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1a is a schematic view of a cam lobe adjacent to a grinding wheel for rough grinding in

accordance with the invention, and **Figure 1b** is a cam lobe adjacent to an abrasive belt for finish grinding in accordance with the invention,

Figure 2 is an elevation and plan of a combined grinding wheel and abrasive belt machine tool showing the grinding wheel presented to the workpiece,

Figure 3 is an elevation and plan view of a combined grinding wheel and abrasive belt machine tool showing the abrasive belt presented to the workpiece,

Figure 4 is an elevation and plan view of a combined grinding wheel and abrasive belt machine tool showing the grinding wheel and belt fitted alongside each other, and

Figure 5 is an elevation and plan view of a combined grinding wheel and abrasive belt showing the grinding wheel and abrasive belt incorporated in separate grinding heads.

Detailed description of the illustrated embodiments

Figure 1a shows a section of a grinding wheel 10, rotating in the direction of arrow 22 about an axis of rotation (not shown) and reciprocally in the direction of arrows 13 to move wheel 10 and its grinding surface towards and away from a cam lobe 14 to be ground. The surface of wheel 10 engages the surface of lobe 14 at an imaginary plane 12 diametrically passing through the axis of rotation of wheel 10 and the base circle axis of lobe 14 at a variable point 24 of cam lobe 14. Lobe 14 is rotating in a controlled manner around an axis 18 in the direction of arrow 16.

The cam lobe 14 has a modified profile 20 which remains after the rough grinding step. Cam lobe 14 is rotated about axis 18 to facilitate its grinding. The controlled angular rotation of the cam lobe 14 is complemented by a controlled reciprocal movement of the grinding wheel in the direction of arrow 13 so that it is in the correct position relative to the angle position of the cam lobe.

Figure 1b shows a section of an abrasive belt 26 moving in direction of arrow 28 over cylindrically curved shoe face 30 of fixed guide shoe 32. Alternatively, as indicated in broken line, the fixed shoe may be replaced by a roller 33 driven by passage of the abrasive belt over its periphery. The belt assembly is selectively securable along axis 34, in the direction of the arrow 36. Belt 26 and its grinding surface is also movable in the direction of arrow 36 to move its grinding surface towards and away from the surface of the cam lobe 40 to be ground. When the grinding surface of moving belt 26 engages the surface of cam lobe 40 at location 38, along a diametric plane passing through the base circle of lobe 40 and the longitudinally extending line of movement 34, a finish grinding of a modified profile such as that shown in Figure 1a, is achievable. The point of engagement between cam lobe 40 and the belt 26 on axis 34, is

denoted by 38. The controlled angular rotation of the cam lobe 40 is complemented by a controlled backwards and forwards reciprocatory movement of belt 26 along axis 34, so that the locus of the belt/lobe engagement at 38 accurately facilitating the grinding of the final shape that the cam lobe is to possess.

Figure 2 shows an elevation 46 and plan view 48 of a dual purpose grinding machine wherein a grinding wheel 50 is conventionally mounted on a spindle (not shown) which rotates in the direction of arrow 51 in a wheel housing 52 about an axis 54 and is driven by a drive motor 56. The grinding surface of grinding wheel 50 is in contact with the surface of a cam lobe 58 of a cam shaft 60, which is fixed between a headstock 64 and a footstock 62. Headstock 64 rotates cam shaft 60 in a conventionally controlled manner about an axis 66 and is in turn driven by an electric motor (not shown) housed in headstock 64. An approximate cam profile can thus be produced by advancing the grinding wheel surface towards cam lobe 50 until the approximate cam profile is achieved.

Footstock 62 is slidable and securable along axis 66 in the directions indicated by arrow 68.

Adjacent to the headstock 64 is a conventional truing or dressing device 70 which is manoeuvred by sliding headstock 64 across the face of grinding wheel 50 or belt 72 with device 70 in contact therewith for truing the grinding wheel 50 or abrasive belt 72 prior to use. When truing is complete, headstock 64 is slid back and secured so as to secure workpiece 60 in position, so that truing device 70 is free of the grinding wheel 50 and belt 72.

A wheelhead 92 also incorporates the abrasive belt assembly 76 which includes the belt 72. Conventional rotational indexing of the wheelhead through 180° about an axis 108 presents abrasive belt 72 instead of wheel 50 to workpiece 60.

Wheelhead 92 is mounted on an underslide 106 which supports and guides wheelhead 92 for rotation about axis 108, so that wheelhead 92 can be rotatably indexed and rigidly locked (by locking means not shown) when in either grinding position.

Wheelhead 92 is mounted on underslide 106 and driven backwards and forwards on slide 134 by a feed member 107 so that the abrasive belt 72 or grinding wheel 50 can be advanced or withdrawn from the workpiece as required at the beginning and ending of a grinding step and reciprocated so as to respond to the changing component profile during rotation of the latter and to readjust position for the next workpiece. Slide 134 is conventionally supported on the machine tool base 136.

Figure 3 shows the grinding machine of Figure 2 with the abrasive belt in contact with the cam lobe. The belt mechanism comprises an abrasion belt tensioning pulley 78 attached by means of arm 80 to a securing member 84. The arms are attached to the securing member by means of pivot bearings 81, and to the body

of the wheelhead 92 by means of a pneumatic cylinder 200. The pneumatic cylinder is retractable allowing the arm to swing down for fitting new belts. The pneumatic cylinder can then be extended at a controlled rate and pressure to correctly tension the abrasive belt 72. The abrasive belt is driven around a larger pulley 86 which is rotated by a belt drive 90 via drive motor 88. The larger pulley 86 is carried by the securing member 84 and the abrasive belt drive motor 88 is secured to the body of the wheelhead 92 via a vibration absorbing platform 94.

The abrasive belt 72 also passes around two belt guide pulleys 96 and 98 which are also carried by securing member 100 so that they are equidistant from the guide shoe 102 and shoe supporting grooved member 104. The guide pulleys are located behind the guide shoe 102 so that the belt passing over the guide shoe protrudes forward of the guide mechanism enabling grinding of the workpiece 105 by the abrasive belt.

Figure 4 shows plan 112 and elevation 114 of an embodiment of the machine wherein the abrasive belt mechanism and grinding wheel mechanism are adjacent to each other and wherein the abrasive belt extends forwardly of the abrasive wheel when the abrasive belt supporting grooved arm 116 has been lowered into the position shown in Figure 4(a). Alternation between abrasive mechanisms is by retraction of the abrasive belt shoe by rotation of supporting arm 116 around axis 118, so that the abrasive belt mechanism is now displaced behind the grinding wheel surface when viewed from the side. Thus, rotation of the arm 116 allows alternative abrasive wheel rough grinding and abrasive belt finish grinding operations, without the non grinding device interfering with the workpiece while the other is active.

The other constructional features are similar to those of the previous examples shown in the drawings except that there is no need for any rotatable indexing means as both mechanisms are functional on the same side of the wheelhead as each other.

In Figure 5 the abrasive belt 120 and the abrasive wheel 122 are located on separate wheelheads 124 and 126 on either side of the machine tool mounting 128. Both wheelheads are slidable over respective support members 130 and 132 and the abrasion mechanism is essentially as hereinbefore described except that in this embodiment it is possible to grind a workpiece from both sides.

After rough grinding, one part of the grinding wheel 122 is retracted and the abrasive belt 120 is advanced and engaged for finish grinding the same part, before the workpiece is axially advanced, to present another region for rough grinding.

Claims

1. A method of grinding the periphery of a workpiece (14) having a re-entrant region of relatively small radius, characterised by the steps of:

- (1) rough grinding the whole periphery to form a modified profile (20), which is an approximation to the final desired profile, using an abrasive grinding wheel (10) of a radius greater than that of the re-entrant region of the periphery, and
- (2) finish grinding the modified profile including the re-entrant region by means of an abrasive belt (26), without removing the workpiece from the machine.
2. A method as claimed in claim 1 wherein the grinding wheel (10) and the abrasive belt (26) are commonly mounted, and in which the intermediate step of presenting the abrasive belt to the workpiece also moves the grinding wheel away from the workpiece.
 3. Apparatus for performing the method of claim 1 or claim 2, comprising a grinding station with a grinding wheel (10) to grind the periphery of a workpiece (14) having a re-entrant region of relatively small radius, the grinding wheel having a radius greater than that of the fixed radius to be obtained in the re-entrant region, characterised in that the grinding wheel is arranged to rough grind the whole periphery to form a modified profile (20) which is an approximation to the final profile, and in that there is associated with the grinding wheel an abrasive belt grinding facility (26) having a guide shoe (32) around which the belt passes and the radius of which is no greater than that of the final radius to be obtained in the re-entrant region, belt drive means and actuating means (116) to move the belt into engagement with the workpiece to finish grind the modified profile to the final profile whilst the workpiece is still within the grinding station.
 4. Apparatus as claimed in claim 3 wherein the actuating means comprises a supporting arm (116) movable to bring the belt grinding facility (26) into engagement with the workpiece (Fig. 4).
 5. Apparatus as claimed in claim 3 or claim 4 wherein the belt grinding facility is mounted adjacent the grinding wheel.
 6. Apparatus as claimed in claim 3 wherein the belt grinding facility (120) is disposed on the side of the workpiece opposite to the grinding wheel (10).
 7. Apparatus as claimed in claim 3 wherein the headstock (64) and footstock (62) are mounted on a carriage which is movable relative to the grinding wheel and belt, to present different regions of a workpiece in succession to the grinding station, so that a whole workpiece may be finished by way of a succession of separate wheel and belt grindings in the same machine.
 8. Apparatus as claimed in claim 3 wherein the grinding wheel and abrasive belt assembly are both mounted on a rotatable wheelhead (92), such that by rotating the wheelhead, either the grinding wheel or the abrasive belt can be presented to the workpiece.
 9. Apparatus as claimed in claim 8 wherein the wheelhead (92) is rotatable about a vertical axis.
 10. Apparatus as claimed in claim 9 wherein the wheelhead (92) is rotatable through 180° about the said vertical axis.
 11. Apparatus as claimed in any one of claims 3 to 10 wherein the drive means is electronically and/or microprocessor controlled to control some or all of speed, direction or rotation, acceleration and deceleration to control the abrasive action of the wheel and the belt.
 12. Apparatus as claimed in any one of claims 3, 4, 6 and 8 to 11, wherein the abrasive belt is mounted alongside the grinding wheel, and the belt and wheel are separately movable towards and away from the workpiece so that when the abrasive belt is grinding, the grinding wheel is clear of the workpiece, and when the grinding wheel is to be engaged, the abrasive belt is retracted so that it does not make contact with the workpiece.
 13. Apparatus as claimed in any one of claims 3 to 5 and 7, wherein the abrasive belt is adapted to engage the workpiece to finish grind a modified profile whilst the grinding wheel is actively rough grinding another axially spaced region of the workpiece.

Patentansprüche

1. Verfahren zum Schleifen der Umfangsfläche eines Werkstückes (14) mit einem einspringenden Bereich mit relativ kleinem Radius, **dadurch gekennzeichnet**, daß
 - (a) die gesamte Umfangsfläche grob geschliffen wird, um ein modifiziertes Profil (20) auszubilden, das eine Annäherung an das gewünschte Endprofil darstellt, wobei eine Schleifscheibe (10) mit einem Radius verwendet wird, der größer ist als der des einspringenden Bereiches der Umfangsfläche, und
 - (b) das modifizierte Profil einschließlich des einspringenden Bereiches mit Hilfe eines Schleifbandes (26) ohne Entnahme des Werkstückes aus der Maschine fertig geschliffen

wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Schleifscheibe (10) und das materialabtragende Schleifband (26) gemeinsam befestigt sind, und daß durch den Zwischenschritt, mit dem das Schleifband dem Werkstück zugeordnet ist, die Schleifscheibe von dem Werkstück weg bewegt wird. 5
3. Einrichtung zur Durchführung des Verfahrens nach Anspruch 1 oder 2, mit einer Schleifstation mit einer Schleifscheibe (10) zum Schleifen der Umfangsfläche eines Werkstückes (14) mit einem einspringenden Bereich mit relativ keinem Radius, wobei die Schleifscheibe einen Radius hat, der größer ist als der feste Radius, der in dem einspringenden Bereich erhalten wird, dadurch gekennzeichnet, daß die Schleifscheibe so ausgelegt ist, daß sie den gesamten Umfang grob schleift, um ein modifiziertes Profil (20) auszubilden, das eine Annäherung an das Endprofil darstellt, und daß der Schleifscheibe eine Bandschleifvorrichtung (26) zugeordnet ist, die einen Führungsschuh (32) aufweist, um den das Band läuft, und dessen Radius nicht größer ist als der Endradius, der in dem einspringenden Bereich erhalten wird, wobei Bandantriebsvorrichtung und Betätigungsvorrichtung (16) das Band in Eingriff mit dem Werkstück bewegen, um das modifizierte Profil in das Endprofil fertigzuschleifen, während das Werkstück noch in der Schleifstation ist. 10 15 20 25 30
4. Einrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Betätigungsvorrichtung einen Auslegerarm (116) aufweist, der so bewegbar ist, daß er die Bandschleifvorrichtung (26) in Eingriff mit dem Werkstück (Fig. 4) bringt. 35
5. Einrichtung nach Anspruch 3 oder 4, dadurch gekennzeichnet, daß die Bandschleifvorrichtung in der Nähe der Schleifscheibe befestigt ist. 40
6. Einrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Bandschleifvorrichtung (120) auf der Seite des Werkstückes gegenüber der Schleifscheibe (10) angeordnet ist. 45
7. Einrichtung nach Anspruch 3, dadurch gekennzeichnet, daß der Spindelstock (64) und der Reitstock (62) auf einem Schiffe befestigt sind, der relativ zur Schleifscheibe und zum Band beweglich ist, damit unterschiedliche Bereiche eines Werkstückes nacheinander der Schleifstation ausgesetzt werden können, und ein gesamtes Werkstück aufgrund einer Folge von getrennten Scheiben- und Band-Schleifvorgängen in der gleichen Maschine fertigbearbeitet werden kann. 50 55

8. Einrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Schleifscheiben- und Schleifbandanordnung beide auf einem drehbaren Schleifkopf (92) befestigt sind, derart, daß durch Drehen des Schleifkopfes entweder die Schleifscheibe oder das Schleifband dem Werkstück dargeboten werden können.
9. Einrichtung nach Anspruch 8, dadurch gekennzeichnet, daß der Schleifkopf (92) um eine vertikale Achse drehbar ist. 10
10. Einrichtung nach Anspruch 9, dadurch gekennzeichnet, daß der Schleifkopf (92) über 180° um die vertikale Achse drehbar ist. 15
11. Einrichtung nach einem der Ansprüche 3 - 10, dadurch gekennzeichnet, daß die Antriebsvorrichtung elektronisch und/oder durch Mikroprozessor gesteuert ausgelegt ist, um einen Teil der oder alle Geschwindigkeiten, Richtung oder Rotation, Beschleunigung und Verzögerung zu steuern und damit den Schleifvorgang der Scheibe und des Schleifbandes zu beeinflussen. 20 25
12. Einrichtung nach einem der Ansprüche 3, 4, 6 und 8 - 11, dadurch gekennzeichnet, daß das Schleifband längs der Schleifscheibe befestigt ist, und Band und Scheibe zum Werkzeug hin und vom Werkzeug weg getrennt so verschiebbar sind, daß dann, wenn das Schleifband schleift, die Schleifscheibe von dem Werkstück abgehoben ist, und wenn die Schleifscheibe in Eingriff gebracht werden soll, das Schleifband zurückgezogen wird, damit es keinen Kontakt mit dem Werkstück gibt. 30
13. Einrichtung nach einem der Ansprüche 3 - 5 und 7, dadurch gekennzeichnet, daß das Schleifband in der Lage ist, das Werkstück zu beaufschlagen, um ein modifiziertes Profil fertig zu schleifen, während die Schleifscheibe aktiv einen anderen, axial versetzten Bereich des Werkstückes grob schleift. 35 40

Revendications

1. Un procédé de meulage de la périphérie d'une pièce à usiner (14) possédant une portion rentrante de rayon relativement petit, caractérisée par les étapes suivantes:
 - (1) dégrossissage à la meule de la périphérie entière pour former un profil modifié (20), qui est une approximation du profil désiré final, en utilisant une meule abrasive (10) d'un rayon plus grand que celui de la portion rentrante de la périphérie, et
 - (2) dressage du profil modifié incluant la portion rentrante à l'aide d'une bande abrasive

(26), sans retirer la pièce à usiner de la machine.

2. Un procédé, selon la revendication 1, dans lequel la meule (10) et la bande abrasive (26) sont communément montées et dans lequel l'étape intermédiaire de présentation de la bande abrasive à la pièce à usiner permet également d'écarter la meule de la pièce à usiner.

3. Un appareil pour exécuter le procédé de la revendication 1 ou de la revendication 2, comprenant un poste de meulage avec une meule (10) pour le meulage de la périphérie d'une pièce à usiner (14) possédant une portion rentrante de rayon relativement petit, la meule possédant un rayon plus grand que le rayon fixe à obtenir dans la portion rentrante, caractérisé par le fait que la meule est disposée de façon à dégrossir la périphérie entière pour former un profil modifié (20) qui est une approximation du profil final, et par le fait qu'à la meule est associée un dispositif de meulage par bande abrasive (26) équipé d'un patin de guidage (32) autour duquel la bande passe et dont le rayon n'est pas supérieur au rayon final à obtenir dans la portion rentrante; un dispositif d'entraînement par courroie et un dispositif de commande (116) pour engager la bande avec la pièce à usiner afin de dresser le profil modifié au profil final tandis que la pièce à usiner se trouve toujours dans le poste de meulage.

4. Un appareil, selon la revendication 3, dans lequel le dispositif de commande comprend un bras de support (116) mobile pour engager le dispositif de meulage par bande (26) avec la pièce à usiner (Fig. 4).

5. Un appareil, selon la revendication 3 ou la revendication 4, dans lequel le dispositif de meulage par bande abrasive est monté à côté de la meule.

6. Un appareil, selon la revendication 3, dans lequel le dispositif de meulage par bande abrasive (120) est disposé sur le côté de la pièce à usiner en face de la meule (10).

7. Un appareil, selon la revendication 3, dans lequel la poupée (64) et la contre-poupée (62) sont montées sur un chariot qui est mobile par rapport à la meule et la bande abrasive, pour présenter successivement différentes portions d'une pièce à usiner au poste de meulage, afin que la pièce à usiner entière soit finie par des meulages successifs par roue et par bande dans la même machine.

8. Un appareil, selon la revendication 3, dans lequel la meule et la bande abrasive sont tous deux montés sur une poupée porte-meule rotative (92), de façon

à ce qu'en tournant la poupée porte-meule, la meule ou la bande abrasive puisse être présentée à la pièce à usiner.

9. Un appareil, selon la revendication 8, dans lequel la poupée porte-meule (92) peut tourner autour d'un axe vertical.

10. Un appareil, selon la revendication 9, dans lequel la poupée porte-meule (92) peut tourner de 180° autour dudit axe vertical.

11. Un appareil, selon une des revendications 3 à 10, dans lequel le dispositif d'entraînement est commandé électroniquement et/ou par microprocesseur pour contrôler une partie ou la totalité de la vitesse, la direction ou rotation, l'accélération et la décélération pour commander l'action abrasive de la roue et de la bande.

12. Un appareil, selon une des revendications 3, 4, 6 et 8 à 11 dans lequel la bande abrasive est montée le long de la meule, et la bande abrasive et la meule peuvent rapprochées ou écartées séparément de la pièce à usiner de sorte que, lorsque la bande abrasive meule, la meule est écartée de la pièce à usiner, et lorsque la meule est engagée, la bande abrasive est rentrée pour ne plus être en contact avec la pièce à usiner.

13. Un appareil, selon une des revendications 3 à 5 et 7, dans lequel la bande abrasive est adaptée pour engager la pièce à usiner afin de dresser un profil modifié tandis que la meule effectue le dégrossissage d'une autre portion axialement espacée de la pièce à usiner.

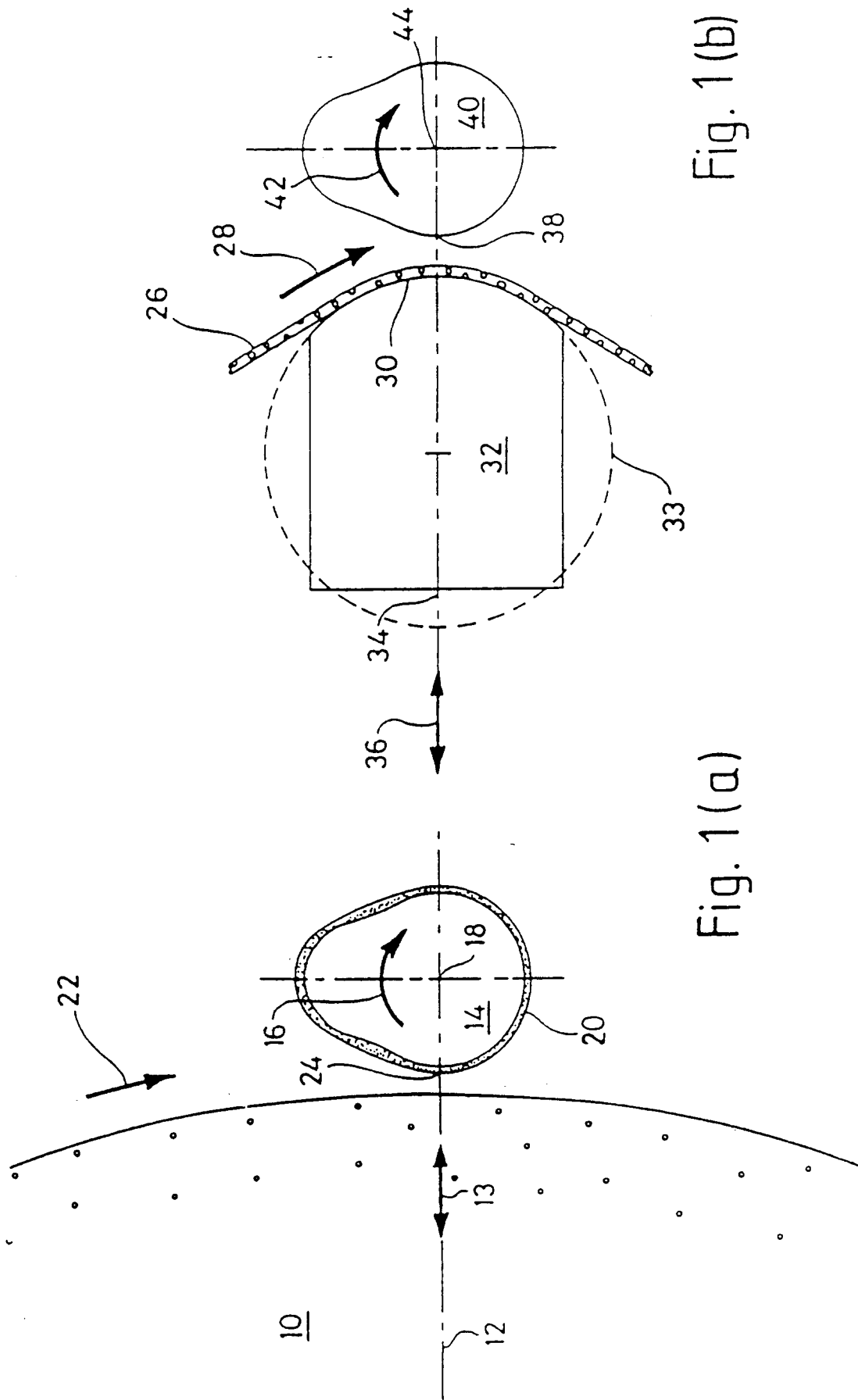
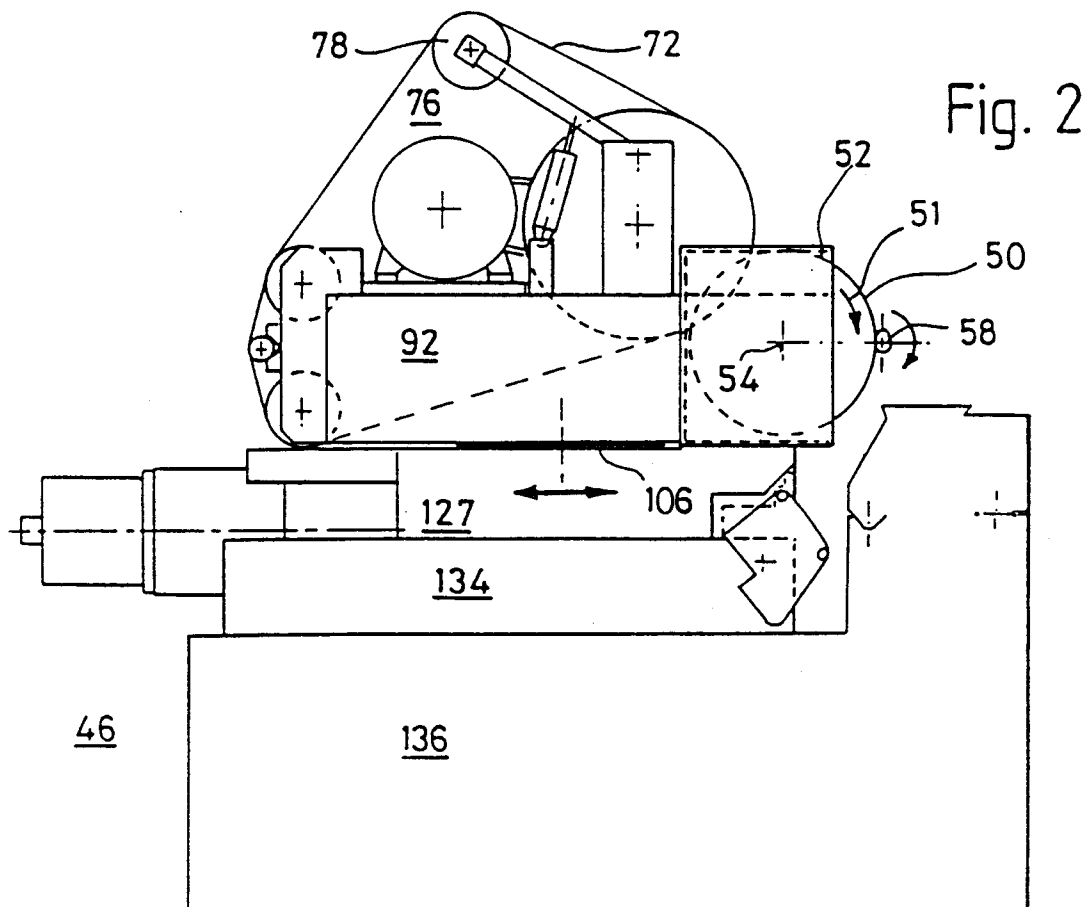
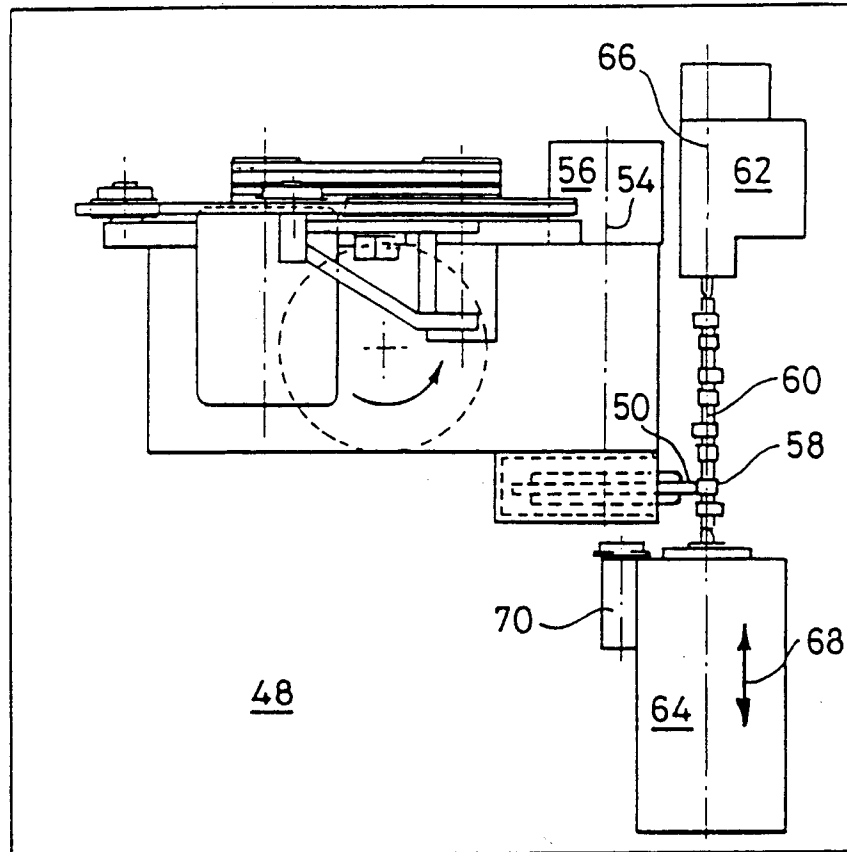


Fig. 1(b)

Fig. 1(a)



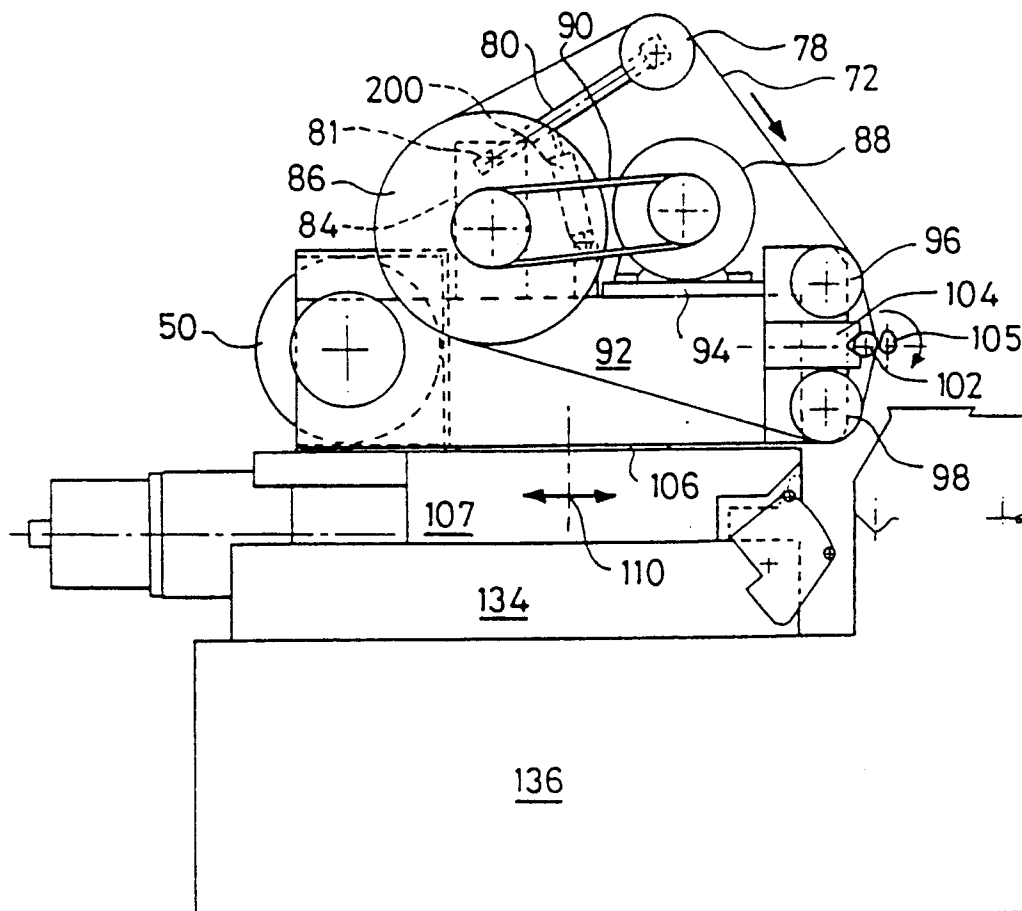
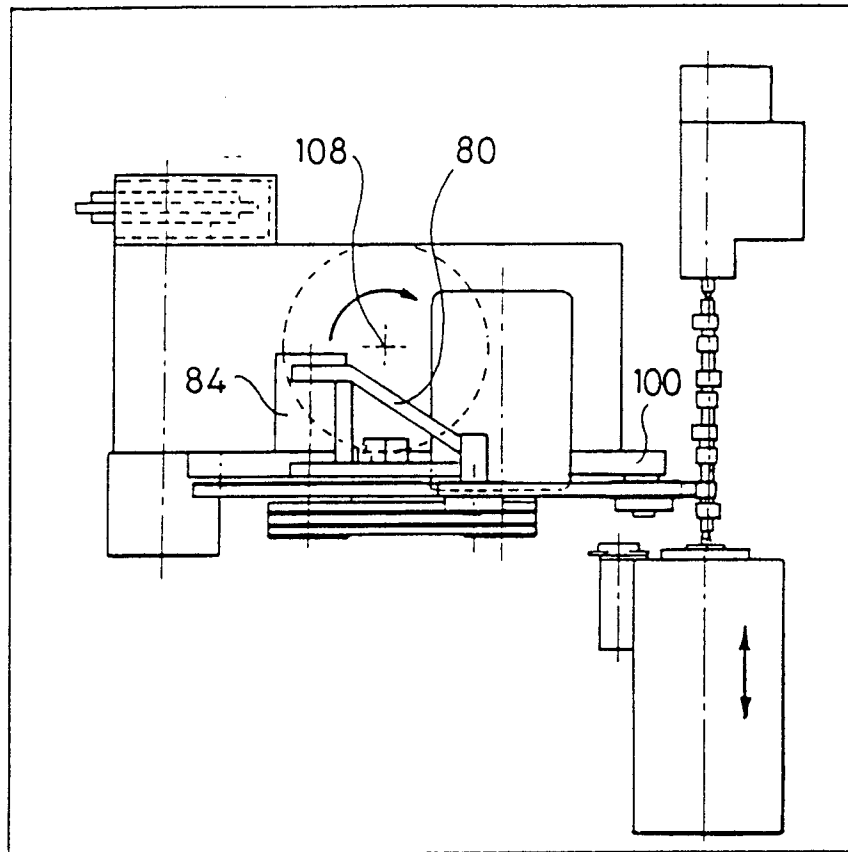
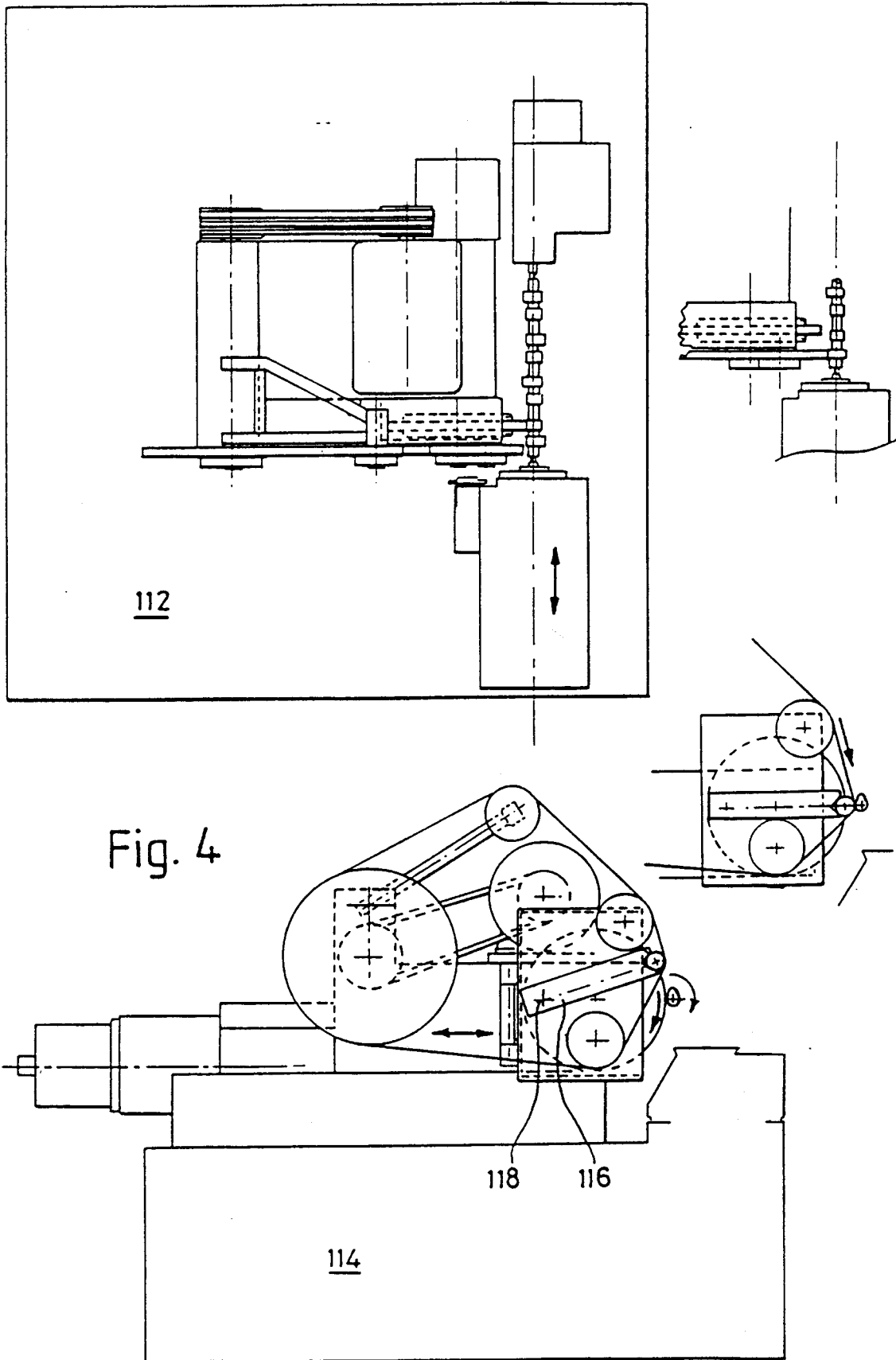


Fig.3



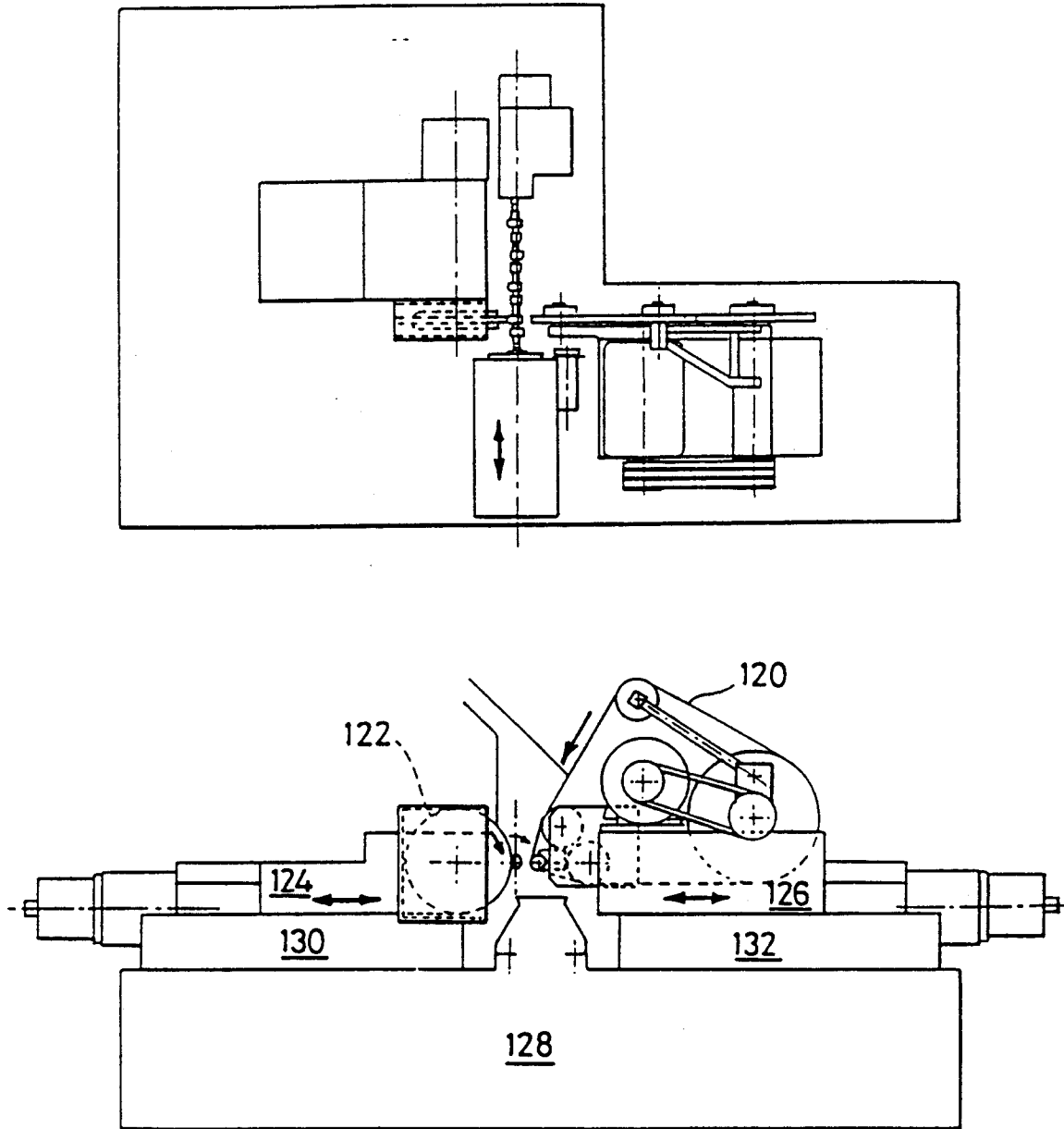


Fig. 5