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(71)(72) Applicant and Inventor: UNDERHAUG, Njål [NO/NO]; Rektor Sælands vei 21, N-4340 Bryne (NO).

(74) Agent: JØRGENSEN, Tor; Bryns Patentkontor A/S, Postboks 9566, Egertorget, N-0128 Oslo 1 (NO).

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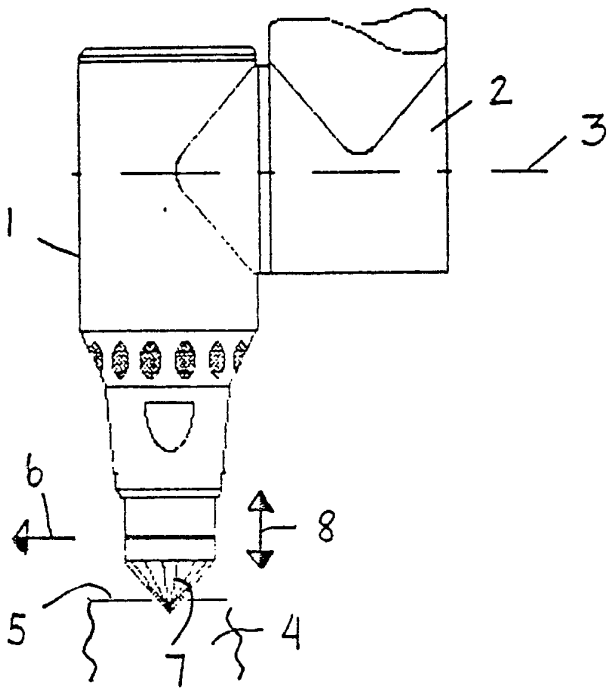
(54) Title: A DEVICE IN A ROTATING DRIVE MEANS FOR A TOOL

(57) Abstract

A device in a drive means for a tool (7), e.g. a file or a milling tool, intended for mounting on the arm (2) of an industrial robot for burring on cast-iron goods (4) or the like, comprising a casing (9) with a motor (10), especially a pneumatic motor for rotating operation of said tool. Said milling tool or file (7) is conically tapered with an angle between 60° and 120°, preferably approximately 90°, and said milling tool or file is arranged to be axially movable and constantly activated by force in an outward direction from said device. A sleeve (12) is provided, via splines on the shaft of said motor (11), and the shaft (13) of tool (7) is rigidly secured to the free outside end of sleeve (12). The shaft is rotatably mounted in a sleeve shaped piston (15) which is provided coaxially outside said sleeve. The piston is arranged to be axially movable in a cylinder (16) in casing (9), and an air duct (22) is extended to said cylinder for supply of compressed air to actuate said piston.



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A DEVICE IN A ROTATING DRIVE MEANS FOR A TOOL

The present invention relates to a device in a rotating drive means for a tool, e.g. a file or a milling tool, intended for mounting on the arm of an industrial robot or another automatic device for burring on machined workpieces or the like, comprising a casing with a motor, especially a pneumatic motor for actuating said tool.

Removal of burr on a workpiece by the aid of an industrial robot is a new and difficult application with special demands on the dynamic properties of the robot. Such a robot should be able to follow a contour on a workpiece with great speed and accuracy at the same time as varying forces are transmitted from the burring tool to the robot arm. Widespread use of industrial robots for burring is completely dependent on a reduction of cycle periods and increase of flexibility. The present robots operate with high speed, but with large and heavy tools attached to the robot arms the properties that may be achieved are reduced below acceptable levels. At the same time as more rigid and more lightweight robot structures as well as improved servo systems are developed it is, thus, necessary to reduce the mass which a robot must move - the tool mass.

Using robots there were, at certain times and in connection with special applications problems with inaccuracy of the workpieces and their fixation in relation to the programed path of the robot. In connection with milling and burring it is necessary to compensate for such inaccuracies by introducing a flexible movement between robot and workpiece. Wear and tear of the milling tool and subsequent changes of geometry in the same cases of application also resulted in a demand for compensating for such wear and tear.

In principle, three different methods may be used for generating and maintaining a constant or adjustable force between milling tool and workpiece:

a) Soft servo - i.e. the servo (power feedback) of the robot is used as a spring.

b) Flexible tool - i.e. there is a spring suspended tool.

c) Flexible workpiece - i.e. the workpiece is suspended in a spring means and the tool is, thus, rigidly fixed to the robot (or to the support if the used robot is carrying the workpiece).

In removing burr, i.e. removing loose material, and bevelling and corresponding applications method b) mainly prooved useful. With this method the entire tool or portions of the tool can be spring-cushioned.

In case of great speed across an uneven surface it is important that the mass of spring is as little as possible (cf. cars and wheel suspension on potholed roads).

When external and internal circular arcs or arcuate contours are to be burred it is important too that the tool is constructed to place the centre of gravity of the burring tool as closely to the central axis of the circular arc as possible. This distance is called centre of gravity distance in this context.

The tool previously used for burring was characterized by the fact that the elastic force and, thus, the elastic movement had a direction orthogonally to the axis of rotation of the burring tool, and that the entire tool for burring was spring-cushioned. Rubber suspension secured spring action in all directions orthogonally to the axis of rotation. This resulted in problems in connection with vibrations of the burring tool. Consequently, the restriction was adopted that the tool only tilts about one axis that is orthogonal to the axis of rotation. The force is provided, e.g. by a mechanical spring arranged to have an approximately linear characteristic, and, thus, yielding an approximately constant force of contact with

the workpiece. The disadvantages of the present methods are:

a) The tool must not only follow the burr but requires a change of the orientation of the axis of rotation for burring circular arcs or arcuate contours extending in one and the same plane. This means that the robot must have an additional degree of freedom (servo), just for this orientation. An additional servo outermost on the robot arm has a very negative influence on the dynamic qualities of the robot.

b) To prevent the weight of the tool from influencing the force of contact in various orientations in space the tilting axis must be placed through the centre of gravity of the grinding tool. This involves large and heavy means of suspension.

c) The geometry of tools will result in a large gravity center distance.

d) The large inertial mass of the grinding tool interferes with high speed on rough burr (large cushioned mass).

The main object of the present invention is to propose a drive means for a tool, e.g. a file or a milling means or the like intended for mounting on the arm of an industrial robot for burring of machined workpieces or the like, so that an additional degree of freedom on the robot may be avoided and that the mass that has to be moved to compensate for inaccuracies of the workpiece is as small as possible, and the gravity centre distance is made as small as possible. It is, furthermore, an object of the invention to indicate, more specifically, a practical embodiment of such a drive means.

The object of the invention is achieved by a device of the above mentioned kind that is characterized by a combination of the following features:

the milling tool or file is conically tapered with an angle between 60° and 120° , preferably approximately 90°, and the milling tool or file is made axially movable and constantly actuated by a force in a direction outwards from the device. According to a further feature of the invention the contact force is equal, independently of the orientation of the device in space during one and the same operation.

A practical embodiment according to the invention is characterized by the fact that a sleeve is provided, via splines on the motor shaft, with the tool shaft rigidly fixed to the free end of said sleeve, that the shaft is rotatably mounted in a sleeve shaped piston, coaxially arranged outside said sleeve, and that the piston is arranged to be rotatable and axially movable in a cylinder in said casing, with an air duct for supplying compressed air to actuate said piston extending to said cylinder.

Further details of the invention will appear from the following disclosure in connection with the drawing showing an embodiment of the invention, and wherein

Figure 1 shows a drive means according to the invention mounted at the end of a robot arm,

Figure 2 shows the device, partly in section, and

Figure 3 shows the device in use for burring workpieces of different shapes, illustrating deviation relative to a nominal workpiece.

Figure 1 shows a drive means according to the invention, generally designated 1, and attached to the end of a robot arm by the aid of a mounting support 2, that is turnable or tiltable about an axis 3. The device is viewed during treatment of a workpiece 4 where burr 5 is to be removed. During burring device 1 is moved by the robot in the direction of arrow 6. To compensate for any possible irregularities on said workpiece

tool 7 is axially movable back and forth in the direction of arrow 8 in device 1.

In Figure 2 the structure of the device is shown in section. The device mainly comprises a casing 9 wherein a motor 10 is mounted. By the aid of sliding grooves or splines a sleeve 12 is mounted to be axially movable on motor shaft 11 and on the outer free end of said sleeve 12 the spindle 13 of a conical file 7 or milling means is secured by the aid of a thread connection 14. Coaxially outside sleeve 12 another sleeve 15 is provided to act as a piston and is axially movable in a sleeve shaped extension 16 of casing 9. Spindle 13 is mounted by the aid of bearings 18 to the inside of said sleeve shaped piston 15. Sleeve shaped cylinder 16 has a stepped portion 19 so that a circular edge 20 facing inwards is formed. Piston 15 is provided with a thickened part or flange 21 at its inner edge, and the outer edge of said thickened part or flange co-operates with edge 20 to limit the axial outward movement of piston 15. Through the rotor of motor 10 an air duct 22 extends and opens at the outer end of motor shaft 11. Compressed air supplied through duct 22 will, thus, enter sleeve 12 and flow through the gap in splines on shaft 11 and into cylinder space 23 behind piston 15. Sleeve 12 and piston 15 are machined with a certain mutual clearing, so that a smaller volume of air will leak out into the slot between said means. This will lubricate and cool the bearings and blow away shavings and dust to prevent the latter from entering the device or the bearings when the tool is in use.

Figure 3 shows how the device according to the invention will compensate for deviations of the workpiece dimensions and deviations of position. In the Figure marked a the position of the workpiece equals the nominal position for which the program of said robot is arranged. In Figure b the workpiece has a positive axial deviation, and burring is achieved due to the fact that tool 7 is automatically displaced somewhat forward by the constant air pressure. In Figure c there is a negative axial deviation, and the tool is retracted further

into said device. In Figure d a negative radial deviation is present, and burring is achieved by the fact that the tool is extended out of the device and in such a manner that burring occurs on the outside portion of the cutting face of said tool. In Figure e there is a positive radial deviation, and the tool is here urged into said device, and burring is achieved at the central portion of the cutting part of the tool.

As will appear from the above mentioned, automatic adaption of the tool is achieved in case of smaller deviations of various workpieces. Burring may occur when said device is guided with the same angle relative to burr in the same plane all the time. In axial movement of the tool, which is the only necessary movement for adaption of the tool to smaller irregularities, it is only necessary to move a small mass, i.e. sleeve 12, tool 7 with spindle 13, piston 15, and bearings 18. In a practical embodiment said means have a total weight of 45 g. By the device according to the invention a most stable structure is achieved, the radial mounting being provided directly inside on spindle 13, and the axial mounting being outermost. By using an air piston for the axial movement a constant pressure may be achieved on the tool in all axial positions.

Piston 15 can rotate freely in cylinder 16. Thus, static friction and stiction are avoided.

C l a i m s:

1. A device in a drive means for a tool, e.g. a file (7) or a grinding means intended for mounting on the arm of an industrial robot to remove burr on machined work-pieces or the like, comprising a casing with a motor, especially a pneumatic motor for rotational operation of said tool,
c h a r a c t e r i z e d i n the combination of the following features:
said file (7) or the like is conically tapered with an angle between 60^{o} and 120^{o}, preferably 90^{o}, and
said file or milling tool is provided so as to be axially movable and activated by force in a direction outwards from said device.

2. A device as defined in claim 1,
c h a r a c t e r i z e d i n that the power activation is equal in all longitudinal positions during the same operation.

3. A device as defined in claim 1 or claim 2,
c h a r a c t e r i z e d i n that a sleeve is provided, via splines on said motor shaft with the shaft of the tool rigidly secured to the free outside end of said sleeve that said shaft is rotatably mounted in a sleeve shaped piston which is provided coaxially outside said sleeve, and that said piston is provided axially movable in a cylinder in said casing with an air channel extended to said cylinder for supply of compressed air for operation of said piston.

4. A device as defined in claim 3, c h a r a c t e r i z e d i n that said air supply channel is arranged so as not to touch the cylinder (16), e.g. by being provided through the rotor of said motor.

5. A device as defined in claim 1, 2, or 3, c h a r a c t e r i z e d i n that said cylinder is shaped as a sleeve opening outwards and at its inner end being secured to said casing, and that there is a stepped portion in the interior cylinder surface with an edge facing said motor and acting as a stop to the outwards directed movement of said piston, said piston at its inner end having an annular expansion or annular flange for cooperation with the edge of said stepped portion.

6. A device as defined in claims 2 and 3, c h a r a c t e r i z e d i n that a valve is provided for adjustment of the air pressure.

7. A device as defined in one or more of the preceding claims, c h a r a c t e r i z e d i n that the shaft of said tool is connected with said sleeve by the aid of threads.

8. A device as defined in one or more of the preceding claims, c h a r a c t e r i z e d i n that the shaft of said tool is mounted in said piston by the aid of bearings absorbing radial and axial forces.

9. A device as defined in one or more of the preceding claims, c h a r a c t e r i z e d i n that sleeve (12) has a small clearing to the piston wall, so that a small volume of air penetrates through said clearing to lubricate and cool said bearings, and to prevent particles from the operation from penetrating into said device.

10. A device as defined in one or more of the preceding claims, c h a r a c t e r i z e d i n that said piston (15) can rotate freely in cylinder (16).

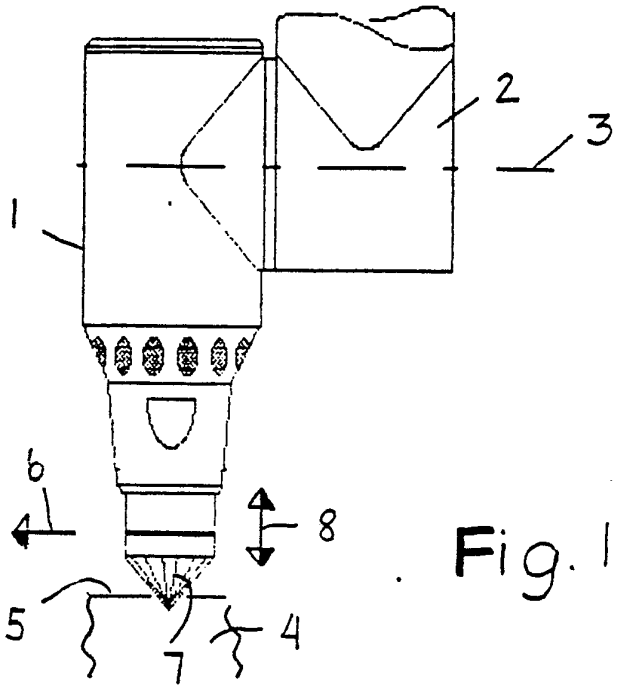

Fig. 1.

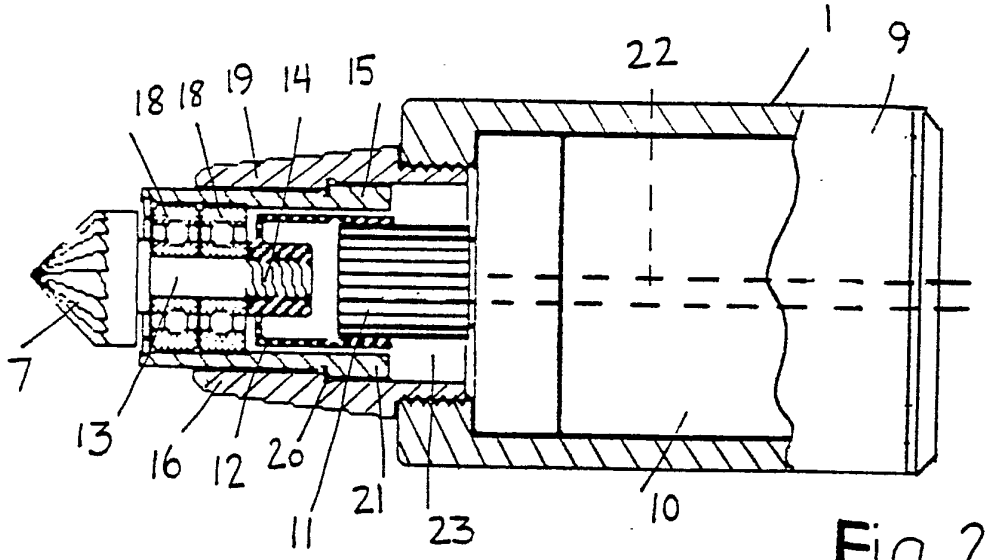

Fig. 2.

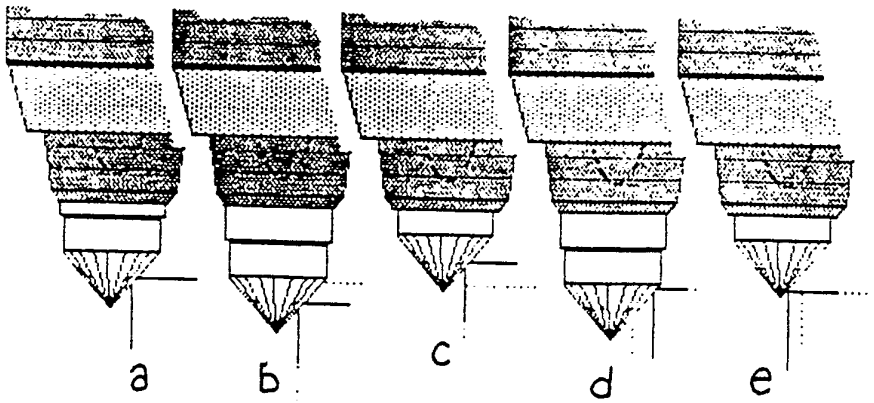

Fig. 3.

INTERNATIONAL SEARCH REPORT

International Application No PCT/NO86/00068

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC 4

B 24 B 27/04, B 25 J 19/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	B 22 D 31/00; B 23 C 3/12; B 23 D 67/00, /06, 69/00, /02; B 24 B 9/00-/06, 19/00, 27/00, /04, 47/22; B 25 J 15/00-/06, 19/00 .../...

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	DE, A, 3 443 444 (ASEA AB) 13 June 1985 See figure 1 and page 6, lines 14-16. & SE, 440201 JP, 60135155 US, 4610075	1-2
Y	US, A, 4 520 597 (ASEA AKTIEBOLAG) 4 June 1985 the whole document. & DE, 3240416 JP, 58090461 SE, 434020	1-2
A	US, A, 3 629 978 (NORTON COMPANY) 28 December 1971 & GB, 1291794 DE, 2118399 .../...	

* Special categories of cited documents: [10]

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1986-12-08	1986 -12- 16
International Searching Authority	**Signature of Authorized Officer**
Swedish Patent Office	Allan Westrin

L.E

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

II Fields Searched (cont).

Nat Cl 49b:5/07; 67a:31/02

US Cl 29:76, 78;
51:47, 99, 126, 134.5, 165.9, 180, 354;
90:12, 14

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers....., because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers....., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	DE, A, 3 317 425 (DAIMLER-BENZ AG) 9 August 1984	
A	DE, A, 3 432 773 (DAIMLER-BENZ AG) 31 January 1985	
A	SE, B, 400 918 (FORALKRANAR AB) 17 April 1978	
A	SE, B, 402 727 (KOCKUMS JERNVERKS AB) 17 July 1978	
A	CH, A, 366 701 (H.A. SCHLATTER AG) 28 February 1963	
A	SE, B, 409 301 (ASEA-ATOM AB) 13 August 1979	