(12) UK Patent Application (19) GB (11) 2 371 005 (13) A

(43) Date of A Publication 17.07.2002

(21) Application No 0127238.4

(22) Date of Filing 13.11.2001

(30) Priority Data
(31) 12348169 (32) 15.11.2000 (33) JP

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(51) INT CL[7]
B24B 7/04 // B24B 41/047 49/08 51/00

(52) UK CL (Edition T)
B3D DCM DMN
U1S S1421

(56) Documents Cited
GB 2344545 A **GB 2337014 A**
US 4742651 A

(58) Field of Search
UK CL (Edition T) **B3D DCB23 DCB5 DCM DFLC DFPG DFPX DMN**
INT CL[7] **B24B 7/00 7/04 17/10 41/04 41/047 41/053 49/00 49/08 51/00**
Online databases: Derwent World Patents Index, Patent Abstracts of Japan and European Patent Office

(54) Abstract Title
Method of abrading both sides of work piece

(57) The method of the present invention is capable of abrading a work piece (25) with fixed load. The method comprises: a first abrading process, in which pressure of a cylinder chamber (16a) of a cylinder unit (16) suspending an upper abrasive plate (14) is adjusted so as to apply first pressure to the work piece (25) via the upper abrasive plate (14) without applying full weight of the upper abrasive plate (14); and a second abrading process, in which the pressure of the cylinder chamber (16a) is readjusted so as to apply second pressure, which is higher than the first pressure, to the work piece (25) via the upper abrasive plate (14) without applying the full weight of the upper abrasive plate (14).

The method may further comprise a third step in which the pressure applied to the work piece is less than the second pressure (see fig 5).

The upper abrasive plate may be provided on its upper face with a reinforcing rib 37; the upper abrasive plate may be connected to a rod 18 of the cylinder unit by means of a holding disc 20 and a plurality of connecting rods 21 which may be fixed to the holding disc 20 or may be suspended from it by means of elastic members such as coil springs (35 fig 6).

FIG.1

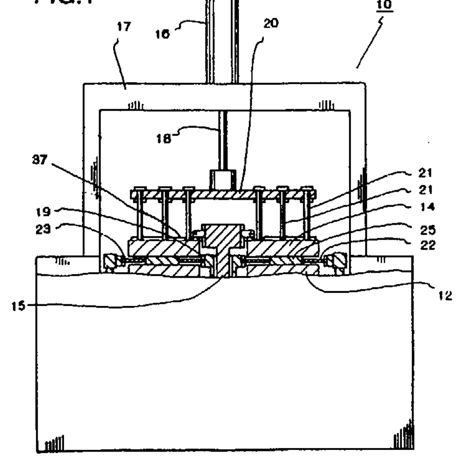

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FIG.1

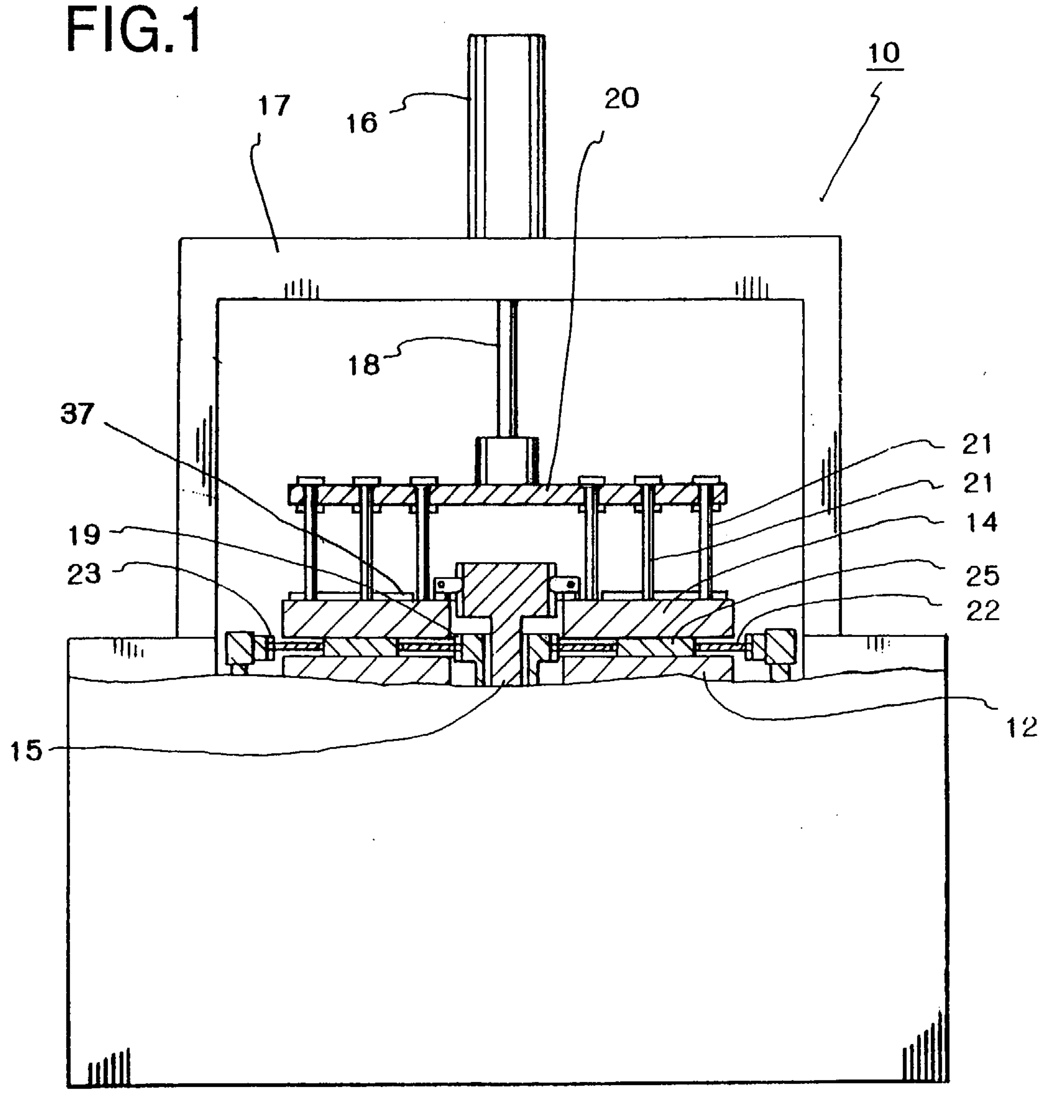


FIG.2

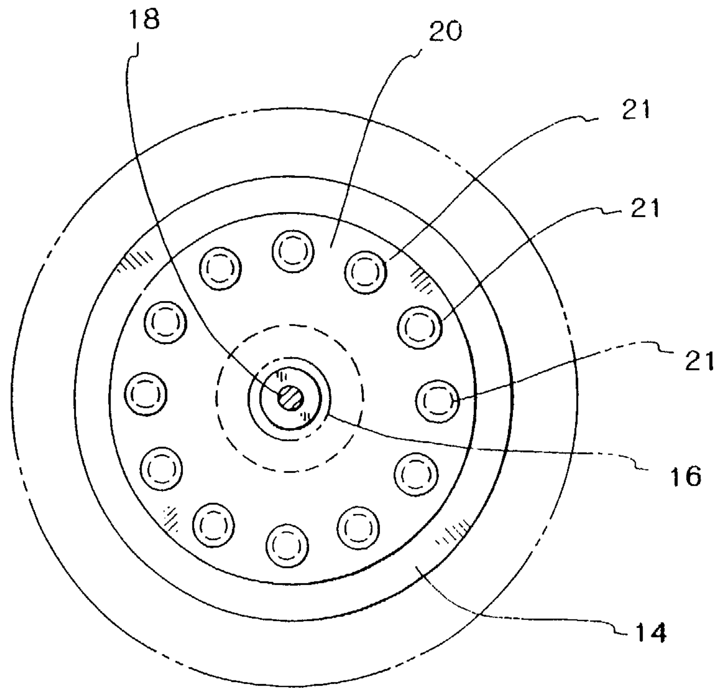


FIG.3

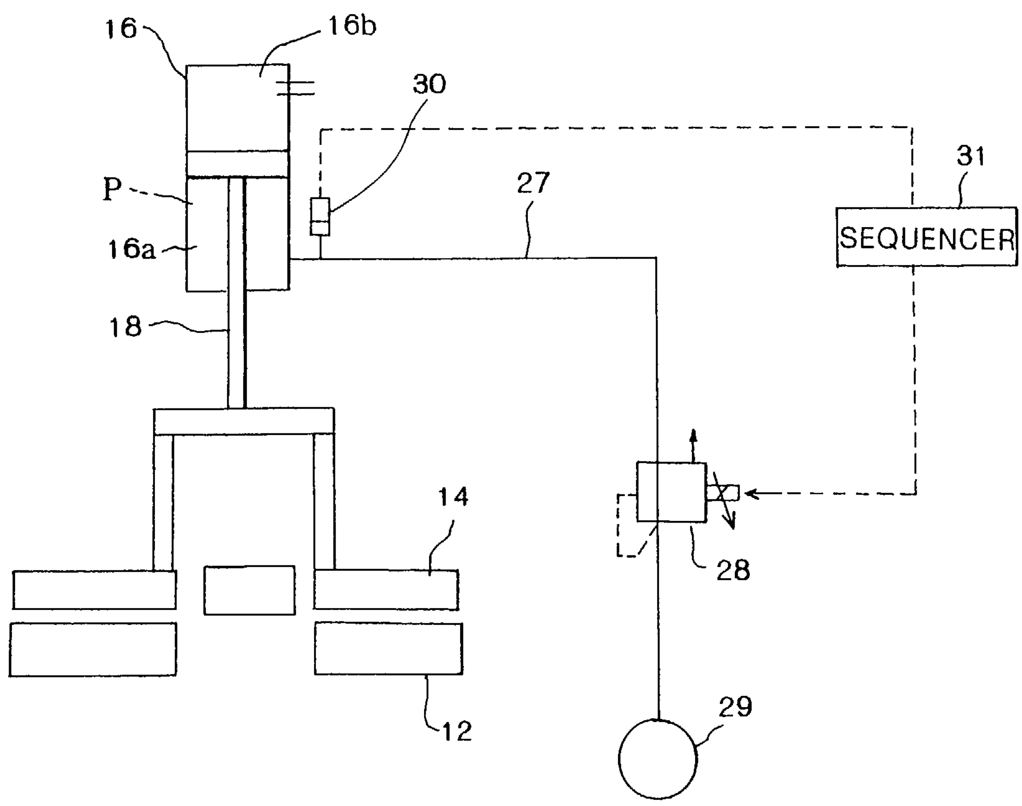


FIG.4

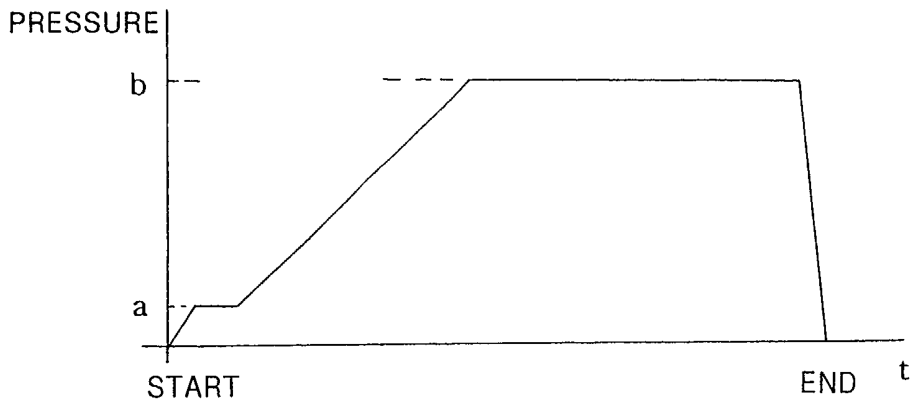


FIG.5

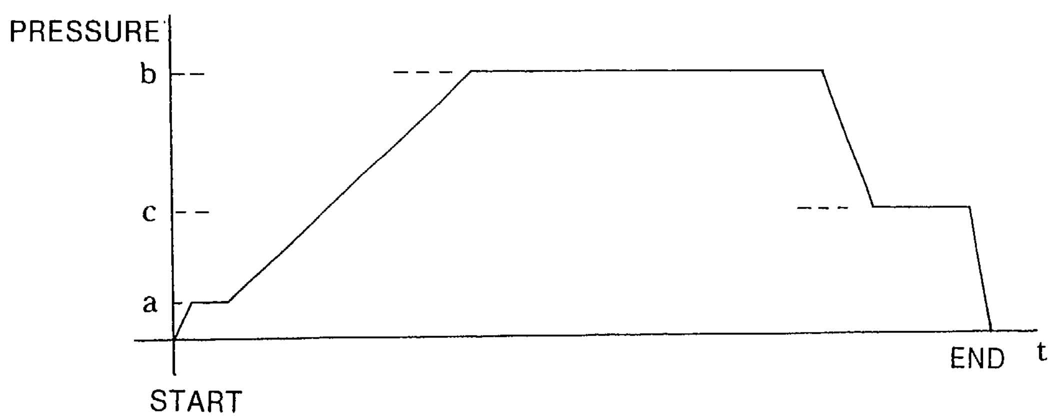
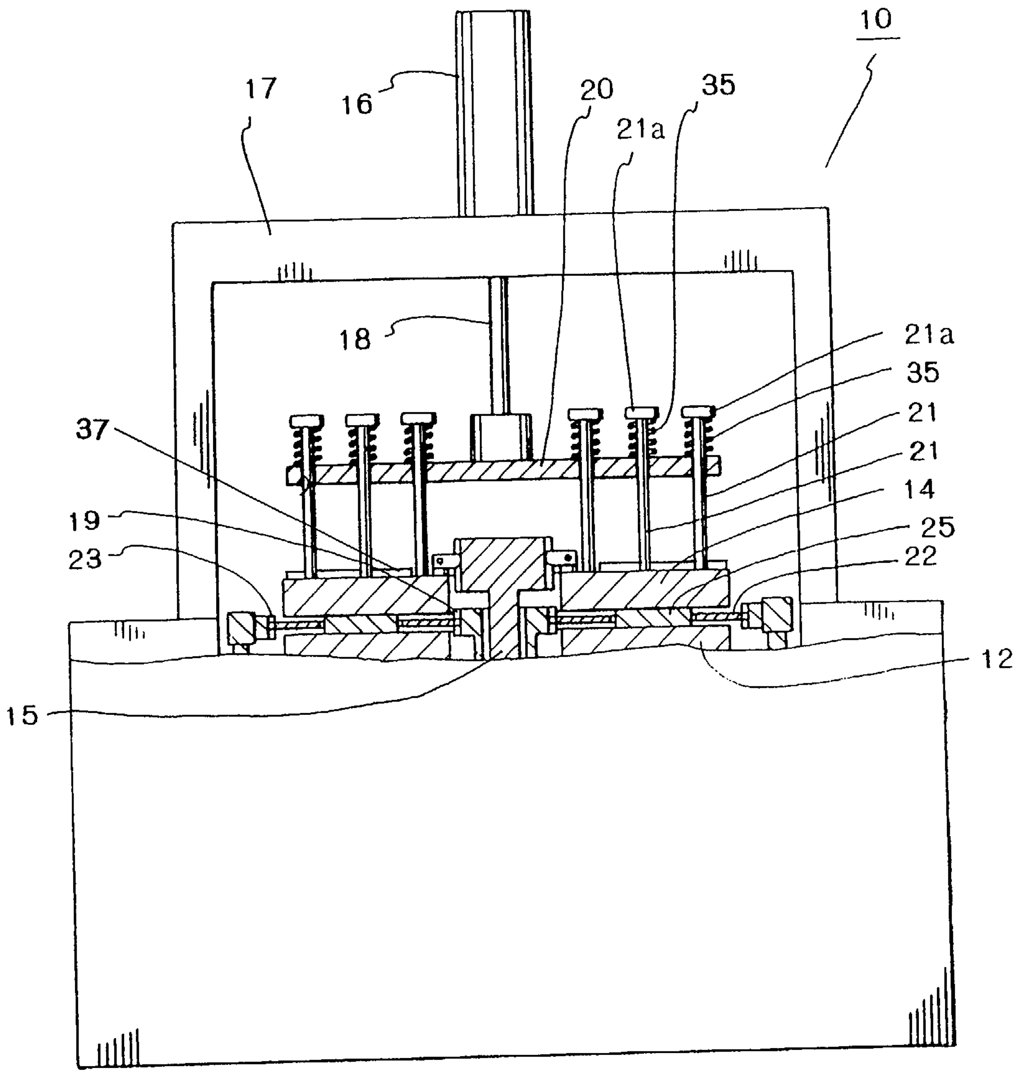


FIG.6



METHOD OF ABRADING BOTH FACES OF WORK PIECE

The present invention relates to a method of abrading both faces of a work piece.

A lapping machine is one of abrasive machines for abrading thin work pieces, e.g., silicon wafers.

In the lapping machine, a carrier holding work pieces is sandwiched between an upper abrasive plate and a lower abrasive plate, which are rotated in the opposite directions. The carrier is driven by a sun gear and an internal gear, so that the work pieces are rotated and moved along a circular orbit. With this action, the both faces of the work pieces can be lapped by the abrasive plates. The upper abrasive plate is vertically moved by a rod of a cylinder unit. When abrasion is started, the upper abrasive plate is slightly suspended by the cylinder unit so as not to apply full weight of the upper abrasive plate. Namely, suddenly applying a great force to the work pieces can be prevented while an initial abrasion step. We call this manner "low pressure abrasion". After the initial abrasion step, the full weight of the upper abrasive plate is applied to lap and finish the work pieces.

The similar structure is employed in a polishing machine. In the polishing machine, polishing cloth is adhered on an abrasive face of each abrasive plate so as to polish the both faces of the work pieces.

In the conventional abrasive machine, e.g., the lapping machine, the polishing machine, the full weight of the upper abrasive plate is applied while a main abrasion step.

By applying the full weight of the upper abrasive plate, deformation of the heavy upper abrasive plate can be prevented and the both faces of the work pieces, e.g., silicon wafers for semiconductor devices, can be made highly flat.

In the case of lapping silicon wafers, for example, preferred pressure for lapping the wafers is 100-120 g/cm^2 or 9.8-11.76 x 10^3 Pa. Therefore, in the case of applying the full weight of the upper abrasive plate, the weight and thickness of the upper abrasive plate must be limited.

However, the upper abrasive plate is gradually abraded and its weight is also varied. For example, the weight of the upper abrasive weight reduced from 500 kg to 495-490 kg in a week.

Reducing the weight of the upper abrasive plate badly influences abrasive rate, so time of abrading the work pieces must be longer. If the weight of the upper abrasive plate is varied, abrasive conditions must be changed every time, and quality of products are not fixed. Since the time of abrading the work pieces must be longer, working efficiency must be lower.

The present invention is invented so as to solve the disadvantages of the conventional method.

It would be desirable to provide a method of abrading both faces of a work piece, in which the work piece can be abraded with fixed load.

According to the present invention there is provided a method of abrading both faces of a work piece, in an abrasive machine including:

a rotatable lower abrasive plate;

a rotatable upper abrasive plate being provided to face the lower abrasive plate so as to clamp the work piece with the lower abrasive plate;

a cylinder unit having a rod, from which the upper abrasive plate is suspended, the cylinder unit moving the upper abrasive plate in the vertical direction; and

the method comprising:

a first abrading process, in which pressure of a cylinder chamber of the cylinder unit is adjusted so as to apply first pressure to the work piece via the upper abrasive plate without applying full weight of the upper abrasive plate; and

a second abrading process, in which the pressure of the cylinder chamber is readjusted so as to apply second pressure, which is higher than the first pressure, to the work piece via the upper abrasive plate without applying the full weight of the upper abrasive plate.

The method may further comprise a third abrading process, in which the pressure of the cylinder chamber is readjusted so as to apply third pressure, which is lower than the second pressure, to the work piece via the upper abrasive plate.

In the method, a reinforcing rib may be provided to an upper face of the upper abrasive plate so as to increase rigidity thereof.

In the method, a holding disk may be fixed to the rod of the cylinder unit,

a plurality of connecting rods may be provided to the holding disk, and

the upper abrasive plate may be fixed to the connecting rods.

By employing the reinforced upper abrasive plate or holding the upper abrasive plate with the connecting rods, the deformation of the upper abrasive plate, which caused by its own weight, can be prevented even if the upper abrasive plate is always suspended for the "low pressure abrasion". Therefore, the both faces of the work piece can be made highly flat.

Note that, a heavy and thick upper abrasive plate may be used so as to increase the rigidity thereof. In this case too, the "low pressure abrasion" is executed, so fixed load or pressure can be applied.

Further, in the method, the first abrading process and the second abrading process may be executed with the steps of:

calculating the constant "A", on the basis of: a formula "W = -A · P + B" (B: weight of the upper abrasive plate, P: total pressure of the cylinder chamber of the cylinder unit, A: proportional constant relating to frictional loss, etc., W: actual load applied from the upper abrasive plate); known weight "B1" of the upper abrasive plate; measured actual load "W1" applied from the upper abrasive plate when optional load is applied to the upper abrasive plate; and measured total pressure "P1" of the cylinder chamber;

calculating a value "P2", which satisfies a formula "W2 = -A · P2 + B1" (W2: set actual load applied from the upper abrasive plate while abrading);

monitoring the pressure in the cylinder chamber; and

adjusting the total pressure in the cylinder chamber to the value "P2", and

the first abrading process and the second abrading process of the next time, in which the work piece is abraded a prescribed amount, may be executed with the steps of:

calculating the value "B1"(= A · P_X) of a balanced state on the basis of the value "W"(= 0) and the measured total pressure "P_X"of the cylinder chamber;

replacing the value "B1" with the value "P_X"; and

calculating a value "P2", which satisfies a formula of "W3 = -A · P3 + B1" (W3: set actual load applied from the upper abrasive plate while abrading);

monitoring the pressure in the cylinder chamber; and

adjusting the total pressure in the cylinder chamber to the value "P3". In this case, the fixed pressure can be easily set every time by simple calculation, so the work pieces can be uniformly abraded every time.

In the method of the present invention, the "low pressure abrasion" can be executed throughout the abrasion, so abrasion of the upper abrasive plate does not badly influence to quality of products. Further, the fixed pressure can be always applied, so the work pieces can be uniformly abraded every time. The abrading conditions can be easily set.

Embodiments of the present invention will now be described by way of examples and with reference to the accompanying drawings, in which:

Fig. 1 is a partially cutaway view of a lapping machine;

Fig. 2 is a plan view showing arrangement of connecting rods;

Fig. 3 is a schematic view of a pressure control mechanism of a cylinder unit;

Fig. 4 is a graph showing change of pressure in a first method;

Fig. 5 is a graph showing change of pressure in a second method; and

Fig. 6 is a partially cutaway view of another lapping machine.

An example of an abrasive machine executing the method of the present invention will be explained with reference to Figs. 1 and 2.

The abrasive machine 10 is a lapping machine capable of abrading both faces of silicon wafers. Note that, the method of the present invention can be applied to polishing machines, too.

A lower abrasive plate 12 is rotated in a horizontal plane by a known driving mechanism (not shown).

An upper abrasive plate 14 is provided to face the lower abrasive plate 12. The upper abrasive plate 14 can be moved in the vertical direction. By engaging an engaging claw with a gear formed at an upper end of a rotary shaft 15, the upper abrasive plate 15 can be rotated. Note that, a rotational direction of the lower abrasive plate 12 is different from that of the upper abrasive plate 14.

A cylinder unit 16 is held by a gate-shaped frame 17. A rod 18 of the cylinder unit 16 is extended in the frame 17, and a holding disk 20 is fixed to a lower end of the rod 18. A size of the holding disk 20 is almost equal to that of the upper abrasive plate 14. A plurality of connecting rods 21 are fixed to the holding disk 20. The upper abrasive plate 14 is fixed to lower ends of the connecting rods 21. As shown in Fig. 2, the connecting rods 21 are uniformly distributed in the holding disk 20.

The upper abrasive plate 14 is connected to the rod 18 by a plurality of the connecting rods 21 and the holding disk 20, and the upper abrasive plate 14 is fixed to the connecting rods 21, which are uniformly arranged. With this structure, the upper abrasive plate 14 is suspended by the rod 18 without deformation.

Since the upper abrasive plate 14 can be suspended without deformation, the "low pressure abrasion" relating to the present invention can be executed.

A carrier 22 is provided on the lower abrasive plate 12 and engaged with a sun gear 19 and an internal gear 23. The sun gear 19 and the internal gear 23 are rotated by a known driving mechanism (not shown), so that the carrier 22 is rotated and moved like a planet on the lower abrasive plate 12.

A plurality of holes are formed in the carrier 22. Work pieces 25 are respectively provided and held in the holes. Therefore, the work pieces 25 are rotated and moved, on the lower abrasive plate 12, along a circular orbit.

A pressure control mechanism of the cylinder unit 16 is shown in Fig. 3.

A lower chamber 16a of the cylinder unit 16 is communicated to an air pressure source 29 via a pipe 27 and a pressure control valve 28; an upper chamber 16b is communicated to the air.

A pressure sensor 30 is connected to the pipe 27, and its connecting point is close to the lower chamber 16a. Pressure in the lower chamber 16a is measured by the pressure sensor 30, and the measured data are sent to a sequencer 31. The sequencer 31 controls degree of opening of the control valve 28 on the basis of the data.

Note that, the upper chamber 16b may be communicated to the air pressure source 29 so as to introduce and discharge air. In this case, "pressure of the cylinder chamber" (described later) means a pressure difference between the chambers 16a and 16b.

A first method of the present invention will be explained with reference to Fig. 4. Firstly, a first abrading process is executed by the steps of: adjusting the pressure in the cylinder chamber 16a of the cylinder unit 16; and applying first pressure "a", e.g., 20-30 g/cm^2, to the work pieces 25without applying full weight of the upper abrasive plate 14 to the work pieces 25. Namely, the "low pressure abrasion" is executed. The pressure applying to the work pieces 25 is gradually increased until reaching the first pressure "a". The first abrading process is executed so as to abrade and remove fine projections of the work pieces 25. Therefore, a great force is not suddenly applied to the work pieces 25.

After the first abrading process is completed, the pressure in the chamber 16a is readjusted, and a second pressure "b", e.g., 100-120 g/cm^2, which is higher than the first pressure "a", is applied to the work pieces 25 via the upper abrasive plate 14 without applying the full weight of the upper abrasive plate 14. This process is a second abrading process. The work pieces 25 are finished by the second abrading process.

The pressure is also gradually increased from the first pressure "a" to the second pressure "b". Since the pressure in the chamber 16a is increased so as to apply the proper pressure, which is less than the full weight of the upper abrasive plate 14, to the work pieces 25, the weight of the upper abrasive plate 14 is greater than that of the conventional upper abrasive plate.

By executing the "low pressure abrasion" described above, the pressure can be maintained or fixed by adjusting the air pressure in the chamber 16a even if the upper abrasive plate 14 is abraded and its weight is reduced. Therefore, the lapping machine 10 can always uniformly abrade the work pieces 25 without sharply changing abrading conditions, e.g., time of abrading.

The adjustment of the air pressure in the chamber 16a, which is required when the upper abrasive plate 14 is abraded, will be explained later.

A second method of the present invention will be explained with reference to Fig. 5. In the second method, the first abrading process and the second abrading process, in which the work pieces 25 are not finished, of the first method are executed, then a third abrading process is executed. In the third abrading process, the pressure in the chamber 16a is readjusted, and a third pressure "c", e.g., 60-90 g/cm^2, which is lower than the second pressure "b", is applied to the work pieces 25 via the upper abrasive plate 14 without applying the full weight of the upper abrasive plate 14. In the second method, the work pieces 25 are finished by the third abrading process.

Since the work pieces 25 are finished with the third pressure "c" lower than the second pressure "b", the both faces of the work pieces 25 can be well polished like mirrors.

Note that, in the second method, the second pressure "b" may be greater than the preferred pressure, e.g., 100-120 g/cm^2, so as to increase abrasive rate, then the work pieces 25 may be finished the third abrading process. By increasing the abrasive rate, the time of abrading the work pieces 25 can be shortened. In this case too, the "low pressure abrasion" is executed from the first abrading process to the third abrading process.

Successively, the abrasion of the upper abrasive plate 14 and the adjustment of the pressure will be explained.

A following formula "Formula 1" is given about the upper abrasive plate 14 and the cylinder unit 16 suspending the upper abrasive plate 14.

$$W = -A \cdot P + B \qquad \text{[Formula 1]}$$

wherein, "B" is actual weight of the upper abrasive plate; "P" is total pressure of the cylinder chamber of the cylinder unit (area x pressure); "A" is a proportional constant relating to frictional loss, etc. (Actually, the value "A" is slightly varied, but it is considered as a constant value here.); and "W" is actual load applied from the upper abrasive plate (total load applied to whole faces of the work pieces).

The load, weight and pressure toward the work pieces 25 are assigned the plus (+) sign; the load, weight and pressure toward the opposite direction are assigned the minus (-) sign.

The steps of the present method will be explained.

(1) Firstly, the constant value "A" is defined.

The known weight of the upper abrasive weight is considered as "B1". The value "B1" may be initially known weight or actually measured weight. Generally, the initially known weight is used.

The value "W1" of the upper abrasive plate 14, to which optional load is applied, is measured by a load indicator, and the total pressure "P1" of the cylinder chamber 16a is simultaneously measured by the pressure sensor 30. The constant value "A" is calculated on the basis of Formula 1 and the measured data. Namely, "A = (B1 - W1) / P1".

(2) Actual load from the upper abrasive plate 14 during the first to third abrading process, which has been optionally set, is considered as "W2". A value "P2", which satisfies a formula "$W2 = -A \cdot P2 + B1$", is calculated. The pressure in the cylinder chamber 16a is continuously monitored so as to adjust the total pressure in the cylinder chamber 16a to the value "P2" during the first to third abrading process. The air pressure in the chamber 16a is always monitored by the pressure sensor 30, and the measured data are inputted to the sequencer 31. The sequencer 31 detects difference between the data and an object value, which has been previously inputted. The sequencer 31 controls the pressure control valve 28 so as to reduce the difference to zero, so that the pressure in the chamber 16a can be maintained at "P2". This feedback control correctly controls the pressure in the chamber 16a.

The abrasive work for a prescribed time, e.g., one day, is executed as described above. The upper abrasive plate 14 is gradually abraded and its weight is also gradually reduced. In the present embodiment, the weight reduced is ignored.

(3) Next time, e.g., the next day, the upper abrasive plate 14 and the pressure in the chamber 16a are balanced so as to abrade the work pieces 25 a prescribed amount.

Firstly, the control valve 28 is closed and the upper abrasive plate 14 is freely suspended. At that time, the pressure "P_X" in the chamber 16a is measured by the pressure sensor 30. The value "P_X" will be gradually reduced with the abrasion of the upper abrasive plate 14.

When the upper abrasive plate 14 and the pressure in the chamber 16a are balanced, the actual load from the upper abrasive plate 14 is zero ("$W = 0$"). Therefore, "$B1 = A \cdot P_X$", and the value "B1" is replaced with the value "P_X" in the formula. Note that, at the beginning the value "$A \cdot P_X$" is less than the value "B1" .

The actual load from the upper abrasive plate 14 during the first to third abrading process, which has been optionally set, is considered as "W3". Actually, the value "W3" is equal to the value "W2". In this state, a value "P3", which satisfies a formula "W3 = -A · P3 + A · P_X", is calculated. The pressure in the cylinder chamber 16a is continuously monitored so as to adjust the total pressure in the cylinder chamber 16a to the value "P3" during the first to third abrading process. The sequencer 31 feedback-controls so as to maintain the pressure in the chamber 16a at "P3" as well.

(4) In the abrasive work of following times or days, the value "B1" is replaced with the value "A · P_X" every time as described in the item (3). The upper abrasive plate 14 is gradually abraded in and its weight is also gradually reduced in the future, but the amount of abrasion of the upper abrasive plate 14 is very small. Therefore, the weight reduced can be ignored.

In the present method, the work pieces can be always abraded with the fixed pressure, which has been set. Therefore the work pieces can be uniformly abraded, and quality of products can be maintained.

Adjustment of the pressure of the cylinder unit may be executed once for a predetermined number of operations or a predetermined time, e.g., one day. Therefore, the abrasive conditions can be set easier.

In the above described embodiment, the connecting rods 21 are fixed to the holding disk. However, in another embodiment shown in Fig. 6, the connecting rods 21 are pierced through the holding disk 20 and capable of moving in the vertical direction. Elastic members, e.g., coil springs 35, are respectively provided between stopper sections 21a of the connecting rods 21 and the holding disk 20. By providing the elastic members 35, the load is gradually applied to the work pieces 25 from the upper abrasive plate 14. Therefore, damaging and breaking the work pieces 25 can be effectively prevented.

The arrangement of the connecting rods 21 is not limited to the example shown in Fig. 2.

In the above described embodiments, a plurality of the rods 21 are connected to the upper abrasive plate 14 so as not to deform the upper abrasive plate 14. The deformation of the upper abrasive plate 14 may be prevented by reinforcing ribs 37, which are provided to an upper face of the upper abrasive plate 14 so as to increase rigidity thereof. For example, the reinforcing ribs may be formed in the radial directions or formed like a lattice. The reinforcing ribs can prevent the deformation of the upper abrasive plate 14.

To increase the rigidity of the upper abrasive plate and prevent the deformation thereof, a heavy and thick upper abrasive plate may be used. In the present invention, the "low pressure abrasion" is executed throughout the abrasive work, so the fixed load can be always applied to the work pieces. Therefore, the work pieces can be uniformly abraded every time, and the abrasive conditions can be set easily.

CLAIMS

1. A method of abrading both faces of a work piece , in an abrasive machine including: a rotatable lower abrasive plate ; a rotatable upper abrasive plate being provided to face said lower abrasive plate so as to clamp the work piece with said lower abrasive plate ; a cylinder unit having a rod , from which said upper abrasive plate is suspended, said cylinder unit moving said upper abrasive plate in the vertical direction;

said method comprising:

a first abrading process, in which pressure of a cylinder chamber of said cylinder unit is adjusted so as to apply first pressure to the work piece via said upper abrasive plate without applying full weight of said upper abrasive plate ; and

a second abrading process, in which the pressure of the cylinder chamber is readjusted so as to apply second pressure, which is higher than the first pressure, to the work piece via said upper abrasive plate without applying the full weight of said upper abrasive plate .

2. The method according to claim 1,

further comprising a third abrading process, in which the pressure of the cylinder chamber is readjusted so as to apply third pressure, which is lower than the second pressure, to the work piece via said upper abrasive plate .

3. The method according to claim 1 or 2,

wherein a reinforcing rib is provided to an upper face of said upper abrasive plate so as to increase rigidity thereof.

4. The method according to claim 1, 2 or 3,

wherein a upper abrasive plate is fixed to the rod of said cylinder unit ,

a plurality of connecting rods are provided to said holding disk , and

said holding disk is fixed to said connecting rods .

5. The method according to claim 1, 2, 3 or 4,

wherein said first abrading process and said second abrading process are executed with the steps of:

calculating the constant "A", on the basis of: a formula "W = -A · P + B" (B: weight of said upper abrasive plate , P: total pressure of the cylinder chamber of said cylinder unit , A: proportional constant relating to frictional loss, etc., W: actual load applied from said upper abrasive plate); known weight "B1" of said upper abrasive plate ; measured actual load "W1" applied from said upper abrasive plate when optional load is applied to said upper abrasive plate ; and measured total pressure "P1" of the cylinder chamber ;

calculating a value "P2", which satisfies a formula "W2 = -A · P2 + B1" (W2: set actual load applied from said upper abrasive plate while abrading);

monitoring the pressure in the cylinder chamber ; and

adjusting the total pressure in the cylinder chamber to the value "P2", and

wherein said first abrading process and said second abrading process of the next time, in which the work piece is abraded a prescribed amount, are executed with the steps of:

calculating the value "B1"(= A · P_X) of a balanced state on the basis of the value "W"(= 0) and the measured total pressure "P_X" of the cylinder chamber ;

replacing the value "B1" with the value "P_X"; and

calculating a value "P2", which satisfies a formula of "W3 = - A · P3 + B1" (W3: set actual load applied from said upper abrasive plate while abrading);

monitoring the pressure in the cylinder chamber ; and

adjusting the total pressure in the cylinder chamber to the value "P3".

6. A method of abrading both faces of a work piece substantially as described with reference to the accompanying drawings.

Application No: GB 0127238.4
Claims searched: 1 to 6
Examiner: Karl Whitfield
Date of search: 9 May 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): B3D (DCB5, DCB23, DCM, DFLC, DFPG, DFPX, DMN)

Int Cl (Ed.7): B24B 7/00, 7/04, 17/10, 41/04, 41/047, 41/053, 49/00, 49/08, 51/00

Other: Online databases: Derwent World Patents Index, Patent Abstracts of Japan and European Patent Office

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2344545 A	(SPEEDFAM) see especially page 9 line 26 to page 10 page 4 & page 12 lines 9 to 22	1 at least
X	GB 2337014 A	(SPEEDFAM) see especially page 8 line 18 to page 9 line 13, page 12 lines 14 to 24 and page 16 lines 26 to 29	1 at least
X	US 4742651	(WITTSTOCK) see especially fig 3	1 at least

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