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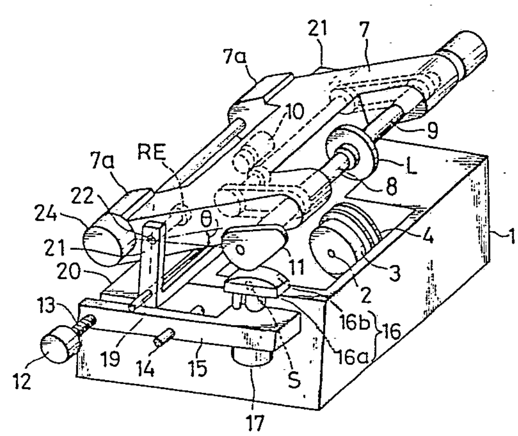
(54) Lens grinding apparatus.

(57) In a lens grinding apparatus in which a lens held by a lens shaft of a swingable carriage body is ground by a V-edging grinder, the lens grinding apparatus of this invention is characterized in that a resilient member, the resilient force of which is adjustable by abutting force adjusting means, is interposed between the rear end portion of the carriage body and a carriage base, a swing down moment of the carriage is calculated with reference to the swing angle of the carriage when a roughly ground lens held between the lens shafts is abutted against the V-edging grinder and the abutting force adjusting means is drive controlled as such that a difference between the pivot down moment and the pivot down preventing moment by the spring becomes constant.

FIG.1



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Description

LENS GRINDING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a lens grinding apparatus in which there can be obtained a position, i.e., a coordinate of the edge of a lens, which was roughly ground and held between two lens rotating shafts of a swingable carriage with respect to a V-groove of a V-beveling or V-edging grinder.

Description of the Prior Art

There is a conventional lens grinding apparatus as shown in Fig. 8. In this lens grinding apparatus, a drive shaft 2 disposed within a front portion of a body 1 is secured thereon with a coarse grinder 3 and a V-edging grinder 4 adjacent to each other. Also, a supporting portion 5 is disposed on a rear portion of the body 1. A supporting shaft 6, which is parallel with the drive shaft 2, is rotatably and movably held by the supporting portion 5 for movement in the axial direction thereof. A carriage 7 is secured at a rear end portion thereof to the supporting shaft 6. Furthermore, a pair of lens shafts 8,9, which are parallel with the supporting shaft 6 and coaxial with each other, are rotatably held by a front end portion of the carriage 7. The lens shaft 9 is adjustable as such that it can be moved forward and backward with respect to the lens shaft 8. By tightening the lens shaft 9, an ophthalmic lens L to be ground is fixedly held between the lens shafts 8 and 9. The lens shafts 8,9 can be rotated in synchronism with each other by a pulse motor 10 which is disposed within the carriage 7. Also, the lens shaft 8 is provided with a template 11 removably mounted on one end portion thereof.

Also, when a pulse motor 12 supported on a frame (not shown) is rotated normally or reversely, a feed screw 13 is rotated. As a result, an arm plate 15, which is supported by a guide shaft 14, is reciprocally moved in the longitudinal direction parallel with the lens shafts 8,9 and the supporting shaft 6. Since one end portion of the supporting shaft 6 is rotatably held by the arm plate 15, the carriage 7 is reciprocally moved in the axial direction of the supporting shaft 6 by means of activation of the pulse motor 12 through the arm plate 15. Also, the arm plate 15 is provided with a contact platform 16 vertically and movably held thereby and with a pulse motor 17 mounted thereon and adapted to move the contact platform 16 in the vertical direction. The contact platform 16 comprises a body 16a and a contact piece 16b mounted on the body 16a in such a manner as to be swingable within a predetermined range in the vertical direction about one end thereof. The contact piece 16b is energized upwardly by spring means (not shown). In case the lens L is going to be ground using such a lens grinding apparatus as described, the template 11 is brought to be contact with the platform 16. In that state, the lens shafts 8,9 are rotated and the coarse grinder 3 is driven to rotate. When the platform 16 is lowered, the lens L is roughly ground into a configuration identical with that of the template 11 by the coarse grinder 3. The lens L, which was roughly ground, is different in radius vector ρ_i from the center of rotation thereof to the peripheral surface thereof at each point in the circumferential direction according to the configuration of the template 11. Also, since both refractive surfaces of the lens L are three-dimensional curved-surfaces as shown in Fig. 9, peripheral edges L_f, L_b of the lens L are changed in the axial direction of the lens shafts 8,9. Therefore, when the edges of the lens L, which was roughly ground as mentioned, is going to be subjected to V-edging treatment, the lateral moving amount of the carriage 7 is required to be controlled according to each radius vector ρ_i since otherwise an ideal V-edging treatment cannot be applied to the peripheral portion of the lens L.

Therefore, in order to satisfy this point, there is considered the apparatus, as shown in Fig. 9, in which the lens L, which was roughly ground, is moved to position above a V-groove 18 of a V-edging grinder 4 and then, the lens shafts 8,9 are repeatedly lowered by a predetermined amount from position of a predetermined height and the carriage 7 is repeatedly laterally moved by means of the vertical movement of the platform 16 in order to measure a movable coordinate of the carriage 7 in the Y-direction (axial direction of the lens shafts 8,9) when the peripheral edges L_f, L_b of the lens L are abutted against inclined surfaces 18a, 18b of the V-groove 18 and the thickness of the edge of the lens which can be obtained from the coordinate per radius vector ρ_i at several places beforehand, thereby to determine the amount of lateral movement of the carriage during the V-edging treatment according to each radius of vector ρ_i. The specific structure of this apparatus is identical with that described in Japanese patent application No. Sho 62-335672 filed by the present applicant.

In such measurement, if the measuring position of the lens L is changed in the circumferential direction, the radius vector ρ_i is also changed. Therefore, if the abutting positions of the peripheral edges L_f, L_b of the lens L against the inclined surfaces 18a, 18b are changed in the circumferential direction, a swing angle θ of the carriage 7 at this time is also changed.

However, the abutting force of the peripheral edges L_f, L_b of the lens L against the inclined surfaces 18a, 18b uses a pivotal moment by the weight of the carriage 7, if the swing angle θ is changed, the abutting force is increased, and therefore, not constant. In order to obtain a comparatively more accurate measurement, it is preferable that the abutting force is small enough and always constant under lens grinding pressure, even if the abutting positions are moved in the circumferential direction to change the radius vector ρ_i at the abutting points.

SUMMARY OF THE INVENTION

It is therefore the object of the present invention to provide a lens grinding apparatus capable of satisfying the above requirement.

In order to achieve this object, there is provided a lens grinding apparatus including a V-edging grinder rotatably mounted on a body of the apparatus, a carriage swingably supported by a supporting shaft parallel with a rotating shaft of the V-edging grinder in such a manner as to be swung about the supporting shaft and adapted to hold a lens to be ground with a lens rotating shaft thereof, and means for measuring the radius vector of the lens, CHARACTERIZED in that the lens grinding apparatus comprises a carriage base having the supporting shaft and reciprocally movably mounted on the body in such a manner as to be moved in a direction parallel with the rotating shaft, a resilient member mounted at one end thereof on either a rear end por tion of the carriage or the carriage base, abutting force adjusting means interposed between the rear end portion of the carriage or the carriage base, on which the resilient member is not mounted, and the other end of the resilient member, and control means for calculating a swing down moment of the carriage with reference to a swing angle of the carriage about the supporting shaft when the lens, which was roughly ground, is abutted against the V-edging grinder and the radius vector of the lens at that time and drive controlling the abutting force adjusting means as such that a difference between the swing down moment and a swing down preventing moment by the abutting force adjusting means becomes constant.

According to the above-mentioned construction, a swing down moment of the carriage is calculated with reference to the swing angle of the carriage when the roughly ground lens is abutted against the V-edging grinder and the radius vector of the lens at that time, and the abutting force adjusting means is drive controlled by the control means as such that a difference between the swing down moment and a swing down preventing moment by the abutting force adjusting means becomes constant. By this, the abutting force of the lens against the V-edging grinder becomes constant even if the radius vector of the lens at its abutting position against the V-edging grinder is changed.

The above and other objects, features and advantages of the present invention will be well appreciated upon reading of the following description of the invention when taken in conjunction with the attached drawings with understanding that some modifications, variations and changes of the same could be made by the skilled person in the art to which the invention pertains without departing from the spirit of the invention or the scope of claims appended hereto.

BRIEF DESCRIPTION OF THE ATTACHED DRAWINGS

Fig. 1 is a perspective view of a lens grinding apparatus according to the present invention;
Fig. 2 is a schematic view of a device for maintaining abutting pressure of a lens against a grinder;
Fig. 3 is a right side view of Fig. 2;
Fig. 4 is a control circuit diagram of the device of Fig. 2;
Fig. 5 through Fig. 7 are schematic views for explaining the operation of the device of Fig. 1 through Fig. 4;
Fig. 8 is a perspective view showing one example of a conventional lens grinder (prior art); and
Fig. 9 is a schematic view for explaining the operation of the lens grinder of Fig. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The embodiment of the present invention will be described hereunder with reference to Figs. 1 through 7.

Fig. 1 is a perspective view of a lens grinder including a device for maintaining abutting pressure against a grinder according to the present invention, in which identical or similar parts of Fig. 8 are denoted by identical reference numerals and description thereof is omitted. Also, the measurement of a peripheral edge position of a lens is performed in the same manner as described in Japanese patent application No. Sho 62-335672 filed by the present applicant.

Therefore, the different points from these will be described hereunder in detail.

A body 1 of the apparatus is provided with a guide shaft 19 extending in a direction parallel with a drive shaft 2 (rotating shaft) of a V-edging grinder 4 and mounted to position (not shown) of a rear portion of the body 1. A carriage base 20 is reciprocally and movably held by the guide shaft 19 in the longitudinally direction thereof. The carriage base 20 is connected with an arm plate 15 and is reciprocally moved in the axial direction of the guide shaft 19 by a pulse motor 12 together with the arm plate 15. The carriage base 20 is provided at both ends in its moving direction with supporting portions 21,21 projecting upward therefrom. Portions in the vicinity of rear end portions 7a,7a of the carriage body or carriage 7 are held by upper end portions of the supporting portions 21,21 as such that the carriage 7 is vertically pivoted by supporting shafts 22,22 coaxial with each other. The gravity G of the carriage 7 is located in front of the supporting shaft 22. Between a body 16a of a contact platform 16 and a contact piece 16b, a contacting sensor S is interposed. This sensor S employs a detector same to one which is provided to a contact platform of the above-mentioned Japanese patent application and therefore, detailed description thereof will be omitted.

The carriage 7 is provided with an abutting force adjusting means 23 mounted on a rear end portion 7a thereof. The abutting force adjusting means 23 includes a pulse motor 24 mounted on the rear end portion 7a, a reduction gear 24a interlocked with the pulse motor 24, a rotating shaft 24b interlocked with the reduction gear 24a, a circular timing plate 25 and a lever 26 mounted on the rotating shaft 24b, and a microswitch 27 mounted on the rear end portion 7a. The timing plate 25 is formed with a V-shaped notch 25a. A roller 27b attached to an actuator lever 27a of the microswitch 27 is abutted against the peripheral surface of the timing plate 25. And, upon engagement of the roller 27b with the notch 25a, the microswitch 26 is switched off.

Between the free end portion or lower end portion of the lever 26 and the carriage base 20, a spring 28 is interposed. The timing plate 25 and the microswitch 27 constitute means for detecting a pivot starting position of the lever 26.

Furthermore, the abutting force adjusting means 23 is drive controlled by CPU 29 (central processing unit) as a calculation control circuit (control circuit). In the CPU 29, power output from the microswitch 26 and a signal from the contacting sensor S are input. Also, the CPU 29 controls the rotating time of the pulse motor 24 through a timer 30. The CPU 29 calculates the rotation angle of the lens shafts 8,9 in accordance with a drive control pulse signal of the pulse motor 10 during rough grinding treatment of the lens and stores the same therein. An electric power is fed to the pulse motor 24 through the timer 30 when the timer 30 is being activated.

Also, the CPU 29 employs a measuring device as disclosed in the above-mentioned Japanese patent application in order to measure a positional coordinate of the peripheral edge of the roughly ground lens L in such a manner as that a radius vector ρ_i of the lens L abutted against the V-edging grinder 4 is found in accordance with the shaft rotation angle of the lens shafts 8,9 and a swing angle θ of the carriage 7, when the roughly ground lens L is abutted against the V-edging grinder 4 in this radius vector position, is calculated based on such obtained radius vector ρ_i and a known carriage arm length. Moreover, the CPU 29 determines the operating time of the timer 30 and the current feeding direction to the pulse motor 24, thereby to allow the timer 30 to control the current feeding time to the pulse motor 24 and the current feeding direction. At this time, the controlling of the current feeding time and the current feeding direction by the timer 30 is started from a position where the microswitch 27 is switched off due to engagement of the roller 27 with the notch 25a and is performed as such that a difference between a swing down moment by weight of the carriage acted on the abutting portion from the swing angle θ of the carriage 7 and a pivot down preventing moment by the spring 28 becomes constant. In this embodiment, although the driving time of the pulse motor 24 is determined by the operating time of the timer 30, it may be designed as such that the number of drive pulse of the pulse motor 24 is found through the above calculation and such found number of drive pulse is input into the pulse motor 24 from the CPU 29 so as to drive control the pulse motor 24 directly by the CPU 29.

This relation will now be described with reference to Fig. 5 through Fig. 7, wherein O denotes the swing center of the carriage 7, G denotes the gravity of the carriage 7, A denotes the length from the swing center O to the axial line O_1 of the lens shaft, C denotes the length from the swing center O to the gravity G, B_0 denotes the length from the swing center O to a point f on which the force of the spring is acted, F_0 denotes the spring force acting on the point f, G_0 denotes the weight at the gravity G, and W_0 denotes the swing down moment which is acted on the abutting point E of the lens against the V-edging grinder and the axial line O_1 by the swing down moment due to the weight G_0.

Fig. 5 shows a case where the carriage 7 is in its horizontal position and where the swing angle thereof is zero. In this case, if the lens grinding radius vector is denoted by ρ_0, the correlation of $A \bullet W_0$, $C \bullet G_0$ and $B \bullet F_0$ becomes as follows;

$A \bullet W_0 + C \bullet G_0 = B \bullet F_0$

At this time, the pulse motor is controlled as such that the lever is brought to its downwardly vertical position.

Also, Fig. 6 shows a case where the radius vector ρ_i is ρ_1 which is larger than ρ_0. In this case, if the length from the swing center O to the point f_1 on which the force of the spring is acted is represented by B_1 and the spring force acting on the point f_1 is represented by F_1, the force relation thereof is arranged as follows;

$$A \cdot W_0 \cos\theta + C \cdot G_0 \cos\theta > B_0 \cdot F_1 \cos\theta$$

$$A \cdot W_0 \cos\theta + C \cdot G_0 \cos\theta = B_1 \cdot F_1 \cos\theta \text{ '}$$

$$(B_0 < B_1)$$

In this case, therefore, the lever is pivoted toward the side departing from the swing center O.

Furthermore, Fig. 7 shows a case where the grinding radius vector ρ_1 is ρ_2 which is smaller than ρ_0. In this case, if the length from the swing center O to the point f_2 on which the force of the spring is acted is represented by B_2 and the spring force acting on the point f_2 is represented by F_2, the force relation is arranged as follows;

$$A \cdot W_0 \cos\theta + C \cdot G_0 \cos\theta < B_0 \cdot F_2 \cos\theta$$

$$A \cdot W_0 \cos\theta + C \cdot G_0 \cos\theta = B_2 \cdot F_2 \cos\theta \text{ '}$$

$$(B_0 > B_2)$$

In this case, therefore, the lever is pivoted toward the side approaching to the swing center O.

Instead of obtaining the swing angle of the carriage by calculation, a swing angle detecting rotary encoder RE may be provided as shown by the broken line of Fig. 1.

Also, although the operating point of the force of the spring 28 acting on the carriage 7 is performed by the pivotal lever 26, the present invention is not necessarily limited to this. For example, it may be designed as such that a spring mounting member is movably mounted on the rear end portion 7a of the carriage 7 in such a manner as to move forward and backward with respect to the front end portion of the carriage 7, so that the upper end portion of the spring 28 is held by the spring mounting member and the spring mounting member is controlled by a pulse motor, a cylinder or the like in such a manner as to move forward and backward with respect to the front end portion of the carriage 7.

According to the present invention, in a lens grinding apparatus including a V-edging grinder rotatably mounted on a body of the apparatus, a carriage swingably supported by a supporting shaft parallel with a rotating shaft of the V-edging grinder in such a manner as to be swung about the supporting shaft and adapted to hold a lens to be ground with a lens rotating shaft thereof, and means for measuring the radius vector of the lens, the lens grinding apparatus comprises a carriage base having the supporting shaft and reciprocally movably mounted on the body in such a manner as to be moved in a direction parallel with the rotating shaft, a resilient member mounted at one end thereof on either a rear end portion of the carriage or the carriage base, abutting force adjusting means interposed between the rear end portion of the carriage or the carriage base, on which the resilient member is not mounted, and the other end of the resilient member, and control means for calculating a swing down moment of the carriage with reference to a swing angle of the carriage about the supporting shaft when the lens, which was roughly ground, is abutted against the V-edging grinder and the radius vector of the lens at that time and drive controlling the abutting force adjusting means as such that a difference between the swing down moment and a swing down preventing moment by the abutting force adjusting means becomes constant. Accordingly, even when the abutting position of the peripheral end of the roughly ground lens against the V-edging grinder is moved in the circumferential direc tion and the radius vector at the abutting point is changed, the abutting force of the peripheral edge of the roughly ground lens against the V-edging grinder can be made smaller enough than the grinding pressure during the lens grinding treatment. Also, this controlling may be utilized not only in a case where the peripheral edge is abutted and measured but also in a case where the grinding pressure during the lens grinding treatment is adjusted.

Also, there can be considered to adopt a method for adjusting the pivot down preventing moment of the carriage by changing the length of a spring instead of the present invention. In this case, however, since it is required to use a spring having a large spring constant and also required to have means for changing a spring length of large torque in order to change the length of a spring, the apparatus is anticipated to become large and to be of energy consuming type. Also, since the adjusting range of the preventing moment is small merely by the adjustment of a spring length, it would be impossible to control, for example, the abutting force adjustment during the measurement of the thickness of the peripheral edge of a lens and the grinding pressure adjustment during the lens grinding treatment by one construction.

On the contrary, since the present invention employs a method for changing the position of the operating point of a spring, the adjusting device becomes small and easy to handle. Furthermore, it is of energy saving type. In addition, the adjusting range of the carriage pivot preventing moment can be taken large and one adjusting mechanism can be used both for adjusting the abutting force during the measurement of the thickness of the peripheral edge of a lens and for adjusting the grinding pressure during the grinding treatment of a lens.

Claims

1. A lens grinding apparatus including
a V-edging grinder (4) rotatably mounted in a body (1) of the apparatus;
a carriage (7) swingably supported by a supporting shaft (6) parallel with a rotating shaft (2) of said V-edging grinder (4) in such a manner as to be swung about the supporting shaft (2) and adapted to hold a lens to be ground (L) with a lens rotating shaft (8,9) thereof; and
means (10,11,12,16,17) for measuring the radius vector of the lens;
CHARACTERIZED IN THAT
said lens grinding apparatus comprises
a carriage base (7a,7a) having the supporting shaft (2) and reciprocally movably mounted on the body (1) in such a manner as to be moved in a direction parallel with the rotating shaft (2);
a resilient member (28) mounted at one end thereof on either a rear end portion (20) of the carriage (7) or the carriage base (7a);
abutting force adjusting means (24,25,26,27,30) interposed between either the rear end portion (20) of said carriage (7) or said carriage base (7a), on which said resilient member (28) is not mounted, and the other end of said resilient member (28); and
control means (29) for calculating a swing down moment (W_0,$W_0\cos\theta$) of said carriage with reference to a swing angle (θ) of said carriage about the supporting shaft (2) when the lens (L), which was roughly ground, it abutted against said V-edging grinder (4) and the radius vector (ρ_i) of the lens (L) at that time and drive controlling said abutting force adjusting means (24,25,26,27,30) as such that a difference

between the swing down moment and a swing down (W_0,$W_0\cos\theta$) preventing moment (F_0,$F_1\cos\theta$,$F_1\cos\theta'$,$F_2\cos\theta$,$F_2\cos\theta'$) by said the abutting force adjusting means becomes (24,25,26,27,30) constant.

2. A lens grinding apparatus of claim 1, wherein said swing angle (θ) can be obtained with reference to the radius of vector (ρ_i) of the lens (L) and a swing diameter (A) of said carriage (7).

3. A lens grinding apparatus of claim 1, wherein said swing angle (θ) is determined by a rotary encoder (RE) which is interposed between the supporting shaft (6) and said carriage (7).

4. A lens grinding apparatus according to any of claim 1 through claim 3, wherein said abutting force adjusting means (24,25,26,27,30) comprises a pulse motor (24) mounted on a rear end portion (7a) of said carriage (7), and a lever (26) mounted on said carriage (7) and being pivoted by said pulse motor (24), said lever (26) being provided on a free end por tion thereof with said resilient member (28).

5. A lens grinding apparatus of claim 4, wherein there is provided pivot starting position detecting means (25,27) for detecting a pivot starting position (25a) of said lever (26).

6. A lens grinding apparatus of claim 5, wherein said pivot starting position detecting means (25,27) comprises a timing plate (25) secured to a rotating shaft (24b) interlocked with the pulse motor (24) and provided at a peripheral portion thereof with a notch (25a), and a microswitch (27) mounted on said carriage (7) in such a manner as to be adjacent to said timing plate (25), a roller (27b) on a front end of an actuator lever (27a) thereof being abutted against the peripheral surface of said timing plate (25).

FIG.1

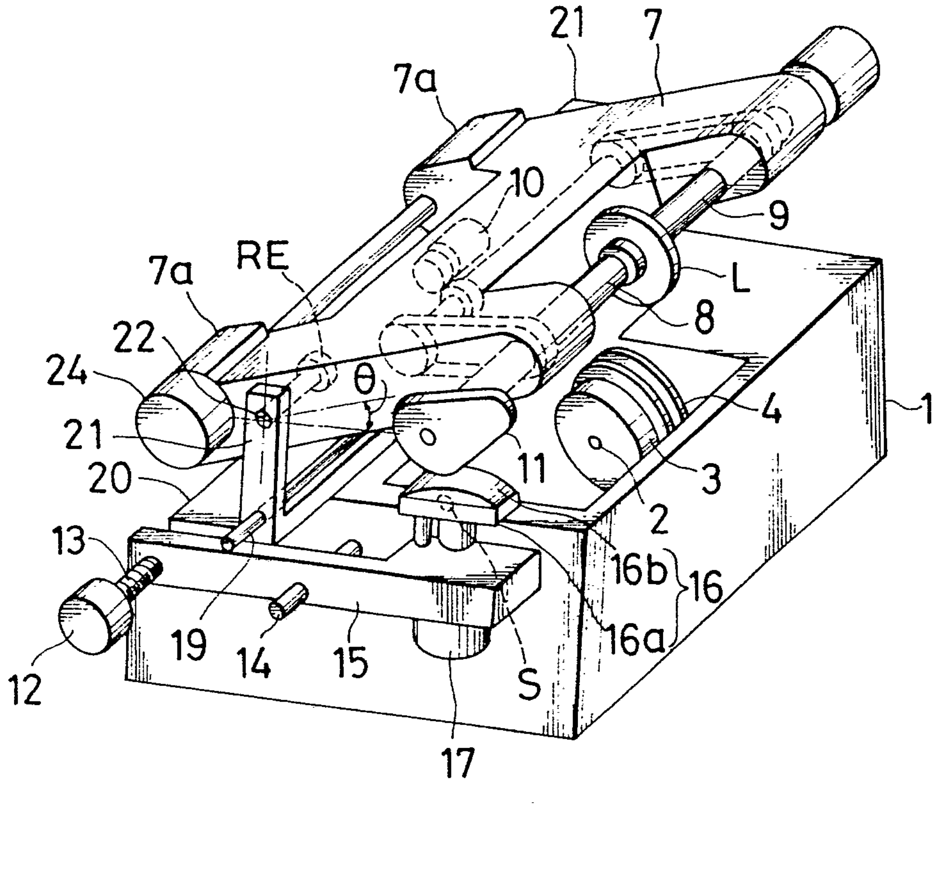

21
7
7a
10
9
7a
RE
L
8
22
24
θ
4
1
21
11
3
20
2
13
16b
16
19
14
15
16a
12
S
17

FIG. 2

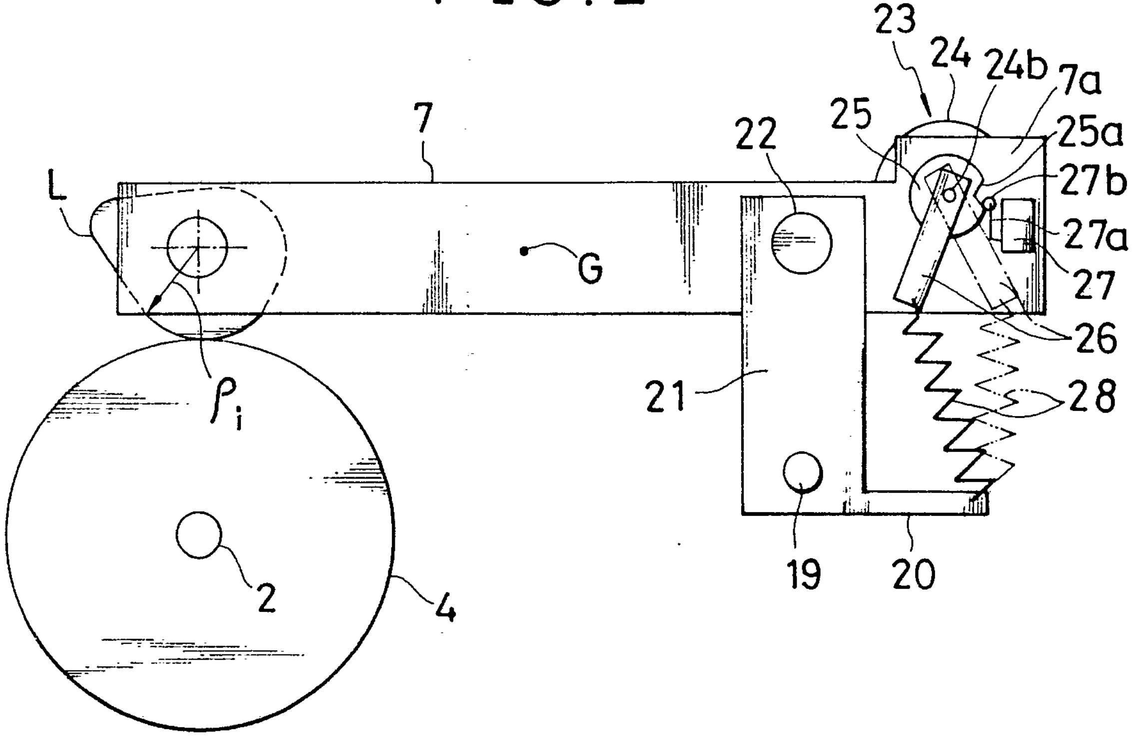

23
24
24b
7a
25
25a
27b
22
7
L
27a
27
G
26
28
21
19
20
2
4

FIG. 3

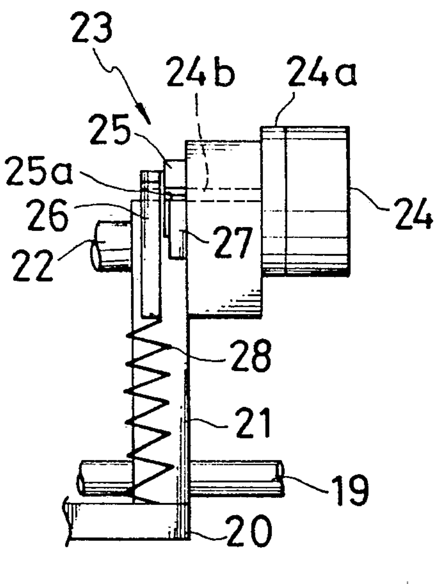

23
24b
24a
25
25a
26
24
22
27
28
21
19
20

FIG. 4

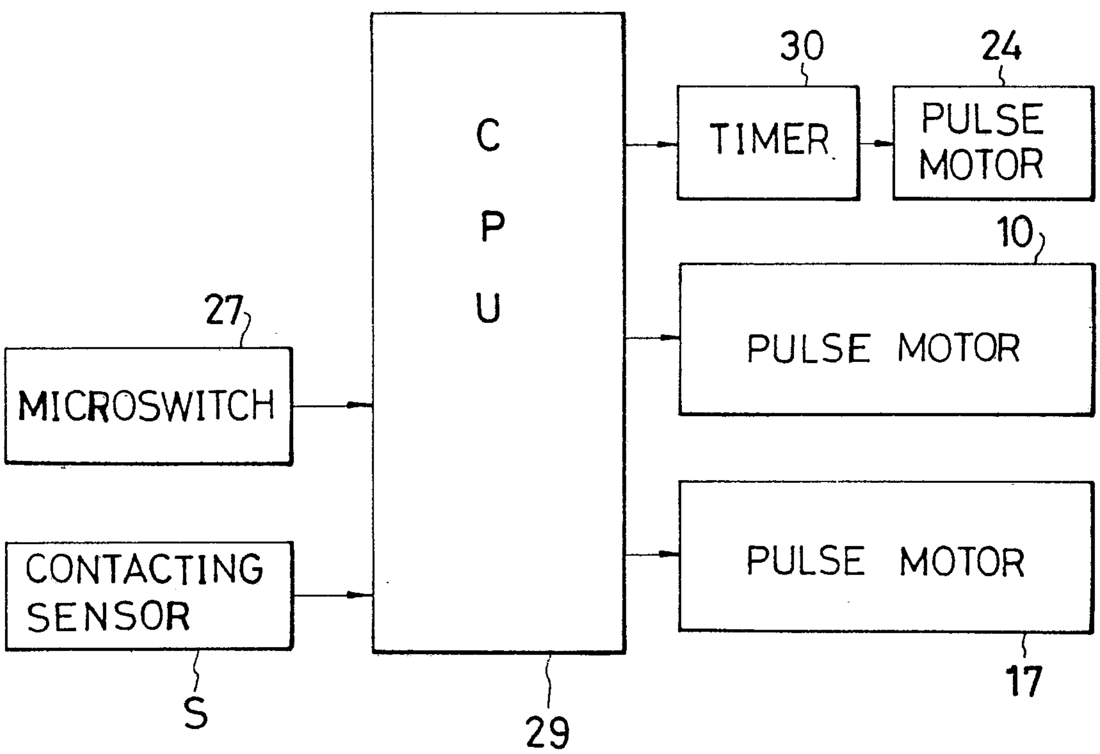
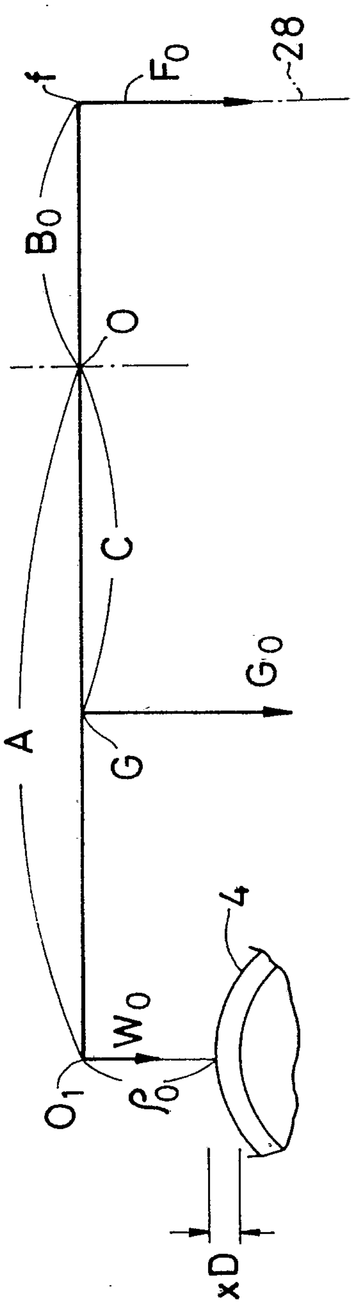

CPU
29
30
TIMER
24
PULSE MOTOR
10
PULSE MOTOR
27
MICROSWITCH
CONTACTING SENSOR
S
PULSE MOTOR
17

FIG.5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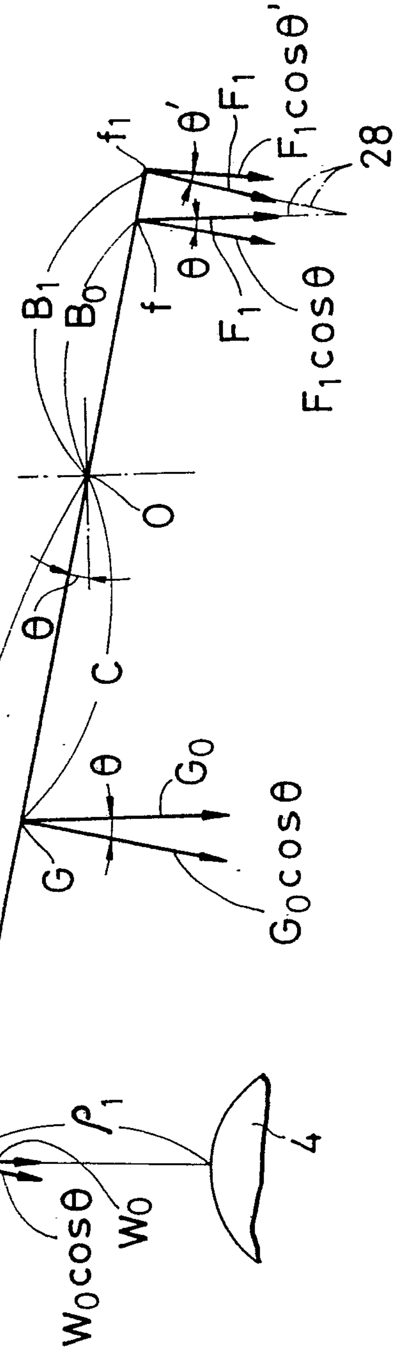
B_0
O
C
G_0
A
G
4
W_0
O_1
ρ_0
xD

FIG.6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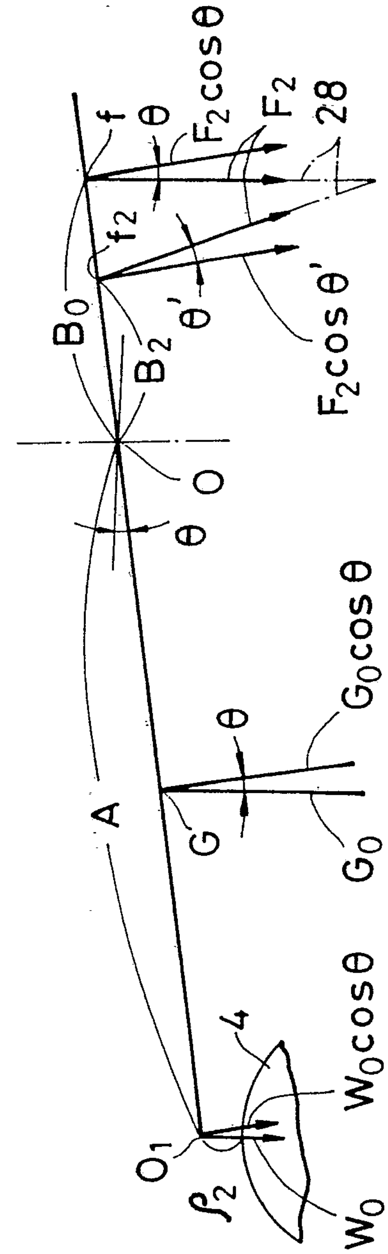
θ'
F_1
$F_1\cos\theta'$
28
B_1
B_0
f
θ
F_1
$F_1\cos\theta$
O
θ
C
G_0
θ
$G_0\cos\theta$
A
G
ρ_1
4
O_1
$W_0\cos\theta$
W_0

FIG.7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θ
$F_2\cos\theta$
F_2
28
f_2
B_0
B_2
θ'
$F_2\cos\theta'$
O
θ
$G_0\cos\theta$
θ
A
G
G_0
$W_0\cos\theta$
4
W_0
O_1
ρ_2
W_0

FIG. 8
PRIOR ART

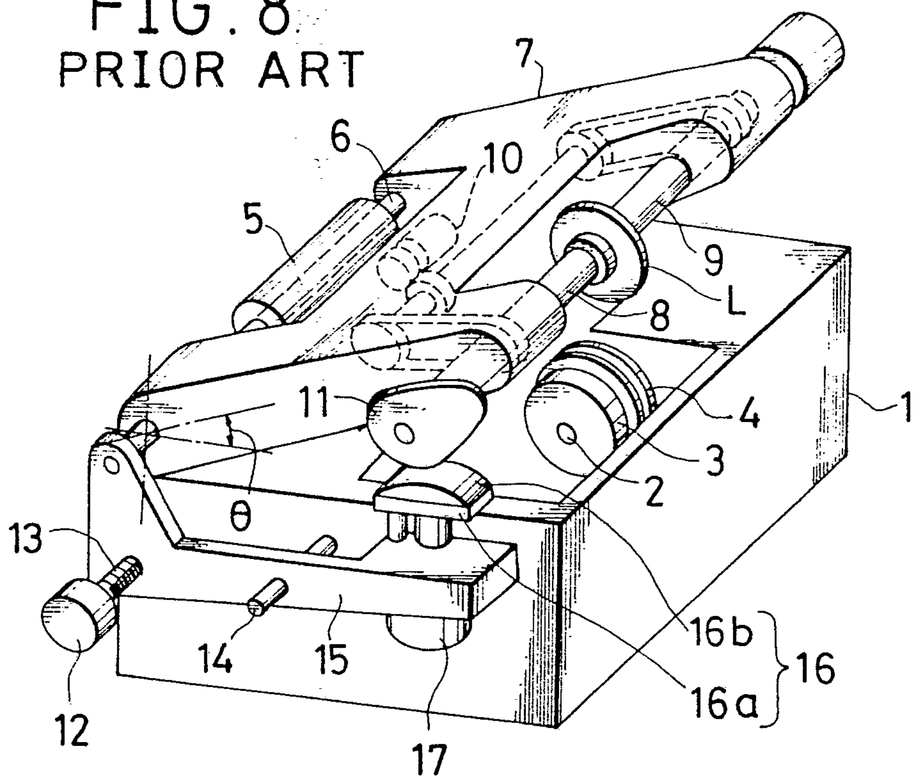

FIG. 9
PRIOR ART