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(54) **Plate reduction press apparatus and methods**

Plattenpressvorrichtung und Verfahren

Dispositif de formage sous pression d'une plaque et procédés

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Description

BACKGROUND OF THE INVENTION

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to a plate thickness reduction press apparatus that transfers and reduces a slab, and the methods concerned with its use.

Prior art

[0002]

1. Fig. 1 shows an example of a roughing mill used for hot rolling, and the roughing mill is provided with work rolls 2a, 2b arranged vertically opposite each other on opposite sides of a transfer line S that transfers a slab-like material 1 to be shaped, substantially horizontally, and backup rolls 3a, 3b contacting the work rolls 2a, 2b on the side opposite to the transfer line.
In the above-mentioned roughing mill, the work roll 2a above the transfer line S is rotated counterclockwise, and the work roll 2b underneath the transfer line S is rotated clockwise, so that the material 1 to be shaped is caught between both work rolls 2a, 2b, and by pressing the upper backup roll 3a downwards, the material 1 to be shaped is moved from the upstream A side of the transfer line to the downstream B side of the line, and the material 1 to be shaped is pressed and formed in the direction of the thickness of the slab. However, unless the nip angle θ of the material 1 to be shaped as it enters into the work rolls 2a, 2b is less than about 17°, slipping will occur between the upper and lower surfaces of the material 1 to be shaped and the outer surfaces of both work rolls 2a, 2b, and the work rolls 2a, 2b will no longer be able to grip and reduce the material 1 to be shaped. More explicitly, when the diameter D of the work rolls 2a, 2b is 1,200 mm, the reduction Δt of a single rolling pass is about 50 mm according to the above-mentioned nip angle θ condition for the work rolls 2a, 2b, so when a material 1 to be shaped with a thickness T0 of 250 mm is rolled, the thickness T1 of the slab after being reduced and formed by a roughing mill becomes about 200 mm.
According to the prior art, therefore, the material 1 to be shaped is rolled in a reversing mill, in which the material is moved backwards and forwards while gradually reducing the thickness of the plate, and when the thickness of the material 1 to be shaped is reduced to about 90 mm, the material 1 is sent to a finishing mill. Another system for reducing and forming the material 1 to be shaped according to the prior art is shown in Fig. 2; dies 14a, 14b with profiles like the plane shape of dies for a stentering press machine are positioned opposite each other above and below a transfer line S, and both dies 14a, 14b are made to approach each other and separate from each other in the direction orthogonal to the direction of movement of the material 1 using reciprocating means such as hydraulic cylinders, in synchronism with the transfer of the material 1, while reducing and forming the material 1 to be shaped in the direction of the thickness of the plate.
The dies 14a, 14b are constructed with flat forming surfaces 19a, 19b gradually sloping from the upstream A side of the transfer line towards the downstream B side of the line, and flat forming surfaces 19c, 19d that continue from the aforementioned forming surfaces 19a, 19b in a direction parallel to and on opposite sides of the transfer line S.
The width of the dies 14a, 14b is set according to the plate width (about 2,000 mm or more) of the material 1 to be shaped.
However, when the material 1 to be shaped is rolled with the reversing method using the roughing mill shown in Fig. 1, space is required at each of the upstream A and downstream B ends of the transfer line S of the roughing mill, for pulling out the material 1 to be shaped as it comes out of the roughing mill, so the equipment must be long and large.
When the material 1 to be shaped is reduced and formed in the direction of its plate thickness using the dies 14a, 14b shown in Fig. 2, the areas of the forming surfaces 19a, 19b, 19c and 19d in contact with the material 1 to be shaped are much longer than those of the dies of a stentering press machine, and the contact areas increase as the dies 14a, 14b approach the transfer line S, so that a large load must be applied to each of the dies 14a, 14b, during reduction.
Furthermore, the power transmission members such as the eccentric shafts and rods for moving the dies 14a, 14b, the housing, etc. must be strong enough to withstand the above reducing loads, so each of these members and the housing must be.made large in size.
Moreover, when the material 1 to be shaped is reduced and formed in the direction of its plate thickness using the dies 14a, 14b, some of the material 1 is forced backwards towards the upstream A side on the transfer line depending on the shape and the stroke of the dies 14a, 14b, therefore, it becomes difficult to transfer the material 1 to be shaped to the downstream B side of the transfer line.
When the material 1 to be shaped is reduced and formed in the direction of its plate thickness using the dies 14a, 14b shown in Fig. 2, the height of the lower surface of the material 1 after being reduced by the dies 14a, 14b is higher than the height of the lower surface of the material 1 immediately before being reduced by the dies, by an amount corresponding to the reduction in thickness.
Consequently, the leading end of the material 1 to

be shaped tends to droop downwards, therefore the table rollers (not illustrated) installed on the downstream B side of the transfer line, to support the material 1 being shaped, may catch the leading end of the material 1, possibly resulting in damage to both the table rollers and the material 1 being shaped.

Recently, the flying-sizing press machine shown in Fig. 3 has been proposed.

This flying-sizing press machine is provided with a housing 4 erected on a transfer line S so as to allow movement of a material 1 to be shaped, an upper shaft box 6a and a lower shaft box 6b housed in window portions 5 of the housing 4 opposite each other on opposite sides of the transfer line S, upper and lower rotating shafts 7a, 7b extending substantially horizontally in the direction orthogonal to the transfer line S and supported by the upper shaft box 6a or the lower shaft box 6b by bearings (not illustrated) on the non-eccentric portions, rods 9a, 9b located above and below the transfer line S, respectively, connected to eccentric portions of the rotating shafts 7a, 7b through bearings 8a, 8b at the end portions thereof, rod support boxes 11a, 11b connected to intermediate portions of the upper and lower rods 9a, 9b by bearings 10a, 10b with spherical surfaces and housed in the window portions 5 of the housing 4 and free to slide vertically, die holders 13a, 13b connected to the top portions of the rods 9a, 9b through bearings 12a, 12b with spherical surfaces, dies 14a, 14b mounted on the die holders 13a, 13b, and hydraulic cylinders 15a, 15b whose cylinder units are connected to intermediate locations along the length of the rods 9a, 9b by means of bearings and the tips of the piston rods are connected to the die holders 13a, 13b through bearings.

The rotating shafts 7a, 7b are connected to the output shaft (not illustrated) of a motor through a universal coupling and a speed reduction gear, and when the motor is operated, the upper and lower dies 14a, 14b approach towards and move away from the transfer line S in synchronism with the transfer operation.

The dies 14a, 14b are provided with flat forming surfaces 16a, 16b gradually sloping from the upstream A side of the transfer line towards the downstream B side of the transfer line so as to approach the transfer line S, and other flat forming surfaces 17a, 17b continuing from the aforementioned forming surfaces 16a, 16b in a direction parallel to the transfer line S.

The width of the dies 14a, 14b is determined by the plate width (about 2,000 mm or more) of the material 1 to be shaped.

A position adjusting screw 18 is provided at the top of the housing 4, to enable the upper shaft box 6a to be moved towards or away from the transfer line S, and by rotating the position adjusting screw 18 about its axis, the die 14a can be raised and lowered through the rotating shaft 7a, rod 9a, and the die holder 13a.

When the material 1 to be shaped is reduced and formed in the direction of the plate thickness using the flying-sizing press machine shown in Fig. 3, the position adjusting screw 18 is rotated appropriately to adjust the position of the upper shaft box 6a, so that the spacing between the upper and lower dies 14a, 16b is determined according to the plate thickness of the material 1 to be shaped by reducing and forming in the direction of plate thickness.

Next, the motor is operated to rotate the upper and lower rotating shafts 7a, 7b, and the material 1 to be shaped is inserted between the upper and lower dies 14a, 14b, and the material 1 is reduced and formed by means of the upper and lower dies 14a, 14b that move towards and away from each other and with respect to the transfer line S while moving in the direction of the transfer line S as determined by the displacement of the eccentric portions of the rotating shafts 7a, 7b.

At this time, appropriate hydraulic pressure is applied to the hydraulic chambers of the hydraulic cylinders 15a, 15b, and the angles of the die holders 13a, 13b are changed so that the forming surfaces 17a, 17b of the upper and lower dies 14a, 14b, on the downstream B side of the transfer line, are always parallel to the transfer line S.

However, the flying-sizing press machine shown in Fig. 3 has much larger contact areas between the forming surfaces 16a, 16b, 17a and 17b of the dies 14a, 14b and the material 1 to be formed, compared to the dies of a plate reduction press machine, and because the above-mentioned contact areas increase as the dies 14a, 14b approach the transfer line S, a large load must be applied to the dies 14a, 14b during reduction.

In addition, the die holders 13a, 13b, rods 9a, 9b, rotating shafts 7a, 7b, shaft boxes 6a, 6b, housing 4, etc. must be strong enough to withstand the reducing load applied to the dies 14a, 14b, so that these members are made larger in size.

Also, the flying-sizing press machine shown in Fig. 3 may suffer from the problem that the leading and trailing ends of the material 1 being reduced and formed are locally bent to the left or right, or with a camber so that when a long material 1 is being formed it generally warps, unless the centers of the reducing forces from the dies 14a, 14b on the material 1 to be shaped are in close alignment when the material 1 is reduced and formed by the upper and lower dies 14a, 14b.

2. With a conventional rolling mill known in the prior art, in which a material is rolled between two work rolls, there is a reduction ratio limit of normally about 25% due to the nip angle limitation. Therefore, it is not possible to reduce the thickness of a material by a large ratio (for example, reducing a material from about 250 mm thickness to 30 to 60 mm) in a single

pass, therefore three or four rolling mills are arranged in tandem in a tandem rolling system, or the material to be rolled is rolled backwards and forwards in a reverse rolling system. However, these systems are accompanied with practical problems such as the need for a long rolling line.

On the other hand the planetary mill, Sendzimir mill, cluster mill, etc. have been proposed as means of pressing that allow a large reduction in one pass. However, with these rolling mills, small rolls press the material to be rolled at a high rotational speed, resulting in a great impact, therefore the life of the bearings etc. is so short that these mills are not suitable for mass production facilities.

On the other hand, various kinds of press apparatus modified from the conventional stentering press machines have been proposed (for example, Japanese patent No. 014139, 1990, unexamined Japanese patent publication Nos. 222651, 1986, 175011, 1990, etc.).

An example of the "Flying-sizing press apparatus" according to the unexamined Japanese patent publication No. 175011, 1990 is shown in Fig. 4; rotating shafts 22 are arranged in the upper and lower sides or the left and right sides of the transfer line Z of a material to be shaped, and the bosses of rods 23 with a required shape are connected to eccentric portions of the rotating shafts 22, and in addition, dies 24 arranged on opposite sides of the transfer line of the material to be shaped are connected to the tips of the rods 23; when the rotating shafts 22 are rotated, the rods 23 coupled to the eccentric portions of the rotating shafts cause the dies 24 to press both the upper and lower surfaces of the material 1 to be shaped, thereby the thickness of the material to be shaped is reduced.

However, the above-mentioned high-reduction means are associated with problems such as (1) a material to be reduced cannot be easily pressed by the flying-sizing apparatus in which the material is reduced as it is being transferred, (2) the means are complicated with many component parts, (3) many parts must slide under heavy loads, (4) the means are not suitable for heavily loaded frequent cycles of operation, etc.

With conventional high-reduction pressing means known in the prior art, the position of the dies is controlled to adjust the thickness of the material to be pressed by means of a screw, wedge, hydraulic cylinder, etc., and as a result, there are the practical problems that the equipment is large, costly, complicated, and vibrates considerably.

3. Conventionally, a roughing-down mill is used to roll a slab. The slab to be rolled is as short as 5m to 12m, and the slab is rolled by a plurality of roughing-down mills or by reversing mills in which the slab is fed forwards and backwards as it is rolled. In addition, a reduction press machine is also used. Recently, because a long slab manufactured by a continuous casting system has been introduced, there is a demand for the continuous transfer of the slab to a subsequent pressing system. When a material is rough rolled using a roughing-down mill, the minimum nip angle (about 17°) must be satisfied, so the reduction limit Δt per pass is about 50 mm. Because the slab is continuous, reverse rolling is not applicable, so that to obtain the desired thickness, a plurality of roughing-down mills must be installed in series, or if a single rolling mill is to be employed, the diameter of the work rolls should be very large.

Consequently, a reduction press machine is used. Fig. 5 shows an example of such a machine in which the dies are pressed by sliders, to provide a flying-press machine that can press a moving slab. Dies 32 provided above and below the slab 1 are mounted on sliders 33, and the sliders 33 are moved up and down by the crank mechanisms 34. The dies 32, sliders 33 and crank mechanisms 34 are reciprocated in the direction of transferring the slab, by the feeding crank mechanisms 35. The slab 1 is conveyed by pinch rolls 36 and transfer tables 37. When the slab is being reduced, the dies 32, sliders 33 and crank mechanisms 34 are moved in the direction of transferring the slab by means of the feeding crank mechanisms 35, and the pinch rolls 36 transfer the slab 1 in synchronism with this transfer speed. A start-stop system can also be used; the slab 1 is stopped when the system is working as a reduction press machine and the slab is reduced, and after completing reduction, the slab is transferred by a length equal to a pressing length, and then pressing is repeated.

There are problems in the design and manufacturing cost of the aforementioned roughing-down mill with large diameter rolls, and the use of rolls with a large diameter results in a shorter life for the rolls because of the low rolling speed and difficulty in cooling the rolls. With the reduction press machine using sliders and feeding crank mechanisms shown in Fig. 5, the cost of the equipment is high because the mechanisms for reciprocating the sliders etc. in the direction of movement of a slab are complicated and large in scale. In addition, the sliders vibrate significantly in the vertical direction. With a reduction press machine using a start-stop system, the slab must be accelerated and decelerated repeatedly from standstill to transfer speed, and vice versa. The slab is transferred using pinch rolls and transfer tables, and these apparatus become large due to the high acceleration and deceleration.

4. When a material is reduced by a large amount, according to the prior art, long dies were used to reduce the material while it was fed through the dies by the length thereof during one or several pressings. Defining the longitudinal and lateral directions as the direction in which the pressed material is moved and

the direction perpendicular to the longitudinal direction, respectively, the material to be pressed by a large amount in the longitudinal direction is pressed by dies that are long in the longitudinal direction using single pressing or by means of a plurality of pressing operations while feeding the material to be pressed in the longitudinal direction. Fig. 6 shows an example of the above-mentioned reduction press machine, and Fig. 7 illustrates its operation. The reduction press is equipped with dies 42 above and below a material 1 to be pressed, hydraulic cylinders 43 for pressing down the dies 42, and a frame 44 that supports the hydraulic cylinders 43. A pressing operation is described using the symbols L for the length of the dies 42, T for the original thickness of the material 1 to be pressed, and t for the thickness of the material after pressing. Fig. 7 (A) shows the state of the dies 42 set to a location with thickness T on a portion of material to be pressed next, adjacent to a portion with thickness t which has been pressed. (B) shows the state in which the dies have pressed down from the state (A). (C) is the state in which the dies 42 have been separated from the material 1 being pressed, that has then been moved longitudinally by the pressing length L, and completely prepared for the next pressing, which is the same state as (A). Operations (A) to (C) are repeated until all the material is reduced to the required thickness.

The longer the dies, the greater the force that is required for reduction, so the reduction press machine must be large. With a press machine, pressing is usually repeated at high speed. When an apparatus with a large mass is reciprocated at a high speed, a large power is required to accelerate and decelerate the apparatus, therefore the ratio of the power required for acceleration and deceleration to the power needed for reducing the material to be pressed is so large that much power is spent on driving the apparatus. When the material is reduced, the volume corresponding to the thinned portion must be displaced longitudinally or laterally because the volumes of the material before and after reduction are substantially the same. If the dies are long, the material is constrained so that it is displaced longitudinally (this phenomenon is called material flow), so that pressing becomes difficult especially when the reduction is large.

When a material to be rolled is reduced conventionally in a horizontal mill, the gap between the rolls of the horizontal mill is set so that the rolls are capable of gripping the material to be rolled considering the thickness of the material after forming, therefore the reduction in thickness allowed for a single pass is limited so that when a large reduction in the thickness is required, a plurality of horizontal mills have to be installed in series, or the material must be moved backwards and forwards through a horizontal mill while the thickness is gradually reduced, according to the prior art. Another system was also proposed in the unexamined Japanese patent publication No. 175011, 1990; eccentric portions are provided in rotating shafts, the motion of the eccentric portions is changed to an up/down movement using rods, and a material to be pressed is reduced continuously by these up/down movements.

The system with a plurality of horizontal mills arranged in tandem (series) has the problems that the equipment is large and the cost is high. The system of passing a material to be pressed backwards and forwards through a horizontal mill has the problems that the operations are complicated and a long rolling time is required. The system disclosed in the unexamined Japanese patent application No. 175011, 1990 has the difficulty that large equipment must be used, because a fairly large rotating torque must be applied to the rotating shafts to produce the required reducing force as the movement of the eccentric portions of the rotating shafts has to be changed to an up/down motion to produce the necessary reducing force.

5. Conventionally, a roughing-down mill is used to press a slab. The slab to be pressed is as short as 5 to 12 m, and to obtain the specified thickness, a plurality of roughing-down mills are provided, or the slab is moved backwards and forwards as it is pressed in the reversing rolling method. Other systems also used practically include a flying press machine that transfers a slab while it is being pressed, and a start-stop reduction press machine which stops conveying the material as it is being pressed and transfers the material during a time when it is not being pressed.

Since long slabs are produced by continuous casting equipment, there is a practical demand for a slab to be conveyed continuously to a subsequent press apparatus. When a slab is rough rolled in a roughing-down mill, there is a nip angle limitation (about 17°), so the reduction per rolling cannot be made so large. Because the slab is continuous, it cannot be rolled by reverse rolling, therefore to obtain the preferred thickness, a plurality of roughing-down mills must be installed in series, or if a single mill is involved, the diameter of the work rolls must be made very large. There are difficulties, in terms of design and cost, in manufacturing such a roughing-down mill with large-diameter rolls, and large diameter rolls must be operated at a low speed when rolling a slab, so the rolls cannot be easily cooled, and the life of the rolls becomes shorter. Because a flying press can provide a large reduction in thickness and is capable of reducing a material while it is being conveyed, the press can continuously transfer the material being pressed to a downstream rolling mill. However, it has been difficult to adjust the speed of the material to be pressed so that the flying press and the downstream rolling mill can operate simultaneously to reduce and roll the material. In addition, it has not been possible to arrange a start-stop reduction press machine and a rolling mill in tandem to reduce a slab continuously; with the start-stop reduction press, the material being pressed is stopped during pressing, and is transferred when it is not being pressed.

Another system in practical use is the flying system in which the sliders that press down on a slab are moved up and down in synchronism with the transfer speed of the slab.

In the start-stop system, the heavy slab is accelerated and decelerated every cycle from standstill to the maximum speed Vmax, and accordingly the capacity of the transfer facilities such as the pinch rolls and transfer tables must be large. Because of the discontinuous operation, it is difficult to carry out further operations on a downstream press machine. The flying system requires a large capacity apparatus to produce the swinging motion, and to accelerate and decelerate the heavy sliders according to the speed of the slab. Another problem with this system is that this large capacity apparatus for producing the swinging motion causes considerable vibrations in the press machine.

Still another problem with this system is that if the speed of the slab deviates from that of the sliders, flaws may be produced in the slab or the equipment may be damaged.

Recently, a high-reduction press machine that can reduce a thick slab (material to be pressed) to nearly 1/3 of its original thickness in a single reduction operation, has been developed. Fig. 8 shows an example of a reduction press machine used for hot pressing. With this reduction press machine, dies 52a, 52b are disposed opposite each other vertically on opposite sides of the transfer line S, and are simultaneously moved towards and away from a material 1 to be pressed that travels on the transfer line S by the reciprocating apparatus 53a, 53b incorporating eccentric axes, rods, and hydraulic cylinders, so that material of a thickness of, for example, 250 mm can be reduced to 90 mm by a single reducing operation. However, the reduction of the aforementioned high-reduction press machine can be as large as 160 mm, that is, the reduction on one side is as large as 80 mm. According to the prior art, there is a small difference of thickness before and after pressing, so the transfer levels of the transfer devices of a press machine on the inlet and outlet sides are substantially the same. With the above-mentioned high-reduction press machine, however; there is the problem that the material 1 to be pressed is bent if the transfer Levels are identical. Another problem of the machine is that the transfer device is overloaded.

[0003] Prior art EP 0 381 919 discloses a plate reduction press apparatus having the features as defined in the preamble of claim 1.

[0004] Prior art US 3,955,391 relates to rolling mills designed to achieve a high reduction.

SUMMARY OF THE INVENTION

[0005] The present invention has been accomplished under the circumstances mentioned above, and

[0006] The second object of the present invention is to provide a plate reduction press apparatus with (1) the capability of a flying press apparatus that can reduce a material to be pressed while it is being moved, (2) small number of component parts and a simple configuration, (3) a reduced number of portions that slide under load, (4) the capability for operating under a heavy load at a high operating rate, and (5) a simply constructed means of adjusting the positions of the dies and correcting the thickness of a material to be pressed.

[0007] The above objects are achieved with a plate reduction press apparatus as defined in claim 1 or claim 13. Preferred embodiments of the inventive apparatus are defined in the dependent claims.

[0008] According to the configuration of the preferred embodiment as defined in dependent claim 5, when the drive shafts are rotated, the upper and lower dies move in a circular path, while rolling laterally at the same time, and are opened and closed by the pair of eccentric shafts of which the phase angles are shifted relative to each other. Consequently, the material to be pressed can be conveyed while being pressed, because the upper and lower dies move in the direction of the line while they are closing. In addition, because the upper and lower dies close with a rolling action, the load during pressing can be reduced. The amount of reduction is determined by the eccentricity of the eccentric shafts, so high-reduction pressing is possible without being limited by a nip angle etc. Moreover, because according to the invention the material to be pressed is conveyed while being reduced, the apparatus operates as a flying press.

[0009] In addition, according to the inventiv apparatus as defined in claim 1 only the eccentric shafts withstand loads during pressing, and the horizontal guide device is acted on by only a rather small load that only cancels the moments applied to the press frames, and furthermore the moments applied to the upper and lower press frames cancel each other, so that the load imposed on the horizontal guide device is further reduced. Therefore, the construction can be simplified with a small number of component parts, and with a small number of portions that slide under load during pressing, and as a result, the apparatus can operate with high loads a a high operating frequency.

[0010] According to a preferred embodiment of the plate reduction press apparatus as specified in Claim 6 the speed of the dies in the line direction can be made to be substantially equal to the speed of feeding the material to be pressed (a slab), so the load on the driving device that rotates and drives the drive shafts can be reduced.

[0011] According to a preferred embodiment specified in Claim 7 a looper device can absorb deviations between the speed of the dies in the line direction and the speed of feeding the material to be pressed, so that the line speed can be synchronized with a finish rolling mill located further downstream.

[0012] The plate reduction press apparatus of the present invention as defined in claim 1 provides upper and lower dies which move in a circular path when the crank shafts rotate, and open and close. Consequently, as the upper and lower dies move in the direction of the line while closing, the material to be pressed can be conveyed while being reduced. The amount of reduction is determined by the eccentricity of the crank shafts, therefore high-reduction pressing is possible without being limited by a nip angle etc. Also, the apparatus operates as a flying press because the material to be pressed is transferred while being reduced.

[0013] In addition, only the crank shafts withstand loads during pressing, and because the horizontal guide devices are acted on by only relatively small loads that are sufficient to only cancel the moments acting on the press frames, and also because the moments applied to the upper and lower press frames cancel each other, the loads on the horizontal guide devices become still smaller. As a result the construction of the apparatus is made simple with few component parts, and with a small number of components that slide under load during pressing, so that the apparatus can operate with large loads at a high operating frequency.

[0014] According to a preferred embodiment as specified in Claim 2 the speed of the dies in the line direction can be made to be substantially the same as the speed of feeding the material to be pressed (a slab), so the load on the driving device

[0015] A preferred embodiment as defined in Claim 4 provides the advantage that by replacing these height adjusting plates, the heights of the dies can be adjusted freely, so compared to a conventional screw mechanism etc., the construction of the apparatus can be made tougher, simpler, and more compact than a conventional one, consequently, the apparatus vibrates less and fails less often than a conventional machine, so the apparatus according to the present invention can be maintained more easily whilst the cost is reduced.

[0016] The plate reduction press apparatus as defined in claim 13 provides the advantage that, when the drive shafts are rotated, the upper and lower eccentric shafts rotate around fixed axes, and due to the rotation of the eccentric shafts, the upper and lower dies move in circular paths while opening and closing. As a result, the upper and lower dies can convey the material to be pressed in the direction of the line while reducing the material, by synchronizing the speed of the press frames in the direction of the line with the speed of the material to be pressed by means of the synchronous eccentric shafts during pressing with the dies. In this way, the amount of the reduction is determined by the eccentricity of the eccentric shafts without any nip angle restriction etc., so high-reduction pressing can be carried out.

[0017] In this apparatus, only the eccentric shafts (dual-eccentric shafts) that rotate around the axes of the fixed shafts withstand loads during pressing, and only rather small loads that merely cancel the moments acting on the press frames are applied to the connection portions, in addition, because the moments acting on the upper and lower press frames cancel each other, the loads are further reduced. Therefore, there are few component parts, the construction is simple, there are only a small number of sliding locations which are loaded during pressing, and the apparatus can operate with high loads at a high operating frequency.

[0018] The other objects and advantages of the present invention will be revealed as follows by referring to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is a schematic view of an example of a rolling mill used for hot rolling.

Fig. 2 is a schematic view showing an example of reduction forming in the direction of plate thickness of a material to be shaped using dies.

Fig. 3 is a conceptual view showing an example of a flying sizing press apparatus.

Fig. 4 is a structural view of a conventional high-reduction press machine.

Fig. 5 is a view showing a conventional flying reduction press machine.

Fig. 6 is a view showing an example of the configuration of a reduction press machine using conventional long dies.

Fig. 7 is a view showing the operation of the apparatus shown in Fig. 6.

Fig. 8 shows the method of reducing thickness used during hot pressing.

Fig. 9 shows the configuration of the press equipment provided with the plate reduction press apparatus according to the invention.

Fig. 10 is a side view of the plate reduction press apparatus shown in Fig. 9.

Fig. 11 is a sectional view along the line A-A in Fig. 10.

Fig. 12 is a schematic view showing the paths in which the dies move.

Fig. 13 is a view showing the movement of the dies in the up and down direction relative to the angular position θ of the drive shafts.

Fig. 14 shows the configuration of a rolling facility provided with the plate reduction press apparatus according to the tenth embodiment of the present invention.

Fig. 15 is a side view of the plate reduction press apparatus shown in Fig. 14.

Fig. 16 is a sectional view along the line A-A in Fig. 15.
Fig. 17 is a schematic view showing the paths in which the dies move.
Fig. 18 is a diagram showing the plate reduction pressing method according to the present invention.
Fig. 19 shows the configuration of a rolling facility provided with the plate reduction press apparatus according to the eleventh embodiment of the present invention.
Fig. 20 is a side view of the plate reduction press apparatus shown in Fig. 19.
Fig. 21 is a sectional view along the line A-A in Fig. 20.
Fig. 22 is a schematic view showing the paths in which the dies move.
Fig. 23 is a view showing the movement of the dies in the up and down direction relative to the angular position θ of the synchronous eccentric shafts.
Fig. 24 shows the configuration of the twelfth embodiment of the present invention.
Fig. 25 is a sectional view along the line X-X in Fig. 24.
Fig. 26 shows one cycle of the operation of a slider.
Fig. 27 shows one cycle of the operation of a slider and the material to be pressed.
Fig. 28 shows the configuration of the thirteenth embodiment of the present invention.
Fig. 29 is a sectional view along the line Y-Y in Fig. 28.
Fig. 30 is a schematic view showing the paths in which the dies move.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] The embodiments of the present invention are described as follows referring to the drawings.

(First embodiment)

[0021] Fig. 9 shows the configuration of a rolling mill operating together with the plate reduction press apparatus according to the present invention. In this figure, a looper device 506 is provided downstream of the plate reduction press apparatus 510 of the present invention, and a finishing rolling mill 505 is installed further downstream. The looper device 506 holds up a material being pressed in a slack loop, and the slack absorbs any differences in the line speeds of the plate reduction press apparatus 510 and the finish rolling mill 505.

[0022] Fig. 10 is a side view of the plate reduction press apparatus shown in Fig. 9, and Fig. 11 is a sectional view along the line A-A in Fig. 10. As shown in Figs. 10 and 11, the plate reduction press apparatus 510 according to the present invention is provided with upper and lower drive shafts 512 arranged opposite each other above and below a material 1 to be pressed and made to rotate, upper and lower pressing frames 514 one end of each of which (right end in figure 31) engages with one of the drive shafts 512 in a freely slidable manner, and the other ends 514b (left end in the figure) of which are connected together in a freely rotatable manner, a horizontal guide device 516 that supports the connection portions 514c of the pressing frames 514 so that they can move in the horizontal direction, and upper and lower dies 518 mounted at one end of the upper and lower pressing frames 514 opposite the material to be pressed. In Fig. 10, 511 indicates the main frame of the unit.

[0023] The upper and lower drive shafts 512 are provided with eccentric shafts 512a at both ends in the lateral direction, which have different phase angles. In addition, spherical seats 515 are provided at the places where the eccentric shafts 512a engage with the press frames 514, and the press frames 514 can roll about the axis X of the drive shafts as shown by the arrows A. The contacting surfaces between the dies 518 and the material 1 to be pressed are circular arcs and are convex towards the material to be pressed, and can smoothly press the material when the press frames roll.

[0024] As shown in Fig. 11, there are driving devices 520 that drive and rotate the drive shafts 512. These driving devices 520 are controlled by a speed controller 522, and the rotational speed of the driving devices 520 can be freely controlled. In this embodiment, height adjusting plates 524 are sandwiched between the dies 518 and the press frames 514, and by changing the thickness of the height adjusting plates 524, the heights of the dies 518 are adjusted.

[0025] Fig. 12 schematically shows the paths in which the dies move; (A) shows the general movement of the dies 518 and the press frames 514, and (B) shows the movement of the dies 518 only. Fig. 13 shows the displacements of the dies 518 in the up and down direction with respect to the angle of rotation θ of the drive shafts. As shown in Figs. 12 and 34, when each drive shaft 512 rotates, the corresponding eccentric shafts 512a rotate in circles with a diameter equal to twice the eccentricity e of the shaft, which cause the up and down press frames 514 to move in such a manner that while the left end portion 514b is moving backwards and forwards in the direction of the line, the right end portion 514a (in Fig. 10) moves up and down. Consequently, as shown in Fig. 12, each of the upper and lower dies 518 move in a circular path with a diameter equal to twice the eccentricity e of the eccentric shafts 512a, and at the same time, the dies open and close and also roll in the lateral direction. Therefore, as the upper and lower dies 518 move in the direction of the line while closing, the material 1 to be pressed can be conveyed while it is being reduced. In addition, because the upper and lower dies 518 close with a rolling action, the loads during pressing can be reduced. The amount of the reduction is determined by the eccentricity e of the eccentric shafts 512a, therefore high-reduction pressing can be carried out without being restricted by a nip angle etc. Also because the material

1 to be pressed is transferred while being reduced, a flying press operation can be achieved.

[0026] As shown in Fig. 12 (B), the dies 518 are mounted at a small angle to the press frames 514 when the dies are open (shown by the solid lines in the figure) so that the parallel portions 518 become parallel to each other during pressing (shown by the double dotted chain lines in the figure). At this time, the area pressed during a cycle is shown by the hatched area in the figure.

[0027] As shown in Fig. 13, the pair of eccentric shafts 512a positioned at the two ends in the lateral direction are shifted in phase relative to each other, and so the ranges in which the two ends press the material 1 to be pressed are different from each other, and because the upper and lower dies 518 close with a rolling action, the loads during pressing can be reduced.

[0028] In addition, the speed controller 522 of the driving devices 520 determines the rotational speed of the drive shafts 512 so that when the dies 518 press, the speed of the dies in the line direction substantially match the feeding speed of the material 1 to be pressed. In this configuration, it is possible to match the speed of the dies 518 in the line direction substantially with the feeding speed of the material 1 to be pressed, therefore loads on the driving devices 520 that drive and rotate the drive shafts 512 can be reduced.

[0029] In this way, the plate reduction press apparatus according to the present invention provides various advantages such as (1) flying press operation is enabled, in which a material to be pressed is reduced while being transferred, (2) the number of component parts is small, and the construction is simple, (3) a small number of components need to slide under load during pressing, (4) high-load and high-cycle operations are possible, (5) the thickness of a material to be pressed can be corrected by adjusting the position of the dies using a simple method, and so forth.

(Second embodiment)

[0030] Fig. 14 shows the configuration of a rolling facility used together with the plate reduction press apparatus according to the present invention. In this figure, a looper device 606 is installed on the downstream side of the hot slab press apparatus 610 according to the present invention, and further downstream, a finishing rolling mill 605 is provided. The looper device 606 holds up a material being pressed in a slack loop, so that the slack length of the material, smooths out any differences between the line speeds of the hot slab press apparatus 610 and the finishing rolling mill 605.

[0031] Fig. 15 is a side view of the hot slab press apparatus shown in Fig. 14, and Fig. 16 is a sectional view along the line A-A in Fig. 15. As shown in Figs. 15 and 16, the hot slab press apparatus 610 according to the present invention is composed of upper and lower crank shafts 612 arranged opposite each other above and below the material 1 to be pressed and made to rotate, upper and lower press frames 614 one end 614a (right end in the figure) of each of which is engaged with one of the crank shafts 612 in a freely slidable manner, and the other ends 614b (left end) are connected together in a freely rotatable manner, a horizontal guide device 616 for supporting the connecting portion 614c of the press frames 614 so that they can move horizontally, and upper and lower dies 618 mounted at one end of each of the upper and lower press frames 614 facing the material 1 to be pressed. In this figure, 611 is the main frame unit.

[0032] As shown in Fig. 16, driving devices 620 are provided to drive and rotate the crank shafts 612, and the driving devices 620 are controlled by a speed controller 622, so that the rotational speed of the driving devices 620 can be freely controlled.

[0033] With this embodiment, height adjusting plates 624 are placed between the dies 618 and the press frames 614, and by changing the thicknesses of the height adjusting plates 624, the heights of the dies 618 are adjusted.

[0034] Fig. 17 schematically shows the paths in which the dies move; (A) shows the general movement of the dies 618 and the press frames 614, and (B) shows the movements of the dies 618 only. As shown in Fig. 17, when the crank shafts 612 rotate, each of the crank shafts 612 rotates in a circle with a diameter equal to twice the eccentricity e of the shaft, and following this motion, the upper and lower press frames 614 move in such a manner that while the left end portion 614b moves backwards and forwards in the direction of the line, the right end portions 614a (in Fig. 15) move up and down. Therefore, as shown in this figure, each of the upper and lower dies 618 moves in a circular path with a diameter equal to twice the eccentricity e of one of the crank shafts 612, and as the upper and lower dies 618 move in the line direction while closing, the material 1 to be pressed can be transferred while it is being pressed. The amount of the reduction depends on the eccentricity e of the crank shafts 612, and a high-reduction pressing operation can be achieved without being restricted by a nip angle etc. In addition, a flying press system can be realized because the material 1 to be pressed is conveyed while being reduced.

[0035] As shown in Fig. 17 (B), the dies 618 are mounted on the press frames 614 at a small angle thereto when the dies are open (solid lines in the figure) so that the parallel portions 618a are parallel to each other during pressing (double-dotted chain lines in the figure). For this configuration the area pressed during a cycle is shown by the hatched area in the figure.

[0036] In addition, the speed controller 622 of the drive devices 620 determines the rotational speed of the crank shafts 612 to make the speed of the dies 618 in the line direction during pressing substantially agree with the feeding speed of the material 1 to be pressed. In this configuration, the speed of the dies 618 in the direction of the line can be made to be substantially identical to the feeding speed of the material 1 to be pressed, so variations in the loads on the crank shafts, caused by a difference in speeds, can be reduced.

[0037] Fig. 18 is a diagram showing how a hot slab is pressed according to the present invention. In this figure, the abscissa and the ordinate indicate the crank angle and the speed in the line direction, respectively. According to the method of the present invention, the speed for feeding a material to be pressed is variable and made equal to the maximum speed of the dies in the line direction. More preferably, the speed of feeding the material to be pressed should be varied in such a manner that the speed is greater than the above-mentioned maximum speed at the beginning of pressing, and then be made smaller at an intermediate time during pressing. Accordingly, the loads applied to the press crank shafts, produced by variations in the inertia forces and speeds of the material to be pressed, can be reduced.

[0038] As can be understood from the above description, the hot slab press apparatus and pressing methods according to the present invention present excellent practical advantages including (1) a flying pressing system can be established to press a material while it is being conveyed, (2) there are few component parts and the construction is simple, (3) there are few parts which slide under load during pressing, (4) the system can be operated at high loads with fast operating cycles, (5) the position of the dies can be adjusted using a simple method, and the thickness of the material to be pressed can be corrected, and so on

(Third embodiment)

[0039] Fig. 19 shows the configuration of a rolling facility used together with the plate reduction press apparatus according to the present invention. In this figure, a looper device 706 is installed on the downstream side of the plate reduction press apparatus 710 according to the present invention, and further downstream, a finishing rolling mill 706 is provided. The looper device 706 holds up a material being pressed in a slack loop, so that the slack portion of the material smooths out any differences in the line speeds of the plate reduction press apparatus 710 and the finish rolling mill 705.

[0040] Fig. 20 is a side view of the plate reduction press apparatus shown in Fig. 19, and Fig. 21 is a sectional view along the line A-A in Fig. 20. As shown in Figs. 20 and 21, the plate reduction press apparatus 710 according to the present invention is provided with upper and lower eccentric drive shafts 715 arranged opposite each other above and below a material 1 to be pressed and driven and rotated by driving devices 720b, upper and lower synchronous eccentric shafts 713 which are rotated by the eccentric drive shafts 715, upper and lower press frames 714 one end 714a of each of which is engaged with one of the synchronous eccentric shafts 713 in a freely slidable manner, and the other ends 714b are connected together in a freely rotatable manner, and upper and lower dies 718 mounted opposite each other at one end of each of the upper and lower press frames 714. In this figure, 711 indicates the main frame unit.

[0041] Referring to Fig. 21, the upper and lower dies 718 are opened and closed by rotating the upper and lower eccentric drive shafts 715, and when the dies 718 are pressing, the speed of the press frames 714 in the direction of the line is synchronized with the speed at which the material to be pressed is being conveyed in the line direction by means of the synchronous eccentric shafts 713, while pressing the material.

[0042] The outer peripheries of the synchronous eccentric shafts 713, are equipped with gear teeth, and the shafts are driven and rotated by the driving devices 720a by the small gear wheels 712a mounted on the drive shafts 712. As shown in Fig. 21, each shaft can be connected to the driving devices 720a, 720b, through universal joints etc., or, although not illustrated, each shaft may also be driven by a differential device.

[0043] Also with this embodiment, height adjusting plates 724 are positioned between the dies 718 and the press frames 714, so by varying the thicknesses of the height adjusting plates 724, the heights of the dies 718 can be adjusted.

[0044] Fig. 22 schematically shows the paths in which the dies move; (A) shows the general movement of the dies 718 and the press frames 714, and (B) shows the movements of the dies 718 only. Fig. 23 shows the displacements of the dies 718 in the up and down direction with respect to the rotational angle θ of the synchronous eccentric shafts. As shown in Figs. 22 and 23, when the drive shafts 712 are rotated, the upper and lower synchronous eccentric shafts 713 rotate around the eccentric drive shafts 715, therefore the synchronous eccentric shafts 715 move in a circle with a diameter equal to twice the eccentricity e thereof, and the outer peripheries thereof cause the upper and lower press frames 714 to move in such a manner that the left end 714b moves backwards and forwards in the line direction, while the right end 714a (in Fig. 20) move up and down. Consequently as shown in Fig. 22 (B), each of the upper and lower dies 718 moves in a circular path with a diameter equal to twice the eccentricity e of the synchronous eccentric shafts 712a, while opening and closing.

[0045] Also as shown in Fig. 23, which shows the relation in speed that results from combining the eccentricity E of the eccentric drive shafts 715 and the eccentricity e of the synchronous eccentric shafts 713, and a pseudo constant speed can be produced over a range by varying the speed pattern. The amount of the reduction at that time depends on the eccentricity e of the synchronous eccentric shafts 713, so a high-reduction operation can be carried out without being restricted by a nip angle etc. Furthermore, because the material 1 to be pressed is conveyed by the synchronous drive devices 716 while being reduced, a flying pressing operation can be easily performed.

[0046] In addition, only the synchronous eccentric shafts 713 (double synchronous eccentric shafts) that are rotated by the eccentric drive shafts 715 withstand loads during pressing, and the connection portion 714c and the synchronous drive devices 716 have to withstand only rather small loads that only cancel moments acting on the press frames 714, and in addition, the moments applied to the upper and lower press frames 714 cancel each other, so the loads on the connection portion and the driving devices are further reduced. As a result, there are few component parts, the construction is simple, there are few portions that slide under load during pressing, and the system can operate under high loads at a high operating rate.

[0047] As shown in Fig. 22 (B), the dies 718 are mounted on the press frames 714 at a slight angle thereto when the dies are open (solid lines in the figure) so that during pressing (double-dotted chain lines in the figure), the parallel portions 718a are parallel to each other. At this time, the area pressed during one cycle is shown by the hatched area in the figure.

[0048] Obviously from the description above, the plate reduction press apparatus according to the present invention provides excellent advantages including (1) a material to be pressed can be pressed by a flying press operation, in which the material is reduced while it is being transferred, (2) there are few component parts and the construction is simple, (3) a small number of parts slide under load during pressing, and (4) the system can be operated at high loads at a high operating rate.

(Fourth embodiment)

[0049] Fig. 24 shows the configuration of the plate reduction press apparatus according to the fourth embodiment of the invention, and Fig. 25 is a sectional view along the line X-X in Fig. 24. Upper and lower dies 802 are provided above and below a material 1 to be pressed. Cooling water is supplied to the inside of the dies 802, to cool the dies. Otherwise, cooling water can also be sprayed from outside. The dies 802 are mounted on sliders 803 through die holders 804, in a detachable manner. Two crank shafts 805 engage in a freely slidable manner with the sliders 803 in the lateral direction of the material 1 to be pressed, arranged in a row in the direction (forward direction) of flow of the material. The crank shafts 805 are composed of eccentric shafts 805b engaging with the sliders 803, and support shafts 805a connected to both ends of the eccentric shafts 805b in the axial direction thereof, and dne of the ends of the support shafts 805a is connected to a driving device not illustrated which drives and rotates the crank 805. The support shafts 805a and the eccentric shafts 805b are connected so that the center line thereof are offset from each other, thus the eccentric shafts 805b are rotated eccentrically around the support shafts 805a.

[0050] Counterweights 806 are attached at each end of the support.shafts 805a of the eccentric shafts 805b. The counterweights 806 are mounted with the centers of gravity thereof offset from the center lines of the support shafts 805a, and the angle of the offset is 180° from the direction of the eccentricity of the eccentric shafts 805b with respect to the support shafts 805a. The inertia forces (unbalanced forces) due to the eccentricity of the counterweights 806 substantially cancel the inertia forces due to the sliders 803, dies 802 and die holders 804, so that the vibration of the apparatus can be reduced greatly.

[0051] The dies 802, sliders 803, die holders 804, crank shafts 805, and counterweights 806 are arranged symmetrically above and below the material 1 to be pressed, and composed into one body by the main frame unit 808. The eccentric shafts 805b are connected to the sliders 803 in a freely rotatable manner through the bearings 807, and the support shafts 805a are supported through the bearings 807 provided on the main frame unit 808, in a freely rotatable manner.

[0052] Next, the operation is described. Fig. 26 shows one cycle of operation of the sliders 803. Fig. 27 illustrates the movements of the sliders 803 and the material 1 to be pressed, during one operating cycle. In Fig. 26, in a cycle time increase in the sequence t1-t2-t3-t4-t1, and the material is pressed during the period ta-tb which includes t2. In Fig. 27, t1-t4 corresponds to t1-t4 in Fig. 26. At t1, the sliders 803 are raised to an intermediate position, and are located at the farthest position in the backward direction. At t2, the state during pressing is shown, and the sliders are located at an intermediate position in the backward and forward direction. At t3, the sliders are partly raised, and at the farther position in the forward direction. Hence, the sliders 803 move forwards during the period t1-t2-t3 as shown by the arrows, and move at the maximum speed at t2 during pressing. Consequently, the material 1 to be pressed is transferred by the pinch rolls 809 when the sliders 803 are pressing, according to the speed of the sliders, thereby the material can be conveyed continuously at a speed most suitable for pressing, even during a pressing period. Because the counterweights 806 move with phase angles offset by 180° from those of the sliders 803, the vibration caused by the sliders 803 is reduced. In addition, the counterweights also function as flywheels that contribute to a reduction of the power required from the driving devices.

(Fifth embodiment)

[0053] The thirteenth embodiment is described next. Fig. 28 shows the configuration of the plate reduction press apparatus according to this embodiment, and Fig. 29 is a sectional view along the line Y-Y in Fig. 28, showing only the half on one side of the lateral center line of the material 1 to be pressed, because the entire construction is symmetrical about the center line. As shown in Figs. 28 and 29, this embodiment of the plate reduction press apparatus according to the present invention is composed of upper and lower crank shafts 815 arranged opposite each other above and below the material 1 to be pressed and driven and rotated, upper and lower press frames 813 one end 813a (right end in the figure) of each of which is engaged with one of the crank shafts in a freely rotatable manner, and the other ends 813b (left ends) are connected together in a freely rotatable manner, horizontal guide devices 819 that guide the connecting portions 813c of the press frames 813 so that they can move horizontally, upper and lower dies 812 mounted at one end 813a of each of the upper and lower press frames 813, facing the material 1 to be pressed, counterweights 816 installed on the crank shafts 815, and a main frame unit 818 that supports the crank shafts 815. The dies 812 are mounted on the ends 813a through the height adjusting plates 814.

[0054] The horizontal guide device 819 is either a hydraulic cylinder, crank mechanism or a servo motor, that moves the connection portions 813c to which the upper and lower press frames 813 are connected, in the direction of transfer of the material to be pressed when the crank shafts 815 rotate.

[0055] The crank shafts 815 are shown in Fig. 29, and are comprised of eccentric shafts 815b that engage with the ends 813a of the press frames 813, and support shafts 815a attached to both ends of the eccentric shafts 815b with their axial center lines offset from each other. The support shafts 815a are supported by the main frame unit 818 through bearings 817, and the eccentric shafts 815b are connected to the ends 813a through the bearings 817. On the support shafts 815a outside the main frame unit 818, counterweights 816 are mounted the centers of gravity of which are offset from the axial center lines of the support shafts 815a, and the angle of the offset is 180° from the direction of the eccentricity of the eccentric shafts 815b relative to the support shafts 815a. A driving device 820 is provided at the end of a support shaft 815a equipped with a counterweight 816, and is controlled by a control device 822.

[0056] The operation of the present embodiment is described next. Fig. 30 schematically shows the path in which the dies 812 move; (A) shows the general movements of the dies 812 and the press frames 813, and (B) shows the movements of the dies 812 only. When the crank shafts 815 rotate, the upper and lower eccentric shafts 815b are rotated by the support shafts 815a, and the eccentric shaft 815b rotates in a circle with a diameter equal to twice the eccentricity e thereof, and the outer periphery thereof causes the upper and lower press frames 813 to move in such a manner that the other ends 813b reciprocate in the direction of the flow of the material to be pressed, while the ends 813a move up and down. Consequently, as shown in Fig. 30 (B), the upper and lower dies 812 move up and down as they travel in a circular path with a diameter equal to twice the eccentricity e of the eccentric shafts 815b.

[0057] As shown in Fig. 28, the horizontal guide device 819 allows the connecting portion 813c of the press frames 813 to move in the direction of flow of the material to be pressed when the dies 812 are pressing, thus the upper and lower dies 812 can move in the direction of the flow of the material to be pressed while the dies are pressing the material. At this time, the amount of the reduction depends on the eccentricity e of the eccentric shafts 815b, therefore high-reduction pressing can be carried out without being limited by a nip angle etc. Because the horizontal guide device 819 allows the material 1 to be pressed to be transferred while being pressed, flying press operations can be easily carried out. In addition, as the counterweights 816 move with an angular offset of 180° from the motion of the ends 813a, they cancel the vibrations due the ends 813a, which reduces the vibration as a whole. In addition, the counterweights can also function as a flywheel which contributes to reducing the power required from the driving devices.

[0058] As can be easily understood from the description above, the present invention can provide a flying reduction press system in which a material to be pressed is reduced while it is being conveyed, by directly rotating the ends of sliders or press frames by eccentrics on crank shafts. Furthermore, as counterweights are provided on the crank shafts, the vibration of the system can be reduced, and because the counterweights function as flywheels, the power required from the driving devices can be reduced. Moreover, because the dies can be moved in the direction of flow of the material to be pressed during the pressing period, thanks to the eccentric motion of the crank shafts, no mechanisms are required to move the dies in the direction of flow of the material to be pressed during pressing, so the construction of the apparatus becomes simple.

[0059] Although the present invention has been explained by referring to a number of preferred embodiments, it should be understood that the scope of claims included in the specification of the present invention should not be limited only to the embodiments described above. To the contrary, the scope of rights according to the present invention shall include all modifications, corrections or the like as long as they are included in the scope of the claims attached.

Claims

1. A plate reduction press apparatus (510, 610, 710) comprising:

upper and lower drive shafts arranged opposite each other above and below a material (1) to be pressed and driven to rotate,
upper and lower press frames (514, 614, 813),
a driving device (520, 620, 820) for driving and rotating said drive shafts, and
upper and lower dies (518, 618, 812) mounted at the ends of the upper and lower press frames (514, 614, 813) facing the material (1) to be pressed; whereby in use said drive shafts rotate to open and close the upper and lower dies (518, 618, 812), and press the material (1) to be pressed, while the material (1) is being trans-

ferred,

characterized in that
one end (514a, 614a, 813a) of each of said upper and lower press frames (514,614,813) engages with one of the said drive shafts such that each of the drive shafts rotates while contacting the corresponding one of the press frames, and the other ends (514b, 614b, 813b) are hinged together in a freely rotatable manner through connecting portions (514c, 614c, 813c), whereby horizontal guide devices (516, 616, 819) support the connecting portions (514c, 614c, 813c) of the said press frames (514, 614, 813) in a horizontally movable manner, and
said upper and lower drive shafts are comprised of a pair of eccentric shafts that are located at both lateral ends.

2. The plate reduction press apparatus (610) specified in Claim 1, in which in use the rotational speed of the said driving device (620) is variable and determined in such a manner that the speed of the dies (618) in the direction of the transfer line during pressing is substantially equal to the feeding speed of the material (1) to be pressed.

3. The plate reduction press apparatus (610) specified in Claim 1, further comprising a looper device (606) that provides a slack portion in the material (1) to be pressed on the downstream side and holds up the material.

4. The plate reduction press apparatus (610) specified in Claim 1, further comprising height adjusting plates (624) that are maintained between the dies (618) and the press frames (614) and adjust the heights of the dies (618).

5. A plate reduction press apparatus (510) according to claim 1, **characterized in that**
said upper and lower drive shafts (512) are comprised of a pair of eccentric shafts (512a) that are located at both lateral ends with a phase angle difference between each other, and
the upper and lower dies (518) are opened and closed with a rolling movement by rotating the drive shafts (512), and the material (1) to be pressed is transferred while the material is pressed with a rolling action.

6. The plate reduction press apparatus (510) specified in Claim 5, in which
the rotational speed of the said driving device (520) is variable, and
the rotational speed is determined in such a manner that the speed of the dies (518) in the direction of the transfer line during pressing is substantially equal to the speed of feeding the material (1) to be pressed.

7. The plate reduction press apparatus (510) specified in Claim 5, comprising a looper device (506) that provides a slack portion in the material (1) to be pressed on the downstream side and holds up the material (1).

8. A plate reduction press apparatus according to claim 1, **characterized in that** the
said drive shafts (815) are comprised of eccentric crank shafts (815b) engaged with the said ends of the press frames (813), and support shafts (815a) arranged on both sides of the eccentric crank shafts (815b) with shaft center lines eccentric to the shaft center lines of the eccentric crank shafts (815b), and at least one of the support shafts (815a) is provided with a counterweight (816) offset with an eccentric center line substantially at an angle of 180°, to the direction of eccentricity of the said eccentric crank shafts (815b).

9. The plate reduction press apparatus specified in Claim 8, in which
the said counterweight (816) has a mass sufficient to store rotating energy and can also function as a flywheel.

10. The plate reduction press apparatus specified in Claim 8 in which the inertia force due to the eccentricity of the said counterweight (816) is determined so as to substantially cancel the inertia force produced by one end of the said press frames (813).

11. A method of operating the plate reduction pressing apparatus according to claim 1, in which the speed of feeding a material (1) to be pressed is made variable with respect to the maximum speed of the dies (618) in the direction of transfer line.

12. The method according to Claim 11, in which the speed of feeding the material (1) to be pressed is made variable in such a manner that at the beginning of pressing, the speed is made higher than the said maximum speed and made lower at an intermediate time in the pressing period.

13. A plate reduction press apparatus (710) comprising:

upper and lower eccentric drive shafts (715) arranged opposite each other above and below a material (1) to be pressed and driven to rotate,
upper and lower synchronous eccentric shafts (713) that rotate around the said eccentric drive shafts (715),
upper and lower press frames (714) one end (714a) of each of which engages with one of the said synchronous eccentric shafts (713) such that each of the drive shafts rotates while contacting the corresponding one of the press

frames, and the other ends (714b) of which are hinged together in a freely rotatable manner,
a driving device for driving and rotating said eccentric drive shafts (715), and
upper and lower dies (718) mounted at ends of the upper and lower press frames (714), facing the material (1) to be pressed, in which

said upper and lower eccentric drive shafts (715) are comprised of a pair of said synchronous eccentric shafts (713) that are located at both lateral ends, whereby in use the upper and lower dies (718) are opened and closed by rotating the upper and lower eccentric drive shafts (715), and when the material (1) to be pressed is being pressed by the dies (718), the synchronous eccentric shafts (713) synchronize the speed of the press frames (714) in the direction of transfer line with the speed of the material (1) to be pressed in the direction of the transfer line.

Patentansprüche

1. Eine Plattenpressvorrichtung (510, 610, 710), umfassend:

obere und untere Antriebswellen, die einander gegenüberliegend oberhalb und unterhalb eines zu pressenden Materials (1) angeordnet sind und um sich zu drehen angetrieben werden,
obere und untere Pressengestelle (514, 614, 813),
eine Antriebseinheit (520, 620, 820) zum Antreiben und Drehen der Antriebswellen, und
obere und untere Pressformen (518, 618, 812), die an den Enden der oberen und unteren Pressengestelle (514, 614, 813) montiert sind und dem zu pressenden Material (1) gegenüberstehen, wobei sich die Antriebswellen bei Betrieb drehen, um die oberen und unteren Pressformen (518, 618, 812) zu öffnen und zu schließen und das zu pressende Material (1) zu pressen, während das Material (1) transferiert wird,

dadurch gekennzeichnet, dass
ein Ende (514a, 614a, 813a) von jedem der oberen und unteren Pressengestelle (514, 614, 813) mit einer der Antriebswellen in Eingriff ist, so dass jede der Antriebswellen sich dreht während sie das entsprechende Pressengestell berührt und die anderen Enden (514b, 614b, 813b) miteinander auf eine frei drehbare Art und Weise durch Verbindungsabschnitte (514c, 614c, 813c) um ein Gelenk gelagert sind, wobei horizontale Führungseinheiten (516, 616, 819) die Verbindungsabschnitte (514c, 614c, 813c) der Pressengestelle (514, 614, 813) auf eine horizontal bewegliche Art und Weise stützen, und
die oberen und unteren Antriebswellen ein Paar von Exzenterwellen umfassen, die an beiden Seitenenden angeordnet sind.

2. Die Plattenpressvorrichtung (610) gemäß Anspruch 1, bei welcher bei Betrieb die Drehgeschwindigkeit der Antriebseinheit (620) variierbar und derart bestimmt ist, dass die Geschwindigkeit der Pressformen (618) in die Richtung der Durchlaufstrecke während des Pressens im Wesentlichen gleich zu der Zufuhrgeschwindigkeit des zu pressenden Materials (1) ist.

3. Die Plattenpressvorrichtung (610) gemäß Anspruch 1, die ferner eine Umführungseinheit (606) umfasst, die einen schlaffen Abschnitt in dem zu pressenden Material (1) auf der nachgelagerten Seite ausbildet und das Material aufhält.

4. Die Plattenpressvorrichtung (610) gemäß Anspruch 1, die ferner Höheneinstellplatten (624) umfasst, die zwischen den Pressformen (618) und den Pressengestellen (614) beibehalten werden und die Höhen der Pressformen (618) einstellen.

5. Eine Plattenpressvorrichtung (510) gemäß Anspruch 1, **dadurch gekennzeichnet, dass**
die oberen und unteren Antriebswellen (512) ein Paar von Exzenterwellen (512a) umfassen, die an beiden Seitenenden mit einem Phasenwinkelunterschied zwischen beiden angeordnet sind, und
die oberen und unteren Pressformen (518) mit einer Drehbewegung durch Drehen der Antriebswellen (512) geöffnet und geschlossen werden und das zu pressende Material (1) transferiert wird, während das Material durch einen Walzvorgang gepresst wird.

6. Die Plattenpressvorrichtung (510) gemäß Anspruch 5, bei welcher die Drehgeschwindigkeit der Antriebseinheit (520) variierbar ist, und
die Drehgeschwindigkeit derart bestimmt wird, dass die Geschwindigkeit der Pressformen (518) in die Richtung der Durchlaufstrecke während des Pressens im Wesentlichen gleich der Zufuhrgeschwindigkeit des zu pressenden Materials (1) ist.

7. Die Plattenpressvorrichtung (510) gemäß Anspruch 5, die eine Umführungseinheit (506) umfasst, die einen schlaffen Abschnitt in dem zu pressenden Material (1) an der nachgelagerten Seite ausbildet und das Material (1) aufhält.

8. Eine Plattenpressvorrichtung gemäß Anspruch 1, **dadurch gekennzeichnet, dass** die Antriebswellen (815) Exzenter-Kurbelwellen (815b), die mit den Enden der Pressengestelle (813) in Eingriff sind, und Stützwellen (815a), die an beiden Seiten der Exzenter-Kurbelwellen (815b) mit den Mittellinien der Wel-

le exzentrisch zu den Mittellinien der Wellen der Exzenter-Kurbelwellen (815b) angeordnet sind, umfassen, und

wenigstens eine der Stützwellen (815a) mit einem Gegengewicht (816) vorgesehen ist, das zu einer Exzenter-Mittellinie im Wesentlichen unter einem Winkel von 180 ° zu der Richtung der Exzentrizität der Exzenter-Kurbelwellen (815b) versetzt ist.

9. Die Plattenpressvorrichtung gemäß Anspruch 8, bei welcher das Gegengewicht (816) eine Masse hat, die ausreicht, um Rotationsenergie zu speichem und auch als ein Schwungrad wirken kann.

10. Die Plattenpressvorrichtung gemäß Anspruch 8, bei welcher die Trägheitskraft aufgrund der Exzentrizität des Gegengewichts (816) derart bestimmt wird, dass die durch eine der Pressengestelle (813) erzeugte Massenkraft im Wesentlichen ausgeglichen wird.

11. Ein Verfahren zum Betreiben der Plattenpressvorrichtung gemäß Anspruch 1, bei welchem die Zufuhrgeschwindigkeit eines zu pressenden Materials (1) abhängig von der maximalen Geschwindigkeit der Pressformen (618) in Richtung der Durchlaufstrecke variierbar eingestellt wird.

12. Das Verfahren gemäß Anspruch 11, bei welchem die Zufuhrgeschwindigkeit des zu pressenden Materials (1) derart variierbar ist, dass am Anfang des Pressens die Geschwindigkeit höher als die maximale Geschwindigkeit und bei einer Zwischenzeit der Pressperiode niedriger eingestellt wird.

13. Eine Plattenpressvorrichtung (710), umfassend:

obere und untere Exzenter-Antriebswellen (715), die einander gegenüberliegend oberhalb und unterhalb eines zu pressenden Materials (1) angeordnet sind und um sich zu drehen angetrieben werden,

obere und untere Synchron-Exzenterwellen (713), die sich um die Exzenter-Antriebswellen (715) drehen,

obere und untere Pressengestelle (714), wobei ein Ende (714a) von jedem mit einer der Synchron-Exzenterwellen (713) in Eingriff ist, so dass jede der Antriebswellen sich dreht während sie das entsprechende Pressengestell berührt und die anderen Enden (714b) dieser miteinander auf eine frei drehbare Art und Weise um ein Gelenk gelagert sind,

eine Antriebseinheit zum Antreiben und Drehen der Exzenter-Antriebswellen (715), und

obere und untere Pressformen (718), die an Enden der oberen und unteren Pressengestelle (714) montiert sind und dem zu pressenden Material (1) gegenüberliegen, bei welchen die oberen und unteren Exzenter-Antriebswellen (715) aus einem Paar von Synchron-Exzenterwellen (713) bestehen, die an beiden Seitenenden angeordnet sind, wobei die oberen und unteren Pressformen (718) während des Betriebs durch die Drehung der oberen und unteren Exzenter-Antriebswellen (715) geöffnet und geschlossen werden, und wenn das zu pressende Material (1) von den Pressformen (718) gepresst wird, die Synchron-Exzenterwellen (713) die Geschwindigkeit der Pressengestelle (714) in Richtung der Durchlaufstrecke mit der Geschwindigkeit des zu pressenden Materials (1) in die Richtung der Durchlaufstrecke synchronisieren.

Revendications

1. Dispositif de pressage de réduction de plaque (510, 610, 710), comportant :

des arbres d'entraînement supérieur et inférieur agencés à l'opposé l'un de l'autre au-dessus et en dessous d'un matériau (1) à presser, et entraînés en rotation,

des châssis de pressage supérieur et inférieur (514, 614, 813),

un dispositif d'entraînement (520, 620, 820) pour entraîner et faire tourner lesdits arbres d'entraînement, et

des matrices supérieure et inférieure (518, 618, 812) montées aux extrémités des châssis de pressage supérieur et inférieur (514, 614, 813) faisant face au matériau (1) à presser ; de sorte qu'en utilisation, lesdits arbres d'entraînement tournent pour ouvrir et fermer les matrices supérieure et inférieure (518, 618, 812), et pour presser le matériau (1) à presser, tandis que le matériau (1) est transféré,

caractérisé en ce que

une première extrémité (514a, 614a, 813a) de chacun desdits châssis de pressage supérieur et inférieur (514, 614, 813) vient en prise avec un desdits arbres d'entraînement, de sorte que chacun des arbres d'entraînement tourne tout en venant en contact avec celui des châssis de pressage qui correspond, et les autres extrémités (514b, 614b, 813b) sont articulées ensemble de manière à pouvoir tourner librement par l'intermédiaire des parties de connexion (514c, 614c, 813c), de sorte que des dispositifs de guidage horizontaux (516, 616, 819) supportent les parties de connexion (514c, 614c, 813c) desdits châssis de pressage (514, 614, 813) d'une manière mobile horizontalement, et

lesdits arbres d'entraînement supérieur et inférieur sont constitués d'une paire d'arbres excentrés qui sont situés aux deux extrémités latérales.

2. Dispositif de pressage de réduction de plaque (610) selon la revendication 1, dans lequel, en utilisation, la vitesse de rotation dudit dispositif d'entraînement (620) est variable et déterminée de telle manière que la vitesse des matrices (618) dans la direction de la ligne de transfert pendant un pressage est sensiblement égale à la vitesse d'alimentation du matériau (1) à presser.

3. Dispositif de pressage de réduction de plaque (610) selon la revendication 1, comportant en outre un dispositif à boucle (606) qui fournit une partie lâche dans le matériau (1) à presser sur le côté aval, et freine le matériau.

4. Dispositif de pressage de réduction de plaque (610) selon la revendication 1, comportant en outre des plaques d'ajustement de hauteur (624) qui sont maintenues entre les matrices (618) et les châssis de pressage (614), et ajustent les hauteurs des matrices (618).

5. Dispositif de pressage de réduction de plaque (510) selon la revendication 1, **caractérisé en ce que**
lesdits arbres d'entraînement supérieur et inférieur (512) sont constitués d'une paire d'arbres excentrés (512a) qui sont situés aux deux extrémités latérales en ayant une différence d'angle de phase entre eux, et
les matrices supérieure et inférieure (518) sont ouvertes et fermées par un déplacement de laminage en faisant tourner les arbres d'entraînement (512), et le matériau (1) à presser est transféré tandis que le matériau est pressé par une action de laminage

6. Dispositif de pressage de réduction de plaque (510) selon la revendication 5, dans lequel
la vitesse de rotation dudit dispositif d'entraînement (520) est variable, et
la vitesse de rotation est déterminée de telle manière que la vitesse des matrices (518) dans la direction de la ligne de transfert pendant un pressage est sensiblement égale à la vitesse d'alimentation du matériau (1) à presser.

7. Dispositif de pressage de réduction de plaque (510) selon la revendication 5, comportant un dispositif à boucle (506) qui fournit une partie lâche dans le matériau (1) à presser sur le côté aval, et freine le matériau (1).

8. Dispositif de pressage de réduction de plaque selon la revendication 1, **caractérisé en ce que** lesdits arbres d'entraînement (815) sont constitués d'arbres coudés excentrés (815b) mis en prise avec lesdites extrémités des châssis de pressage (813), et des arbres de support (815a) agencés sur les deux côtés des arbres coudés excentrés (815b), des lignes centrales d'arbre étant excentrées par rapport aux lignes centrales d'arbre des arbres coudés excentrés (815b), et
au moins un des arbres de support (815a) est muni d'un contrepoids (816) décalé par rapport à une ligne centrale excentrée sensiblement sur un angle de 180°, vers la direction d'excentricité desdits arbres coudés excentrés (815b).

9. Dispositif de pressage de réduction de plaque selon la revendication 8, dans lequel
ledit contrepoids (816) a une masse suffisante pour stocker une énergie de rotation, et peut également fonctionner en tant que volant.

10. Dispositif de pressage de réduction de plaque selon la revendication 8, dans lequel la force d'inertie due à l'excentricité dudit contrepoids (816) est déterminée de manière à sensiblement annuler la force d'inertie produite par une extrémité desdits châssis de pressage (813).

11. Procédé d'actionnement du dispositif de pressage de réduction de plaque selon la revendication 1, dans lequel la vitesse d'alimentation d'un matériau (1) à presser est rendue variable par rapport à la vitesse maximum des matrices (618) dans la direction de la ligne de transfert.

12. Procédé selon la revendication 1, dans lequel la vitesse d'alimentation du matériau (1) à presser est rendue variable de telle manière qu'au début du pressage la vitesse est rendue supérieure à ladite vitesse maximum, et est rendue inférieure à un instant intermédiaire lors de la période de pressage.

13. Dispositif de pressage de réduction de plaque (710), comportant :

des arbres d'entraînement excentrés supérieur et inférieur (715) agencés à l'opposé l'un de l'autre au-dessus et en dessous d'un matériau (1) à presser, et entraînés en rotation,
des arbres excentrés synchrones supérieur et inférieur (713) qui tournent autour desdits arbres d'entraînement excentrés (715),
des châssis de pressage supérieur et inférieur (714), dont une première extrémité (714a) de chacun vient en prise avec un desdits arbres excentrés synchrones (713), de sorte que chacun des arbres d'entraînement tourne tout en venant en contact avec celui des châssis de pressage qui correspond, et dont les autres extrémités (714b) sont articulées ensemble de manière à pouvoir tourner librement,

un dispositif d'entraînement pour entraîner et faire tourner lesdits arbres d'entraînement excentrés (715), et
des matrices supérieure et inférieure (718) montées aux extrémités des châssis de pressage supérieur et inférieur (714) faisant face au matériau (1) à presser, dans lequel

lesdits arbres d'entraînement excentrés supérieur et inférieur (715) sont constitués d'une paire desdits arbres excentrés synchrones (713) qui sont situés aux deux extrémités latérales, de sorte qu'en utilisation, les matrices supérieure et inférieure (718) sont ouvertes et fermées en faisant tourner les arbres d'entraînement excentrés supérieur et inférieur (715), et lorsque le matériau (1) à presser est pressé par les matrices (718), les arbres excentrés synchrones (713) synchronisent la vitesse des châssis de pressage (714) dans la direction de la ligne de transfert avec la vitesse du matériau (1) à presser dans la direction de la ligne de transfert.

FIG. 1

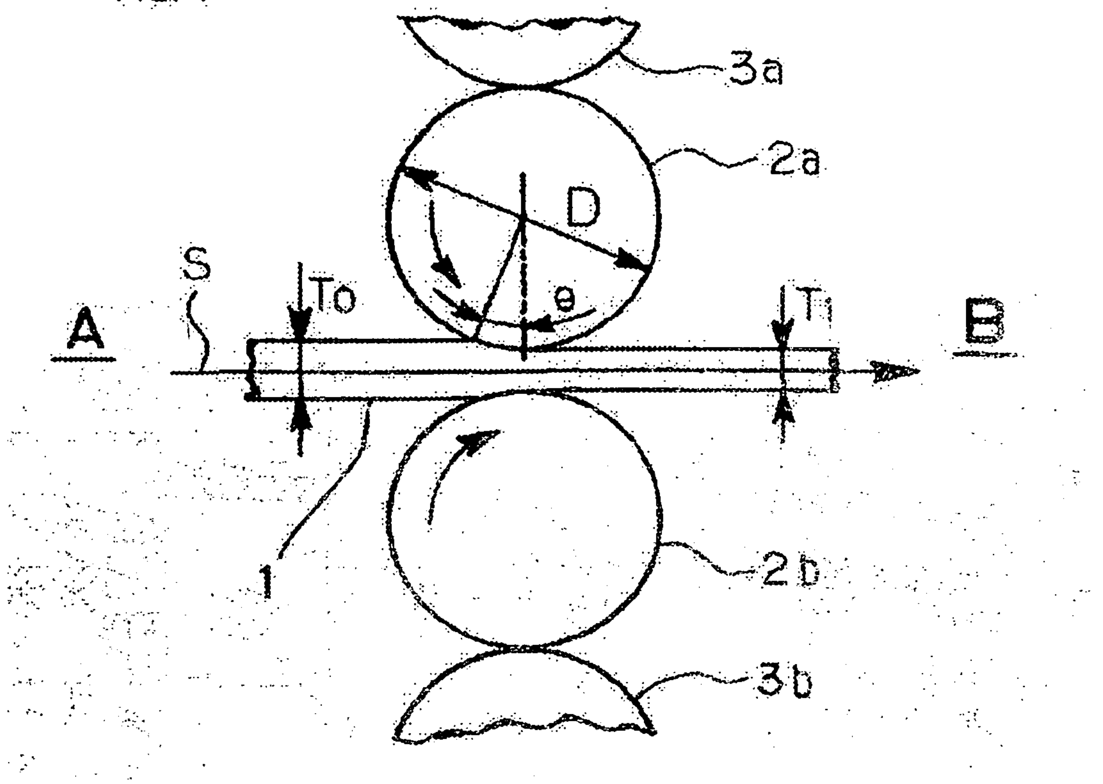


FIG. 2

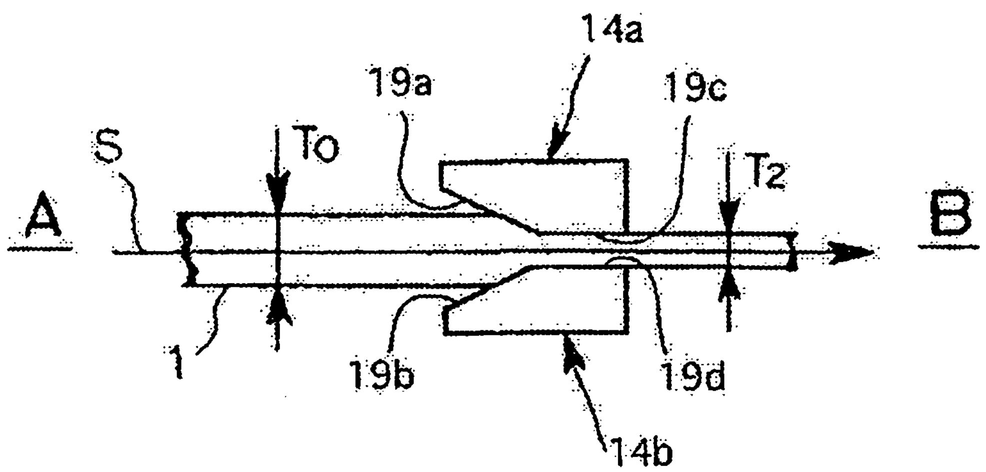


FIG. 3

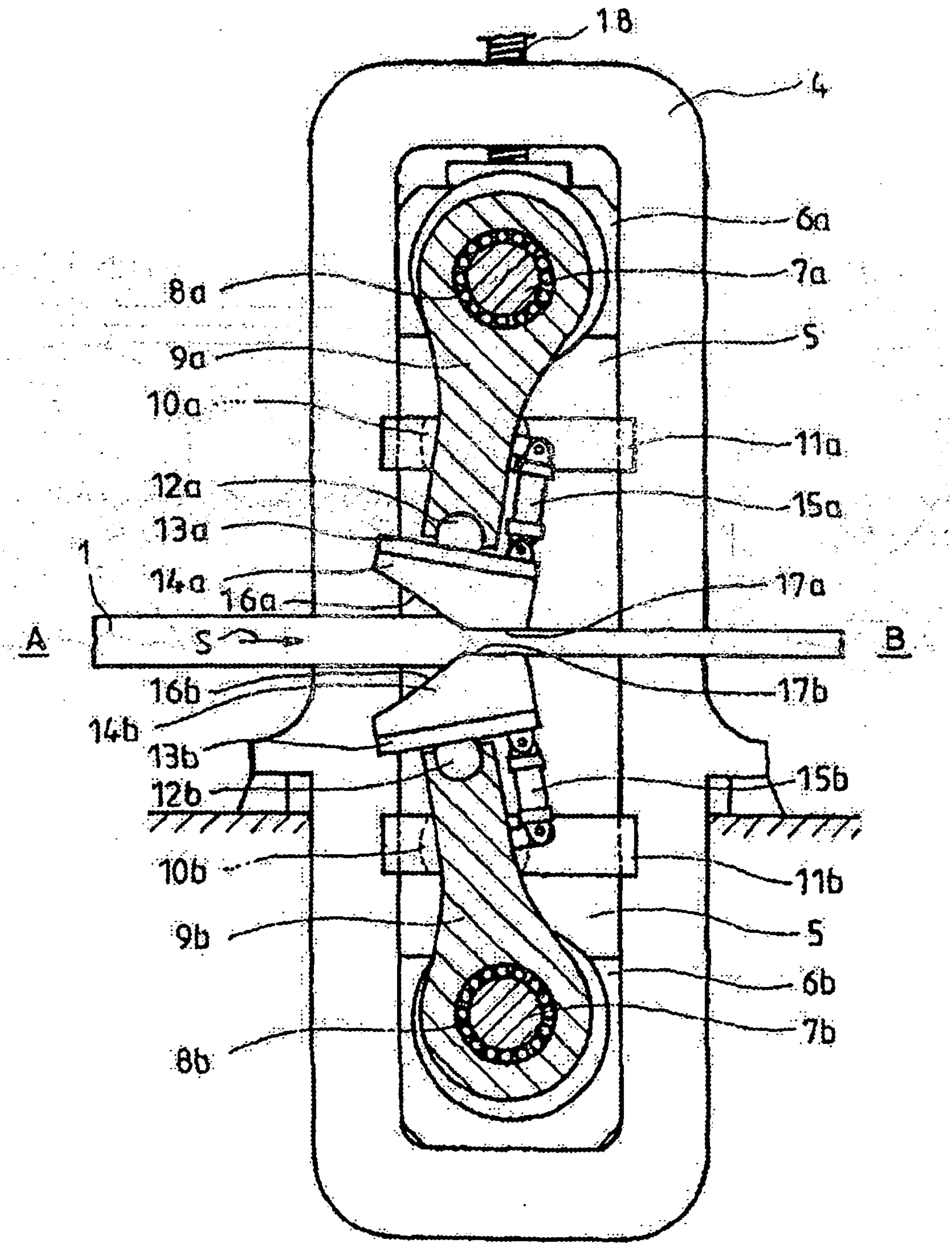

18
4
6a
7a
8a
9a
5
10a
11a
12a
15a
13a
1
14a
16a
17a
A
S
B
16b
17b
14b
13b
15b
12b
10b
11b
9b
5
6b
7b
8b

FIG. 4

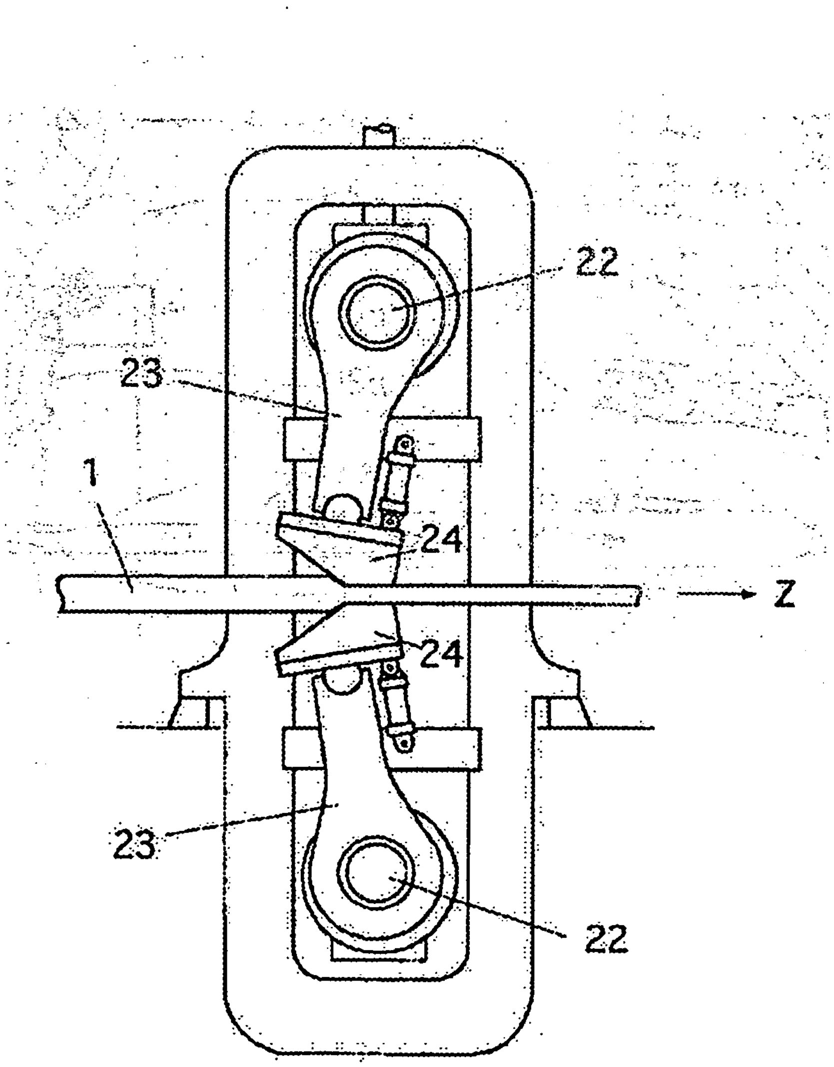


FIG. 5

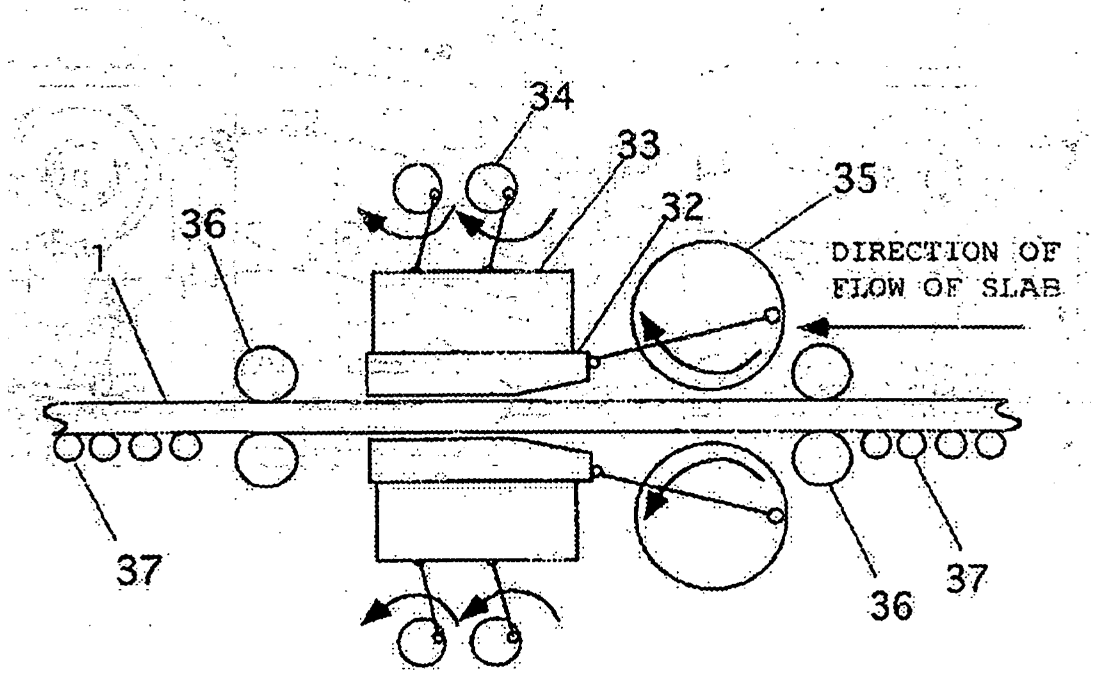
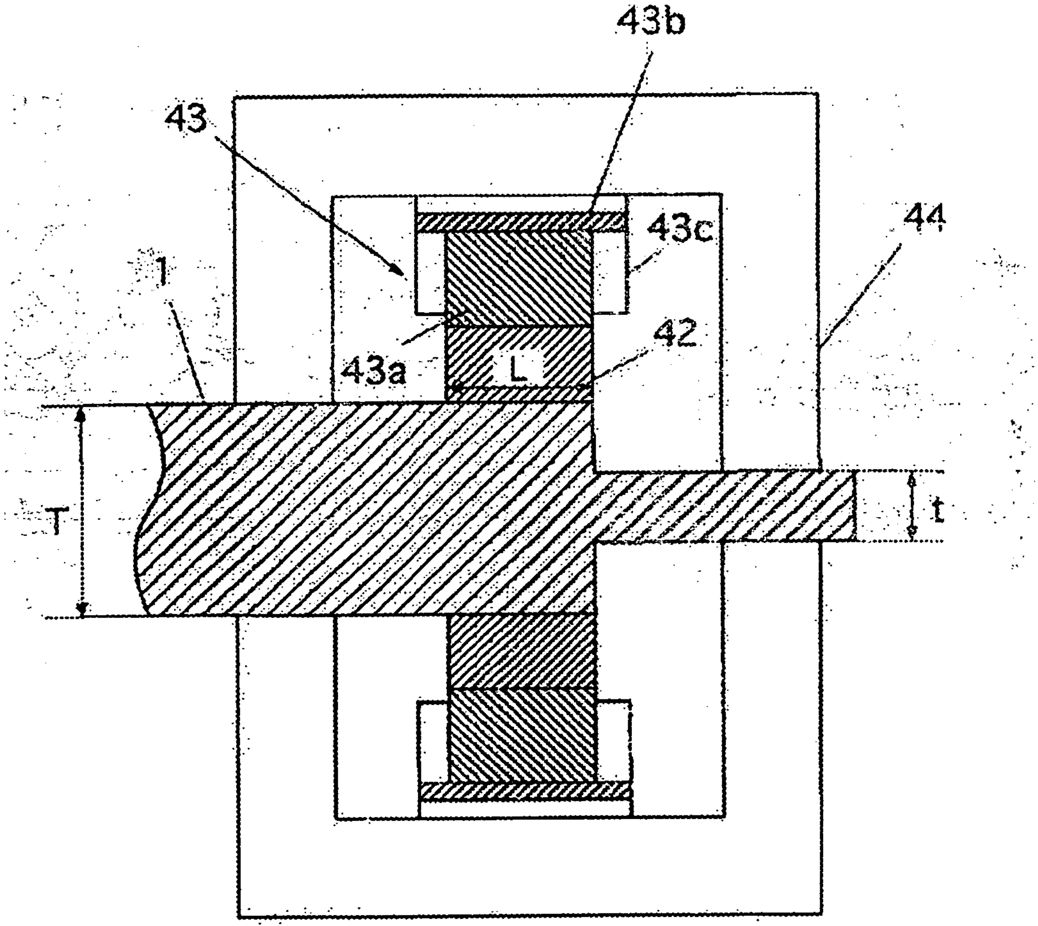


FIG. 6



TRANSFER DIRECTION OF
MATERIAL TO BE PRESSED

FIG. 7

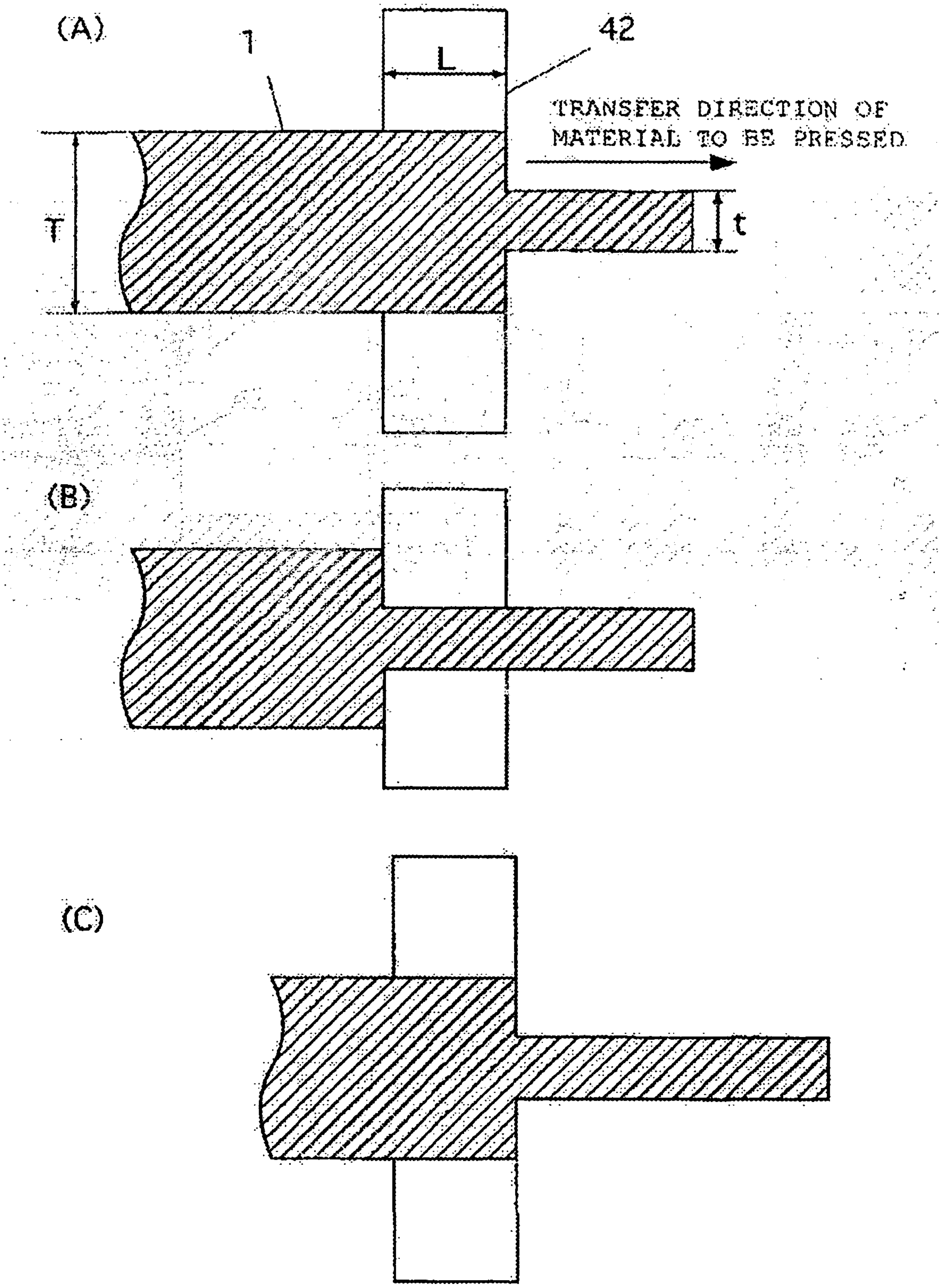


FIG. 8

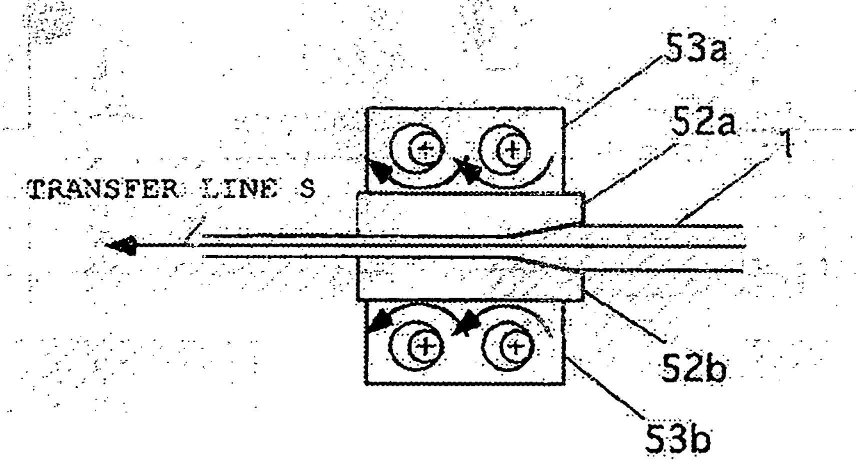


FIG. 9

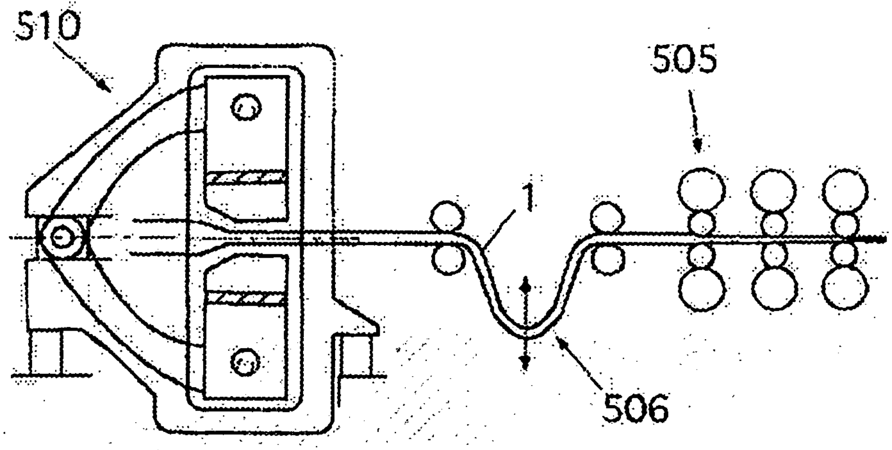

510
505
1
506

FIG. 10

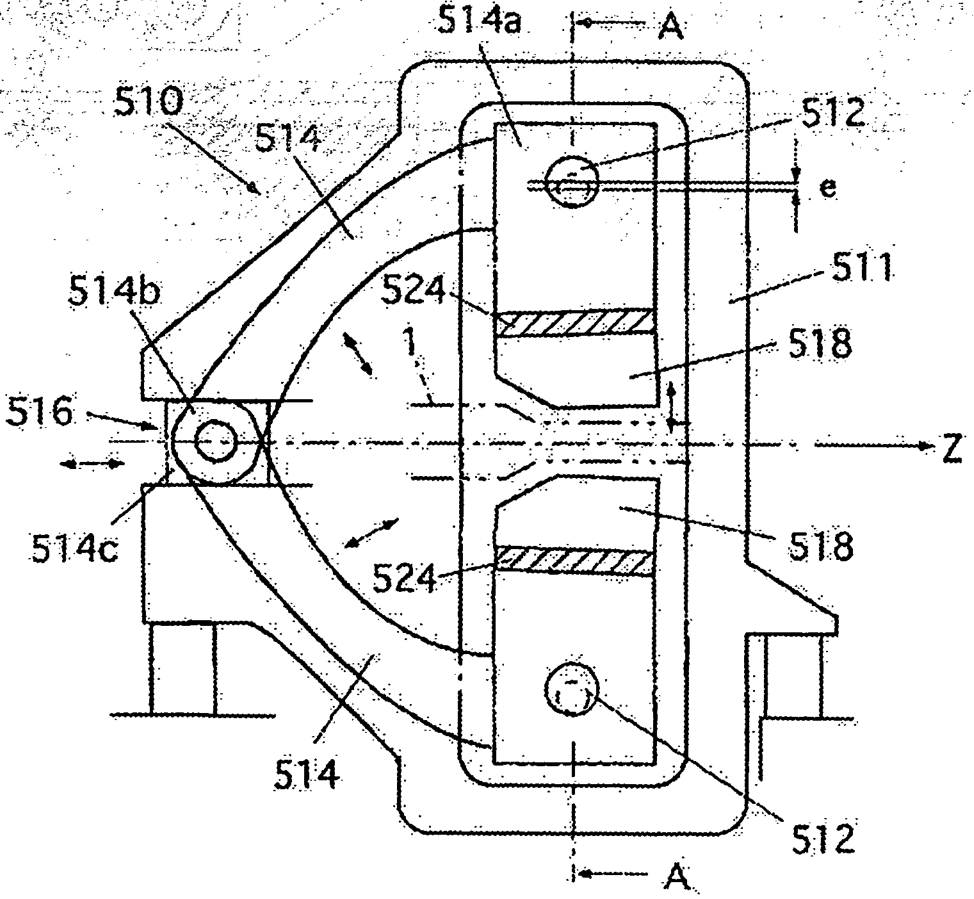

514a
A
510
514
512
e
511
514b
524
1
518
516
Z
514c
518
524
514
512
A

FIG. 11

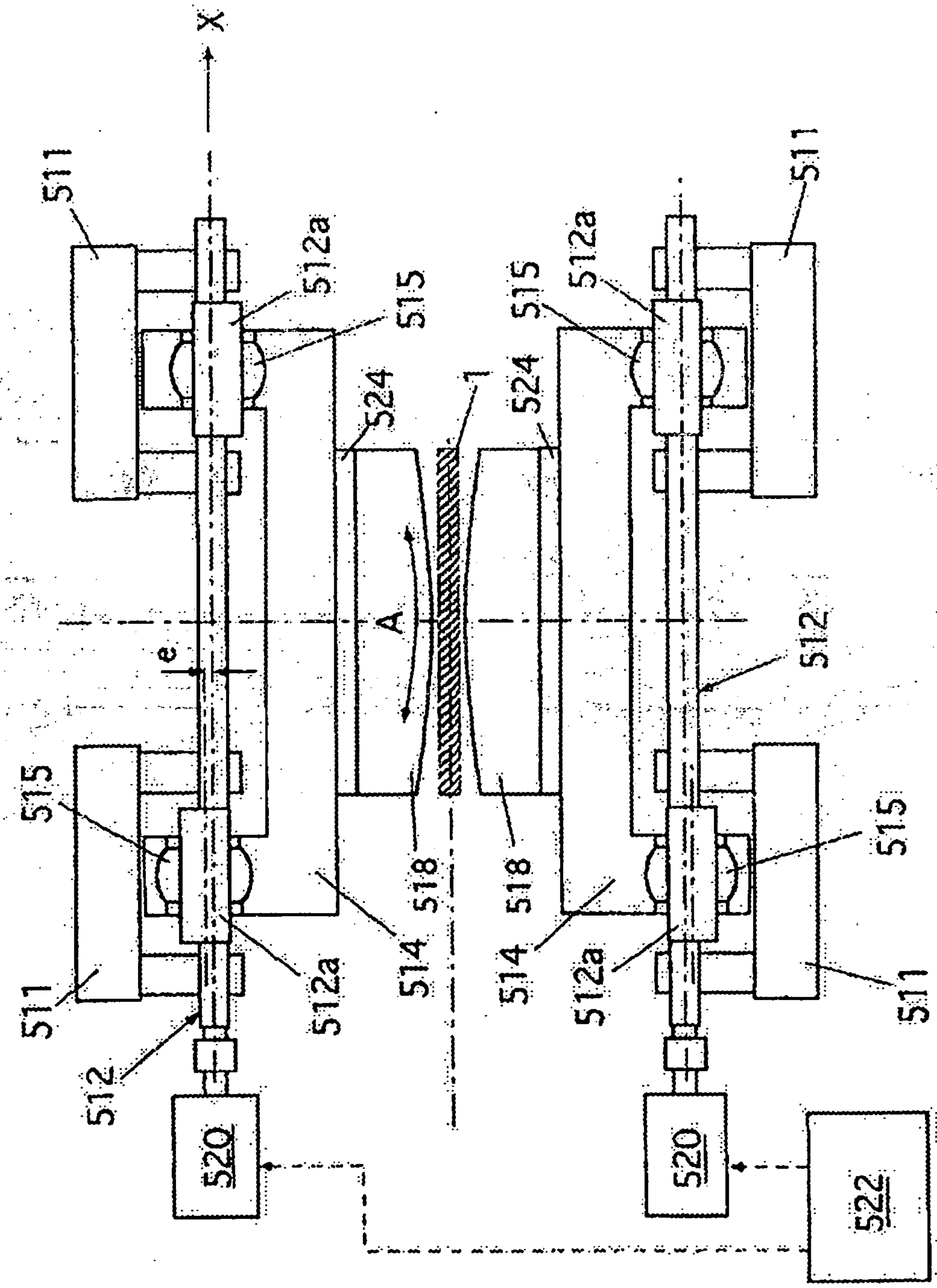


FIG. 12

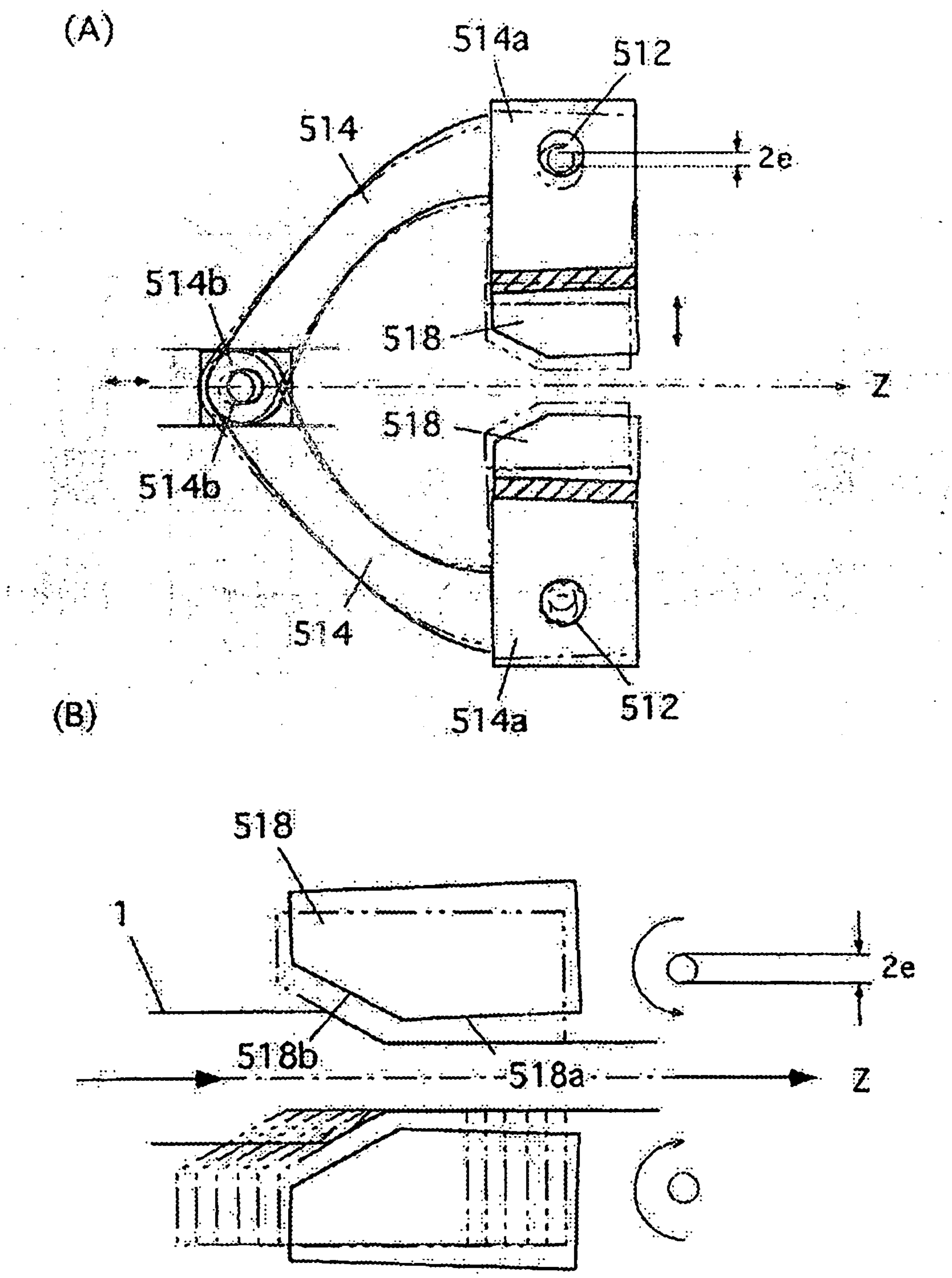

(A)
514a
512
514
2e
514b
518
Z
518
514b
514
(B)
514a
512
518
1
2e
518b
518a
Z

FIG. 13

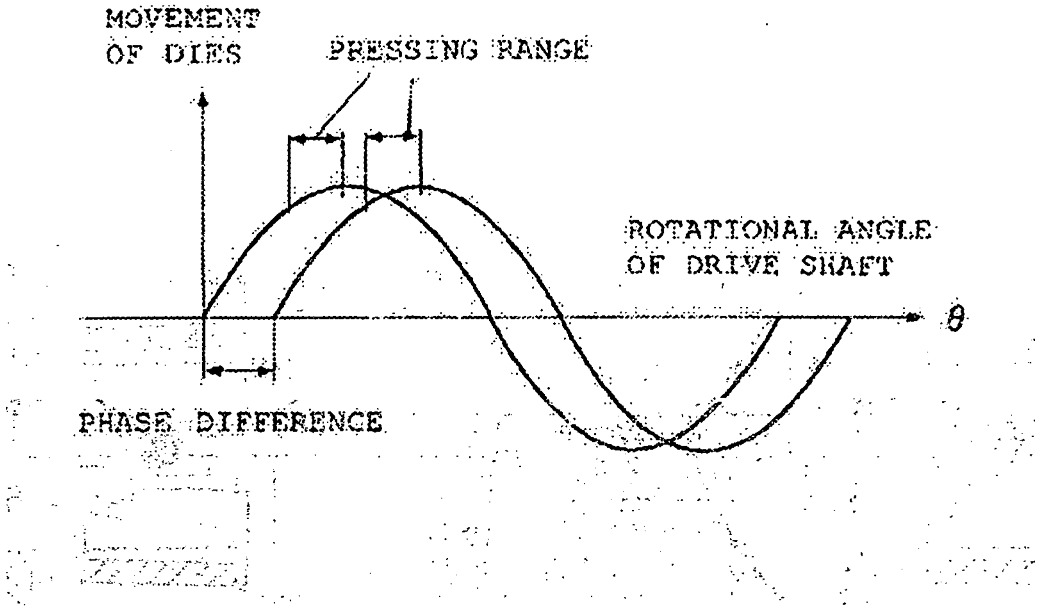

MOVEMENT
OF DIES
PRESSING RANGE
ROTATIONAL ANGLE
OF DRIVE SHAFT
θ
PHASE DIFFERENCE

FIG. 14

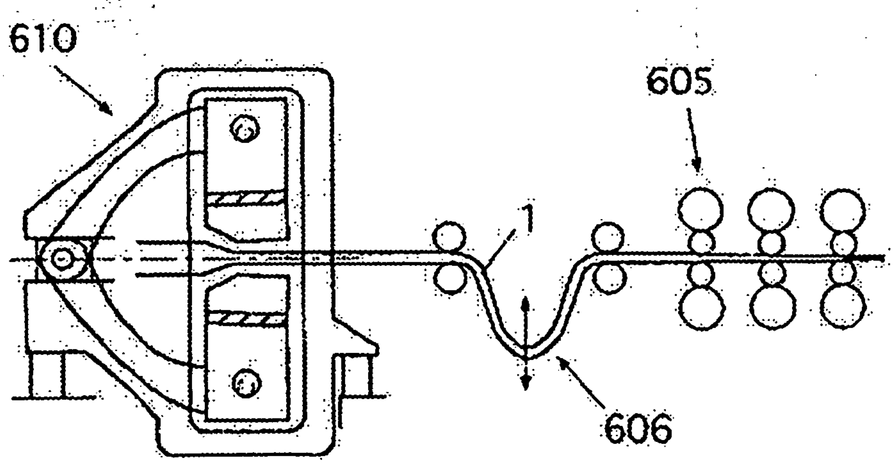

610
605
1
606

FIG. 15

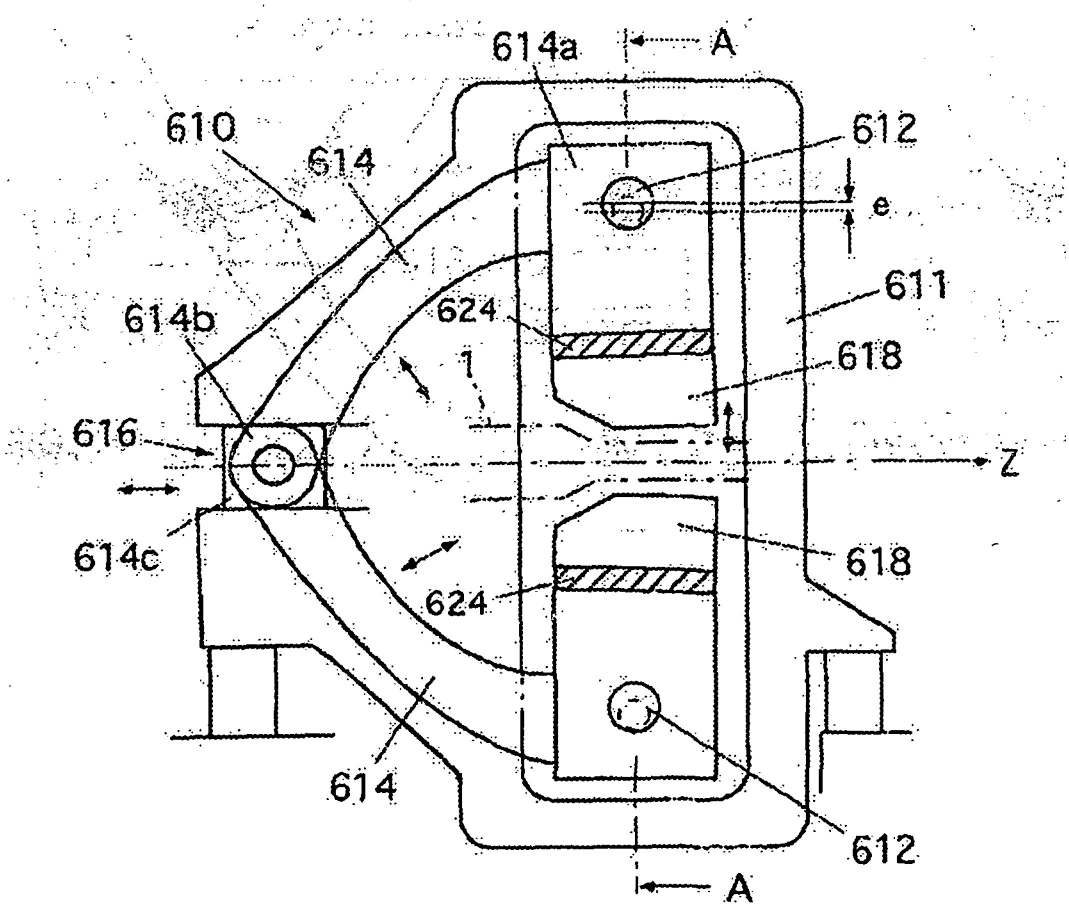

614a
A
610
614
612
e
611
614b
624
1
618
616
Z
614c
618
624
614
612
A

FIG. 16

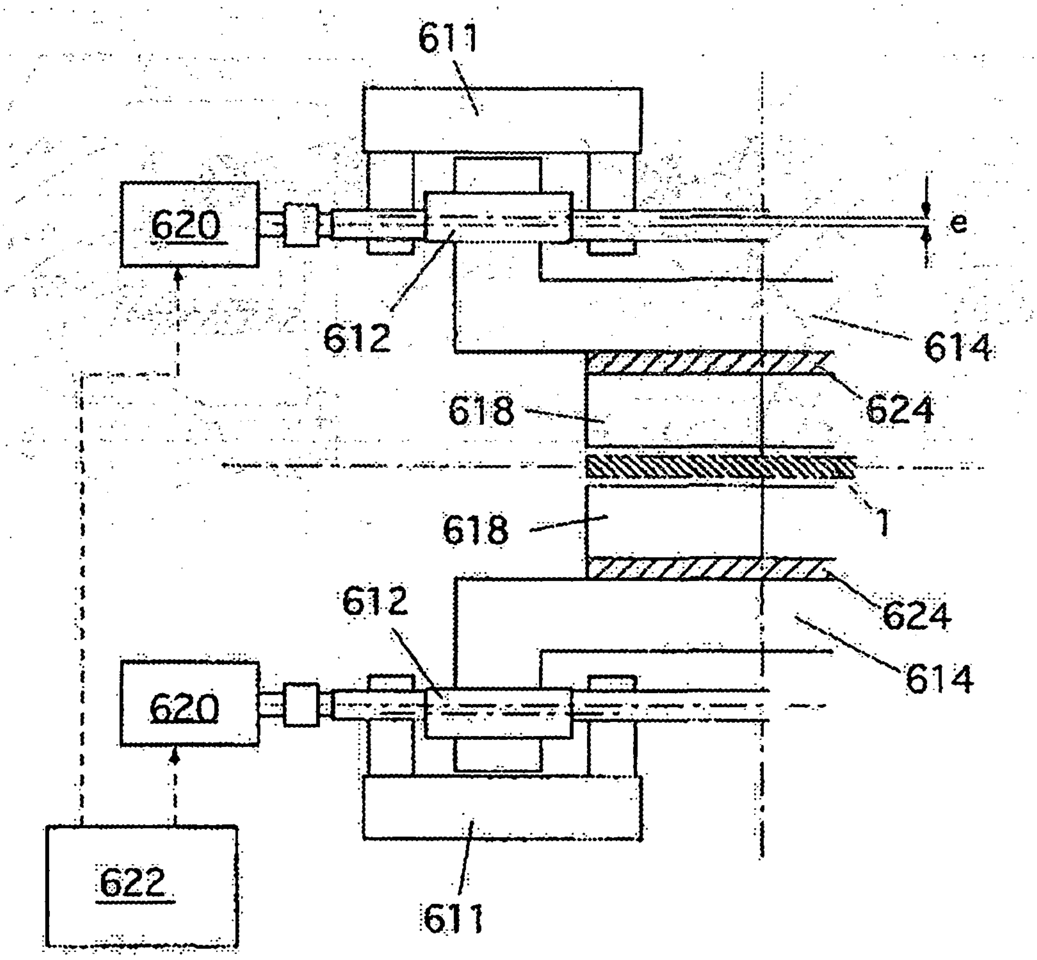


FIG. 17

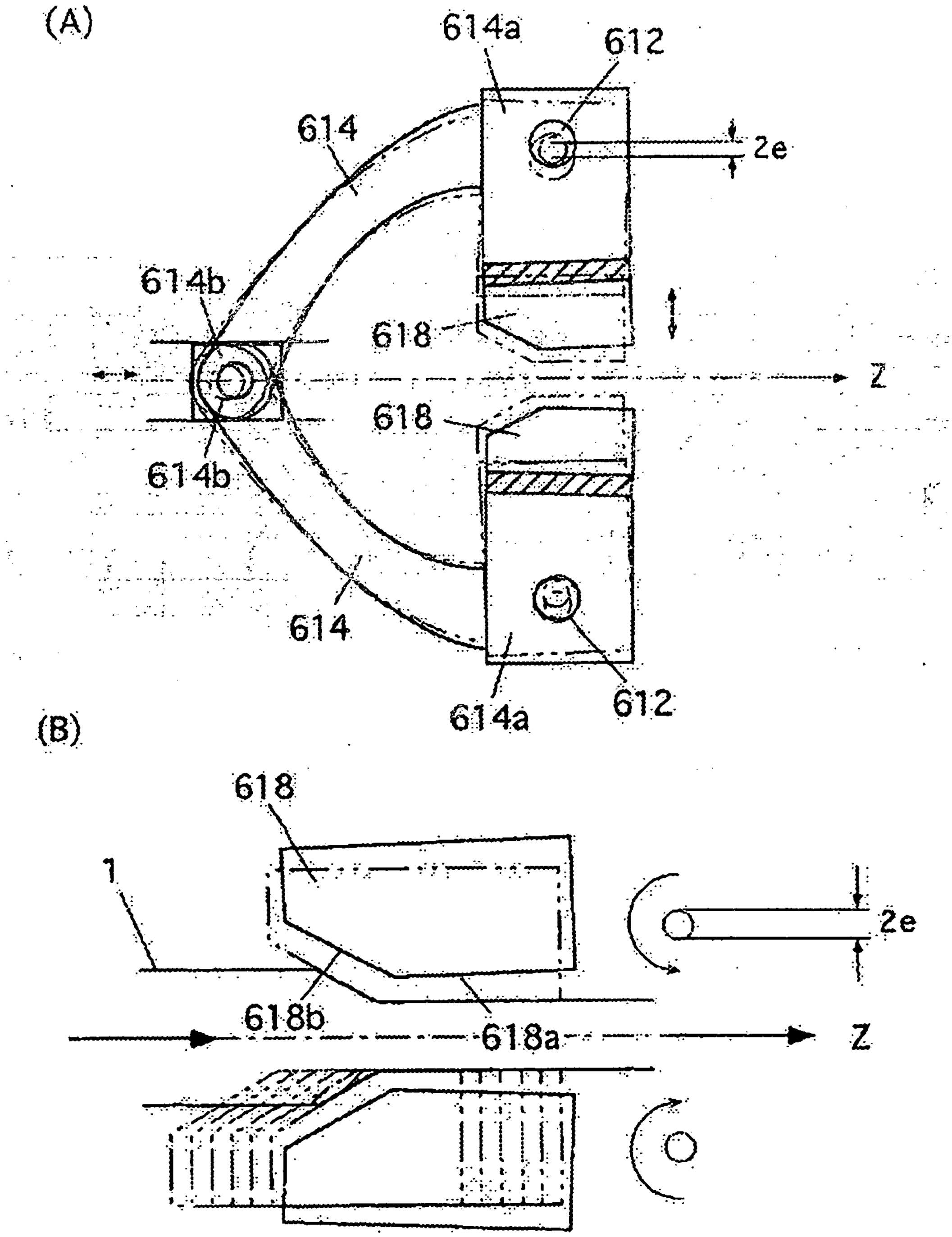

(A)
614a
612
614
2e
614b
618
Z
618
614b
614
614a
612
(B)
618
1
2e
618b
618a
Z

FIG. 18

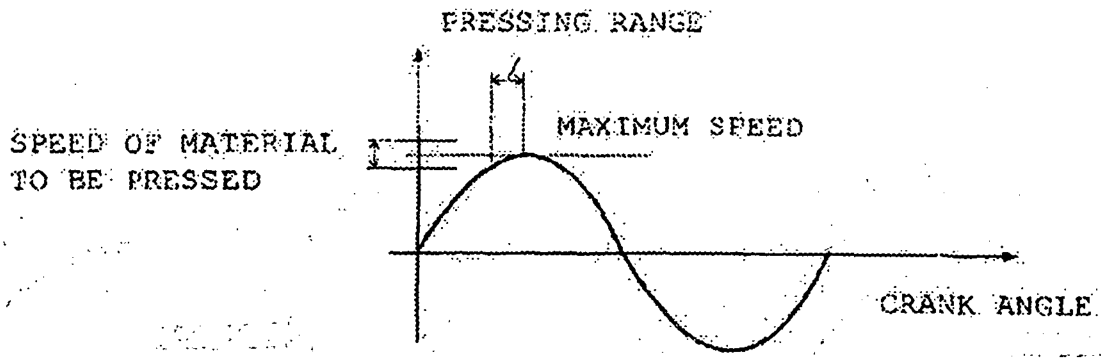

PRESSING RANGE
MAXIMUM SPEED
SPEED OF MATERIAL
TO BE PRESSED
CRANK ANGLE

FIG. 19

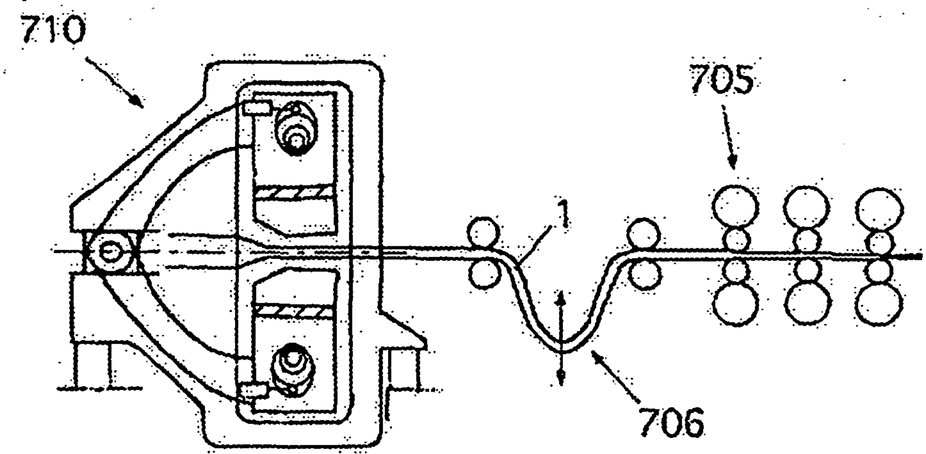

710
705
1
706

FIG. 20

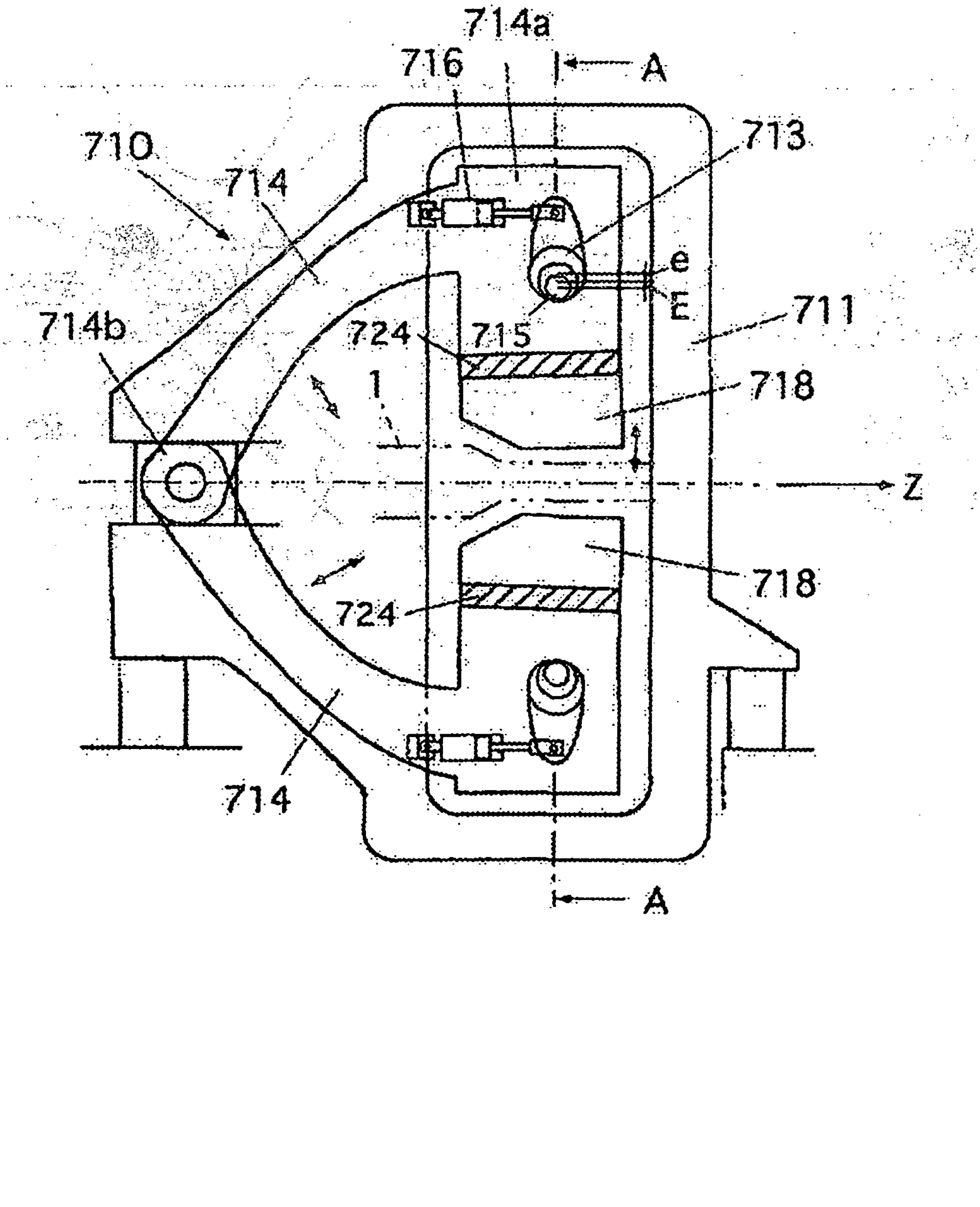


FIG. 21

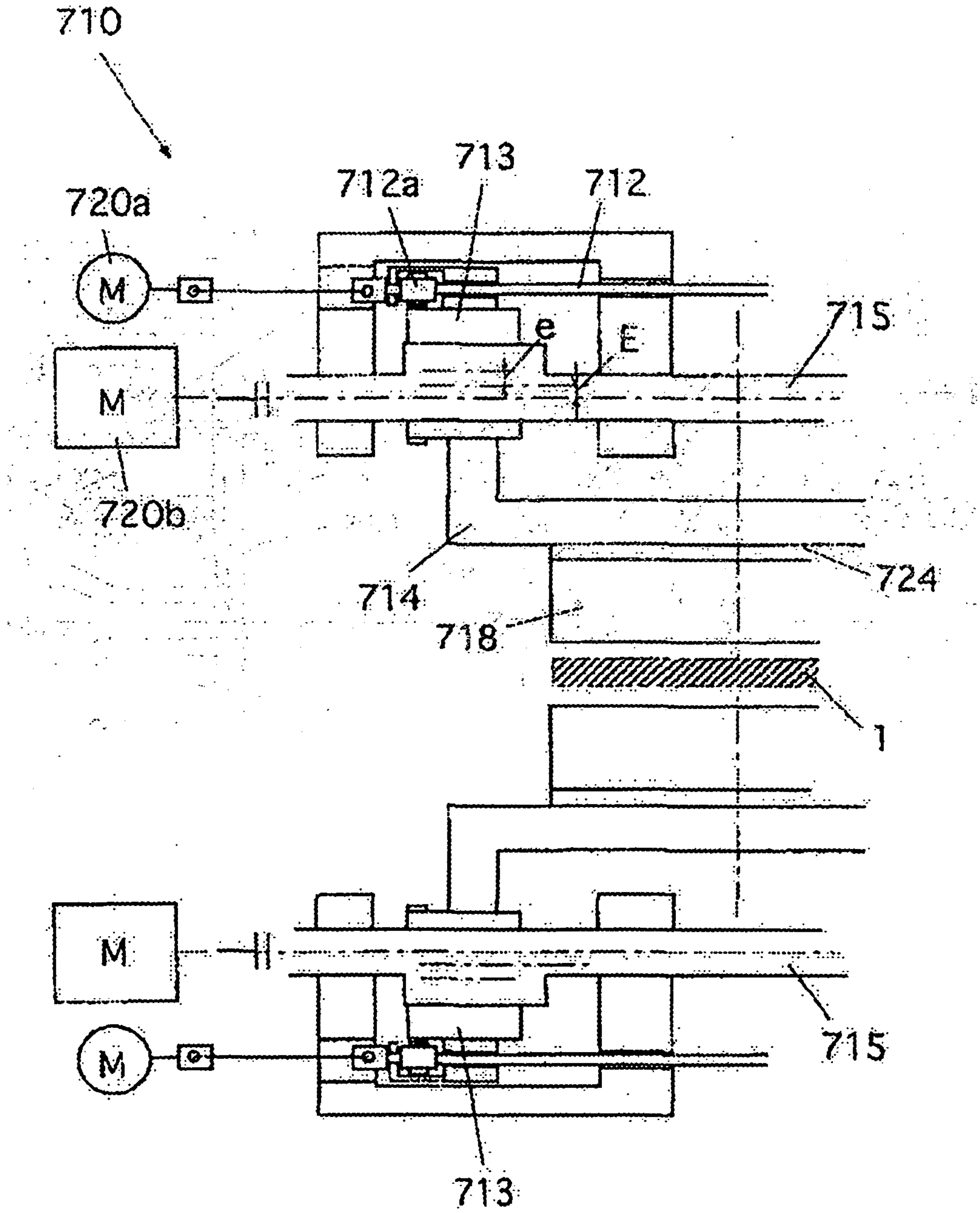
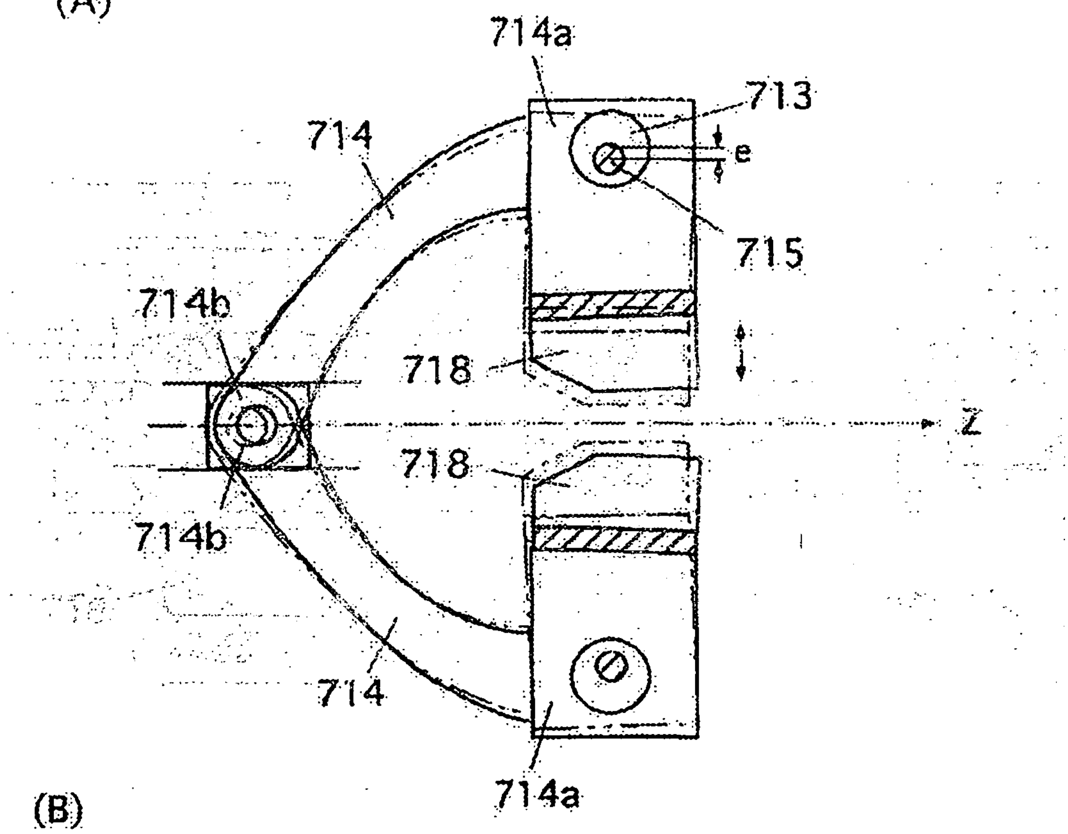


FIG. 22

(A)


714a
713
714
e
715
714b
718
Z
718
714b
714
714a

(B)

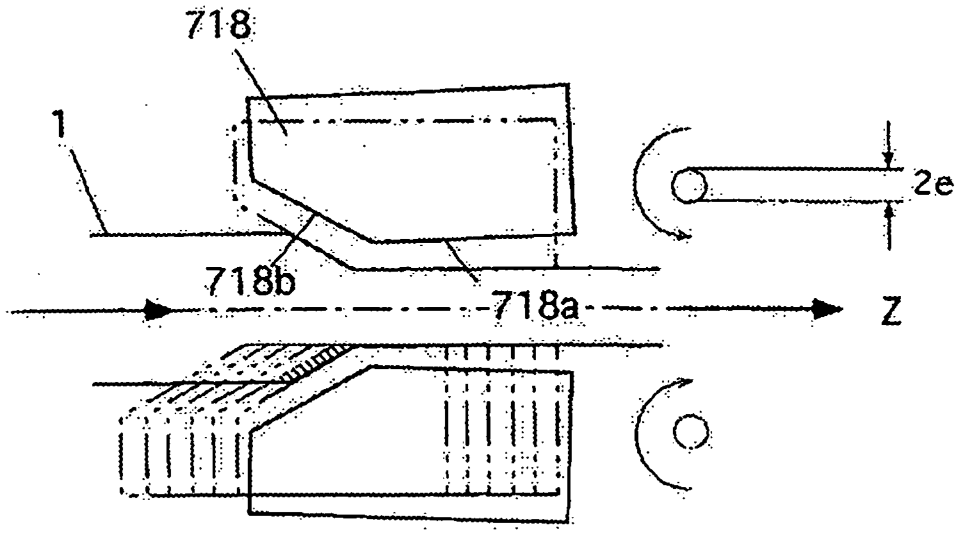

718
1
2e
718b
718a
Z

FIG. 23

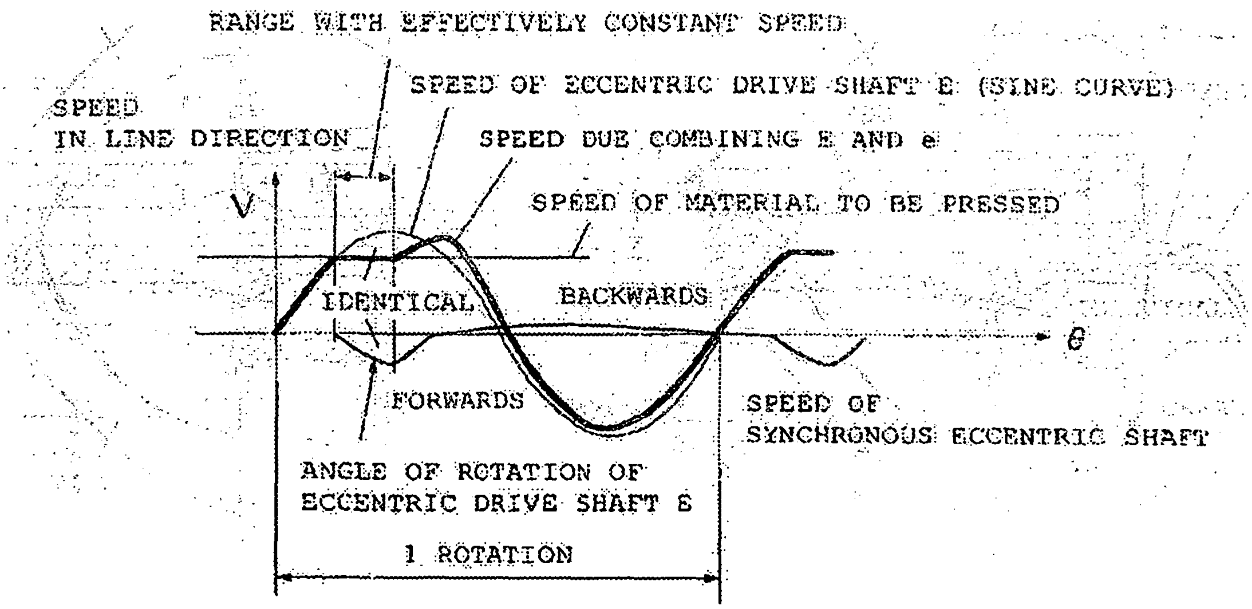

RANGE WITH EFFECTIVELY CONSTANT SPEED
SPEED OF ECCENTRIC DRIVE SHAFT E (SINE CURVE)
SPEED
IN LINE DIRECTION
SPEED DUE COMBINING E AND e
V
SPEED OF MATERIAL TO BE PRESSED
IDENTICAL
BACKWARDS
θ
FORWARDS
SPEED OF
SYNCHRONOUS ECCENTRIC SHAFT
ANGLE OF ROTATION OF
ECCENTRIC DRIVE SHAFT E
1 ROTATION

FIG. 24

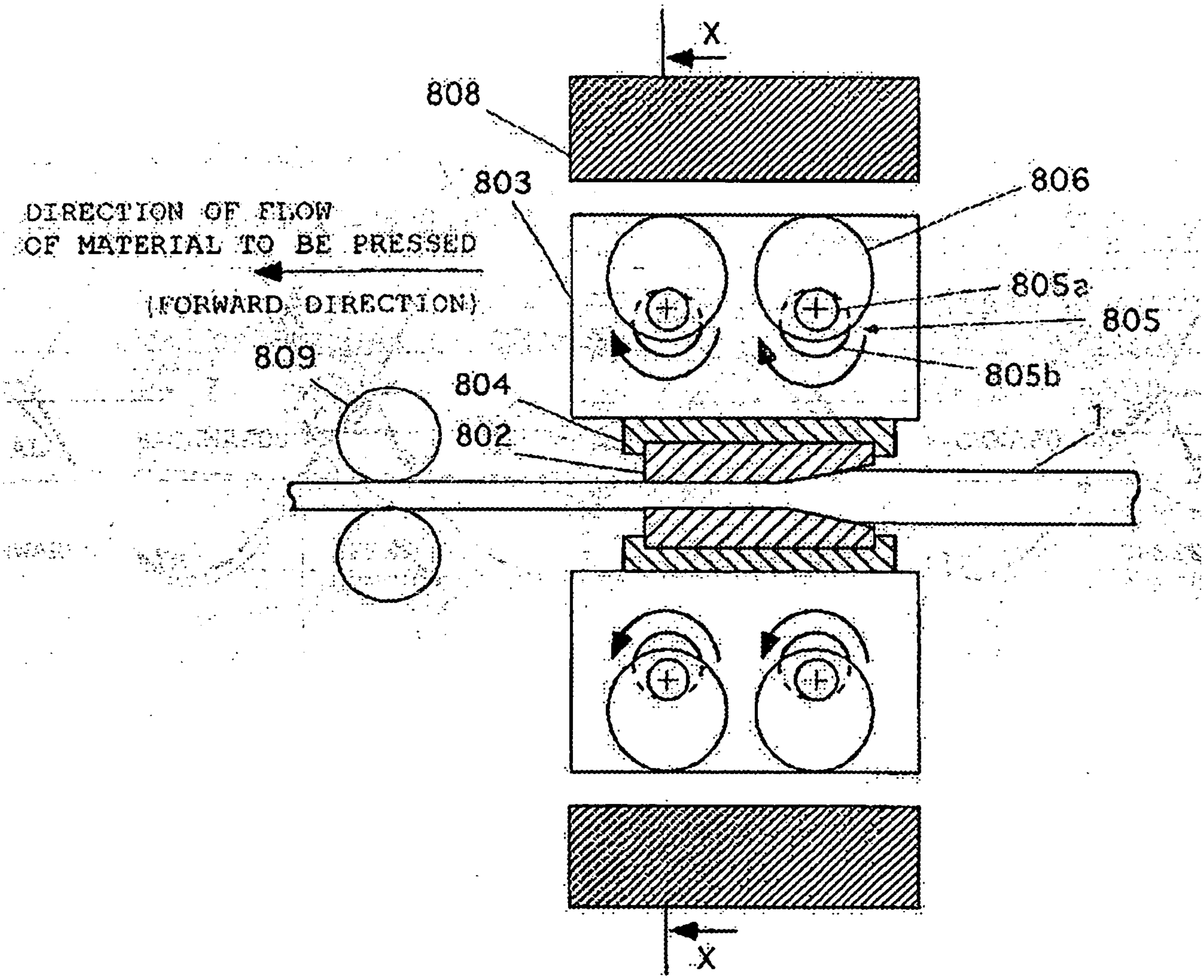

X
808
803
806
DIRECTION OF FLOW
OF MATERIAL TO BE PRESSED
(FORWARD DIRECTION)
805a
805
809
805b
804
802
1
X

FIG. 25

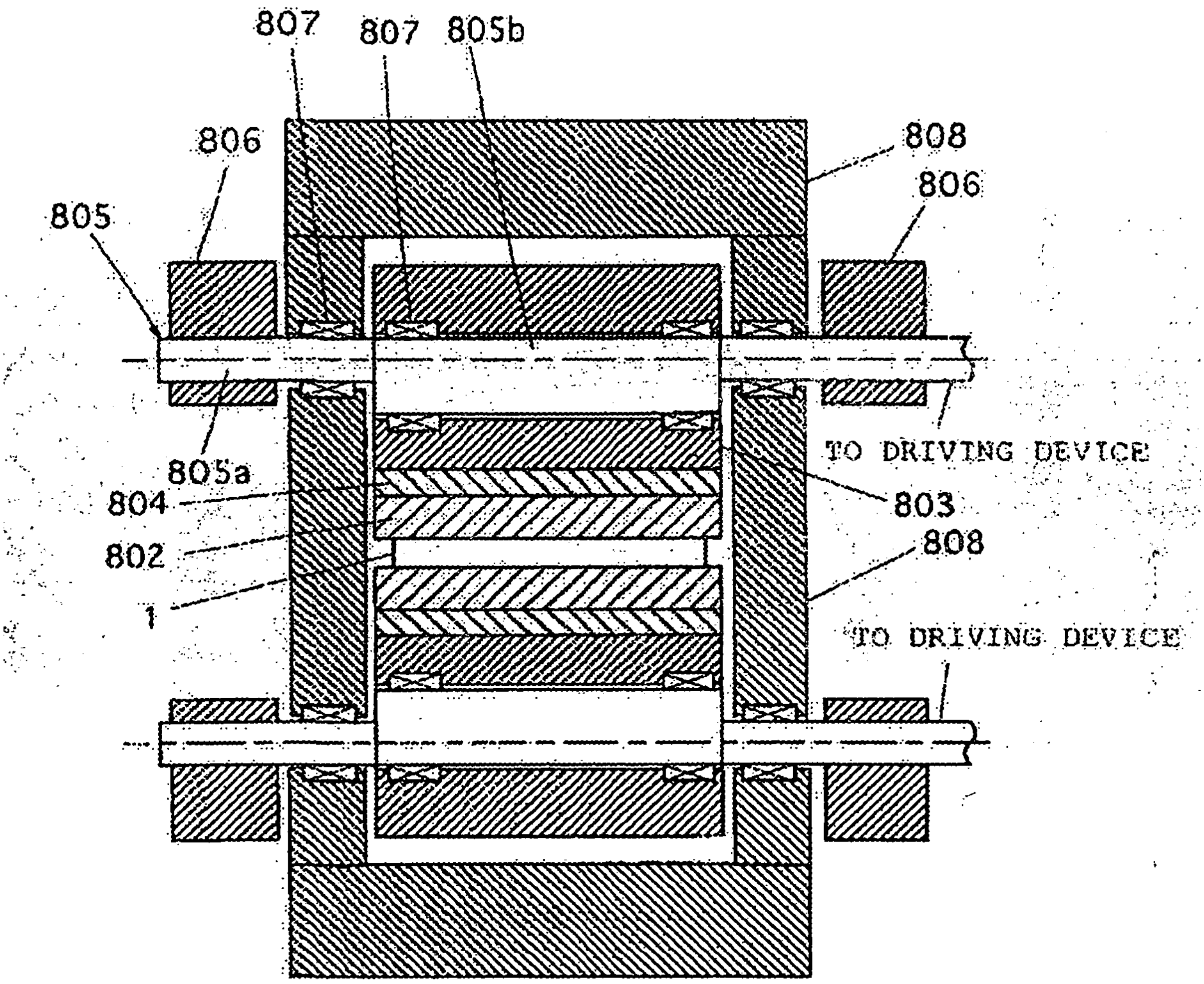

807
807
805b
806
808
806
805
805a
804
802
1
803
808
TO DRIVING DEVICE
TO DRIVING DEVICE

FIG. 26

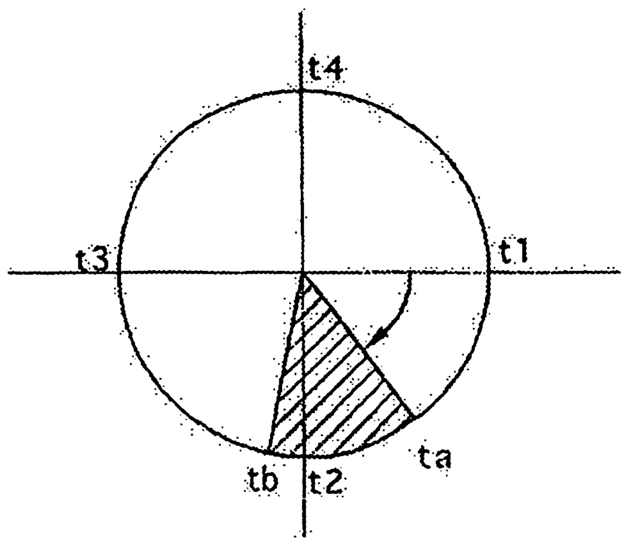

t4
t3
t1
ta
tb
t2

FIG. 27

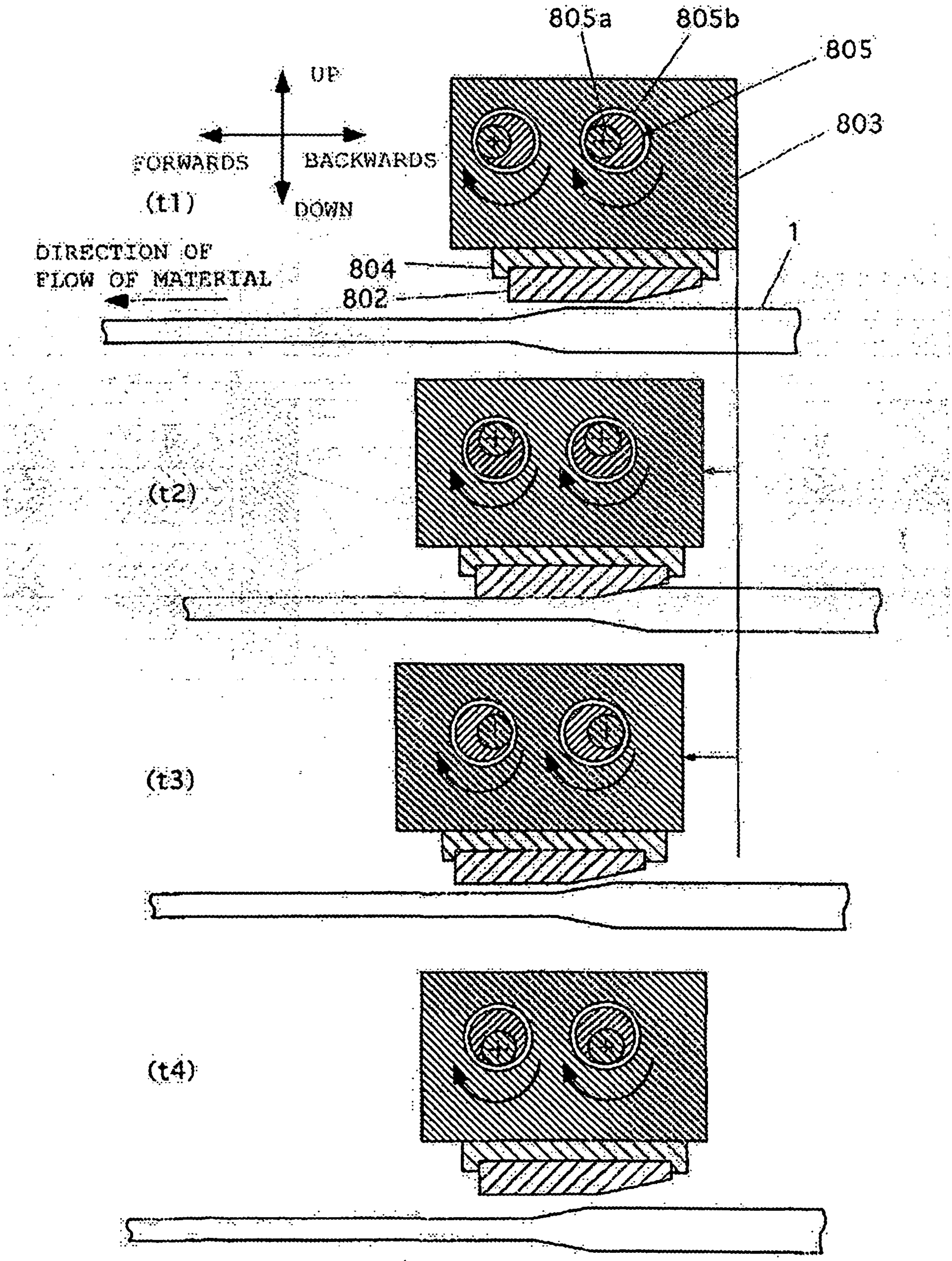

805a
805b
805
803
UP
FORWARDS
BACKWARDS
DOWN
(t1)
DIRECTION OF
FLOW OF MATERIAL
804
802
1
(t2)
(t3)
(t4)

FIG. 28

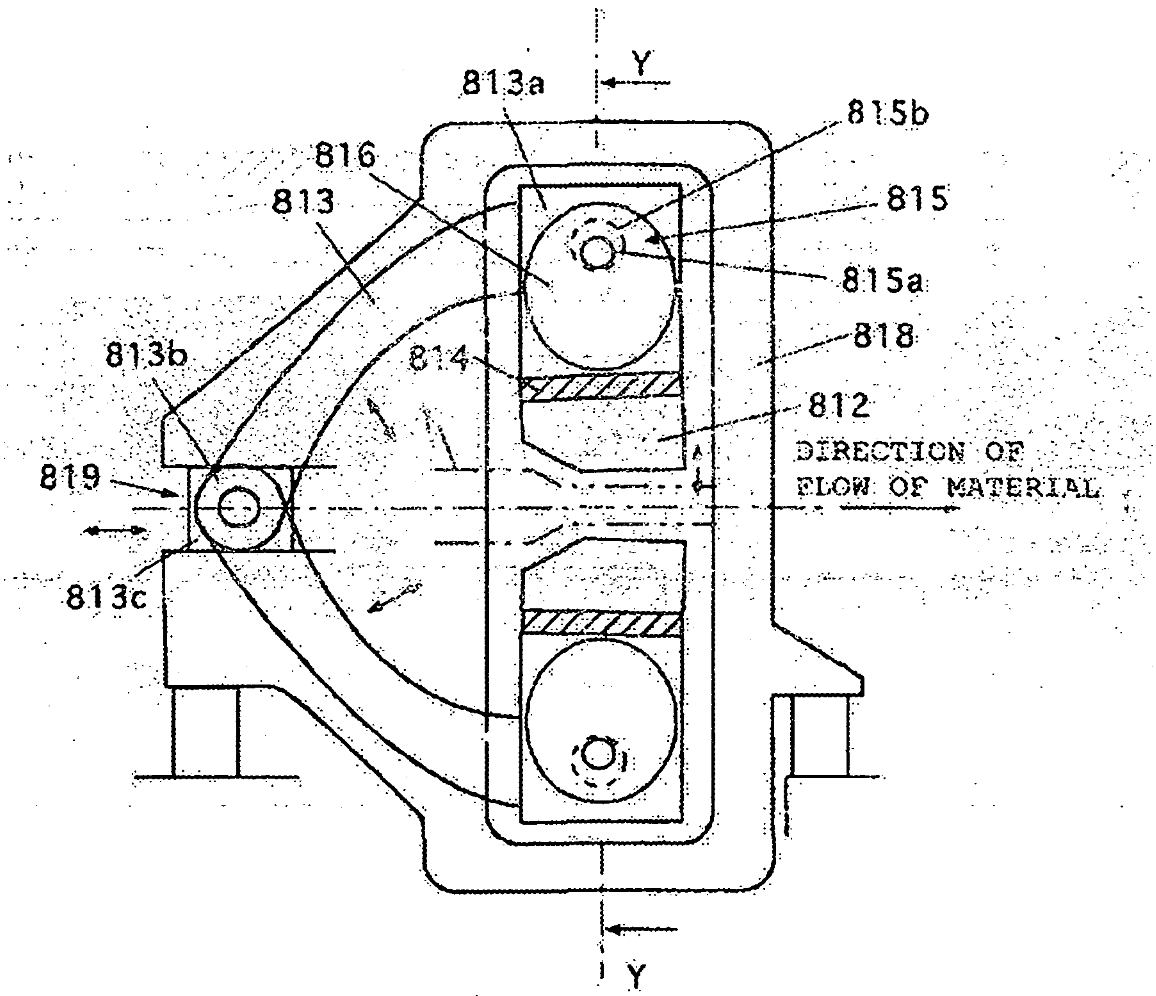

813a
Y
815b
816
815
813
815a
818
813b
814
812
DIRECTION OF
FLOW OF MATERIAL
819
813c
Y

FIG. 29

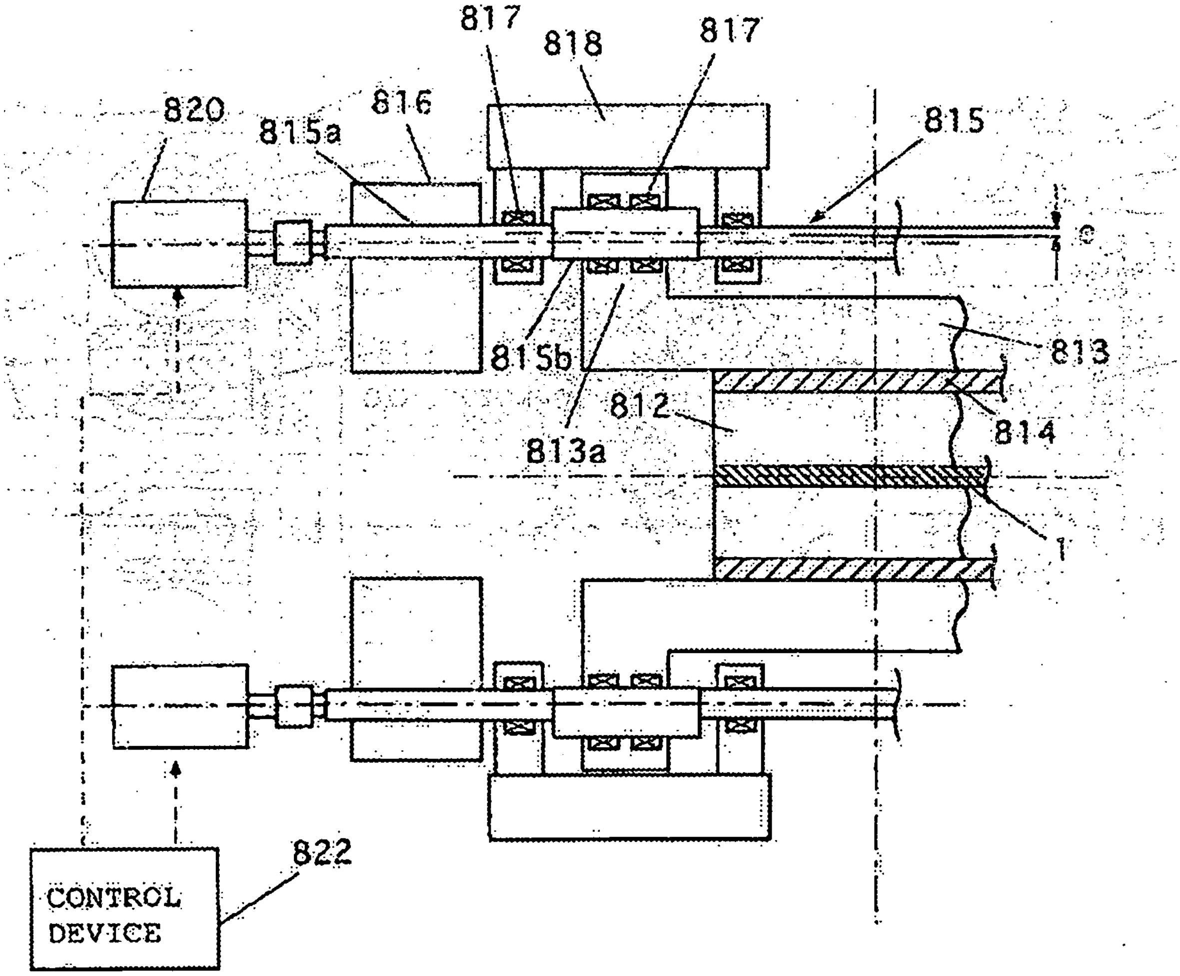
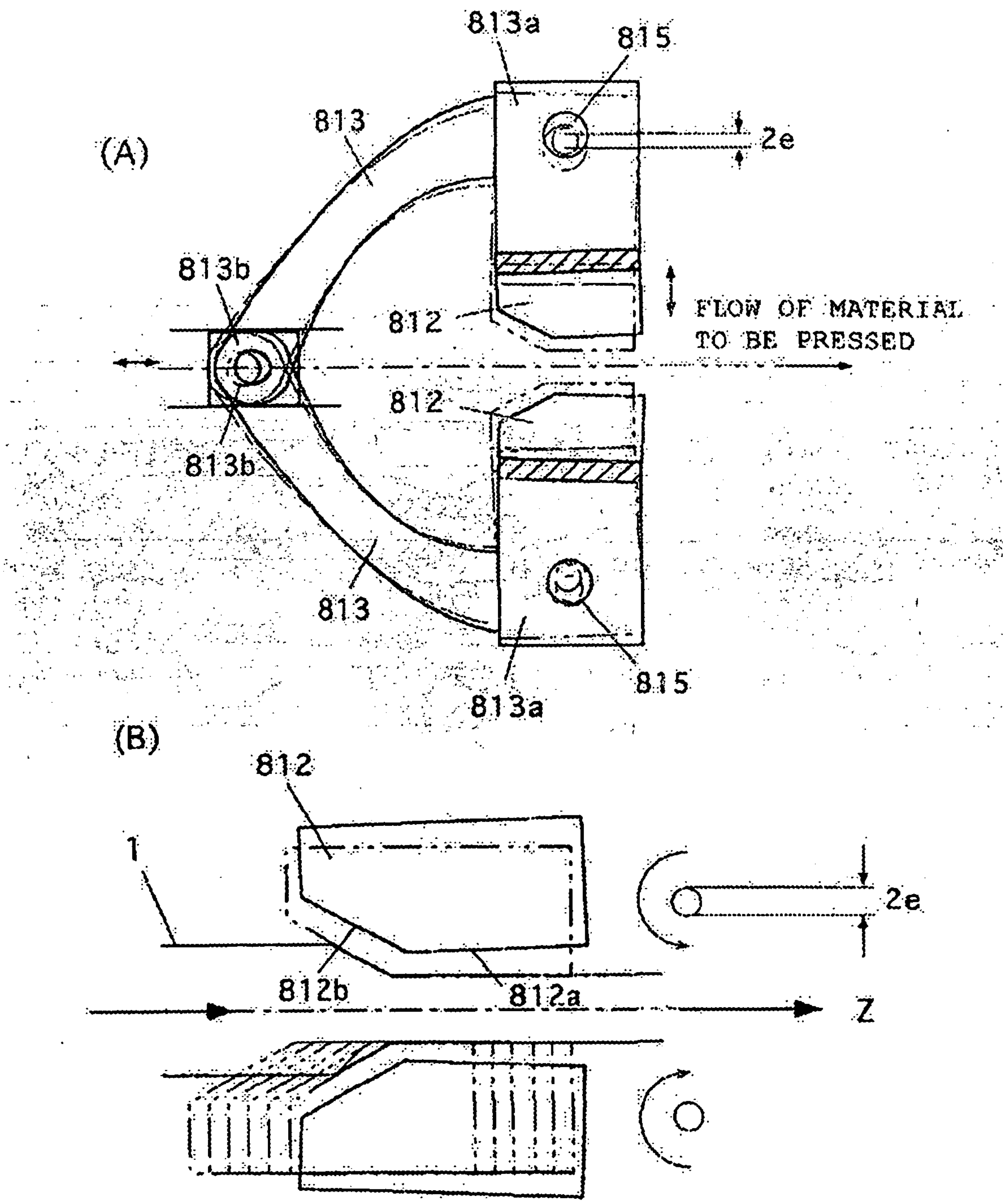

817
818
817
820
816
815a
815
e
815b
813
812
814
813a
1
822
CONTROL
DEVICE

FIG. 30


(A)
813a
815
813
2e
813b
812
FLOW OF MATERIAL
TO BE PRESSED
812
813b
813
815
813a
(B)
812
1
2e
812b
812a
Z

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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