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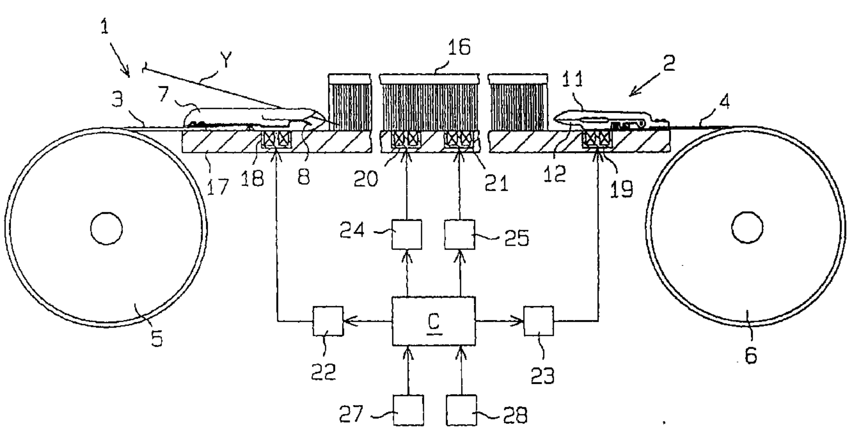
(54) Weft insertion method and apparatus for rapier loom

(57) A weft inserting apparatus for a rapier loom for weaving a fabric by inserting a weft through a shed formed by warps by reciprocatively moving feeding and receiving rapier heads through the shed. The feeding and receiving rapier heads (1; 2) are each constituted by a combination of a stationary gripper member (7; 11) and a movable gripper member (8; 12) made of a magnetic material. Electromagnets (18; 19) are disposed at both ends of a sley (17), respectively, while electromagnets (20; 21) are disposed at a mid portion of the sley. The movable gripper member (8) of the feeding rapier head (1) positioned in opposition to the electromagnets (19; 21) is displaced from a weft grip position to a weft release position by controlling the magnetic action of the electromagnets (18; 20), while the movable gripper member (12) of the receiving rapier head (2) disposed oppositely to the electromagnets (19; 21) is displaced from the weft grip position to the weft release position by controlling the magnetic action of the electromagnets (19; 21). The weft insertion can be carried out with high reliability while positively protecting the weft against injury.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a rapier loom for weaving fabric by inserting a deft into a shed defined between warps by using at least one rapier head moved reciprocatively through the shed. More particularly, the present invention is concerned with a weft insertion method and an apparatus for carrying out the same for a rapier loom of the type mentioned above,

2. Description of Related Art

In the hitherto known rapier loom, fabric is woven by inserting a weft into a shed defined between layers of warps (hereinafter also referred to as an inter-warp shed) by using a feeding rapier head such as one disclosed in Japanese Unexamined Patent Application Publication No. 195373/1993 (JP-A-5-195373). Parenthetically, the feeding rapier head is referred to as the giver in the above publication. The weft inserted into the inter-warp shed by means of the feeding rapier head is transferred to a receiving rapier head (which is referred to as the taker in the above publication). The weft transferred to the receiving rapier head is caused to pass through the shed by retracting (i.e. , moving backwardly) the receiving rapier head. Each of the feeding rapier head and the receiving rapier head is constituted by a combination of a stationary gripper member and a movable gripper member. For effectuating the transfer of the weft from the feeding rapier head to the receiving rapier head, the latter is positioned to a mid position substantially corresponding to a center of the fabric being woven as viewed in the widthwise direction thereof in a standby state in which the associated gripper members are opened. The feeding rapier head releases the weft at the mid position mentioned above. The weft as released is then gripped by the receiving rapier head. Thus, the weft transfer between the feeding rapier head and the receiving rapier head has been accomplished.

In the case of the copier loon disclosed in JP-A-5-195373, the above-mentioned opening/closing operation of the rapier heads at the mid position of the fabric as viewed in the direction widthwise thereof is executed by a pair of levers constituting parts of a clamp opener disposed underneath the fabric. More specifically, the clamp opener is driven by a servo-motor which is controlled in conformance with movements of both the rapier heads, each of which is also adapted to be driven by a servo-motor. A driving system for driving controllably the clamp opener and the rapier heads is adopted for the purpose of realizing the weft transfer from the feeding rapier head to the receiving rapier head while avoiding the possibility of injuring or damaging the weft.

However, the levers of the clamp opener for opening and closing the rapier heads are so arranged as to enter the inter-warp shed space from the underside of the lower warp layer by pushing aside the individual warps. This motion of the clamp opener levers is carried out once for every weft insertion shot or cycle. Thus, it is apparent that the warps are likely to be injured as a result of frequent entrance and exit of the clamp opener levers to and from the shed through the warp layer, which gives rise to a problem in the conventional rapier loom.

SUMMARY OF THE INVENTION

In the light of the state of the art described above, it is an object of the present invention to provide a weft insertion method for a rapier loom which method is capable of inserting a weft into an inter-warp shed by using a rapier head with high reliability and without injuring the same.

It is another object of the present invention to provide a weft inserting apparatus for carrying out the method mentioned above.

In view of the above and other objects which will become apparent as the description proceeds, the present invention is directed to a rapier loom for weaving a fabric by inserting a weft through a shed formed by warps by using at least one rapier head constituted by a combination of a stationary gripper member and a movable gripper member into said shed.

In the rapier loom mentioned above, there is provided according to a general aspect of the present invention a weft insertion method which features that the aforementioned movable gripper member is so implemented as to respond to a magnetic force of a magnetic force exerting means to thereby assume selectively a weft grip position and a weft release position, that the magnetic force exerting means is changed over between a first state in which the magnetic force exerting means exerts a magnetic force to the movable gripper member and a second state in which the magnetic force exerting means exerts no magnetic force to the movable gripper member, and that the movable gripper member is positionally changed over between the weft grip position and the weft release position by switching the magnetic force exerting means between the first state and the second state mentioned above, wherein the weft is gripped by the movable gripper member when the movable gripper member is changed over from the weft release position to the weft grip position, while the weft is released when the movable gripper member is changed over from the weft grip position to the weft release position.

In the weft insertion method described above, the movable gripper member is disposed at the weft grip position when the magnetic force of the magnetic force exerting means does not act on the movable gripper member, while the magnetic force of the magnetic force exerting means acts on the movable gripper member, the latter is disposed at the weft release position. Thus, when the weft is to be gripped by the rapier head, the movable gripper member is displaced (i.e., positionally changed over) to the weft grip position from the weft release position. Upon reaching of the movable gripper member at the weft grip position, the weft is gripped between the stationary gripper member and the movable gripper member. On the other hand, when the weft is to be released from the rapier head, the movable gripper member is displaced to the weft release position from the weft grip position. Upon reaching of the movable gripper member at the weft release position, the weft is released from the state gripped or grasped between the stationary gripper member and the movable gripper member.

Upon transfer of the weft from the feeding rapier head to the receiving rapier head, the latter waits for arrival of the receiving rapier head at a weft transfer position, e.g. at a mid position as viewed in the direction widthwise of the fabric being woven, while the movable gripper member of the receiving rapier head is disposed at the weft release position. Upon arrival of the feeding rapier head gripping the weft at the weft transfer position, the movable gripper member of the receiving rapier head is caused to assume the weft grip position, whereupon the weft is gripped by the receiving rapier head, while the movable gripper member of the feeding rapier head is positioned at the weft release position, whereupon the weft gets rid of the `gripping action of the feeding rapier head.

Further, provided according to a second aspect of the present invention is a weft insertion method which features that the movable gripper member is so implemented as to be responsive to a magnetic force of electromagnetic means to thereby assume selectively a weft grip position and a weft release position, and that the electromagnetic means is changed over between a first state in which the electromagnetic means exerts a magnetic force to the movable gripper member and a second state in which the electromagnetic means exerts no magnetic force to the movable gripper member, wherein upon application of the magnetic force, the electromagnetic means is first applied with an over-excitation voltage, which is then followed by application of a rated voltage. The movable gripper member is positionally changed over between a weft grip position and a weft release position by switching the electromagnetic means between the first and second states mentioned above. The weft is gripped by the movable gripper member by positionally switching the movable gripper member from the weft release position to the weft grip position, while the weft is released when the movable gripper member is changed over to the weft release position from the weft grip position.

In the weft insertion method according to the second aspect of the invention, the over-excitation voltage is first applied to the electromagnet upon application of the magnetic force thereof to the movable gripper member, which is then followed by application of the rated voltage. Due to application of the over-excitation voltage, the positional change-over of the movable gripper member from the weft grip position to the weft release position is performed rapidly, whereby the loom can be operated at an increased speed, to an advantage.

The present invention is also directed to be a rapier loom for weaving a fabric by inserting a weft through a shed formed between warp layers by inserting at least one rapier head constituted by a combination of a stationary gripper member and a movable gripper member into the shed, wherein a piezoelectric device is interposed between the stationary gripper member and the movable gripper member.

In the rapier loom mentioned above, there is provided according to a third aspect of the present invention a weft insertion method which features that the piezoelectric device is switched between a first state in which a voltage is applied to the piezoelectric device and a second state in which no voltage is applied to the piezoelectric device, that the movable gripper member is positionally changed over between a weft grip position and a weft release position by switching the piezoelectric device between the first and second states mentioned above, and that the weft is gripped by the movable gripper member when it is changed over from the weft release position to the weft grip position, while the weft is released by positionally changing over the movable gripper member to the weft release position from the weft grip position.

With the arrangement described above, the piezoelectric device undergoes contraction and expansion in response to application of a voltage thereto and clearing thereof. Thus, by controlling the voltage application to the piezoelectric device, the positional change-over of the movable gripper member between the weft grip position and the weft release position can controllably be carried out.

As mentioned previously, the present invention is also concerned with an apparatus for carrying out the weft insertion methods described above. Thus, there is provided according to a further aspect of the invention a weft inserting apparatus for the rapier loom described hereinbefore, which apparatus features that the movable gripper member is at least partially composed of a magnetic force responsive portion, and that a magnetic force exerting means is installed at a position in the vicinity of the weft insertion path, wherein the movable gripper member is exchangeably positioned between a weft grip position and a weft release position by switching the state of the magnetic force exerting means between a first state in which magnetic force of the a magnetic force exerting means acts on the magnetic force responsive portion of the movable gripper member and a second state in which the magnetic force of the magnetic force exerting means does not act on the magnetic force responsive portion.

Further, for a rapier loom which includes a feeding rapier head constituted by a stationary feeding gripper and a movable feeding gripper and a receiving rapier head constituted by a stationary receiving gripper and a movable receiving gripper, wherein both of the feeding rapier head and the receiving rapier head are inserted into a shed formed by layers of warps for inserting and passing a weft into and through the shed by transferring the weft caught by the feeding rapier head to the receiving rapier head, there is provided according to a further aspect of present invention a weft inserting apparatus which features that it is comprised of a first magnetic force responsive member constituting at least a portion of the movable feeding gripper, a second magnetic force responsive member constituting at least a portion of the movable receiving gripper, a feeding magnetic force exerting means disposed in the vicinity of a weft insertion dead center point located on a weft insertion path of the feeding rapier head, a receiving magnetic force exerting means disposed at a side of a weft insertion dead center point on a weft insertion path of the receiving rapier head, a first switching means for switching the feeding magnetic force exerting means between a first state in which a magnetic force of the feeding magnetic force exerting means acts on the magnetic force responsive member of the movable feeding gripper and a second state in which the magnetic force of the feeding magnetic force exerting means does not act on the magnetic force responsive member of the movable feeding gripper to thereby change over the movable feeding gripper between a weft grip position and a weft release position, and a second means for switching the receiving magnetic force exerting means between a first state in which a magnetic force of the receiving magnetic force exerting means acts on the magnetic force responsive member of the movable receiving gripper and a second state in which the magnetic force of the receiving magnetic force exerting means does not act on the magnetic force responsive member of the movable receiving gripper to thereby change over the movable receiving gripper between a weft grip position and a weft release position.

In a preferred mode for implementing the weft inserting apparatus according to the present invention, a plurality of the feeding magnetic force exerting means may be disposed in series to one another along the weft insertion path of the feeding rapier head.

In another preferred mode for carrying out the invention, a plurality of the receiving magnetic force exerting means may be disposed in series to one another along the weft insertion path of the receiving rapier head.

By virtue of the arrangements mentioned above, the feeding rapier head undergoes sequentially the magnetic actions exerted by a plurality of feeding magnetic force exerting means disposed in series along the weft insertion path, while the receiving rapier head equally undergoes sequentially the magnetic actions of plural receiving magnetic force exerting means disposed serially along the weft insertion path. Thus, it is possible to change over the rapier head between the weft releasing state and the weft gripping state even when the rapier head is being moved.

In yet another preferred mode for carrying out the present invention, the magnetic force exerting means may be constituted by at least one electromagnet, wherein the weft inserting apparatus may further include a voltage application control means for controlling application of a voltage to the electromagnet, an applied voltage level setting means for setting a level of voltage applied to the electromagnet, a voltage application timing setting means for setting a timing at which the voltage is applied to the electromagnet.

In the weft inserting apparatus of the structure described above, the timings at which the voltage is applied to the electromagnet is set at the voltage application timing setting means, while the voltage application control means commands the voltage application timings on the basis of the data set at the voltage application timing setting means. On the other hand, the voltage level setting means serves for setting the level of voltage to be applied at the preset timings. In this case, the voltage application timing control means as well as the timing/level setting means may be implemented in the form of, for example, a microcomputer.

In still another preferred mode for carrying out the present invention, a buffer sheet of a soft material may be interposed between the magnetic force exerting means and the movable gripper member such that upon positioning of the movable gripper member at the weft release position, the weft is gripped between the buffer sheet and the movable gripper member.

According to a further aspect of the present invention, there is provided for a rapier loom for weaving a fabric by inserting a weft through a shed formed by layers of warps by inserting at least one rapier head constituted by a combination of a stationary gripper member and a movable gripper member into the shed, a weft inserting apparatus which features that a piezoelectric device for driving the movable gripper member is interposed between the movable gripper member and the stationary gripper member, and that the movable gripper member is positionally changed over between a weft grip position and a weft release position by switching the piezoelectric device between a first state in which a voltage is applied thereto and a second state in which no voltage is applied thereto.

In the weft inserting apparatus of the structure described above, changes in the length of the piezoelectric stack means in response to application of a voltage and removal thereof is made use of for positionally changing over the movable gripper member between the weft grip position and the weft release position. The change-over mechanism as well as the controller to this end can be implemented inexpensively in a simplified structure while ensuring high reliability for the operation of the weft inserting apparatus and hence that of the rapier loom.

The above and other objects, features and attendant advantages of the present invention will more easily be understood by reading the following description of the preferred embodiments thereof taken, only by way of example, in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the course of the description which follows, reference is made to the drawings, in which:

Fig. 1 is a partially broken-away front side view showing a weft inserting apparatus for a rapier loom according to a first embodiment of the present invention;
Fig. 2 is an enlarged front side view showing schematically a major portion of the weft inserting apparatus;
Fig, 3 is a view similar to Fig. 2 and shows the major portion of the weft inserting apparatus in a weft transferring state:
Fig. 4 is a timing chart for illustrating application of voltages to electromagnets employed in the weft inserting apparatus shown in Fig. 1;
Fig. 5 is a vertical sectional view showing a modification in respect to the disposition of the electromagnet;
Fig. 6 is an enlarged front side view showing a major portion in a weft inserting apparatus according to another embodiment of the present invention;
Fig. 7 is a view similar to Fig. 2 and shows a major portion of a weft inserting apparatus for a rapier loom according to another embodiment of the present invention;
Fig. 8 is a timing chart for illustrating application of voltages to electromagnets employed in the weft inserting apparatus shown in Fig. 5;
Fig. 9 is a timing chart for illustrating application of voltages to electromagnets employed in the weft inserting apparatus according to another embodiment of the present invention;
Fig. 10 is a timing chart for illustrating application of voltages to electromagnets employed in the weft inserting apparatus according to yet another embodiment of the present invention;
Fig. 11 is a timing chart for illustrating application of voltages to electromagnets employed in the weft inserting apparatus according to still another embodiment of the present invention;
Fig. 12 is a view similar to Fig. 2 and shows a major portion of a weft inserting apparatus for a rapier loom according to a further embodiment of the present invention;
Fig. 13 is a view similar to Fig. 2 and shows a major portion of a weft inserting apparatus for a rapier loom according to a still further embodiment of the present invention;
Fig. 14 is a view similar to Fig. 2 and shows a major portion of a weft inserting apparatus for a rapier loom according to a yet further embodiment of the present invention;
Fig. 15 is a timing chart for illustrating application of voltages to electromagnets employed in the weft inserting apparatus according to another embodiment of the present invention;
Fig. 16 is a partially broken-away enlarged sectional view showing a structure of a piezoelectric device for driving a movable gripper member according to a further embodiment of the present invention; and
Fig. 17 is a view similar to Fig. 2 and shows a major portion of a weft inserting apparatus for a rapier loom according to a further embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, the present invention will be described in detail in conjunction with what is presently considered as preferred or typical embodiments thereof by reference to the drawings. In the following description, like reference characters designate like or corresponding parts throughout the several views. Also in the following description, it is to be understood that such terms as "left", "right", and the like are words of convenience and are not to be construed as limiting terms.

At first, a weft insertion apparatus for a rapier loom according to a first embodiment of the present invention will be described by reference to Figs. 1 to 4, in which a reference numeral 1 denotes a feeding rapier head which is adapted to be inserted into a shed defined between layers of warps (not shown) from a weft insertion starting side, and a numeral 2 denotes a receiving rapier head which is adapted to be inserted into the shed from a weft insertion end or terminal side. The feeding rapier head 1 and the receiving rapier head 2 are fixedly mounted at both tip end portions of rapier bands 3 and 4 which are wound around rapier wheels 5 and 6, respectively. The rapier wheels 5 and 6 are reciprocatively rotated in the directions opposite to each other. More specifically, the feeding rapier head 1 is inserted into the inter-warp shed upon forward rotation (i.e., rotation in a given one direction) of the rapier wheel 5, while the feeding rapier head 1 is retracted from the shed upon backward rotation (i.e., rotation in the direction opposite to the given one direction) of the rapier wheel 5. On the other hand, the receiving rapier head 2 is inserted into the shed defined by the warps upon forward rotation of the rapier wheel 6, while it is retracted upon backward rotation thereof.

As shown in Figs. 3 and 4, the feeding rapier head 1 is constituted by a combination of a stationary feeding gripper 7 made of a non-magnetic material and a movable feeding gripper 8 of a magnetic material. The stationary feeding gripper 7 is integrally formed with a supporting member 7a, a gripping surface 7b and a position limiting member 7c. Fixedly mounted on the supporting member 7a are the movable feeding gripper 8, a tip end portion of the rapier band 3 and a leaf spring 9 by means of clamping screws 10. The movable feeding gripper 8 is made of a metal material having a resiliency so as to serve as a spring. A gripping surface 8a is formed at a tip end portion of the movable feeding gripper 8. The gripping surfaces 7b and 8a are adapted to be detachably brought into contact with each other. The position limiting member 7c serves to restrict or limit the downward displacement of the movable feeding gripper 8.

Again referring to Figs. 2 and 3, the receiving rapier head 2 is constituted by a combination of a stationary receiving gripper 11 made of a nonmagnetic material and a movable receiving gripper 12 of a magnetic material. Coupled rotatably or swingably to the stationary receiving gripper 11 is the movable receiving gripper 12 by means of a pivot 13. The movable receiving gripper 12 is made of a metal material. Formed at tip end portions of the stationary receiving gripper 11 and the movable receiving gripper 12, respectively, are gripping surfaces 11a and 12a facing oppositely to each other, The gripping surfaces 11a and 12a are adapted to be detachably brought into contact with each other. A tip end portion of the rapier band 4 is fixedly mounted on the movable receiving gripper 12 by means of clamping screws 14. The stationary receiving gripper 11 is integrally formed with a supporting member 11b and a position limiting member 11c. A compression spring 15 is interposed between the supporting member 11b and the movable receiving gripper 12. The position limiting member 11c serves as a stopper for limiting a downward movement of the movable receiving gripper 12.

The feeding rapier head 1 and the receiving rapier head 2 are caused to move into the inter-warp shed upon forward rotations of the rapier wheels 5 and 6, respectively, and encounter each other at a mid position as viewed in the widthwise direction of a fabric being woven. On the other hand, when the rapier wheels 5 and 6 are rotated in the reverse or backward directions, respectively, the feeding rapier head 1 and the receiving rapier head 2 are caused to retract from the shed defined by the layers of warps. The position of the feeding rapier head 1 shown in Fig. 1 represents a position distanced at maximum from the inter-warp shed. This position will be referred to as the retraction dead center point or position. Similarly, the state of the receiving rapier head 2 shown in Fig. 1 represents a position distanced maximally from the inter-warp shed. This position will be referred to as the retraction dead center position of the receiving rapier head 2.

The receiving rapier head 2 is adapted to run on and along a slay 17 which supports a reed 16. The running path of the receiving rapier head 2, i.e., the weft insertion path, is so designed or determined as not to interface with the reed 16 when it is retracted farthest from the cloth fell of the fabric being woven. As can be seen in Fig. 1, electromagnets 18 and 19 are mounted at both end or terminal portions, respectively, of the sley 17. More specifically, the electromagnet 18 is installed at a position immediately below the weft insertion path for the feeding rapier head 1, while the electromagnet 19 is installed at a position immediately underneath the weft insertion path of the receiving rapier head 2. Further, a pair of electromagnets 20 and 21 are embedded in the sley 17 substantially at mid portions thereof, respectively. In more concrete, the electromagnet 20 is installed at a position immediately below the weft insertion path of the feeding rapier head 1, while the electromagnet 21 is disposed immediately beneath the weft insertion path of the receiving rapier head 2.

A magnetic-field region over which the magnetic force of the electromagnet 18 is active lies in the vicinity of the retraction dead center position of the feeding rapier head 1, while a corresponding region of the electromagnet 19 lies in the vicinity of the retraction dead center position of the receiving rapier head 2. On the other hand, the magnetic-field region of the electromagnet 20 lies in the vicinity of the position at which the feeding rapier head 1 encounters the receiving rapier head 2, i.e., a so-called weft insertion dead center position of the feeding rapier head 1. On the other hand, the magnetic-field region of the electromagnet 21 lies in the vicinity of the position at which the receiving rapier head 2 encounters the feeding rapier head 1, i.e., the weft insertion dead center position of the receiving rapier head 2. The magnetic force of the electromagnet 18 acts on the movable feeding gripper 8 of the feeding rapier head 1 located in the vicinity of the retraction dead center position, while that of the electromagnet 20 acts on the movable feeding gripper 8 of the feeding rapier head 1 located in the vicinity of the weft insertion dead center position. Similarly, the magnetic force of the electromagnet 21 acts on the movable receiving gripper 12 of the receiving rapier head 2 located in the vicinity of the weft insertion dead center position thereof.

Under the influence of the magnetic forces of the electromagnets 18 and 20, the movable feeding gripper 8 is caused to bend or angularly move toward the electromagnets 18 and 20 around a fulcrum defined by the supporting member 7a against their own resiliences and that of the leaf spring 9. Due to this angular displacement, the movable feeding gripper 8 is positionally changed over to a weft release position shown in Fig. 3 from a weft grip position shown Fig. 2. The downward movement of the movable feeding gripper 8 is limited by the position limiting member 7c. In the state where the downward movement of the movable feeding gripper 8 is stopped by the position limiting member 7c, the movable feeding gripper 8 assumes a position closest to the electromagnet 18 or 20. However, the warps are positively prevented from being sandwiched between the movable feeding gripper 8 and the electromagnet 18; 20 and thus protected against any injury.

Similarly, under the influence of the magnetic forces of the electromagnets 19 and 21, the movable receiving gripper 12 is caused to bend or angularly move toward the electromagnets 19 and 21 around the pivot pin 13 against the spring force of the compression spring 15. Due to this angular displacement, the movable receiving gripper 12 is positionally changed over to a weft release position shown in Fig. 3 from a weft grip position shown Fig. 2. The downward movement of the movable receiving gripper 12 is limited by the stopper or position limiting member 11c. In the state where the downward movement of the movable receiving gripper 12 is limited by the position limiting member 11c, the movable receiving gripper 12 assumes a position closest to the electromagnet 19 or 21. However, the warps are positively prevented from being sandwiched between the movable receiving gripper 12 and the electromagnet 19; 21 and thus protected against any injury.

As can be seen from Fig. 1, the electromagnets 18, 19, 20 and 21 which serve as magnetic force exerting means are electrically energized through the driving circuits 22, 23, 24 and 25, respectively, under the control of a control computer C. More specifically, the driving circuits 22 to 25 serving as applied voltage setting means apply a rated voltage V_0 to the electromagnets 18, 19, 20, 21, respectively. On the other hand, the control computer (or computerized controller, to say in another way) C serving as the voltage application control means is equipped with a voltage application timing setting unit 27 and a rotary encoder 28. The voltage application timing setting unit 27 serves for inputting to the control computer C the voltage application timing control signals for the electromagnets 18 to 21, respectively. On the other hand, the rotary encoder 28 serves for detecting rotational angles or angular positions of the loom. On the basis of the loom rotation angle information available from the output of the rotary encoder 28, the control computer C issues commands to the driving circuits 22 to 25 applications of the rated voltage V_0, in response to which the driving circuits 22 to 25 apply the rated voltage V_0 to the electromagnets 18 to 21 at the preset timings, respectively.

Referring to Fig. 4, a waveform D_1 represents an amplitude and a timing of a voltage applied to the electromagnet 18, while a waveform D_2 represents an amplitude and a timing of a voltage applied to the electromagnet 19. Further, a waveform E_1 represents an amplitude and a timing of a voltage applied to the electromagnet 20, while a waveform E_2 represents an amplitude and a timing of a voltage applied to the electromagnet 21. In the timing chart shown in Fig. 4, the voltage V is taken along the ordinate with a rotation angle (or angular position) θ of the loom being taken along the abscissa. Each of the voltages represented by the waveforms D_1, D_2, E_1 and E_2 is a rated voltage V_0. The timings Td_1, Td_2, Te_1 and Te_2 at which the rated voltage V_0 is applied are set by the voltage application timing setting unit 27 to be subsequently inputted to the control computer C. The control computer C issues voltage application commands to the driving circuits 22 to 25 on the basis of the angular position information of the loom as detected by the rotary encoder 28 and the information concerning the voltage application timings Td_1, Td_2, Te_1 and Te_2, as supplied from the timing setting unit 27. In response to the voltage application commands mentioned above, the driving circuits 22 to 25 apply the rated voltage V_0 to the electromagnets 18 to 21, respectively.

When the voltage of the waveform D_1 is applied, the position of the movable feeding gripper 8 of the feeding rapier head 1 is changed over to the weft release position from the weft grip position. The feeding rapier head 1 then starts the weft insertion in the state in which the movable feeding gripper 8 is disposed at the weft release position. The position of the movable feeding gripper 8 is changed over from the weft release position to the weft grip position in the vicinity of the retraction dead center position. Through the positional change-over mentioned above, the weft Y is retained between the gripping surfaces 7b and 8a of the feeding grippers 7 and 8, respectively, of the feeding rapier head 1. The feeding rapier head 1 takes up the weft Y at a weft take-up position in the vicinity of the retraction dead center position, whereby the weft Y is inserted into the shed. The electromagnet 18 serves as the weft take-up magnetic means.

As shown in Fig. 2, the receiving rapier head 2 arrives at the weft insertion dead center position in precedence to the feeding rapier head 1. The movable receiving gripper 12 of the receiving rapier head 2 arrived at the weft insertion dead center position is changed over from the weft grip position to the weft release position in response to application of the voltage represented by the waveform E_2. The receiving rapier head 2 then waits for arrival of the feeding rapier head 1 in the state in which the movable receiving gripper 12 is disposed at the weft release position. The weft Y retained by the feeding rapier head 1 arrived at the weft insertion dead center position is transferred to the receiving rapier head 2 to be thereby positioned between the gripping surfaces 11a and 12a thereof. When the weft Y is positioned to lie between the gripping surfaces 11a and 12a, the voltage application to the electromagnet 21 is interrupted, which results in that the movable receiving gripper 12 is changed over to the weft grip position from the weft release position. Through this positional change-over, the weft Y is now retained between the gripping surfaces 11a and 12a of the receiving rapier head 2, as can be seen in Fig. 3. The movable feeding gripper 18 of the feeding rapier head 1 arrived at the weft insertion dead center position is changed over from the weft grip position to the weft release position in response to application of the voltage represented by the waveform E_1. As a consequence, the weft Y gets rid of the gripping action of the feeding rapier head 2. Thus, it can be said that the electromagnet 20 serves as the feeding magnetic force exerting means, while the electromagnet 21 serves as the receiving magnetic force exerting means.

Subsequently, both the feeding rapier head 1 and the receiving rapier head 2 are moved backwardly or retracted toward the respective retraction dead center positions, whereby the weft Y held by the receiving rapier head 2 is caused to extend through the inter-warp shed. The movable receiving gripper 12 of the receiving rapier head 2 arrived at the weft release position located immediately before the retraction dead center position is changed over from the weft grip position to the weft release position in response to application of the voltage represented by the waveform D_2. As a consequence, the weft Y gets rid of the gripping action of the receiving rapier head 2. Thus, it can be said that the electromagnet 21 serves as the weft releasing magnetic force exerting means. Subsequently, the reed 16 starts beating operation from the most retracted position thereof.

As will be appreciated from the above description, positions of the movable grippers 8 and 12 of the rapier heads 1 and 2, respectively, are changed over from the weft grip position to the weft release position under the action of the electromagnets 18 to 21. Upon disappearance of influence of the magnetic force, the movable grippers 8 and 12 are changed over from the weft release position to the weft grip position under the influence of the spring forces. The driving forces for positionally changing over the movable grippers 8 and 12 between the weft grip position and the weft release position are provided by the magnetic forces generated by the electromagnets 18 to 21 and the spring forces of the rapier heads 1 and 2 themselves. Thus, the mechanism for positionally changing over the movable grippers 8 and 12 between the weft grip position and the weft release position will never provide interference to the warps, which in turn means that the warps can positively be protected from injury upon operations of the rapier heads 1 and 2.

The arrangement for positively actuating the movable grippers 8 and 12 under the action of the magnetic forces makes it possible to ensure the optimal timings for open/close operations of the rapier heads 1 and 2, whereby setting of the optimal timings for the gripping and release operations of the weft Y can be facilitated. On the other hand, easiness in setting the optimal timings for gripping and releasing of the weft Y can ensure reliable taking-up of the weft Y by the feeding rapier head 1 as well as reliable transfer of the weft Y from the feeding rapier head 1 to the receiving rapier head 2. Certainly, the weft Y may also be caught without opening and closing the feeding rapier head 1. It should however be mentioned that the arrangement that the weft Y is introduced into between the gripping surfaces 7b and 8a in the state where the movable feeding gripper 8 is disposed at the weft release position and then the movable feeding gripper 8 is disposed at the weft grip position is more reliable when compared with the arrangement of catching the weft Y with the feeding rapier head 1 in the closed state thereof. At this juncture, it should also be added that the timing at which the weft Y is released from the feeding rapier head 1 exerts influence to the final insertion posture or state of the weft Y, which in turn affects the quality of the fabric. Besides, easiness of setting the optimal timing for the release of the weft Y from the feeding rapier head 1 contributes to improvement of the fabric quality.

The electromagnets 18 and 20 installed on the slay 17 and the movable feeding gripper 8 of the feeding rapier head 1 are positioned mutually very closely every time the magnetic forces of the electromagnets 16 and 20 become active. Thus, the magnetic forces of the electromagnets 18 and 20 can effectively act on the movable feeding gripper 8. Similarly, the electromagnets 19 and 21 mounted on the slay 17 and the movable receiving gripper 12 of the receiving rapier head 2 are positioned mutually very closely upon activation of the electromagnets 19 and 21. Thus, the magnetic forces of the electromagnets 19 and 21 can effectively act on the movable receiving gripper 12. Furthermore, by setting properly the resiliency of the movable feeding gripper 8 itself and the spring force of the leaf spring 9, the movable feeding gripper 8 can be changed over to the weft grip position from the weft release position at a high speed. Similarly, by setting appropriately the spring force of the compression spring 15, it is possible to change over the movable receiving gripper 12 from the weft release position to the weft grip position at a high speed. In this conjunction, it should be noted that the resiliency of the movable feeding gripper 8 itself and the spring force of the leaf spring 9 are selected to be sufficiently large for gripping the weft Y without fail. Similarly, the spring force of the compression spring 15 is set large enough to grip the weft with reliability. The amplitude of the rated voltage V_0 is so selected as to be capable of changing over the movable grippers 8 and 12 from the weft grip position to the weft release position against the spring force mentioned above.

Thus, by combining appropriately the preset magnetic forces and spring forces, the change-over of the movable grippers 8 and 12 between the weft grip position and the weft release position can be effected at a high speed. Further, interposition of the leaf spring 9 in the manner mentioned previously facilitates the setting of the desired spring force. In this conjunction, adjustment of the spring force of the leaf spring 9 can easily be realized by changing the number of the leaf springs 9 or the length thereof. It goes without saying that the high-speed positional change-over of the movable grippers 8 and 12 between the weft grip position and the weft release position allows the loom to operate at a high rotation speed.

The apparatus for opening and closing the rapier heads 1 and 2 by using the electromagnets 18 to 21 according to the instant embodiment of the present invention can be implemented in a simplified structure of a compact size when compared with the clamp opener apparatus disclosed in JP-A-5-195373 mentioned previously. With the structure of the prior art clamp opener, the lever for opening and closing the rapier head is brought into direct contact with the rapier head. Consequently, both the lever and the rapier head undergo friction and abrasion, which results in error in the opening degree of the rapier head as well as the timings at which it is opened and closed. Besides, heat generated due to the friction impairs the precision of the parts constituting the rapier head. Of course, abrasion of the rapier head and deviation of precision of the parts provide obstruction to reliable transfer of the weft Y from the feeding (giver) rapier head to the receiver (taker) rapier head. By contrast, in the case of the apparatus according to the instant embodiment of the invention, the movable grippers 8 and 12 are changed over contactless between the weft grip position and the weft release position. Thus, neither abrasion nor aberrations in the precision of the parts due to the direct contact open/close operation can take place.

Furthermore, clearance between the rapier heads 1 and 2 running on the top surface of the sley 17 is realized with high accuracy. Accordingly, the structure in which the electromagnets 18 to 21 are installed on the sley 17 increases the accuracy of clearance between the electromagnets 18 to 21 and the movable grippers 8 and 12. It is self-explanatory that such high accuracy of clearance between the electromagnets 18 and 21 and the movable grippers 8 and 12 is very advantageous in realizing the high-speed positional change-over of the movable grippers 8 and 12 between the weft grip position and the weft release position.

Now, another embodiment of the present invention will be described by reference to Figs. 5 and 6. As is shown in Fig. 6, the sley in the weft inserting apparatus according to the instant embodiment is divided into three sley members 17a, 17b and 17c at a mid portion as viewed in the direction widthwise of the fabric. The individual sley members 17a, 17b and 17c are supported via sley swords 29 on a rocking shaft 30 (see Fig. 5) which is adapted to be reciprocatively rocked or swung by a reed driving mechanism (not shown). There are mounted electromagnets 18 and 19 at lateral sides of the sley members 17a and 17c, respectively. An electromagnet 20 is interposed between the sley members 17a and 17b with another electromagnet 21 being interposed between the sley members 17b and 17c. Each of the electromagnets 18 to 21 is supported on a breast beam 32 by way of a bracket 31. Parenthetically, the breast beam 32 is employed for supporting a fell plate serving for preventing the downward displacement of a fabric (not shown), a temple device for preventing shrinkage of fabric and an expansion bar, wherein very high accuracy is ensured for the positional relation between the sley 17 and the breast beam 32. Thus, clearances between the electromagnets 18 to 21 supported on the breast beam 32 and the movable grippers 8 and 12 of the rapier heads 1 and 2 can easily be realized with high accuracy. Besides, because the electromagnets 18 to 21 and electric wires therefor are provided fixedly, possibility of breakage of the wires and occurrence of failure in the electromagnets 18 to 21 can positively be suppressed. Additionally, the sley 17 as a whole can be implemented in light weight, which is very beneficial for increasing the beating operation speed.

Another embodiment of the weft inserting apparatus according to the present invention will be described by reference to Figs. 7 and 8. In these drawings. Fig. 7 will also be referenced in the description of other embodiments shown in Figs. 8 to 10. In the weft inserting apparatus according to the instant embodiment of the invention, a movable feeding gripper 8A of the feeding rapier head 1 is comprised of a non-magnetic member 8b and a magnetic member 8c disposed to face in opposition to the electromagnet. Similarly, a movable receiving gripper 12A of the receiving rapier head 2 is comprised of a non-magnetic member 12b and a magnetic member 12c with the magnetic member 12c positioned to face oppositely to the electromagnet. The non-magnetic members 8b and 12b may preferably be made of a resin material with the magnetic members 8c and 12c being formed of a metal material with a view to implementing the rapier heads 1 and 2 in light weight. Needless to say, a light-weight structure of the rapier heads 1 and 2 is advantageous in that they can be moved or operated with an increased speed.

The positions at which the electromagnets 18 to 21 are mounted are same as in the case of the weft inserting apparatus according to the first embodiment of the invention. Driving circuits 22A, 23A, 24A and 25A for electrically energizing the electromagnets 18 to 21, respectively, are each designed for outputting either one of the rated voltage V_0 and the over-excitation voltage V_1 in response to a command issued by the control computer C. Referring to Fig. 8, a waveform D_3 represents an amplitude and a timing of a voltage applied to the electromagnet 18, while a waveform D_4 represents an amplitude and a timing of a voltage applied to the electromagnet 19. Further, a waveform E_3 represents an amplitude and a timing of a voltage applied to the electromagnet 20, while a waveform E_4 represents an amplitude and a timing of a voltage applied to the electromagnet 21. Each of the voltages represented by the waveforms D_3, D_4, E_3 and E_4 has a rated voltage level V_0 and an over-excitation voltage level V_1. The timings Td_{03}, Td_{04}, Te_{03} and Te_{04} at which the rated voltage V_0 is applied as well as the timings Td_{13}, Td_{14}, Te_{13} and Te_{14} at which the over-excitation voltage V_1 is applied are set by the voltage application timing setting unit 27 and inputted to the control computer C. The control computer C issues voltage application commands for applying the rated voltage V_0 or the over-excitation voltage V_1 to the driving circuits 22A to 25A on the basis of angular position information of the loom as detected by the rotary encoder 28 and the information concerning the voltage application timings mentioned above. In response to the voltage application commands mentioned above, the driving circuits 22A to 25A apply the rated voltage V_0 and the over-excitation voltage V_1 to the electromagnets 18 to 21, respectively, at such timings the illustrated in Fig. 8.

Upon application of the magnetic forces of the electromagnets 18 and 20 to the magnetically responsive movable feeding gripper 8A as well as upon application of the magnetic forces of the electromagnets 19 and 21 to the magnetically responsive receiving gripper 12A, the over-excitation voltage V_1 is first applied to the electromagnets 18; 20 and the electromagnets 19; 21. In succession to application of the over-excitation voltage V_1, the rated voltage V_0 is applied. In response to application of the over-excitation voltage V_1, the movable grippers 8A and 12A are rapidly changed over to the weft release position from the weft grip position. It is self-explanatory that the rapid change-over of the movable grippers 8A and 12A makes it possible to operate the loom at an increased speed.

Now, description will be directed to the weft inserting apparatus according to another embodiment of the invention by referring to Figs. 7 and 9. In the case of the weft inserting apparatus now under consideration, the movable feeding gripper 8B of the feeding rapier head 1 is comprised of a non-magnetic member 8b and a permanent magnet 8d, wherein the permanent magnet 8d is disposed in opposition to the electromagnet. Similarly, the movable receiving gripper 12B of the receiving rapier head 2 is composed of a non-magnetic member 12b and a permanent magnet 12d which is disposed in opposition to the electromagnet. The positions at which the electromagnets 18 to 21 are installed are same as those of the weft inserting apparatus described hereinbefore in conjunction with the first embodiment of the invention.

The driving circuits 22B, 23B, 24B and 25B for electrically energizing the electromagnets 18 to 21, respectively, are each designed for outputting either one of the rated voltage $(+)V_0$ of plus polarity and the rated voltage $(-)V_0$ of minus polarity in response to a command issued by the control computer C. Referring to Fig. 9, a waveform D_5 represents amplitudes and timings of voltages applied to the electromagnet 18, while a waveform D_6 represents amplitudes and timings of voltages applied to the electromagnet 19. Further, a waveform E_5 represents amplitudes and timings of voltages applied to the electromagnet 20, while a waveform E_6 represents amplitudes and timings of voltages applied to the electromagnet 21. The timings $(+)Td_5$, $(+)Td_6$, $(+)Te_5$ and $(+)Te_6$ at which the positive rated voltage $(+)V_0$ is applied as well as the timings $(-)Td_5$, $(-)Td_6$, $(-)Te_5$ and $(-)Te_6$ at which the negative rated voltage $(-)V_0$ is applied are set by the voltage application timing setting unit 27 to be inputted to the control computer C. The control computer C issues voltage application commands for applying the positive rated voltage $(+)V_0$ or the negative rated voltage $(-)V_0$ to the driving circuits 22B to 25B on the basis of angular position information of the loom as obtained from the output of the rotary encoder 28 and the information concerning the voltage application timings mentioned above. In response to the voltage application commands mentioned above, the driving circuits 22B to 25B apply the rated voltage $(+)V_0$ of plus polarity or the rated voltage $(-)V_0$ of minus polarity to the electromagnets 18 to 21, respectively, at the timings illustrated in Fig. 9.

The movable feeding gripper 8B is held at the weft grip position under the resiliency of the movable feeding gripper 8B and the spring force of the leaf spring 9 when no magnetic forces of the electromagnets 18 and 20 are exerted. Similarly, the movable receiving gripper 12B are held at the weft grip position under the spring force of the compression spring 15 when neither the electromagnet 19 nor the electromagnet 21 are active. The magnetic force as generated upon application of the rated voltage $(+)V_0$ of plus polarity acts as a magnetic attracting force for the movable grippers 8B and 12B, while the magnetic force generated upon application of the rated voltage $(-)V_0$ of minus polarity acts as a repulsing magnetic force. In response to the magnetic attracting force generated upon application of the rated voltage $(+)V_0$ of plus polarity, the movable gripper 8B or 12B is positionally shifted to the weft release position from the weft grip position. On the other hand, in response to the magnetic repulsing force generated upon application of the rated voltage $(-)V_0$ of minus polarity, the movable gripper 8B or 12B is shifted to the weft grip position from the weft release position. In this manner, the positional changing-over of the movable grippers 8B and 12B to the weft grip position from the weft release position is effected by electrically energizing the electromagnets 18 to 21 in the manner described above. For this reason, so far as the feeding rapier head 1 is concerned, magnitude of the spring force for gripping or grasping the weft under the resiliency of the movable feeding gripper 8B itself and that of the leaf spring 9 may be reduced to a necessary minimum. The same holds true for the spring force of the compression spring 15 for allowing the receiving rapier head 2 to grip the weft. By selecting the resiliency of the movable feeding gripper 8B and the spring force of the leaf spring 9 as small as possible in this manner, the positional change-over of the movable feeding gripper 8B to the weft release position from the weft grip position can be accomplished with an increased speed. Similarly, by selecting the spring force of the compression spring 15 as small as possible, the positional shift of the movable receiving gripper 12B to the weft release position from the weft grip position can be realized at an enhanced speed.

Next, description will be directed to a weft inserting apparatus according to another embodiment of the invention by reference to Figs. 7 and 10. In the case of the weft inserting apparatus according to the instant embodiment, the movable feeding gripper 8B of the feeding rapier head 1 is comprised of a non-magnetic member 8b and a permanent magnet 8d, wherein the permanent magnet 8d is so disposed as to face in opposition to the electromagnet. Similarly, the movable receiving gripper 12B of the receiving rapier head 2 is composed of a non-magnetic member 12b and a permanent magnet 12d which is disposed in opposition to the electromagnet. The positions at which the electromagnets 18 to 21 are installed are same as those of the weft inserting apparatus described hereinbefore in conjunction with the first embodiment.

The driving circuits 22C, 23C, 24C and 25C for electrically energizing the electromagnets 18 to 21, respectively, are each designed for outputting either one of the rated voltage $(+)V_0$ of plus polarity, the rated voltage $(-)V_0$ of minus polarity, the over-excitation voltage $(+)V_1$ of plus polarity and the over-excitation voltage $(-)V_1$ of minus polarity in response to a command issued by the control computer C. Referring to Fig. 10, a waveform D_7 represents amplitudes and timings of voltages applied to the electromagnet 18, while a waveform D_8 represents amplitudes and timings of voltages applied to the electromagnet 19. Further, a waveform E_7 represents amplitudes and timings of voltages applied to the electromagnet 20, while a waveform E_8 represents amplitudes and timings of voltages applied to the electromagnet 21. The timings $(+)Td_{07}$, $(+)Td_{08}$; $(+)Te_{07}$, $(+)Te_{08}$ at which the positive rated voltage $(+)V_0$ is applied as well as the timings $(-)Td_{07}$, $(-)Td_{08}$; $(-)Te_{07}$, $(-)Te_{08}$ at which the negative rated voltage $(-)V_0$ is applied are set by the voltage application timing setting unit 27 to be subsequently loaded to the control computer C. Similarly, the timings $(+)Td_{17}$, $(+)Td_{18}$; $(+)Te_{17}$, $(+)Te_{18}$ at which the over-excitation voltage $(+)V_1$ of plus polarity is applied as well as the timings $(-)Td_{17}$, $(-)Td_{18}$; $(-)Te_{17}$, $(-)Te_{18}$ at which the over-excitation voltage $(-)V_1$ of minus polarity is applied are preset by the voltage application timing unit 27 and inputted to the control computer C. The control computer C issues voltage application commands for applying the rated voltage $(+)V_0$ of plus polarity, the rated voltage $(-)V_0$ of minus polarity, the over-excitation voltage $(+)V_1$ of plus polarity or the over-excitation voltage $(-)V_1$ of minus polarity to the driving circuit 22C; 25C on the basis of the angular position information of the loom as obtained from the output of the rotary encoder 28 and the information concerning the voltage application timings mentioned above. In response to the voltage application commands mentioned above, the driving circuits 22C to 25C apply selectively the rated voltage $(+)V_0$ of plus polarity, the rated voltage $(-)V_0$ of minus polarity, the over-excitation voltage $(+)V_1$ of plus polarity or the over-excitation voltage $(-)V_1$ of minus polarity to the electromagnets 18 to 21, respectively, at such timings as illustrated in Fig. 10.

In the weft inserting apparatus according to the instant embodiment of the invention, there can equally be obtained similar advantageous effects as mentioned previously in conjunction with the embodiment illustrated in Figs. 8 and 9. Additionally, because the over-excitation voltage is applied when the movable feeding gripper 8B or the movable receiving gripper 12B is to be changed over from the weft release position to the weft grip position as well, transition of the movable gripper 8B or 12B to the weft grip position from the weft release position can be realized at a further increased speed. Of course, the high-speed positional change-over of the movable feeding gripper 8B and the movable receiving gripper 12B from the weft release position to the weft grip position contributes to a high-speed operation of the loom, Among others, the high-speed operation of the movable feeding gripper 8B for allowing the feeding rapier head 1 to catch the weft is very effective for speeding up the weft insertion starting operation of the feeding rapier head 1.

Figure 11 shows a version of the weft inserting apparatus in which the movable grippers 8B and 12B additionally provided with the permanent magnets 8d and 12d are adopted. When the movable feeding gripper 8B or the movable receiving gripper 12B is shifted to the weft grip position from the weft release position, the over-excitation voltage $(+)V_1$ of plus polarity is applied first, as is represented by the waveforms D_9, D_{10}, E_9, E_{10}. However, when the movable feeding gripper 8B or the movable receiving gripper 12B is to be changed over from the weft release position to the weft grip position, only the rated voltage $(-)V_0$ of minus polarity is applied. By making use of the over-excitation voltage $(+)V_1$ of plus polarity upon changing-over of the movable feeding gripper 8B or the movable receiving gripper 12B from the weft release position to the weft grip position, resiliency of the movable grippers 8B and 12B as well as the spring forces of the leaf spring 9 and the compression spring 15 can be increased, which in turn enables the movable feeding gripper 8B or the movable receiving gripper 12B to be shifted from the weft release position to the weft grip position at an increased speed.

Next, description will turn to the weft inserting apparatuses according to yet further embodiments of the present invention by reference to Figs. 12 and 13. In the case of these embodiments, the position limiting members 7c and 11c are spared in the stationary grippers 7 and 11 of the rapier heads 1 and 2, respectively. Instead thereof, buffer sheets 33 of a soft material such as moquette are secured to the sley 17 and the electromagnets 20 and 21 in the case of the embodiment shown in Fig. 12, while in the apparatus shown in Fig. 13, the buffer sheets 33 are fixedly mounted only on the electromagnets 18 to 21, respectively. When the movable feeding gripper 8A (or 8B) and the movable receiving gripper 12A (or 12B) are located at the weft release position, the warps are gripped between the movable gripper 8A (or 8B); 12A (or 12B) and the buffer sheet 33. In that case, the buffer sheet 33 functions to prevent the warps sandwiched between the movable gripper 8A (or 8B); 12A (or 12B) and the electromagnet from being injured. It should further be mentioned that omission of the position limiting members 7c and 11c contributes to lightweight implementation of the rapier heads 1 and 2.

Parenthetically, it should also be added that in place of using the moquette for forming the buffer sheet 33, the latter may be made of a sheet material such as of a synthetic resin, woven fabric, leather or the like.

Next, another embodiment of the present invention will be described by reference to Figs. 14 and 15. In the weft inserting apparatus according to the instant embodiment, a plurality of (three in this case) electromagnets 20A, 20B and 20C are disposed along the weft insertion path in the vicinity of the weft insertion dead center position. Furthermore, a plurality of (three in this case) electromagnets 21A, 21B and 21C are disposed along the weft insertion path in the vicinity of the weft insertion dead center position of the receiving rapier head 2. The electromagnets 20A, 20B and 20C serve as the weft feeding magnetic force exerting means, while the electromagnets 21A, 21B and 21C serve as the weft receiving magnetic force exerting means. As the movable grippers of the feeding rapier head 1, the movable feeding gripper 8A or 8B shown in Fig. 7 is employed, while as the movable gripper for the receiving rapier head 2, the movable receiving gripper 12A or 12B is used.

A waveform E_{11} shown in Fig. 15 indicates an amplitude and application timing of the rated voltage applied to the electromagnet 20A by a driving circuit $24D_1$. On the other hand, a waveform E_{12} shown in the same figure indicates an amplitude and application timing of the rated voltage applied to the electromagnet 20B by a driving circuit $24D_2$. Further, a waveform E_{13} indicates a magnitude and application timing of the rated voltage applied to the electromagnet 20C by a driving circuit $24D_3$, while a waveform E_{14} indicates a magnitude and application timing of the rated voltage applied to the electromagnet 21A by a driving circuit $25E_1$. Furthermore, a waveform E_{15} indicates a magnitude and application timing of the rated voltage applied to the electromagnet 21B by a driving circuit $25E_2$, while a waveform E_{16} indicates a magnitude and application timing of the rated voltage applied to the electromagnet 21C by a driving circuit $25E_3$. Energization/deenergization of the electromagnets 20A, 20B and 20C is performed in a relaying manner, so to say. Similarly, energization/deenergization of the electromagnets 21A, 21B and 21C is carried out in a relaying manner. The energization/deenergization of the electromagnets 20A, 20B and 20C in a relaying manner makes it possible to change over the position of the movable feeding gripper 8A (or 8B) between the weft grip position and the weft release position in the course of moving of the feeding rapier head 1. Equally, the energization and deenergization of the electromagnets 21A, 21B and 21C in the relaying fashion permits the positional change-over of the movable receiving gripper 12A (or 12B) between the weft grip position and the weft release position even when the receiving rapier head 2 is moving. Thus, even in the case where the weft insertion is performed through cooperation of the rapier heads 1 and 2 within a short time, there can be ensured a sufficient time for effecting the positional shifts of the movable feeding gripper 8A (or 8B) and the movable receiving gripper 12A (or 12B) between the weft grip position and weft release position, respectively. At this juncture, it should be noted that availability of a sufficient time for the positional change-over of the movable feeding gripper 8A (or 8B) and the movable receiving gripper 12A (or 12B) can enhance the reliability of the weft transfer operation from the feeding rapier head 1 to the receiving rapier head 2.

As a modification of the weft inserting apparatus according to the instant embodiment of the invention, the voltage of minus polarity may be applied to the electromagnet in succession to a application of the voltage of plus polarity when the movable feeding gripper 8B and the movable receiving gripper 12B are employed, In that case, there can be obtained advantageous effects similar to those described previously in conjunction with the embodiment shown in Fig. 9. As another modification, the energization/deenergization of the electromagnets in the relaying fashion may be performed only for the operation of the feeding rapier head 1 or alternatively only for the operation of the receiving rapier head 2.

Finally, description will turn to yet another embodiment of the present invention by reference to Figs. 16 and 17. In the case of the weft inserting apparatus now under consideration, the feeding rapier head 1 is implemented by securing fixedly a base end portion of a flexible movable feeding gripper 8C to the stationary feeding gripper 7A. A piezoelectric device 35 is interposed between the stationary feeding gripper 7A and the movable feeding gripper 8C. On the other hand, the receiving rapier head 2 is implemented in such a structure in which a base end portion of a flexible movable feeding gripper 8C is secured to the stationary receiving gripper 11A. Equally, a piezoelectric device 36 is interposed between the stationary receiving gripper 11A and the movable receiving gripper 12C. Electric wires connected to the piezoelectric devices 35 and 36 are laid down along the rapier bands 3 and 4, respectively.

As is shown in Fig, 16, the piezoelectric device 35 (or 36) is realized in such a structure in which piezoelectric elements 35a (or 36a) are stacked alternately with electric conductors 35b (or 36b) with the piezoelectric element 35a (or 36a) being sandwiched between the conductors 35b (or 36b). One of the electric conductors 35b and 36b sandwiching the piezoelectric element 35a or 36a is connected to an electrode of plus polarity of a power source while the other is connected to the electrode of minus polarity. Upon application of a voltage to the piezoelectric device 35 or 36, the piezoelectric element 35a or 36a expands in the stacking direction, which results in that the piezoelectric device 35 or 36 as a whole expands. The movable feeding gripper 8C of the feeding rapier head is disposed at the weft grip position upon voltage application to the piezoelectric device 35 and changed over to the weft release position in response to clearing of the applied voltage. On the other hand, the movable receiving gripper 12C of the receiving rapier head is disposed at the weft grip position in response to the voltage application to the piezoelectric device 36 and shifted to the weft release position when the voltage applied to the piezoelectric device 36 is cleared. Although the expansion/contraction of the piezoelectric devices 35, 36 is small, deformation or vibration of the piezoelectric devices 35, 36 is magnified due to lever-like implementation of the flexible movable feeding gripper 8C as well as that of the movable receiving gripper 12C, whereby expansion/contraction of the piezoelectric device 35 or 36 is translated to effective displacement of the gripping surfaces 8a and 12a.

The driving force for changing over the movable gripper 8C or 12C between the weft grip position and the weft release position originates in the expansion/contraction of the piezoelectric device 35 or 36. Thus, the mechanism for changing over the movable gripper 8C or 12C between the weft grip position and the weft release position is positively prevented from interfering with the warp. To say in another way, the warps can positively be protected against injury or damage due to the switching operations of the feeding rapier head 1 and the receiving rapier head 2.

The structure in which the movable gripper 8C or 12C is positively moved in response to the expansion/contraction of the piezoelectric device 35 or 36 facilitates setting of optimal timings for switching operations of the rapier heads 1 and 2, which in turn facilitates setting of the optimal timings for the gripping and releasing of the weft. On the other hand, easiness in setting the optimal timings for gripping and releasing of the weft can assure positive pick-up of the weft Y by the feeding rapier head 1 as well as positive transfer of the weft Y from the feeding rapier head 1 to the receiving rapier head 2.

In the case of the weft inserting apparatus according to the instant embodiment of the invention, the spring member for gripping the weft is rendered unnecessary. Further, the driving mechanism for shifting the movable gripper 8C and 12C between the weft grip position and the weft release position can be realized only by a small size piezoelectric device, which contributes to further simplified and compact implementation of the driving mechanisms mentioned previously. Incidentally, the electric wires connected to the piezoelectric device may be replaced by tapes or straps or tape-like material admixed with electrically conductive material. Besides, the driving means may be implemented in the form of a wireless driving means.

In the weft inserting apparatus according to the present invention, permanent magnets can be used as the magnetic force exerting means. By way of example, a permanent magnet may be disposed in the vicinity of the retraction dead center position at the weft insertion starting side. In the state in which the movable gripper of the feeding rapier head for the weft transfer is disposed at the weft release position, the weft insertion by the receiving rapier head is started. In that case, the weft can positively be caught by the weft feeding rapier head when such arrangement is adapted that the magnetic action of the permanent magnet becomes rapidly lowered substantially at the time point when the weft is caught. Alternatively, the permanent magnet may be disposed in the vicinity of the retraction dead center position at the weft insertion terminal side. The movable gripper of the receiving rapier head is disposed at the weft release position under the action of the magnetic force generated by the permanent magnet, whereupon the weft as transported by the receiving rapier head is released therefrom.

As will now be understood from the foregoing description, with such arrangement of the weft inserting apparatus for the rapier loom that the movable gripper is positionally changed over between the weft grip position and the weft release position by switching the magnetic force exerting means between the state in which the magnetic force thereof acts on the magnetic force responsive movable gripper and the state in which the magnetic force does not act on the movable gripper or alternatively by switching the piezoelectric stack means between the state in which a voltage is applied thereto and the state in which no voltage is applied, there is achieved the aimed advantageous effect that the weft insertion can be performed with high reliability while substantially avoiding injury or damage to the warps.

Many features and advantages of the present invention are apparent form the detailed description and thus it is intended by the appended claims to cover all such features and advantages of the system which fall within the true spirit and scope of the invention. Further, since numerous modifications and combinations will readily occur to those skilled in the art, it is not intended to limit the invention to the exact construction and operation illustrated and described.

By way of example, the present invention can be applied to a rapier loom in which each of the rapier heads is secured at a tip end of a rod which is adapted to be linearly and reciprocatively moved as well as a rapier loom in which the weft insertion is performed only by using a rapier head which is inserted into a shed defined by the warps from a weft insertion starting side.

Accordingly, all suitable modifications and equivalents may be resorted to, falling within the spirit and scope of the invention.

A weft inserting apparatus for a rapier loom for weaving a fabric by inserting a weft through a shed formed by warps by reciprocatively moving feeding and receiving rapier heads through the shed. The feeding and receiving rapier heads (1; 2) are each constituted by a combination of a stationary gripper member (7; 11) and a movable gripper member (8; 12) made of a magnetic material. Electromagnets (18; 19) are disposed at both ends of a sley (17), respectively, while electromagnets (20; 21) are disposed at a mid portion of the sley. The movable gripper member (8) of the feeding rapier head (1) positioned in opposition to the electromagnets (19; 21) is displaced from a weft grip position to a weft release position by controlling the magnetic action of the electromagnets (18; 20), while the movable gripper member (12) of the receiving rapier head (2) disposed oppositely to the electromagnets (19; 21) is displaced from the weft grip position to the weft release position by controlling the magnetic action of the electromagnets (19; 21). The weft insertion can be carried out with high reliability while positively protecting the weft against injury.

Claims

1. A weft inserting apparatus for a rapier loom for weaving a fabric by inserting a weft through a shed formed by warps by reciprocatively moving rapier head means, comprising a combination of stationary and movable gripper members connected to one end of rapier band means, through said shed with the weft being gripped between the stationary and movable gripper members, said movable gripper member being positionally changed over between a weft grip position and a weft release position by drive means when the weft is gripped and released, characterized in that:

    an actuator for producing a force when it is in an operative state is provided in said rapier head means with said actuator being connected to said movable gripper member;
    means for selectively supplying an electric energy to said actuator is provided to cause said actuator to be brought into the operative state from an inoperative state, in which the force is not produced; and
    the changeover of said movable gripper member between said weft grip position and said weft release position is performed by changing over the state of said actuator between the operative state and the inoperative state.

2. A weft inserting apparatus according to claim 1, characterized in that said actuator comprises piezoelectric stack means and that when said actuator is in the operative position, a voltage is applied to said piezoelectric stack means and when said actuator is in the inoperative position, no voltage is applied thereto.

3. A weft inserting apparatus according to claim 1 or 2, characterized in that said rapier head means comprises feeding and receiving rapier heads each including stationary and movable gripper members, the weft being inserted into said shed by transferring the weft caught by said feeding rapier head to said receiving rapier head.

4. A weft inserting apparatus according to any one of claims 1 to 3, characterized in that said actuator is constituted by at least one electromagnet; and that said weft inserting apparatus further comprises: voltage application control means for controlling application of voltage to said electromagnet;

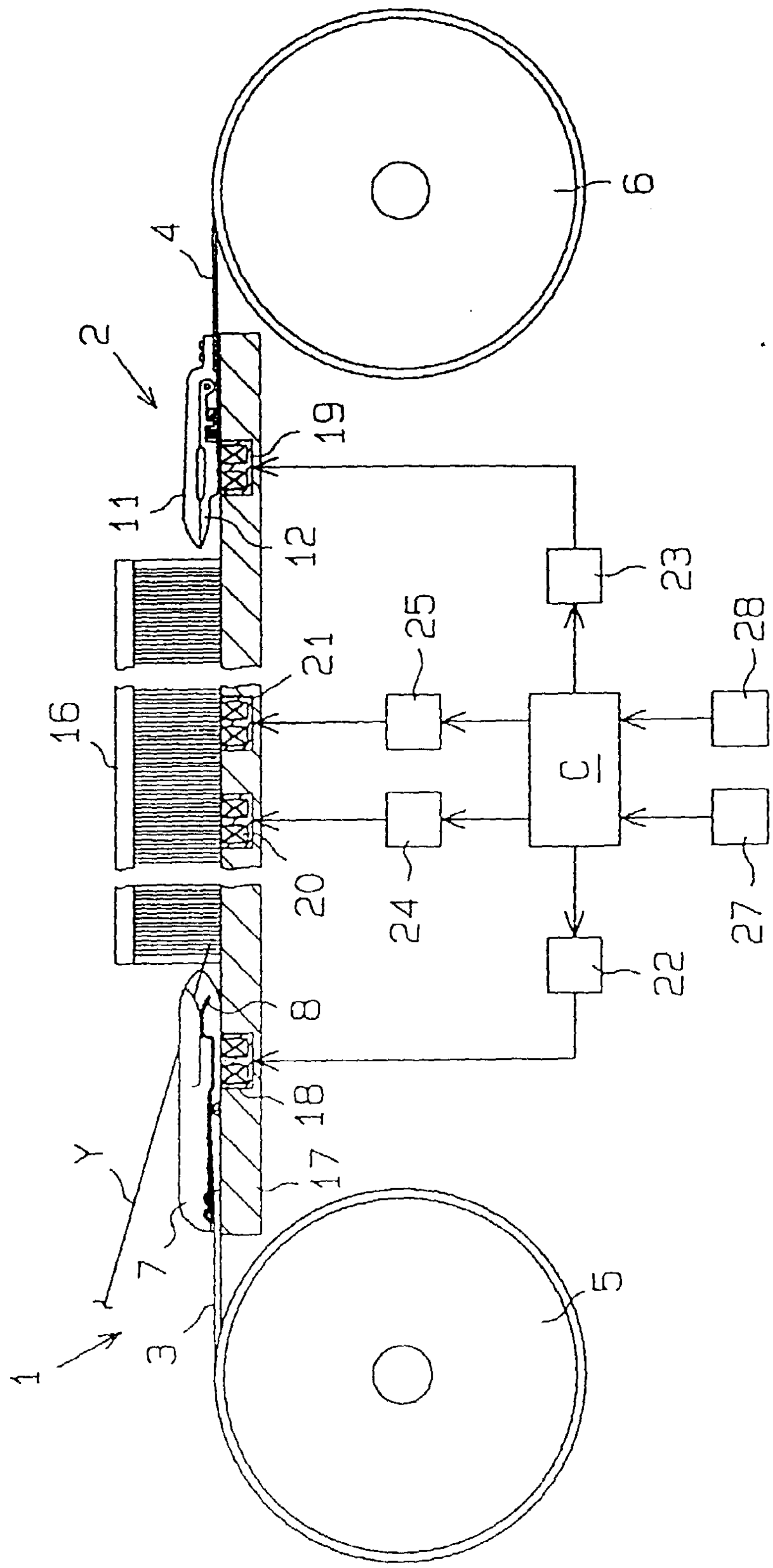
    applied voltage level setting means for setting a level of voltage applied to said electromagnet; and
    voltage application timing setting means for setting a timing at which said voltage is applied to said electromagnet.

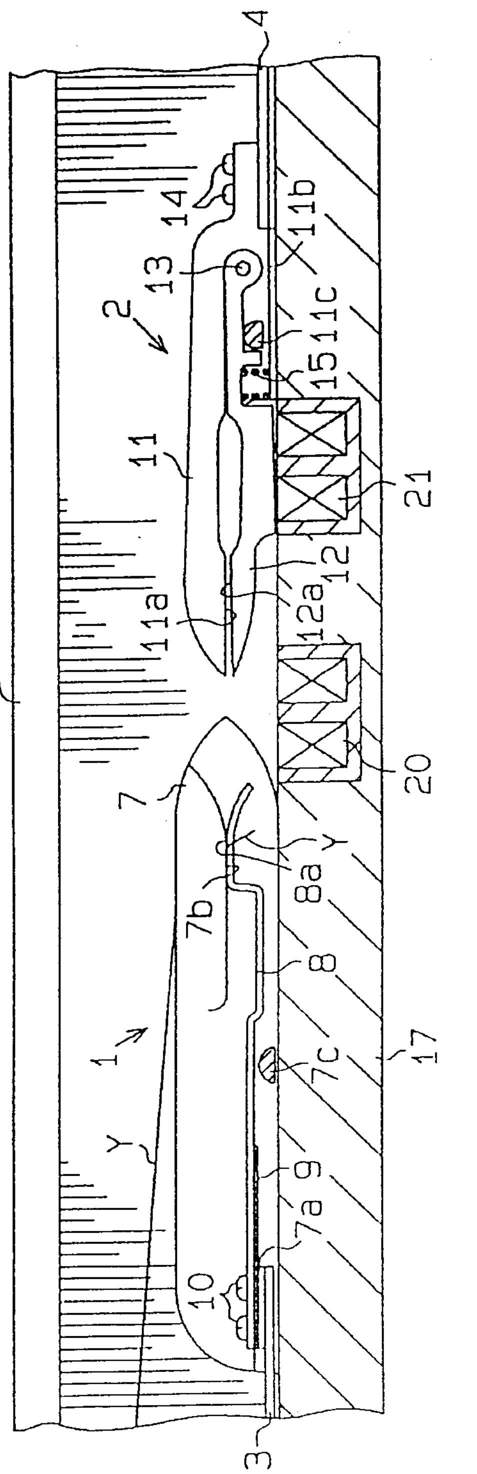
5. A weft inserting apparatus according to any one of claims 1 to 4, characterized in that spring means is provided in association with said movable gripper member, and said movable gripper member is held in a weft gripping state under a spring force of said spring means and changed over to a weft releasing state under influence of said magnetic force.

6. A weft inserting apparatus according to any one of claims 1 to 5, characterized in that an additional actuator is provided in the vicinity of a retraction dead center position of said rapier head for changing over said movable gripper member to said weft release position from said weft gripping position upon arrival of said rapier head at said retraction dead center position.

7. A weft inserting apparatus according to any one of claims 1 to 6, characterized in that said actuator is comprised of an electromagnet which is initially applied with an over-excitation voltage and then applied with a rated voltage for changing over said movable gripper member from said weft grip position to said weft release position.

FIG. 1

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7b
7c
8
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11b
11c
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12a
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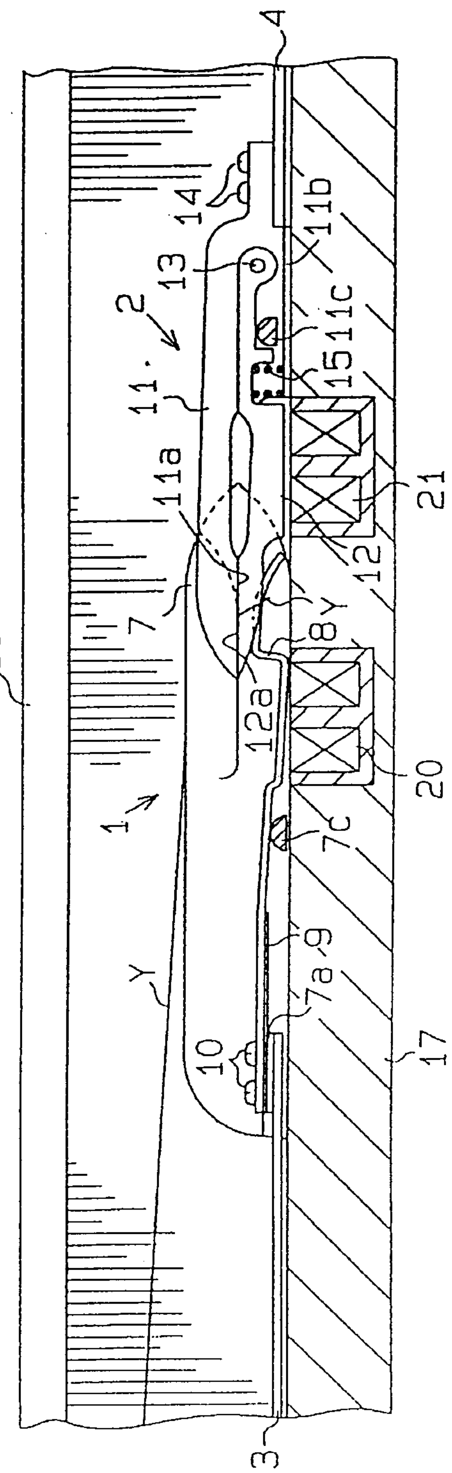
14
15
16
17
20
21
Y

FIG. 2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7a
7c
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16
17
20
21
Y

FIG. 3

FIG. 4

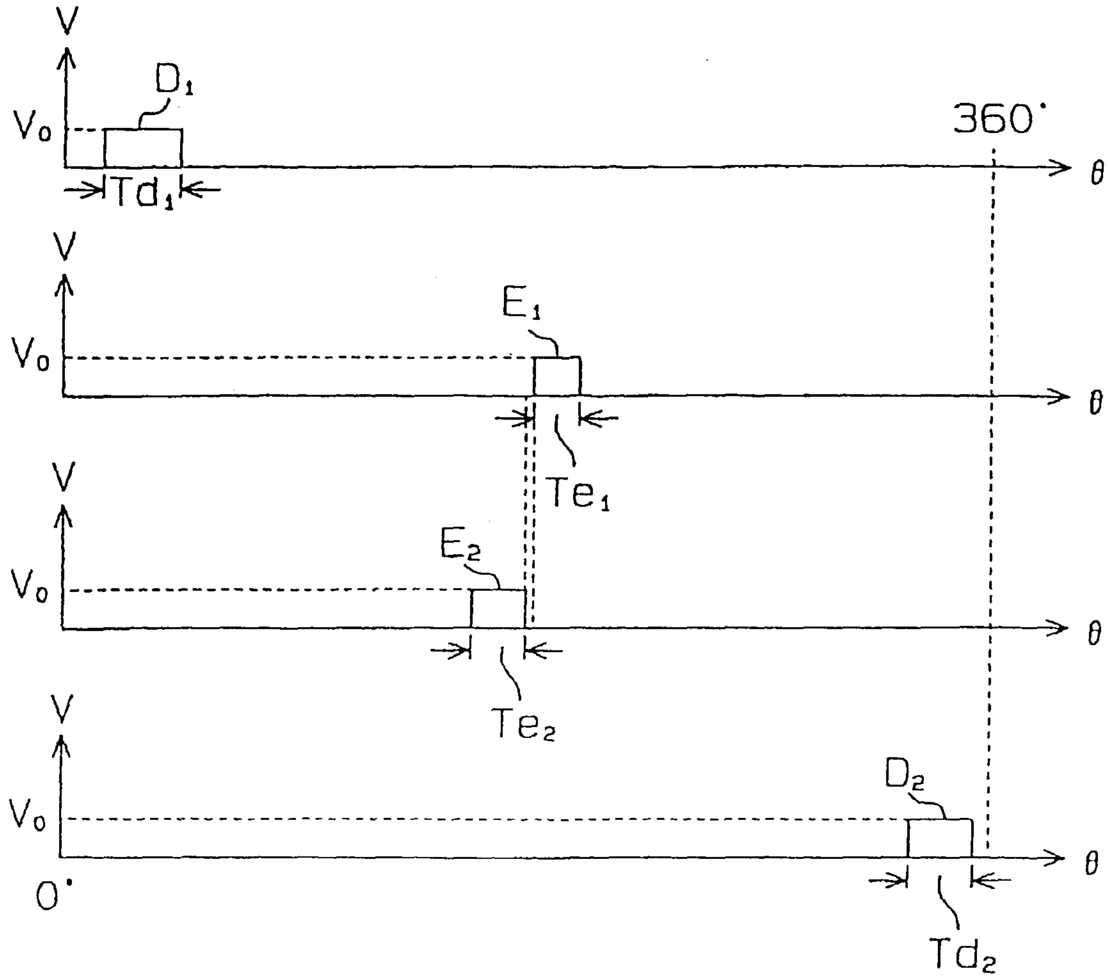

V
V0
D1
Td1
360°
θ
V
V0
E1
Te1
θ
V
V0
E2
Te2
θ
V
V0
D2
Td2
0°
θ

FIG. 5

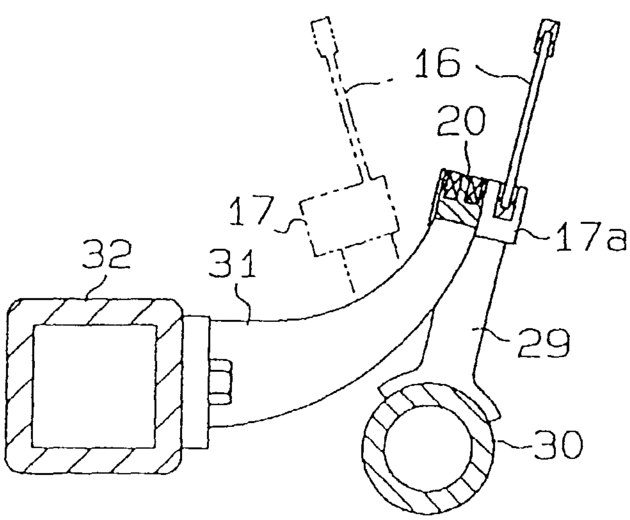
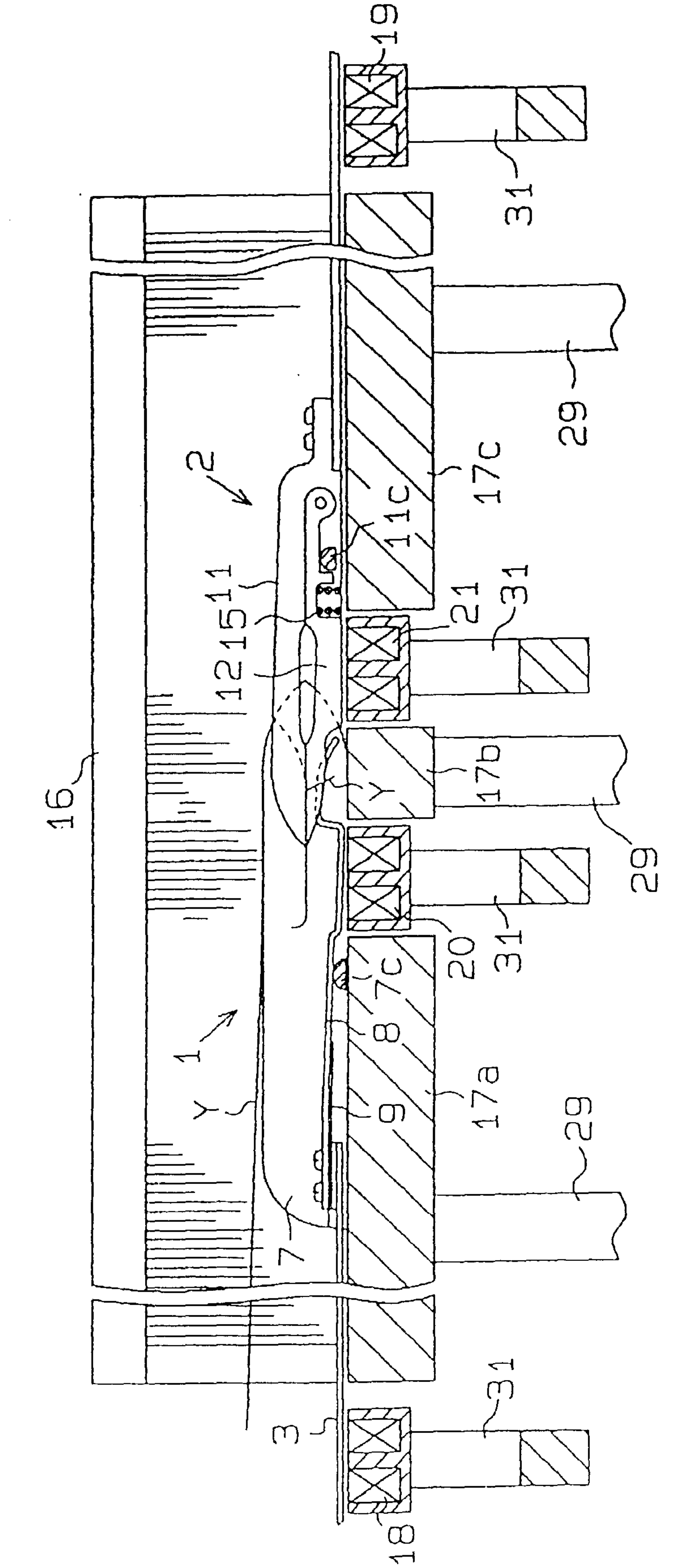

16
20
17
17a
32
31
29
30

FIG. 6


19
31
29
17c
11c
2
11
15
12
21
31
16
17b
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29
20
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7c
8
1
Y
9
17a
29
7
3
31
18

FIG. 7

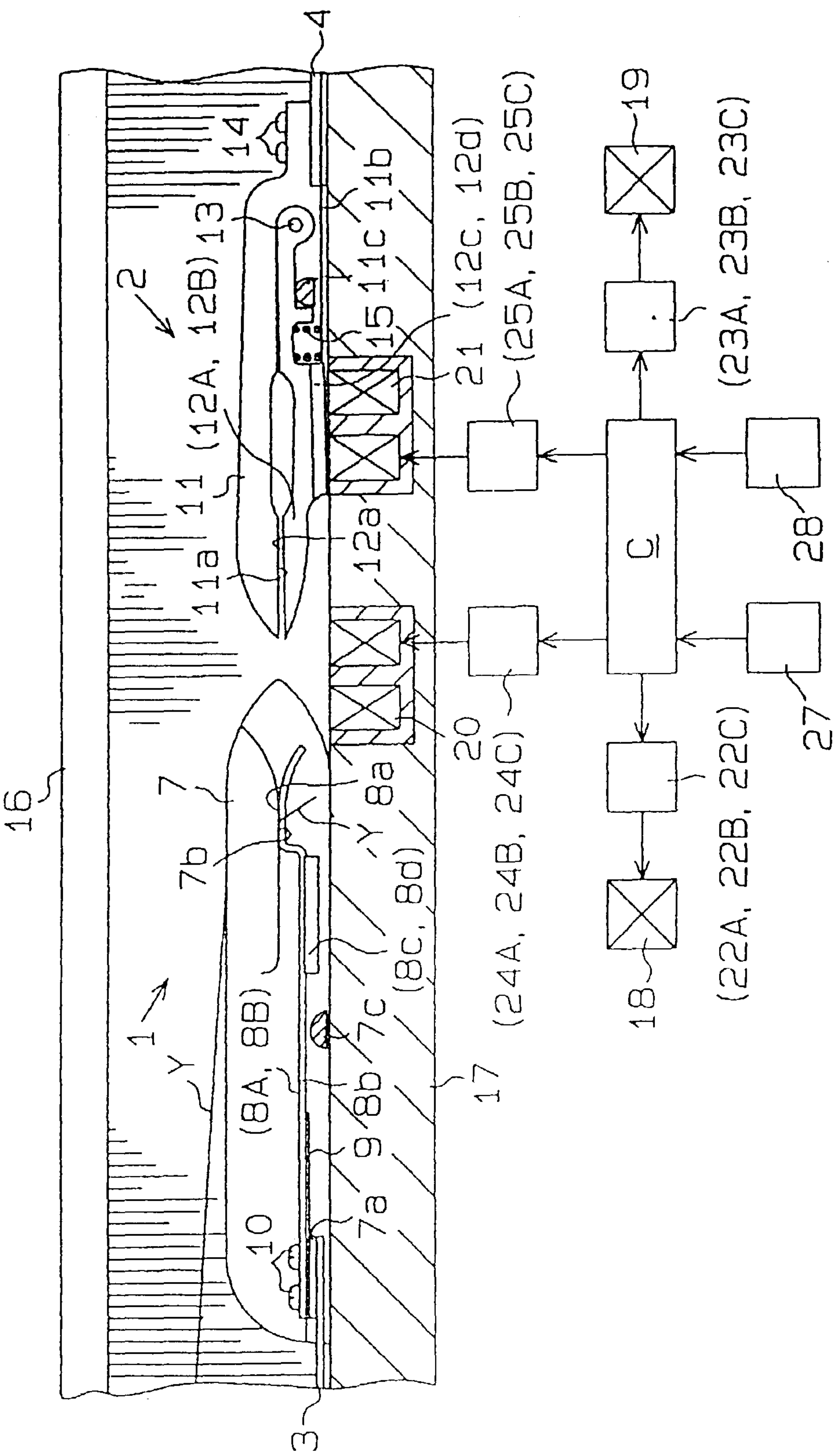

1
2
3
4
7
7a
7b
7c
8a
(8A, 8B)
8b
(8c, 8d)
9
10
11
11a
11b
11c
(12A, 12B)
12a
(12c, 12d)
13
14
15
16
17
18
19
20
21
C
(22A, 22B, 22C)
(23A, 23B, 23C)
(24A, 24B, 24C)
(25A, 25B, 25C)
27
28
Y

FIG. 8

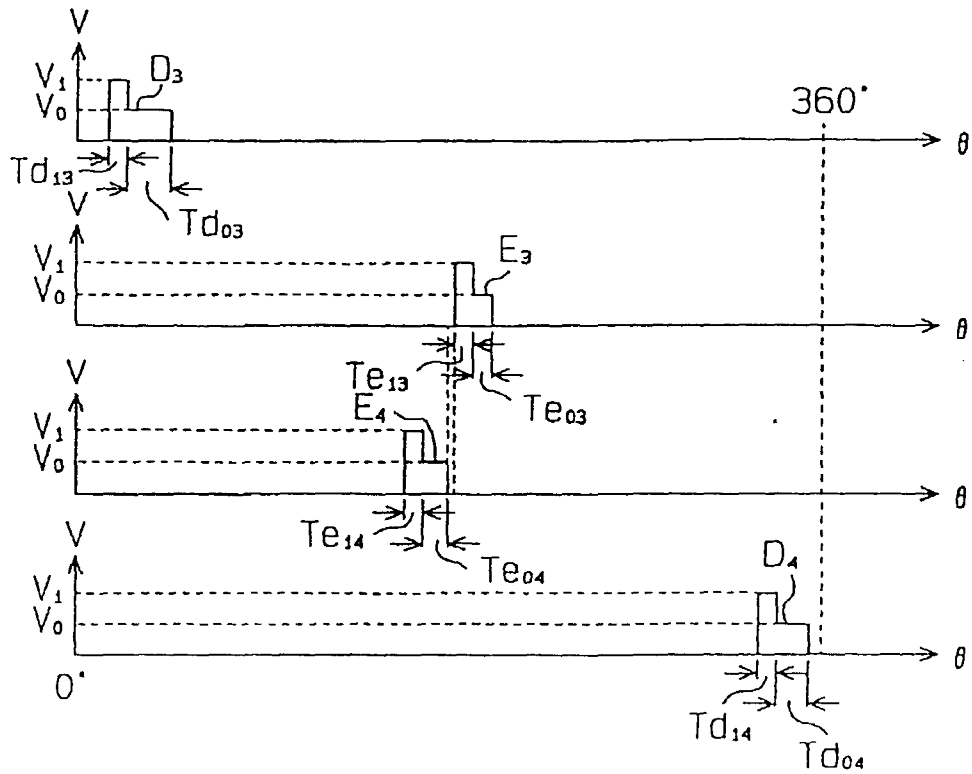

V
V1
V0
D3
360°
θ
Td13
Td03
E3
Te13
Te03
E4
Te14
Te04
D4
0°
Td14
Td04

FIG. 9

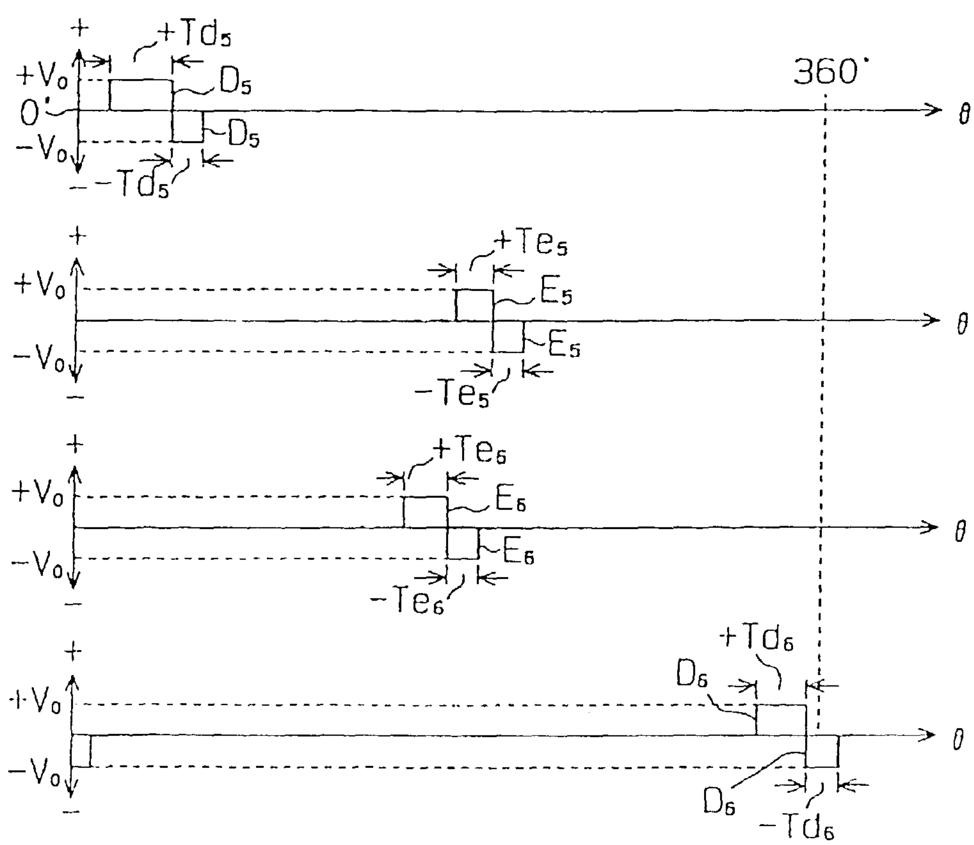
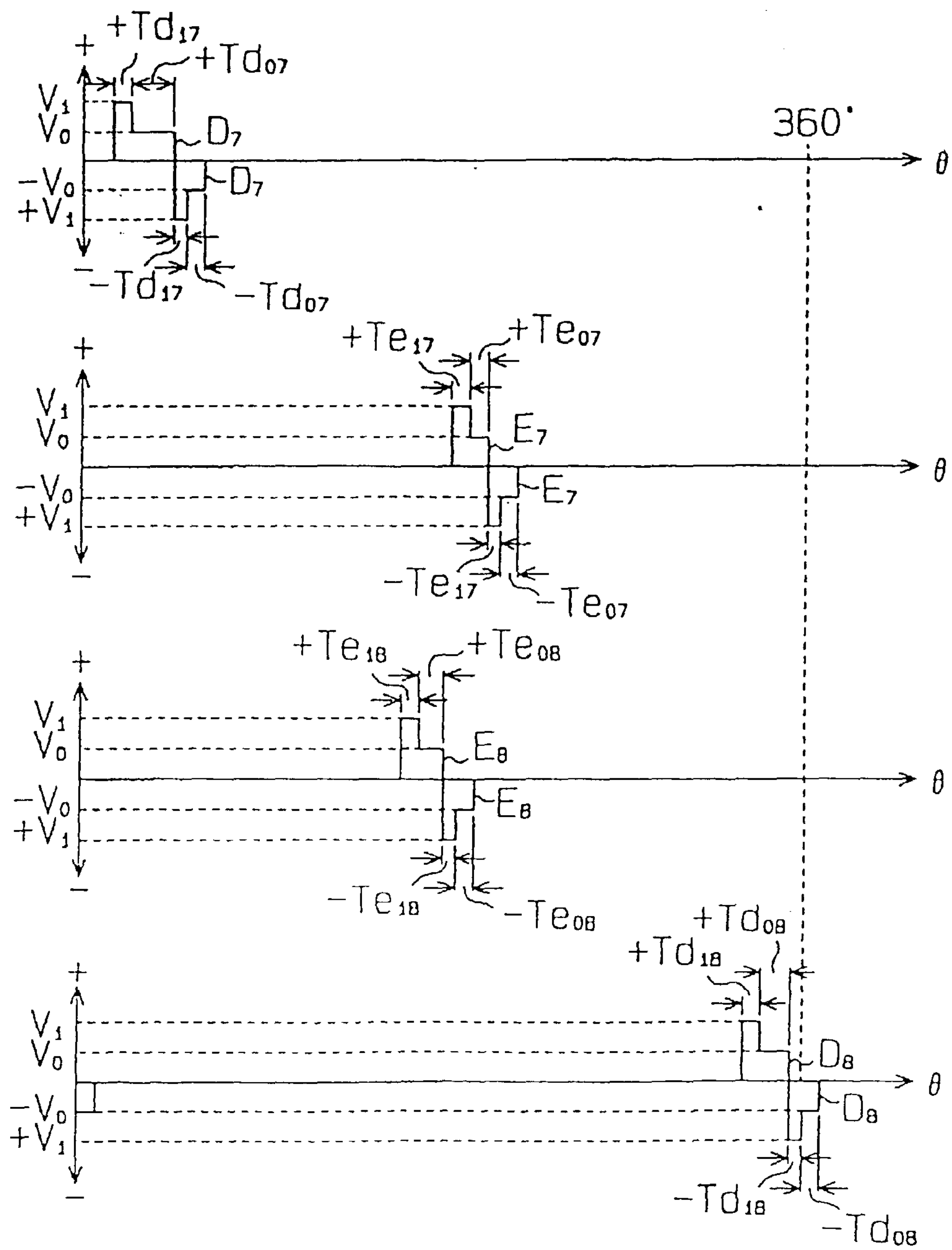

+
+Td5
+V0
D5
360°
0°
θ
-V0
-Td5
-
+Te5
E5
-Te5
+Te6
E6
-Te6
+Td6
D6
-Td6

FIG. 10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+Td07
+
V1
V0
D7
360°
θ
-V0
+V1
D7
-
-Td17
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+Te17
+Te07
E7
E7
-Te17
-Te07
+Te18
+Te08
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D8
D8
-Td18
-Td08

FIG. 11

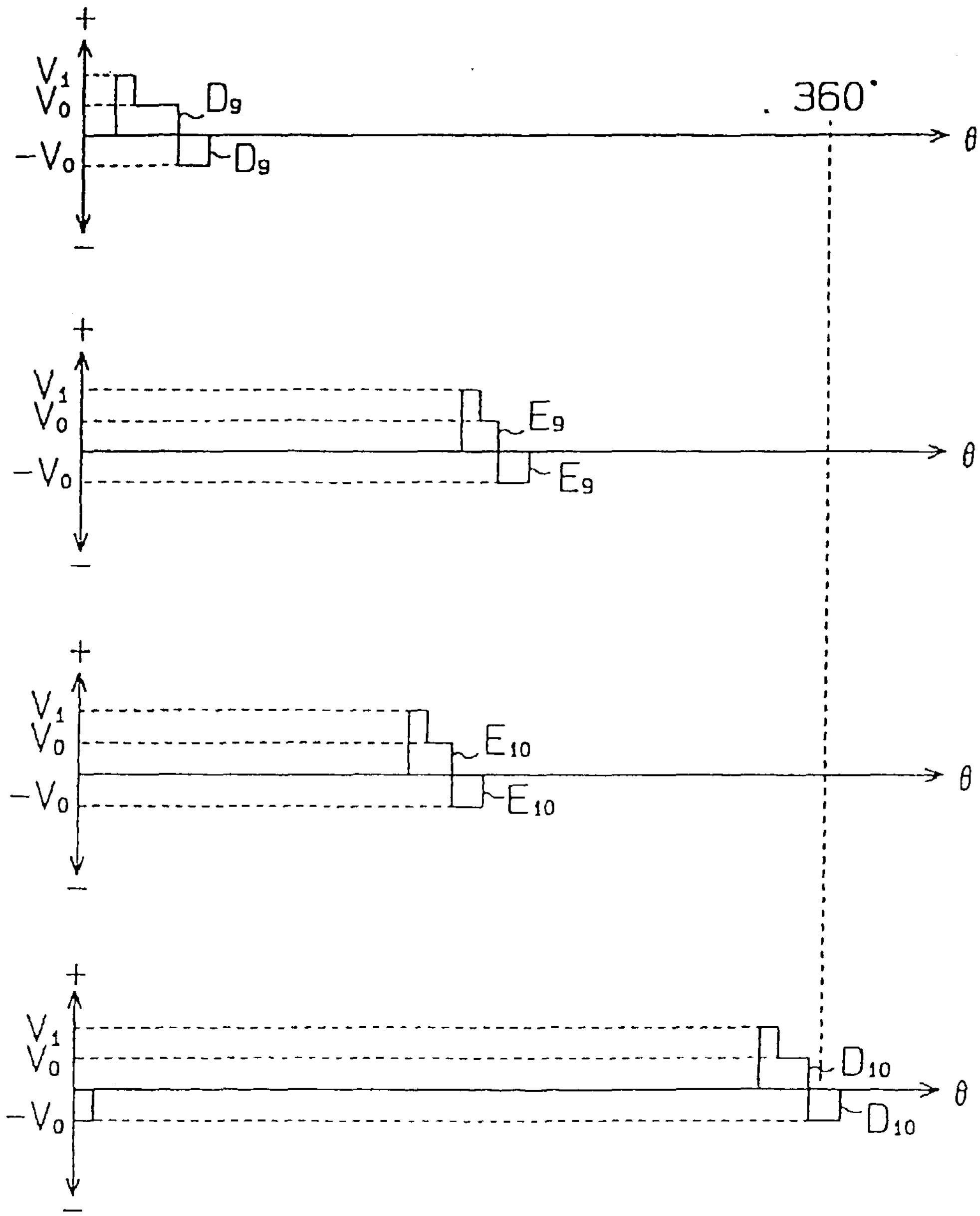
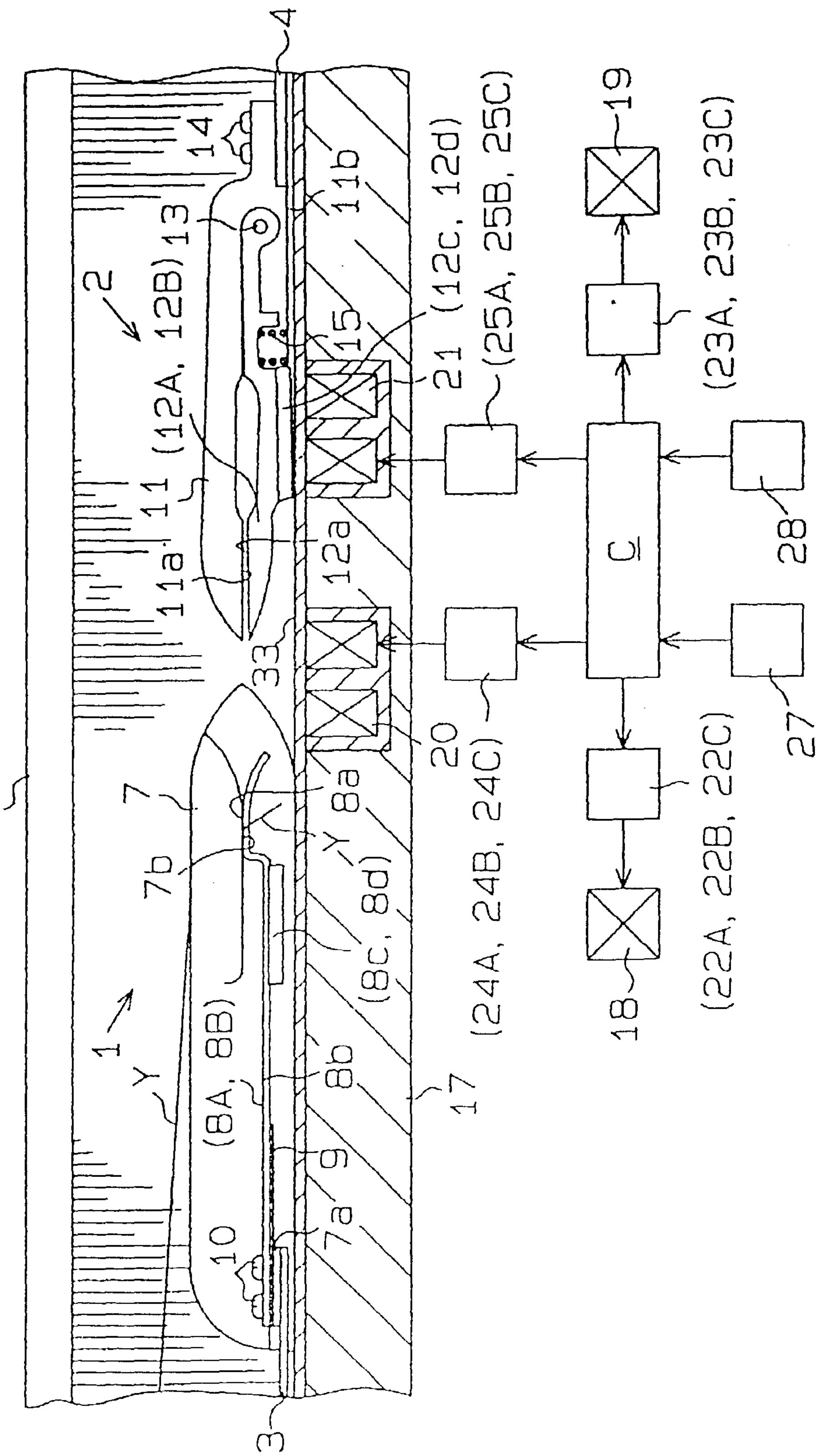


FIG. 12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11a
12a
11b
15
21
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(25A, 25B, 25C)
19
(23A, 23B, 23C)
C
28
27
33
20
(24A, 24B, 24C)
(22A, 22B, 22C)
18
16
7
8a
Y
7b
(8c, 8d)
1
Y
(8A, 8B)
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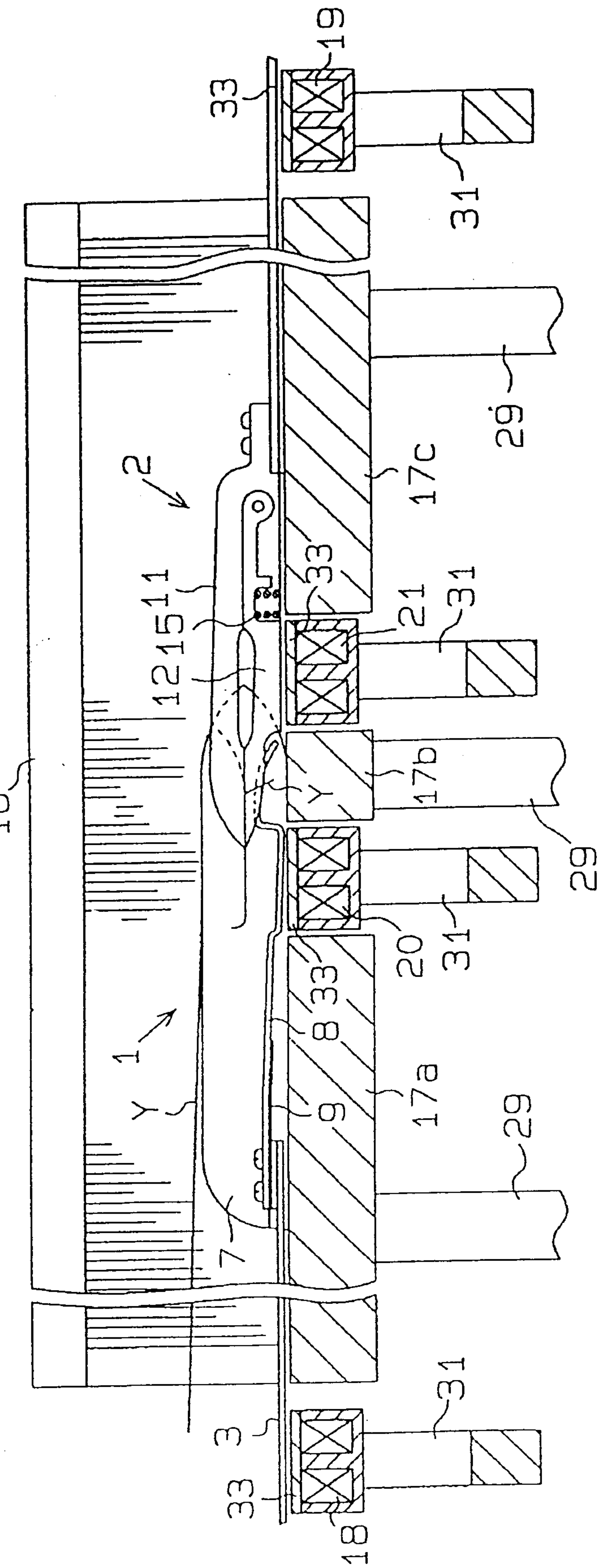
17
9
7a
10
3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16
17b
Y
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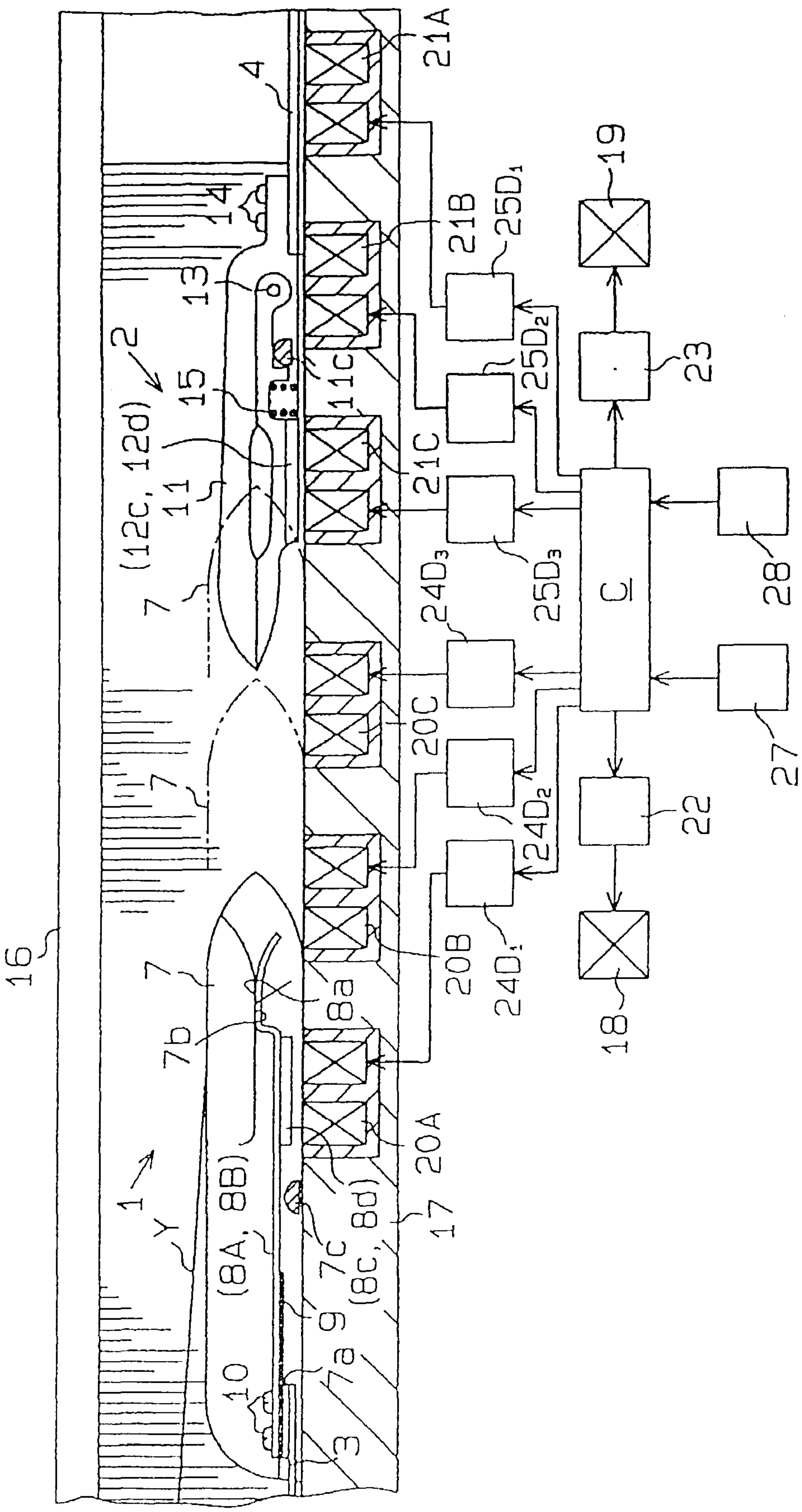
8
33
1
Y
9
17a
29
7
3
33
18

Fig. 13

FIG. 14


16
1
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7a
7b
7c
(8A, 8B)
(8c, 8d)
8a
9
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11
11c
(12c, 12d)
13
14
15
17
18
19
20A
20B
20C
21A
21B
21C
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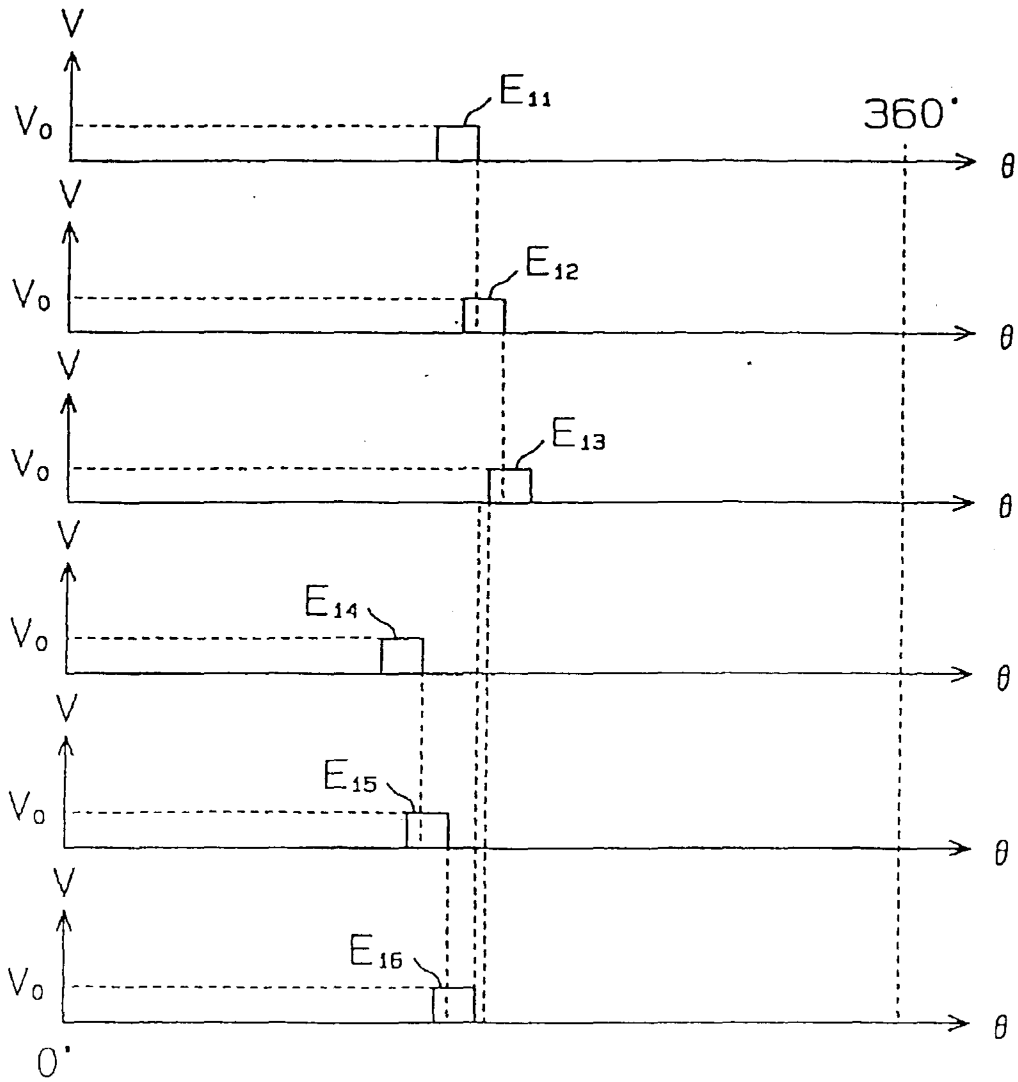
23
24D1
24D2
24D3
25D1
25D2
25D3
27
28
C

FIG. 15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θ
E_{12}
E_{13}
E_{14}
E_{15}
E_{16}
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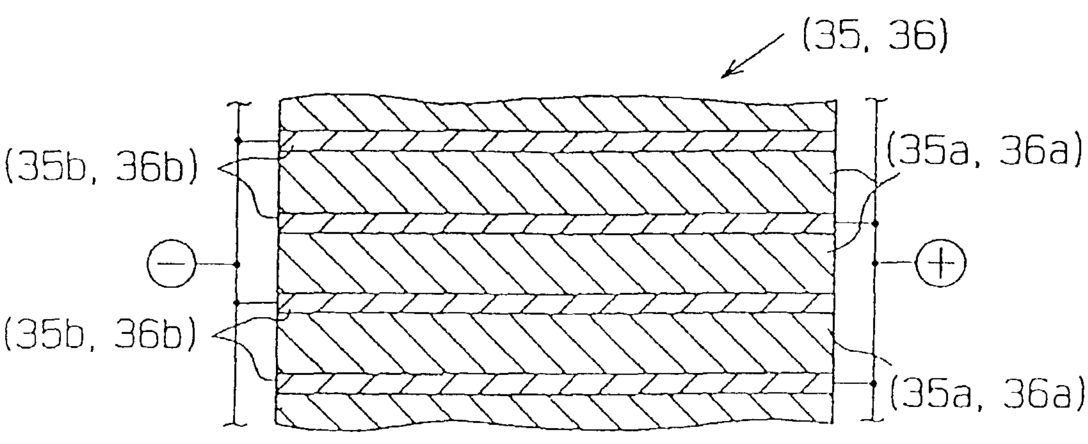
FIG. 16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(35a, 36a)
(35b, 36b)
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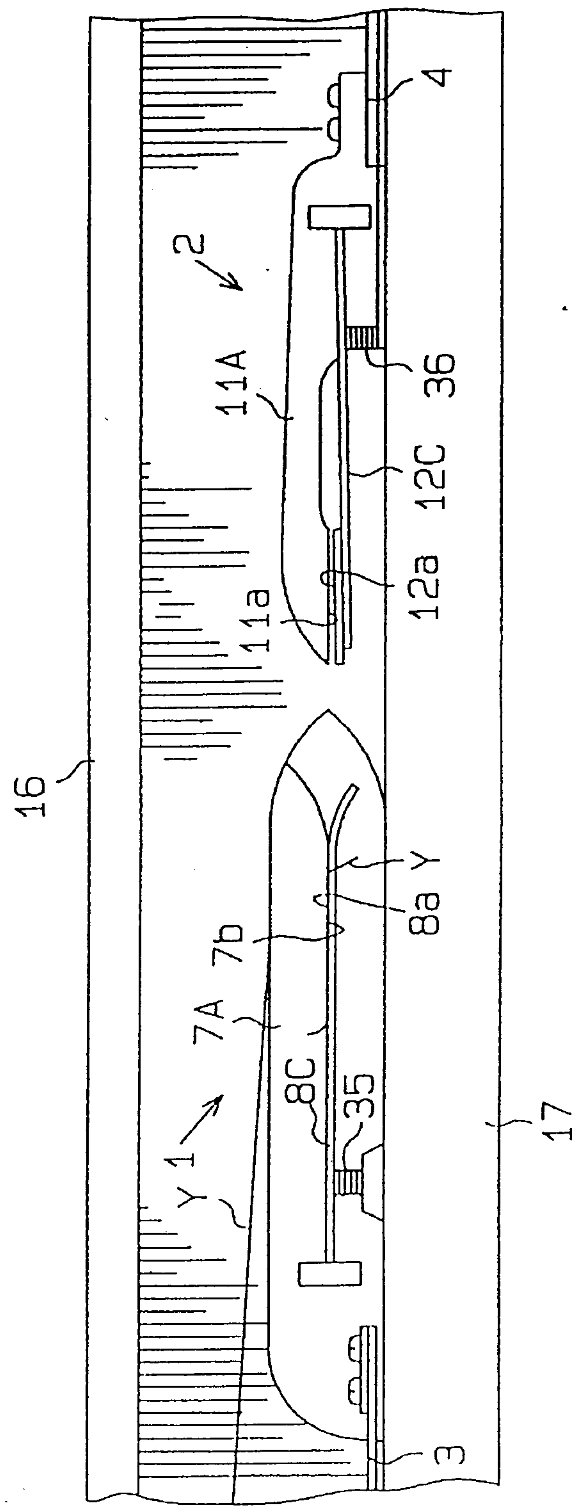
FIG. 17



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 10 5886

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	GB 2 059 455 A (NORTHROP WEAVING MACHINERY LTD) 23 April 1981 * page 2, line 94 - page 3, line 81; figures *	1-4	D03D47/12 D03D47/20
Y	EP 0 299 553 A (PICANOL NV) 18 January 1989 * column 2, line 36 - line 41 * * column 3, line 8 - line 47; figures 1,2 *	1-3	
Y	US 3 963 229 A (VAN DUYNHOVEN ADRIANUS HENRICU) 15 June 1976 * the whole document *	4	
P,A	EP 0 624 671 A (RUETI AG MASCHF) 17 November 1994 * column 5, line 22 - line 35; figure 8 *	1,4-6	
A	FR 2 372 256 A (PIQUEMAL JEAN) 23 June 1978 * page 1, line 25 - line 29; figures 1-4 *	1,6	**TECHNICAL FIELDS SEARCHED (Int.Cl.6)**
A,D A	EP 0 526 390 A (SULZER AG) 3 February 1993 * column 5, line 17 - line 24; figure 7 * & JP 05 195 373 A	1	D03D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 July 1998	Rebiere, J-L

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