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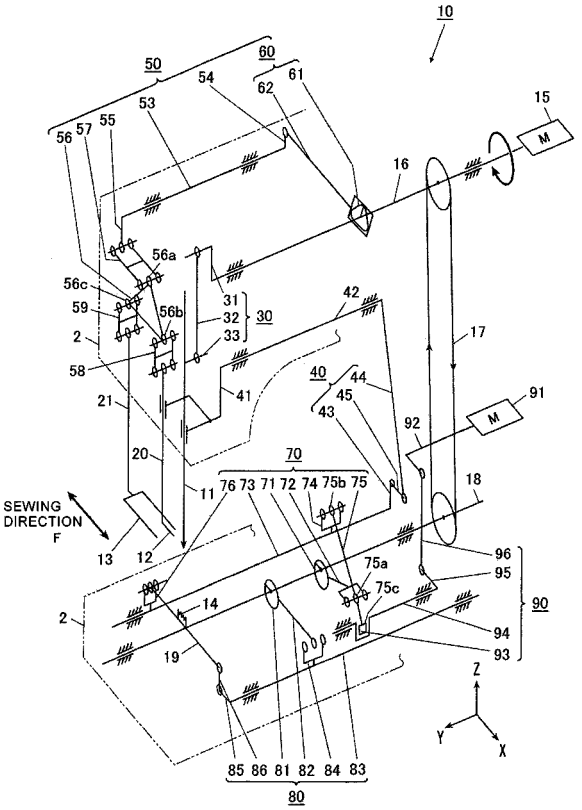
(54) **Bottom and top feed sewing machine**

(57) A bottom and top feed sewing machine includes a feed dog and a top feed foot which contact a workpiece on a throat plate from below and above respectively to perform a feeding operation, a bottom side back-and-forth feed mechanism which drives the feed dog back and forth, a bottom side up-and-down feed mechanism which drives the feed dog up and down, a top side back-and-forth feed mechanism which drives the top feed foot back and forth, and a top side up-and-down feed mechanism which drives the top feed foot in an up and down direction. The top side up-and-down feed mechanism includes a cam mechanism which takes out a reciprocating movement from a rotational movement of a rotary shaft which performs a rotational drive. The cam mechanism includes a triangular cam having an outer circumference, a shape of which is obtained by connecting two kinds of circular arcs, each of three vertices of an equilateral triangle being a center of small and large circular arcs, and a cam follower having receiving surfaces which hold the triangular cam therebetween. The triangular cam is fixed and supported on the rotary shaft so as to rotate around a position, which is on a perpendicular line drawn down to a base from one of the vertices and is closer to the base than the center of the equilateral triangle is, and such that, when a needle bar which performs stitching by an up-and-down movement is located at the upper dead point of the up-and-down movement, the top feed foot is located at the upper dead point of the reciprocating movement along the up-and-down direction.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a bottom and top feed sewing machine having a top feed foot.

BACKGROUND ART

[0002] A conventional bottom and top feed sewing machine includes a feed dog which performs a reciprocating movement in a back-and-forth direction of a cloth feed while being protruded out from and retracted into a throat plate from below, a top feed foot which moves in the back-and-forth direction while moving up and down from above the throat plate in synchronization with the feed dog, a feed dog side back-and-forth feed mechanism which gives a back-and-forth reciprocating movement to the feed dog, and a feed dog side up-and-down feed mechanism which gives an up-and-down reciprocating movement to the feed dog, a top feed foot side back-and-forth feed mechanism which gives a back-and-forth reciprocating movement to the top feed foot, and a top feed foot side up-and-down feed mechanism which gives an up-and-down reciprocating movement to the top feed foot (see, e.g., JP 3529414 B).

[0003] The top feed foot side up-and-down feed mechanism includes a circular eccentric cam which is fixed and mounted on an upper shaft, an up-down rod which engages with the eccentric cam at one end portion, an up-and-down feed arm which performs a reciprocating rotation in accordance with a reciprocating displacement of the up-down rod in its longitudinal direction, and a bell crank which rotates in accordance with the reciprocating rotation of the up-and-down feed arm, and the up-and-down movement is transmitted to the top feed foot from the bell crank.

[0004] On the other hand, the top feed foot side back-and-forth feed mechanism includes a middle shaft to which a reciprocating rotation movement is transmitted from a lower shaft which performs a reciprocating rotation, and a middle shaft front arm fixed to the middle shaft, and transmits a back-and-forth reciprocating movement of an swinging end of the middle shaft front arm to the feed foot.

[0005] By suitably adjusting the mutual phases of the up-and-down reciprocating movement by the up-and-down feed mechanism and the back-and-forth reciprocating movement by the back-and-forth feed mechanism and by transmitting them to the top feed foot, the feed foot is made to perform an elliptical motion, and the feeding operation by the top feed foot is implemented by using a movement trajectory of a lower half of the elliptical motion.

[0006] Fig. 14 is a diagram showing a positional displacement D and a speed displacement V which correspond to the up-down direction of the top feed foot and are generated by the circular eccentric cam of the feed foot side up-and-down feed mechanism described above.

[0007] In the above conventional bottom and top feed sewing machine described above, the top feed foot side up-and-down feed mechanism uses the circular eccentric cam to takes out the up-and-down reciprocating movement from the upper shaft. Therefore, the positional displacement D describes a substantially cosine curve, and when the displacement reaches an approximately zero point (a point G shown in the diagram) by a downward movement, the top feed foot lands on a workpiece on the throat plate (it is to be noted that, in Fig. 14, the displacement at zero point represents the height of the throat plate, and although the top feed foot cannot actually move downward from the throat plate, for the convenience of description, the diagram is presented in accordance with a trajectory which will be described if the throat plate does not exist).

[0008] On the other hand, as shown in the diagram, the speed displacement V of the top feed foot becomes the fastest at the point G where the top feed foot lands on the workpiece. Therefore, there is a problem in that an impact at the time of landing is large so that an impact noise and vibration are large, and further in that mechanical durability is deteriorated. In order to address this, there are methods, such as increasing the strength of the top feed foot and its supporting structure. In this case, however, there is a drawback that components are enlarged or expensive and high-quality materials are used, so that the manufacturing cost of the sewing machine increases.

SUMMARY OF THE INVENTION

[0009] It is an object of the present invention to reduce the speed of a top feed foot when the top feed foot lands on a workpiece.

[0010] According to a first aspect of the invention, a bottom and top feed sewing machine comprises:

a feed dog which contacts a workpiece on a throat plate from below to perform a feeding operation;
a top feed foot which contacts the workpiece on the throat plate from above to perform a feeding operation;
a bottom side back-and-forth feed mechanism which gives a reciprocating movement along a feeding direction to the feed dog;
a bottom side up-and-down feed mechanism which gives a reciprocating movement along an up-and-down direction

to the feed dog;
a top side back-and-forth feed mechanism which gives a reciprocating movement along the feeding direction to the top feed foot; and
a top side up-and-down feed mechanism which gives a reciprocating movement along the up-and-down direction to the top feed foot,

wherein the feed dog and the top feed foot cooperate to feed the workpiece.

[0011] The bottom and top feed sewing machine is **characterized in that**,

the top side up-and-down feed mechanism comprises a cam mechanism which takes out a reciprocating movement from a rotational movement of a rotary shaft which performs a rotational drive,
the cam mechanism comprises a triangular cam having an outer circumference, a shape of which is obtained by connecting two kinds of circular arcs, each of three vertices of an equilateral triangle being a center of small and large circular arcs, and a cam follower having at least one set of receiving surfaces facing each other and contacting the outer circumference so as to place the triangular cam therebetween,
the triangular cam is fixed and supported on the rotary shaft so as to rotate around a position, which is on a perpendicular line drawn down to a base from one of the vertices and is closer to the base than the center of the equilateral triangle is, and
the triangular cam is fixed and supported on the rotary shaft such that, when a needle bar which performs stitching by an up-and-down movement is located at the upper dead point of the up-and-down movement, the top feed foot is located at the upper dead point of the reciprocating movement along the up-and-down direction.

[0012] According to a second aspect of the invention, when the needle bar is located at the upper dead point, the base is oriented in a vertical direction or in a horizontal direction.

[0013] According to a third aspect of the invention, when a length of one side of the equilateral triangle is 1, a distance from the vertex to the rotation center of the triangular cam is 0.7 or more but 1.0 or less.

[0014] According to a fourth aspect of the invention, the position of the rotation center is an intersection point of the perpendicular line and the base.

According to a fifth aspect of the invention, a bottom and top feed sewing machine comprises:

a feed dog which contacts a workpiece on a throat plate from below to perform a feeding operation;
a top feed foot which contacts the workpiece on the throat plate from above to perform a feeding operation;
a bottom side back-and-forth feed mechanism which gives a reciprocating movement along a feeding direction to the feed dog;
a bottom side up-and-down feed mechanism which gives a reciprocating movement along an up-and-down direction to the feed dog;
a top side back-and-forth feed mechanism which gives a reciprocating movement along the feeding direction to the top feed foot; and
a top side up-and-down feed mechanism which gives a reciprocating movement along the up-and-down direction to the top feed foot,

wherein the feed dog and the top feed foot cooperate to feed the workpiece.

[0015] The bottom and top feed sewing machine is **characterized in that**,

the top side up-and-down feed mechanism comprises a cam mechanism which takes out a reciprocating movement from a rotational movement of a rotary shaft which performs a rotational drive,
the cam mechanism comprises a triangular cam having an outer circumference, a shape of which is obtained by connecting two kinds of circular arcs, each of three vertices of an equilateral triangle being a center of small and large circular arcs, and a cam follower having at least two sets of receiving surfaces facing each other and contacting the outer circumference so as to place the triangular cam therebetween,
the triangular cam is fixed and supported on the rotary shaft so as to rotate around one of the vertices,
the cam follower performs a reciprocating movement in accordance with a combined displacement of displacements received by the two sets of receiving surfaces, and
the triangular cam is fixed and supported on the rotary shaft such that, when a needle bar which performs stitching by an up-and-down movement is located at the upper dead point of the up-and-down movement, the top feed foot is located at the upper dead point of the reciprocating movement along the up-and-down direction.

[0016] According to a sixth aspect of the invention, when the needle bar is located at the upper dead point, the base

of the equilateral triangle, which is farthest away from the vertex located at the rotation center of the triangular cam, is oriented in a vertical direction, and

when the needle bar is located at the upper dead point, the two sets of mutually parallel receiving surfaces of the cam follower are inclined within a range of 40 to 50° with respect to a direction of the reciprocating movement of the cam follower.

[0017] According to a seventh aspect of the invention, the two sets of mutually parallel receiving surfaces are all inclined at 45° with respect to the direction of the reciprocating movement of the cam follower.

[0018] According to the first and second aspects of the invention, the cam mechanism of the top side up-and-down feed mechanism receives displacement by the at least one set of receiving surfaces from the triangular cam whose rotation center is offset, and takes out the reciprocating movement. The triangular cam has a characteristic that a speed is greatly reduced at a position which is almost in the middle of one maximum displacement and the other maximum displacement in a certain positional displacement in a reciprocating direction. Accordingly, by attaching the triangular cam to the rotary shaft such that the top feed foot is located at the upper dead point when the needle bar is located at the upper dead point, and by using the triangular cam to give the up-and-down movement of the top feed foot, it is possible to reduce a speed at a position in the middle from the upper dead point to the lower dead point of the top feed foot. As a result, it is possible to avoid a situation in which the downward movement speed of the top feed foot is at a maximum when the top feed foot lands on a workpiece. Because the top feed foot lands on the workpiece at a low speed, it is possible to reduce impact and improve the durability of the mechanisms, and it is also possible to avoid a heavy blow to the workpiece. Along with this, it is also possible to avoid an increase in production cost due to reinforcement of the top feed foot.

[0019] Additionally, since the triangular cam is used whose outer circumferential shape is a geometric shape obtainable by a function, design and manufacture can be performed far easily than a case in which a unique cam is designed and manufactured so as to result in the same characteristic, and a reduction in production cost can be achieved.

[0020] According to the third aspect of the invention, it is possible to further reduce the speed when the top feed foot lands, and it is possible to further improve the durability of the mechanisms, the protection of the workpiece, and the cost reduction.

[0021] According to the fourth aspect of the invention, the speed made almost zero at the midpoint of the maximum amplitude. Thus, it is possible to make the downward movement speed to almost zero when the top feed foot lands. Therefore, it is possible further improve the durability of the mechanisms, the protection of the workpiece, and the cost reduction.

[0022] According to the fifth and sixth aspects of the invention, the cam mechanism of the top side up-and-down feed mechanism receives displacement by the at least two sets of receiving surfaces from the triangular cam, and takes out the reciprocating movement through the combined displacement. The triangular cam has a characteristic that a speed is greatly reduced at a position which is almost in the middle of one maximum displacement and the other maximum displacement by combining the two positional displacements in the reciprocating direction. Accordingly, by attaching the triangular cam to the rotary shaft such that the top feed foot is located at the upper dead point when the needle bar is located at the upper dead point, and by using the triangular cam to give the up-and-down movement to the top feed foot, it is possible to reduce a speed at the middle position from the upper dead point to the lower dead point of the top feed foot. As a result, it is possible to avoid a situation in which the downward movement speed of the top feed foot is at a maximum when the top feed foot lands on a workpiece. Because the top feed foot lands on the workpiece at a low speed, it is possible to reduce impact and improve the durability of the mechanisms, and it is also possible to avoid a heavy blow to the workpiece. Along with this, it is also possible to avoid an increase in production cost due to reinforcement of the top feed foot.

[0023] Additionally, since the triangular cam is used whose outer circumferential shape is a geometric shape obtainable by a function, design and manufacture can be performed far easily than a case in which a unique cam is designed and manufactured so as to result in the same characteristic, and a reduction in production cost can be achieved.

[0024] According to the seventh aspect of the invention, it is possible to further reduce the speed when the feed foot lands, and it is possible to further improve the durability of the mechanisms, the protection of the workpiece, and the cost reduction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Fig. 1 is a mechanism diagram showing a schematic configuration of a unison feed sewing machine according to a first embodiment of the invention.

[0026] Fig. 2 is an explanatory view showing an outer shape of a triangular cam in detail.

[0027] Fig. 3 is a configuration diagram of a cam mechanism which is viewed from the surface side of the unison feed

sewing machine.

[0028] Fig. 4 is an explanatory view showing a displacement in an X-axis direction generated in an engaging portion of an up-and-down movement rod in accordance with the rotation of the triangular cam.

[0029] Fig. 5 is diagram showing a positional displacement and a speed displacement of the triangular cam which are generated in a given direction in a case in which a coefficient k=0.7.

[0030] Fig. 6 is diagram showing the positional displacement and the speed displacement of the triangular cam which are generated in the given direction in a case in which the coefficient k=0.8.

[0031] Fig. 7 is diagram showing the positional displacement and the speed displacement of the triangular cam which are generated in the given direction in a case in which the coefficient k=0.866.

[0032] Fig. 8 is diagram showing the positional displacement and the speed displacement of the triangular cam which are generated in the given direction in a case in which the coefficient k=0.9.

[0033] Fig. 9 is diagram showing the positional displacement and the speed displacement of the triangular cam which are generated in the given direction in a case in which the coefficient k=1.0.

[0034] Fig. 10 is a configuration diagram of a cam mechanism of a second embodiment which is viewed from the surface side of the unison feed sewing machine.

[0035] Fig. 11 is a configuration diagram of a cam mechanism of a third embodiment which is viewed from the surface side of the unison feed sewing machine.

[0036] Fig. 12 is a configuration diagram of a cam mechanism of a fourth embodiment which is viewed from the surface side of the unison feed sewing machine.

[0037] Fig. 13 is diagram showing a positional displacement and a speed displacement which are generated in a given direction according to the cam mechanism of the fourth embodiment.

[0038] Fig. 14 is diagram showing a positional displacement and a speed displacement which are generated in a given direction by a conventional cam mechanism.

DETAILED DESCRIPTION

[0039] First Embodiment

[0040] Hereinafter, a first embodiment of the invention will be described in detail based on Figs. 1 to 9. In this embodiment, a unison feed sewing machine 10 which is one kind of bottom and top feed sewing machine will be described as an example. The unison feed sewing machine 10 includes a needle bar 11 which holds a sewing needle, a top feed foot 12 which contacts a workpiece on a throat plate from above and performs a feeding operation, a presser foot 13 which moves up and down alternately with the top feed foot 12, a feed dog 14 which contacts the workpiece on the throat plate from below and performs a feeding operation, a sewing machine motor 15 used as a main driving source for a sewing operation, an upper shaft 16 serving as a rotary shaft which performs a rotational drive by the sewing machine motor 15, a lower shaft 18 which performs a rotational drive by the sewing machine motor 15 via the upper shaft 16 and a timing belt 17, a needle up-and-down movement mechanism 30 which moves the needle bar 11 up and down, a top side back-and-forth feed mechanism 40 which gives a back-and-forth reciprocating movement along a cloth feeding direction to the needle bar 11 and the top feed foot 12, a top side up-and-down feed mechanism 50 which gives an up-and-down reciprocating movement to the top feed foot 12 and the presser foot 13, a bottom side back-and-forth feed mechanism 70 which gives a back-and-forth reciprocating movement along the cloth feeding direction to the feed dog 14, a bottom side up-and-down feed mechanism 80 which gives an up-and-down reciprocating movement to the feed dog 14, a feed-adjusting mechanism 90 which adjusts a feed amount of the feed dog 14, and a sewing machine frame 2 which supports the respective structures described above.

[0041] In the following description, a direction, which is parallel to the upper surface of the throat plate of the unison feed sewing machine 10 and extends along the cloth feeding direction, is defined as an X-axis direction, a direction, which is parallel to the upper surface of the throat plate of the sewing machine and orthogonal to the X-axis direction, is defined as an Y-axis direction, and a direction, which is perpendicular to the throat plate of the sewing machine, is defined as a Z-axis direction. It is assumed that the throat plate of the unison feed sewing machine 10 is provided such that the upper surface thereof is horizontal when the sewing machine 10 is set on a horizontal plane.

[0042] Needle Up-and-Down Movement Mechanism

[0043] The needle up-and-down movement mechanism 30 includes a rotary spindle 31 (shown by a simple straight line in Fig. 1) which is fixed and mounted on one end of the upper shaft 16 extending along the Y-axis direction, an eccentric rod 32 which has one end rotatably supported in a position eccentric from the rotation center of the rotary spindle 31, and a needle bar holder 33 which is fixed and mounted on the needle bar 11.

[0044] The eccentric rod 32 has one end supported on the rotary spindle 31 by a pivot extending along the Y-axis direction, and has the other end connected to the needle bar holder 33 by a pivot extending along the Y-axis direction.

[0045] This configuration enables the needle up-and-down movement mechanism 30 to convert the rotational motion of the upper shaft 16 to a reciprocating movement in the up-and-down direction, thereby giving the reciprocating movement

to the needle bar 11.

[0046] Bottom Side Up-and-Down Feed Mechanism

[0047] The bottom side up-and-down feed mechanism 80 includes an up-and-down movement cam 81 which is a circular eccentric cam fixed and supported on the lower shaft 18 extending along the Y-axis direction, an up-and-down movement rod 82 which rotatably holds the up-and-down movement cam 81 at one end thereof, an up-and-down feed shaft 83 which performs a reciprocating rotation, a transmission arm 84 which is fixed and mounted on the up-and-down feed shaft 83 and performs a reciprocating rotation around the up-and-down feed shaft 83, an up-and-down feed arm 85 which is fixed and mounted on the up-and-down feed shaft 83 and performs a rotational movement around the up-and-down feed shaft 83, and a link body 86 which connects one end of a feed table 19 which has the feed dog 14 mounted to a rotation end of the up-and-down feed arm 84.

[0048] The transmission arm 84 is fixed and supported on the up-and-down feed shaft 83 and oriented such that its longitudinal direction extends substantially along the Z-axis direction. The other end of the up-and-down movement rod 82 is connected to the rotation end of the transmission shaft 84. On the other hand, since an orbiting motion around the lower shaft 18 is given to the one end of the up-and-down movement rod 82 from the up-and-down movement cam 81, only the reciprocating displacement along the X-axis direction is transmitted to the rotation end of the transmission arm 84. As the rotation end of the transmission arm 84 performs a reciprocating rotation along the X-axis direction, the up-and-down feed shaft 83 performs a reciprocating rotation.

[0049] The up-and-down feed arm 85, which is fixed and supported on one end of the up-and-down feed shaft 83, is oriented such that its longitudinal direction extends substantially along the X-axis direction. As a result, in accordance with the reciprocating rotation of the up-and-down feed shaft 83, the rotation end of the up-and-down feed arm 85 performs a reciprocating rotation along the up-and-down direction, and gives the reciprocating movement in the up-and-down direction to one end of the feed table 19 via the link body 86.

[0050] Bottom Side Back-and-Forth Feed Mechanism

[0051] The bottom side back-and-forth feed mechanism 70 includes a back-and-forth movement cam 71 which is a circular eccentric cam fixed and supported on the lower shaft 18, a back-and-forth movement rod 72 which rotatably holds the back-and-forth movement cam 71 at one end thereof, a back-and-forth feed shaft 73 which performs a reciprocating rotation, a transmission arm 74 which is fixed and mounted on the back-and-forth feed shaft 73 and performs a reciprocating rotation around the back-and-forth feed shaft 73, a bell crank 75 which connects the other end of the back-and-forth movement rod 72 to the rotation end of the transmission arm 74, and a back-and-forth feed arm 76 which is fixed and mounted on the back-and-forth feed shaft 73 and performs a reciprocating rotation around the back-and-forth feed shaft 73.

[0052] The transmission arm 74 is fixed and supported on the back-and-forth feed shaft 73 and is oriented such that its longitudinal direction extends substantially along the Z-axis direction. Accordingly, the rotation end of the transmission arm 74 performs a reciprocating rotation substantially along the X-axis direction.

[0053] The bell crank 75 has a first connecting point 75a connected to the other end of the back-and-forth movement rod 72 and has a second connecting point 75b connected to the rotation end of the transmission arm 74. A third connecting point 75c of the bell crank 75 is configured such that a direction in which the reciprocating movement is performed can be changed to any directions along an X-Z plane by the feed-adjusting mechanism 90 which will be described later. As a result, when an orbiting motion is performed at one end of the back-and-forth movement rod 72 by the back-and-forth movement cam 71, the first connecting point 75a of the bell crank 75 performs the reciprocating movement so as to be brought into contact with or separated from the lower shaft 18, and the third connecting point 75c performs the reciprocating movement along a direction determined by the feed-adjusting mechanism 90. Also, a motion which is about the same as the motion in an X-axis direction component of the reciprocating movement of the third connecting point 75c is transmitted to the second connecting point 75b connected to the rotation end of the transmission arm 74.

[0054] As a result, the back-and-forth feed shaft 73 and the back-and-forth feed arm 76 perform reciprocating rotations with an angle adjusted by the feed-adjusting mechanism 90.

[0055] The back-and-forth feed arm 76 is fixed and supported on the back-and-forth feed shaft 73 and is oriented such that its longitudinal direction extends substantially along the Z-axis direction. Accordingly, the rotation end of the back-and-forth feed arm 76 performs a reciprocating rotation substantially along the X-axis direction, and gives the back-and-forth reciprocating movement to the feed table 19 by the reciprocating rotation of the back-and-forth feed shaft 73.

[0056] As described above, the up-and-down reciprocating movement is given to the one end of the feed table 19, by the bottom side up-and-down feed mechanism 80, and the back-and-forth reciprocating movement is given to the other end of the feed table 19 by the bottom side back-and-forth feed mechanism 70. Since both of the reciprocating movements of the feed mechanisms 70 and 80 have the sewing machine motor 15 as a driving source, their cycles coincide with each other. Accordingly, by suitably adjusting the phases and combining the reciprocating movements that the feed mechanisms transmit to the feed table 19, depending on the orientations and positions of the components of each of the feed mechanisms 70 and 80, it is possible to give a substantially elliptical motion which is long in the cloth feeding direction to the feed dog 14 mounted on the feed table 19.

[0057] The feed dog 14 is arranged such that its tooth tip protrudes to some degree from the upper surface of the throat plate when passing through an upper end of the trajectory of the elliptical motion, and contacts the workpiece on the upper surface of the throat plate from below to give the feeding movement.

[0058] Feed-Adjusting Mechanism

[0059] The feed-adjusting mechanism 90 includes a feed-adjusting motor 91 which is a pulse motor serving as a driving source for feed adjustment, an output arm 92 which rotates on an output shaft of the feed-adjusting motor 91 as an axis, an angular piece 93 which is provided at the third connecting point 75c of the bell crank 75 of the bottom side back-and-forth feed mechanism 70 described above, a substantially cylindrical angle-adjusting body 94 which has a guide groove which slidably supports the angular piece 93, an input arm 95 which performs rotation with the angle-adjusting body 94 as an axis, and a link body 96 which connects the rotation end of the output arm 92 to the rotation end of the input arm 95.

[0060] The angle-adjusting body 94 is formed with a slightly circular-arc guide groove along its radial direction, and the angular piece 93 is fitted thereinside, and is able to perform a reciprocating movement along the guide groove. Further, the angle-adjusting body 94 is oriented such that the centerline of the cylindrical shape thereof extends along the Y-axis direction, and is supported a sewing machine frame so as to be rotatable around the centerline. Accordingly, when the angle-adjusting body 94 rotates, the direction of the guide groove changes, and the direction of the reciprocating movement of the angular piece 93 is adjusted. This determines the movement direction of the third connecting point 75c of the bell crank 75 of the bottom side back-and-forth feed mechanism 70, and adjusts the movement amount of the feed dog 14 in the feeding direction (in the X direction).

[0061] The rotational movement of the angle-adjusting body 94 is given via the output arm 92, the link body 96, and the input arm 95 from the adjusting motor 91. This adjusting motor 91 is driven in accordance with a control command based on a feed amount set in a control means of the unison feed sewing machine 10 which is not shown.

Top Side Back-and-Forth Feed Mechanism

[0062] The top side back-and-forth feed mechanism 40 obtains a swinging driving force for the needle bar 11 and the top feed foot 12 from the back-and-forth feed shaft 73 of the bottom side back-and-forth feed mechanism 70 described above, thereby synchronizing the feed dog 14 and the top feed foot 12.

[0063] That is, the top side back-and-forth feed mechanism 40 includes a needle bar swinging frame 41 which supports the needle bar 11 and a supporting rod 20 of the top feed foot 12 so as to be movable up and down, a needle bar swinging shaft 42 which swingably supports the needle bar swinging frame 41, an output arm 43 which is fixed and supported on one end of the back-and-forth feed shaft 73, an input arm 44 which is fixed and supported on one end of the needle bar swinging shaft 42 and extends downward, and a link body 45 which connects the rotation end of the output arm 43 to the rotation end of the input arm 44.

[0064] The needle bar swinging shaft 42 is supported by the sewing machine frame so as to be rotatable along the Y-axis direction, and the needle bar swinging frame 41 swings integrally with the needle bar swinging shaft 42 on the needle bar swinging shaft 42 so that the lower end of the needle bar 11 and the top feed foot 12 located at the lower end of the instruction bar 20 can reciprocate along the X-axis direction (along the cloth feeding direction).

[0065] On the other hand, a reciprocating rotation is given to the needle bar swinging shaft 42 via the output arm 43, the link body 45, and the input arm 44 from the back-and-forth feed shaft 73 which performs a reciprocating rotation so that the feed dog 14 and the needle bar 11 can perform a reciprocating movement in the cloth feeding direction in synchronization with the top feed foot 12.

[0066] Top Side Up-and-Down Feed Mechanism

[0067] The top side up-and-down feed mechanism 50 includes a triangular cam 61 which is fixed and supported on the upper shaft 16, an up-and-down movement rod 62 serving as a cam follower which rotatably holds the triangular cam 61 at one end thereof, an up-and-down feed shaft 53 which performs a reciprocating rotation, a transmission arm 54 which is fixed and mounted on the up-and-down feed shaft 53 and performs a reciprocating rotation around the up-and-down feed shaft 53, an up-and-down feed arm 55 which is fixed and mounted on the up-and-down feed shaft 53 and performs a reciprocating rotation around the up-and-down feed shaft 53, a bell crank 56 which has first to third connecting points 56a, 56b, and 56c connected to the up-and-down feed arm 55, the top feed foot 12, and the presser foot 13, a link body 57 which connects the first connecting point 56a to the rotation end of the up-and-down feed arm 55, a link body 58 which connects the second connecting point 56b to the supporting rod 20 which supports the top feed foot 12, and a link body 59 which connects the third connecting point 56c to the supporting rod 21 which supports the presser foot 13.

[0068] The triangular cam 61 and the up-and-down movement rod 62 have a characteristic of giving a certain reciprocating displacement substantially along the X-axis direction by their cooperation, but these will be described later in detail.

[0069] The transmission arm 54 is arranged substantially along the Z-axis direction to transmit the reciprocating rotation

to the up-and-down feed shaft 53 as a reciprocating displacement is input to the rotation end of the transmission arm from the up-and-down movement rod 62 along the X-axis direction as described above.

[0070] On the other hand, the up-and-down feed arm 55 is also arranged along the Z-axis direction, and the rotation end of the up-and-down feed arm 55 also performs a reciprocating movement along the X-axis direction by the reciprocating rotation of the up-and-down feed shaft 53.

[0071] The bell crank 56 is triangular, and is arranged in such a position that one side which connects the second connecting point 56b to the third connecting point 56c is oriented substantially in the X-axis direction, and the first connecting point 56a is located above the one side. In this arrangement, when input is performed to one side (second connecting point 56b side) of the reciprocating movement along the X-axis direction on the first connecting point 56a, the bell crank 56 performs a rotational movement which moves down the second connecting point 56b with respect to the third connecting point 56c, thereby moving down the top feed foot 12. Further, when input is performed to the other side (third connecting point 56c side) of the reciprocating movement along the X-axis direction, the bell crank 56 performs the rotational movement which moves down the third connecting point 56c with respect to the second connecting point 56b, thereby moving down the presser foot 13. When the top feed foot 12 (or the presser foot 13) reaches the throat plate by its downward movement, it cannot move down any further. Therefore, the operation is performed to move the presser foot 13 (or the top feed foot 12) upward instead. That is, when the top feed foot 12 performs the downward movement, the upward movement of the presser foot 13 is performed accordingly, and when the feed foot 13 performs the downward movement, the upward movement of the top feed foot 12 is performed accordingly. Each of the up-and-down reciprocating movement of the top feed foot 12 and the up-and-down reciprocating movement of the presser foot 13 are performed for one stroke during one rotation of the upper shaft 16.

[0072] Cam Mechanism of Top Side Up-and-Down Feed Mechanism

[0073] The triangular cam 61 and the up-and-down movement rod 62 described above form the cam mechanism 60. Fig. 2 is an explanatory view showing the outer shape of the triangular cam 61 in detail, and Fig. 3 is a configuration diagram of the cam mechanism 60 which is viewed from the surface side of the sewing machine 10.

[0074] The triangular cam 61 has an outer circumference whose shape is obtained by connecting two kinds circular arcs, each of three vertices of an equilateral triangle being a center of small and large circular arcs, and has a circumferential surface formed along the outer circumferential shape as a cam surface. That is, the triangular cam 61 is configured to have the outer circumferential shape by forming, around a vertex of an equilateral triangle, a circular arc (referred to as a large circular arc A), which is the outer edge of a sector shape having a central angle of 60° and a radius R that encompasses the entire region of the equilateral triangle, and a circular arc (referred to as a small circular arc a) having a radius r and a central angle of 60° directly opposite to the large circular arc A, for each of the vertices of the equilateral triangle, and by alternately connecting the ends of the large circular arcs and the small circular arcs. The radius R of the large circular arc A, the radius r of the small circular arc a, and the length T of one side of the equilateral triangle satisfy $R = r + T$.

[0075] According to this outer circumferential shape, the width of the triangular cam 61 in a straight line passing through the vertex always becomes $r + R$.

[0076] General triangular cams that conventionally exist have the outer diameter described above, and rotates around one of the vertices of the equilateral triangle. On the other hand, the triangular cam 61 applied in the sewing machine 10 of the invention has a position on a perpendicular line P drawn down from one of the vertices to the corresponding base and beyond the central point C of the equilateral triangle as its rotation center S. In order to distinguish from the other two bases, the base to which the perpendicular line P is drawn down will be referred to as "the base U". By arranging the rotation center S of the triangular cam 61 as described above, the base U is arranged to be closer to the rotation center S compared with the other two bases (that is, is arranged closest to the rotation center S among the three bases).

[0077] Because the triangular cam 61 is fixed and supported on the upper shaft 16, rotation is given completely in synchronization with the up-and-down movement of the needle bar 11. That is, the triangular cam 61 makes one revolution during one stroke of the needle bar 11. Further, the triangular cam 61 is fixed and mounted on the upper shaft 16 so as to have such a phase that the top feed foot 12 is located at the upper dead point of its up-and-down reciprocating movement when the needle bar 11 is located at the upper dead point of its up-and-down reciprocating movement.

[0078] As a result, when the needle bar 11 is located at the upper dead point, the base U of the triangular cam 61 extends along the vertical up-and-down direction.

[0079] The up-and-down movement rod 62 is configured by a rod portion 63 which has one end rotatably connected to the rotation end of the transmission arm 54 via the stepped screw 69, and an engaging portion 64 which engages with the triangular cam 61 at the other end of the rod portion 63.

[0080] The engaging portion 64 is formed in an annular shape having a square-shaped opening formed therein, the length of one side of the inside square set be $r + R$, and is configured to engage with the triangular cam 61 in a state where the triangular cam 61 is received therein. Further, a set of cam-receiving surfaces 65 and 66 along two facing sides of the square shape are parallel to each other, and are parallel to the up-and-down feed shaft 53. Further, the cam-receiving surfaces 65 and 66 are substantially orthogonal to the direction of a movement to be given to the trans-

mission arm 54 (here, the longitudinal direction of the rod portion 63). The cam-receiving surfaces 65 and 66 give a reciprocating rotation to the transmission arm 54 and the up-and-down feed shaft 53 by the displacement received from the triangular cam 61. Further, the displacement which the receiving surfaces 67 and 68 receive is absorbed as the up-and-down movement rod 62 rotates around the stepped screw 69, and is hardly transmitted to the transmission arm 54 as a displacement.

[0081] Next, the relationship between the displacement and the speed along the X-axis direction transmitted to the transmission arm 54 from the triangular cam 61 and the cam-receiving surfaces 65 and 66 of the up-and-down movement rod 62, and the position of the rotation center of the triangular cam 61 described above will be described in detail.

[0082] Fig. 4 is an explanatory view showing the displacement in the X-axis direction of the position of the central point C of the triangular cam 61, i.e., the displacement in the X-axis direction transmitted the transmission arm 54 from the up-and-down movement rod 62 in accordance with the rotation of the triangular cam 61. The description will be given on the premise that the triangular cam 61 rotates clockwise with the shaft angle of the upper shaft 16 and the phase of the triangular cam 61 in the state of Fig. 3 being 0°. In the state where the shaft angle of the upper shaft 16 and the phase of the triangular cam 61 are 0°, the top feed foot 12 and the needle bar 11 are each located at the upper dead point. Further, since the position of the central point C of the triangular cam 61 in a state in which the shaft angle of the upper shaft 16 and the phase of the triangular cam 61 are 90° is the center of the amplitude in the X-axis direction of the position of the central point C of the triangular cam 61, description will be made with a displacement at said position being 0. Additionally, because the displacement in the Z direction hardly affects the displacement in the X direction, in order to simplify the description, in the following expressions are described with the displacement in the Z direction being 0.

[0083] When the shaft angle of the upper shaft 16 is defined as θ, and the displacement in the X-axis direction of the central point C of the triangular cam 61 is defined $f(\theta)$, the central point C of the triangular cam 61 shows positional displacements as follows.

$$\text{In the section of 0 to 30°, } f(\theta)=-0.5T-k\cdot T\cdot\sin(\theta-(\pi/2))$$

$$\text{In the section of 30 to 90°, } f(\theta)=0.5T-T\cos(\theta-(\pi/6))-k\cdot T\cdot\sin(\theta-(\pi/2))$$

$$\text{In the section of 90 to 150°, } f(\theta)=-0.5T+T\cos(\theta-(5\pi/6))-k\cdot T\cdot\sin(\theta-(\pi/2))$$

$$\text{In the section of 150 to 210°, } f(\theta)=0.5T-k\cdot T\cdot\sin(\theta-(\pi/2))$$

$$\text{In the section of 210 to 270°, } f(\theta)=-0.5T+T\cos(\theta-(7\pi/6))-k\cdot T\cdot\sin(\theta-(\pi/2))$$

$$\text{In the section of 270 to 330°, } f(\theta)=0.5T+T\cos(\theta-(5\pi/6))-k\cdot T\cdot\sin(\theta-(\pi/2))$$

$$\text{In the section of 330 to 360°, } f(\theta)=-0.5T-k\cdot T\cdot\sin(\theta-(\pi/2))$$

[0084] In the respective expressions, k is a ratio of the distance from the vertex of the equilateral triangle to the rotation center S to the length T of one side of the equilateral triangle being 1.

[0085] Further, the speed $f'(\theta)$ of the central point C of the triangular cam 61 in the respective sections are as follows.

$$\text{In the section of 0 to 30°, } f'(\theta)=-k\cdot T\cdot\cos(\theta-(\pi/2))$$

In the section of 30 to 90°, $f'(\theta)=T\sin(\theta-(\pi/6))-k\cdot T\cdot\cos(\theta-(\pi/2))$

In the section of 90 to 150°, $f'(\theta)=-T\sin(\theta-(5\pi/6))-k\cdot T\cdot\cos(\theta-(\pi/2))$

In the section of 150 to 210°, $f'(\theta)=-k\cdot T\cdot\cos(\theta-(\pi/2))$

In the section of 210 to 270°, $f'(\theta)=-T\sin(\theta-(7\pi/6))-k\cdot T\cdot\cos(\theta-(\pi/2))$

In the section of 270 to 330°, $f'(\theta)=-T\sin(\theta-(5\pi/6))-k\cdot T\cdot\cos(\theta-(\pi/2))$

In the section of 330 to 360°, $f'(\theta)=-k\cdot T\cdot\cos(\theta-(\pi/2))$

[0086] Here, the relationship between the positional displacement D and the speed displacement V of the position of the central point C of the triangular cam 61 when a coefficient k varies are shown in Figs. 5 to 8. The diagrams of the positional displacement D and the speed displacement V of Figs. 5 to 8 show the position $f(\theta)$ and the speed $f'(\theta)$ by continuously connecting all the sections of 0° to 360°. The top feed foot 12 lands on the workpiece in the phase of the point G in the diagrams. Here, the point G is set to be the exactly middle position in the up-and-down swing.

[0087] Fig. 5 shows a case where k= 0.7, Fig. 6 shows a case where k= 0.8, Fig. 7 shows a case where k= 0.866, Fig. 8 shows a case where k= 0.9, and Fig. 9 shows a case where k= 1.0. The value of k= 0.866 of Fig. 7 is the case where the rotation center S of the triangular cam 61 is set to the intersection point of the perpendicular line and the base U. In this case, it is found that the speed V=0 is in the phase of the point G where the top feed foot 12 lands on the workpiece. Further, also in the case of k= 0.7 to 1.0 where the rotation center is near thereto, it is found that the top feed foot 12 lands on the workpiece in the phase of the point G at a speed which is equal to or lower than half the maximum speed of the upward movement or the downward movement. That is, it is found that sufficient speed reduction is possible when the top feed foot 12 lands.

[0088] Operation of Unison Feed Sewing Machine

[0089] According to the unison feed sewing machine 10 having the configuration described above, the needle up-and-down movement mechanism 30 gives the up-and-down movement to the needle bar 11 driving the sewing machine motor 15. In addition, an elliptical motion is given to the feed dog 14 by the cooperation of the bottom side back-and-forth feed mechanism 70 and the bottom side up-and-down feed mechanism 80, whereby the feeding operation from below the workpiece is executed.

[0090] The top feed foot 12 and the presser foot 13 are moved up and down alternately by the top side up-and-down feed mechanism 50, and the top feed foot 12 executes the up-and-down movement together with the needle bar 11.

[0091] Further, the top side back-and-forth feed mechanism 40 receives the swinging movement from the back-and-forth feed shaft 73 of the bottom side back-and-forth feed mechanism 70, and gives the back-and-forth swinging movement to the needle bar 11 and the upper feed foot 12. At this time, the bottom side back-and-forth feed mechanism 70 swings backward when the needle bar 11 and the top feed foot 12 are moving up, and swings forward when the needle bar 11 and the top feed foot 12 are moving down. Accordingly, feeding is performed by the top feed foot 12 while the workpiece is pierced with the sewing needle, so that an effective feeding is implemented even with a workpiece which is heavy or thick. Additionally, the forward feeding operation by the top feed foot 12 and the forward feeding operation by the feed dog 14 are simultaneously performed, and this operation also contributes to the implementation of the effective feeding.

[0092] Moreover, since the top side up-and-down feed mechanism 50 includes the cam mechanism 60 described above, when the top feed foot 12 moves down from the upper dead point to the lower dead point, the downward movement speed decreases temporarily to 0 at a midpoint therebetween, whereby the impact of landing of the top feed foot 12 is moderated and reduced.

[0093] As described above, in the cam mechanism 60 of the unison feed sewing machine 10, the up-and-down

movement rod 62 receives the displacement by the receiving surfaces 65 and 66 from the triangular cam 61 whose rotation center is offset, and takes out the reciprocating movement. Further, the triangular cam 61 has a characteristic that the speed is greatly reduced at a position which is almost in the middle position of one maximum displacement and the other maximum displacement in terms of the positional displacement in a certain reciprocating direction (here, the X-axis direction). Therefore, by converting this into a reciprocating rotation and transmitting it to the up-and-down feed shaft 53 so as to use it to give the up-and-down movement to the top feed foot 12, it is possible to reduce the speed at the middle position from the upper dead point to the lower dead point of the top feed foot 12. As a result, it is possible to avoid a situation in which the downward movement speed is becomes the maximum when the top feed foot 12 lands. Due to the low-speed landing, it is possible to reduce impact and improve the durability of the mechanisms, and it is also possible to avoid a heavy blow to the workpiece. Along with this, it is also possible to avoid an increase in production cost due to reinforcement of the top feed foot.

[0094] Particularly, in the unison feed sewing machine 10, the rotation center of the triangular cam 61 is set at the intersection point S of the perpendicular line P drawn down from an vertex of the equilateral triangle and the base U. Thus, the speed can be set to 0 at the midpoint between two phases at which maximum amplitude are generated. Also, by making an adjustment such that the top feed foot 12 lands on the throat plate at the midpoint, the downward movement speed when the top feed foot 12 lands on the workpiece can be made almost 0, and it is possible to more effectively implement improvement in durability of the mechanisms, the protection of the workpiece, and cost reduction.

[0095] Second Embodiment

[0096] Another example of the cam mechanism will be described with reference to Fig. 10.

[0097] The cam mechanism 60A includes the same triangular cam 61 as the one described above, a two-pronged up-and-down movement rod 62A, and a link body 67A which transmits the swinging movement given to the up-and-down movement rod 62A from the triangular cam 61 to the transmission arm 54.

[0098] The up-and-down movement rod 62A includes a rod portion 63A having one end rotatably supported inside the sewing machine frame by the pivot 69A, and an engaging portion 64A which is engaged with the triangular cam 61 at the other end of the rod portion 63A. The engaging portion 64A includes a set of cam-receiving surfaces 65A, 66A which contact the outer circumference of the triangular cam so as to place the triangular cam 61 therebetween. The cam-receiving surfaces 65A, 66A are flat surfaces that are parallel to the longitudinal direction of the rod portion 63A, and thereby, make it possible to rotate the up-and-down movement rod 62A around the pivot 69A. Differently from the up-and-down movement rod 62 described above, the up-and-down movement rod 62A is arranged so as to extend substantially along the Z-axis direction. The swinging movement generated in the engaging portion 64A of the up-and-down movement rod 62A is given to the rotation end of the transmission arm 54 by the link body 67A.

[0099] Also in this case, the triangular cam 61 is fixed and mounted on the upper shaft 16 such that the phase thereof is adjusted such that the top feed foot 12 is located at the upper dead point when the needle bar 11 is located at the upper dead point. As a result, at the upper dead point of the needle bar 11, the base U of the triangular cam 61 is oriented in the vertical up-and-down direction.

[0100] By incorporating the cam mechanism 60A into the unison feed sewing machine 10 instead of the cam mechanism 60, it is possible to obtain the same advantages as the foregoing unison feed sewing machine 10.

[0101] Third Embodiment

[0102] Another example of the cam mechanism will be described with reference to Fig. 11.

[0103] This cam mechanism 60B includes the same triangular cam 61 as the first embodiment, the same two-pronged up-and-down movement rod 62A as the second embodiment, and a link body 67B A four-bar link mechanism is configured by the cam mechanism 60B and the transmission arm 54.

[0104] The up-and-down movement rod 62A extends substantially along the X-axis direction to connects one end of the rod portion 63A to the rotation end of the transmission arm 54 by the stepped screw 69.

[0105] The link body 67B has one end rotatably connected to the sewing machine frame by a pivot 68B, and has the other end connected to the engaging portion 64A of the up-and-down movement rod 62A via a stepped screw 66B. Thereby, a swinging movement is given to the engaging portion 64A of the up-and-down movement rod 62A in a direction orthogonal to the longitudinal direction of the rod portion 63A of the up-and-down movement rod 62A by the triangular cam 61. Although this direction of swinging movement does not coincide with the direction in which reciprocating rotation is given to the transmission arm 54, the portion of the up-and-down movement rod 62A on the side of the engaging portion 64A is limited in the trajectory of movement by the link body 67B. As a result, the reciprocating movement is performed also in the longitudinal direction of the rod portion 63A of the up-and-down movement rod 62A, so that reciprocating rotation can be given to the transmission arm 54.

[0106] Also in this case, the phase of the triangular cam 61 is fixed and mounted on the upper shaft 16 such that the phase thereof is adjusted such that the top feed foot 12 is located at the upper dead point when the needle bar 11 is located at the upper dead point. However, in this example, when the needle bar 11 is located at the upper dead point, as shown in Fig. 11, the base U of the triangular cam 61 is oriented in the horizontal direction.

[0107] Accordingly, by incorporating the cam mechanism 60B into the unison feed sewing machine 10 instead of the

cam mechanism 60, it is possible to obtain the same advantages as the foregoing unison feed sewing machine 10.

[0108] Fourth Embodiment

[0109] Another example of the cam mechanism will be described with reference to Figs. 12 and 13.

[0110] This cam mechanism 60C includes a triangular cam 61C which has the same outer circumferential shape as the foregoing triangular cam 61 and which is fixed and supported on the upper shaft 16 such that the position of the rotation center coincide with one of the vertices of the equilateral triangle, and an up-and-down movement rod 62C which rotatably holds the triangular cam 61C at one end thereof.

[0111] The up-and-down movement rod 62C includes a rod portion 63C which has one end rotatably connected to the rotation end of the transmission arm 54 via the stepped screw 69, and an engaging portion 64C which is engaged with the triangular cam 61C at the other end of the rod portion 63C.

[0112] The engaging portion 64C has a structure which is formed in an annular shape which has a square opening formed therein, has the length of one side of the inside square is set to r + R, and is engaged with the triangular cam 61C in a state in which the triangular cam 61C is received therein. A set of cam-receiving surfaces 65C, 66C along two opposite sides of the square shape are parallel to each other, and are parallel to the up-and-down feed shaft 53. Further, the cam-receiving surfaces 65C, 66C are inclined at about 45° with respect to the direction of the movement (here, the longitudinal direction of the rod portion 63) to be given to the transmission arm 54. Another set of cam-receiving surfaces 67C, 68C along two opposite sides of the square shape are also parallel to each other, and are parallel to the up-and-down feed shaft 53. Further, the cam-receiving surfaces 67C, 68C are inclined at about 45° with respect to the direction of the movement (here, the longitudinal direction of the rod portion 63C) to be given to the transmission arm 54, and are orthogonal to the cam-receiving surfaces 65C, 66C described above. As a result, a displacement, which is obtained by combining the displacements which two sets of receiving surfaces 65C, 66C and 67C, 68C receive from the triangular cam 61C, is given to the up-and-down movement rod 62C in its longitudinal direction.

[0113] The triangular cam 61C is also fixed and mounted on the upper shaft 16 such that the phase thereof is adjusted such that the top feed foot 12 is located at the upper dead point when the needle bar 11 is located at the upper dead point. Further, when the needle bar 11 is located at the upper dead point, the base U which becomes the farthest from the rotation center of the triangular cam 61C (in this example, not a base closest to the rotation center but the base which is farthest from the rotation center), as shown in Fig. 12, is oriented in the vertical up-and-down direction. Moreover, when the needle bar 11 is located at the upper dead point, all of the four cam-receiving surfaces 65C, 66C, 67C, 68C are inclined at about 45° with respect to the reciprocating movement direction of the up-and-down movement rod 62C when viewed in the Y-axis direction. It is preferable that the angle of inclination of each of the cam-receiving surfaces 65C, 66C, 67C, 68C be within a range of 40 to 50°.

[0114] Fig. 13 shows the positional displacement D and speed displacement V according to the cam mechanism 60C. As shown in Fig. 13, there is a period during which the speed decreases while the cam mechanism 60C shifts from one maximum amplitude to the other maximum amplitude. That is, when the cam mechanism 60C is used for the up-and-down movement of the top feed foot 12, deceleration can be made in the way of reaching the lower dead point from the upper dead point, and the deceleration can be made at the time of landing.

[0115] Accordingly, by incorporating the cam mechanism 60C into the unison feed sewing machine 10 instead of the cam mechanism 60, it is possible to obtain the same effects as the foregoing unison feed sewing machine 10.

[0116] While the triangular cam is fixed and supported by the upper shaft 16 in this embodiment, the triangular cam may be fixed to another shaft as long as the shaft makes a single rotation during a single up-and-down movement of the needle bar 11. It is needless to say that other mechanisms can also be suitably changed without departing from the spirit of the invention.

Claims

1. A bottom and top feed sewing machine (10) comprising:

a feed dog (14) which contacts a workpiece on a throat plate from below to perform a feeding operation;
a top feed foot (12) which contacts the workpiece on the throat plate from above to perform a feeding operation;
a bottom side back-and-forth feed mechanism (70) which gives a reciprocating movement along a feeding direction to the feed dog (14);
a bottom side up-and-down feed mechanism (80) which gives a reciprocating movement along an up-and-down direction to the feed dog (14);
a top side back-and-forth feed mechanism (40) which gives a reciprocating movement along the feeding direction to the top feed foot (12); and
a top side up-and-down feed mechanism (50) which gives a reciprocating movement along the up-and-down direction to the top feed foot (12),

wherein the feed dog (14) and the top feed foot (12) cooperate to feed the workpiece,
characterized in that

the top side up-and-down feed mechanism (50) comprises a cam mechanism (60, 60A, 60B) which takes out a reciprocating movement from a rotational movement of a rotary shaft (16) which performs a rotational drive,
the cam mechanism comprises (60, 60A, 60B) a triangular cam (61) having an outer circumference, a shape of which is obtained by connecting two kinds of circular arcs (A, a), each of three vertices of an equilateral triangle being a center of small and large circular arcs, and a cam follower (62, 62A) having at least one set of receiving surfaces (65, 66, 67, 68) facing each other and contacting the outer circumference so as to place the triangular cam (61) therebetween,
the triangular cam (61) is fixed and supported on the rotary shaft (16) so as to rotate around a position, which is on a perpendicular line (P) drawn down to a base (U) from one of the vertices and is closer to the base (U) than the center (c)of the equilateral triangle is, and
the triangular cam (61) is fixed and supported on the rotary shaft (16) such that, when a needle bar (11) which performs stitching by an up-and-down movement is located at the upper dead point of the up-and-down movement, the top feed foot (12) is located at the upper dead point of the reciprocating movement along the up-and-down direction.

2. The bottom and top feed sewing machine (10) according to claim 1, whrein, when the needle bar (11) is located at the upper dead point, the base (U) is oriented in a vertical direction (Z) or in a horizontal direction (X).

3. The bottom and top feed sewing machine (10) according to claim 1 or 2, wherein, when a length (T) of one side of the equilateral triangle is 1, a distance from the vertex to the rotation center of the triangular cam (61) is 0.7 or more but 1.0 or less.

4. The bottom and top feed sewing machine (10) according to claim 3, wherein, the position of the rotation center is an intersection point (S) of the perpendicular line (P) and the base (U).

5. A bottom and top feed sewing machine (10) comprising:

a feed dog (14) which contacts a workpiece on a throat plate from below to perform a feeding operation;
a top feed foot (12) which contacts the workpiece on the throat plate from above to perform a feeding operation;
a bottom side back-and-forth feed mechanism (70) which gives a reciprocating movement along a feeding direction to the feed dog (14);
a bottom side up-and-down feed mechanism (80) which gives a reciprocating movement along an up-and-down direction to the feed dog (14);
a top side back-and-forth feed mechanism (40) which gives a reciprocating movement along the feeding direction to the top feed foot (12); and
a top side up-and-down feed mechanism (50) which gives a reciprocating movement along the up-and-down direction to the top feed foot (12),

wherein the feed dog (14) and the top feed foot (12) cooperate to feed the workpiece,
characterized in that

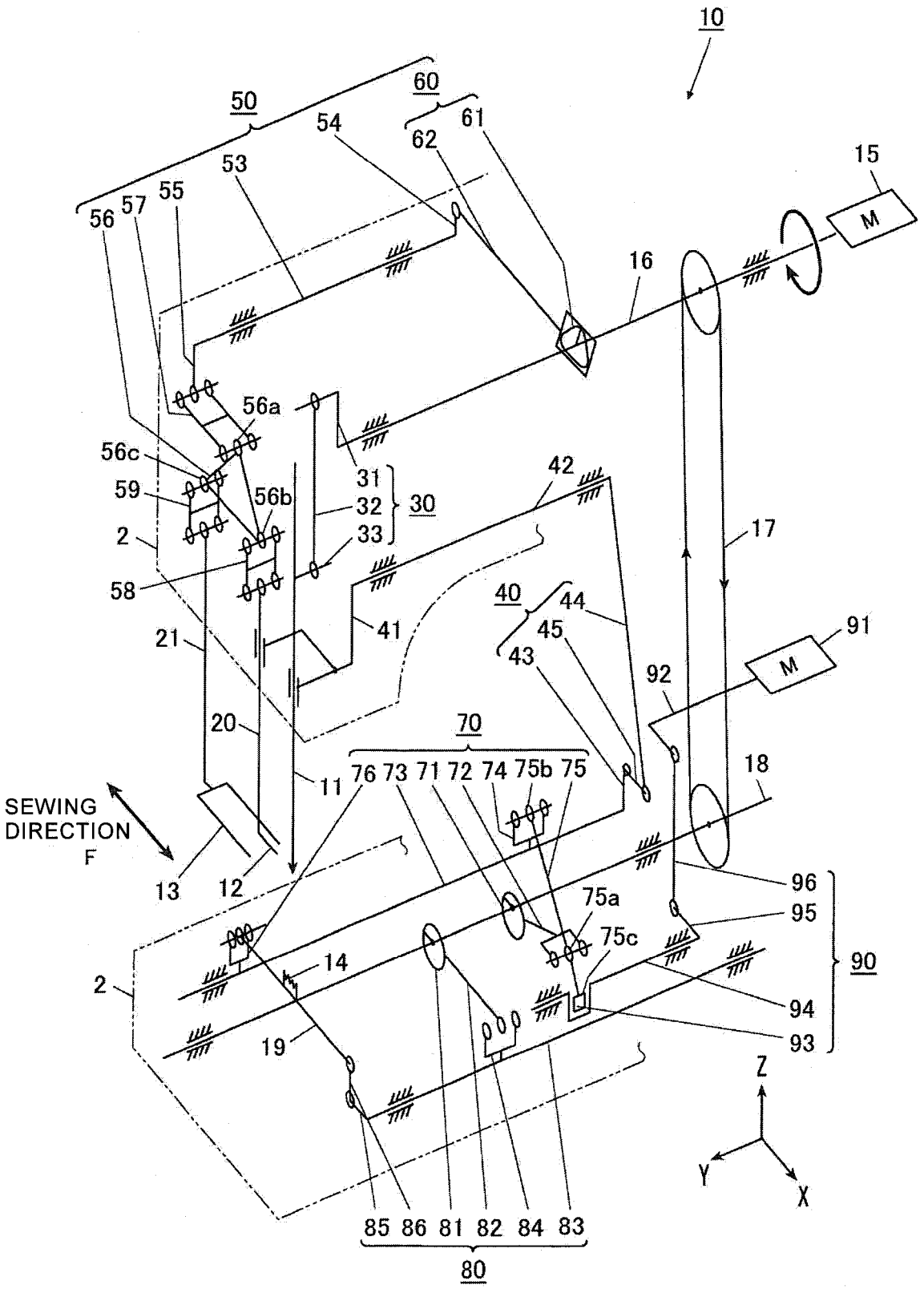
the top side up-and-down feed mechanism (50) comprises a cam mechanism (60C) which takes out a reciprocating movement from a rotational movement of a rotary shaft (16) which performs a rotational drive,
the cam mechanism (60C) comprises a triangular cam (61C) having an outer circumference, a shape of which is obtained by connecting two kinds of circular arcs (A, a), each of three vertices of an equilateral triangle being a center of small and large circular arcs, and a cam follower (62C) having at least two sets of receiving surfaces (65C, 66C, 67C, 68C) facing each other and contacting the outer circumference so as to place the triangular cam (6 1 C) therebetween,
the triangular cam (61C) is fixed and supported on the rotary shaft (16) so as to rotate around one of the vertices,
the cam follower (62C) performs a reciprocating movement in accordance with a combined displacement of displacements received by the two sets of receiving surfaces (65C, 66C, 67C, 68C), and
the triangular cam (62C) is fixed and supported on the rotary shaft such that, when a needle bar (11) which performs stitching by an up-and-down movement is located at the upper dead point of the up-and-down movement, the top feed foot (12) is located at the upper dead point of the reciprocating movement along the up-and-down direction.

6. The bottom and top feed sewing machine (10) according to claim 5, wherein, when the needle bar (11) is located at the upper dead point, the base (U) of the equilateral triangle, which is farthest away from the vertex located at the rotation center of the triangular cam (62C), is oriented in a vertical direction (Z), and

when the needle bar (11) is located at the upper dead point, the two sets of mutually parallel receiving surfaces (65C, 66C, 67C, 68C) of the cam follower (62C) are inclined within a range of 40 to 50° with respect to a direction of the reciprocating movement of the cam follower (62C).

7. The bottom and top feed sewing machine (10) according to claim 5 or 6, wherein the two sets of mutually parallel receiving surfaces (65C, 66C, 67C, 68C) are all inclined at 45° with respect to the direction of the reciprocating movement of the cam follower (62C).

FIG. 1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50
60
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62
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56c
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56b
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42
2
58
17
40
44
45
43
41
21
91
M
92
20
70
76 73 71 72 74 75b 75
18
11
SEWING DIRECTION F
13
12
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75c
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14
2
94
93
19
Z
Y
X
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80

FIG. 2

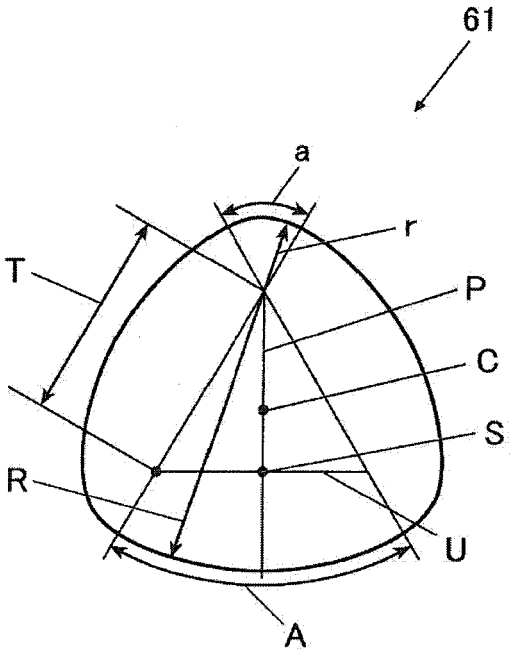


FIG. 3

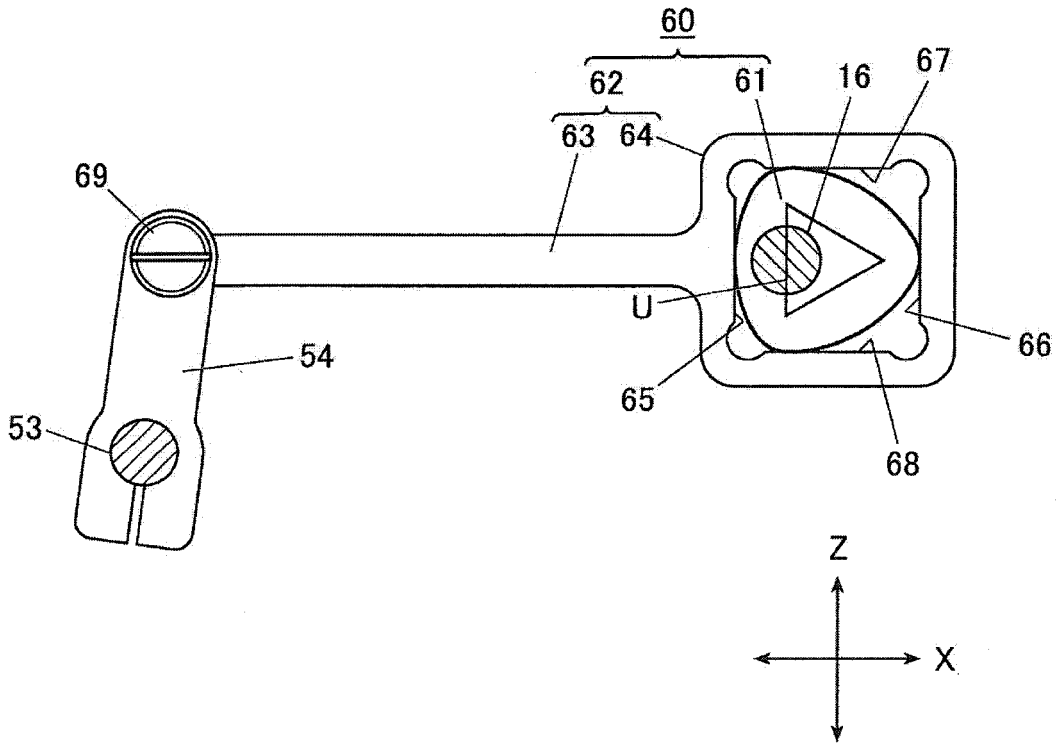


FIG. 4

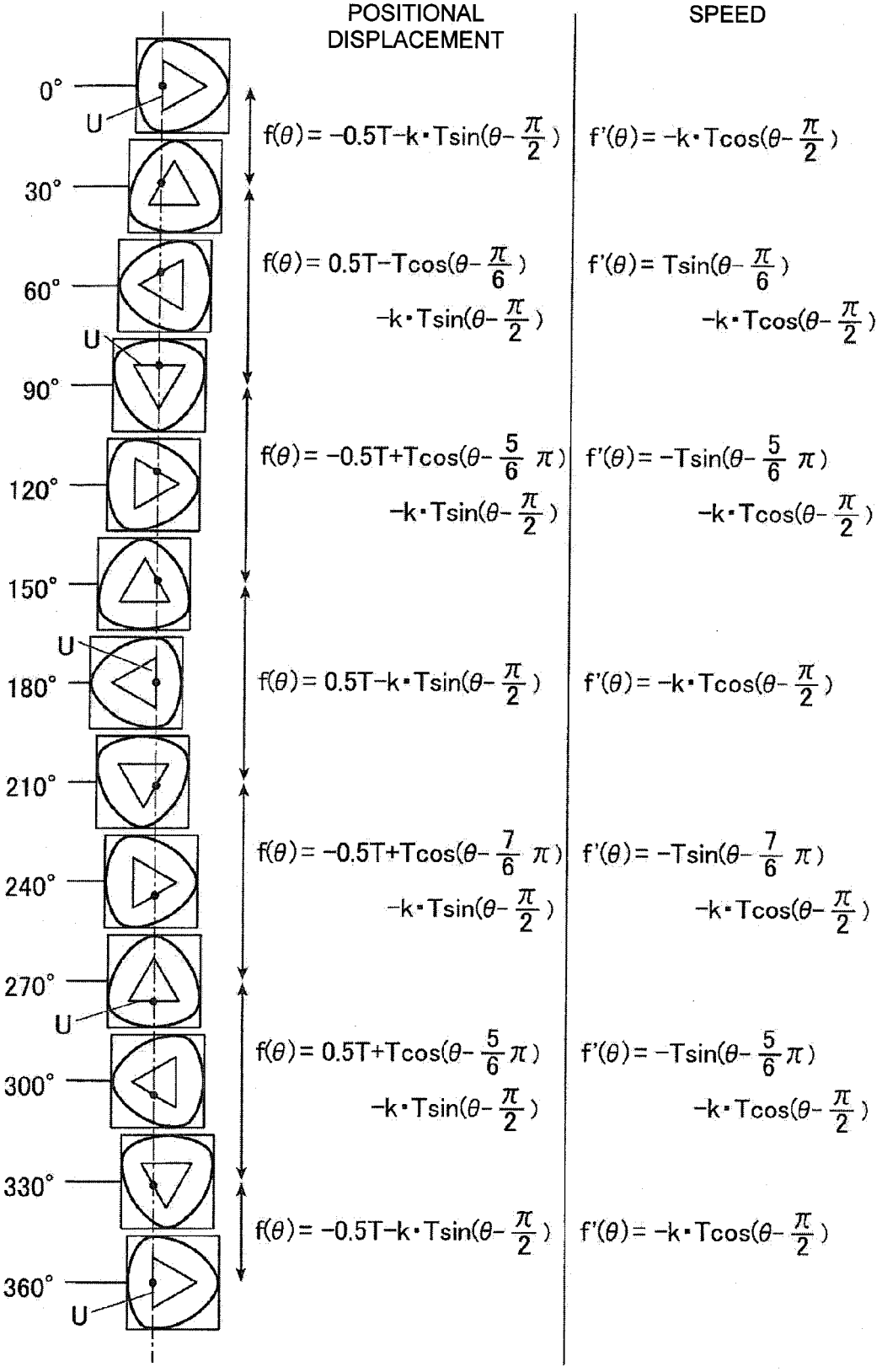

POSITIONAL DISPLACEMENT
SPEED
0°
U
30°
60°
U
90°
120°
150°
U
180°
210°
240°
270°
U
300°
330°
360°
U
f(θ) = −0.5T−k·Tsin(θ− π/2)
f'(θ) = −k·Tcos(θ− π/2)
f(θ) = 0.5T−Tcos(θ− π/6) −k·Tsin(θ− π/2)
f'(θ) = Tsin(θ− π/6) −k·Tcos(θ− π/2)
f(θ) = −0.5T+Tcos(θ− 5/6 π) −k·Tsin(θ− π/2)
f'(θ) = −Tsin(θ− 5/6 π) −k·Tcos(θ− π/2)
f(θ) = 0.5T−k·Tsin(θ− π/2)
f'(θ) = −k·Tcos(θ− π/2)
f(θ) = −0.5T+Tcos(θ− 7/6 π) −k·Tsin(θ− π/2)
f'(θ) = −Tsin(θ− 7/6 π) −k·Tcos(θ− π/2)
f(θ) = 0.5T+Tcos(θ− 5/6 π) −k·Tsin(θ− π/2)
f'(θ) = −Tsin(θ− 5/6 π) −k·Tcos(θ− π/2)
f(θ) = −0.5T−k·Tsin(θ− π/2)
f'(θ) = −k·Tcos(θ− π/2)

FIG. 5

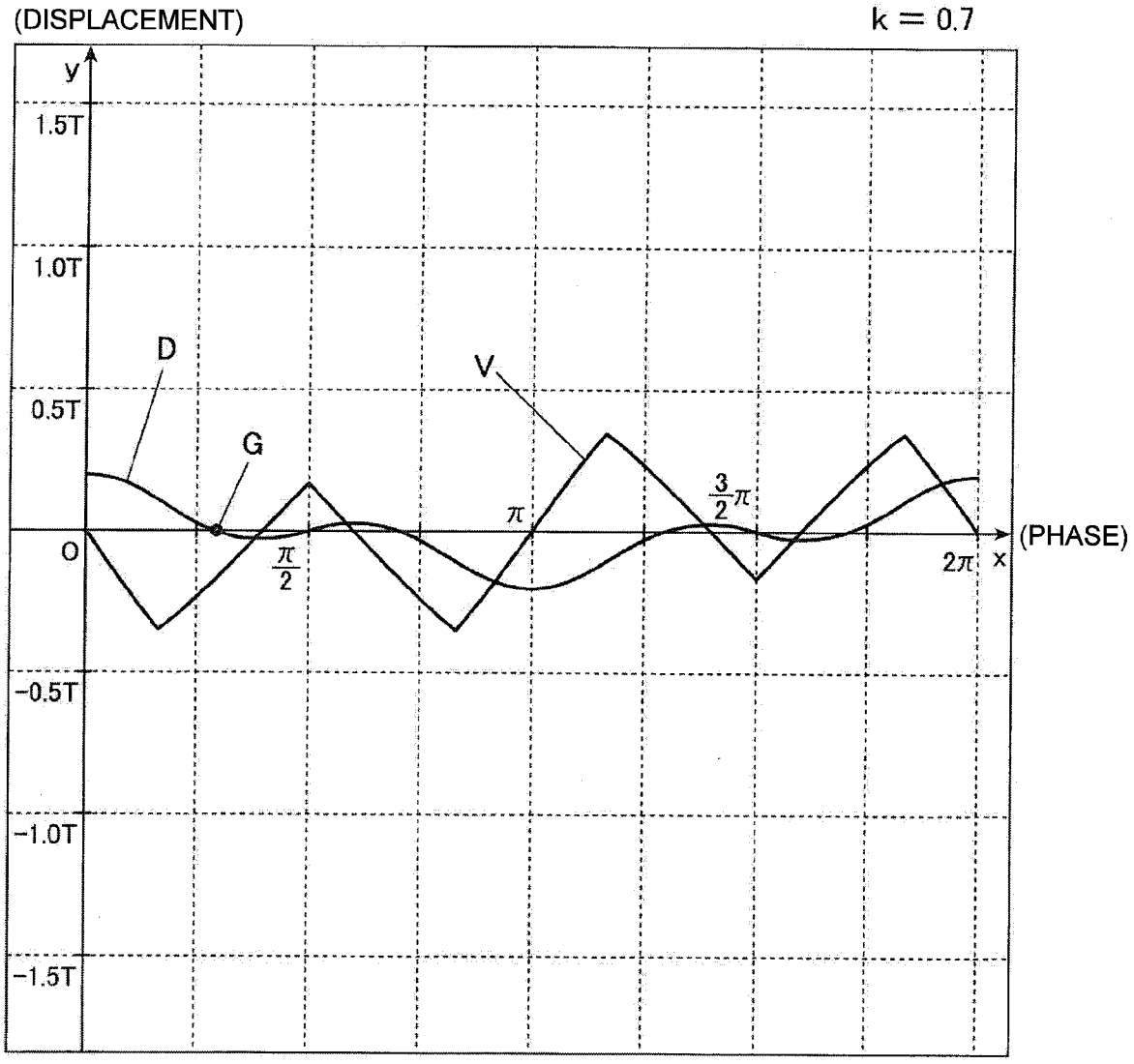

(DISPLACEMENT)
k = 0.7
y
1.5T
1.0T
0.5T
O
−0.5T
−1.0T
−1.5T
D
G
V
π/2
π
3/2π
2π
x
(PHASE)

FIG. 6

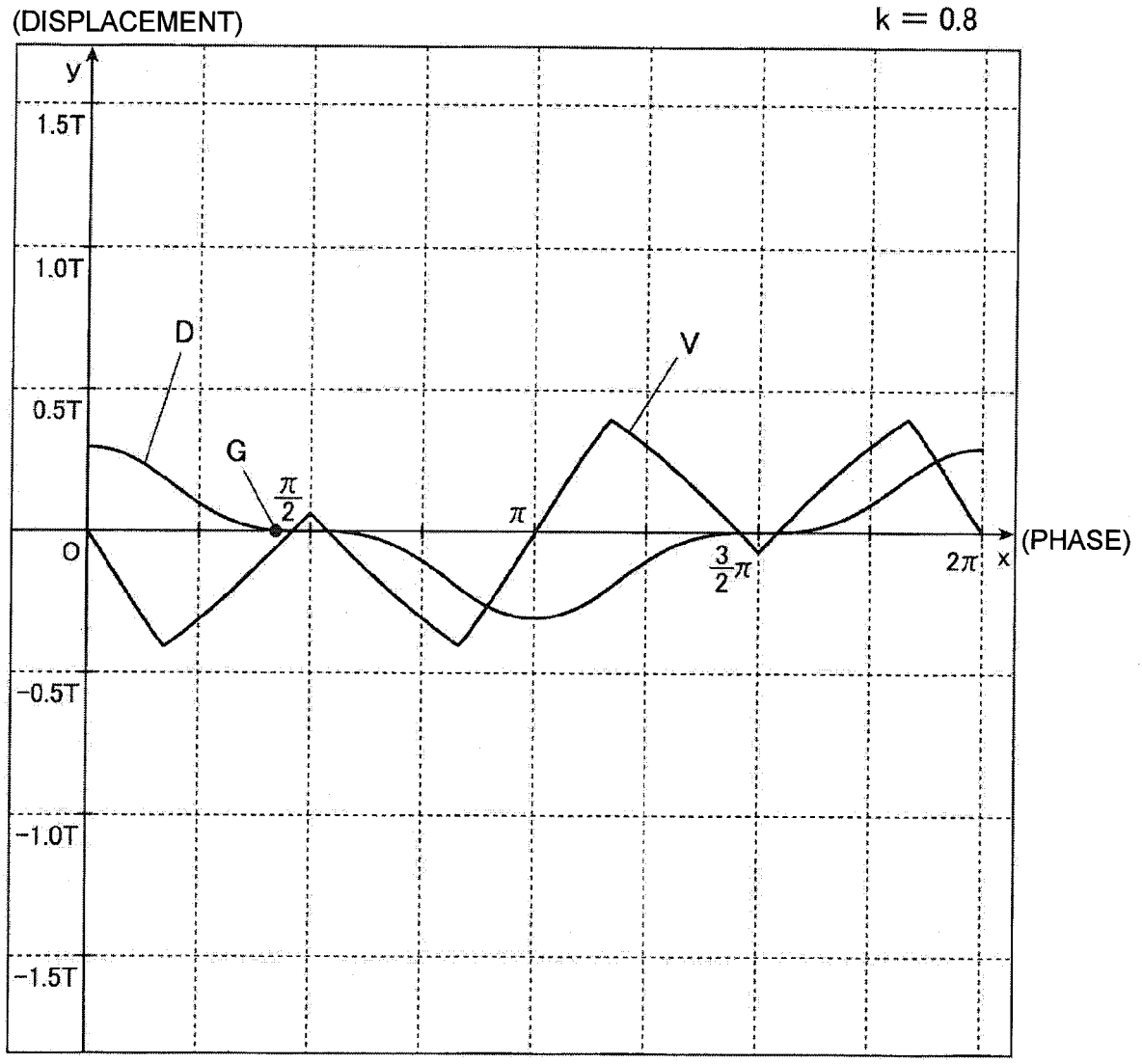

(DISPLACEMENT)
k = 0.8
y
1.5T
1.0T
0.5T
O
−0.5T
−1.0T
−1.5T
D
V
G
π/2
π
3/2π
2π
x
(PHASE)

FIG. 7

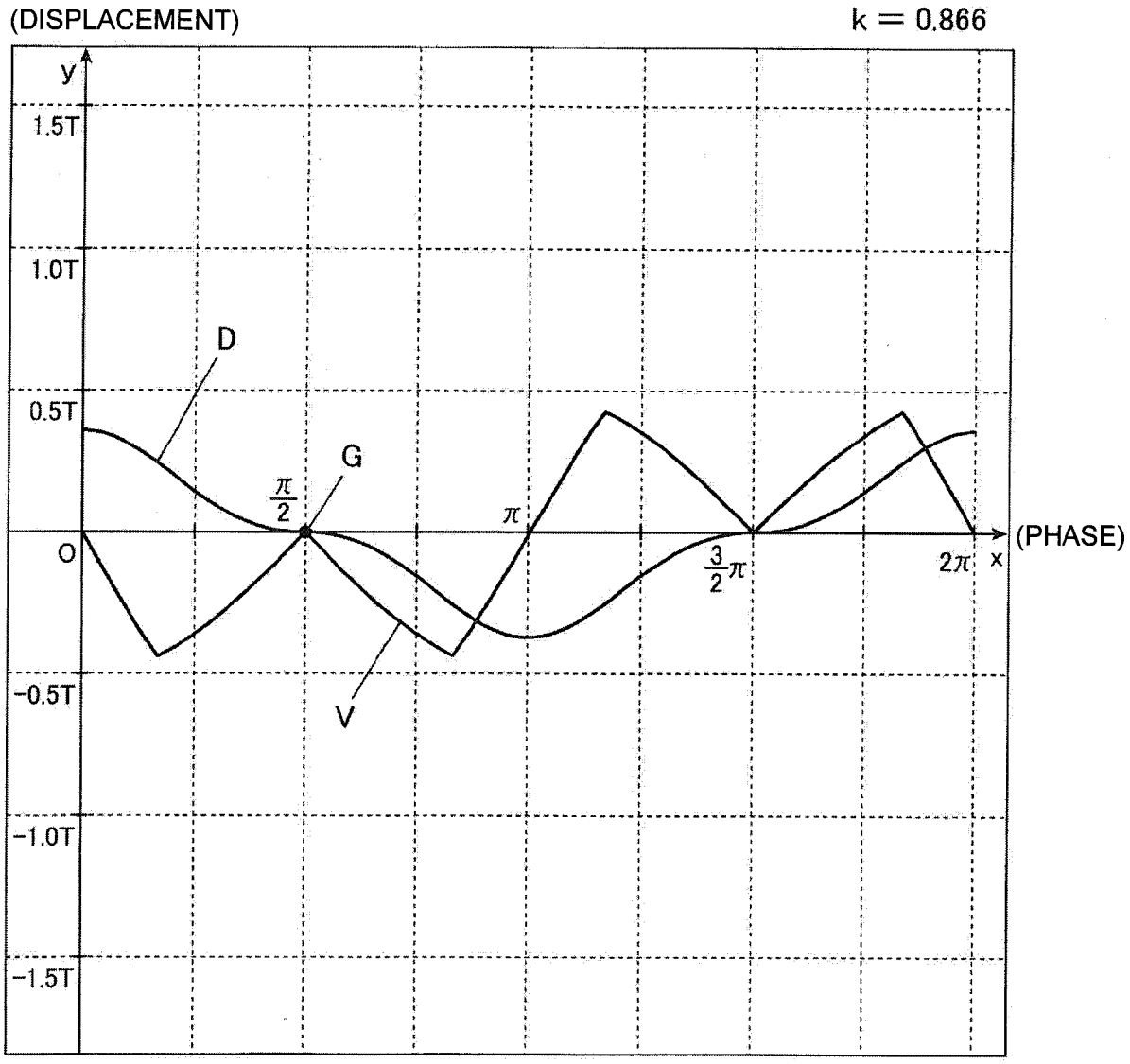

(DISPLACEMENT)
k = 0.866
y
1.5T
1.0T
0.5T
O
-0.5T
-1.0T
-1.5T
D
G
V
π/2
π
3/2π
2π
x
(PHASE)

FIG. 8

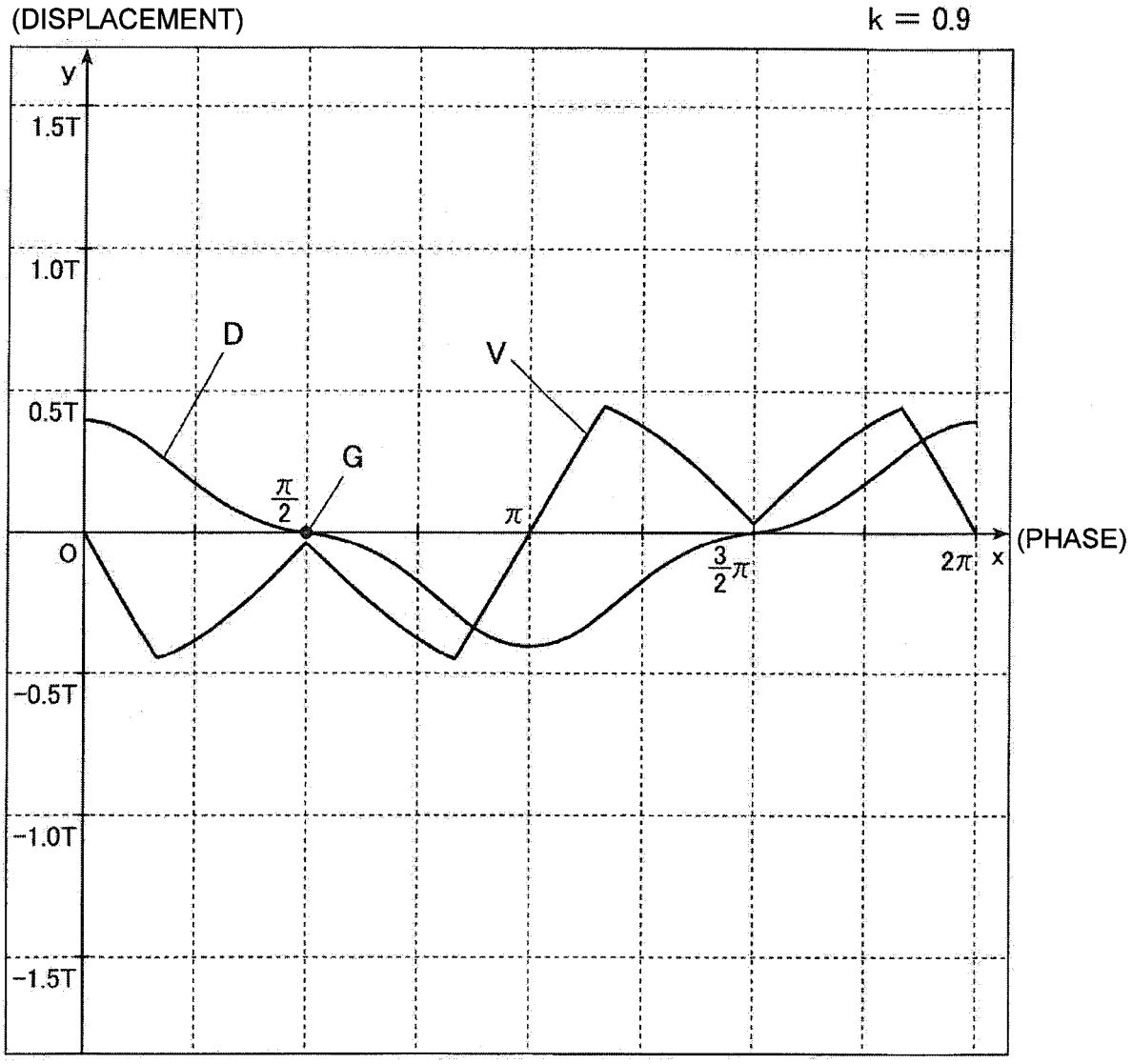

(DISPLACEMENT)
k = 0.9
y
1.5T
1.0T
0.5T
O
−0.5T
−1.0T
−1.5T
D
V
G
π/2
π
3/2π
2π
x
(PHASE)

FIG. 9

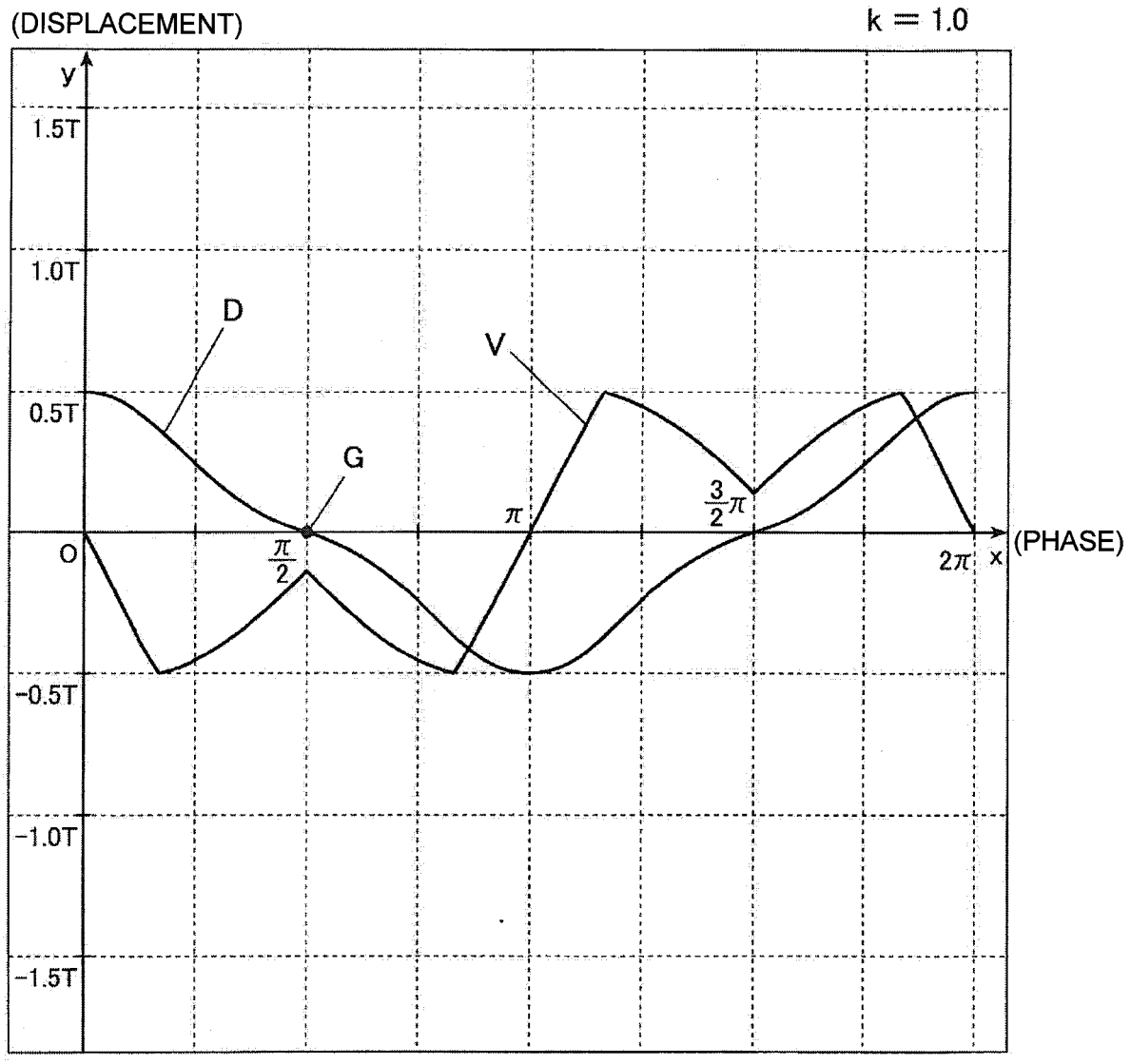

(DISPLACEMENT)
k = 1.0
y
1.5T
1.0T
0.5T
O
-0.5T
-1.0T
-1.5T
D
V
G
π/2
π
3/2π
2π
x
(PHASE)

FIG. 10

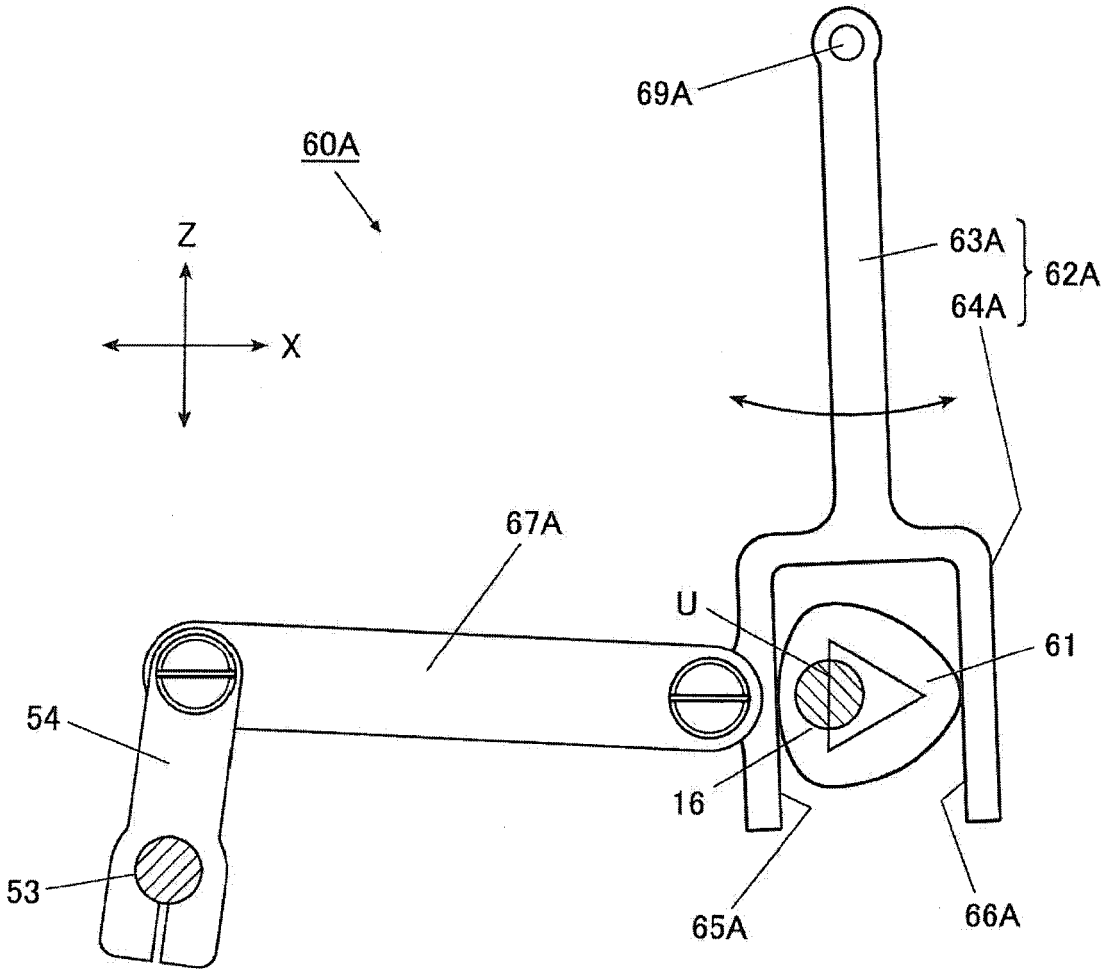


FIG. 11

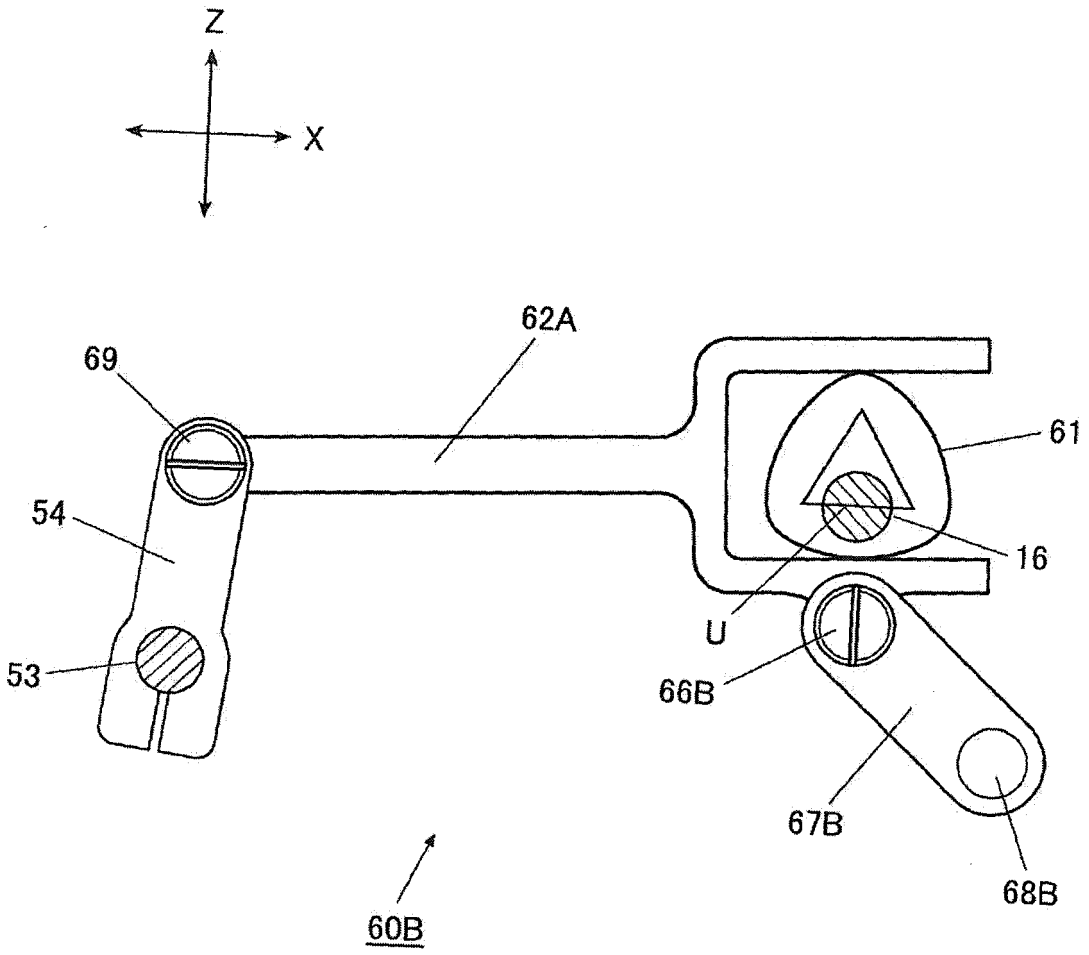


FIG. 12

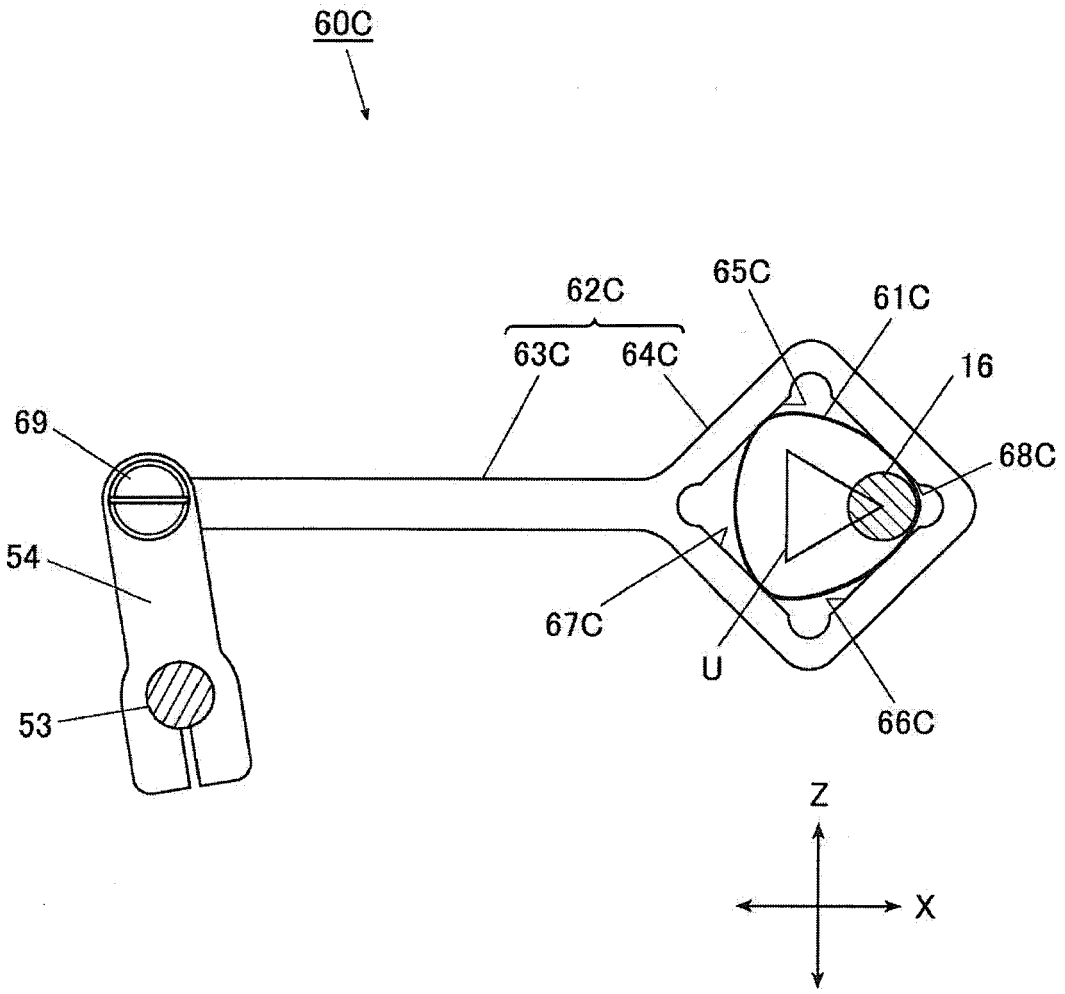


FIG. 13

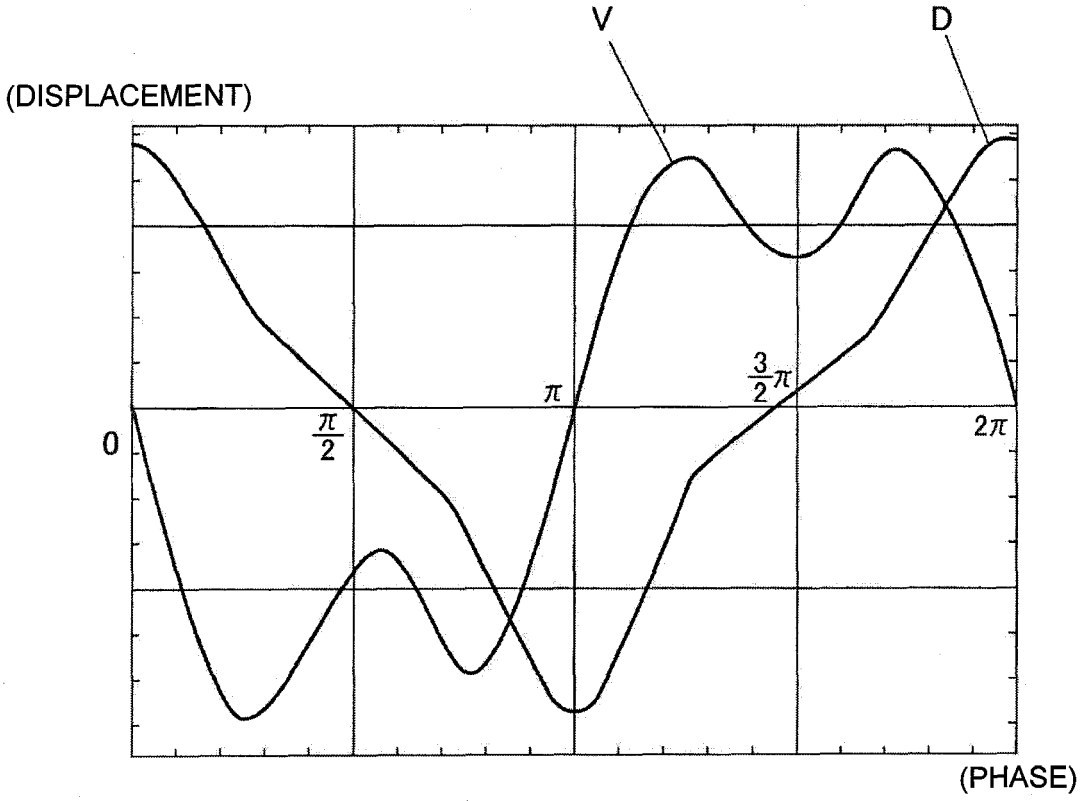
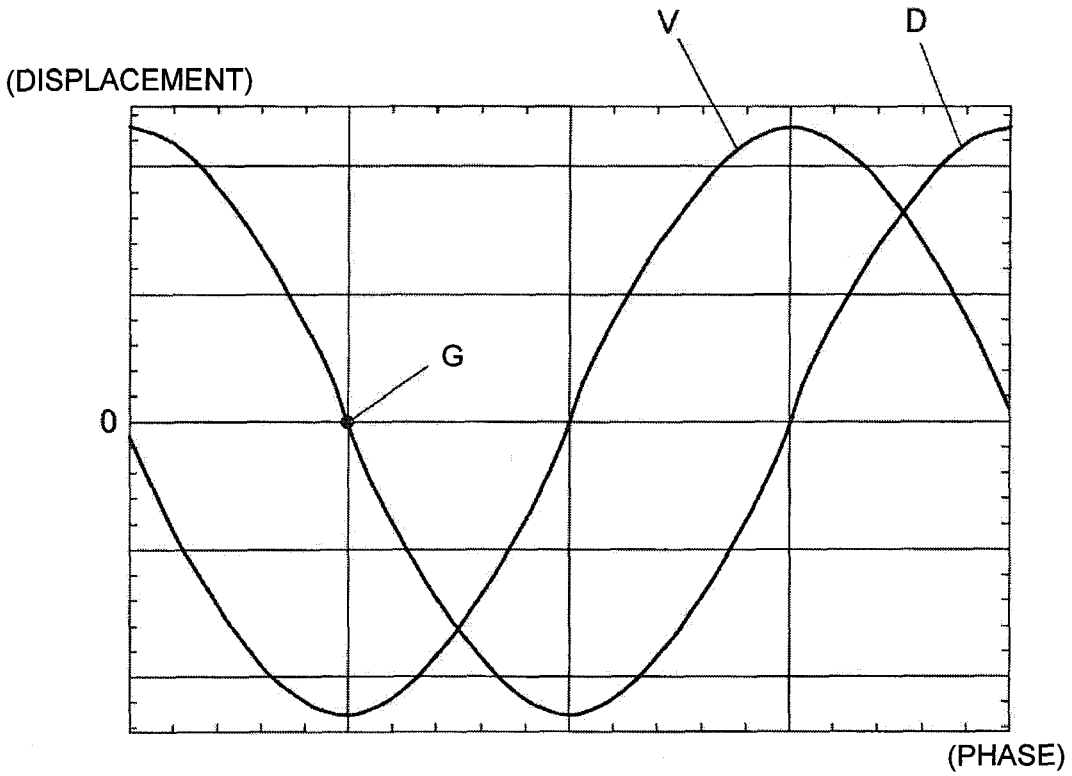


FIG. 14



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Patent documents cited in the description

- JP 3529414 B **[0002]**