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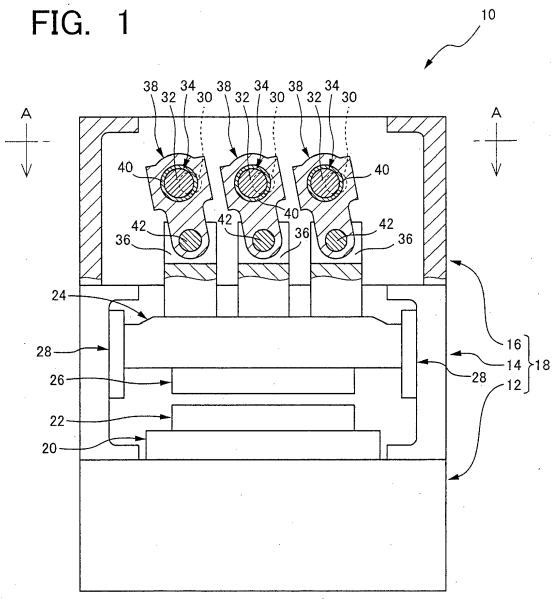
(54) PRESSING MACHINE

(57) A pressing machine having a structure improved to smoothly transmit a rotary driving force among a plurality of crankshafts, and so as to have improved start/stop performance and improved press forming accuracy, and so as to permit reduction of a cycle time required for forming the desired product. In the pressing machine having a plurality of crankshafts (34) each having main shaft portions (30) and an eccentric shaft portion (32), at least one first connection lever (48) is attached to the eccentric shaft portions (32) of the plurality of crankshafts for rotating the plurality of crankshafts in synchronization with each other, and a second connection lever (56) is attached to pins (54) which are formed integrally with the respective crankshafts, and positions of which as seen in a circumferential direction of the main shaft portions are different from those of the eccentric shaft portions.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention generally relates to a pressing machine, and more particularly to a pressing machine having an improved structure configured to smoothly transmit a rotary driving force among a plurality of crankshafts that move a slider or slide member to which a pressing die is attached.

BACKGROUND ART

[0002] As a pressing machine driven by crankshafts, there is known a pressing machine configured to cause a reciprocatory movement of the slider, to which the pressing die is attached, by synchronous rotary motions of a plurality of crankshafts. As an example of such pressing machine, the applicant of this invention disclosed, in JP-A-9-155595 (Patent Document 1), a pressing machine configured to transmit a rotary motion of at least one of the plurality of crankshafts to the other crankshafts through yokes. In this pressing machine, the rotary motion of the at least one rotated crankshaft (driving crankshaft) is transmitted to the other crankshafts (driven crankshafts) through the yokes, such that the driven crankshafts are rotated in synchronization with the driving crankshaft.

[0003] However, the above-described transmitting mechanism using the yokes has an inherent problem of difficulty in smoothly transmitting the rotary motion among the plurality of crankshafts, due to presence of a dead center, which is a position at which axes of main portions (axes of rotation) of the respective crankshafts and axes of eccentric portions of the respective crankshafts are all located in a common plane, and a driving force is linearly transmitted from the driving crankshaft to the driven crankshafts through the yokes, so that a direction of rotation of the driven crankshafts is instantaneously unfixed.

[0004] Under the above-described circumstances, JP-U-52-53476 (Patent Document 2) discloses a slider-moving apparatus in a pressing machine having two sliders disposed on its respective right and left sides and two slider-driving gears which are spaced apart from each other and which move the respective right and left sliders. This publication discloses that a rotary driving force can be smoothly and surely transmitted from one of the above-described two gears to the other gear through two links which connect the two gears to each other such that the two links have a phase difference therebetween, so that the driving force applied to one of the two sliders is transmitted to the other slider.

[0005] However, in the pressing machine configured as described above, a number of gear members having a large moment of inertia (inertia force) are used, so that the pressing machine as a whole has an extremely large moment of inertia, giving rise to a problem that the pressing machine has a poor operating response at the time of initiation and termination of its operation, namely, so-called start/stop performance of the pressing machine is low. Further, the driving force applied from a power source to the one of the above-described two sliders is transmitted to the other slider through the links and a plurality of gears, resulting in the poor operating response (start/stop performance) of the pressing machine and low accuracy of synchronization of movements of the right and left sliders. Moreover, at the time of initiation and termination of the operation of the pressing machine, an amount of rotation of crankshafts and an amount of movement of the sliders may vary from nominal values due to the moment of inertia, giving rise to a risk of deterioration of press forming accuracy and an inherent problem of difficulty in reducing a cycle time required for forming a desired product using the pressing machine.

[0006] Further, in the apparatus disclosed in Patent Document 2, each of idler gears consists of co-axially disposed two gears, and the above-described two links are connected to the respective two gears, in order to avoid an interference between the two links, an interference between the links and the gears (idler gear) and an interference between the links and shaft members of the gears (idler gear). Further, the two gears constituting the idler gear are configured so as to be rotated in synchronization with each other through an intermediate gear having a large width. Accordingly, the apparatus as a whole has an extremely complex structure. The apparatus even has an inherent problem of an increase of its cost due to a large number of components and necessity to take measures for controlling accuracy and backlashes of the gears for synchronously moving the right and left sliders.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0007]

Patent Document 1: JP-A-9-155595
Patent Document 2: JP-U-52-53476

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0008] The invention was made in view of the background art described above. It is therefore a problem to be solved by the invention to provide a pressing machine having an improved structure configured to smoothly transmit a rotary driving force among a plurality of crankshafts, and so as to have improved start/stop performance and improved press forming accuracy, and so as to permit reduction of a cycle time required for forming a desired product.

SOLUTION TO PROBLEM

[0009] In order to solve the above-described problem, the present invention provides a pressing machine comprising: a plurality of crankshafts each of which has two co-axially disposed main shaft portions and an eccentric shaft portion disposed between and eccentrically with respect to the two main shaft portions, and which are rotatably supported at their main shaft portions by a frame, such that their axial directions are parallel to each other, and such that they are spaced apart from each other with a predetermined distance therebetween; connecting rods connected at one of their opposite end portions to the eccentric shaft portions of the plurality of crankshafts; a slider connected to the other end portions of the connecting rods, and reciprocated by displacements of the eccentric shaft portions caused by rotary motions of the plurality of crankshafts about respective axes of their main shaft portions; at least one first connection lever attached to the eccentric shaft portions of the plurality of crankshafts, for transmitting a rotary driving force transmitted to one of the plurality of crankshafts to another of the plurality of crankshafts, so that the plurality of crankshafts are rotated in synchronization with each other; eccentric levers each provided on an axial end portion of one of the two main shaft portions of the respective crankshafts, which axial end portion outwardly projects from the frame, such that the eccentric levers extend in a direction perpendicular to axial directions of the main shaft portions; pins provided so as to project from the respective eccentric levers in a direction parallel to the axial directions of the main shaft portions, and such that positions of the pins as seen in a circumferential direction of the main shaft portions are different from those of the eccentric shaft portions, and such that distal end portions of the pins are located axially outwardly of corresponding ends of the respective crankshafts; and a second connection lever attached to the distal end portions of the respective pins, whereby the rotary driving force is smoothly transmitted to the another of the plurality of crankshafts by cooperating actions of the at least one first connection lever and the second connection lever.

[0010] In a preferred form of the pressing machine according to the invention, the eccentric shaft portions and the pins have a phase difference of 90° therebetween during the rotary motions of the crankshafts about the respective axes of their main shaft portions.

[0011] In other preferred form of the pressing machine according to the invention, an eccentricity amount of an axis of each of the pins with respect to the axis of the main shaft portions is larger than an eccentricity amount of an axis of the eccentric shaft portion with respect to the axis of the main shaft portions.

[0012] In a further preferred form of the pressing machine according to the invention, the second connection lever has a thickness smaller than that of the at least one first connection lever.

[0013] In a still further preferred form of the pressing machine according to the invention, the at least one first connection lever comprises a plurality of first connection levers each connecting the eccentric shaft portions of adjacent ones of the plurality of crankshafts to each other, and the plurality of first connection levers comprise two first connection levers which are disposed on respective opposite sides of a portion of the eccentric shaft portion of one of the plurality of crankshafts connected to corresponding one of the connecting rods, as seen in an axial direction of the eccentric shaft portion, and extend from the eccentric shaft portion of the above-indicated one crankshaft in respective opposite directions which are perpendicular to the axial direction of the eccentric shaft portion and parallel to a plane including axes of the eccentric shaft portions of the above-indicated one crankshaft and two other crankshafts disposed on respective opposite sides of the above-indicated one crankshaft.

[0014] In a yet further preferred form of the pressing machine according to the invention, the above-indicated one of the plurality of crankshafts to which the rotary driving force is transmitted is interposed between two other crankshafts which are rotated with the rotary driving force received from the above-indicated one of the plurality of crankshafts, and the at least one first connection lever comprises two first connection levers connecting the eccentric shaft portion of the above-indicated one of the plurality of crankshafts respectively to the eccentric shaft portions of the above-indicated two other crankshafts, and wherein the two first connection levers are attached to the above-indicated one of the plurality of crankshafts, such that the two first connection levers are disposed on respective opposite sides of a portion of the eccentric shaft portion of the above-indicated one crankshaft connected to corresponding one of the connecting rods, as seen in an axial direction of the eccentric shaft portion, and extend from the eccentric shaft portion of the above-indicated one crankshaft in respective opposite directions which are perpendicular to the axial direction of the eccentric shaft portion and parallel to a plane including axes of the eccentric shaft portions of the above-indicated one crankshaft

and the above-indicated two other crankshafts.

[0015] In a further preferred form of the pressing machine according to the invention, the eccentric shaft portion has a large-diameter portion and at least one small-diameter portion which has a diameter smaller than that of the large-diameter portion and which is formed co-axially with the large-diameter portion, and the one end portion of each of the connecting rods is connected to the large-diameter portion, while the at least one first connection lever is attached to the at least one small-diameter portion.

[0016] In a further preferred form of the pressing machine according to the invention, the slider has an elongate rectangular shape as seen in its plan view, and the plurality of crankshafts are disposed such that their axial directions are perpendicular to a longitudinal direction of the slider, and such that they are spaced apart from each other in the longitudinal direction of the slider.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0017] In the pressing machine according to the invention, the at least one first connection lever is attached to the eccentric shaft portions of the plurality of crankshafts, while the second connection lever is attached to the pins each of which is provided on the axial end portion of corresponding one of the two main shaft portions of the respective crankshafts through the eccentric lever, and positions of which as seen in the circumferential direction of the main shaft portions are different from those of the eccentric shaft portions. Accordingly, the rotary driving force transmitted to one of the plurality of crankshafts is smoothly transmitted to another one of the plurality of crankshafts by the cooperating actions of the first and second connection levers.

[0018] Therefore, during the rotary motions of the crankshafts, there is a phase difference between positions at which the at least one first connection lever is attached to the crankshafts and positions at which the second connection lever is attached to the crankshafts, as seen in the direction of rotation of the crankshafts. Accordingly, even when the above-indicated another crankshaft reaches the dead center in a mechanism for transmitting the rotary driving force through the at least one first connection lever, the direction of rotation of the above-indicated another crankshaft is fixed by a force applied to that crankshaft by the second connection lever. Thus, the pressing machine as a whole does not have an actual dead center when the rotary driving force is transmitted among the plurality of crankshafts, whereby the rotary driving force can be smoothly transmitted among the plurality of crankshafts.

[0019] The pressing machine according to the invention requires no gear members, so that the pressing machine is not affected by a large moment of inertia of the gear members, whereby start/stop performance (operating response) of the pressing machine is advantageously improved, and a desired pressing operation can be performed with a high degree of press forming accuracy using the pressing machine, and a cycle time required for forming the desired product using the pressing machine can be effectively reduced. Further, the pressing machine as a whole has a simplified structure, since it requires no gear members, resulting in an advantage of reduction of a cost of its production.

[0020] Further, the eccentric levers are each provided on the axial end portion of corresponding one of the two main shaft portions of the respective crankshafts, which axial end portion outwardly projects from the frame, so that there is no need to increase the size of the frame in order to attach the second connection lever to the pins projecting from the eccentric levers. Accordingly, a distance between the main shaft portions of each crankshaft supported by the frame (distance between bearings) is not increased, resulting in an advantage that a high degree of concentricity between the main shaft portions can be easily obtained.

[0021] Further, the second connection lever is attached to the distal end portions of the respective pins, which distal end portions are located axially outwardly of the corresponding ends of the respective crankshafts, so that an interference between the second connection lever and the crankshafts can be advantageously prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

Fig. 1 is a schematic front elevational view of a pressing machine according to one embodiment of the invention, partly in cross section;
Fig. 2 is a cross sectional view taken along a line A-A in Fig. 1;
Fig. 3 is a fragmentary cross sectional view taken along a line B-B in Fig. 2;
Fig. 4 is a fragmentary cross sectional view taken along a line C-C in Fig. 2;
Fig. 5 is a fragmentary cross sectional view taken along a line D-D in Fig. 2;
Fig. 6 is an enlarged fragmentary cross sectional view taken along a line E-E in Fig. 5;
Fig. 7 is a fragmentary cross sectional view corresponding to that of Fig. 3 and showing an operating state of the pressing machine of Fig. 1 different from that shown in Fig. 1;
Fig. 8 is a fragmentary cross sectional view corresponding to that of Fig. 4 and showing the operating state of the

pressing machine of Fig. 1 different from that shown in Fig. 1;
Fig. 9 is a fragmentary cross sectional view corresponding to a part of the view of Fig. 2 and showing the operating state of the pressing machine of Fig. 1 different from that shown in Fig. 1;
Fig. 10 is a schematic cross sectional view corresponding to that of Fig. 2 and showing a pressing machine according to another embodiment of the invention;
Fig. 11 is a schematic cross sectional view corresponding to that of Fig. 2 and showing a pressing machine according to a further embodiment of the invention.

MODE FOR CARRYING OUT THE INVENTION

[0023] To clarify the invention more specifically, embodiments of the invention will be described by reference to the drawings.

[0024] Referring first to the front elevational view of Fig. 1 partly in cross section, there is shown a pressing machine 10 according to one embodiment of the invention. The pressing machine 10 has a one-piece frame 18 consisting of a lower portion 12, an intermediate portion 14 and an upper portion 16. A lower die 22 is attached to an upper surface of a bolster 20 fixedly mounted on the lower portion 12 of the frame 18, while an upper die 26 is attached to a lower surface of a slider (slide member) 24 disposed within the intermediate portion 14 of the frame 18. The lower die 22 and the upper die 26 cooperate with each other to constitute a pressing die. The slider 24 is configured so as to be movable in the vertical direction while being guided by a pair of slider guides 28 provided in opposition to each other on inner surfaces of the intermediate portion 14 of the frame 18. A plurality of crankshafts 34 (three crankshafts 34 in this embodiment) each having main shaft portions 30 and an eccentric shaft portion 32 are rotatably supported by the upper portion 16 of the frame 18, as described later.

[0025] The slider 24 has rod portions 36 integrally formed so as to vertically upwardly project from its upper surface, such that the rod portions 36 are connected to the respective crankshafts 34 through respective connecting rods 38. More specifically described, each connecting rod 38 is connected at one of its opposite end portions (upper end portion) to the eccentric shaft portion 32 of the corresponding crankshaft 34 through a sleeve 40, and at the other end portion (lower end portion) to an upper end portion of the corresponding rod portion 36 of the slider 24 through a crank pin 42. The connecting rod 38 is rotatable relative to the eccentric shaft portion 32 and the crank pin 42, and pivotable about the crank pin 42. Thus, the pressing machine 10 is configured to cause a reciprocatory movement of the slider 24 by displacements of the eccentric shaft portions 32 caused by rotary motions of the crankshafts 34 about respective axes (P) of their main shaft portions 30. Along with the reciprocatory movement (movement in downward and upward directions) of the slider 24, the upper die 26 is moved toward and away from the lower die 22, to perform a pressing operation with respect to a workpiece disposed between the upper and lower dies 26 and 22, as in the conventional pressing machine.

[0026] The main shaft portions 30 of each crankshaft 34 are disposed coaxially with each other, and rotatably supported by the frame 18 (its upper portion 16) through respective bearings 44, as shown in Fig. 2. Accordingly, the axis (P) of each main shaft portion 30 serves as an axis of rotation of each crankshaft 34. Although not shown in Fig. 2, in this embodiment, the slider 24 is a flat plate having a large thickness and an elongate rectangular shape as seen in its plan view. Accordingly, the upper portion 16 of the frame 18 has an elongate rectangular shape in its cross section taken in a horizontal plane. The crankshafts 34 are disposed such that their axial directions are perpendicular to the longitudinal direction of the slider 24, in other words, the axes (P) of rotation of the crankshafts 34 extend in the transverse direction of the slider 24, and such that the crankshafts 34 are spaced apart from each other in the longitudinal direction of the slider 24 (upper portion 16 of the frame 18).

[0027] The eccentric shaft portion 32 of each crankshaft 34 is disposed between and eccentrically with respect to the main shaft portions 30, such that the eccentric shaft portion 32 extends parallel to the main shaft portions 30, and such that an axis (Q) of the eccentric shaft portion 32 is spaced apart from the axis (P) of the main shaft portions 30 by a predetermined distance (X) in a radial direction of the main shaft portions 30 (in this embodiment, in the left direction as seen in Fig. 2). The distance (X) between the axis (P) of the main shaft portions 30 and the axis (Q) of the eccentric shaft portion 32 in the radial direction is defined as an eccentricity amount (X) of the eccentric shaft portion 32. The eccentric shaft portion 32 has a large-diameter portion 32a constituting its axially central portion, and small-diameter portions 32b which are provided on respective opposite sides of the large-diameter portion 32a and which constitute respective opposite end portions of the eccentric shaft portion 32. The large-diameter portion 32a and the small-diameter portions 32b are disposed coaxially with each other. The above-described one end portion of each connecting rod 38 is connected to the large-diameter portion 32a of the eccentric shaft portion 32. Partition plates 46 in the form of small plate pieces are formed integrally with the eccentric shaft portion 32, between the large-diameter portion 32a and the respective small-diameter portions 32b.

[0028] In the pressing machine 10 of this embodiment, the adjacent two crankshafts 34 are connected to each other by a rotary-driving-force transmission lever 48 (hereinafter referred to as a "transmission lever 48") as a first connection lever in the form of an elongate plate. Each transmission lever 48 is rotatably attached to the eccentric shaft portions

32 of the respective crankshafts 34 through respective sleeves 50 (as shown in Figs. 3 and 4).

[0029] More specifically described, as shown in Figs. 2 and 3, the leftmost crankshaft 34 and the intermediate crankshaft 34 as seen in those figures are connected to each other at their small-diameter portions 32b provided in one of opposite axial end portions (lower end portions as seen in Fig. 2) of the respective crankshafts 34, by the transmission lever 48. On the other hand, as shown in Figs. 2 and 4, the rightmost crankshaft 34 and the intermediate crankshaft 34 as seen in those figures are connected to each other at their small-diameter portions 32b provided in the other axial end portions (upper end portions as seen in Fig. 2) of the respective crankshafts 34, by the other transmission lever 48. Thus, the two transmission levers 48 are attached to the intermediate crankshaft 34, such that the two transmission levers 48 are disposed on respective opposite sides of the portion (large-diameter portion 32a) of the intermediate crankshaft 34 connected to the connecting rod 38, as seen in the axial direction of the eccentric shaft portion 32 of the intermediate crankshaft 34. Further, the two transmission levers 48 extend from the eccentric shaft portion 32 of the intermediate crankshaft 34 in respective opposite directions which are perpendicular to the axial direction of the eccentric shaft portion 32 and parallel to a plane including the axes (Q) of the eccentric shaft portions 32 of the intermediate, leftmost and rightmost crankshafts 34.

[0030] On the other hand, as shown in Figs. 2, 5 and 6, eccentric levers 52 in the form of plates are each provided on an axial end portion (lower end portion as seen in Fig. 2) of one of the two main shaft portions 30 of the respective crankshafts 34, which axial end portion outwardly projects from the upper portion 16 of the frame 18, such that the eccentric levers 52 extend in the same radial direction of the main shaft portions 30, which radial direction is different from the direction of eccentricity of the eccentric shaft portions 32 with respect to the main shaft portions 30. In this embodiment, the eccentric levers 52 extend in an upward direction as seen in Figs. 5 and 6, such that the direction of extension of the eccentric levers 52 has a phase difference of 90° with respect to the direction of eccentricity of the eccentric shaft portions 32.

[0031] Further, pins 54 in the form of small-diameter round rods are integrally provided in distal end portions of the respective eccentric levers 52, such that the pins 54 project in a direction parallel to the axial direction of the main shaft portions 30. Namely, the pins 54 are disposed eccentrically with respect to the main shaft portions 30, such that the pins 54 extend parallel to the main shaft portions 30, and such that positions of the pins 54 as seen in the circumferential direction of the main shaft portions 30 are different from those of the eccentric shaft portions 32. In this embodiment, as shown in Fig. 5, the direction of eccentricity of the eccentric shaft portions 32 with respect to the main shaft portions 30 and a direction of eccentricity of the pins 54 with respect to the main shaft portions 30 form an angle θ (90° in this embodiment) threrebetween about the axis (P) of the main shaft portions 30. In this respect, it is noted that a distance (Y) from the axis (P) of the main shaft portions 30 to an axis (R) of each pin 54 in a direction perpendicular to those axes is defined as an eccentricity amount (Y) of the pin 54. The eccentricity amount (Y) is set so as to be larger than the above-described eccentricity amount (X) of the eccentric shaft portion 32.

[0032] Further, as is apparent from Figs. 2 and 6, the pins 54 project from the eccentric levers 52 such that distal end portions of the pins 54 are located axially outwardly of corresponding ends of the respective crankshafts 34 (main shaft portions 30).

[0033] A dead-center escape lever 56 (hereinafter referred to as an "escape lever 56") as a second connection lever in the form of an elongate plate is rotatably attached to the distal end portions of the pins 54 through respective sleeves 58, as shown in Fig. 5. Thus, the plurality of crankshafts 34 are connected to each other at one of their opposite axial end portions by the escape lever 56 through the eccentric levers 52 and the pins 54.

[0034] In this embodiment, a clutch mechanism 60 is integrally assembled with respect to the other axial end portion (upper end portion as seen in Fig. 2) of the intermediate crankshaft 34, which axial end portion outwardly projects from the upper portion 16 of the frame 18, as shown in Fig. 2, and a flywheel 62 is rotatably supported by the above-described other axial end portion of the intermediate crankshaft 34 through a ball bearing or other mechanism not shown. Thus, in the pressing machine 10 of this embodiment, the intermediate crankshaft 34 among the plurality of crankshafts 34 serves as the crankshaft (hereinafter referred to as a "driving crankshaft") which is rotated with a constant-velocity rotary motion of the flywheel 62 transmitted through the clutch mechanism 60. On the other hand, the crankshafts 34 disposed on the respective opposite sides of the driving crankshaft 34 serve as the crankshafts (hereinafter referred to as "driven crankshafts") which are rotated with a rotary driving force received from the driving crankshaft 34.

[0035] In the pressing machine 10 constructed as described above, the rotary driving force transmitted to the driving crankshaft 34 is further transmitted to the driven crankshafts 34 mainly through the transmission levers 48, whereby all crankshafts 34 are rotated in synchronization with each other.

[0036] By the way, Figs. 1-6 show an operating state of the pressing machine 10 at a moment of its operation. At this moment, as shown in Figs. 3 and 4, the adjacent crankshafts 34 connected to each other by the transmission levers 48 are positioned such that the axes (P) of the main shaft portions 30 of the respective crankshafts 34 and the axes (Q) of the eccentric shaft portions 32 of the respective crankshafts 34 are all located in a common plane (plane which is indicated by an imaginary straight line L in Figs. 3 and 4 and which is perpendicular to the plane of Figs. 3 and 4), and a center line of each of the transmission levers 48 attached to the eccentric shaft portions 32 of the respective crankshafts 34 is

also located in the above-described plane.

[0037] In the above-described operating state, the driven crankshafts 34 connected to the driving crankshaft 34 by the transmission levers 48 are instantaneously rotatable in both of the clockwise and counterclockwise directions, even where the driving crankshaft 34 is rotated in the clockwise direction as seen in Figs. 3 and 4 (as indicated by a thin arrow-ended line in those figures), so that the direction of rotation of the driven crankshafts 34 is not univocally fixed. Namely, the driven crankshafts 34 are positioned at the dead center in a mechanism for transmitting the rotary driving force through the transmission levers 48.

[0038] On the other hand, at this moment, as shown in Fig. 5 showing the connection between the crankshafts 34 and the escape lever 56, the direction of eccentricity of the pins 54 with respect to the main shaft portions 30 and the direction of eccentricity of the eccentric shaft portions 32 with respect to the main shaft portions 30 form the angle θ therebetween. In other words, there is a difference of θ between a rotational phase of the positions (pins 54) at which the escape lever 56 is attached to the crankshafts 34 and a rotational phase of the positions (eccentric shaft portions 32) at which the transmission levers 48 are attached to the crankshafts 34. Therefore, a force is applied to the driven crankshafts 34 by the escape lever 56 such that the driven crankshafts 34 are rotated in the same direction as the driving crankshaft 34.

[0039] By application of the force to the driven crankshafts 34 by the escape lever 56, the driven crankshafts 34 escape from the dead center in the mechanism for transmitting the rotary driving force through the transmission levers 48. Thus, by cooperating actions of the transmission levers 48 and the escape lever 56, the driven crankshafts 34 are rotated in synchronization with the driving crankshaft 34 in the predetermined direction of rotation of the driving crankshaft 34.

[0040] Figs. 7-9 show another moment of rotary motions of the crankshafts 34, namely, the moment at which the slider 24 is positioned at its bottom dead center. At this moment, the driving crankshaft 34 acts so as to press the eccentric shaft portion 32 of the driven crankshaft 34 disposed on its left side, in the left direction through the transmission lever 48, so that the above-described driven crankshaft 34 is rotated, as shown in Fig. 7. As a result, the driving crankshaft 34 receives a rightward force (indicated by a blank arrow in Fig. 7) as a reaction force from the transmission lever 48.

[0041] On the other hand, the driving crankshaft 34 acts so as to pull the eccentric shaft portion 32 of the driven crankshaft 34 disposed on its right side, in the left direction through the other transmission lever 48, so that the above-described driven crankshaft 34 is rotated, as shown in Fig. 8. As a result, the driving crankshaft 34 receives a rightward force (indicated by a blank arrow in Fig. 8) as a reaction force from the other transmission lever 48. As described above, the driving crankshaft 34 receives the substantially equal forces in the same direction at its portions disposed on the respective opposite sides of the connecting rod 38, while the driving crankshaft 34 is rotated, as shown in Fig. 9.

[0042] It will be understood from the foregoing description of this embodiment that the transmission levers 48 as the first connection levers are attached to the eccentric shaft portions 32 of the respective crankshafts 34, and the escape lever 56 as the second connection lever is attached to the pins 54 which are provided in the axial end portions of the respective crankshafts 34 through the eccentric levers 52, such that the positions of the pins 54 as seen in the circumferential direction of the main shaft portions 30 are different from those of the eccentric shaft portions 32. Accordingly, by the cooperating actions of the transmission levers 48 and the escape lever 56, the rotary driving force transmitted to the driving crankshaft 34 can be smoothly transmitted to the other crankshafts 34.

[0043] Namely, while the driving crankshaft 34 is rotated, there is a phase difference between the positions (eccentric shaft portions 32) at which the transmission levers 48 are attached to the crankshafts 34 and the positions (pins 54) at which the escape lever 56 is attached to the crankshafts 34. Therefore, even when the driven crankshafts 34 are positioned at the dead center in the mechanism for transmitting the rotary driving force through the transmission levers 48, the direction of rotation of the driven crankshafts 34 is univocally fixed by the escape lever 56. Thus, the pressing machine 10 as a whole does not have an actual dead center when the plurality of crankshafts 34 are rotated in synchronization with each other, so that the rotary driving force can be smoothly transmitted among the plurality of crankshafts 34.

[0044] Further, the pressing machine 10 of this embodiment requires no gear members, so that the pressing machine 10 is not affected by a large moment of inertia of the gear members, whereby start/stop performance (operating response) of the pressing machine 10 is advantageously improved, and a desired pressing operation can be performed with a high degree of press forming accuracy using the pressing machine 10, and a cycle time required for forming a desired product using the pressing machine 10 can be effectively reduced. Namely, the pressing machine 10 is configured to directly move the connecting rods 38 by the crankshafts 34, so that the pressing machine 10 has a high degree of operating response and permits advantageous reduction of the cycle time required for formation of the desired product.

[0045] The pressing machine 10 as a whole has a simplified structure and a reduced number of components, since it requires no gear members, resulting in an advantage of reduction of a cost of its production.

[0046] Further, the eccentric levers 52 are each provided on the axial end portion of the one of the two main shaft portions 30 of the respective crankshafts 34, which axial end portion outwardly projects from the upper portion 16 of the frame 18, so that there is no need to increase sizes of the upper portion 16 and the frame 18 as a whole, in order to attach the escape lever 56 to the pins 54 projecting from the eccentric levers 52. Accordingly, a distance between the main shaft portions 30 of each crankshaft 34 supported by the upper portion 16 of the frame 18 (distance between the bearings 44) is not increased, resulting in an advantage that a high degree of concentricity between the main shaft

portions 30 can be easily obtained.

[0047] As described above, the main shaft portions 30 of each crankshaft 34 are supported by the upper portion 16 of the frame 18 with a short distance (span) therebetween, so that the crankshaft 34 effectively exhibits a sufficiently high strength to resist to its flexural deformation. Namely, in the crankshaft 34, a large force (reaction force) is applied from the transmission lever 48 to the eccentric shaft portion 32 which is disposed between the main shaft portions 30 within the upper portion 16 of the frame 18. However, the eccentric shaft portion 32 is disposed between the main shaft portions 30 supported with the above-indicated short span, so that a risk of flexural deformation of the eccentric shaft portion 32 is advantageously reduced. As a result, the weight (diameter) of the crankshaft 34 can be reduced to further reduce a moment of inertia of the crankshaft 34, whereby the operating response of the pressing machine 10 and accuracy of synchronization of the rotary motions of the crankshafts 34 can be improved, and the cycle time required for forming the desired product using the pressing machine 10 can be further reduced.

[0048] Further, the escape lever 56 is attached to the distal end portions of the respective pins 54 which project from the eccentric levers 52 such that their distal end portions are located axially outwardly of the corresponding ends of the respective crankshafts 34, so that an interference between the escape lever 56 and the crankshafts 34 can be advantageously prevented.

[0049] Even where the slider 24 has the elongate rectangular shape as seen in its plan view in order to permit a pressing operation with respect to a workpiece having a large width, the plurality of crankshafts 34 can be disposed such that their axial directions are perpendicular to the longitudinal direction of the slider 24 (i.e., the axial directions of the crankshafts 34 extend in the transverse direction of the slider 24), and such that the crankshafts 34 are spaced apart from each other in the longitudinal direction of the slider 24. Accordingly, the distance between the main shaft portions 30 of each of the crankshafts 34(distance between the bearings 44) is not increased, so that a high degree of concentricity between the main shaft portions 30 can be easily obtained, and the crankshafts 34 can be easily produced.

[0050] In the above-described embodiment, the eccentricity amount (Y) of each pin 54 with respect to the main shaft portions 30 is set so as to be larger than the eccentricity amount (X) of the eccentric shaft portion 32. Namely, the distance (Y) from the axis (P) of the main shaft portions 30 to the axis (R) of the pin 54 is larger than the distance (X) from the axis (P) of the main shaft portions 30 to the axis (Q) of the eccentric shaft portion 32. In this respect, it is noted that during the rotary motions of the crankshafts 34, the axis (P) of the main shaft portions 30 serves as the fulcrum point, and the axis (R) of the pin 54 serves as a point of action. Since the distance (Y) is set so as to be larger than the distance (X) as described above, a force (load) applied to the pins 54 and the escape lever 56 during the rotary motions of the crankshafts 34 is smaller than that applied to the transmission levers 48. Accordingly, the escape lever 56 can have a thickness smaller than that of the transmission levers 48. Further, the diameter of the pins 54 and the thickness of the escape lever 56 can be reduced to reduce their weights and the moment of inertia.

[0051] In the above-described embodiment, the plurality of transmission levers 48 are provided, and the eccentric shaft portions 32 of the adjacent crankshafts 34 are connected to each other by each of the plurality of transmission levers 48. Further, the two transmission levers 48 are attached to the crankshaft 34 (driving crankshaft 34 in the above-described embodiment) interposed between the other two crankshafts 34, such that the two transmission levers 48 are disposed on the respective opposite sides of the portion (large-diameter portion 32a) of the driving crankshaft 34 connected to the connecting rod 38, as seen in the axial direction of the eccentric shaft portion 32 of the driving crankshaft 34. Further, the two transmission levers 48 extend from the eccentric shaft portion 32 of the driving crankshaft 34 in respective opposite directions which are perpendicular to the axial direction of the eccentric shaft portion 32 and parallel to the plane including the axes (Q) of the eccentric shaft portions 32 of the driving crankshaft 34 and the other two crankshafts 34. Therefore, the two forces applied from the two transmission levers 48 to the respective two axial portions of the driving crankshaft 34 in the direction perpendicular to its axial direction are balanced with respect to each other, so that the two forces do not act on the driving crankshaft 34 so as to cause inclination of its axis (P). Accordingly, flexure of the driving crankshaft 34 or inclination of its axis is prevented, and a high degree of concentricity of its main shaft portions 30 is assured, whereby the driving crankshaft 34 can be more smoothly rotated.

[0052] A pressing machine 64 having a structure according to another embodiment of the invention is shown in the cross sectional view of Fig. 10 corresponding to that of Fig. 2. The reference signs used to denote the members and portions of the pressing machine 10 are used to denote the corresponding members and portions of the pressing machine 64 shown in Fig. 10, which will not be described redundantly.

[0053] The pressing machine 64 shown in Fig. 10 has a structure in which the plurality of crankshafts 34 are connected to each other by a single transmission lever 48. In the pressing machine 64 constructed as described above, the rotary driving force transmitted to the driving crankshaft 34 can be smoothly transmitted to the driven crankshafts 34 by the cooperating actions of the transmission lever 48 and the escape lever 56, as in the pressing machine 10 of the above-described embodiment.

[0054] In this pressing machine 64, the eccentric shaft portion 32 of each crankshaft 34 is formed such that a direction of eccentricity of the large-diameter portion 32a and a direction of eccentricity of the small-diameter portions 32b are opposite to each other. Namely, during the rotatory motion of the crankshaft 34, there is a phase difference of 180°

between the large-diameter portion 32a and the small-diameter portions 32b. The pressing machine 64 constructed as described above has a characteristic that where known dynamic balances (not shown) are connected to the small-diameter portions 32b which are not connected to the transmission lever 48, vibration of the slider 24 caused along with its reciprocatory movement can be offset to reduce vibration of the pressing machine 64 as a whole.

[0055] Although the representative embodiments of the invention have been described for illustrative purpose only, it is to be understood that the invention is by no means limited to the details of the illustrated embodiments.

[0056] The position of each pin 54 relative to the position of the eccentric shaft portion 32 as seen in the circumferential direction of the main shaft portions 30 is not limited to that in the above-described embodiments. Namely, the angle θ formed between the direction of eccentricity of the eccentric shaft portions 32 with respect to the main shaft portions 30 and the direction of eccentricity of the pins 54 with respect to the main shaft portions 30 is not limited, as long as the angle θ is not 0° and 180°. In the cases where the angle θ is 0° and 180°, the positions (eccentric shaft portions 32) at which the transmission lever 48 is attached to the crankshafts 34 and the positions (pins 54) at which the escape lever 56 is attached to the crankshafts 34 reach the dead center at the same time, so that the transmission lever 48 and the escape lever 56 cannot cooperate with each other to allow the driven crankshafts 34 to advantageously escape from the dead center. The angle θ is preferably set at 90°, so that there is a phase difference of 90° between the pins 54 and the eccentric shaft portions 32, as seen in the direction of rotation of the crankshafts 34.

[0057] The number of the crankshafts 34 is not limited to that in the above-described embodiments, as long as a plurality of crankshafts 34 (at least two crankshafts) are provided. Fig. 11 shows a pressing machine 66 having four crankshafts 34. The pressing machine 66 is provided with three transmission levers 48, namely, a first transmission lever 48 connecting two adjacent ones of the four crankshafts 34, a second transmission lever 48 connecting the other two adjacent crankshafts 34, and a third transmission lever 48 connecting the two adjacent inner crankshafts 34. The first and third transmission levers 48 are disposed on respective opposite sides of the large-diameter portion 32a of one of the two adjacent inner crankshafts 34, as seen in the axial direction of the eccentric shaft portion 32 of that crankshaft 34. Further, the first and third transmission levers 48 extend from the eccentric shaft portion 32 of the above-indicated one inner crankshaft 34 (driving crankshaft 34) in respective opposite directions which are perpendicular to the axial direction of the eccentric shaft portion 32 and parallel to a plane including the axes (Q) of the eccentric shaft portions 32 of the above-indicated two adjacent crankshafts 34 and the above-indicated one inner crankshaft 34. The second and third transmission levers 48 are disposed on respective opposite sides of the large-diameter portion 32a of the other of the two adjacent inner crankshafts 34, as seen in the axial direction of the eccentric shaft portion 32 of that crankshaft 34. Further, the second and third transmission levers 48 extend from the eccentric shaft portion 32 of the above-indicated other inner crankshaft 34 (driven crankshaft 34) in respective opposite directions which are perpendicular to the axial direction of the eccentric shaft portion 32 and parallel to a plane including the axes (Q) of the eccentric shaft portions 32 of the above-indicated other two adjacent crankshafts and the above-indicated other inner crankshaft 34. Accordingly, not only the flexure of the driving crankshaft 34 is advantageously prevented, as in the above-described embodiment, but also flexure of the driven crankshaft 34 (the second crankshaft 34 as seen from the left in Fig. 11) interposed between the driving crankshaft 34 and the leftmost crankshaft 34 is advantageously prevented.

[0058] The direction of extension of the eccentric levers 52 and their form are not limited to those in the above-described embodiments. The eccentric levers 52 may take the form of "L" having a bent intermediate portion, for example. Namely, it suffices that the positions of the pins 54 integrally formed with the respective eccentric levers 52 are different from the positions of the eccentric shaft portions 32 as seen in the circumferential direction of the main shaft portions 30.

[0059] Various known mechanisms may be employed as the mechanism for transmitting the rotary driving force to the driving crankshaft 34. It is possible to provide such mechanism in the same axial end portion of the crankshaft 34 as the escape lever 56, depending on the structure of the mechanism.

[0060] It is to be understood that the present invention may be embodied with various changes, modifications and improvements, which may occur to those skilled in the art, without departing from the spirit and scope of the invention, and that such changes, modifications, and improvements are also within the scope of the invention.

NOMENCLATURE OF REFERENCE SIGNS

10, 64, 66:	Pressing machine	18:	Frame
24:	Slider	30:	Main shaft portion
32:	Eccentric shaft portion	32a:	Large-diameter portion
32b:	Small-diameter portion	34:	Crankshaft
38:	Connecting rod	48:	Transmission lever
52:	Eccentric lever	54:	Pin
56:	Escape lever	60:	Clutch mechanism
62:	Flywheel		
P:	Axis of main shaft portions		

(continued)

Q:	Axis of eccentric shaft portion	R:	Axis of pin
L:	Imaginary straight line		

Claims

1. A pressing machine (10, 64, 66) comprising:

a plurality of crankshafts (34) each of which has two co-axially disposed main shaft portions (30) and an eccentric shaft portion (32) disposed between and eccentrically with respect to the two main shaft portions (30), and which are rotatably supported at their main shaft portions (30) by a frame (18), such that their axial directions are parallel to each other, and such that they are spaced apart from each other with a predetermined distance therebetween;
connecting rods (38) connected at one of their opposite end portions to the eccentric shaft portions (32) of said plurality of crankshafts (34);
a slider (24) connected to the other end portions of said connecting rods (38), and reciprocated by displacements of said eccentric shaft portions (32) caused by rotary motions of said plurality of crankshafts (34) about respective axes of their main shaft portions (30);
at least one first connection lever (48) attached to said eccentric shaft portions (32) of said plurality of crankshafts (34), for transmitting a rotary driving force transmitted to one of said plurality of crankshafts (34) to another of the plurality of crankshafts (34), so that the plurality of crankshafts (34) are rotated in synchronization with each other;
eccentric levers (52) each provided on an axial end portion of one of said two main shaft portions (30) of the respective crankshafts (34), which axial end portion outwardly projects from said frame (18), such that the eccentric levers (52) extend in a direction perpendicular to axial directions of said main shaft portions (30);
pins (54) provided so as to project from the respective eccentric levers (52) in a direction parallel to the axial directions of said main shaft portions (30), and such that positions of the pins (54) as seen in a circumferential direction of said main shaft portions (30) are different from those of said eccentric shaft portions (32), and such that distal end portions of the pins (54) are located axially outwardly of corresponding ends of the respective crankshafts (34); and
a second connection lever (56) attached to said distal end portions of the respective pins (54),
whereby said rotary driving force is smoothly transmitted to said another of the plurality of crankshafts (34) by cooperating actions of said at least one first connection lever (48) and said second connection lever (56).

2. The pressing machine (10, 64, 66) according to claim 1, wherein said eccentric shaft portions (32) and said pins (54) have a phase difference of 90° therebetween during the rotary motions of said crankshafts (34) about the respective axes of their main shaft portions (30).

3. The pressing machine (10, 64, 66) according to claim 1 or 2, wherein an eccentricity amount of an axis of each of said pins (54) with respect to the axis of said main shaft portions (30) is larger than an eccentricity amount of an axis of said eccentric shaft portion (32) with respect to the axis of said main shaft portions (30).

4. The pressing machine (10, 64, 66) according to any one of claims 1 to 3, wherein said second connection lever (56) has a thickness smaller than that of said at least one first connection lever (48).

5. The pressing machine (10, 66) according to any one of claims 1 to 4, wherein said at least one first connection lever (48) comprises a plurality of first connection levers (48) each connecting said eccentric shaft portions (32) of adjacent ones of said plurality of crankshafts (34) to each other, and
the plurality of first connection levers (48) comprise two first connection levers (48) which are disposed on respective opposite sides of a portion of the eccentric shaft portion (32) of one of the plurality of crankshafts (34) connected to corresponding one of said connecting rods (38), as seen in an axial direction of the eccentric shaft portion (32), and extend from the eccentric shaft portion (32) of said one crankshaft (34) in respective opposite directions which are perpendicular to the axial direction of the eccentric shaft portion (32) and parallel to a plane including axes of the eccentric shaft portions (32) of said one crankshaft (34) and two other crankshafts (34) disposed on respective opposite sides of said one crankshaft (34).

6. The pressing machine (10, 66) according to any one of claims 1 to 4, wherein said one of the plurality of crankshafts (34) to which said rotary driving force is transmitted is interposed between two other crankshafts (34) which are rotated with said rotary driving force received from said one of the plurality of crankshafts (34), and
said at least one first connection lever (48) comprises two first connection levers (48) connecting the eccentric shaft portion (32) of said one of the plurality of crankshafts (34) respectively to the eccentric shaft portions (32) of said two other crankshafts (34), and
wherein said two first connection levers (48) are attached to said one of the plurality of crankshafts (34), such that the two first connection levers (48) are disposed on respective opposite sides of a portion of the eccentric shaft portion (32) of said one crankshaft (34) connected to corresponding one of said connecting rods (38), as seen in an axial direction of the eccentric shaft portion (32), and extend from the eccentric shaft portion (32) of said one crankshaft (34) in respective opposite directions which are perpendicular to the axial direction of the eccentric shaft portion (32) and parallel to a plane including axes of the eccentric shaft portions (32) of said one crankshaft (34) and said two other crankshafts (34).

7. The pressing machine (10, 64, 66) according to any one of claims 1 to 6, wherein said eccentric shaft portion (32) has a large-diameter portion (32a) and at least one small-diameter portion (32b) which has a diameter smaller than that of the large-diameter portion (32a) and which is formed co-axially with the large-diameter portion (32a), and said one end portion of each of said connecting rods (38) is connected to the large-diameter portion (32a), while said at least one first connection lever (48) is attached to the at least one small-diameter portion (32b).

8. The pressing machine (10, 64, 66) according to any one of claims 1 to 7, wherein said slider (24) has an elongate rectangular shape as seen in its plan view, and said plurality of crankshafts (34) are disposed such that their axial directions are perpendicular to a longitudinal direction of the slider (24), and such that they are spaced apart from each other in the longitudinal direction of the slider (24).

FIG. 1

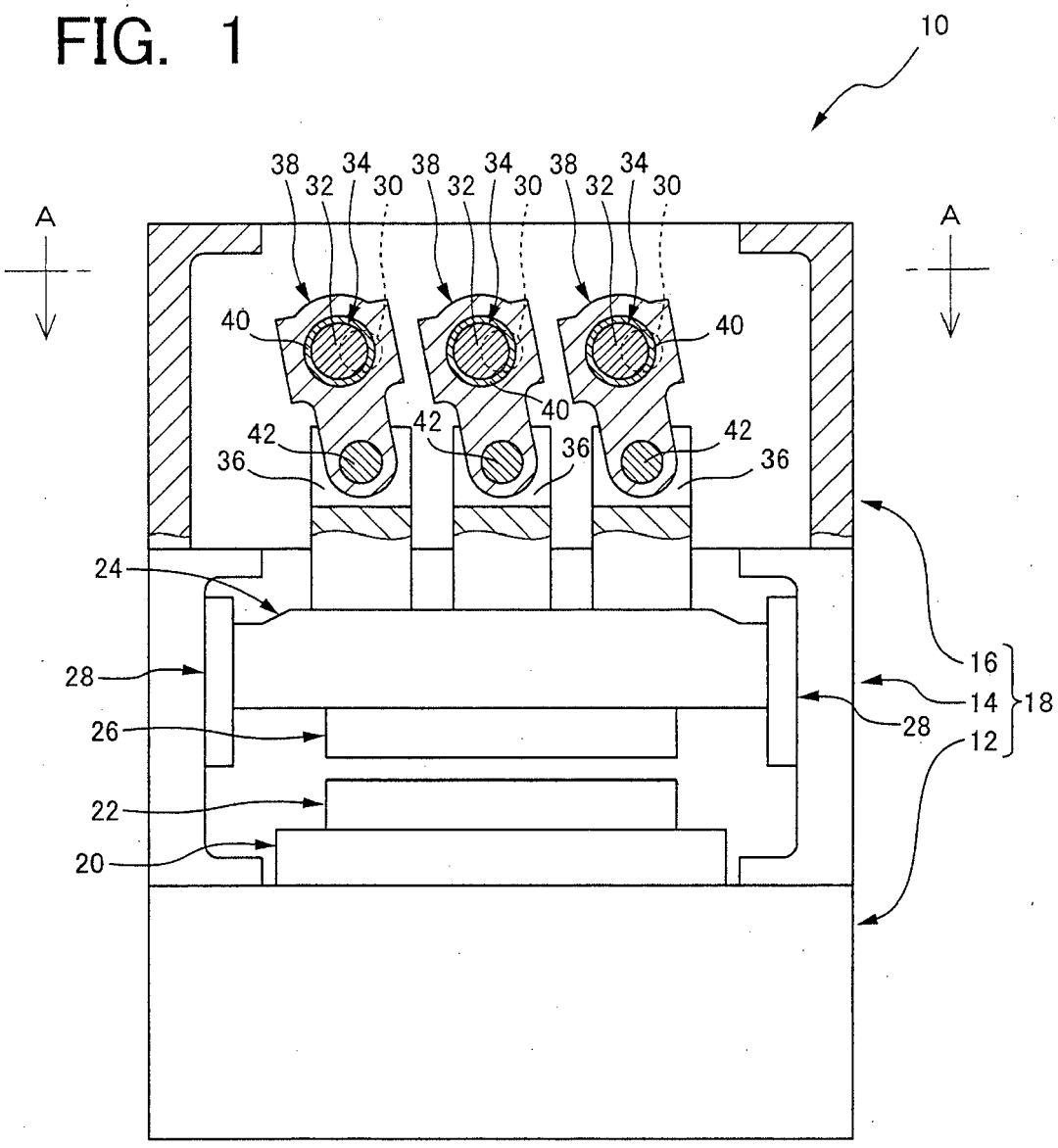


FIG. 2

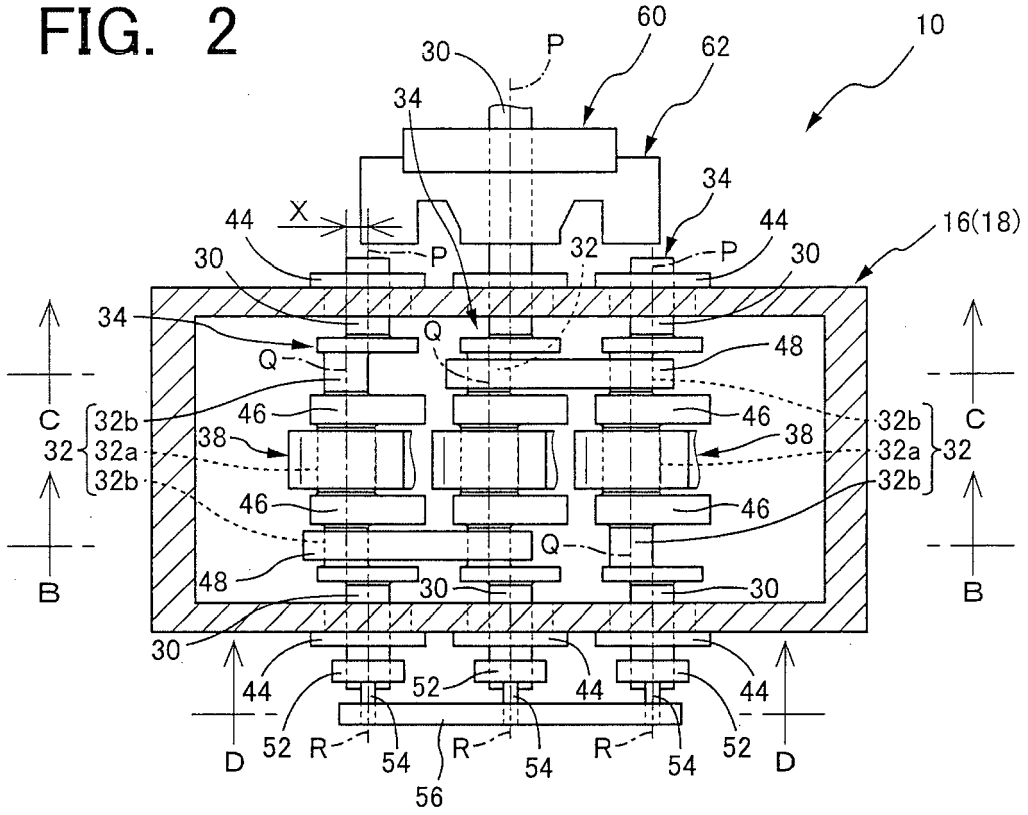
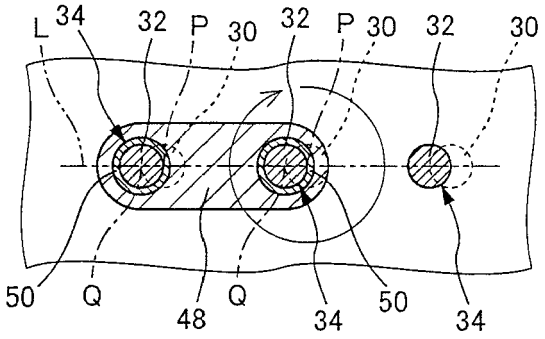


FIG. 3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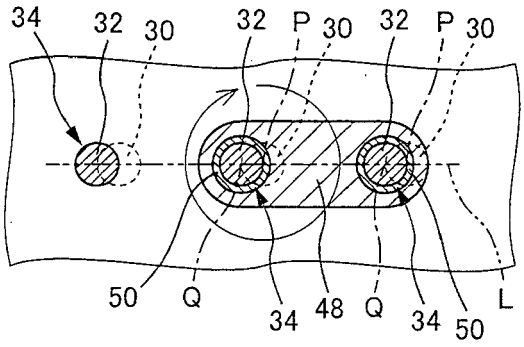
34

FIG. 4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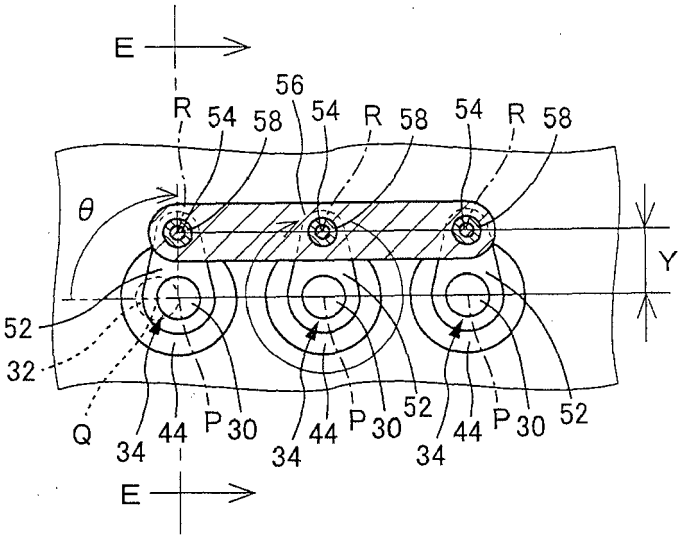
L

FIG. 5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34
44
P
30
52
E

FIG. 6

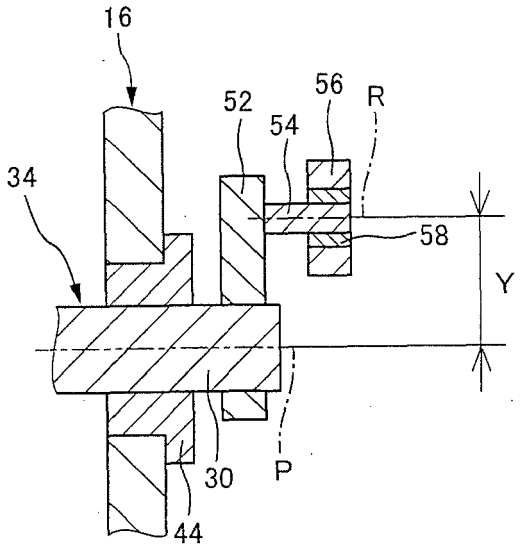
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FIG. 7

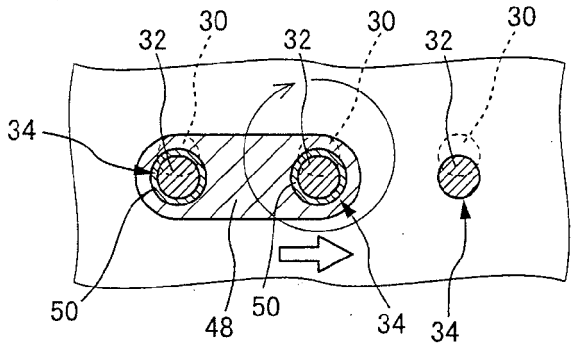

FIG. 8

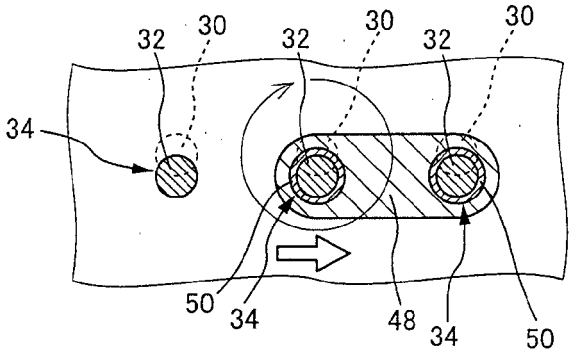

FIG. 9

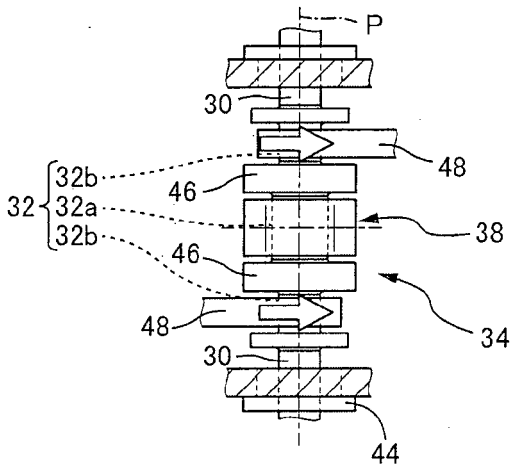

FIG. 10

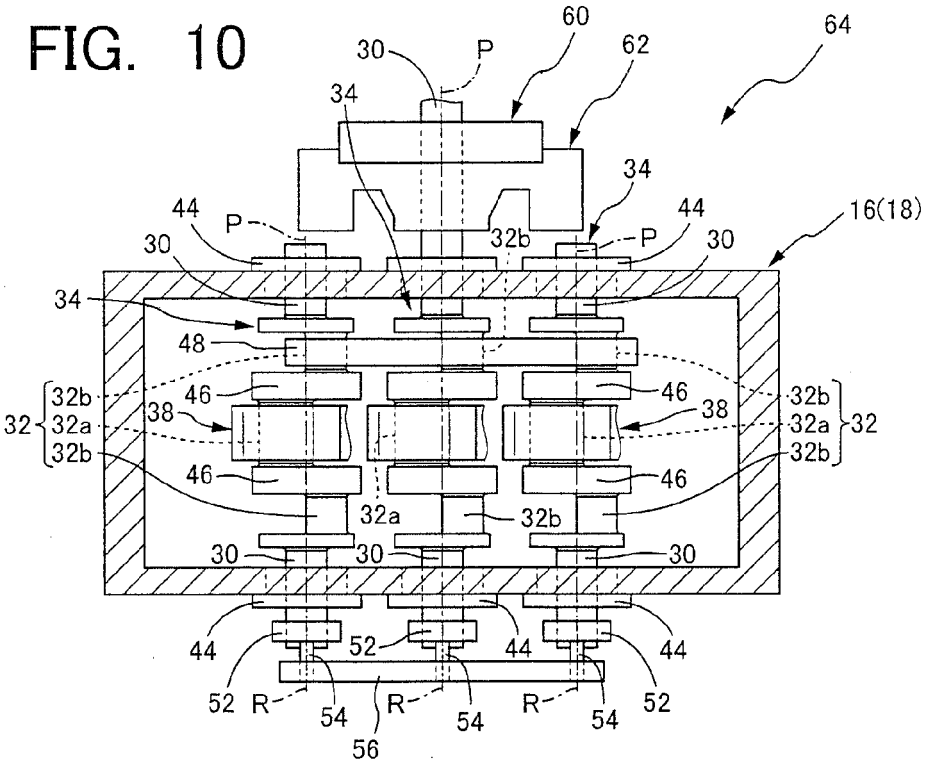
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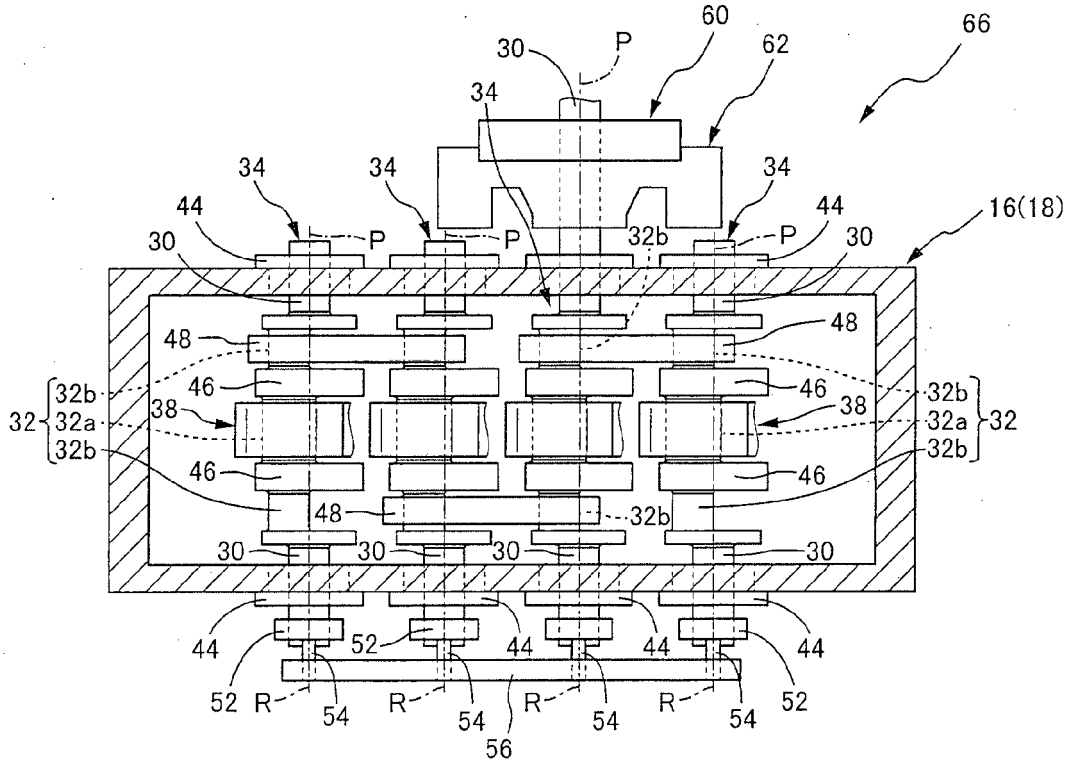
FIG. 11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EUROPEAN SEARCH REPORT

Application Number
EP 15 00 2851

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A	US 5 720 201 A (YOSHIDA AKIHIRO [JP] ET AL) 24 February 1998 (1998-02-24) * claims; figures * -----	1	INV. B30B1/26
A	WO 2011/012290 A1 (DIEFFENBACHER GMBH & CO KG [DE]; GRAF MATTHIAS [DE]) 3 February 2011 (2011-02-03) * claims; figures * -----	1	
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TECHNICAL FIELDS SEARCHED (IPC)

B30B
F16H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	28 January 2016	Baradat, Jean-Luc

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28-01-2016

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- JP 52053476 U **[0004] [0007]**