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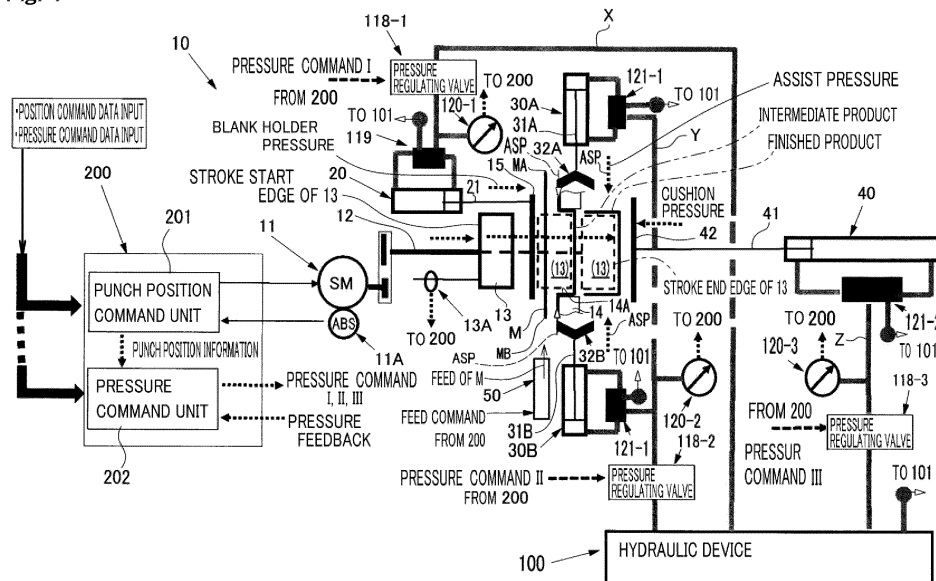
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**(54) ASSIST DRAWING DEVICE**

(57) Provided is an assist drawing device (10) by which, when a punch (13) is moved from a stroke start edge toward a stroke end edge in accordance with a command from a control device (200) to a punch drive unit, and drawing is performed in cooperation with a drawing die (14) to thereby perform the drawing, assist drawing is performed while pressing a blank material (M) against the drawing die (14) by a blank holder (15) and

pressing both end surfaces of the blank material (M) by assist punches (32A and 32B), and in which the control device (200) includes an assist pressure control unit configured to control an assist punch drive unit such that, when the assist drawing is performed, an assist pressure of the assist punches (32A and 32B) reaches a target assist pressure in accordance with a position of the punch (13).

*Fig. 1*

## Description

**[0001]** The present invention relates to a control technology for an assist drawing device configured to perform assist drawing.

**[0002]** In general drawing, as described in, for example, JP 2009 90 318 A1, regardless of a product shape, forming is performed on a blank (material) 3 using a punch 2, a die 1, and a blank holder (wrinkle presser) 4 (see Fig. 8A).

**[0003]** In drawing with a rectangular cylinder as illustrated in Fig. 8B, a large tensile stress acts on a material at four round-chamfered corner (four corner) portions 2R of the punch 2. Thus, cracking or thinning of the material is liable to occur in portions exposed to the large tensile stress, and hence there are circumstances that it is difficult to reduce chamfering radius of the round-chamfered corner (four corner) portions 2R, round-chamfered shoulder portions (shoulder radius portions) 2r, round-chamfered shoulder portions Rd of the die 1 or increase a drawing depth.

**[0004]** In view of the above, the applicant of the present invention has proposed, in JP 2013 271 683 A or JP 2016 132 978 A, an assist drawing method or apparatus that performs drawing with a punch 7 and a die 8 while assist punches (pressurizing plates) 6 press both arc-shaped end portions 5A and 5B of a blank material 5 in a longitudinal direction toward a center of the blank material 5 at the time of drawing, as illustrated in Fig. 7A and Fig. 7B. Reference numeral 9 in Fig. 7A indicates a blank holder that suppresses wrinkles of the blank material 5. It is considered that, in drawing, a tensile stress applied to the material causes thinning, cracking, or the like. Thus, in the assist drawing method or apparatus, a compressive stress field is formed at a location of the material to which the tensile stress is applied during forming so that thinning, cracking, or the like is suppressed, thereby being capable of increasing a forming limit.

**[0005]** According to such assist drawing method, even in a product in which a ratio between a product height (drawing depth) and a product width (short-axis side of a substantially oblong cross section orthogonal to a drawing depth direction) exceeds a drawing limit of a metal material, forming can be favorably performed by drawing without causing thinning, cracking, or the like.

**[0006]** However, there are circumstances that a drawn product (product in which a ratio between a product width and a product height is relatively large) that may cause thinning, cracking, or the like is produced even by assist drawing, for example, when an aluminum alloy is used as the material.

**[0007]** In the related-art devices like those of JP 2013 271 683 A and JP 2016 132 978 A, the assist punches (pressurizing plates) 6 are pressed by a pressurizing device which uses a fluid pressure or the like, for example, a hydraulic pressure at an assist pressure (pressurizing force) ASP determined in advance so as not to cause thinning, cracking, or the like. However, it has been

confirmed that thinning, cracking, or the like cannot be prevented by only pressing at the predetermined assist pressure during the assist drawing.

**[0008]** Moreover, when deep drawing of an aluminum alloy or the like is to be performed, it is conceivable to adopt a method of using a transfer press machine disclosed in JP 2021 158 014 A1 to increase the number of times of drawing or to perform ironing a plurality of times after the drawing (method of machining to a predetermined depth in a plurality of steps). However, the punch is pulled out and inserted into the machined product a plurality of times in accordance with the number of times of machining, and hence a large amount of machining oil (lubricant) is required. Further, the material generates heat during the machining, and hence a large amount of coolant oil is also required. As a result, there is an increase in production cost, such as an increase in cost for a production facility, an increase in complexity, and an increase in production time.

**[0009]** Thus, according to the present invention, there is provided an assist drawing device, including a punch, which has a shape conforming to a product shape, and is configured to be linearly reciprocated between a stroke start edge and a stroke end edge, a drawing die, which has an opening conforming to the product shape, and is configured to perform drawing on a blank material having a plate shape in cooperation with the punch, a blank holder configured to press the blank material against the drawing die at a blank holder pressure, a pair of assist punches, which are movably inserted between the drawing die and the blank holder, and are arranged opposed to each other so as to be capable of pressing end surfaces of the blank material from opposing directions at an assist pressure, a punch drive unit configured to drive the punch. The assist drawing device according to the present invention further includes an assist punch drive unit configured to supply the assist pressure to the pair of assist punches, in which, when the punch is moved from the stroke start edge toward the stroke end edge in accordance with a command from the control device to the punch drive unit, and drawing is performed in cooperation with the drawing die, assist drawing is performed while pressing the blank material against the drawing die by the blank holder and pressing both end surfaces of the blank material by the pair of assist punches, and in which the control device includes an assist pressure control unit configured to control the assist punch drive unit such that, when the assist drawing is performed, the assist pressure of the pair of assist punches reaches a target assist pressure in accordance with a position of the punch.

**[0010]** In at least one aspect of the present invention, the assist drawing device may further include punch position information acquisition means configured to acquire position information on the punch, and the assist pressure control unit may be configured to control, based on the actual position information on the punch acquired by the punch position information acquisition means, the assist punch drive unit such that the assist pressure of the

pair of assist punches reaches the target assist pressure in accordance with the position of the punch.

**[0011]** In at least one aspect of the present invention, the assist drawing device may further include assist pressure information acquisition means configured to acquire assist pressure information on the pair of assist punches, and the assist pressure control unit may be configured to control, based on the actual assist pressure information acquired by the assist pressure information acquisition means, the assist punch drive unit such that the assist pressure of the pair of assist punches reaches the target assist pressure in accordance with the position of the punch.

**[0012]** In at least one aspect of the present invention, the control device may be configured to use the command to the punch drive unit to move the punch from a current position, and the assist pressure control unit may be configured to set the target assist pressure in accordance with the position of the punch to the target assist pressure at a position after the movement from the current position of the punch in accordance with the command from the control device to the punch drive unit; and to execute pressure synchronization control of changing the target assist pressure in accordance with the position of the punch from the target assist pressure at the current position of the punch to the target assist pressure at the position after the movement.

**[0013]** In at least one aspect of the present invention, the assist drawing device may further include a blank holder drive unit configured to supply a blank holder pressure to the blank holder, a cushion pad configured to press the blank material at a cushion pressure from a direction opposing the movement of the punch when the assist drawing is performed, and a cushion pad drive unit configured to supply the cushion pressure to the cushion pad. The control device may be configured to control at least one of the blank holder drive unit or the cushion pad drive unit such that, when the assist drawing is performed, at least one of the blank holder pressure or the cushion pressure reaches a target blank holder pressure or a target cushion pressure in accordance with the position of the punch.

**[0014]** A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying figures, wherein

Fig. 1 is a block diagram for schematically illustrating an overall configuration of an assist drawing device according to an embodiment of the present invention;

Fig. 2 is an example of a flowchart of setting operation data for performing assist drawing by a control device of the assist drawing device according to the embodiment;

Fig. 3A is an example of a flowchart (part 1, S11 to S17) for the control device of the assist drawing device according to the embodiment to allow the assist drawing to be performed in an automatic operation;

Fig. 3B is the example of the flowchart (part 2, S18 to S32);

Fig. 4 is a process diagram for illustrating an example of a punch target position, a target blank holder pressure, a target assist pressure, and a target cushion pressure in the assist drawing given by the control device of the assist drawing device according to the embodiment;

Fig. 5 is a table for showing an example of the punch target position, the target blank holder pressure, the target assist pressure, and the target cushion pressure in the assist drawing given by the control device of the assist drawing device according to the embodiment;

Fig. 6 is a block diagram of a configuration example of a hydraulic device in the embodiment;

Fig. 7A is a front view (as viewed from a direction orthogonal to a press direction) of a forming apparatus, for explaining assist drawing;

Fig. 7B is a plan view (as viewed from the press direction) of the forming apparatus, for explaining the assist drawing;

Fig. 8A is a front view (as viewed from a direction orthogonal to the press direction) for explaining general drawing; and

Fig. 8B is a plan view (as viewed from the press direction).

**[0015]** Now, an embodiment of the present invention is described with reference to the attached drawings. Note that, the present invention is not limited to the embodiment described below.

**[0016]** The present invention has been made in view of the above-mentioned circumstances, and has an object to provide an assist drawing device having a relatively simple and low-cost configuration, but enabling fine control of an assist pressure during assist drawing, to thereby be capable of forming a product having a deeper depth (product in which a ratio between a product width and a product height is equal to or larger than a predetermined ratio) while suppressing thinning, cracking, or the like.

**[0017]** As illustrated in a block diagram of Fig. 1, an assist drawing device 10 according to this embodiment is provided with a punch 13 coupled, through intermedia-

tion of a ball screw mechanism or the like, to a shaft 12 driven by a servomotor 11. That is, the punch 13 can be linearly reciprocated along a left-right direction in Fig. 1 between a stroke start edge (home position: initial position) and a stroke end edge (maximum stroke position) while being guided by a slide guide (or a linear guide) or the like along a long-axis direction of the shaft 12 in accordance with a rotation direction of the shaft 12.

**[0018]** The servomotor 11 in this embodiment corresponds to an example of a drive source of a punch drive unit of the present invention.

**[0019]** The servomotor 11 is provided with an encoder (encoder of the absolute type) 11A which can acquire an absolute value of a rotation angle, and a detection signal thereof is input to a control device 200. A punch position command unit 201 of the control device 200 uses this detection signal to control, in a feedforward manner, drive of the servomotor 11, and in turn, a position (movement amount) of the punch 13.

**[0020]** Moreover, a linear scale 13A which detects a predetermined position (for example, a distance from the stroke end edge) of the punch 13 is provided. A detection signal of the linear scale 13A is input to the control device 200, and the control device 200 acquires an actual position of the punch 13 based on this detection signal (position information).

**[0021]** The linear scale 13A in this embodiment corresponds to an example of punch position information acquisition means of the present invention. As this punch position information acquisition means, together with the linear scale 13A, or in place of the linear scale 13A, the encoder mounted to the servomotor 11 may be used.

**[0022]** The punch 13 has a transverse cross-sectional shape (for example, rectangular shape) corresponding to an inside shape of a formed product. In this embodiment, the transverse cross-section is a surface obtained by cutting a product or a formed product (machined product) on a plane substantially parallel with a top surface or a bottom surface of the product.

**[0023]** Moreover, the assist drawing device 10 is provided with a drawing die 14 having an opening portion 14A which accommodates an outer periphery of the punch 13 in such a manner as to be movable along the reciprocating direction of the punch 13, to thereby perform the drawing in cooperation with the punch 13.

**[0024]** Moreover, the assist drawing device 10 according to this embodiment is provided with a blank holder 15 which presses a blank material (plate-shape material) M, for example, an aluminum alloy against a top surface of the drawing die 14 at a predetermined pressurizing force to thereby perform blank holding, when the assist drawing is performed.

**[0025]** This pressurizing force (blank holder pressure) of the blank holder 15 applied to the plate-shape material M (top surface of the drawing die 14) is supplied by an output portion 21 of a hydraulic cylinder 20. The pressurizing force of the output portion 21 is supplied by a hydraulic pressure of the hydraulic cylinder 20, and this

hydraulic pressure is supplied from a hydraulic device 100 via a hydraulic line X. The hydraulic pressure of the hydraulic cylinder 20 can be controlled to a desired value by the control device 200 with a pressure regulating valve 118-1 serving as pressure regulating means capable of controlling a pressure. The pressurizing force (hydraulic pressure supplied to the hydraulic cylinder 20) of the blank holder 15 is acquired (detected) by a hydraulic pressure sensor 120-1, which is an example of blank holder pressure information detection means, and an acquired value (data) thereof is input to the control device 200.

**[0026]** In this configuration, the hydraulic cylinder 20, the hydraulic device 100, and the like in this embodiment correspond to an example of a blank holder drive unit of the present invention.

**[0027]** A solenoid switching valve 119 of Fig. 1 is configured to be capable of switching a flow passage of the hydraulic pressure in accordance with a control command from the control device 200, and is controlled to release the hydraulic pressure of the hydraulic cylinder 20, and to switch the movement direction of the output portion 21 of the hydraulic cylinder 20, and in turn, the blank holder 15.

**[0028]** Moreover, in the assist drawing device 10 according to this embodiment, the servomotor 11 is driven in accordance with a command from the punch position command unit 201 to move the punch 13 rightward in Fig. 1, to thereby draw the blank material M with the punch 13 and the drawing die 14 in cooperation. At this time, the assist drawing is performed while the blank material M is pressed against the top surface of the drawing die 14 at the predetermined pressurizing force to perform the blank holding by a bottom surface (surface on the blank material M side) of the blank holder 15, and, simultaneously one end portion MA and another end portion MB of the blank material M are pressurized in a predetermined manner (see an assist pressure ASP in Fig. 1, Fig. 7A, Fig. 7B, and the like) by assist punches 32A and 32B from outsides toward a center of the blank material M.

**[0029]** In this configuration, for example, shapes of the one end portion MA and the another end portion MB of the blank material M as viewed in a direction along the movement direction of the punch 13 may be shapes illustrated in Fig. 7B, and shapes of the assist punches 32A and 32B may be shapes illustrated in Fig. 1 corresponding to the shapes of the one end portion MA and the another end portion MB, but the shapes are not limited thereto.

**[0030]** The block diagram of Fig. 1 as a whole is a diagram viewed in a direction orthogonal to the movement direction of the punch 13 (diagram viewed in the same direction as a viewing direction of a diagram obtained by rotating Fig. 7A counterclockwise by 90 degrees), but the assist punches 32A and 32B are illustrated as a diagram viewed in the direction along the movement direction of the punch 13 (that is, a diagram viewed in the same direction as a viewing direction of a

diagram obtained by rotating Fig. 7B counterclockwise by 90 degrees).

**[0031]** The assist punches 32A and 32B are movably inserted between the bottom surface of the blank holder 15 and the top surface of the drawing die 14, and are configured to pressurize the blank material 10 from the outside toward the center through use of assist cylinders (hydraulic cylinders) 30A and 30B. The assist punches 32A and 32B are substantially integral with output portions 31A and 31B of the assist cylinders 30A and 30B, which are hydraulic cylinders (linear actuators), respectively. A pressurizing force (assist pressure) of the assist punches 32A and 32B is supplied through a hydraulic pressure of the assist cylinders 30A and 30B, and this hydraulic pressure is supplied from the hydraulic device 100 via a hydraulic line Y. The hydraulic pressure of the assist cylinders 30A and 30B can be controlled to a desired value by the control device 200 with a pressure regulating valve 118-2 serving as pressure regulating means capable of controlling a pressure. The pressurizing force (hydraulic pressure supplied to the assist cylinders 30A and 30B) of the assist punches 32A and 32B is acquired (detected) by a hydraulic pressure sensor 120-2, and an acquired value (data) thereof is input to the control device 200.

**[0032]** In this configuration, the assist cylinders 30A and 30B, the hydraulic device 100, and the like in this embodiment correspond to an example of an assist punch drive unit of the present invention. Moreover, the hydraulic pressure sensor 120-2 corresponds to an example of assist pressure information acquisition means of the present invention.

**[0033]** A solenoid switching valve 121-1 of Fig. 1 is configured to be capable of switching a flow passage of the hydraulic pressure in accordance with a control command from the control device 200, and is controlled to release the hydraulic pressure of the assist cylinders 30A and 30B, and to switch the movement directions of the output portions 31A and 31B of the assist cylinders 30A and 30B, and in turn, the assist punches 32A and 32B.

**[0034]** Moreover, the assist drawing device 10 according to this embodiment is provided with a cushion pad 42 which presses the blank material M at a predetermined pressurizing force from a direction opposing to the punch 13 when the assist drawing is performed.

**[0035]** The cushion pad 42 is substantially integral with an output portion 41 of a die cushion (cushion cylinder) 40, which is a hydraulic cylinder. The pressurizing force (cushion pressure) of the cushion pad 42 is supplied by a hydraulic pressure of the die cushion 40, and this hydraulic pressure is supplied from the hydraulic device 100 via a hydraulic line Z. The hydraulic pressure of the die cushion 40 can be controlled to a desired value by the control device 200 with a pressure regulating valve 118-3 serving as pressure regulating means capable of controlling a pressure. The pressurizing force (hydraulic pressure supplied to the die cushion 40) of the cushion pad 42 is acquired (detected) by a hydraulic pressure

sensor 120-3, which is an example of cushion pressure information detection means, and an acquired value (data) thereof is input to the control device 200.

**[0036]** In this configuration, the die cushion 40, the hydraulic device 100, and the like in this embodiment correspond to an example of a cushion pad drive unit of the present invention.

**[0037]** A solenoid switching valve 121-2 of Fig. 1 is configured to be capable of switching a flow passage of the hydraulic pressure in accordance with a control command from the control device 200, and is controlled to release the hydraulic pressure of the die cushion 40, and to switch the movement direction of the output portion 41 of the die cushion 40, and in turn, the cushion pad 42.

**[0038]** Moreover, each of the above-mentioned pressure regulating valves 118-1, 118-2, and 118-3 may be, for example, a solenoid proportional pressure reducing valve (with a relieving mechanism), and is configured to apply pressure reducing control to a hydraulic pressure of the hydraulic line upstream of each thereof based on a control command from the control device 200, to thereby be capable of controlling a hydraulic pressure of the hydraulic line downstream of each thereof to a desired value.

**[0039]** An example of a block diagram of the hydraulic device 100 in this embodiment is illustrated in Fig. 6. In this block diagram, reference symbol 101 denotes "oil tank," reference symbol 102 denotes "suction strainer," reference symbol 103 denotes "oil temperature & level gauge (oil level gauge with oil temperature gauge)," reference symbol 104 denotes "oil inlet & air breather (oil supply opening/air breather)," reference symbol 105 denotes "gear pump," reference symbol 106 denotes "coupling," reference symbol 107 denotes "electric motor," reference symbol 108 denotes "line filter," reference symbol 109 denotes "check valve (inline check valve)," reference symbol 110 denotes "accumulator," reference symbol 111 denotes "pressure gauge (glycerin pressure gauge)," reference symbol 112 denotes "stop valve," reference symbol 113 denotes "trochoid pump," reference symbol 114 denotes "oil cooler," reference symbol 115 denotes "check valve (right angle check valve)," reference symbol 116 denotes "manifold block," reference symbol 117 denotes "relief valve," reference symbols 118-1 to 118-3 denote "electro-hyd, proportional reducing valve (reducing valve with solenoid proportional relieving mechanism)" (pressure regulating valve), reference symbol 119 denotes "solenoid valve (solenoid switching valve)," reference symbols 120-1 to 120-3 denote "pressure sensors (hydraulic pressure sensors)," reference symbols 121-1 and 121-2 denote "solenoid valve (solenoid switching valve)," reference symbol 122 denotes "F.C valve (flow rate control valve)," reference symbol 124 denotes "relief valve," reference symbol 125 denotes "stop valve," reference symbol 126 denotes "suction strainer," reference symbol 127 denotes "gate valve," reference symbol 128 denotes "manifold block," reference symbol 129 denotes "solenoid

valve (solenoid switching valve)," reference symbol 130 denotes "relief valve," reference symbol 132 denotes "pressure sensor (pressure switch)," and reference symbol 133 denotes "terminal box."

**[0040]** The control device 200 is formed of various interfaces, an A/D converter, various memories, a CPU, and the like, and is configured to be capable of executing input and output of various types of information, various types of calculation, various programs, and the like.

**[0041]** The punch position command unit 201 of the control device 200 drives the servomotor 11 while referring to the detection signal of the encoder 11A in accordance with position command data (schedule (action data No.) of the assist drawing set in advance and the like) input (set) through execution of a flowchart of Fig. 2 described later and the like, to thereby move the punch 13 in each process to a target position of thereof.

**[0042]** In this embodiment, as an example thereof is illustrated in Fig. 4 and shown in Fig. 5, target positions (P1 to P7) of the processes of the punch 13 are distances from the stroke end edge (maximum stroke position) (corresponding to the position of the target position P6) of the punch 13.

**[0043]** The target position P1 is a start position of the first process (process No. 1), and the target position P2 is an end position of the first process (process No. 1) and a start position of the second process (process No. 2).

**[0044]** The target position P3 is an end position of the second process (process No. 2) and a start position of the third process (process No. 3). The target position P4 is an end position of the third process (process No. 3) and a start position of the fourth process (process No. 4). The target position P5 is an end position of the fourth process (process No. 4) and a start position of the fifth process (process No. 5). The target position P6 is an end position of the fifth process (process No. 5) and a start position of the sixth process (process No. 6). The target position P7 is an end position of the sixth process (process No. 6).

**[0045]** In Fig. 4 and Fig. 5, the first process is a punching process, the second process is a drawing process, the third process to the fifth process are an ironing process, and the sixth process is a knockout (removal) process of the finished product. Those processes are schematically illustrated and shown, respectively.

**[0046]** Moreover, a pressure command unit 202 of the control device 200 transmits pressure commands I, II, and III set in accordance with the target position of the punch 13 to "the hydraulic cylinder 20 for driving the blank holder," "the assist cylinders 30A and 30B," and "the die cushion 40," respectively, in accordance with pressure command data (a schedule (action data No.) of the assist drawing set in advance and the like) input (set) through execution of the flowchart of Fig. 2 described later and the like, and applies control such that each of the target pressures (assist target pressure, blank holder target pressure, and cushion target pressure) is achieved in accordance with information on an actual position of the

punch 13 detected by the linear scale 13A.

**[0047]** In this configuration, a portion relating to the assist pressure control of the pressure command unit 202 corresponds to an example of an assist pressure control unit of the present invention.

**[0048]** Fig. 2 is the flowchart of setting the operation data for the assist drawing device 10 to perform the assist drawing in this embodiment. This flowchart is executed by the control device 200.

**[0049]** In Step (denoted as S in the flowchart, and the same applies hereinafter) 1 of Fig. 2, a worker (or operator) turns on an operation power supply of the assist drawing device 10.

**[0050]** In Step 2, "Create action processes?" is displayed on a monitor or the like, and the worker makes selection. When determination of YES is made, the control device 200 proceeds to Step 3. When determination of NO is made, this flow is ended to transition to other operation (for example, flowcharts of Fig. 3A and Fig. 3B).

**[0051]** In Step 3, the worker selects a "created data No." As the "created data No.," a table for storing a pattern of the assist drawing processes is assigned to each No. in accordance with, for example, a difference in specifications of the finished product.

**[0052]** In Step 4, the worker inputs data for each machining process of the assist drawing machining to the selected "created data No." This data may be, for example, data acquired at the time of test production or the like. In this example, there is exemplified a case in which the start to the end of the assist drawing is divided into processes including a first process to a sixth process (process No. 1 to process No. 6).

**[0053]** In Step 5, the control device 200 sets the data input in Step 4 to "action data No." corresponding to "created data No.," and ends this flow. Pieces of data to be set to each of the first process to the sixth process to be set to the "action data No." include data 1: the target position P of the punch 13 in this process, data 2: a movement speed of the punch 13, data 3: a target blank holder pressure in this process, data 4: a target assist pressure in this process, data 5: a target cushion pressure in this process, data 6: a wait time, data 7: pressure synchronization selection, and the like. Those pieces of data are individually set.

**[0054]** As an example, a process diagram (process map) (diagram illustrating a relationship among the process No. 1 to the process No. 6 (process sequence), "the target positions (P1 to P7) of the punch 13," "(1) the target blank holder pressures (target pressurizing forces of the blank holder 15)," "(2) the target assist pressures (target pressurizing forces of the assist punches 32A and 32B)," and "(3) the target cushion pressures (target pressurizing forces of the cushion pad 42)" as illustrated in Fig. 4 is created in advance based on the data acquired at the time of the test production or the like, and a table thereof is referred to, to thereby input, for example, the target positions (P1 to P7) of the punch 13 in the processes as, for example, the data 1 of the "created data No. 1."

After that, the target blank holder pressures corresponding to those target positions of the punch 13 are input as data 3 of "created data No. 1." The target assist pressures corresponding to those target positions of the punch 13 are input as data 4 of "created data No. 1." The target cushion pressures corresponding to those target positions of the punch 13 are input as data 5 of "created data No. 1." The punch target positions P1 to P7 of the punch 13 indicate the distances from the stroke end edge (maximum stroke position) (position of P6=0 mm) of the punch 13. A table showing the target pressures of the process map of Fig. 4 in the sequence of the processes is shown in Fig. 5.

**[0055]** Also, for the movement speed of the punch 13 of the data 2, the wait time of the data 6, the pressure synchronization selection of the data 7, and the like, data acquired in advance at the time of the test production or the like is input.

**[0056]** The movement speed of the punch 13 (data 2) is a movement speed at the time of the movement from the target position of the punch 13 in the current process to the target position of the punch 13 in the next process.

**[0057]** The wait time (data 3) is a freely selected time for which the punch 13 is stopped (held) in each process. The pressurizing force of each of the blank holder 15, the assist punches 32A and 32B, and the cushion pad 42 changes in accordance with the position of the punch 13 and presence or absence of the synchronization setting.

**[0058]** Moreover, the pressure synchronization selection of the data 7 is a flag indicating a state of the selection of a form of a change in current pressure of each pressure (assist pressure, blank holder pressure, or cushion pressure) to the target pressure (set pressure) in the next process at the time of transition to the next process (period from transition start to transition completion) or the like. Description is now given of the assist pressure as an example, and the form of the change (increase or decrease) to the target pressure can be selected such that the form of the assist pressure with respect to the movement (position change) of the punch 13 is, for example, a proportional (linear) form, a curvilinear form, or a combination thereof while the assist pressure is synchronized with the movement (position change) of the punch 13. The blank holder pressure and the cushion pressure may be similar thereto.

**[0059]** The pressure synchronization control of generating the pressure commands in correspondence to (in synchronization with) the position of the punch 13 as described above may be feedforward control, or so-called feedback control of acquiring a deviation between the detection result of each of the hydraulic pressure sensors 120-1 to 120-3 and the target value, and reducing the deviation may also be executed.

**[0060]** The control device 200 executes the flowcharts illustrated in Fig. 3A and Fig. 3B based on the operation data (action data No.) created through the execution of the flowchart of Fig. 2 and the like, to thereby allow the assist drawing to be performed.

**[0061]** Fig. 3A and Fig. 3B are explanatory flowcharts for illustrating an automatic operation action of the assist drawing device which performs the assist drawing in this embodiment.

**[0062]** In Step 11, the worker turns on the operation power supply of the assist drawing device 10.

**[0063]** In Step 12, the worker selects whether or not the automatic operation is to be performed in accordance with the monitor display or the like. When a determination of YES is made, the control device 200 proceeds to Step 13. When a determination of NO is made, the control device 200 ends this flow to transition to other operation.

**[0064]** In Step 13, a desired "action data No." is selected from an action data group created and stored through the execution of the flowchart of Fig. 2 or the like. The "action data No." is selected from, for example, data No. 1 to data No. 99.

**[0065]** In Step 14, in response to completion of the selection of the "action data No.," the control device 200 refers to and sets the corresponding "action data No."

**[0066]** In Step 15, determination is made on whether or not the punch 13, the blank holder 15, the assist punches 32A and 32B, and the cushion pad 42 of the assist drawing device 10 are at home positions (initial positions). When a determination of YES is made, the control device 200 proceeds to Step 17. When a determination of NO is made, the control device 200 proceeds to Step 16.

**[0067]** In Step 16, the worker manually returns the punch 13, the blank holder 15, the assist punches 32A and 32B, and the cushion pad 42 to the home positions.

**[0068]** In Step 17, the setting of the various types of data for performing the assist drawing is completed, and the punch 13, the blank holder 15, the assist punches 32A and 32B, and the cushion pad 42 are at the home positions, the worker presses a push button to ON (PB\_ON) to start the assist drawing action from the home position (target position P1) toward the end position (target position P2) of the first process (process No. 1). The control device 200 proceeds to Step 18.

**[0069]** In Step 18, the control device 200 determines, based on the detection information of the hydraulic pressure sensor 120-1, whether or not the pressurizing force of the blank holder 15 (hydraulic pressure supplied to the hydraulic cylinder 20) is a blank holder set pressure (target blank holder pressure in this process). When a determination of NO is made, the control device 200 instructs (outputs) the blank holder set pressure in accordance with the operation data set to the corresponding "action data No." to control the pressure regulating valve 118-1 in Step 19, and returns to Step 18. When a determination of YES is made, the control device 200 proceeds to Step 20.

**[0070]** In Step 20, the control device 200 determines, based on the detection information of the hydraulic pressure sensor 120-2, whether or not the pressurizing force of the assist punches 32A and 32B (hydraulic pressure supplied to the assist cylinders 30A and 30B) is an assist set pressure (target assist pressure in this process).

When a determination of NO is made, the control device 200 instructs (outputs) the assist set pressure in accordance with the corresponding "action data No." to control the pressure regulating valve 118-1 in Step 21, and returns to Step 20. When a determination of YES is made, the control device 200 proceeds to Step 22.

**[0071]** In Step 22, the control device 200 determines, based on the detection information of the hydraulic pressure sensor 120-3, whether or not the pressurizing force of the cushion pad 42 (hydraulic pressure supplied to the die cushion 40) is a cushion set pressure (target cushion pressure in this process). When a determination of NO is made, the control device 200 instructs (outputs) the cushion set pressure in accordance with the corresponding "action data No." to control the pressure regulating valve 118-1 in Step 23, and returns to Step 22. When a determination of YES is made, the control device 200 proceeds to Step 24. The processing in Step 18, Step 20, and Step 22 may be executed in parallel.

**[0072]** In Step 24, the control device 200 determines whether or not a set time of a wait timer (wait time) has been reached. When a determination of YES is made, the control device 200 proceeds to Step 26. When a determination of NO is made, the control device 200 waits (stops) for the set time in Step 25, and returns to Step 24.

**[0073]** In Step 26, the control device 200 determines whether or not the pressure synchronization setting is given. When a determination of NO is made, the control device 200 proceeds to Step 27, refers to the selected "action data No." to move each portion in accordance with the action data in the next process, and then proceeds to Step 30.

**[0074]** When a determination of YES is made, the control device 200 proceeds to Step 28. The control device 200 determines that "each of the pressures (assist pressure, blank holder pressure, and cushion pressure) during the transition to the next process is changed (increased or decreased) to the target pressure (set pressure) in the next process in synchronization with the position change of the punch 13," and proceeds to Step 29. The control device 200 moves each portion in accordance with the action data in the next process including the form of the change in each pressure to the target pressure with respect to the position change of the punch 13 in accordance with the selection situation, and proceeds to Step 30.

**[0075]** In Step 30, the control device 200 determines whether or not the final process (in this example, the sixth process (process No. 6)) has been completed. When a determination of NO is made, the control device 200 returns to Step 18. When a determination of YES is made, it is considered that the assist drawing for one blank material M is completed, and hence the control device 200 proceeds to Step 31. The control device 200 starts a feeder 50 (see Fig. 1) which supplies a new blank material M and supplies the next blank material M to the assist drawing device 10. The control device 200 also returns each of the portions (punch 13, blank holder 15, assist

punches 32A and 32B, and cushion pad 42) to the home position (initial position), and proceeds to Step 32.

**[0076]** In Step 32, for the assist drawing for the next blank material M, the control device 200 instructs the movement of each of the portions (punch 13, blank holder 15, assist punches 32A and 32B, and cushion pad 42) from the home position (target position P1) to the end position (target position P2) in the first process (process No. 1), and returns to Step 18.

**[0077]** As described above, in this embodiment, the control device 200 executes the first process (process No. 1) to the sixth process (process No. 6) of the assist drawing machining, to thereby use single punch 13 to allow the assist drawing of the blank material M to be performed.

**[0078]** For example, there may be provided such a configuration that the control device 200 ends this flow, for example, when the control device 200 counts the number of times of the completion of the assist drawing machining for the blank material M, and the assist drawing machining is completed for a predetermined number of blank materials M, or when a signal indicating that the blank materials M are out of stock or the like is received from the feeder 50.

**[0079]** As described above, according to this embodiment, the position of the punch 13 which is moved at the time of the assist drawing is acquired (detected) to control the assist pressure, the blank holder pressure, and the cushion pressure in accordance with the movement of the punch 13 such that the target assist pressure, the target blank holder pressure, and the target cushion pressure set in accordance with the position of the punch 13 are achieved, and hence the assist pressure, the blank holder pressure, and the cushion pressure are appropriately controlled in accordance with the movement of the punch 13 during the assist drawing. Thus, a product having a deeper depth (product in which a ratio between a product width and a product height is larger than a predetermined ratio) can be formed while suppressing thinning, cracking, or the like.

**[0080]** That is, according to this embodiment, it is possible to provide an assist drawing device having a relatively simple and low-cost configuration, but enabling finely control of the assist pressure (further, the combination of this assist pressure and at least one of the blank holder pressure or the cushion pressure), to thereby be capable of forming a product having a deeper depth (product in which a ratio between a product width and a product height is equal to or larger than the predetermined ratio) while suppressing thinning, cracking, or the like, and to provide a control method therefor. As a result, unlike the related art, it is not required to use a plurality of punches designed such that the shape gradually approaches that of the finished product to perform drawing at a plurality of stages, and hence it is possible to produce a high-quality finished product with a single punch. Further, it is also possible to drastically suppress the amount of machining oil (lubricant oil) and coolant oil



to be used, which have been a problem in the case of performing drawing at a plurality of stages. Thus, it is possible to contribute to a reduction in cost for a production facility, simplification, a reduction in production time, and in turn, a reduction in production cost.

**[0081]** In this embodiment, description has been given of the case in which the three pressures, that is, the assist pressure, the blank holder pressure, and the cushion pressure are controlled in accordance with the movement of the punch 13 so that the three target pressures, that is, the target assist pressure, the target blank holder pressure, and the target cushion pressure are achieved, but the present invention is not limited to this case. There may be provided such a configuration the assist pressure is controlled in accordance with the movement of the punch 13 so that at least the target assist pressure of the target assist pressure, the target blank holder pressure, and the target cushion pressure set in accordance with the position of the punch 13 is achieved in accordance with the position of the punch 13 moved at the time of the assist drawing. That is, it is possible to form a product having a deeper depth (product in which a ratio between a product width and a product height is equal to or larger than a predetermined ratio) while suppressing thinning, cracking, or the like by providing such a configuration that the assist pressure is appropriately controlled in accordance with the movement of the punch 13 during the assist drawing.

**[0082]** When only the assist pressure is controlled in accordance with the movement of the punch 13, there may be provided such a configuration that the blank holder pressure and the cushion pressure are set constant regardless of the position of the punch or the like.

**[0083]** Incidentally, there has been exemplified the case in which, in Step 18 to Step 25 of Fig. 3B, the pressures (assist pressure, blank holder pressure, and cushion pressure) are detected by the hydraulic pressure sensors (120-1, 120-2, and 120-3), respectively, and the control is executed in the feedforward manner so that the current pressures reach the respective target values, but the configuration is not limited to this case. In Step 19, Step 21, and Step 23, the control device 200 may be caused to execute the so-called feedback control in which the control device 200 obtains the deviations between the current pressures detected by the hydraulic pressure sensors (120-1, 120-2, and 120-3) and the target blank holder pressure, the target assist pressure, and the target cushion pressure, respectively, and controls the pressure regulating valves (118-1, 118-2, and 118-3) so that the deviations decrease, and returns to Step 18. It is possible to suppress, through the feedback control, an occurrence of overshoot, hunting, and the like of each of the pressures (assist pressure, blank holder pressure, and cushion pressure) with respect to each target value. Thus, accurate pressure control can be achieved, and in turn can contribute to achievement of high-quality assist drawing.

**[0084]** In this embodiment, the servomotor 11 has

been described as an example of the drive source of the punch drive unit of the punch 13, but the drive source is not limited to the servomotor 11. The drive source may be other electric motor, a linear motor, a linear actuator which uses a fluid pressure, or the like.

**[0085]** Moreover, in this embodiment, the assist cylinders 30A and 30B, which are the hydraulic cylinders, have been described as an example of the drive sources of the assist punch drive units of the assist punches 32A and 32B. However, the drive sources are not limited to the hydraulic cylinders, and may be electric motors, linear motors, other linear actuators which use a fluid pressure, or the like. Moreover, in this embodiment, the die cushion (cushion cylinder) 40 which is the hydraulic cylinder has been described as an example of the drive source of the cushion pad drive unit of the cushion pad 42, but the drive source is not limited to the die cushion 40. The drive source may be an electric motor, a linear motor, other linear actuator which uses a fluid pressure, or the like.

**[0086]** Moreover, the planar shape of the blank material M, the number of the assist punches and the drive sources therefor, an arrangement of the assist punches on a plane of the blank material M, and the like may appropriately be changed in accordance with the product. They are not limited to those exemplified in Fig. 1, Fig. 7, and the like.

**[0087]** Moreover, the transverse cross-sectional shape of the product (punch 13) after the completion of the assist drawing is not limited to a rectangular shape such as a square or a rectangle. The transverse cross-sectional shape may be a rhombus, other polygonal shape, a circular shape, an ellipsoidal shape, or the like, and is not particularly limited in the present invention. Moreover, the drawing depth is not limited.

**[0088]** Moreover, in this embodiment, the material of the blank material M has been described as the aluminum alloy or the like, but the present invention is not limited to the case in which the material is the aluminum alloy, and the present invention may be applied to a blank material made of other material.

**[0089]** According to the present invention, it is possible to provide an assist drawing device having a relatively simple and low-cost configuration, but enabling fine control of the assist pressure during the assist drawing, to thereby be capable of forming a product having a deeper depth (product in which a ratio between a product width and a product height is equal to or larger than a predetermined ratio) while suppressing thinning, cracking, or the like.

**[0090]** The embodiment described above is merely an example for describing the present invention, and as a matter of course, various modifications may be made without departing from the gist of the present invention.

## REFERENCE SIGNS

**[0091]**

1 die  
 2 punch  
 2R round-chamfered corner portions  
 2r round-chamfered shoulder portions  
 3 blank (material)  
 4 blank holder  
 5 blank material  
 5A end portion  
 5B end portion  
 6 assist punch  
 7 punch  
 8 die  
 9 blank holder  
 10 assist drawing device  
 11 servomotor  
 11A encoder  
 12 shaft  
 13 punch  
 13A linear scale  
 14 drawing die  
 14A opening portion  
 15 blank holder  
 20 hydraulic cylinder  
 21 outlet portion  
 30A assist cylinder  
 30B assist cylinder  
 31A output portion  
 31B output portion  
 32A assist punch  
 32B assist punch  
 40 die cushion/ cushion cylinder  
 41 output portion  
 42 cushion pad  
 50 feeder  
 100 hydraulic device  
 101 oil tank  
 102 suction strainer  
 103 oil temperature & level gauge  
 104 oil inlet & air breather  
 105 gear pump  
 106 coupling  
 107 electric motor  
 108 line filter  
 109 check valve  
 110 accumulator  
 111 pressure gauge  
 112 stop valve  
 113 trochoid pump  
 114 oil cooler  
 115 check valve  
 116 manifold block  
 117 relief valve  
 118-1 electro-hyd / proportional reducing valve /  
 pressure regulating valve  
 118-2 electro-hyd / proportional reducing valve /  
 pressure regulating valve  
 118-3 electro-hyd / proportional reducing valve /  
 pressure regulating valve

119 solenoid (switching) valve  
 120-1 hydraulic pressure sensor  
 120-2 hydraulic pressure sensor  
 120-3 hydraulic pressure sensor  
 5 121-1 solenoid switching valve  
 121-2 solenoid switching valve  
 122 flow rate control valve  
 124 relief valve  
 125 stop valve  
 10 126 suction strainer  
 127 gate valve  
 128 manifold block  
 129 solenoid valve  
 130 relief valve  
 15 132 pressure sensor  
 133 terminal box  
 200 control device  
 201 punch position command unit  
 202 pressure command unit  
 20 ASP assist pressure  
 I, II, III pressure command  
 M blank material  
 MA end portion  
 MB another end portion  
 25 P1-P7 target positions  
 Rd round-chamfered shoulder portions  
 S1-S6 method steps  
 S11-S32 method steps  
 X hydraulic line  
 30 Y hydraulic line  
 Z hydraulic line

### Claims

- 35 **1.** An assist drawing device (10), comprising:  
 40 a punch (13), which has a shape conforming to a product shape, and is configured to be linearly reciprocated between a stroke start edge and a stroke end edge;  
 45 a drawing die (14), which has an opening conforming to the product shape, and is configured to perform drawing on a blank material (M) having a plate shape in cooperation with the punch (13);  
 50 a blank holder (15) configured to press the blank material (M) against the drawing die (14) at a blank holder (15) pressure;  
 55 a pair of assist punches (32A, 32B), which are movably inserted between the drawing die (14) and the blank holder (15), and are arranged opposed to each other so as to be capable of pressing end surfaces of the blank material (M) from opposing directions at an assist pressure;  
 a punch drive unit configured to drive the punch (13); and  
 an assist punch drive unit configured to supply the assist pressure to the pair of assist punches

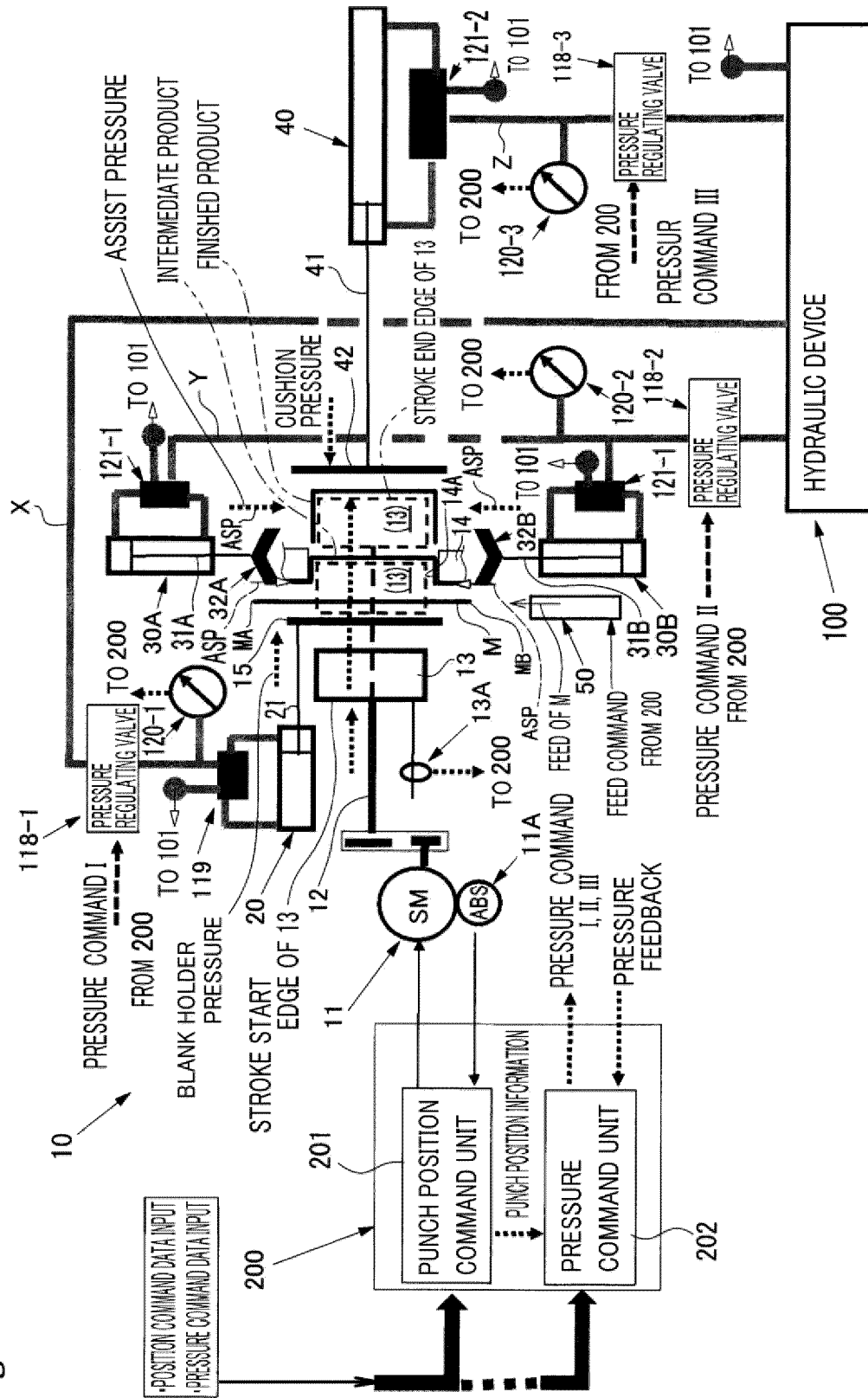
- (32A, 32B),  
 wherein, when the punch (13) is moved from the stroke start edge toward the stroke end edge in accordance with a command from a control device (200) to the punch drive unit, and drawing is performed in cooperation with the drawing die (14), assist drawing is performed while pressing the blank material (M) against the drawing die (14) by the blank holder (15) and pressing both end surfaces of the blank material (M) by the pair of assist punches (32A, 32B), and wherein the control device (200) includes an assist pressure control unit configured to control the assist punch drive unit such that, when the assist drawing is performed, the assist pressure of the pair of assist punches (32A, 32B) reaches a target assist pressure in accordance with a position of the punch (13).
2. The assist drawing device (10) according to claim 1, further comprising punch position information acquisition means configured to acquire position information on the punch (13), wherein the assist pressure control unit is configured to control, based on the actual position information on the punch (13) acquired by the punch position information acquisition means, the assist punch drive unit such that the assist pressure of the pair of assist punches (32A, 32B) reaches the target assist pressure in accordance with the position of the punch (13).
3. The assist drawing device (10) according to claim 1 or 2, further comprising assist pressure information acquisition means configured to acquire assist pressure information on the pair of assist punches (32A, 32B), wherein the assist pressure control unit is configured to control, based on the actual assist pressure information acquired by the assist pressure information acquisition means, the assist punch drive unit such that the assist pressure of the pair of assist punches (32A, 32B) reaches the target assist pressure in accordance with the position of the punch (13).
4. The assist drawing device (10) according to any one of claims 1 to 3,
- wherein the control device (200) is configured to use the command to the punch drive unit to move the punch (13) from a current position, and wherein the assist pressure control unit is configured to:
- set the target assist pressure in accordance with the position of the punch (13) to the target assist pressure at a position after the movement from the current position of the

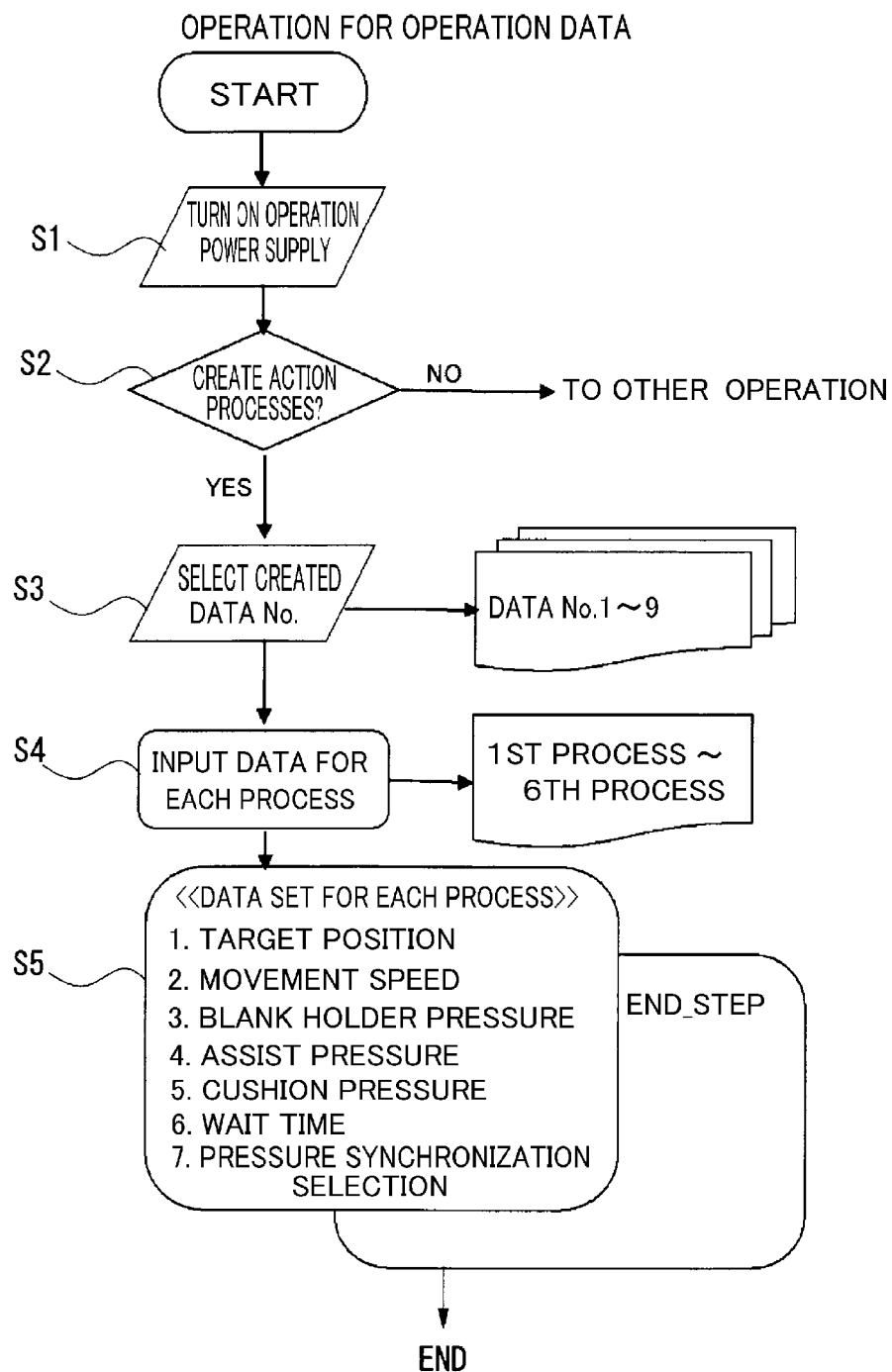
punch (13) in accordance with the command from the control device (200) to the punch drive unit; and  
 execute pressure synchronization control of changing the target assist pressure in accordance with the position of the punch (13) from the target assist pressure at the current position of the punch (13) to the target assist pressure at the position after the movement.

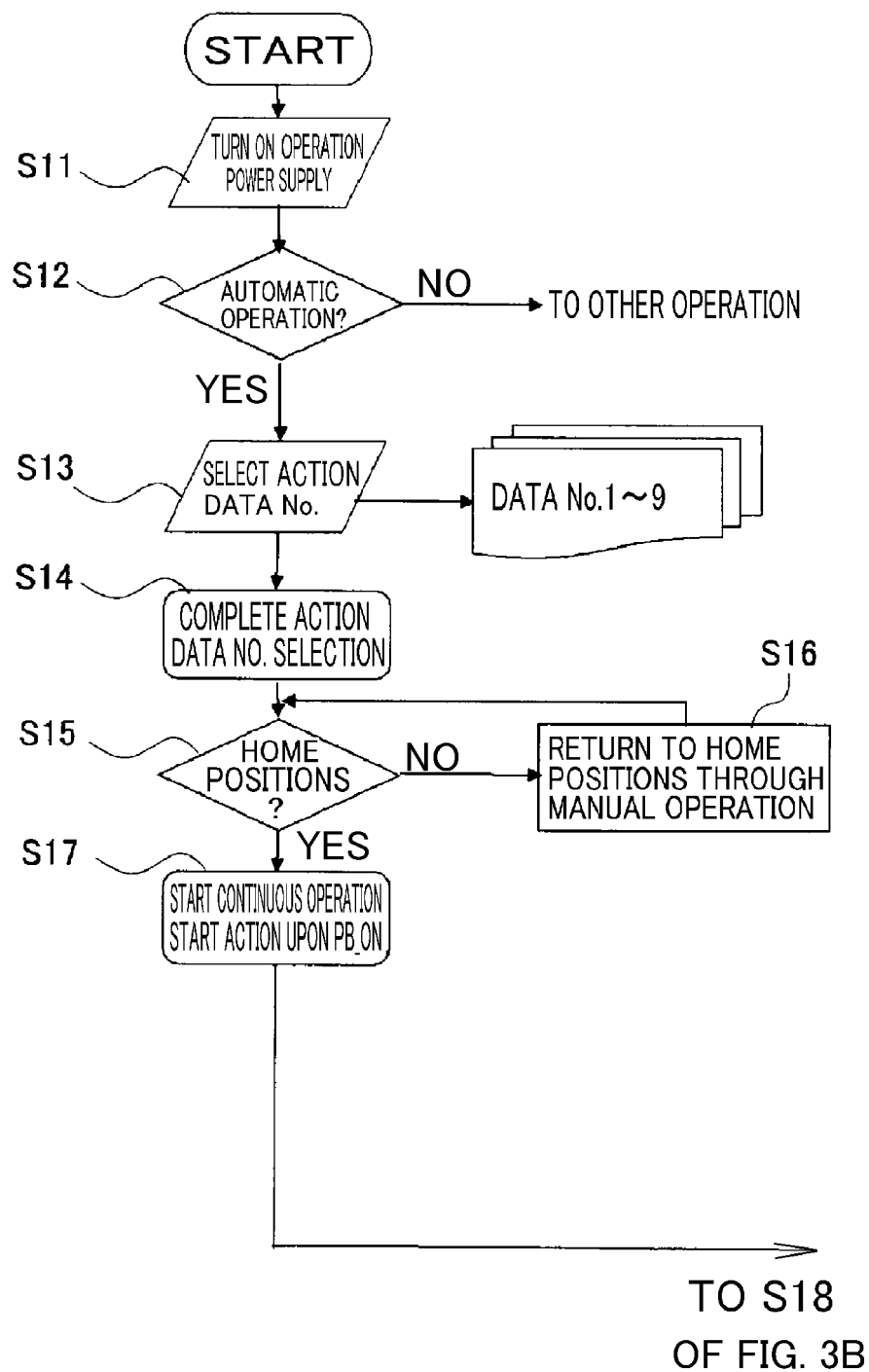
5. The assist drawing device (10) according to any one of claims 1 to 4, further comprising:

a blank holder (15) drive unit configured to supply a blank holder (15) pressure to the blank holder (15);  
 a cushion pad (42) configured to press the blank material (M) at a cushion pressure from a direction opposing the movement of the punch (13) when the assist drawing is performed; and  
 a cushion pad drive unit configured to supply the cushion pressure to the cushion pad (42), wherein the control device (200) is configured to control at least one of the blank holder (15) drive unit or the cushion pad drive unit such that, when the assist drawing is performed, at least one of the blank holder (15) pressure or the cushion pressure reaches a target blank holder pressure or a target cushion pressure in accordance with the position of the punch (13).

Fig. 1



**FIG. 2**

**FIG. 3A**

**FIG. 3B**

FROM S17 OF FIG. 3A

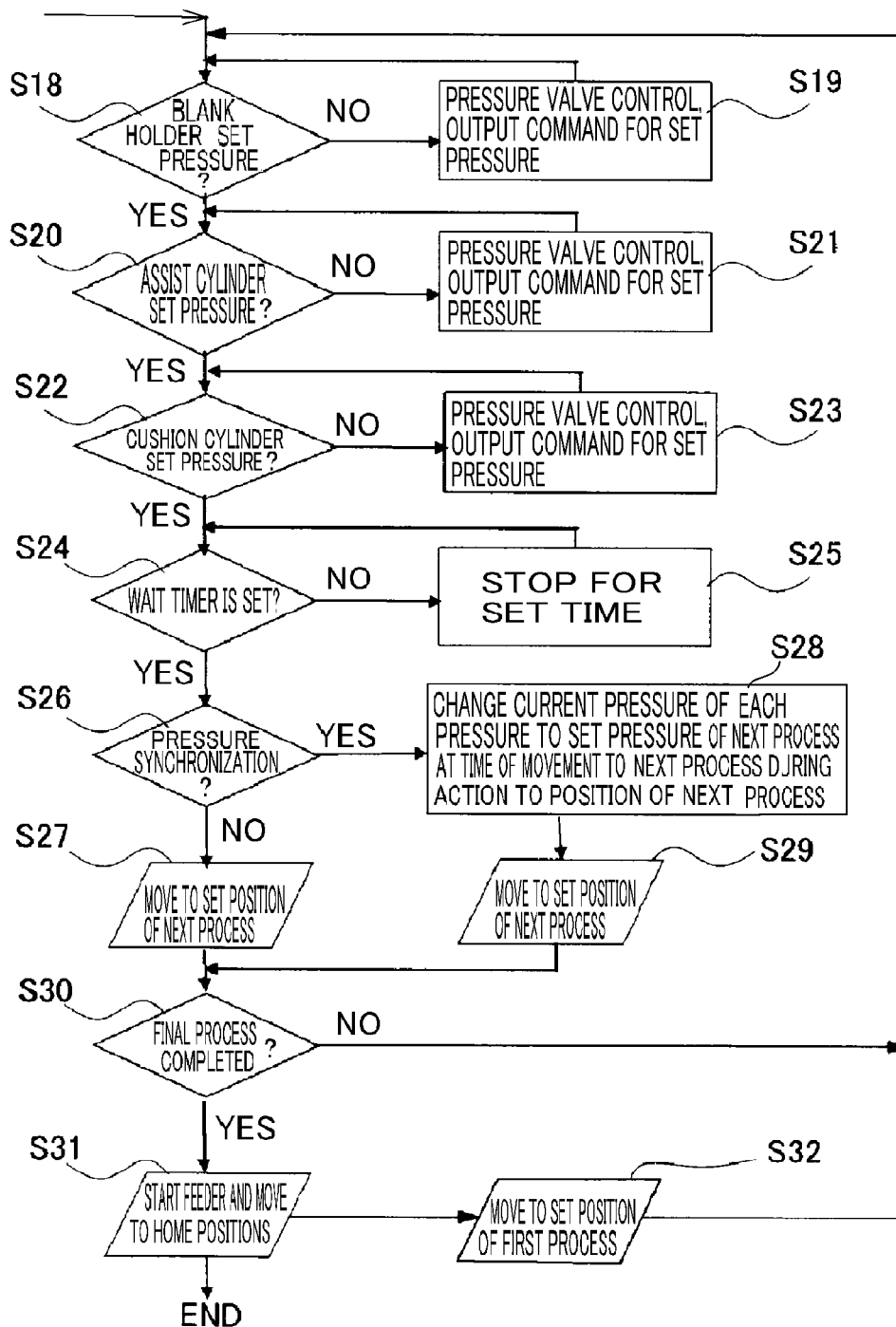


FIG. 4

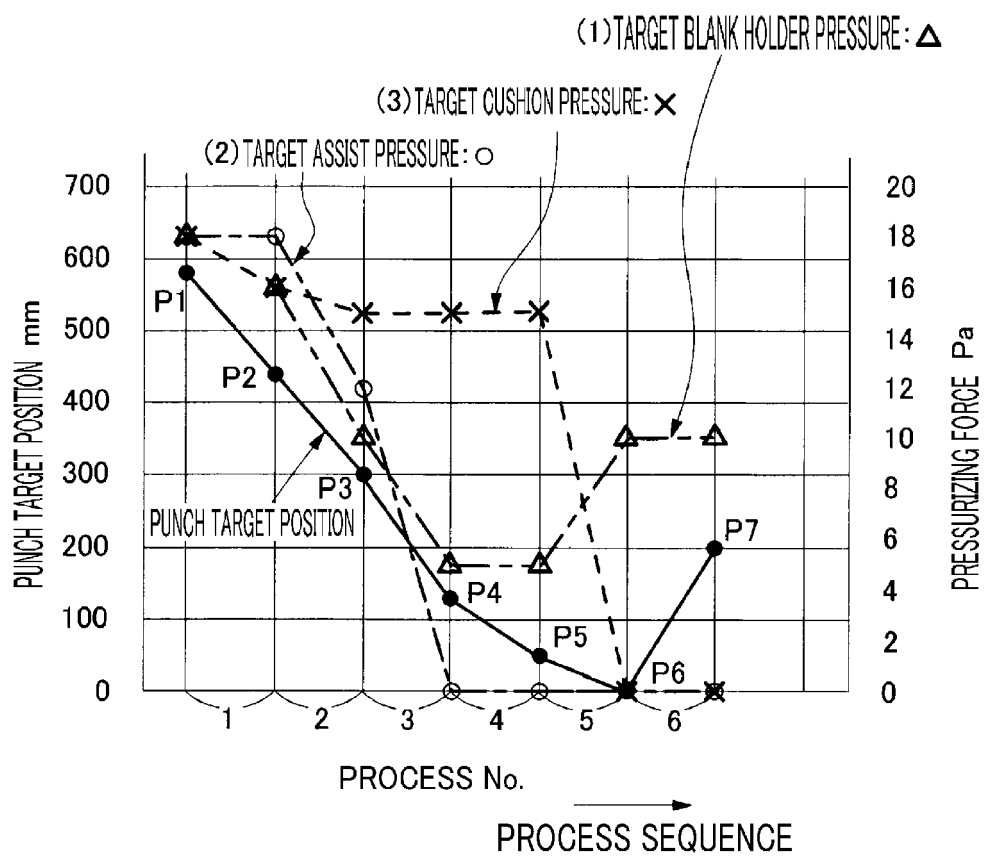




FIG. 5

| PROCESS No.                                              | 1      | 2       | 3      | 4      | 5     | 6    | 7      |
|----------------------------------------------------------|--------|---------|--------|--------|-------|------|--------|
| PUNCH TARGET POSITION<br>(DISTANCE FROM STROKE END EDGE) | P1=580 | P2= 440 | P3=300 | P4=130 | P5=50 | P6=0 | P7=200 |
| mm                                                       |        |         |        |        |       |      |        |
| TARGET BLANK HOLDER PRESSURE MPa                         | 18     | 16      | 10     | 5      | 5     | 10   | 10     |
| TARGET ASSIST PRESSURE MPa                               | 18     | 18      | 12     | 0      | 0     | 0    | 0      |
| TARGET CUSHION PRESSURE MPa                              | 18     | 16      | 15     | 15     | 15    | 0    | 0      |

FIG. 6

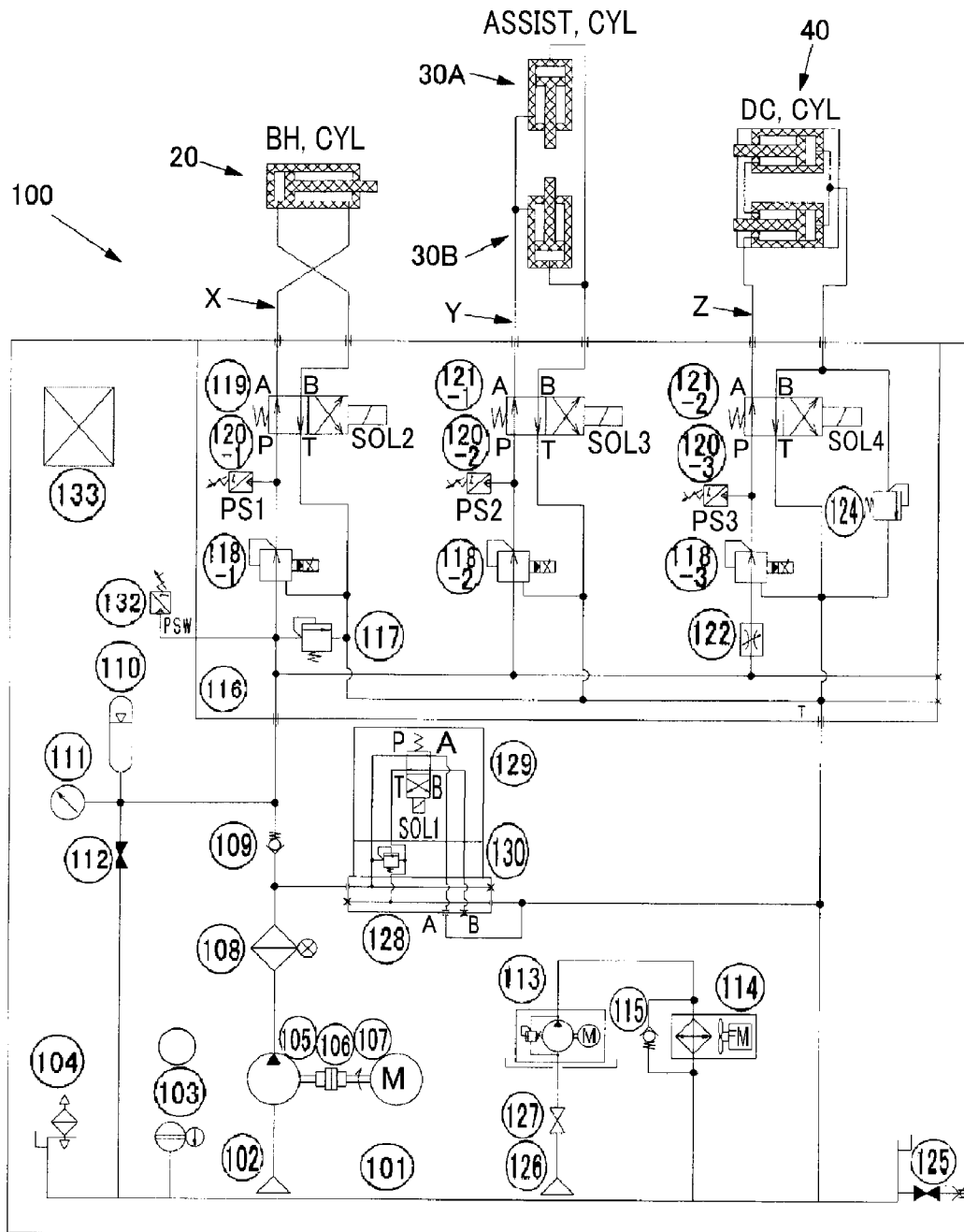


FIG. 7A

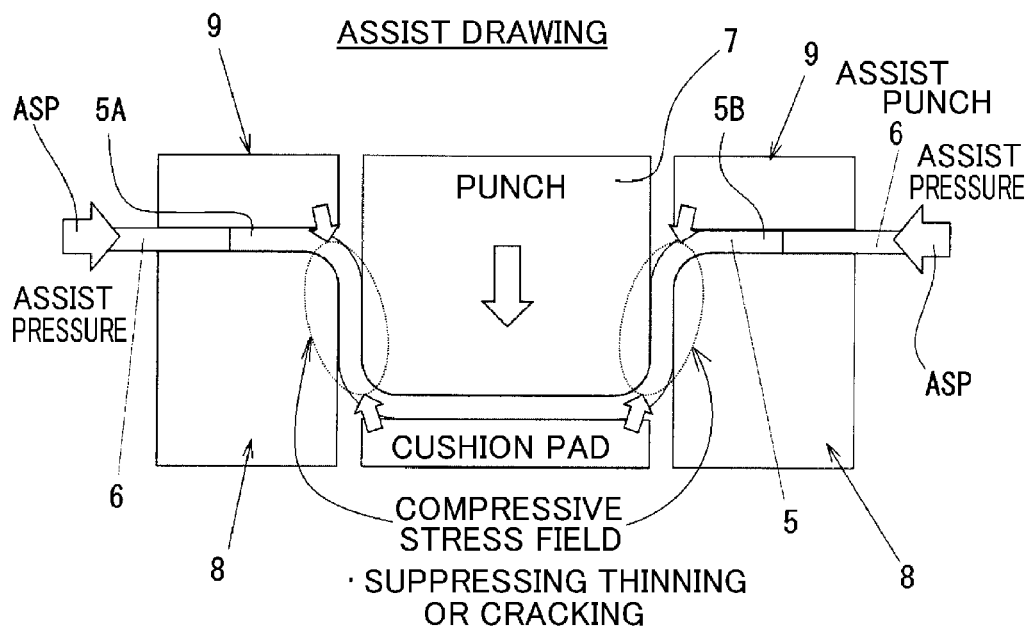
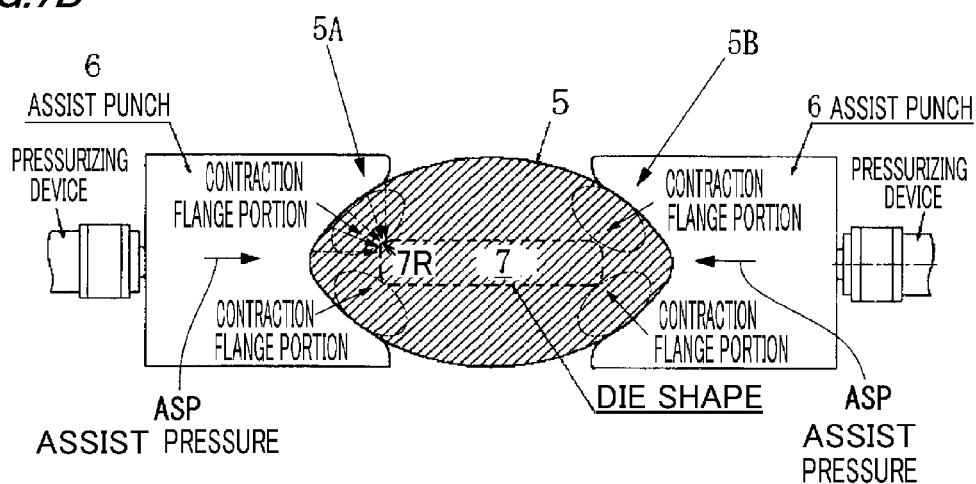
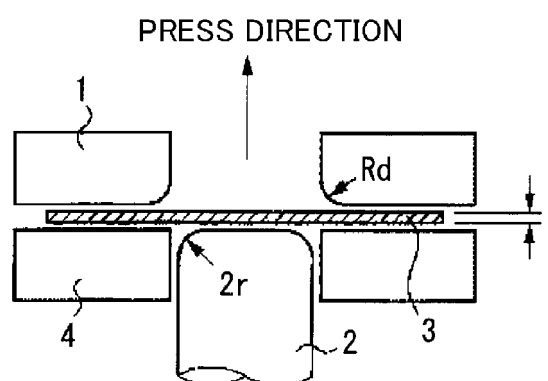


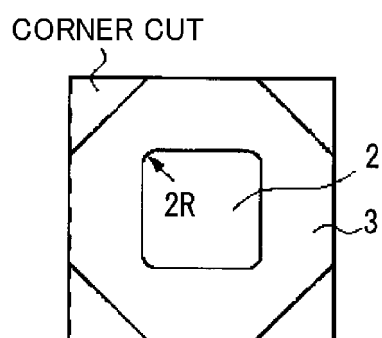
FIG. 7B



**FIG. 8A**



**FIG. 8B**





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Application Number

EP 24 19 7936

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| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Citation of document with indication, where appropriate, of relevant passages                                                  | Relevant to claim                | CLASSIFICATION OF THE APPLICATION (IPC)     |
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