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(54) Pressing method and system wherein cushion pin load is detected by load detector for diagnosis for even distribution of blank holding force

(57) Pressing method and system wherein a drawing operation on a blank (40) is performed by a die (18) and a punch (10) during a movement of the die with a pressure ring (28) relative to the punch against a movement resistance applied to a cushion platen (26), such that the blank is held by and between the pressure ring and the die, with a blank holding force which is generated based on the movement resistance of the cushion platen and is transmitted to the pressure ring through cushion pins (22) interposed between the cushion platen and the pressure ring, and wherein a load which is transmitted to the pressure ring through each cushion pin (22) during the drawing operation is detected, and a determination is made as to whether the blank is adequately held by the blank holding force, depending upon whether a predetermined characteristic value or values of the detected load transmitted through each cushion pin satisfies a predetermined condition for even distribution of the blank holding force to the pressure ring through all of the cushion pins.

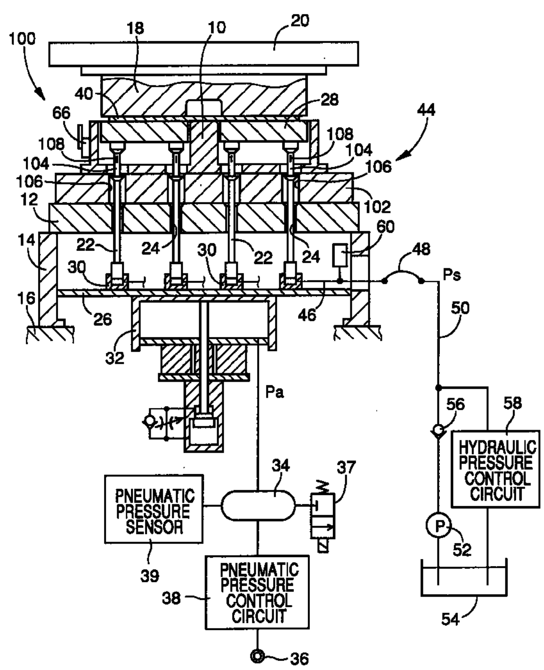

FIG. 1

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to pressing method and system for performing a drawing operation on a blank, which method and system assure high accuracy of diagnosis for adequate holding of the blank, and also relates to a device suitably used in such pressing method and system for detecting loads transmitted to the blank through cushion pins.

Discussion of the Related Art

There is widely used a pressing system including (a) a die and a punch cooperating to perform a drawing operation on a blank to draw the blank along a forming surface of the punch, (b) a cushion platen, (c) resistance applying means for applying a resistance to a movement of the cushion platen, (d) a pressure ring cooperating with the die to hold the blank at a peripheral portion thereof during the drawing operation, and (e) a plurality of cushion pins interposed in parallel with each other between the cushion platen and the pressure ring, for transmitting a blank holding force based on the above-indicated resistance to the pressure ring, wherein the drawing operation is performed when the pressure ring and the die are moved relative to the punch in a pressing direction against the above-indicated resistance. During the drawing operation, the cushion platen is lowered against the resistance applied thereto by the resistance applying means, while the cushion platen has a substantially horizontal attitude, and the punch is fixedly positioned on a bolster disposed above the cushion platen. The cushion pins are supported at their lower ends by the cushion platen such that the cushion pins extend through respective through-holes formed through the bolster and respective through-holes formed through the punch. The cushion pins support at their upper ends the pressure ring. The die disposed above the punch and pressure ring is reciprocated in the vertical direction by suitable drive means, so that the die and the pressure ring are moved relative to the punch so as to perform the drawing operation on the blank.

Also known is a pressing system further including (f) a plurality of fluid-actuated balancing cylinders which are disposed on the cushion platen such that the lower ends of the cushion pins are associated with the pistons of the respective fluid-actuated balancing cylinders. The fluid-actuated balancing cylinders are hydraulic cylinders having respective pressure chambers communicating with each other, and the pistons of these cylinders are held in their neutral positions during the drawing operation with the blank held by and between the pressure ring and the die, so that the blank holding force acts evenly or uniformly on the pressure ring through all of the cushion pins. An example of this type of pressing system is disclosed in JP-A-6-304800 (published in 1994). In this pressing system, the blank holding force is evenly distributed to the pressure ring and the blank through the fluid in the hydraulic cylinders and the cushion pins, so as to establish a desired distribution of the blank holding force depending upon the arrangement of the cushion pins, irrespective of dimensional and positional errors or variations such as a length variation of the cushion pins and an inclination of the cushion platen with respect to the horizontal plane.

For even distribution of the blank holding force over the entire area of the pressure ring, the pistons of all the hydraulic cylinders should be held between their upper and lower stroke ends, namely, placed in their neutral positions, during the drawing operation on the blank, irrespective of the length variation of the cushion pins and other dimensional and positional errors. To this end, an optimum initial hydraulic pressure Pso in the hydraulic cylinders prior to the drawing operation is determined so as to satisfy the following equation (1):

$$Xav = (Fs - n \cdot As \cdot Pso)V/n^2 \cdot As^2 \cdot K \qquad (1)$$

where,

- Xav: average operating stroke of the pistons of the hydraulic cylinders (from the upper stroke ends)
- As: pressure-receiving area of the hydraulic cylinders
- K: modulus of elasticity of volume of the fluid
- V: initial volume of the working fluid
- Fs: blank holding force
- n: number of the cushion pins 22 (or the corresponding hydraulic cylinders)

The average operating stroke Xav of the pistons of the balancing hydraulic cylinders is an average of the operating strokes of these pistons from their upper stroke ends, which permits all of the cushion pins to be in abutting contact with the underside of the pressure ring. The average operating stroke Xav is determined by experiments or other suitable method so that the pistons of all the hydraulic cylinders are pushed down by the respective cushion pins away from their upper stroke ends but are held apart from the lower stroke ends (not bottomed), even in the presence of the dimensional and positional errors such as the length variation of the cushion pins and the inclination of the cushion platen. The volume V is the total volume of the working fluid in a hydraulic circuit including the pressure chambers of the hydraulic cylinders and a conduit connecting the pressure chambers.

JP-A-6-312225 (published in 1994) proposes a diagnostic device for a pressing system, which is adapted to diagnose the pressing system to check if the blank holding force is in an optimum range which permits even distribution of the blank holding force during the drawing operation such that the the pistons of all the balancing hydraulic cylinders are held in their neutral positions. This diagnosis is effected according to a relationship between the blank holding force and the hydraulic pressures which are generated during the drawing operation. Alternatively, the diagnostic device disclosed in the above publication is adapted to check if the hydraulic pressure generated during the drawing operation substantially coincides with a predetermined optimum value which permits the even distribution of the blank holding force.

Thus, the known diagnostic device is arranged to determine that the blank holding force is evenly distributed, if the pistons of all of the balancing fluid-actuated cylinders are held in their neutral positions. However, the neutral positions of the pistons of the balancing cylinders do not necessarily mean substantially even distribution of the actual blank holding force to the pressure ring and the blank through the cushion pins, and the known diagnostic device does not assure the diagnosis with consistently high accuracy and does not permit sufficiently intricate or fine control of the load which is transmitted through each cushion pin to the pressure ring. In the case where the diagnosis for even distribution of the blank holding force is effected by comparing the actually generated hydraulic pressure with the predetermined optimum value, it is impossible to detect which one of the hydraulic cylinders is defective (e.g., in the position of its piston during the drawing operation) leading to uneven distribution of the blank holding force. Accordingly, it is extremely cumbersome to find out and remove a cause for the uneven distribution.

While the above problems are experienced on the pressing system equipped with the fluid-actuated balancing cylinders, the pressing system not equipped with such fluid-actuated balancing cylinders does not have means suitable for diagnosing the system for adequate holding of the blank during the drawing operation. In this case, the user of the pressing system must check the quality of the product actually produced by the drawing operation on the blank, to determine whether the blank is adequately held by the pressure ring.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to make it possible to effect a highly accurate diagnosis of a pressing system for adequate holding of the blank or a sufficiently intricate control of the distribution of the blank holding force, or facilitate or speed-up the diagnosis and adjustment or remedy to find out and remove a cause for inadequate holding of the blank.

The above object may be achieved according to one aspect of the present invention to provide a method of pressing a blank in a pressing system including (a) a die and a punch cooperating to perform a drawing operation on the blank to draw the blank along a forming surface of the punch, (b) a cushion platen, (c) a resistance applying means for applying a resistance to a movement of the cushion platen, (d) a pressure ring cooperating with the die to hold the blank at a peripheral portion thereof during the drawing operation, and (e) a plurality of cushion pins interposed in parallel with each other between the cushion platen and the pressure ring, for transmitting a blank holding force based on the resistance to the pressure ring, wherein the drawing operation is performed when the pressure ring and the die are moved relative to the punch in a pressing direction against the resistance, the method comprising the steps of: detecting a load which is transmitted to the pressure ring through each of the cushion pins during the drawing operation; and determining whether the blank is adequately held by the blank holding force, depending upon whether at least one predetermined characteristic value of the detected load transmitted through each cushion pin satisfies a predetermined condition.

In the present pressing method, the load which is transmitted to the pressure ring through each cushion pin is detected, and the determination as to whether the blank is adequately held by the blank holding force is effected depending upon whether the predetermined characteristic value of the detected load of each pin satisfies the predetermined condition or not. The load which is transmitted to the pressure ring through each cushion pin directly represents a local blank holding force to be transmitted to the pressure ring through that cushion pin. According to the present method, therefore, the pressing system (which may or may not be equipped with fluid-actuated balancing cylinders) can be diagnosed with high accuracy to determine whether the blank is held by and between the pressure ring and the die with a desired distribution of the blank holding force, which is established when the predetermined condition is satisfied by the predetermined characteristic value of the detected load of each cushion pin. Further, the use of the detected load transmitted through each cushion pin permits a sufficiently intricate control or adjustment of the distribution of the blank holding force on the pressure ring (and the blank). The present pressing method also permits easy identification or determination of the cushion pins for which the characteristic value of the detected load is not satisfied, whereby the pressing system can be easily and efficiently inspected, adjusted or repaired to find out and remove a cause for inadequate distribution of the blank holding force. The pressing method according to this aspect of the invention provides these advantages for not only a pressing system equipped with the fluid-actuated balancing cylinders, but also a pressing system not equipped with the balancing cylinders.

The present method uses at least one predetermined characteristic value of the detected load of each cushion pin, which may be selected from among a waveform, a peak value, an average value, an oscillation frequency and a damping coefficient of the waveform of the load which is detected during the drawing operation by one movement of the die and the punch relative to each other in the pressing direction. In one preferred form of the invention, each characteristic value of the detected load satisfies the predetermined condition if the characteristic value is held within a tolerance range or if a difference or variation in the characteristic values of the individual cushion pins is held within a tolerance range. These tolerance ranges are determined by an optimum characteristic value of the load to be transmitted through the cushion pin, for example, an optimum waveform of the load, or an optimum peak value, an optimum average value, an optimum oscillation frequency or an optimum damping coefficient of the load. These optimum waveform and values are determined depending upon the desired blank holding force, so as to to permit the blank to be drawn into a product having a desired quality. Thus, the predetermined condition may be the tolerance range of the selected characteristic value of the cushion pin load or the tolerance range of a variation of the characteristic pin load values of all the cushion pins. In the former case, the same tolerance range may be used for all of the cushion pins, or different tolerance ranges may be used for the individual cushion pins, respectively.

The object indicated above may also be achieved according to a second aspect of the present invention, which provides a method of pressing a blank in a pressing system including (a) a die and a punch cooperating to perform a drawing operation on the blank to draw the blank along a forming surface of the punch, (b) a cushion platen, (c) a plurality of fluid-actuated balancing cylinders disposed on the cushion platen and having respective pressure chambers communicating with each other, (d) a resistance applying means for applying a resistance to a movement of the cushion platen, (e) a pressure ring cooperating with the die to hold the blank at a peripheral portion thereof during the drawing operation, and (f) a plurality of cushion pins interposed in parallel with each other between the pressure ring and the balancing cylinders, respectively, for transmitting a blank holding force based on the resistance to the pressure ring, wherein the drawing operation is performed when the pressure ring and the die are moved relative to the punch in a pressing direction against the resistance, the method comprising the steps of: detecting a load which is transmitted to the pressure ring through each of the cushion pins during the drawing operation; and determining that the blank holding force is evenly distributed to the pressure ring through the cushion pins, if at least one predetermined characteristic value of the detected load transmitted through each cushion pin satisfies a predetermined condition.

The present pressing method according to the second aspect of this invention is applicable to a pressing system equipped with the fluid-actuated balancing cylinders disposed between the cushion platen and the cushion pins. In the present method, a determination is made as to whether the blank holding force is evenly distributed to the pressure ring through all of the cushion pins. This method provides substantially the same advantages as the method according to the first aspect of the invention.

In one preferred form of the method according to the second aspect of the invention, the predetermined characteristic value of the detected load consists of a predetermined load value or an oscillation frequency of a waveform of the detected load. In this case, the blank holding force is determined to be evenly distributed to the pressure ring through the cushion pins with the pistons of all of the balancing cylinders being placed at neutral positions between upper and lower stroke ends thereof, if the predetermined load value or the oscillation frequency is held within a predetermined tolerance range, for all of the plurality of cushion pins.

In one advantageous arrangement of the above preferred form of the invention, the pressing method further comprises the steps of: determining that at least one of the pistons of the balancing cylinders has been moved to the lower stroke end during the drawing operation, if the predetermined load value or the oscillation frequency is larger than an upper limit of the predetermined tolerance range, for at least one of the cushion pins; and determining that at least one of the pistons of the balancing cylinders remains at the upper stroke end during the drawing operation, if the predetermined load value or the oscillation frequency is smaller than a lower limit of the predetermined tolerance range, for at least one of the cushion pins.

If the piston of a certain fluid-actuated balancing cylinder is bottomed or moved to its lower stroke end during the drawing operation, the load transmitted through the corresponding cushion pin tends to be larger than when the piston is held at its neutral position between the upper and lower stroke ends. Conversely, if the piston of the balancing cylinder remains at its upper stroke end during the drawing operation, the load of the corresponding cushion pin tends to be smaller than when the piston is held at its neutral position. Further, the piston of the balancing cylinder is moved down to its lower stroke end, the oscillation frequency of the corresponding cushion pin load tends to be higher than when the piston is held at its neutral position (than the frequency of pressure oscillation of the fluid in the balancing cylinder). If the piston remains at its upper stroke end, the oscillation frequency tends to be lower than when the piston is held at its neutral position, because the load transmitted through the cushion pin is almost zero or comparatively small and the cushion pin load has substantially no oscillation. In view of this fact, the blank holding force can be determined to be evenly distributed through the cushion pins (with the pistons of all the balancing cylinders being placed at their neutral positions), if the characteristic load values or oscillation frequencies of the load detected for all of the cushion pins are held within the predetermined tolerance range. If the characteristic load value or oscillation frequency of the detected load of any one of the cushion pins is larger than the upper limit of the tolerance range, the piston of the corresponding balancing cylinder can be determined to have been moved to its lower stroke end. If the characteristic load value or oscillation frequency of the detected load of any one of the cushion pins is smaller than the lower limit of the tolerance range, the piston of the corresponding balancing cylinder can be determined to remain at its upper stroke end. In the latter two cases, the pressure of the fluid in the balancing cylinders may be adjusted so as to permit the pistons of all the balancing cylinders to be placed in the neutral positions during the drawing operation, so that the blank holding force can be evenly distributed to the pressure ring through all of the balancing cylinders and all of the cushion pins. Where the piston of the balancing cylinder is moved to the lower stroke end, the pressure of the fluid is increased. Where the piston remains at its upper stroke end, the pressure of the fluid is lowered.

According to another preferred form of the second aspect of this invention, the above-indicated at least one predetermined characteristic value consists of at least one of a peak value, an average value and an oscillation frequency of a waveform of the load detected during the drawing operation by one movement of the die and the punch relative to each other in the pressing direction.

In the above preferred form of the pressing method, the determination as to whether the blank holding force is evenly distributed to the pressure ring through the cushion pins is effected depending upon whether the selected load value or oscillation frequency of the detected load transmitted through each of the cushion pins is held within the predetermined tolerance range or not. Accordingly, the present method is effective to not only establish the even distribution of the blank holding force, but also permit the drawing operation to be performed such that the load value or oscillation frequency of the load of each cushion pin is held within the tolerance range, whereby the product manufactured by pressing has consistently high quality.

The oscillation frequency of the detected cushion pin load is a reciprocal of the oscillation period of the waveform of the detected load. Therefore, the oscillation period may be used in place of the oscillation frequency, to determine whether the pistons are placed in the neutral position, or moved to the lower stroke ends or remain at its upper stroke ends. The method using the oscillation period provides substantially the same advantages as the method using the oscillation frequency.

According to a further preferred form of the second aspect of this invention, the above-indicated at least one predetermined characteristic value of the detected load transmitted through each cushion pin includes at least one of a peak value, an average value and an oscillation frequency of the waveform of the load detected during the drawing operation by one movement of the die and the punch relative to each other in the pressing direction.

The peak value, average value and oscillation frequency of the detected cushion pin load can be comparatively easily obtained on the basis of the waveform of the detected load, and can be recognized as numerical values. The use of the numerical characteristic values permits easier and more accurate diagnosis of the pressing system for adequate holding of the blank or even distribution of the blank holding force, than the use of the pin load waveform itself, which requires a memory of a relatively large capacity to store data representative of the pin load waveform.

The object indicated above may also be achieved according to a third aspect of this invention, which provides a pressing system including (a) a die and a punch cooperating to perform a drawing operation on a blank to draw the blank along a forming surface of the punch, (b) a cushion platen, (c) a resistance applying means for applying a resistance to a movement of the cushion platen, (d) a pressure ring cooperating with the die to hold the blank at a peripheral portion thereof during the drawing operation, and (e) a plurality of cushion pins interposed in parallel with each other between the cushion platen and the pressure ring, for transmitting a blank holding force based on the resistance to the pressure ring, wherein the drawing operation is performed when the pressure ring and the die are moved relative to the punch in a pressing direction against the resistance, the pressing system comprising: load detecting means for detecting a load which is transmitted to the pressure ring through each of the cushion pins during the drawing operation; reference data memory means for storing data representative of a predetermined condition which is satisfied by at least one predetermined characteristic value of the detected load transmitted through each cushion pin if the blank is adequately held by the blank holding force; and diagnostic means for determining whether the blank is adequately held by the blank holding force, depending upon whether the at least one predetermined characteristic value of the detected load satisfies the predetermined condition.

The present pressing system constructed according to the third aspect of this invention is suitable to practice the pressing method according to the first aspect to the invention. To practice the method, the load which is transmitted to the pressure ring through each cushion pin is detected by the load detecting means. The diagnostic means determines whether the blank is adequately held by the blank holding force, depending upon whether at least one characteristic value of the detected load satisfies a predetermined condition the data of which are stored in the reference data memory. The present pressing system provides substantially the same advantages as the pressing method according to the first aspect of the invention.

The object indicated above may also be achieved according to a fourth aspect of the present invention, which provides a load detecting device used with the pressing system constructed according to the above-described third aspect of the invention, for detecting the load transmitted to the pressure ring through each of the cushion pins, wherein the cushion platen is moved down against the resistance while maintaining a substantially horizontal attitude, and the punch is fixedly positioned on a bolster disposed above the cushion platen, the plurality of cushion pins extending through through-holes formed through the bolster and the punch such that the cushion pins are supported at lower ends thereof by the cushion platen and support at upper ends thereof the pressure ring, the load detecting device comprising: a load detecting block interposed between the bolster and the punch and having through-holes through which the cushion pins extend; and load sensing pins disposed in series on the upper ends of the cushion pins, respectively, and having a length substantially equal to a height dimension of the load detecting block, each of the load sensing pins having a load sensor attached thereto for detecting a load acting thereon, as the load which is transmitted to the pressure ring through each cushion pin.

The present load detecting device constructed according to the fourth aspect of the invention is suitably used to practice the pressing method according to the first aspect of the invention, more specifically, to detect the load which is transmitted to the pressure ring through each cushion pin. In this load detecting device, the load detecting block is interposed between the bolster and the punch, and the load sensing pins are disposed in series on the upper ends of the cushion pins, respectively. The length of each load sensing pin is substantially equal to the height dimension of the load detecting block. Each load sensing pin has a load sensor attached thereto for detecting a load acting thereon during the drawing operation, as the load transmitted to the pressure ring through the cushion pin. The load detecting device is easily installed on the pressing system, together with a die set. That is, when a drawing operation is performed with a new die set, the load detecting block is mounted on the bolster, and the cushion pins with the load sensing pins attached thereto are installed so as to extend through the through-holes formed through the bolster and punch. Therefore, the present load detecting device can be readily installed on a conventional press, such that the load detecting block is disposed on the bolster while the cushion pins with the load sensing pins attached thereto are installed in place of the conventional cushion pins. Thus, the conventional press can be easily and economically equipped with the present load detecting device without a significant structural modification.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and optional objects, features, advantages and technical and industrial significance of the present invention will be better understood by reading the following detailed description of a presently preferred embodiment of the intention, when considered in connection with the accompanying drawings, in which:

Fig. 1 is a schematic view illustrating a pressing system constructed according to one embodiment of the present invention;

Fig. 2 is a block diagram illustrating a control arrangement provided in the pressing system of Fig. 1;

Fig. 3 is a view showing a display and panel provided in the control arrangement of Fig. 2;

Fig. 4 is a view for explaining a waveform of a load acting on a cushion pin in the pressing system of Fig. 1;

Fig. 5 is a block diagram indicating various functional portions of a controller of the pressing system of Fig. 1, which are adapted to adjust the pressure in balancing hydraulic cylinders for even distribution of a blank holding force to a pressure ring in the pressing system of Fig. 1, by effecting an on-line diagnosis for the even distribution of the blank holding force during a drawing operation on the blank;

Fig. 6 is a flow chart illustrating a diagnostic and hydraulic pressure adjusting routine executed by the functional portions of Fig. 5;

Fig. 7 is a block diagram indicating various functional portions of the controller of the pressing system, which are adapted to effect a diagnostic routine for detecting an optimum range of an initial blank holding force within which the blank holding force is evenly distributed; and

Fig. 8 is a flow chart illustrating the diagnostic routine to be executed by the functional portions of Fig. 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to Fig. 1, there is shown a press having a base 16, a press carrier 14 mounted on the base 16, and a bolster 12 disposed on the press carrier 14 such that the bolster 12 extends in a substantially horizontal direction. A punch 10 is attached to the bolster 12, while a die 18 is carried by a slide plate 20 which is vertically reciprocated by a suitable drive mechanism. The bolster 12 has a multiplicity of through-holes 24 formed through its thickness in a suitable matrix pattern, so that cushion pins 22 extend through the through-holes 24, respectively. Below the bolster 12, there is disposed a cushion platen 26 supporting the cushion pins 22, such that the cushion platen 26 has a substantially horizontal attitude. The cushion pins 22 support at their upper ends a pressure ring 28 which is disposed adjacent to the punch 10. The positions and the number of the cushion pins 22 are suitably determined depending upon the size and shape of the pressure ring 28. The punch 10 includes a base portion having a plurality of through-holes corresponding to the cushion pins 22 installed extending through the selected through-holes 24 of the bolster 12. The cushion pins 22 extend also through the through-holes of the punch 10. The cushion platen 26 is provided with a multiplicity of balancing hydraulic cylinders 30 corresponding to the multiple through-holes 24. The hydraulic cylinders 30 have respective pistons and piston rods. The cushion pins 22 are installed such that the lower end faces are held in abutting contact with the upper end faces of the piston rods of the hydraulic cylinders 30, respectively. The hydraulic cylinders 30 function as fluid-actuated balancing cylinders for even distribution of a blank holding force to the pressure ring 28 through the cushion pins 22.

The cushion platen 26 is disposed within the press carrier 14 indicated above, such that the cushion platen 26 is movable in the vertical direction and biased upwards by resistance applying means in the form of a cushioning pneumatic cylinder 32. The pressure chamber of the pneumatic cylinder 32 communicates with an air tank 34 to which compressed air is supplied from a pneumatic air source 36 through a pneumatic pressure control circuit 38. To the air tank 34, there are connected a shut-off valve 37 and a pneumatic pressure sensor 39. Pneumatic pressure Pa in the air tank 34 and the pneumatic cylinder 32 is regulated by the pneumatic pressure control circuit 38 and shut-off valve 37, depending upon a desired value of the blank holding force acting on the pressure ring 28, as described below in detail. When the die 18 is moved down with the slide plate 20, a blank 40 is gripped at its peripheral portion by and between the die 18 and the pressure ring 28, by the blank holding force based a biasing force of the cushioning pneumatic cylinder 32, that is, based on the pneumatic pressure Pa in the pneumatic cylinder 32. When the die 18 and the pressure ring 28 are further lowered against the biasing force of the pneumatic cylinder 32, the die 18 and the punch 10 cooperate to perform a drawing operation on the blank 40, so as to draw the blank 40 along the forming surface of the punch 10. The biasing force of the cushioning pneumatic cylinder 32 provides a resistance to the downward movement of the cushion platen 26, whereby the blank holding force is generated.

The balancing hydraulic cylinders 30 have respective pressure chambers communicating with each other through a conduit 46 which is connected to a conduit 50 through a flexible tube 48. The conduit 50 is connected to a pneumatically driven hydraulic pump 52, which is adapted to pressurize the working oil pumped up from a reservoir 54, so that the pressurized oil delivered by the pump 52 is supplied to the pressure chambers of the hydraulic cylinders 30 through a check valve 56 provided in the conduit 50. To the conduit 50, there is connected a hydraulic pressure control circuit 58 which incorporates a pressure relief valve. The hydraulic pump 52 and the hydraulic pressure control circuit 58 are controlled so that hydraulic pressure Ps in the conduit 50 and the hydraulic cylinders 30 is regulated such that the pistons of all of the hydraulic cylinders 30 associated with the cushion pins 22 installed are held in their neutral positions during the drawing operation performed on the blank 40. Namely, the hydraulic pressure Ps is regulated so that the blank holding force generated based on the pneumatic pressure Pa is evenly distributed to the pressure ring 28 (and the blank 40) through the individual cushion pins 22. The hydraulic pressure Ps is detected by a hydraulic pressure sensor 60 connected to the conduit 46.

In the present pressing system, there is provided a load detecting device 100 adapted to detect a load Fp which acts on each cushion pin 22 or which is transmitted through each cushion pin 22 to the pressure ring 28. The load Fp will be referred to as "pin load Fp" where appropriate. The load detecting device 100 includes a load detecting block 102 fixedly disposed on the bolster 12 described above, and load sensing pins 104 which are disposed in series with the corresponding cushion pins 22. The punch 10 is disposed on the load detecting block 102. Like the bolster 12, the load detecting block 102 has a multiplicity of through-holes 106 which are aligned with the multiple through-holes 24, respectively, and which are formed in a matrix pattern corresponding to that of the through-holes 24. The desired number of the cushion pins 22 are installed so as to extend through the selected ones of the through-holes 24 and the corresponding through-holes 106, depending upon the size and shape of the punch 10 and pressure ring 28, which cooperate with the die 18 to constitute a die set. The press having the bolster 12 and the load detecting block 102 is adapted to receive different kinds of die sets depending upon the product to be manufactured by pressing, and the cushion pins 22 are installed at selected positions extending through the selected through-holes 24, 106, depending upon the specific die set used. In the present embodiment, the through-holes 106 are provided corresponding to the through-holes 24, and each through-hole 106 permits only one of the cushion pins 22 to extend therethrough. However, the load detecting block 102 may have through-holes each of which permits two or more cushion pins 22 to extend therethrough.

Each of the load detecting pins 104 is fixed, by suitable fixing means such as a screw, to the upper end portion of the corresponding cushion pin 22. The pins 104, which are provided for all of the cushion pins 22 installed on the press, have respective load sensors 108 in the form of strain gages. Each load detecting pin 104 has a length substantially equal to the height or thickness dimension of the load detecting block 102, so that the relative height position of the punch 10 and the pressure ring 28 after the load detecting device 100 is installed on the press remains unchanged with respect to that before the installation of the load detecting device 100. Thus, the load detecting device 100 installed on the press does not have an influence on the drawing operation to be performed on the blank 40. The individual load sensing pins 104 are given respective identification numbers which are used when the pin load values Fp are detected by the corresponding load sensors 108. These identification numbers may be used to identify the corresponding load sensors 108 and the cushion pins 22 to which the respective load sensing pins 104 are fixed.

The hydraulic pressure Ps and the pneumatic pressure Pa are controlled by a control unit 62 shown in Fig. 2. The control unit 62 is adapted to receive output signals of the pneumatic pressure sensor 39, hydraulic pressure sensor 60 and load sensors 108 through respective amplifiers. The control unit 62 includes a microcomputer incorporating a central processing unit (CPU), a random-access memory (RAM) and a read-only memory (ROM). The microcomputer operates to perform signal processing operations according to control programs stored in the ROM, so as to regulate the pneumatic and hydraulic pressures Pa, Ps, effect an on-line diagnosis or a diagnosis and an adjustment for establishing even distribution of the blank holding force, as described below. To the control unit 62, there are connected a display and control panel 68, a TEST PRESS switch 67 and a slide position sensor 69. The TEST PRESS switch 67 is provided at a suitable position on the press, and generates a TEST PRESS signal SS when the switch 67 is turned on by the operator of the press. The slide position sensor 69 is provided to detect the position of the slide plate 20 and generates a SLIDE POSITION signal SD indicative of the position of the slide plate 20 during a drawing cycle. The control unit 62 receives the TEST PRESS signal SS and the STROKE signal SD. The display and control panel 68 has various operator's control switches and displays such as indicators 70 and 71 for indicating the hydraulic and pneumatic pressures Ps, Pa.

The RAM of the control unit 62 stores machine information indicative of the specifications of the press, such as a weight Wa of the cushion platen 26, an average weight Wp of the cushion pins 22, a pressure-receiving area Aa of the cushioning pneumatic cylinder 32, and a pressure-receiving area As of each balancing hydraulic cylinder 30. On the other hand, an ID card 66 attached to the punch 10 as shown in Fig. 1 stores die set information such as a weight of the pressure ring 28, the number "n" of the cushion pins 22 installed, an optimum blank holding force Fso, an optimum value Fpmaxo of a maximum peak value Fpmax of the pin load Fp, an optimum value Fpavo of an average of the pin load Fpav, and an optimum oscillation frequency ωo of the waveform of the pin load Fp. The optimum blank holding force Fso is an optimum value of the blank holding force Fs which assures a desired quality of the product manufactured by a drawing operation on the blank 40. The control unit 62 receives the die set information from the ID card 66 through a transceiver 64 as shown in Fig. 2. The ID card 66 has a data memory for storing the die set information, and has a function of transmitting the die set information to the control unit 62 through the transceiver 64 in response to an appropriate signal received from the transceiver 64, and a function of rewriting the die set information in response to an appropriate signal also received from the transceiver 64.

The pin load Fp oscillates or vibrates as indicated in the graph of Fig. 4, due to an oscillatory variation in the hydraulic pressure Ps in the balancing hydraulic cylinders 30. The maximum peak value Fpmax of the pin load Fp is the highest one of the peak values of the waveform of the pin load Fp, as indicated in the graph wherein the maximum peak value Fpmax occurs at a position ST1 of the slide plate 20. In the graph, ST2 represents the lower stroke end of the slide plate 20. The average pin load value Fpav is an average of the pin load Fp during a time period between the moments when the press slide 20 reaches the positions ST1 and ST2 during its downward movement. The oscillation frequency ω is a reciprocal of an oscillation period T of the pin load Fp. The optimum blank holding force Fso, optimum average pin load value Fpavo and optimum oscillation frequency ωo are values obtained when the product manufactured by a drawing operation on the blank 40 has a desired quality, that is, when the pistons of all of the balancing hydraulic cylinders 30 associated with the installed cushion pins 22 are placed in their neutral positions during the drawing operation on the blank 40. The average pin load value Fpav may be an average of all maximal and minimal values during the time period between the moments corresponding to the slide positions ST1 and ST2. However, the average pin load value Fpav is preferably obtained by integrating the pin load value Fp. The oscillation frequency ω is held substantially constant throughout the entire operating stroke of the slide plate 20, and may be obtained on the basis of a time interval (oscillation period T) between adjacent maximal values of the pin load value Fp. The maximum peak value Fpmax, average pin load value Fpav and oscillation frequency ω vary depending upon whether the pistons of the balancing hydraulic cylinders 30 associated with the installed cushion pins 22 are placed in their neutral positions or not. If the pistons remain at their upper stroke ends, the values Fpmax, Fpav and ω tend to be smaller than when the pistons are placed in their neutral positions. If the pistons are bottomed or moved down to their lower stroke ends, the values Fpmax, Fpav and ω tend to be larger than when the pistons are placed in their neutral positions.

The optimum maximum peak value Fpmaxo, optimum average value Fpavo and optimum oscillation frequency ωo of the pin load Fp for each die set are predetermined for each of the individual presses. However, the optimum average value Fpavo may be the same for the different presses, since the value Fpavo is not influenced by a variation in the machine specifications of the presses. In the present embodiment wherein provisions are made for permitting the pistons of all the hydraulic cylinders 30 to be placed in the neutral positions, the individual cushion pins 22 do not have a considerably large variation or difference in the characteristics of their load value Fp. Therefore, the same set of values Fpmaxo, Fpavo and ωo is used for all of the cushion pins 22. However, different sets of values Fpmaxo, Fpavo and ωo are set for the individual cushion pins 22, respectively. For example, the press may be adapted such that some of the pistons of the hydraulic cylinders 30 are bottomed to establish the minimum distance between the cushion platen 26 and the pressure ring 28, with suitable spacers being interposed between the cushion platen 26 and the pressure ring 28, so that the pistons of the other hydraulic cylinders 30 are placed in their neutral positions. In this case, the values Fpmaxo, Fpavo and ωo are desirably set for each of the cushion pins 22 corresponding to the bottomed pistons of the hydraulic cylinders 30. If the press is not provided with the hydraulic cylinders 30, the values Fpmaxo, Fpavo and ωo are desirably set for each of the cushion pins 22, since the individual cushion pins 33 have a large variation in the characteristics of the load value Fp.

There will be described the on-line diagnosis effected under the control of the control unit 62. The optimum value of the pneumatic pressure Pa in the cushioning pneumatic cylinder 32 is calculated according to the following equation (2), so as to establish the optimum blank holding force Fso:

$$Pa = (Fso + Wa + n \cdot Wp + Wr)/Aa \qquad (2)$$

The pneumatic pressure Pa is regulated by controlling the pneumatic pressure control circuit 38 and the shut-off valve 37. As explained above, the weights Wa, Wp and the pressure-receiving area Aa are stored as part of the machine information in the ROM of the control unit 62, while the weight Wr, number n and optimum blank holding force Fso are sent from the ID card 66 to the control unit 62 as part of the die set information. An initial value Pso of the hydraulic pressure Pso may be determined according to the equation (1) indicated above, or by performing test drawing operations, and established by controlling the hydraulic pump 52 and hydraulic pressure control circuit 58, so that the pistons of all of the hydraulic cylinders 20 associated with the installed cushion pins 22 are placed in their neutral positions for permitting even distribution of the blank holding force Fs to the pressure ring 28 through the cushion pins 22. Alternatively, the initial hydraulic pressure Pso may be established in a manner similar to the manner in which the on-line diagnosis is effected as described below.

The functional block diagram of Fig. 5 shows the functional portions of the control unit 62 which are operated when the on-line diagnostic and hydraulic pressure adjusting routine illustrated in the flow chart of Fig. 6 is executed. In this diagnostic, steps S1-S3 are implemented by a data storing portion 114 of the control unit 62. The routine is initiated with step S1 to determine whether the position of the slide plate 20 represented by the SLIDE POSITION signal SD is the upper stroke end of the slide plate 20. If an affirmative decision (YES) is obtained in step S1, namely, when the SLIDE POSITION signal SD indicates that the slide plate 20 is placed at its upper stroke end, the control flow goes to step S2 to read the output signals of all the load sensors 108 representative of load values Fp of the corresponding cushion pins 22, as the slide plate 20 is lowered down to the lower stroke end. The load values Fp represented by the output signals of the load sensors 108 are stored in a data memory 116 of the control unit 62, in relation to the position of the slide plate 20 in its operating stroke. The analog output signals of the load sensors 108 are converted by an A/D converter 112 into digital signals, which are received by the data storing portion 114 and stored into the data memory 116 by the data storing portion 114. Step S2 is followed by step S3 to determine whether the slide plate 20 has reached its lower stroke end. Steps S2 and S3 are repeatedly implemented until an affirmative decision (YES) is obtained in step S3. Thus, the detected load values Fp at different positions of the slide plate 20 between the upper and lower stroke ends are stored in the data memory 116. It will be understood that steps S1-S3 are provided to detect the load Fp which is transmitted through each cushion pin 22, and that the data storing portion 114 and the load detecting device 100 cooperate to constitute load detecting means for detecting the load values Fp of the cushion pins 22. The slide position sensor 74 is adapted to detect at least the upper and lower stroke ends of the slide plate 20. The slide position sensor 74 may be an absolute type rotary encoder for detecting the angular position of a crankshaft used in the drive mechanism for reciprocating the slide plate 20.

When the affirmative decision (YES) is obtained in step S3, the control flow goes to step S4 in which a characteristic calculating portion 118 of the control unit 62 shown in Fig. 5 calculates characteristic values of the load values Fp of all of the cushion pins 22, namely, the maximum peak value Fpmax, average value Fpav and oscillation frequency ω of the load Fp of each cushion pin 22, on the basis of the load values Fp stored in the data memory 116. Step S4 is followed by steps S5-S8 which are implemented by a diagnostic portion 120 of the control unit 62 shown in Fig. 5, to determine whether the blank holding force Fs is evenly distributed to the pressure ring 28 through the cushion pins 22, and also determine, where appropriate, whether the piston of the hydraulic cylinder 30 corresponding to any cushion pin 22 is bottomed or not. Described more specifically, step S5 is implemented to determine whether the maximum peak value Fpmax, average value Fpav and oscillation frequency ω stored in the data memory 116 are held within respective tolerance ranges which are determined on the basis of the optimum values Fpmaxo, Fpavo and ωo received from the ID card 66. Data representative of the tolerance ranges are stored in a reference data memory 122 of the control unit 62. If the values Fpmax, Fpav, ω for all of the cushion pins 22 are all held within the respective tolerance ranges, the diagnostic portion 120 determines that the blank holding force Fs is evenly distributed to the pressure ring 28 through the cushion pins 22. In this case, the control flow goes to step S6 to provide an indication of the even distribution of the blank holding force Fs. If any of the values Fpmax, Fpav, ω for any of the cushion pins 22 is not held within the tolerance range, the diagnostic portion 120 determines that the blank holding force Fs is not evenly distributed. In this case, the control flow goes to step S7 to provide an indication of uneven distribution of the blank holding force Fs. Steps S6 and S7 are implemented by a display control portion 126 of the control unit 62 shown in Fig. 5, which is adapted to activate one of two indicator lights 82, 84 on the display and control panel 68 of Fig. 3, for indicating that the distribution of the blank holding force Fs is normal or abnormal.

Step S7 is followed by step S8 to determine whether the piston of the hydraulic cylinder 30 for each cushion pin 22 for which any of the values Fpmax, Fpav and ω has not been found in step S5 to be held within the tolerance range is bottomed (moved down to its lower stroke end). This determination is made by determining whether the values Fpmax, Fpav, ω are larger or higher than the upper limits of the respective tolerance ranges. If an affirmative decision (YES) is obtained in step S8, it means that the piston of the hydraulic cylinder 30 corresponding to the cushion pin 22 in question is bottomed. In this case, the control flow goes to step S9 to increase the initial hydraulic pressure Ps of the hydraulic cylinder 30 by a predetermined amount α. If a negative decision (NO) is obtained in step S8, it means that the piston of the corresponding hydraulic cylinder 30 remains at its upper stroke end. In this case, the control flow goes to step S10 to reduce the initial hydraulic pressure Pso by a predetermined amount β. If the blank holding force Fs is constant, that is, if the pneumatic pressure Pa of the cushioning pneumatic cylinder 32 is constant, an increase in the initial hydraulic pressure Pso will cause an increase in a hydraulic pressure Psx which is generated in the hydraulic cylinder 30 during a drawing operation on the blank 40, whereby the operating stroke of the piston of the hydraulic cylinder 30 during the drawing operation is accordingly reduced, so that the bottoming of the piston is eliminated. On the other hand, a decrease in the initial hydraulic pressure Pso will cause a decrease in the hydraulic pressure Psx, whereby the operating stroke of the piston of the hydraulic cylinder 30 is increased, so that the piston is moved down from the upper stroke end to the neutral position. Steps S9 and S10 are implemented by a hydraulic pressure control portion 124 of the control unit 62 shown in Fig. 5, which controls the hydraulic pump 52 and the hydraulic pressure control circuit 58 so as to adjust the initial hydraulic pressure Pso. As a result of the diagnostic and hydraulic pressure adjusting routine of Fig. 6, the initial hydraulic pressure Pso is regulated so that the blank holding force Fs is evenly distributed to the pressure ring 28 through all of the cushion pins 22 installed, so as to assure the intended quality of the product manufactured by the drawing operation on the blank 40.

The routine of Fig. 5 may be formulated so as to activate the display and control panel 68 to indicate the cushion pin or pins 22 for which the negative decision (NO) is obtained in step S5 for more than a predetermined number of times. More specifically, the panel 68 is adapted to indicate the identification number or position of the corresponding load sensing pin or pins 104. Similar indication may be provided on the panel 68 where the initial hydraulic pressure Pso deviates from a predetermined permissible range as a result of the adjustment in steps S9 and S10.

In the routine of Fig. 6 according to the present embodiment, the tolerance ranges of the maximum peak value Fpmax, average value Fpav and oscillation frequency ω of the pin load Fp for each cushion pin 22 are determined on the basis of the optimum values Fpmaxo, Fpavo and ωo which are received from the ID card 66 as part of the die set information received from the ID card 66. These tolerance ranges are used to determine whether the blank 40 is adequately held by the blank holding force Fs, more specifically, whether the blank holding force Fs is evenly distributed to the pressure ring 28 through the cushion pins 22. Thus, it will be understood that the tolerance ranges are used as a predetermined condition that should be satisfied when the blank 40 is adequately held by the blank holding force Fs. It will also be understood that the reference data memory 122 functions as reference data memory means for storing data representative of the predetermined condition which is satisfied by the characteristic values of the pin load Fp if the blank 40 is adequately held. The tolerance ranges indicated above may be determined on the basis of the optimum values Fpmaxo, Fpavo and ωo, depending upon various factors which may cause dimensional, positional and other errors or variations, and depending upon the desired quality of the product. For instance, the upper and lower limits of the tolerances ranges may be determined by adding a suitable value to the optimum values Fpmaxo, Fpav and ωo and subtracting a suitable value from the optimum values, or by multiplying the optimum values by suitable ratio values. Steps S5 and S8 are provided as a step of determining whether the blank 40 is adequately held by the blank holding force, depending upon whether the detected characteristic values of the load transmitted through each cushion pin 22 satisfy the predetermined condition. The diagnostic portion 20 functions as diagnostic means for determining whether the blank 40 is adequately held, depending upon whether the detected characteristic values satisfy the predetermined condition.

As shown in Fig. 3, the display and control panel 68 has three indicators 85-87 for indicating average values of the maximum peak value Fpmax, average value Fpav and oscillation frequency ω of the loads of all the cushion pins 22. The display and control panel 68 may have suitable pushbuttons or switches for using these average values as the optimum values Fpmaxo, Fpav and ωo used in the routine of Fig. 6, or for storing these average values in the ID card 66 in place of the corresponding values already stored therein. In this case, the average values of the values Fpmax, Fpav, ω obtained in a test or try pressing operation in which the blank 40 is drawn into the product having the desired quality may be used as the optimum values Fpmaxo, Fpavo, ωo stored in the ID card 66.

There will be described an operation of the control unit 62 for effecting a diagnosis for detecting an optimum range of the blank holding force Fs within which the blank holding force Fs is evenly distributed. The block diagram of Fig. 7 shows the functional portions of the control unit 62 which are operated when a diagnostic routine illustrated in the flow chart of Fig. 8 is executed. This routine is initiated with step Q1 to determine whether an AUTO-MAN selector switch 72 is placed in an AUTO position. If an affirmative decision (YES) is obtained in step Q1, the control flow goes to step Q2 to determine whether a SETUP pushbutton is depressed. When the selector switch 72 is placed in the AUTO position and the SETUP pushbutton 74 is depressed, the control flow goes to step Q3 in which an initial blank holding force Fsn is set at one of ten predetermined values (Fs1 through Fs10). The initial blank holding force Fsn is decremented from the largest value to the smallest value each time step Q3 is implemented. The initial blank holding force Fsn is the blank holding force Fs when the die 18 has just been brought into abutting contact with the blank 40 placed on the pressure ring 28, that is, the blank holding force Fs before the volume of the cushioning pneumatic cylinder 32 begins to be reduced. In the present embodiment, the initial blank holding force Fsn is decremented from the largest value Fs1 of 200 tons down to the smallest value Fs20 of 20 tons, in decrements of 20 tons. These initial blank holding values Fs1-Fs10 are stored in the control unit 62. Before the routine of Fig. 8 is initiated, the initial hydraulic pressure Pso of the balancing hydraulic cylinders 30 is suitably adjusted by the hydraulic pump 52 and the hydraulic pressure control circuit 58 according to the diagnostic and hydraulic pressure adjusting routine of Fig. 6, as described above.

Step Q3 is followed by step Q4 in which the pneumatic pressure Pa is calculated according to the above equation (2), using the initial blank holding force Fsn (set in step Q3) as the optimum blank holding force Fso, and the actual pneumatic pressure Pa is adjusted to the calculated value Pa. In the first cycle of execution of the routine, the initial blank holding force Fs1 of 200 tons is used in the equation (2) to calculate the pneumatic pressure Pa. Steps Q3 and Q4 are implemented by a holding force changing portion 128 of the control unit 62 shown in Fig. 7. If a test pressing operation indicates that the number n of the cushion pins 22 should be changed, the number n which is used in the equation (2) is changed through a NUMBER setting switch 75 provided on the display and control panel 68.

After the pneumatic pressure Pa is adjusted in step Q4, the control flow goes to step Q5 to turn on a buzzer in a predetermined sounding pattern, and step Q6 to determine whether the TEST PRESS switch 67 provided on the press has been turned on. When the TEST PRESS switch 67 is turned on by the operator in response to the activation of the buzzer, and the TEST PRESS signal SS described above is applied to the control unit 62. Then, step Q7 is implemented to turn off the buzzer. Step Q7 is followed by step Q8 to read the output signals of all the load sensors 108 representative of load values Fp of the corresponding cushion pins 22, as the slide plate 20 is lowered down to the lower stroke end during the test pressing cycle initiated by operation of the TEST PRESS switch 67. The load values Fp represented by the output signals of the load sensors 108 are stored in a data memory 134 of the control unit 62. Step Q8 is implemented by a data storing portion 130 shown in Fig. 7. The analog output signals of the load sensors 108 are converted by the A/D converter 112 into digital signals, which are received by the data storing portion 130 and stored into the data memory 134 by the data storing portion 130, as indicated in Fig. 7. Step Q8 is provided to detect the load Fp which is transmitted through each cushion pin 22, and the data storing portion 130 implementing step Q8 and the load detecting device 100 cooperate to constitute means for detecting the load Fp.

Step Q8 is followed by step Q9 in which a characteristic calculating portion 136 of the control unit 62 shown in Fig. 7 calculates characteristic values of the load values Fp of all of the cushion pins 22, namely, the maximum peak value Fpmax, average value Fpav and oscillation frequency ω of the load Fp of each cushion pin 22, on the basis of the load values Fp stored in the data memory 134. Step Q9 is followed by step Q10 which is implemented by a diagnostic portion 138 of the control unit 62 shown in Fig. 7, to determine whether the blank holding force Fs is evenly distributed to the pressure ring 28 through the cushion pins 22. This determination is effected depending upon whether the calculated characteristic values Fpmax, Fpav, ω satisfy a predetermined condition. Described more specifically, step Q10 is implemented to determine whether variations or differences of the maximum peak value Fpmax, average value Fpav and oscillation frequency ω of all the cushion pins 22 are held within respective predetermined tolerance ranges. Data representative of these tolerance ranges are stored in a reference data memory 140. If the variations of the values Fpmax, Fpav, ω of all of the cushion pins 22 are all held within the respective tolerance ranges, the diagnostic portion 138 determines that the blank holding force Fs is evenly distributed to the pressure ring 28 through the cushion pins 22. In this case, the pistons of the hydraulic cylinders 30 corresponding to all the cushion pins 22 are placed in the neutral positions during the test pressing operation, and the load values Fp of all the cushion pins 22 are substantially equal to each other. If the piston of any hydraulic cylinder 30 is bottom or moved down to its lower stroke end or remains at its upper stroke end, the characteristic values Fpmax, Fpav, ω of the corresponding cushion pin 22 tend to differ from those of the other cushion pins 22 to a considerable extent . Therefore, the determination of the even or uneven distribution of the blank holding force Fs can be made on the basis of the variations or differences of the characteristic values of the load Fp of the cushion pins 22. The diagnostic portion 138 may be adapted to determine whether the oscillation frequency ω rather than its variation is held within a predetermined tolerance range, in determining whether the characteristic values of the pin load Fp satisfy the predetermined condition. The diagnostic portion 138 adapted to implement step Q10 functions as means for checking whether the blank 40 is adequately held by the blank holding force Fp, and the reference data memory 140 functions as memory means for storing data representative of the predetermined condition which is used by the diagnostic portion 138 to determine that the blank 40 is adequately held.

If an affirmative decision (YES) is obtained in step Q10, the control flow goes to step Q11 to turn on one of ten indicator lights 78 on the panel 68, which corresponds to the currently established initial blank holding force Fsn (set in step Q3). Step Q11 is implemented by a display control portion 142 shown in Fig. 7. Step Q11 is followed by step Q12 to determine whether the initial blank holding force Fsn which has been established last in step Q3 is the smallest value Fs20 of 20 tons. Steps Q3-S20 are repeatedly implemented by changing the initial blank holding force Fsn from 200 tons to 20 tons, so that the determination in step Q10 is effected for all of the ten values of the initial blank holding force Fsn. Since the indicator lights 78 corresponding to the values of the initial blank holding force Fsn for which the affirmative decision (YES) is obtained in step Q10 are turned on as indicated by hatching in Fig. 3, the operator is informed of the optimum range of the initial blank holding force Fsn within which the blank holding force Fs is evenly distributed to the pressure ring 28 through all of the cushion pins 22. The hatching in Fig. 3 indicates an example of the optimum range of the initial blank holding force Fsn, which is detected by the test pressing operation initiated by the TEST PRESS switch 67.

As described above, the diagnostic routine of Fig. 8 permits the operator to detect the optimum range of the initial blank holding force Fsn within which the blank holding force Fs is evenly distributed. When a die set (consisting of the punch 10, die 18 and pressure ring 28) is prepared for producing a desired part, test pressing operations are performed by changing the initial blank holding force Fsn within the detected optimum range, so as to detect the optimum blank holding force Fs that assures the desired quality of the part produced by pressing. Further, the detected optimum range of the initial blank holding force Fsn can be used to adjust the blank holding force Fs depending upon the properties of the blank 40. If the optimum blank holding force Fs cannot be detected within the detected optimum range of the initial blank holding force Fsn, the number n of the cushion pins 22 (number of the balancing hydraulic cylinders 30) or the initial hydraulic pressure Pso is suitably changed, to change the optimum range of the initial blank holding force Fsn so that the optimum blank holding force Fs is found within the changed optimum range of the initial blank holding force Fsn.

The system constructed according to one embodiment of the present invention described above is adapted to detect the load Fp which is transmitted through each cushion pin 22 to the pressure ring 28, and determine whether the selected characteristics of the load values Fp of all the cushion pins 22 (more precisely, maximum peak value Fpmax, average value Fpav and oscillation frequency ω) satisfy a predetermined condition for even distribution of the blank holding force Fs to the pressure ring 28 through the cushion pins 22. The detected load Fp accurately represents a local blank holding force which is actually transmitted to the pressure ring 28 through each cushion pin 22. Therefore, the present arrangement permits accurate diagnosis to determine whether the blank 40 is adequately held with the blank holding force being evenly distributed through the cushion pins 22, and also permits intricate adjustment of the distribution of the local blank holding forces through the cushion pins 22.

The on-line diagnostic and hydraulic pressure adjusting routine of Fig. 6 is adapted to diagnose the pressing system for even distribution of the blank holding force Fs, depending upon whether the characteristic values Fpmax, Fpav and ω of the load Fp for all of the cushion pins 22 are held within the predetermined tolerance ranges determined on the basis of the optimum values Fpmaxo, Fpavo and ωo. If any one of these three characteristic values of the load Fp for any one of the cushion pins 22 is larger than the upper limit of the corresponding tolerance range, the piston of the hydraulic cylinder 30 associated with the cushion pin 22 in question is determined to be bottomed (moved down to its lower stroke end) during a pressing cycle, and the initial hydraulic pressure Pso of the corresponding hydraulic cylinder 30 is increased by a predetermined amount. If any one of the characteristic values of the load Fp for any one of the cushion pins 22 is smaller than the lower limit of the tolerance range, the piston of the corresponding hydraulic cylinder 30 is determined to remain at its upper stroke end during the pressing cycle, and the initial hydraulic pressure Pso of that hydraulic cylinder 30 is lowered by a predetermined amount. As a result, the initial hydraulic pressure Pso of the hydraulic cylinder 30 is automatically adjusted so as to establish the even distribution of the blank holding force Fs. This arrangement facilitates the adjustment of the press, reduces the burden on the operator of the press, and minimizes the reject ratio of the parts produced by pressing. It is noted in particular that the present arrangement not only assures the even distribution of the blank holding force Fs during a drawing operation on the blank 40, but also permits the drawing operation to be performed such that the maximum peak value Fpmax, average value Fpav and oscillation frequency ω of the load Fp associated with each of the cushion pins

22 are held within the predetermined tolerance ranges which are determined by the optimum values Fpmaxo, Fpavo and ωo that are received from the ID card 66. Thus, the present arrangement ensures consistently high quality of the product.

In the preferred form of the on-line diagnostic and hydraulic pressure adjusting routine of Fig. 6, the control unit 62 is adapted to activate the display and control panel 68 for indicating the positions or identification numbers of the abnormal cushion pins 22 (or the corresponding load sensing pins 104 or load sensors 108) for which the negative decision (NO) is obtained in step S5 for more than a predetermined number of times, or if the initial hydraulic pressure Pso becomes higher or lower than the upper or lower limit of a permissible range as a result of the adjustment in steps S9, S10 which are implemented when the negative decision is obtained in step S5. This preferred arrangement permits the operator to easily identify the abnormal cushion pins 22 or hydraulic cylinders 30, and facilitates the inspection, adjustment and repair of the press, leading to improved operating efficiency of the pressing system.

On the other hand, the diagnostic routine of Fig. 8 is adapted to diagnose the pressing system for even distribution of the blank holding force Fs, depending upon whether the differences or variations of the characteristic values Fpmax, Fpav, ω of the load Fp of the cushion pins 22 are held within respective tolerance ranges, during test pressing cycles performed with different values of the initial blank holding force Fsn. Therefore, the diagnostic routine of Fig. 8 permits easy and accurate detection of the optimum range of the initial blank holding force Fsn within which the blank holding force is evenly distributed to the pressure ring 28 through the cushion pins 22.

In the present embodiment, the maximum peak value Fpmax, average value Fpav and oscillation frequency ω of the pin load Fp are used as the characteristic values of the pin load Fp. These characteristic values can be comparatively readily obtained from the waveform of the pin load Fp, and can be recognized as numerical values. The use of the numerical characteristic values permits easier and more accurate detection of the optimum range of the initial blank holding force Fsn, than the use of the pin load waveform itself, which requires a relatively large capacity of the reference data memories 122, 140.

In the present embodiment, the load detecting device 100 is used to detect the load values Fp of all the cushion pins 100. The load detecting device 100 is easily installed on a conventional press, together with a die set. That is, when a new die set is installed on the conventional press, the load sensing block 102 is mounted on the bolster 12, and the cushion pins 22 with the load sensing pins 104 attached thereto are installed in place of the conventional cushion pins. Thus, the conventional press can be easily and economically equipped with the present load sensing device without a significant structural modification.

While the presently preferred embodiment of the present invention has been described above in detail by reference to the accompanying drawings, it is to be understood that the invention may be otherwise embodied.

In the illustrated embodiment, the load sensors 108 in the form of strain gages for detecting the load Fp transmitted through the cushion pins 22 are provided on the load sensing pins 104 which are fixed to the upper ends of the cushion pins 22 and which extend through the through-holes formed through the base portion of the punch 10 mounted on the load sensing block 102. However, the load sensors such as strain gages and load cells may be disposed at any other positions in the path of transmission of the blank holding force from the cushion platen 26 to the pressure ring 28. For instance, the load sensors may be disposed on the cushion pins 22 per se, or on the bosses formed on the underside of the pressure ring 28 for abutting contact with the cushion pins 22. Alternatively, the load sensors may be disposed between the above-indicated bosses and the cushion pins 22, between the pistons of the hydraulic cylinders 30 and the cushion pins 22, or between the hydraulic cylinders 30 and the cushion platen 26.

While the maximum peak value Fpmax, average value Fpav and oscillation frequency ω are used as the characteristic values of the pin load Fp in the illustrated embodiment, the other characteristic values such as the damping coefficient of the pin load Fp may be used in the routine of Fig. 6 and/or the routine of Fig. 8. The maximum peak value Fpmax may be replaced by other peak values (maximal or minimal values), and the average value Fpav need not be an average between the moments corresponding to the positions ST1 and ST2 of the slide plate 20.

Although the pressure chambers of all the balancing hydraulic cylinders 30 communicate with each other, the hydraulic cylinders 30 may consist of two or more groups of hydraulic cylinders which are disposed in respective areas corresponding to local portions of the pressure ring 28, such that the pressure chambers of the hydraulic cylinders of each group communicate with each other. In this case, the initial hydraulic pressure values Pso of the individual groups of hydraulic cylinders are controlled independently of each other, and the reference data memory 122 store data representative of different reference conditions used to check the respective groups of hydraulic cylinders for even distribution of the blank holding force.

The illustrated embodiment uses the hydraulic cylinders 30 as the fluid-actuated balancing cylinders for even distribution of the blank holding force. However, the fluid-actuated balancing cylinders may be operated with a working liquid such as a gel, other than the working oil. Further, the principle of the present invention is applicable to a pressing system not equipped with the fluid-actuated balancing cylinders, provided that the pin load Fp is detected to diagnose the pressing system for even distribution of the blank holding force Fs through the cushion pins 22.

While the cushioning pneumatic cylinder 32 is provided as means for applying or generating a resistance to a movement of the cushion platen 26, the resistance may be generated by any other means such as a hydraulic cylinder provided with a pressure releasing mechanism, or by a suitable spring.

It is to be understood that the present invention may be embodied with various other changes, modifications and improvements, which may occur to those skilled in the art.

Claims

1. A method of pressing a blank (40) in a pressing system including (a) a die (18) and a punch (10) cooperating to perform a drawing operation on said blank to draw the blank along a forming surface of the punch, (b) a cushion platen (26), (c) a resistance applying means (32) for applying a resistance to a movement of said cushion platen, (d) a pressure ring (28) cooperating with said die to hold the blank at a peripheral portion thereof during the drawing operation, and (e) a plurality of cushion pins (22) interposed in parallel with each other between said cushion platen and said pressure ring, for transmitting a blank holding force based on said resistance to said pressure ring, wherein said drawing operation is performed when said pressure ring and said die are moved relative to said punch in a pressing direction against said resistance, said method comprising the steps of:

   detecting a load which is transmitted to said pressure ring (28) through each of said cushion pins (22) during said drawing operation; and
   determining whether said blank (40) is adequately held by said blank holding force, depending upon whether at least one predetermined characteristic value of the detected load transmitted through said each cushion pin (22) satisfies a predetermined condition.

2. A method according to claim 1, wherein said at least one predetermined characteristic value includes at least one of a peak value, an average value and an oscillation frequency of a waveform of said load detected during said drawing operation by one movement of said die and said punch relative to each other in said pressing direction.

3. A method according to claim 1 or 2, wherein said step of determining comprises determining that said blank is adequately held by said holding force, if each of said at least one predetermined characteristic value of said detected load is held within a predetermined range which is determined by an optimum value of said each predetermined characteristic value of said detected load, which optimum value assures even distribution of said blank holding force to said pressure ring (28) through all of said cushion pins (22).

4. A method according to any one of claims 1-3, wherein said step of determining comprises determining that said blank holding force is evenly distributed to said pressure ring (28) through all of said cushion pins (22) and through all of a plurality of fluid-actuated balancing cylinders (30), if said at least one predetermined characteristic value satisfies said predetermined condition, said balancing cylinders being disposed on said cushion platen (26) such that said cushion pins are interposed in parallel with each other between said pressure ring and said balancing cylinders, respectively, said balancing cylinders having respective pressure chambers communicating with each other.

5. A method according to claim 4, wherein said step of determining comprises determining that said blank holding force is evenly distributed to said pressure ring through all of said cushion pins and all of said balancing cylinders with pistons of said balancing cylinders being placed at neutral positions thereof between upper and lower stroke ends thereof, if said at least one predetermined characteristic value satisfies said predetermined condition, said pistons of said balancing cylinders being associated with said cushion pins, respectively.

6. A method according to claim 5, further comprising the steps of: determining that at least one of said pistons of said balancing cylinders has been moved to the lower stroke end or remains at the upper stroke end during said drawing operation, if said at least one predetermined characteristic value does not satisfy said predetermined condition; and if said at least one predetermined characteristic value does not satisfy said predetermined condition, adjusting a pressure in said balancing cylinders so that said pistons are placed in said neutral positions during said drawing operation, for even distribution of said blank holding force to said pressure ring through said cushion pins and said balancing cylinders.

7. A method according to any one of claims 1-6, wherein said step of detecting a load comprises the steps of: interposing a load detecting block (102) between said punch (10) and a bolster (12) disposed above said cushion platen (26); and disposing load sensing pins (104) in series on upper ends of said cushion pins (22), respectively, such that said cushion pins with said load sensing pins disposed thereon extend through through-holes (24) formed through said bolster, through-holes (106) formed through said load detecting block, and

through-holes formed through said punch, each of said load sensing pins having a length substantially equal to a height dimension of said load detecting block, and having a load sensor (108) attached thereto for detecting a load acting thereon, as said load which is transmitted to said pressure ring through said each cushion pin.

8. A method according to any one of claims 1-7, further comprising the steps of: performing a plurality of test pressing cycles each of which comprises moving said die (18) and said pressure ring (28) relative to said punch (10) in said pressing direction against said resistance so as to perform said drawing operation on said blank (40), such that an amount of said resistance generated by said resistance applying means (32) is changed as said plurality of test pressing cycles are performed; and providing an indication of an optimum range of said amount of resistance within which said at least one predetermined characteristic value of said detected load satisfies said predetermined condition, said step of detecting and said step of determining being effected in each of said test pressing cycles.

9. A method according to claim 8, wherein said performing a plurality of test pressing cycles comprises changing a pressure in a cushioning pneumatic cylinder (32) disposed as said resistance applying means so as to support said cushion platen (26), so that said amount of said resistance is changed to change said blank holding force as said test pressing cycles are performed.

10. A method of pressing a blank (40) in a pressing system including (a) a die (18) and a punch (10) cooperating to perform a drawing operation on said blank to draw the blank along a forming surface of the punch, (b) a cushion platen (26), (c) a plurality of fluid-actuated balancing cylinders (30) disposed on said cushion platen and having respective pressure chambers communicating with each other, (d) a resistance applying means (32) for applying a resistance to a movement of said cushion platen, (e) a pressure ring (28) cooperating with said die to hold the blank at a peripheral portion thereof during the drawing operation, and (f) a plurality of cushion pins (22) interposed in parallel with each other between said pressure ring and said balancing cylinders, respectively, for transmitting a blank holding force based on said resistance to said pressure ring, wherein said drawing operation is performed when said pressure ring and said die are moved relative to said punch in a pressing direction against said resistance, said method comprising the steps of:

detecting a load which is transmitted to said pressure ring (28) through each of said cushion pins (22) during said drawing operation; and

determining that said blank holding force is evenly distributed to said pressure ring (28) through said cushion pins, if at least one predetermined characteristic value of the detected load transmitted through said each cushion pin (22) satisfies a predetermined condition.

11. A pressing method according to claim 10, wherein each of said fluid-actuated balancing cylinders (30) has a piston associated with a corresponding one of said cushion pins, and said at least one predetermined characteristic value of said detected load consists of one of a predetermined load value and an oscillation frequency of a waveform of said detected load, said step of determining comprising determining that said blank holding force is evenly distributed to said pressure ring through said cushion pins with said pistons of all of said balancing cylinders being placed at neutral positions between upper and lower stroke ends thereof, if said one of said predetermined load value and said oscillation frequency is held within a predetermined tolerance range, for all of said plurality of cushion pins.

12. A pressing method according to claim 11, further comprising the steps of: determining that at least one of said pistons of said balancing cylinders has been moved to the lower stroke end during said drawing operation, if said one of said predetermined load value and said oscillation frequency is larger than an upper limit of said predetermined tolerance range, for at least one of said cushion pins; and determining that at least one of said pistons of said balancing cylinders remains at the upper stroke end during said drawing operation, if said one of said predetermined load value and said oscillation frequency is smaller than a lower limit of said predetermined tolerance range, for at least one of said cushion pins.

13. A method according to any one of claims 10-12, wherein said at least one predetermined characteristic value includes at least one of a peak value, an average value and an oscillation frequency of a waveform of said load detected during said drawing operation by one movement of said die and said punch relative to each other in said pressing direction.

14. A method according to any one of claims 10-13, wherein said step of detecting a load comprises the steps of: interposing a load detecting block (102) between said punch (10) and a bolster (12) disposed above said cushion platen (26); and disposing load sensing pins (104) in series on upper ends of said cushion pins (22), respectively, such that

said cushion pins with said load sensing pins disposed thereon extend through through-holes (24) formed through said bolster, through-holes (106) formed through said load detecting block, and through-holes formed through said punch, each of said load sensing pins having a length substantially equal to a height dimension of said load detecting block, and having a load sensor (108) attached thereto for detecting a load acting thereon, as said load which is transmitted to said pressure ring through said each cushion pin.

15. A method according to any one of claims 10-14, further comprising the steps of: performing a plurality of test pressing cycles each of which comprises moving said die (18) and said pressure ring (28) relative to said punch (10) in said pressing direction against said resistance so as to perform said drawing operation on said blank (40), such that an amount of said resistance generated by said resistance applying means (32) is changed as said plurality of test pressing cycles are performed; and providing an indication of an optimum range of said amount of resistance within which said at least one predetermined characteristic value of said detected load satisfies said predetermined condition, said step of detecting and said step of determining being effected in each of said test pressing cycles.

16. A method according to claim 15, wherein said performing a plurality of test pressing cycles comprises changing a pressure in a cushioning pneumatic cylinder (32) disposed as said resistance applying means so as to support said cushion platen (26), so that said amount of said resistance is changed to change said blank holding force as said test pressing cycles are performed.

17. A pressing system including (a) a die (18) and a punch (10) cooperating to perform a drawing operation on a blank to draw the blank along a forming surface of the punch, (b) a cushion platen (26), (c) a resistance applying means (32) for applying a resistance to a movement of said cushion platen, (d) a pressure ring (40) cooperating with said die to hold the blank at a peripheral portion thereof during the drawing operation, and (e) a plurality of cushion pins (22) interposed in parallel with each other between said cushion platen and said pressure ring, for transmitting a blank holding force based on said resistance to said pressure ring, wherein said drawing operation is performed when said pressure ring and said die are moved relative to said punch in a pressing direction against said resistance, said pressing system comprising:

load detecting means (62, 100, 114) for detecting a load which is transmitted to said pressure ring (28) through each of said cushion pins (22) during said drawing operation;

reference data memory means (122) for storing data representative of a predetermined condition which is satisfied by at least one predetermined characteristic value of the detected load transmitted through said each cushion pin (22) if said blank (40) is adequately held by said blank holding force; and

diagnostic means (62, 120) for determining whether said blank (40) is adequately held by said blank holding force, depending upon whether said at least one predetermined characteristic value of said detected load satisfies said predetermined condition.

18. A pressing system according to claim 19, further comprising a bolster (12) fixedly disposed between said cushion platen platen (26) and said punch (10) and having through-holes (24), and wherein said cushion pins (22) extends extend through said through-holes formed through said bolster and through through-holes formed through said punch, such that said cushion pins are supported at lower ends thereof by said cushion platen and support at upper ends thereof said pressure ring,

and wherein said load detecting means (62, 100, 114) comprises a load detecting device (100) which includes a load detecting block (102) interposed between said bolster and said punch and having through-holes (106) through which said cushion pins extend, respectively; and load sensing pins (104) disposed in series on said upper ends of said cushion pins, respectively, and having a length substantially equal to a height dimension of said load detecting block, each of said load sensing pins having a load sensor (108) attached thereto for detecting a load acting thereon, as said load which is transmitted to said pressure ring through said each cushion pin.

19. A pressing system according to claim 17 or 18, further comprising:

a die set information memory (66) storing die set information which includes an optimum value of each of said at least one predetermined characteristic value of said detected load transmitted through said each cushion pin; and

a transceiver (64) for receiving said die set information from said die set information memory, said reference data memory means (122) storing data representative of a tolerance range of said each predetermined characteristic value of said detected load, which tolerance range is determined by said optimum value.

20. A load detecting device used with the pressing system defined in claim 17, for detecting said load transmitted to said pressure ring (28) through each of said cushion pins (22), wherein said cushion platen (26) is moved down against said resistance while maintaining a substantially horizontal attitude, and said punch (10) is fixedly positioned on a bolster (12) disposed above said cushion platen, said plurality of cushion pins extending through through-holes formed through said bolster and said punch such that said cushion pins are supported at lower ends thereof by said cushion platen and support at upper ends thereof said pressure ring, said load detecting device comprising:

a load detecting block (102) interposed between said bolster (12) and said punch (10) and having through-holes (106) through which said cushion pins (22) extend; and
load sensing pins (104) disposed in series on said upper ends of said cushion pins, respectively, and having a length substantially equal to a height dimension of said load detecting block, each of said load sensing pins having a load sensor (108) attached thereto for detecting a load acting thereon, as said load which is transmitted to said pressure ring (28) through said each cushion pin.

21. A load detecting device according to claim 20, wherein each of said load sensor (108) comprises a strain gage.

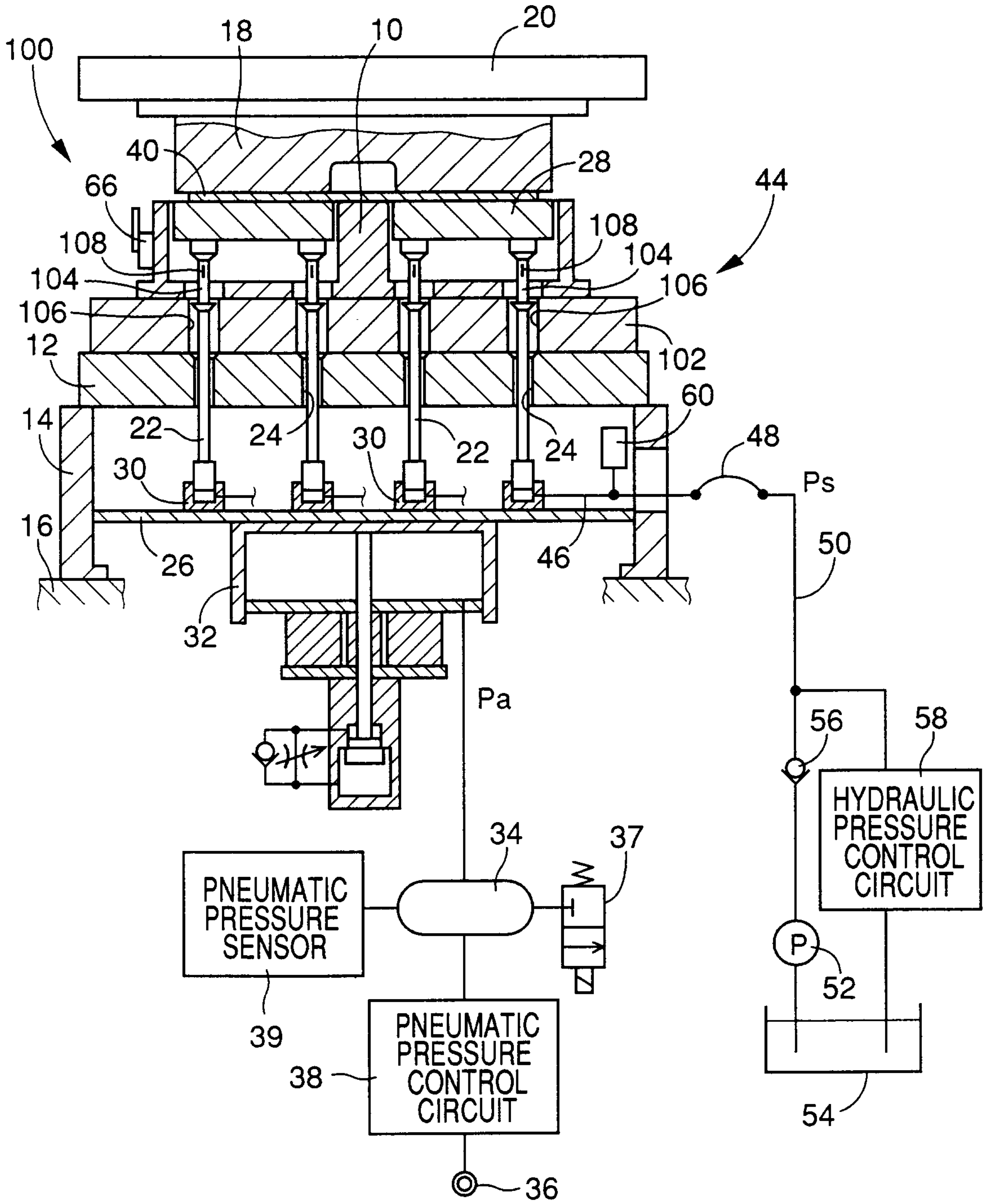
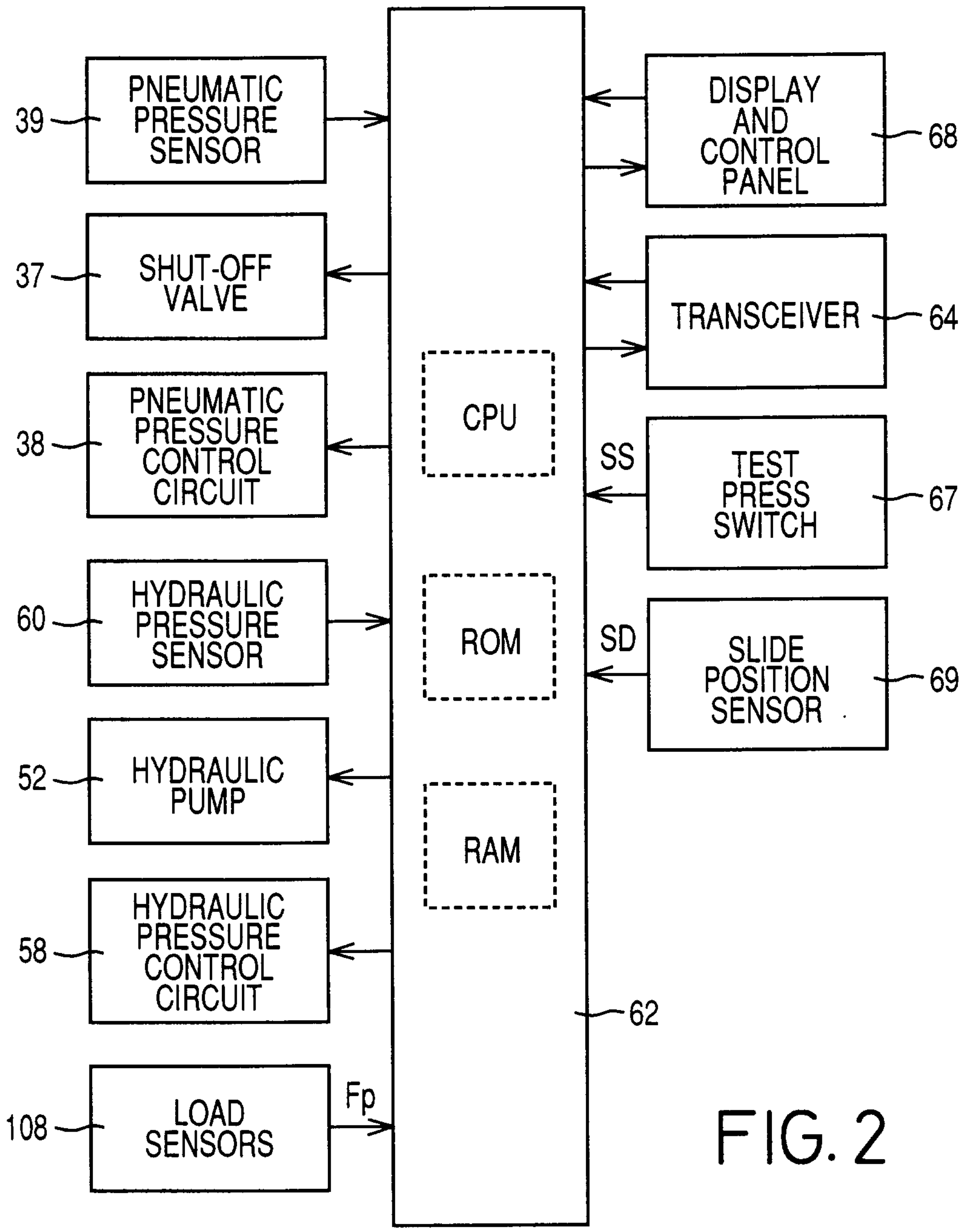

100
18
10
20
40
28
66
44
108
108
104
104
106
106
12
102
60
14
22
24
30
22
24
48
Ps
30
16
26
46
50
32
Pa
56
58
HYDRAULIC
PRESSURE
CONTROL
CIRCUIT
34
37
PNEUMATIC
PRESSURE
SENSOR
P
52
39
PNEUMATIC
PRESSURE
CONTROL
CIRCUIT
38
54
36

FIG. 1



39
PNEUMATIC PRESSURE SENSOR
37
SHUT-OFF VALVE
38
PNEUMATIC PRESSURE CONTROL CIRCUIT
60
HYDRAULIC PRESSURE SENSOR
52
HYDRAULIC PUMP
58
HYDRAULIC PRESSURE CONTROL CIRCUIT
108
LOAD SENSORS
Fp
CPU
ROM
RAM
62
DISPLAY AND CONTROL PANEL
68
TRANSCEIVER
64
SS
TEST PRESS SWITCH
67
SD
SLIDE POSITION SENSOR
69

FIG. 2

FIG. 3

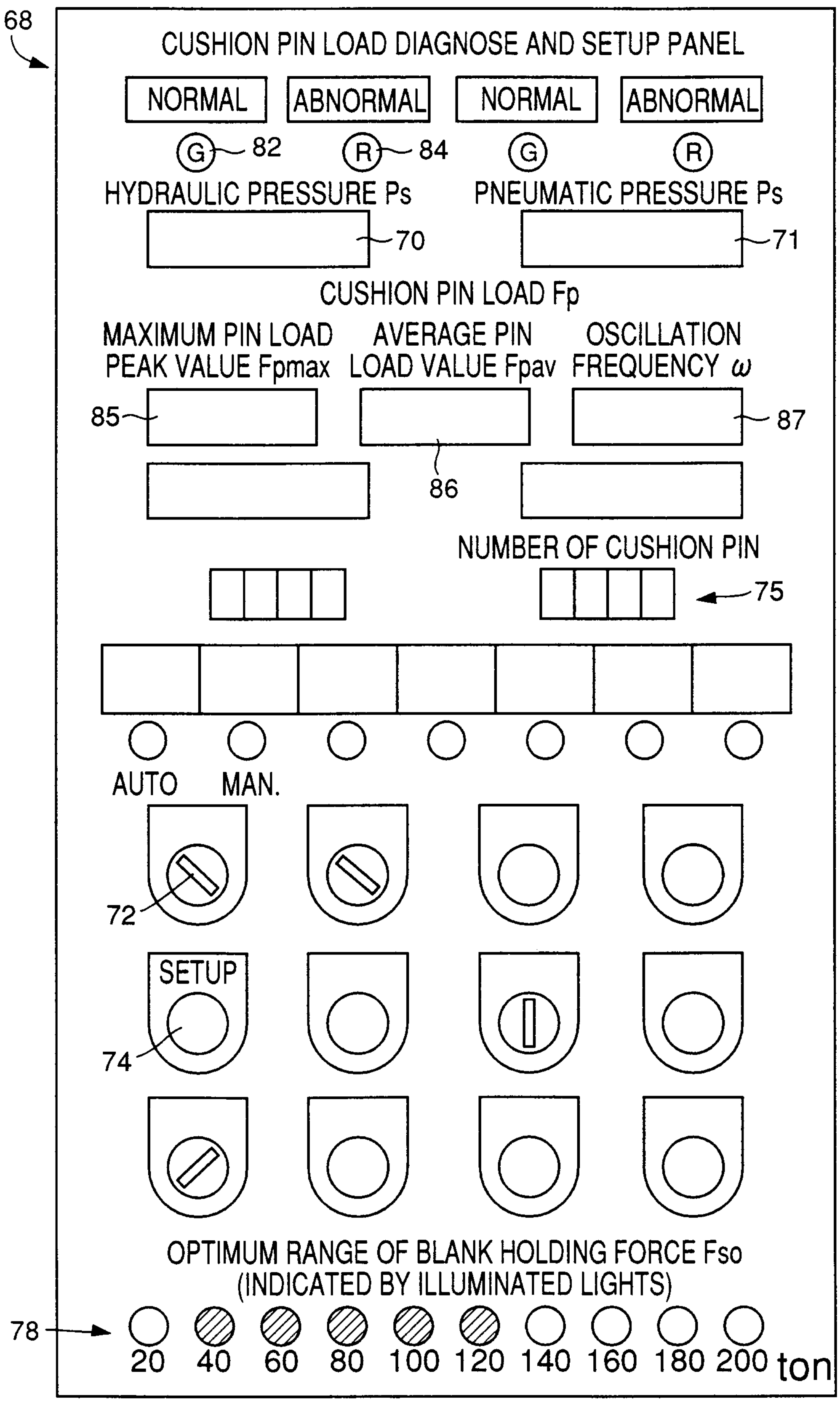
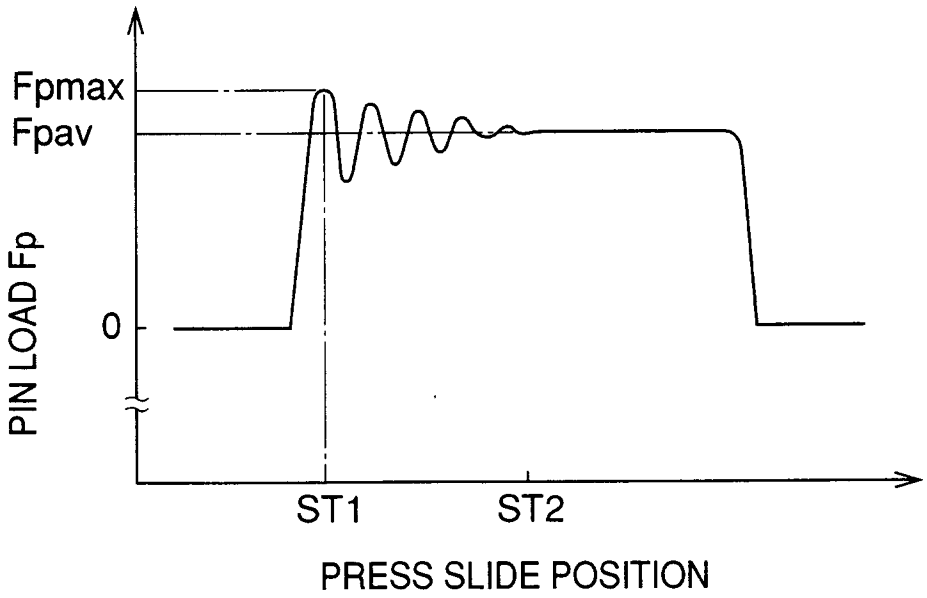

68
CUSHION PIN LOAD DIAGNOSE AND SETUP PANEL
NORMAL
ABNORMAL
NORMAL
ABNORMAL
G
82
R
84
G
R
HYDRAULIC PRESSURE Ps
PNEUMATIC PRESSURE Ps
70
71
CUSHION PIN LOAD Fp
MAXIMUM PIN LOAD PEAK VALUE Fpmax
AVERAGE PIN LOAD VALUE Fpav
OSCILLATION FREQUENCY ω
85
86
87
NUMBER OF CUSHION PIN
75
AUTO
MAN.
72
SETUP
74
OPTIMUM RANGE OF BLANK HOLDING FORCE Fso
(INDICATED BY ILLUMINATED LIGHTS)
78
20
40
60
80
100
120
140
160
180
200
ton

FIG. 4



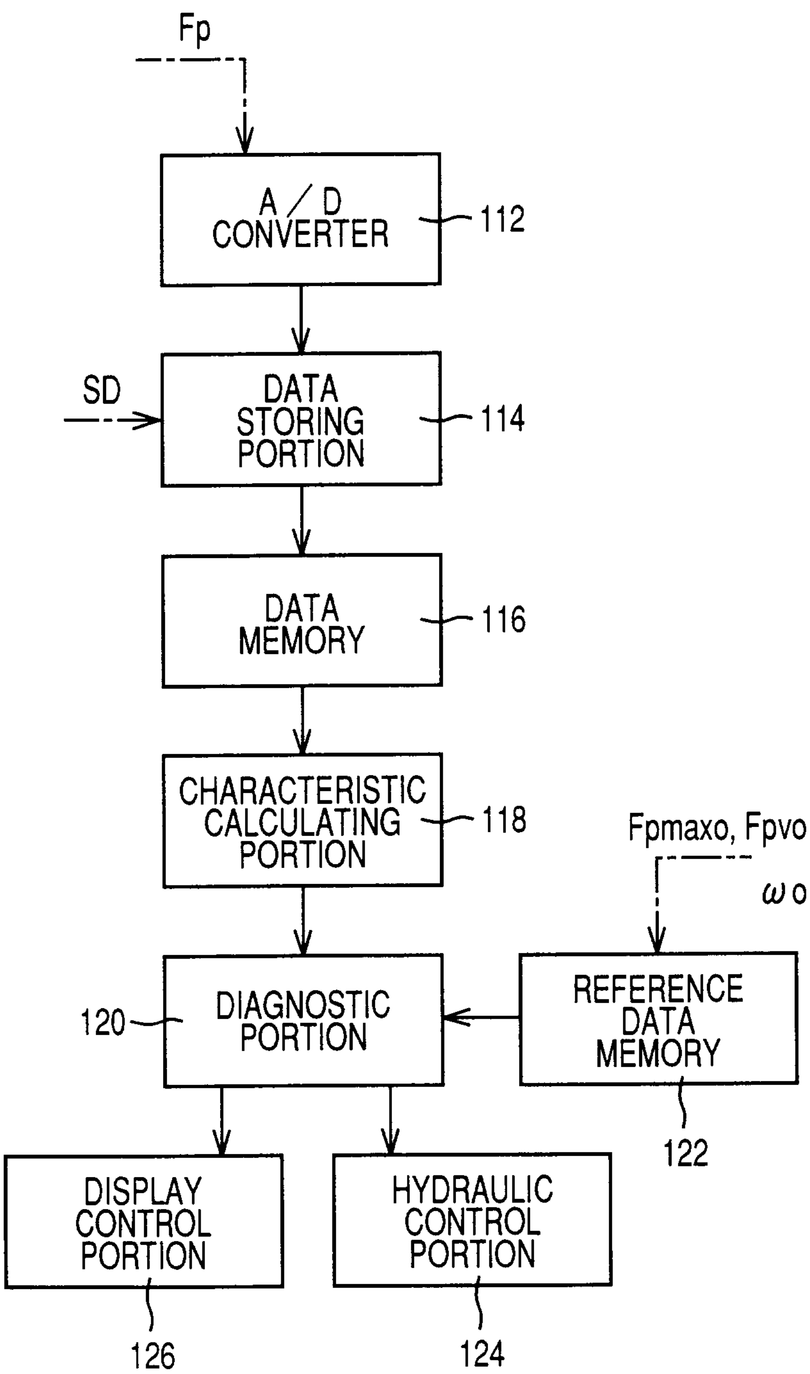
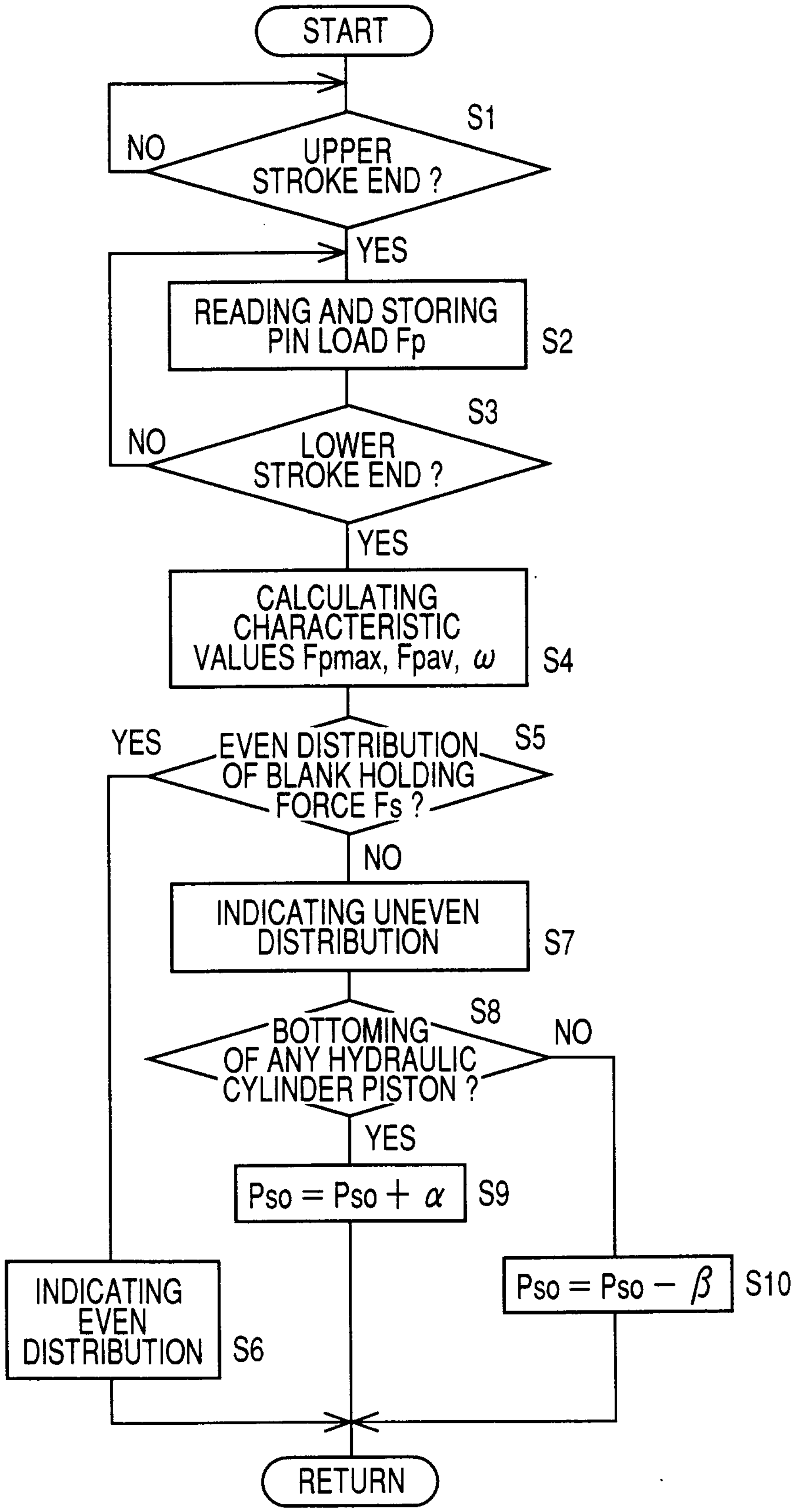

Fp
A / D
CONVERTER
112
SD
DATA
STORING
PORTION
114
DATA
MEMORY
116
CHARACTERISTIC
CALCULATING
PORTION
118
Fpmaxo, Fpvo
ωo
120
DIAGNOSTIC
PORTION
REFERENCE
DATA
MEMORY
122
DISPLAY
CONTROL
PORTION
HYDRAULIC
CONTROL
PORTION
126
124

FIG. 5

FIG. 6



START
S1
NO
UPPER STROKE END ?
YES
READING AND STORING PIN LOAD Fp
S2
S3
NO
LOWER STROKE END ?
YES
CALCULATING CHARACTERISTIC VALUES Fpmax, Fpav, ω
S4
YES
EVEN DISTRIBUTION OF BLANK HOLDING FORCE Fs ?
S5
NO
INDICATING UNEVEN DISTRIBUTION
S7
BOTTOMING OF ANY HYDRAULIC CYLINDER PISTON ?
S8
NO
YES
Pso = Pso + α
S9
Pso = Pso − β
S10
INDICATING EVEN DISTRIBUTION
S6
RETURN

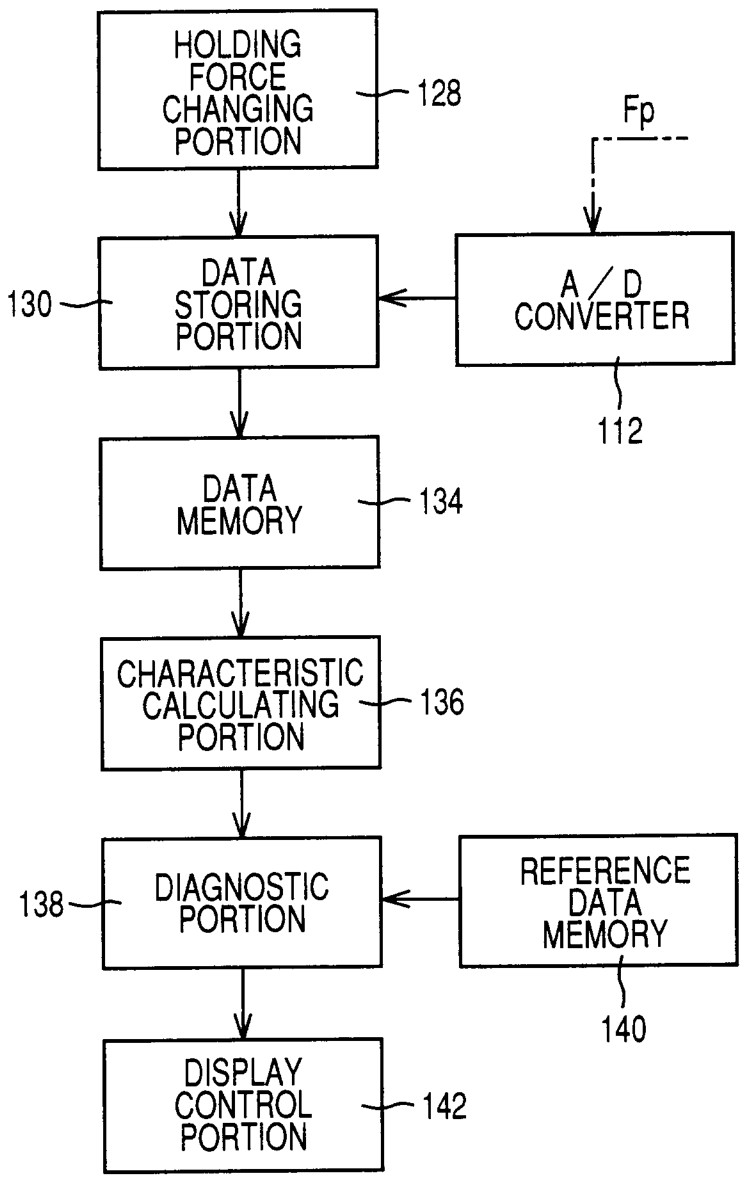
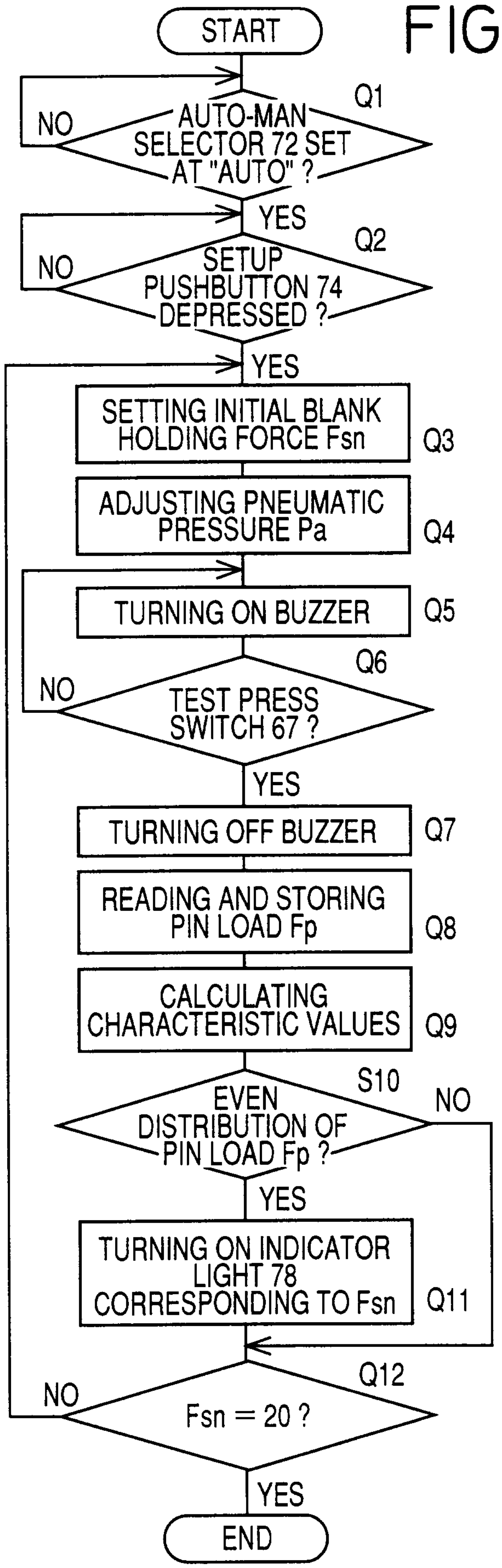

HOLDING FORCE CHANGING PORTION
128
Fp
DATA STORING PORTION
130
A / D CONVERTER
112
DATA MEMORY
134
CHARACTERISTIC CALCULATING PORTION
136
DIAGNOSTIC PORTION
138
REFERENCE DATA MEMORY
140
DISPLAY CONTROL PORTION
142

FIG. 7

FIG. 8


START
AUTO-MAN SELECTOR 72 SET AT "AUTO" ?
Q1
NO
YES
SETUP PUSHBUTTON 74 DEPRESSED ?
Q2
NO
YES
SETTING INITIAL BLANK HOLDING FORCE Fsn
Q3
ADJUSTING PNEUMATIC PRESSURE Pa
Q4
TURNING ON BUZZER
Q5
TEST PRESS SWITCH 67 ?
Q6
NO
YES
TURNING OFF BUZZER
Q7
READING AND STORING PIN LOAD Fp
Q8
CALCULATING CHARACTERISTIC VALUES
Q9
EVEN DISTRIBUTION OF PIN LOAD Fp ?
S10
NO
YES
TURNING ON INDICATOR LIGHT 78 CORRESPONDING TO Fsn
Q11
Fsn = 20 ?
Q12
NO
YES
END

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 10 6834

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP-A-0 622 133 (TOYOTA JIDOSHA KABUSHIKI KAISHA)	1,3-6, 10,11,17	B21D24/14
A	* claims 1-46; figures 1-3 *	7-9, 12-16, 18-21	

X	EP-A-0 596 696 (TOYOTA JIDOSHA KABUSHIKI KAISHA)	1,4	
A	* claims 1,19,28; figure 1 *	7-16,20	

A	EP-A-0 613 740 (FIAT AUTO S.P.A.)	1,2,10, 13	
	* claims 1-7; figures 1,2 *		

A	US-A-4 745 792 (JAMES M. STORY ET AL.)	1-17	
	* abstract; claims 1-8; figures 1,2 *		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
B21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	15 July 1996	Cuny, J-M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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