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(54) **METHOD OF PLASTIC FORMING.**

(57) A method of plastic forming in which a blank in the die undergoes plastic deformation with the advance of a punch whose moving speed is controllable. Deformation of the die incurred by am impact caused when the punch strikes the die is prevented by slow advance of the punch until the die touches the blank. When the punch comes into contact with the die, the pressure to move the punch forward, while interfering with the advance of the punch, is raised to a limit at which plastic deformation occurs. The advance speed of the punch is controlled so that, with release of the pressure having interrupted the advance of the punch, distortion speed of the blank may be made substantially uniform almost throughout the area subjected to plastic forming. Uniform stress acting on the die as a result of uniformized distortion speed of the blank leads to a uniform amount of deformation of the die almost throughout area subjected to plastic forming, whereby lowering of precision in forming caused by fluctuations in the deformation amount of the die is prevented. With the pressure of ejecting means made relatively higher than that of the punch at the time of ejection, spring-back of the die is prevented by ejection of the blank under pressure.

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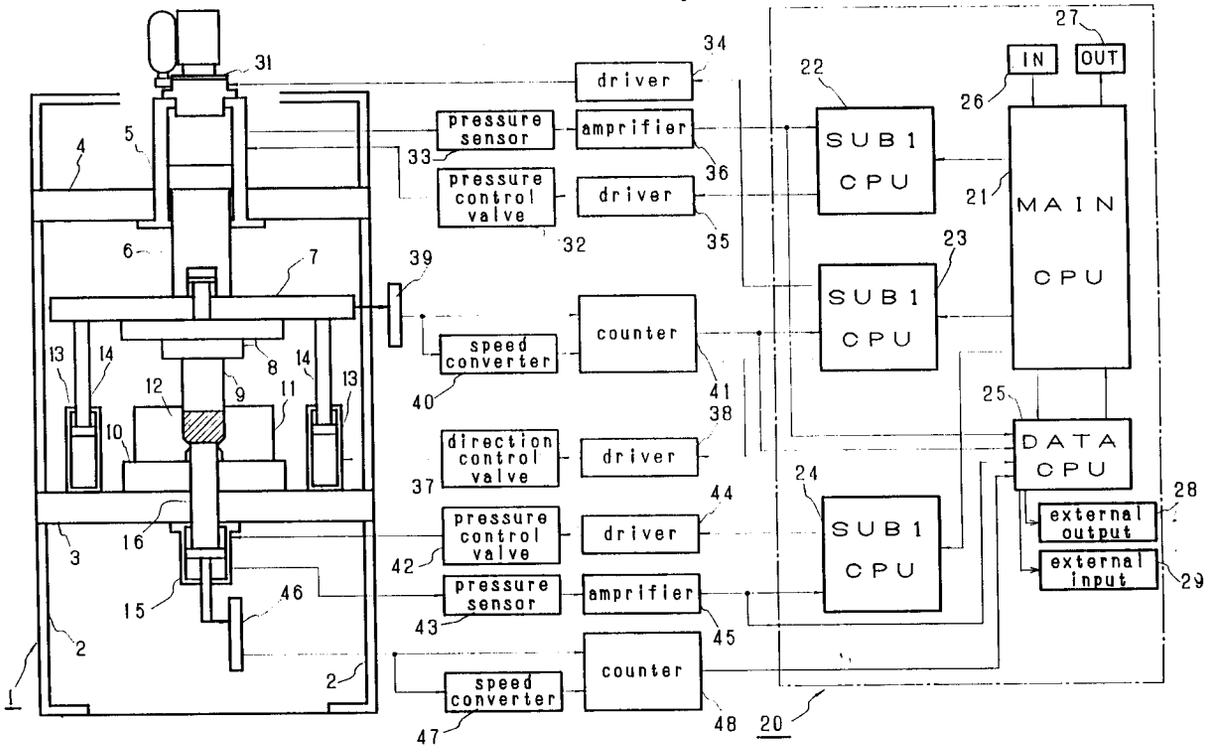
FIG. 1


driver
pressure sensor
amprifier
pressure control valve
driver
speed converter
counter
direction control valve
driver
pressure control valve
driver
pressure sensor
amprifier
speed converter
counter
SUB 1 CPU
SUB 1 CPU
SUB 1 CPU
MAIN CPU
DATA CPU
IN
OUT
external output
external input

TECHNICAL FIELD

The present invention relates to a plasticity working method using a press machine, and more particularly to a plasticity working method adapted to prevent deterioration in precision of a product due to deformation of a die during the plasticity working.

BACKGROUND TECHNIQUE

Heretofore, the plasticity working method is known in which pressure capable of producing plastic deformation is applied to a blank or object set in a die to obtain a product having a desired shape.

However, when a conventional plasticity working method is adopted, sufficient plastic precision is not obtained only by the plasticity working due to the following reasons and it is necessary to finish the product by processes subsequent to the plasticity working in the case of a product requiring high plastic precision.

Thus, the causes are now described in accordance with the lapse of time of the plasticity working.

The influence of impact upon collision of a punch against the blank is first considered.

In a crank press and a link press, the speed of the punch is high when the punch comes into contact with the blank and accordingly large impact is applied to the blank in a moment that the punch collides against the blank. The shape of the die is largely deformed by the impact and the working precision is deteriorated.

The influence of deformation of the die during the plasticity working is next considered.

In the plasticity working, the force applied to the blank from the punch is also transmitted to the die as stress. Accordingly, since it is impossible that the die provides the absolute rigidity, it is difficult to avoid the die from being deformed during the plasticity working. Specifically, in the case of an apparatus in which strong pressure is applied as in a cold forging press machine, the die is deformed largely.

If the die is deformed uniformly over all area of the die for the plasticity working even if the die is deformed during the plasticity working, a margin for the deformation can be provided in the die in anticipation of the deformation in the form of the die. However, since the deformation amount of the die during the working is varied momentarily unpredictably in the case of the general plasticity working, improvement of the working precision can not be expected even if the deformation margin is provided in the die.

The influence of the spring back of the die upon knocking out is further considered.

That is, the strong plastic pressure is applied to the die during the plasticity working and the die is also deformed by the plastic pressure. The plastic pressure is released when the punch is separated from the blank upon the knocking out and accordingly the die is returned to its initial shape by its own resilience. At this time, a damage is added to the knocked out product.

DISCLOSURE OF THE INVENTION

The present invention has been made in view of the above problems and an object of the present invention is to provide a plasticity working method having increased working precision to obtain sufficient product precision without requiring subsequent processes.

In brief, the plasticity working method of the present invention using a plasticity working apparatus including a punch having a moving speed capable of being controlled by a fluid pressure, a die to which a blank is attached, support means for preventing a forward movement of the punch by a fluid pressure and eject means for ejecting a plastically worked blank by the fluid pressure, whereby a pressure is applied through the punch to the blank attached to the die to thereby plastically deform the blank, comprising a first step of forward moving the punch slowly until the tip of the punch comes into contact with the blank, a second step of preventing a further forward movement of the punch by the support means while both of the fluid pressure for forward moving the punch and the fluid pressure for forward moving the support means are increased when the tip of the punch comes into contact with the blank, a third step of releasing the fluid pressure for forward moving the support means when the fluid pressure for forward moving the punch reaches a critical pressure that causes the plastic deformation in the blank, a fourth step of forward moving the punch at a speed that a deformation speed occurring in the blank by a plastic pressure applied by means of the punch is substantially uniform over generally all area during the plasticity working, and a five step of making relatively higher the fluid pressure applied to the eject means than the fluid pressure applied to the punch in a state where the fluid pressure is applied to both of the punch and the eject means so that the blank is knocked out from the die.

The influence of impact upon collision of the punch against the blank can be reduced by forward moving the punch slowly until the tip of the punch comes into contact with the blank.

Since deflection of the die during the plasticity working occurs by stress produced in the blank

due to the plastic pressure applied to the blank from the punch, the deflection of the die during the plasticity working is uniformed by controlling the speed of the forward movement of the punch so that the stress produced due to the plastic pressure is substantially uniformed over generally all area of the plasticity working.

If the stress produced in the blank is defined as a and a deformation amount of the blank is defined as ϵ the following equation (1) is generally formed between a deformation speed $\dot{\epsilon}$ and the stress σ.

$$\sigma = k\dot{\epsilon}^m \quad (1)$$

where k is a constant,
m is a deformation speed responsive index, and

$$\dot{\epsilon} = d_\epsilon/dt$$

Since an essential variable is only the deformation speed $\dot{\epsilon}$ in the equation (1), the stress σ is made constant by controlling the speed of the punch so that the deformation speed $\dot{\epsilon}$ is constant, so that the deflection of the die can be uniformed over all area of the plasticity working.

In the present invention, however, since the punch is slowly moved forward for the period until the punch comes into contact with the blank, it is difficult to increase the speed of the forward movement of the punch from this state to a desired speed in a moment.

Accordingly, in the present invention, the fluid pressure for forward moving the punch is previously increased to the critical pressure that causes the plastic deformation in the blank while a force of the forward movement of the punch is supported by a backup cylinder acting as support means in the state where the punch and the blank are in contact with each other, and the backup cylinder is released from the state where the fluid pressure is increased to the critical pressure so that the pressure supported by the backup cylinder is applied to the blank to thereby increase the speed of the forward movement of the punch to an ideal speed more rapidly.

Furthermore, in the present invention, the fluid pressure for forward moving a counter punch acting as eject means is made relatively higher than the fluid pressure for forward moving the punch in the state that the fluid pressure is applied to both of the punch and the counter punch to thereby forward move the counter punch in the state where a pressure is applied to the blank, so that the blank is ejected to the die. Accordingly, since the spring back of the die does not occur until the product is ejected from the die, a damage produced in the product by the spring back can be avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a cold forging press machine and its control system according to an embodiment of the present invention;
Fig. 2 is an enlarged view of the periphery of a die; and
Fig. 3 is a flow chart showing a control operation.

BEST MODE FOR IMPLEMENTING THE PRESENT INVENTION

Referring now to the accompanying drawings, an embodiment of the present invention is described in detail.

Fig. 1 is a block diagram of a cold forging press machine 1 and its control system according to an embodiment of the present invention.

A bed 3 and a cylinder fixing plate 4 are fixedly mounted to a frame of the cold forging press machine 1. A main cylinder 5 is fixedly mounted to the cylinder fixing plate 4. A slide 7 is fixedly attached to a lower end surface of a piston 6 of the main cylinder 5.

A punch 9 is attached to a lower end surface of the slide 7 through a fixing member 8. A die 11 is mounted to an upper end surface of the bed 3 through a fixing plate 10 just under the punch 9. A blank 12 to be worked is mounted in the die 11.

Fixedly mounted on the upper end surface of the bed 3 is a backup cylinder 13 for supporting the slide 7 from under the slide. A piston 14 of the backup cylinder 13 has a stroke to be able to reach the lower end surface of the slide 7.

A knock-out cylinder 15 is fixedly mounted to a lower end surface of the bed 3. A piston in the knock-out cylinder 15 acts as a counter punch 16 for knocking out the plastically worked blank 12.

Numeral 20 denotes a controller. The controller 20 includes a CPU 21 for controlling the whole system, sub-CPU's 22, 23 and 24 for controlling respective objects to be controlled, a CPU 25 for controlling input and output of memory data, an external output unit 28 such as input/output interfaces 26 and 27 and a CRT, and an external input unit 29 such as a keyboard and an external memory.

The main cylinder 5 is provided with a flow control valve 31 for controlling an amount of oil flowing in the main cylinder 5, a pressure control valve 32 for controlling a pressure in the main cylinder 5, and a pressure sensor 33 for detecting a pressure in the main cylinder 5. The flow control valve 31 and the pressure control valve 32 are controlled by the controller 20 through drivers 34 and 35, respectively. Further, a detection output signal of the pressure sensor 33 is supplied to the

controller 20 through an amplifier 36.

The backup cylinder 13 is provided with a directional control valve 37 having a high-speed response and three states (forward movement, backward movement and holding) for changing over a flowing direction of oil. The directional control valve 37 is controlled by the controller 20 through a driver 38.

Numeral 39 denotes a photoelectric transducer type position sensor for detecting a position of the slide 7 and numeral 40 denotes a speed converter for differentiating an output of the position sensor 39 to convert it into an operation speed of the slide 7. Outputs of the position sensor 39 and the speed converter 40 are supplied to the controller 20 through a counter 41.

The knock-out cylinder 15 is provided with a pressure control valve 42 for controlling a pressure in the knock-out cylinder 15 and a pressure sensor 43 for detecting the pressure in the knock-out cylinder 15. The pressure control valve 42 is controlled by the controller 20 through a driver 44. A detection output of the pressure sensor 43 is supplied to the controller 20 through an amplifier 45.

Numeral 46 denotes a photoelectric transducer type position sensor for detecting a position of the counter punch 16. Numeral 47 denotes a speed converter for differentiating an output of the position sensor 46 to convert it into an operation speed of the counter punch 16. Outputs of the position sensor 46 and the speed converter 47 are supplied to the controller 20 through a counter 48.

Referring now to Fig. 2 showing an enlarged view and Fig. 3 showing a flow chart, operation of the apparatus of Fig. 1 performing the forward extrusion molding is described.

In the forward extrusion molding, first of all, deformation occurs in the blank 12 when the blank 12 passes through the vicinity of a point P of Fig. 2 in which a sectional shape of the die 11 is changed and accordingly in order to maintain the deformation speed $\dot{\epsilon}$ to be constant, the working speed in all area of the plastic working is required to be maintained constant. Thus, in the forward extrusion molding, it is necessary to control so that a falling speed of the punch 9 is uniform in all area of the plastic working.

Prior to the actual working, various data (for example, a pressurizing force at a yield point of the blank 1 and a position of the slide 7 when the lower end surface of the punch 9 comes into contact with the blank 12, a pressurization speed corresponding to the position of the slide 7 during the plastic working and the like) are supplied to the external input unit 29 and set in the data CPU 25.

For example, when a signal indicative of the completion of setting the blank is supplied from a conveyor apparatus not shown through the input interface 26, the controller 20 controls the flow control valve 31 through the driver 34 to feed oil to the main cylinder 5 to lower the slide 7.

At this time, the controller 20 receives the output of the position sensor 39 through the counter 41 to monitor the position of the slide 7.

When the slide 7 is lowered until the lower end surface of the punch 9 comes into contact with the blank 12 mounted in the die 11, the controller 20 controls the directional control valve 37 through the driver 38 to feed oil to the backup cylinder 13 so that the piston 14 is moved up and the slide 7 is supported by the backup cylinder 13.

When the slide 7 is supported by the backup cylinder 13, the controller 20 controls the flow control valve 31, the pressure control valve 32 and the directional control valve 37 while the controller 20 confirms from the output of the position sensor 39 that the position of the slide 7 is not varied, to thereby increase the pressure of the main cylinder 5 and the backup cylinder 13.

Accordingly, the pressure produced by the main cylinder 5 at this time is supported by the backup cylinder 13.

When the controller 20 understands from the output of the pressure sensor 33 that the pressure applied to the blank 12 is increased to a value just before the yield point of material, the controller 20 controls the directional control valve 37 to open the backup cylinder 13 and controls the flow control valve 31 to lower the slide 7. The pressure produced by the main cylinder 5 in response to opening of the backup cylinder 13 is applied to the blank 12, so that the blank 12 is plastically deformed by the punch 9.

In the plastic working at this time, the controller 20 controls the flow control valve 31 while monitoring the slide position produced by the position sensor 39 and the pressurized speed produced by the speed converter 40, to thereby control the pressurized speed so that the slide 7 is lowered at a constant speed.

The slide 7 is naturally lowered by the pressurizing operation. When the controller 20 understands from the output of the position sensor 39 that the slide 7 reaches a predetermined braking point, the controller 20 controls the directional control valve 37 to operate the backup cylinder 13 to thereby brake the lowering operation of the slide 7, and thereafter lowers the slide 7 to a bottom dead center while controlling turning on and off of the directional control valve 37.

When the controller 20 understands from the output of the position sensor 39 that the slide 7 reaches the predetermined bottom dead center, the controller 20 controls the pressure control valve 42 to increase the pressure of the knock-out cylinder 15 to be equal to the pressure of the main cylinder

5 while monitoring the output of the pressure sensor 43 through the amplifier 45.

When the controller 20 understands from the output of the pressure sensor 43 that the pressure of the knock-out cylinder 15 reaches the pressure of the main cylinder 5, the controller 20 controls the pressure control valve 32 to reduce the pressure of the main cylinder 5 while monitoring the output of the pressure sensor 33.

By reducing the pressure of the main cylinder 5, the counter punch 16 is moved up and the plastically worked blank 12 is soon knocked out from the die 11. At this time, since the blank 12 is pressurized between the counter punch 16 and the punch 9, the spring back of the die 11 does not occur until the blank 12 escapes from the die 11 and the product is not damaged by the spring back of the die 11.

In this manner, after the product has been knocked out, the controller 20 controls the flow control valve 31, the directional control valve 37 and the pressure control valve 4 to move the main cylinder 5 to the upper limit position thereof and the backup cylinder 13 and the knock-out cylinder 15 to the lower limit position thereof to thereby complete one plastically working operation.

The foregoing has described an example in which the present invention is applied to the forward extrusion molding, while the present invention can be applied to, for example the backward extrusion molding as it is.

Further, the foregoing has described an example in which the present invention is applied to the plasticity working using the cold forging press, while since the present invention essentially intends to improve the product precision by controlling the deformation amount of the die uniformly, the cold forging press having large deformation of the die is shown as the embodiment and the present invention can be applied to the whole plasticity working widely.

INDUSTRIAL AVAILABILITY

As described above, according to the present invention, since the slide is lowered slowly until the punch comes into contact with the blank, deformation of the die due to the impact occurring when the punch comes into contact with the blank is prevented and deterioration of the product precision due to deformation of the die by the impact occurring when the punch comes into contact with the die is also prevented.

Further, according to the present invention, both of the fluid pressure for forward moving the punch and the fluid pressure for forward moving the support means are increased in the state where the forward movement of the punch is prevented by the support means and the fluid pressure for forward moving the support means is released when the fluid pressure for forward moving the punch reaches the critical pressure that the blank is plastically deformed. Accordingly, the forward moving speed of the punch can be increased to a desired speed.

In addition, according to the present invention, the deformation speed occurring in the blank in substantially all area of the plastic working is maintained substantially constant and as a result the stress applied to the die is also maintained constant. Thus, in accordance with the present invention, deformation of the die during the plastic working is maintained constant. Accordingly, by providing the deformation margin involving the previously anticipated predetermined deformation amount in the die, the product with high precision can be obtained only by the plasticity working without finishing by the subsequent process.

Furthermore, according to the present invention, since the blank is ejected while the pressure is applied to the blank, the spring back of the die does not occur until the blank is ejected, so that the product is not damaged by the spring back of the die to contribute to the precision of the product.

Claims

1. A plasticity working method using a plasticity working apparatus including a punch having a moving speed capable of being controlled by a fluid pressure, a die to which a blank is attached and support means for preventing a forward movement of said punch by a fluid pressure, whereby a pressure is applied through said punch to said blank attached to the die to thereby plastically deform said blank, comprising:

a first step of forward moving said punch slowly until the tip of said punch comes into contact with said blank;

a second step of preventing a further forward movement of said punch by said support means while both of the fluid pressure for forward moving said punch and the fluid pressure for forward moving said support means are increased when the tip of said punch comes into contact with said blank;

a third step of releasing the fluid pressure for forward moving said support means when the fluid pressure for forward moving said punch reaches a critical pressure that causes the plastic deformation in said blank; and

a fourth step of forward moving said punch at a speed that a deformation speed occurring in said blank by a plastic pressure applied by means of said punch is substantially uniform

over substantially all area during the plasticity working.

2. A plasticity working method using a plasticity working apparatus including a punch having a moving speed capable of being controlled by a fluid pressure, a die to which a blank is attached and eject means for ejecting a plastically worked blank by a fluid pressure, whereby a pressure is applied through said punch to said blank attached to said die to thereby plastically deform said blank, comprising:

a first step of forward moving said punch at a speed that a deformation speed occurring in said blank by a plastic pressure applied by means of said punch is substantially uniform over substantially all area during the plasticity working; and

a second step of increasing the fluid pressure applied to said eject means relatively as compared with the fluid pressure applied to said punch in a state where the fluid pressure is applied to both of said punch and said eject means, so that said blank is knocked out from said die.

3. A plasticity working method using a plasticity working apparatus including a punch having a moving speed capable of being controlled by a fluid pressure, a die to which a blank is attached, support means for preventing a forward movement of said punch by a fluid pressure and eject means for ejecting a plastically worked blank by a fluid pressure, whereby a pressure is applied through said punch to said blank attached to said die to thereby plastically deform said blank, comprising:

a first step of forward moving said punch slowly until the tip of said punch comes into contact with said blank;

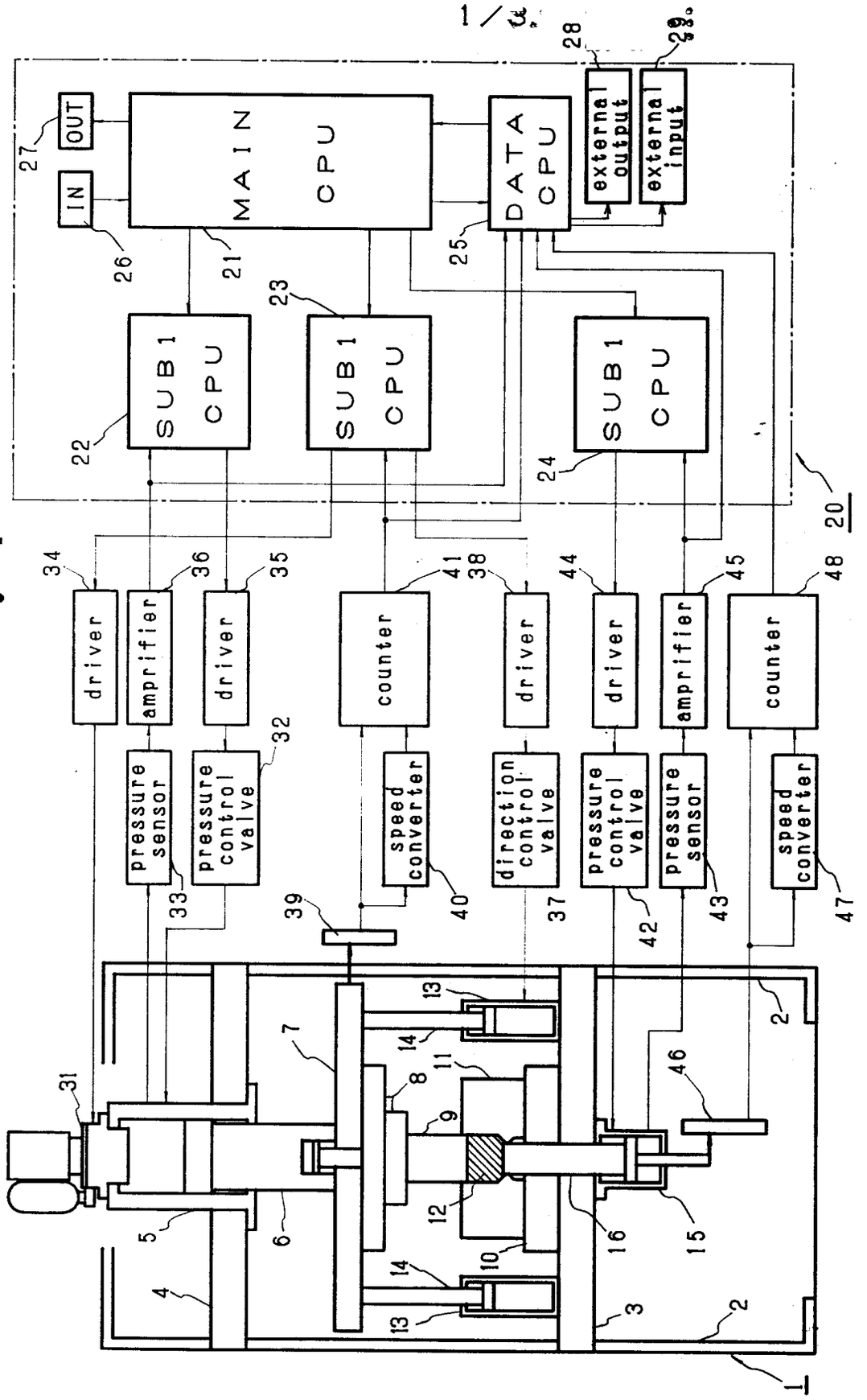
a second step of preventing a further forward movement of said punch by said support means while both of the fluid pressure for forward moving said punch and the fluid pressure for forward moving said support means are increased when the tip of said punch comes into contact with said blank;

a third step of releasing the fluid pressure for forward moving said support means when the fluid pressure for forward moving said punch reaches a critical pressure that causes the plastic deformation in said blank;

a fourth step of forward moving said punch at a speed that a deformation speed occurring in said blank by a plastic pressure applied by means of said punch is substantially uniform over substantially all area during the plasticity working; and

a five step of increasing the fluid pressure applied to said eject means relatively as compared with the fluid pressure applied to said punch in a state where the fluid pressure is applied to both of said punch and said eject means, so that said blank is knocked out from said die.

FIG. 1


MAIN CPU
DATA CPU
SUB1 CPU
SUB1 CPU
SUB1 CPU
OUT
IN
external output
external input
driver
amprifier
driver
counter
driver
driver
amprifier
counter
pressure sensor
pressure control valve
speed converter
direction control valve
pressure control valve
pressure sensor
speed converter
20
21
22
23
24
25
26
27
28
29
31
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36
37
38
39
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42
43
44
45
46
47
48

FIG. 2

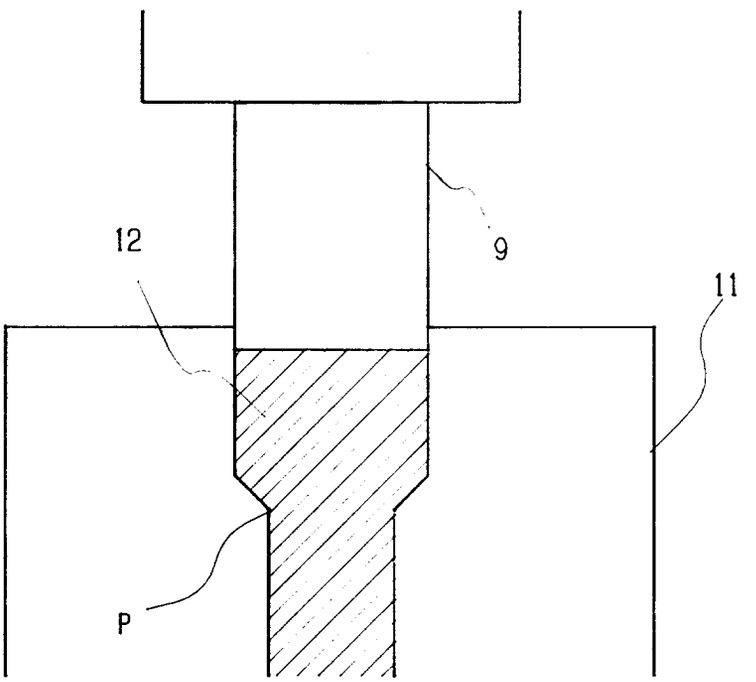
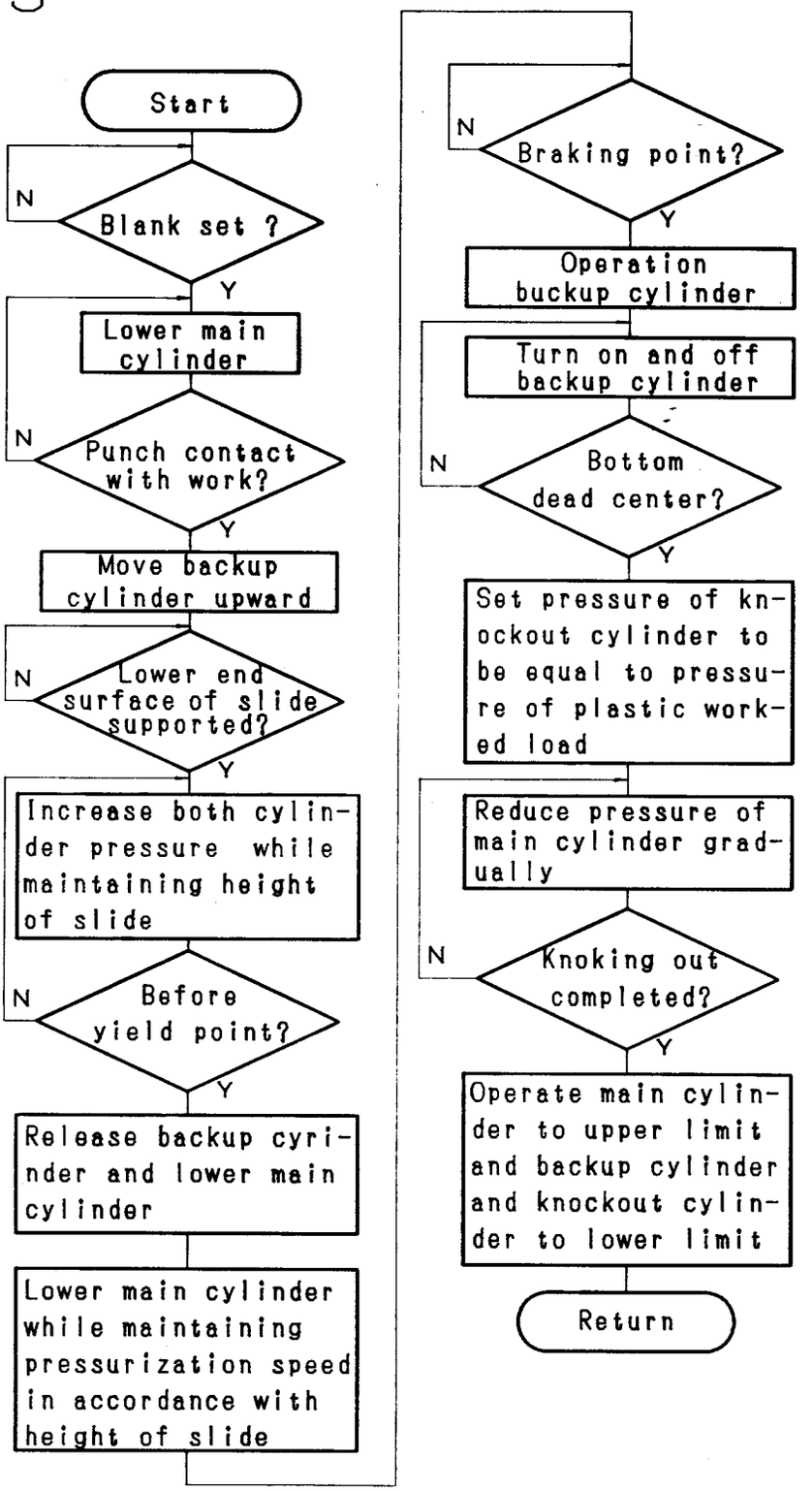


FIG. 3


Start
Blank set ?
N
Y
Lower main cylinder
Punch contact with work?
N
Y
Move backup cylinder upward
Lower end surface of slide supported?
N
Y
Increase both cylinder pressure while maintaining height of slide
Before yield point?
N
Y
Release backup cyrinder and lower main cylinder
Lower main cylinder while maintaining pressurization speed in accordance with height of slide
Braking point?
N
Y
Operation buckup cylinder
Turn on and off backup cylinder
Bottom dead center?
N
Y
Set pressure of knockout cylinder to be equal to pressure of plastic worked load
Reduce pressure of main cylinder gradually
Knoking out completed?
N
Y
Operate main cylinder to upper limit and backup cylinder and knockout cylinder to lower limit
Return

INTERNATIONAL SEARCH REPORT

International Application No PCT/JP91/00958

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[5] B21J5/06, B30B1/32, B30B15/18

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	B21J5/00-5/02, 5/06, 5/10-5/12, 7/20-7/28, 7/34, 9/10-9/16, 9/20, B30B1/32-1/38, 15/16-15/24

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1926 - 1990
Kokai Jitsuyo Shinan Koho	1971 - 1990

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	JP, A, 60-191700 (Aida Engineering Co., Ltd.), September 30, 1985 (30. 09. 85), (Family: none)	1, 3
Y	JP, U, 62-113838 (Toyota Motor Corp.), July 20, 1987 (20. 07. 87), (Family: none)	1, 3
X,Y	JP, Y2, 57-29948 (Aida Engineering Co., Ltd.), June 30, 1982 (30. 06. 82), Line 30, column 3 to line 5, column 4 (Family: none)	2, 3

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
September 26, 1991 (26. 09. 91)	October 14, 1991 (14. 10. 91)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	