(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 893 171 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
27.01.1999 Bulletin 1999/04

(21) Application number: 98113902.5

(22) Date of filing: 24.07.1998

(51) Int. Cl.^{6}: **B21D 22/22**, G06F 17/50, B21D 24/00

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **24.07.1997 JP 198899/97**

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(54) Methods for constructing a die for press bending machine and determining cushion forces therefore

(57) A simulation method for realizing a very approximate contour of the press bent product to the actual contour is proposed on a mathematical model in which a distance between a pair of clamping parts is kept at a constant. Also, a method of determining the clamping pressure which keeps the distance at the constant is proposed. By these methods, a preparation period for mass production by press working is reduced.

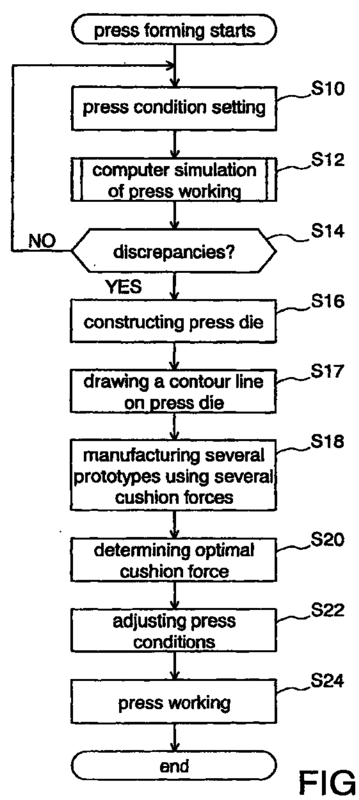

FIG. 1

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Description

Field of the Invention

The present invention relates to methods for preparing production activities in which a plate-like deformable material (blank) is bent into a desired shape by press working or stamping. In particular, the present invention relates to methods for designing a press die in a relatively short time and methods for optimizing press or stamping conditions in a relatively short time. This specification describes a series of processes, such as designing the press die, optimizing the press conditions, performing press working and actually pressing or stamping the blank into the desired shape.

Description of the Related Art

In known methods of press forming, a press die (usually a punch and a die) is first designed and manufactured and a plurality of prototypes are produced using a variety of press conditions. The press conditions are determined based upon factors that are known to influence the final shape of the pressed prototypes, such as the clamping pressure of the punch and die, the pressure (cushion pressure) applied to the outer periphery of the material to be pressed, the shape of the material before press working and the position of the material within the press die when the press working operation is initiated.

The press die can be modified or redesigned if defects, such as ruptures, wrinkles or a failure to meet a predetermined shape accuracy, are found on the pressed prototypes. In the process of modifying the press die, the shape of the punch and/or die typically is adjusted. For instance, the radius of a circular surface of the press die can be increased if ruptures are found in the pressed prototypes, and the shape of the press die can be modified if the shape of the pressed prototype fails to meet the predetermined shape accuracy.

Press conditions also can be adjusted in response to the results of the prototyping operation. For example, the clamping pressure (cushion pressure) exerted on the outer periphery of the material can be increased if wrinkles appear in the pressed prototypes. By repeating a circle of manufacturing prototypes, modifying the press die and adjusting the press conditions, it becomes possible to produce pressed prototypes having the predetermined or desired shape. Once satisfactory results have been obtained, production activities can be started.

However, known methods for designing a press die, in which the press die is modified and the press conditions are adjusted by repeating the above-described cycles, can take a considerable amount of time. As a result, the design process may require a considerable amount of time.

In order to minimize design time, techniques have been developed to design the press die and to optimize press conditions by simulating phenomena that arise during the press working operation. These techniques utilize computer simulations based upon finite element method in order to substantially reduce the number of prototypes that must be manufactured in order to determine appropriate press conditions.

In order to reduce the amount of calculations needed for such simulations, the press die is treated as a rigid body and the clamping pressure exerted on the outer periphery of the blank (deformable material) is assumed to be uniform along the entire length of the outer periphery of the material in the mathematical models for these simulations.

An example of such a mathematical model can be described with reference to FIG. 11. This computer calculation simulates the phenomena that arise when the outer periphery of a plate-like material 102 (blank) is clamped or pressed by die 100 and cushion ring 104 while an inner sphere of material 102 is press worked between die 100 and punch 106. In the mathematical model used in the simulation, deformation of material 102 is calculated using the assumption that die 100, punch 106 and cushion ring 104 are rigid bodies and that the clamping pressure applied to the outer periphery of material 102 between die 100 and cushion ring 104 is uniformly distributed along the entire length of the outer periphery of material 102. These assumptions are made in order to reduce the amount of calculations required for the simulation.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide simulation techniques that produces a model that closely approximates actual press working results.

Another object of the invention is to provide techniques that can determine optimum clamping pressures in a relatively short time based upon the results of the simulations taught herein.

Methods for designing a press bending die preferably comprise performing computer simulations to model the intended press bending operation and manufacturing several prototypes under several clamping conditions to identify the proper clamping pressure.

The simulation preferably is performed with the assumption that the distance between a pair of holddown parts, which parts exert clamping pressure on the periphery of the material during the press working operation, is fixed as a constant value. When the distance between the pair of clamping parts is kept constant, the contour of the bent material after the press working operation, as calculated by the computer simulation, closely approximates the contour of the bent material that is actually press worked. Using the present invention, the press die can be treated as the rigid body, and the deformation of the press die need not be calculated. A variety of studies have proved that simulations based upon these assumption are unexpectedly superior to simulations based up on the assumption that the clamping pressure is uniformly distributed along the overall length of the periphery of the material.

According to this simulation technique, the clamping pressure required to keep the distance of the clamping parts at the value used in the computer simulation process need not be calculated.

After the simulations, prototypes of the desired bent product may be manufactured using a variety of clamping pressures in order to determine the optimal clamping pressure for the press working operation. The contours of the prototypes thus manufactured are compared with contours calculated using the computer simulations and the optimal clamping pressure is then determined based upon this comparison.

According to the present teachings, highly accurate simulations can be obtained and optimal clamping pressures can be determined with smaller numbers of prototypes than using known design techniques.

Further objects and aspects of the invention will be understood more fully upon reviewing the following description of the preferred embodiments with reference to the drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a representative comprehensive procedure for designing a press forming die.

FIG. 2 shows a representative flow chart for simulating the design process.

FIG. 3 shows a initial state in which a blank is set in a press machine and prepared for the press working process.

FIG. 4 shows an intermediate state of the press working process.

FIG. 5 shows a completed state of the press working process.

FIG. 6 shows a comparison of the contour of a bent product obtained by simulation and a pressed prototype actually prepared by the die.

FIGS. 7(A) and 7(B) show states of increasing and decreasing resistance force at bead sections of the holddown parts.

FIGS. 8(A) and 8(B) show a technique for increasing the clamping pressure by adding an additional cushion layer 12C.

FIG. 9 shows a perspective view of a press die.

FIG. 10 shows a perspective view of a press die.

FIG. 11 shows a partially enlarged view of a known press machine.

FIG. 12 shows how material is expanded and compressed using a press working technique.

FIG. 13 shows a reason that known computer simulations do not correspond closely to actual press working.

PREFERRED EMBODIMENTS OF THE PRESENT INVENTION

Preferred embodiments of the present invention will be described with reference to the drawings. In the following description, a force exerted between a pair of holddown parts, namely a clamping pressure exerted on the outer periphery of the material, will be called a "cushion force". Also, the terms "press bending" and "press working" will be used to describe a metal stamping process. Finally, the terms "blank" and "plate-like deformable material" are used interchangeably in this specification.

The applicant has found that the known computer techniques based upon finite element method do not yield satisfactory results, because great differences between the simulation result and the actual result are sometimes found when the press die is treated as the rigid body and the clamping pressure exerted on the outer periphery of the material is assumed to be uniform. Due to these differences, the optimum clamping pressure for pressing the outer periphery of the material can not be adequately determined by such simulations.

When a flat plate-like deformable material or blank is bent along the central section of the blank (see FIGS. 3 to 5), the overall thickness of the blank tends to reduce, while the thickness of the blank clamped between die 100 and cushion ring 104 tends to thicken. This phenomenon is shown in FIG. 12, in which reference numeral 102a depicts the outer periphery of the blank prior to press working, and 102b designates the outer periphery of the blank after press working. Reference numeral 108 designates the inner periphery of the final product formed by press working.

When the blank is bent, material is pulled by the punch 106 and the thickness of the blank is reduced from 102a to 102b. As a result, the volume of the material that was distributed over length L2 prior to press working is collected or concentrated into a shorter length L4 after pass working. As a result, the thickness of the material in a location M2 in which the blank is bent tends to thicken. However, in a location M4 in which the blank is not bent, the thickness of the material is only slightly reduced.

If the thickness of the material clamped between die 100 and cushion ring 104 is thin in the location M4 and is thick in the location M2, the clamping pressure between die 100 and cushion ring 104 concentrates into the location in which the thickness of the material is thick. In spite of this fact, known computer simulation techniques are based on an assumption that the clamping pressure exerted on the outer periphery of the material is uniformly distributed along the overall length of the outer periphery of the material. Therefore, known simulation techniques using typical boundry conditions can not simulate the state of actual deformation accurately.

Microscopic studies further confirm that such simulation techniques do not accurately represent the press bending operation. For example, when some material is being concentrated by the press working operation (in FIG. 12, material extending over length L2 is concentrated into a shorter length L4), the flat material begins to corrugate as the bending proceeds. Then, as shown in FIG. 13, only a portion of material 102 comes in a partial contact with die 100 and cushion ring 104. The clamping pressure between die 100 and cushion ring 104 is thus concentrated on partial contact areas C1, C2. As a result, the clamping pressure varies from place to place in the actual press working operation.

While pressure distribution may be calculated by the computer, such calculation will not provide a good result as long as the press die is treated as a rigid body, because the press die is deformed in the actual press working due to the pressure concentration on the partial contact areas C1, C2.

Also, the deformation of the press die could be calculated in accordance with the clamping pressure distribution. However, this calculation requires a substantial number of calculations, and therefore is not practical using currently available simulation techniques.

Referring to FIG. 1, a procedure for designing a preferred press forming die is shown. According to this method, conditions to perform press working ("press conditions"), are first set up on a computer (Step S10) that is capable of performing finite element method calculations. The above-described press, (boundry) conditions may be input into the computer program, including such information as the shape of the press die (die and punch), the distance between a pair of holddown parts, the shape of the blank prior to press working, the physical properties of the blank and the position of the blank with respect to the press die. Some press machines include a bead section within the press die, and information about the shape of the bead is accordingly utilized in the computer simulation when such a press machine is used. Importantly though, the cushion force exerted on the blank by the pair of holddown parts, is not utilized as a boundry condition in the present simulation. Instead, the distance between the pair of holddown parts is utilized as a boundry condition. Using this model and this set of boundry conditions, phenomena that arise during press working are simulated on the computer based on the inputted press (boundry) conditions (Step S12).

Referring to FIG. 2, a procedure for simulating the press working operation is explained. Preferably, calculations for the computer simulation are performed by a dynamic dissolution method using a nonlinear analytic solver on the finite element method equation. Preferably, commercial available software named LS-DYNA™ from Livermore Software Technology Corporation in California, U.S.A. is utilized to perform the present simulations.

In the simulation procedure shown in FIG. 2, simulations of the drawing process are performed first (Step S30). This simulation process S30 covers the steps of setting material 14 in press machine 10 as shown in FIG. 3 , securing the outer periphery of material 14 between a pair of holddown parts 12a and 16a with die 12 moved downward-as shown in FIG. 4, and press working the material with die 12 moved further downward as shown in FIG. 5. A contour of press bent material 14 (a pressed product) is thus obtained as a result of the simulation. This simulation is performed using the assumption that die 12, cushion ring 16 and punch 18 are rigid bodies and therefore none of these elements deform during the press working operation.

As shown in FIGS. 3 to 5, each of holddown parts 12a, 16a comprise a portion of die 12 and cushion ring 16, respectively. In this simulation, a distance G between the pair of holddown parts 12a, 16a is fixed at a value in which preferably a predetermined distance α is added to the thickness t of material 14 . The predetermined distance α can be derived from the shape and mechanical properties of material 14. Under actual press working conditions, the distance α may vary in certain portions of material 14. However, the variations of the distance α are so small that good simulation results can be obtained by treating this distance as a constant along the entire length of the periphery of material 14. For this reason, a constant value is preferably utilized as the predetermined distance α for the entire periphery of material 14. In this representative embodiment, the distance α is set to be equal to 5% of the thickness t of material 14. Accordingly, the distance between the pair of holddown parts G is treated as constant (105% of the material thickness) over the entire periphery of material 14 in this simulation.

FIGS. 3 to 5 show a cross section of a preferred die and punch set. In an actual press die, holddown parts 12a, 16b completely encircle punch 18, such that holddown parts 12a, 16b clamp or hold the entire periphery of blank 14. Holddown part 12a is disposed at the bottom of die 12 and holddown part 16a is disposed at the top of cushion ring 16. Moreover, a convex bead shaped portion 12b is disposed within holddown part 12a and a concave bead shaped portion 16b is disposed within holddown part 16a. The bead section for the press bending machine preferably is composed of convex portion of bead 12b and concave portion of bead 16b and beads 12b and 16b cooperate to apply a resistance force to blank 14 when it is being drawn inwardly during the press working process. Moreover, the cushion force is applied to blank 14 through die 12 and cushion ring 16 by machine cushion 20. The amount of the material that is drawn inwardly may be controlled by the above-noted resistance force and cushion force.

Under actual press working conditions, the cushion force exerted on pair of holddown parts 12a and 16a by machine cushion 20 is fixed as a constant. Therefore, prior art simulations were typically performed with the premise that the cushion force is a constant. In this representative embodiment however, the above-described premise is not utilized and the simulations are based instead upon the assumption that the distance between the pair of holddown parts 12a and 16a is feed at the value of $t+\alpha$.

When the simulation for the drawing process is completed in Step S30, a stamping (trimming) simulation (Step S32) and a bending simulation (Step S34) are performed. In the stamping simulation, material 14 is stamped by a stamping press machine and the contour of the stamped material is calculated. In the bending simulation, material 14 is bent by a bending press machine and the contour of the bent material is calculated.

Finally, a removing simulation is performed as the final stage of the simulations (Step S36). In the actual press working operation, the material is removed from the drawing die, stamping die and bending die, respectively, after each step of drawing, stamping and bending. However, in the simulations of this representative embodiment, the material is removed from the die only after the bending process is completed. In the removing simulation, the contour of material 14 after removal from the die is calculated considering additional factors, such as elastic recovery in which the blank assumes a shape that is intermediate between the original shape and the shape immediately before removal from the die. Thus, contours that closely approximate the actual pressed product can be calculated using the present teachings.

After completing the simulations, Step S14 is performed as shown in FIG. 1. The contour of the material calculated by simulations in Step S12 is displayed on a computer screen (or printed out) and is examined for defects in the desired shape (Step S14). Potential defects include the contour not having a predetermined accuracy, ruptures, wrinkles and excessive concentration of stress in the material. These defects can be determined from the results of the computer simulation.

If defects are found (Step S14), Steps S10 and S12 are repeated using new boundry conditions until the defects are eliminated. In particular, the shapes of the die and punch or the shapes of bead sections may be changed. Thus, the above-described virtual simulations are iteratively performed to identify the shape of the press die and the press conditions that will theoretically prevent defects in the final bent product.

Once the simulations have been satisfactorily completed, a press die is manufactured based on the shape of the die and the punch thus calculated (Step S16). For example, die 12, cushion ring 16 and punch 18 are manufactured for press machine 10 shown in FIG. 3. Then, the press die (die 12, cushion ring 16 and punch 18) is mounted in the press machine, and prototypes are manufactured. A plurality of prototypes are manufactured using a variety of different cushion forces (Step S18). For example, in the case of press machine 10 shown in FIG. 3, the strength of the cushion force exerted on the outer periphery of material 14 can be altered by cushion machine 20.

As shown in FIG. 9, contour line 56 of unbent blank 14 may be drawn on the press die manufactured in Step S16 (Step S17). This contour line 56 is drawn in order to ensure that the operator places blank 14 onto holddown part 52a in the same exact location that was utilized in the computer simulations of Step S12. Contour line 56 may be drawn by etching die 52 or by marking with a pen by using a plotter, a robot arm or similar devices. Also, as shown in FIG. 10, contour line 58 of the simulated press product after bending may be marked on holddown part 52a in order to evaluate the results of the press bending prototyping operation. That is, the contour of the simulated product can be compared to the contour of the actual product to determine whether the cushion force is appropriate.

If contour line 56 of unbent blank 54 is directly drawn on the press die, blank 54 can be positioned in the press die more accurately. With the more accurate positioning of unbent blank 14, the difference in inflows of the materials for various clamping pressures can be more accurately determined. Therefore, the optimal clamping force for obtaining press bent product 54 that closely approximates the contour of the simulated press bent product can be quickıy determined.

A pressed prototype having a contour that closely approximates the simulated contour obtained in Step S12 can be determined by manufacturing a plurality of prototypes in Step S18 using a variety of cushion forces. The optimal cushion force can be selected by identifying the pressed prototype that most closely resembles the desired simulated product (Step S20).

In FIG. 6, the shape of the pressed product generated by the simulation (one dot chain line) and the shape of the pressed prototypes (solid line) actually pressed with a various cushion forces are compared.

Differences between the shapes indicate differences in inflows of the materials that are actually drawn by the press die from the inflows that are predicted by the simulation. Table 1 shows differences between the shapes of five prototypes and the shapes predicted by the simulation for five different cushion forces.

As indicated in FIG. 6, if the solid line (shape of a prototype) is inside the one dot chain line (simulated shape), the difference is shown as a negative value and if the solid line is outside the one dot chain line, the difference is shown as a positive value.

Table 1

cushion pressure [T/cm^2]	Difference (mm) between solid line and one dot chain line in FIG. 6					
	Pa	Pb	Pc	Pd	Pe	Pf
30	-4	-25	-10	-10	-10	-5
40	0	-15	0	0	0	-2
50	7	0	5	10	10	0
60	5	10	5	10	12	4
75	10	20	5	13	15	10

When the cushion force is 30[T/cm^2], the cushion force is too low and too much of the material is drawn inward by the bending action of punch 18 on blank (material) 14 as shown in FIG. 5. As a result, the shape of the pressed prototype is smaller than the simulated result. To the contrary, when the cushion force is 75[T/cm^2], the force is too high and only a limited amount of material is permitted to be drawn inward. Therefore, the shape of the pressed prototype is larger than the simulated result. According to the results shown in Table 1, the difference between the simulated contour and the prototype shape are the smallest when the cushion force is 40[T/cm^2]. The results in this table indicate that a prototype with the contour most approximate to the contour calculated by the simulation therefore can be produced using a cushion force of 40[T/cm^2], because when such a cushion force is used, the distance between pair of holddown parts 12a and 16a will be 105% of the material thickness during the press working operation.

As briefly discussed above, if line 56 of the simulated contour is drawn directly on the press die in Step S17, the difference in shapes of the pressed products can be easily and quickly determined. Thus, the result of the actual press working can be accurately and quickly compared with the simulation result. Therefore, it is possible to determine the clamping force for obtaining an actual contour of the press worked material that is most approximate to the contour of press worked material 54 obtained by simulation.

In the final steps for constructing the press bending machine, the press die or the press conditions may be modified by reviewing the pressed product which is press bent with the cushion force determined in Step S20 (Step S22). For example, the resistance force by the bead section can be decreased if any breakage is found in the bent product by decreasing the radius R1 of the convex bead 12b in FIG. 7(A) to the radius R2 (R2<R1) as shown in FIG. 7(B). Moreover, the height of the convex portion of bead 12b can be lowered such that it is not semi-spherically shaped. Further, the resistance force by the bead section can be increased, if wrinkles are found, by widening radius R1 of the convex section of bead 12b in FIG. 7(A).

Moreover, in many prototypes, portions of the bent product may not have scratches on the surfaces. Scratches arise when material 14 contacts holddown parts 12a and 16a. Portions of the bent product having no scratches indicate that no cushion force has been exerted on those portions and is shown as a gap between die 12 and blank 14 in FIG. 8(A). In this case, an additional cushion layer 12c can be added, by welding for example, to bring blank 14 into contact with die 12a, as shown in the FIG. 8(B). As a result, a uniform cushion force can be exerted over the entire outer periphery of material 14 and thereby prevent the concentration of stress in the bent product. After such modifications have been made, preparation processes for production activities are completed and press working for mass production can begin, as shown in Step S24.

In this embodiment, the simulation of Step S12 is performed using the condition that the distance between the pair of holddown parts is fixed as a constant value, so that the phenomena approximate to those in the actual press working operation can be simulated in spite of the assumption that the press dies are rigid bodies. Therefore, the press die manufactured in the Step S16 and the press conditions determined in Step S20 are very close to the optimum from the beginning and Step S22 can be completed in a relatively short time.

Specifically, in this embodiment, the above Step S12 (simulation process) utilizes the condition that the distance between the pair of holddown parts is fixed as the constant, instead of the known prerequisite that the cushion force is fixed as the constant. Therefore, the contour of the pressed material that is more closely approximate to those of the actual pressed material can be calculated by simulations. Accordingly, it has become possible to manufacture the press die after the shape of the press die for producing the pressed material with the desired shape becomes clear.

In this embodiment, the optimum cushion force to be exerted on the outer periphery of the material is not determined from the simulation in Step S12. Rather, in this embodiment, the optimum force can be selected in a relatively short time from the sequence of the processes that the press die is manufactured based on the shape of the press die calculated in Step S12 (die manufacturing process of Step S16), prototypes are manufactured using the press die so manufactured with cushion force of varying strength (prototype manufacturing process of Step S18), then, the optimum cushion force is determined by comparing the contours of the prototypes with that of the simulation (clamping pressure determining process of Step S20). In this sequence of processes, it is possible to determine the press conditions that produce the pressed product approximate to the pressed product calculated in the simulation process in a relatively short time.

Those skilled in the art will recognize that various features of the above-described method for press forming, such as structures, shapes, sizes, qualities of materials, placements and operation conditions, are not restricted in the present teachings. For example, the following representative embodiments may be implemented:

(1) In Step S20, the cushion force can be determined to be the one with the smallest difference in inflows among the materials that are actually pressed a plurality of times. Mathematical methods may also be used instead of the above-described method to determine the cushion force most approximate to the result of simulations. Specifically, cushion forces on each position where the inflows are compared are set as standards. A cushion force most approximate to the straight line by the least scare method, for example, is then calculated by a multiple regression analysis, for example. The outcomes of the press molding may be more closely approximated in the simulations by performing the press molding in Step S24 with the cushion force thus calculated.
(2) The material may be molded a plurality of times (five times in the example shown in the table 1) in Step S18. In Step S20, the outcomes of the molding (contours of the material and the amounts of inflows) is then input into a data base. In subsequent designs, the actual moldings of the material may be reduced, because the cushion force is determined using the data in the data base so as to supplement the actual molding data. As a result, it is possible to minimize the number of moldings necessary to complete the design, so that the lead time to prepare for manufacturing can be further shortened.
(3) The relation of the predetermined distance α utilized as the molding condition in Step S10 and the cushion force determined in Step S20 is input into the data base. In addition, information such as shapes of the die, shapes of the bead section, distance between the holddown parts, shapes of the material, and placement of the material can be input into the data base and associated with the predetermined distance α if appropriate. Thus, the accumulated data base can be utilized to determine the cushion force corresponding to the predetermined distance α.

Claims

1. A method for constructing a press bending machine for bending a plate-like deformable material, comprising the steps of:

calculating using a finite element method a contour of a bent material after press working by simulating phenomena that arise when an inner periphery of said material is press worked between a pair of press dies while an outer periphery of said material is clamped between a pair of holddown parts, under a condition that a distance between said pair of holddown parts is fixed as a constant;
constructing a press die in accordance with the result of said calculation.

2. A method as in claim 1 further comprising the steps of:

manufacturing a plurality of prototypes by using said press die, and altering clamping pressure being exerted on said outer periphery of the material of each prototype; and
determining the clamping pressure that produces a contour that is most approximate to said calculated contour by comparing said calculated contour with those of the plurality of prototypes.

3. A method according to claim 2, wherein the constant is a thickness of the material added to a predetermined thickness.

4. A method according to claim 2 wherein a contour line is drawn on one press die and/or prototypes along the contour obtained by the calculation step.

5. A method according to claim 2 wherein a contour line of the material before press bending is drawn on one press die.

6. A method of determining clamping pressure to be exerted on a pair of holddown parts, comprising the steps of:

calculating a contour of a bent material after press working by simulating phenomena that arise when an inner periphery of said material is press worked between a pair of press dies while an outer periphery of said material is clamped between the pair of holddown parts under a condition that a distance between the pair of holddown parts is fixed as a constant;
constructing a press bending machine based on the result of said calculation step;
manufacturing a plurality of prototypes by using said press bending machine and altering clamping pressure exerted on said outer periphery of the material of each prototype; and
determining the clamping pressure that produces a contour that is most approximate to said calculated contour by comparing said calculated contour with those of the plurality of prototypes.

7. A method according to claim 6 wherein a contour line is drawn on one press die and/or prototypes along the contour obtained by the calculation step.

8. A method according to claim 6 wherein a contour line of the material before press working is drawn on one press die.

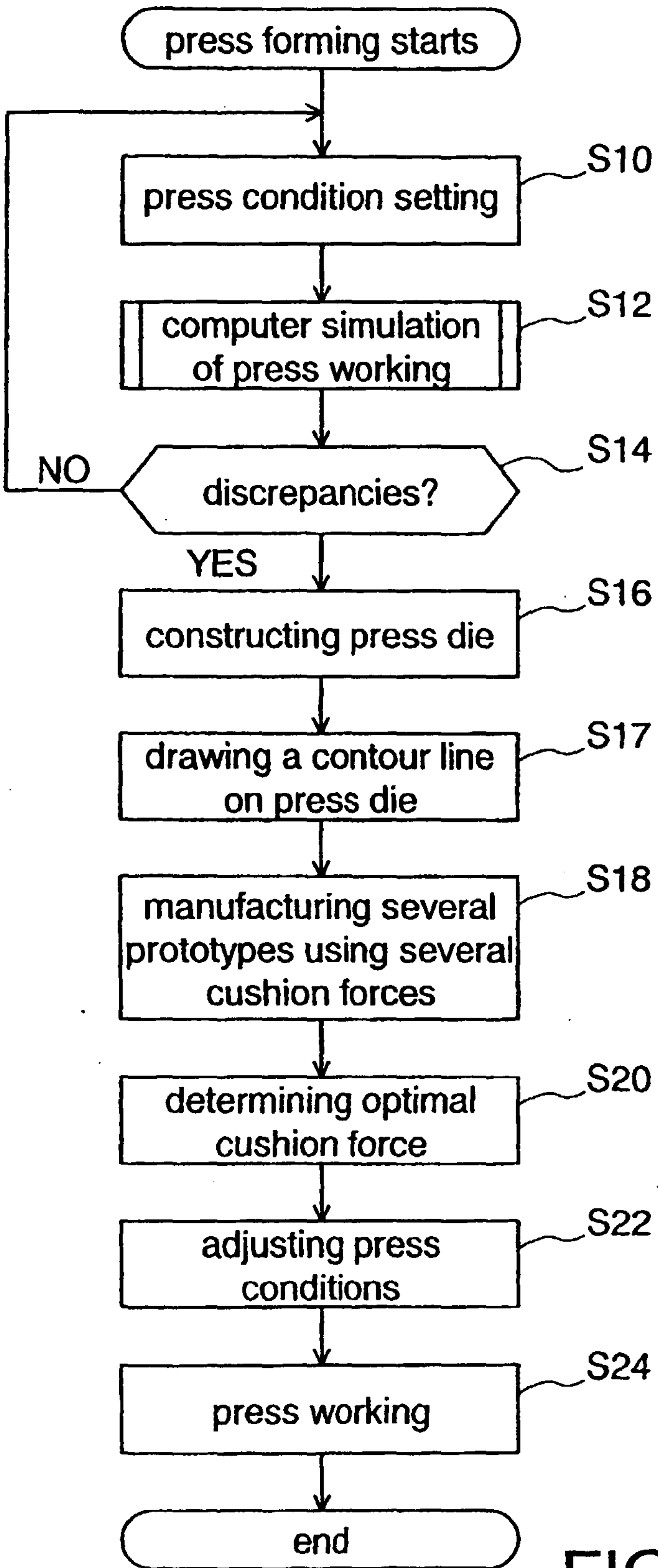
press forming starts
press condition setting
S10
computer simulation of press working
S12
discrepancies?
S14
NO
YES
constructing press die
S16
drawing a contour line on press die
S17
manufacturing several prototypes using several cushion forces
S18
determining optimal cushion force
S20
adjusting press conditions
S22
press working
S24
end

FIG. 1

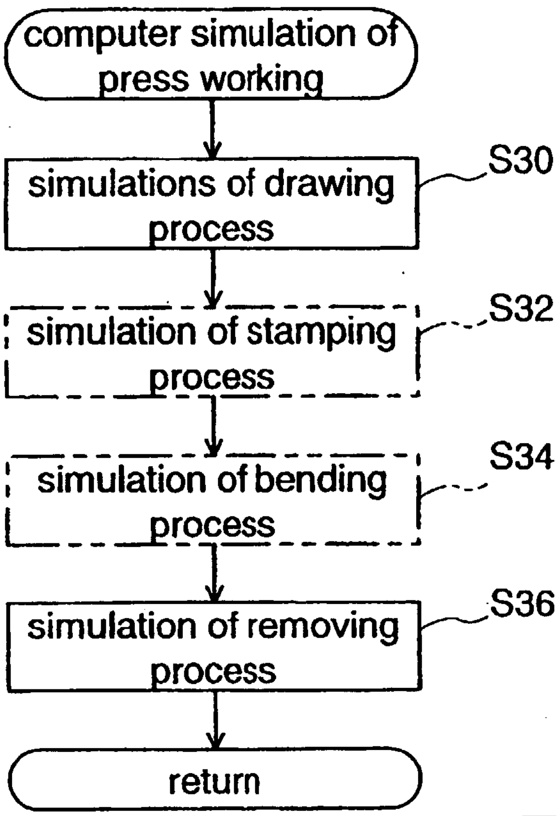
computer simulation of press working
simulations of drawing process
S30
simulation of stamping process
S32
simulation of bending process
S34
simulation of removing process
S36
return

FIG. 2

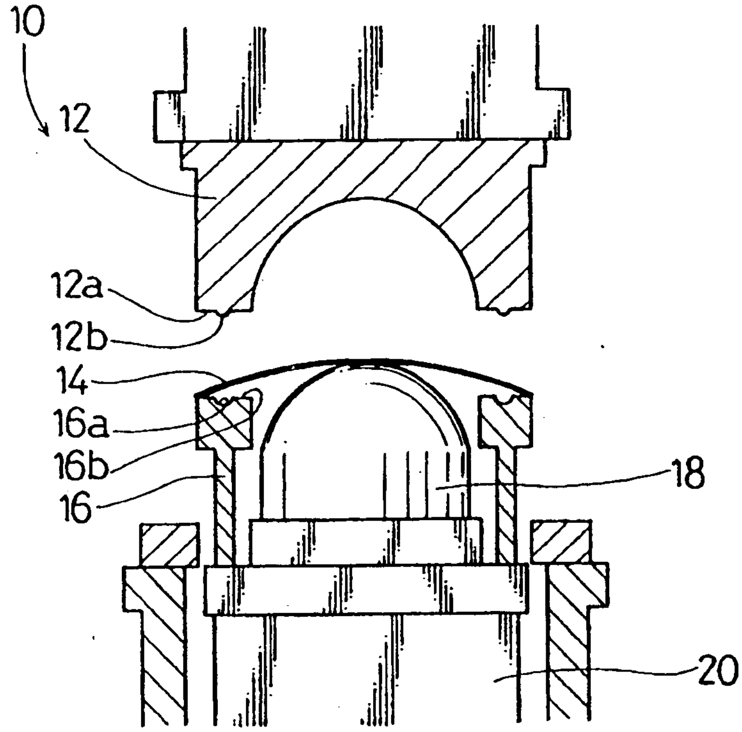

FIG.3

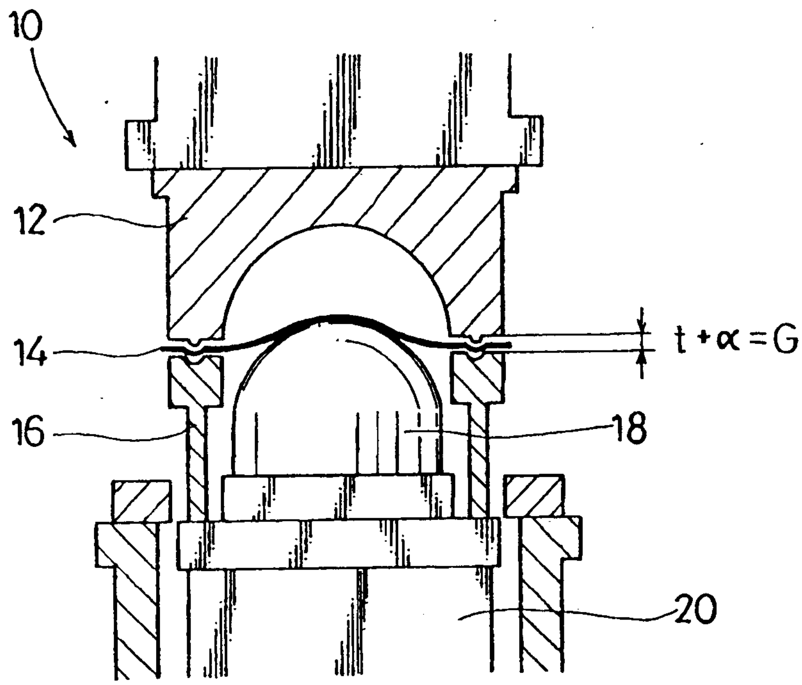

FIG.4

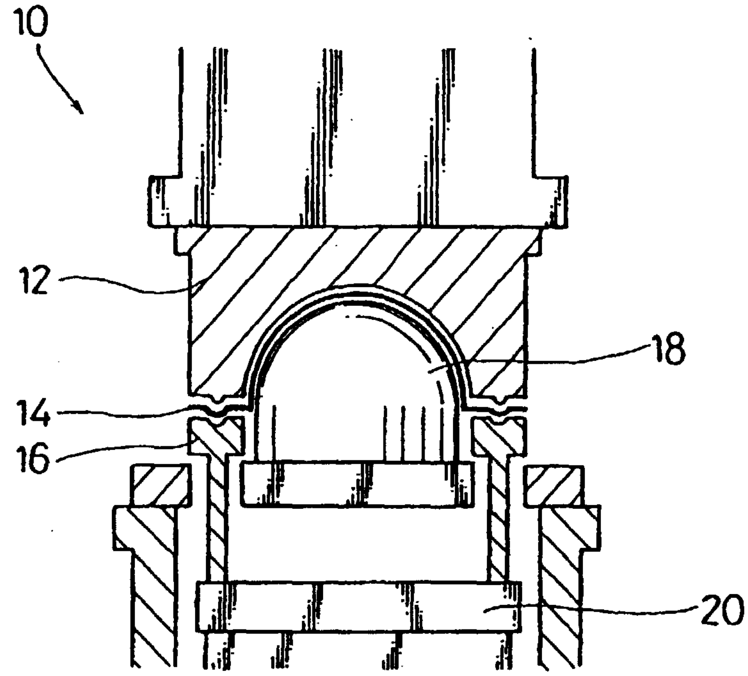

FIG.5

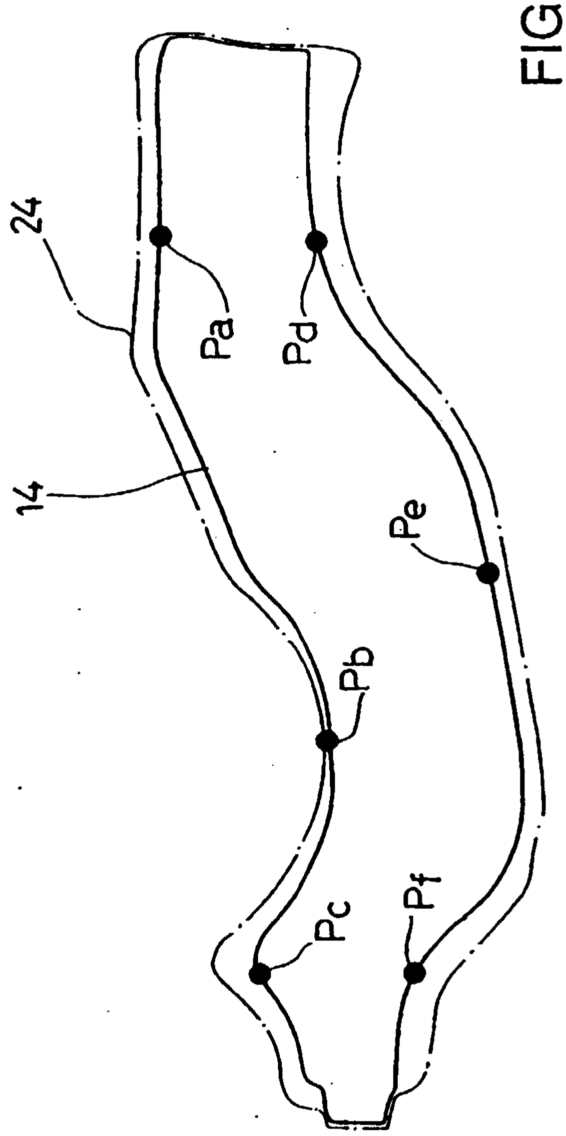

FIG.6

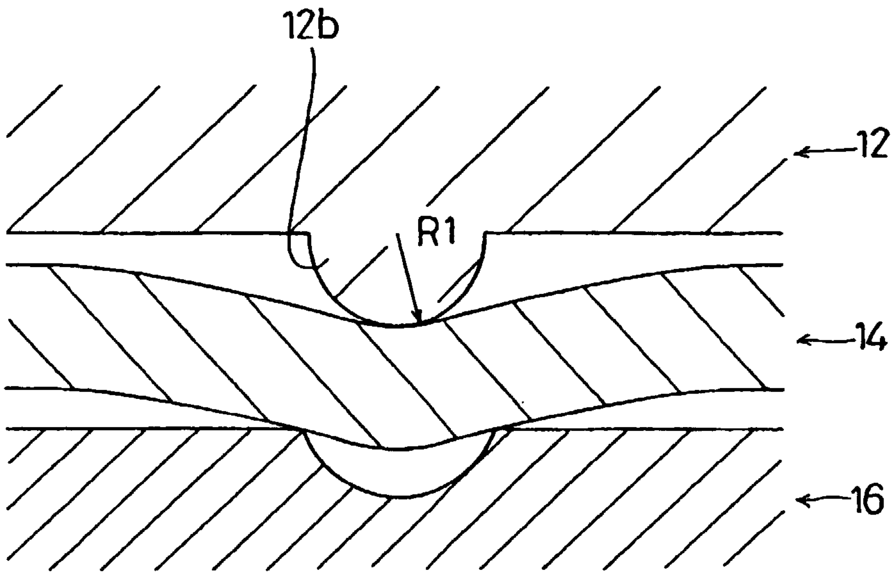

FIG.7 (A)

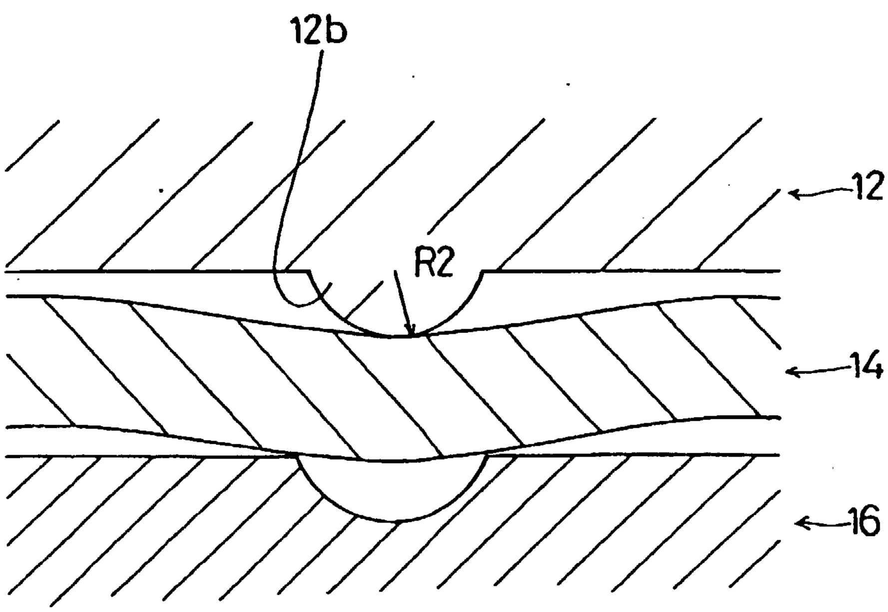

FIG.7 (B)

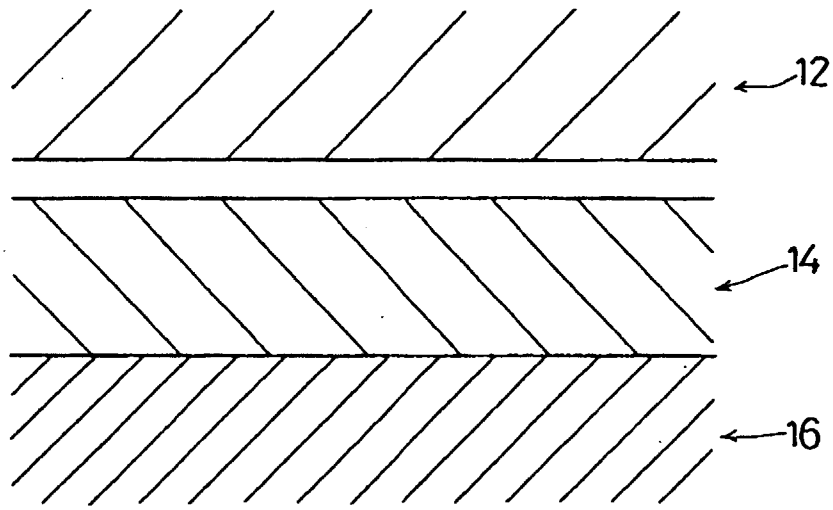

FIG.8 (A)

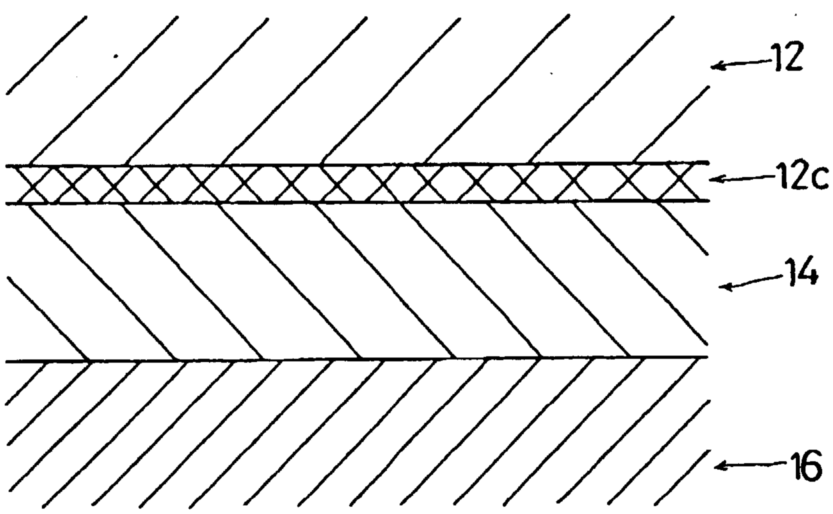

FIG.8 (B)

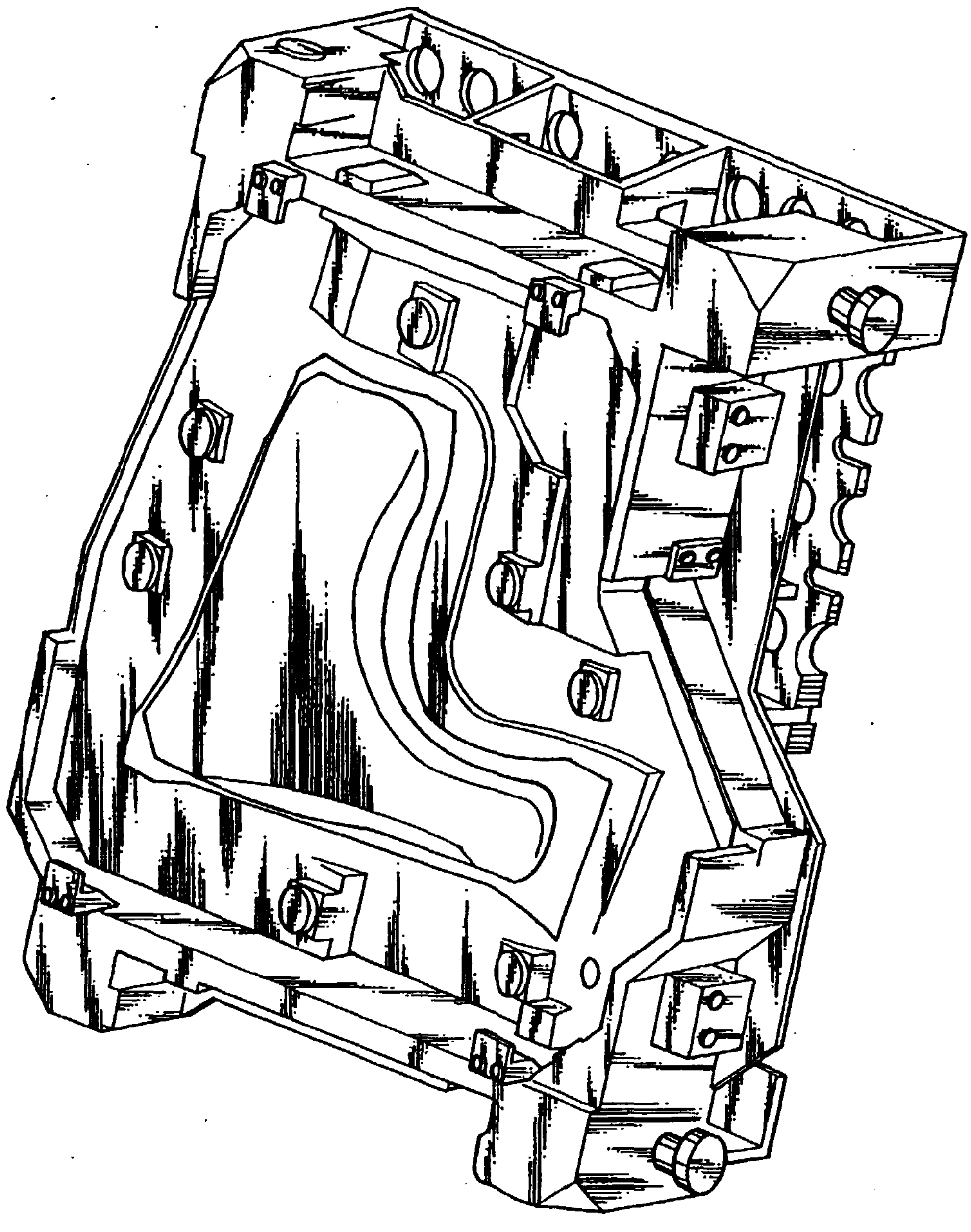

FIG.9

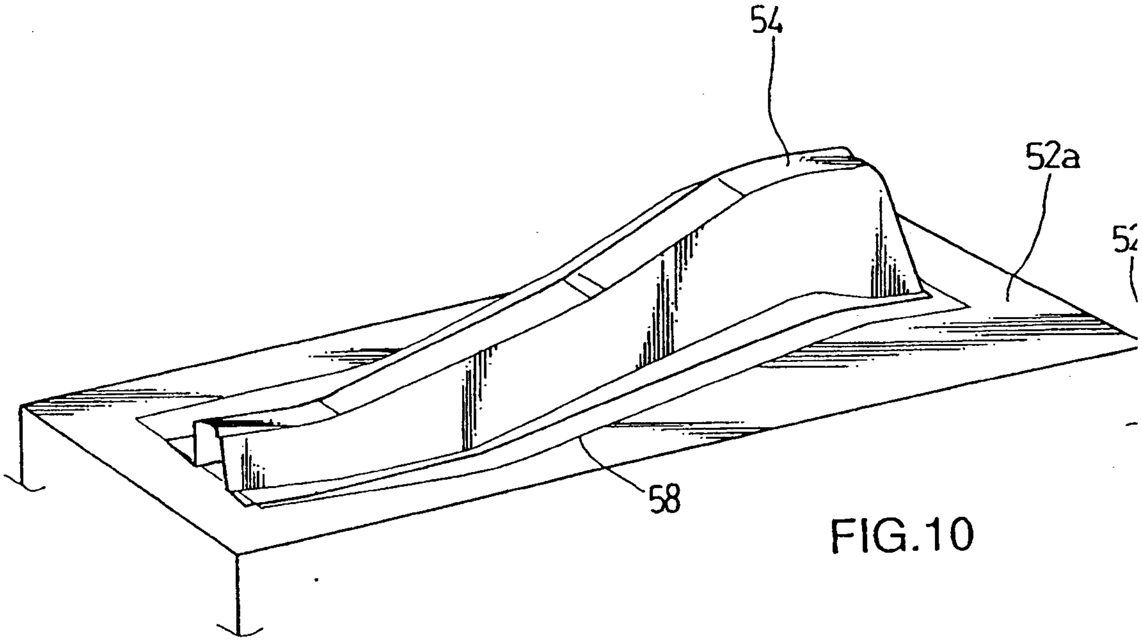

FIG.10

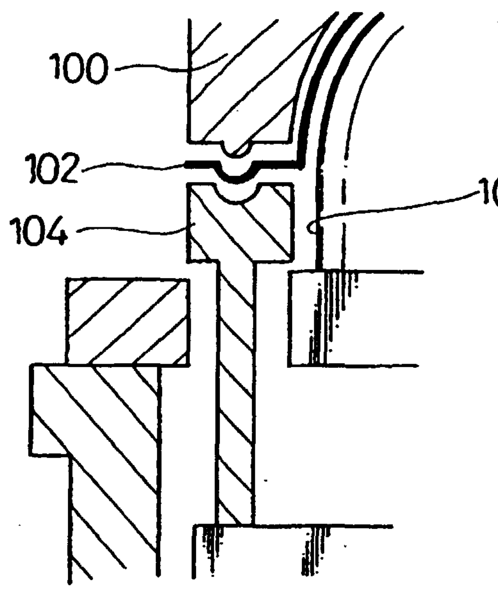

FIG.11

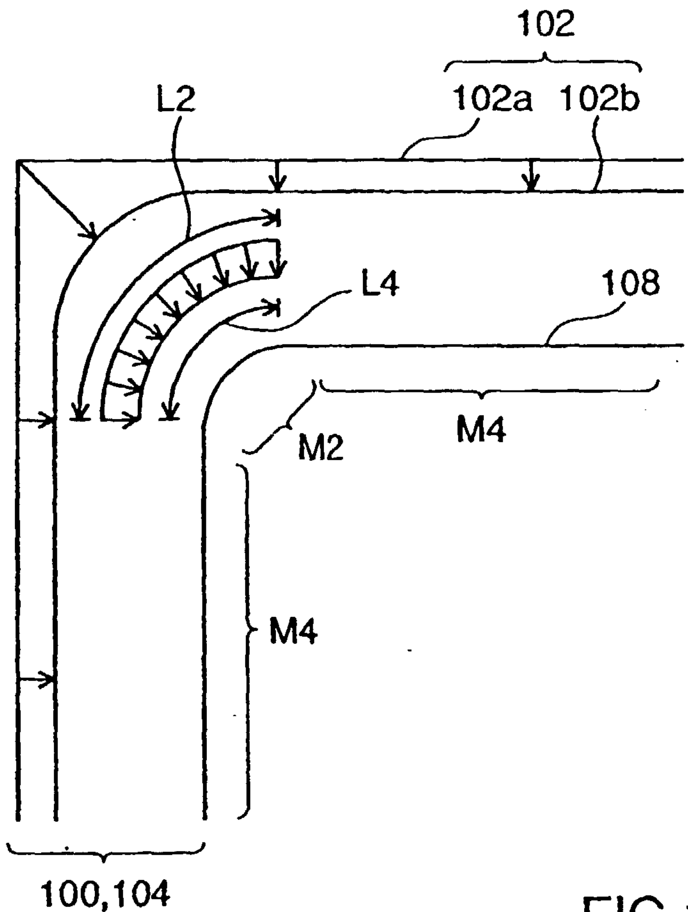

FIG.12

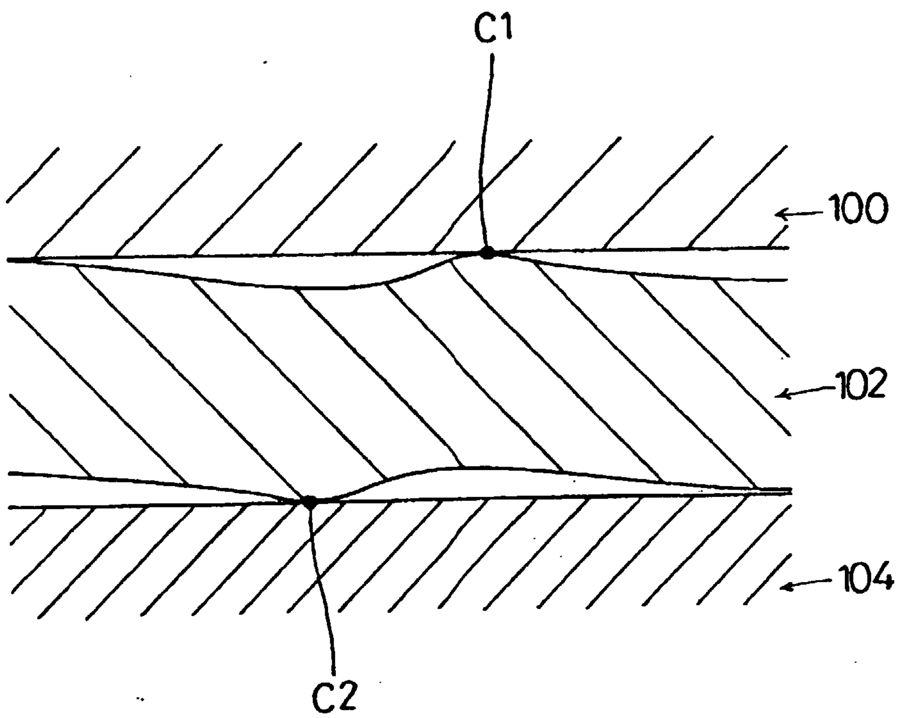

FIG.13

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 11 3902

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)
A	US 5 379 227 A (FORD MOTOR COMPANY) 3 January 1995 * claim 1 * ---	1	B21D22/22 G06F17/50 B21D24/00
A	US 5 463 558 A (FORD MOTOR COMPANY) 31 October 1995 * claim 1 * ---	1	
A	EP 0 773 075 A (TOYOTA JIDOSHA KABUSHIKI) 14 May 1997 * claim 1 * -----	6	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B30B G05B G06F B21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	5 November 1998	Vinci, V

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