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I-10121 Torino (IT)(54) **Process and hydraulic press for the pressing of sheets.**

(57) Process for the pressing of metal sheets which provides for the use of a hydraulic press whose blank holder is controlled so as to exert on the sheet in the pressing phase a restraining pressure which is alternately variable, with a pre-determined frequency, between zero and a pre-determined maximum, the value of the maximum pressure and the frequency depending on the properties of the sheet to be pressed.

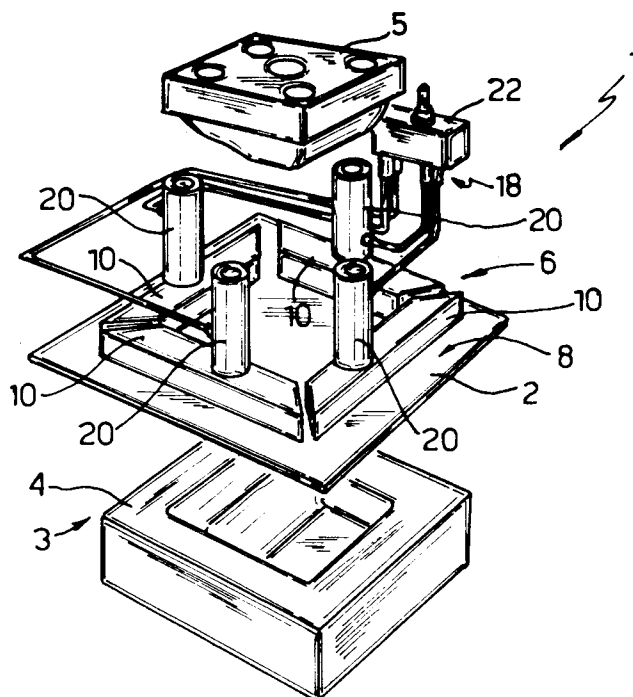


Fig. 1

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The invention concerns a process for the pressing of metal sheets, particularly the deep drawing (drawing) of motor vehicle body components.

The invention also concerns a hydraulic press capable of implementing the above-mentioned pressing process.

5 In known pressing processes a sheet is installed between a matrix and a punch of the die, clamped with pre-determined force by a blank holder which has the task of restraining the sheet against the matrix in the course of the plastic deformation operation. The value of the clamping pressure exerted by the blank holder against the sheet in the pressing phase is fixed and is determined by trials working initially on a batch of test sheets, to be then kept constant for the entire production phase.

10 This method of working at "constant pressure" has a number of disadvantages particularly in the case of dies of complex shape and for deep drawing, which generally result in a relatively high percentage of rejects due to the formation of flaws on the sheet or the rupture of the sheet itself.

To overcome these disadvantages Italian patent application No. 67049-A/90 by this Applicant proposes using a hydraulic press in which the blank holder is actuated with a clamping pressure that is pulsating or alternately variable with a pre-determined law between a minimum value and a maximum value. However, 15 not even this system has proved to be totally effective in reducing rejects in the pressing of certain particularly complex components or pressing sheets which are made of aluminium or have properties that are different from those of steel sheet. Consequently some steel sheet body components have to be produced with special, very expensive so-called "back-hardening" sheets with a high work-hardening capability; and, however, it is not yet possible to produce vehicles with bodies entirely of aluminium on an industrial scale at acceptable cost unless they are restricted to body shapes that are extremely simple and unacceptable from the style point of view. 20

The object of the invention is to provide an improved process of the pulsating pressure type disclosed above which enables the disadvantages of the latter to be overcome in a simple and economic manner thus 25 enabling sheets, including aluminium sheets, to be processed in complex shapes at low cost.

The basis of the invention is therefore provided by a process for the pressing of metal sheets comprising the phases of : arranging a sheet between a matrix and a punch of a die which are shaped in the shape of a component to be obtained; and deforming the sheet by means of the said matrix and punch, restraining the sheet between these latter exerting on the sheet, by means of a blank holder, a pulsating 30 pressure alternately variable between a minimum value and a maximum value; characterized in that a minimum restraining pressure equal to zero is exerted on the sheet; the said pulsating pressure having a predetermined frequency which is selected according to the mechanical properties of the sheet to be pressed. The choice of cancelling the restraining pressure altogether or, substantially, leaving the sheet completely free in the processing phase at the point at which the lower pressure oscillation value is reached 35 has been found to be surprisingly effective for the purpose of improving the results obtainable with the known process, particularly if associated with a pressure oscillation law substantially of the "stepwise" type (with substantially instantaneous passage from the zero value to the maximum one) and selecting the oscillation frequency according to the mechanical properties of the sheet.

In particular, the pulsating pressure variation frequency is between zero and 20 Hz inclusive and is 40 selected at a value that is higher, the lower the hardness of the sheet used. In this way even aluminium sheets become easy to process.

Furthermore, particularly when pressing sheets which require the higher frequencies, such as aluminium sheets, the frequency of the said pulsating pressure is made to vary in the course of the pressing operation, particularly in the course of the active stroke of the punch and in any event so as to obtain at least one 45 pressure variation cycle from zero to the maximum value for every 8-10 mm of depth of drawing of the sheet. In this way the rejects are reduced, substantially to zero, even where very complex pressings are involved.

The process according to the invention can be implemented on a hydraulic press for the pressing of sheets, of the type comprising at least one blank holder controlled by actuators via a hydraulic control 50 circuit comprising valve means for alternately pressurizing/depressurizing the blank holder actuators, characterized in that the said valve means are capable of causing the pressure exerted on the sheet by the blank holder to vary between a pre-determined maximum value and a minimum value equal to zero; the said valve means comprising timing means for selectively varying the alternate pressurizing/depressurizing frequency of the said actuators on a continuous basis.

55 Further features and advantages of the process and the press according to the invention will emerge from the detailed description which follows, supplied purely by way of a non-exhaustive example, with reference to the accompanying drawing, in which :

- Fig. 1 is a schematic perspective view of a press according to the invention; and

- Fig. 2 shows a block diagram of a control circuit for the blank holder of the press in Fig. 1.

With reference to Figs. 1 and 2, in the assembly 1 represents a hydraulic press for the pressing of metal sheets 2, made of steel or aluminium or light alloy, for example, particularly to obtain body components of a vehicle which are known and not shown for reasons of simplicity; press 1 comprises a die 3 formed by least one matrix 4 and at least one punch 5 having a profile that is conjugate and shaped like the body component to be obtained, and a blank holder 6 capable of acting on the sheet 2 in correspondence with a perimetric portion 8 thereof.

According to one of the main features of the invention, the blank holder 6, rather than being made of a single piece, consists of a multiplicity of restraining elements 10, four in number for example, one for each side of the sheet 8, which can be controlled independently of each other. In fact, press 1 comprises a hydraulic circuit 18 to control actuators 20 associated with the blank holder 6, particularly associated, singly or in pairs (or three or more according to need) with each restraining element 10. With reference to Fig. 2 also, the circuit 18 comprises in its turn a valve assembly 22 controlled by an electronic microprocessor unit 23 and capable of controlling the inflow and outflow of control fluid to each actuator 20 associated with each element 10, independently for each said element 10.

In particular, the valve assembly 22 is of the same type as vehicle anti-lock brake systems (ABS) and so is not described for reasons of simplicity. Substantially, it is capable of selectively intercepting the flow supplied by a pump 24 towards each actuator 20 for very short periods of time and, possibly, of connecting the actuator to an outlet 25, so as to generate in the actuators 20 a control pressure variable with a periodic law or with a substantially stepwise profile between zero (corresponding to the point at which assembly 22 completely intercepts the said flow and then prevents it from reaching the actuator 20 and, if necessary, connects the actuator 20 to the outlet 25) and a pre-determined maximum value dependent on the characteristic of the pump 24 and, for example, adjustable via the assembly 22 by drawing under the control of the unit 23 (corresponding to the point at which the assembly 22 connects, directly or with drawing towards a pressure control valve which forms part of that assembly, the actuator 20 with the pump 24).

According to a further feature of the invention the unit 23 is capable of controlling the assembly 22 (for example comprising a set of "on-off" type solenoid valves) so as to be able to vary on a continuous basis the periodicity, i.e. the frequency, of the periodic pressure variation law in the actuators 20, for example between a minimum frequency equal to zero (the pressure does not vary and remains constant) and a maximum frequency equal to approximately 20 Hz. Consequently, each element 10 is capable of applying to the sheet 2 a restraining pressure variable between zero (corresponding to the point at which the actuator/the actuators controlling this element 10 are at zero pressure) and a maximum pressure that is adjustable at will, with a frequency which can also be varied as desired between 0 and 20 Hz.

Finally the control circuit 18 is completed by a hydraulic accumulator 26 for supplying the assembly 22 at constant pressure, a filter 27 and a valve assembly 28 which controls an actuator 29 (not shown in Fig. 1) for raising the blank holder 6, and also exhaust valves 30 of actuators 20.

Working with the press 1 described it is possible to implement a process of pressing the sheets 2 in which a sheet is drawn between the matrix 4 and the punch 5 in the shape of the component to be obtained, for example, a body component of a motor vehicle, restraining the sheet by means of the blank holder 6 exerting on it a pulsating pressure variable alternately between a minimum value equal to zero and a maximum value which can be pre-determined at will. Following experimental trials conducted by the applicant it has also been found that the pulsating pressure must have a frequency selected according to the mechanical properties of the sheet to be pressed, particularly between zero and 20 Hz inclusive (the installation must be capable of achieving the zero value also, but the minimum operating frequency must be not less than 3 Hz) and of a value that is higher, the lower the hardness/strength of the sheet 2 being processed. For example, if sheet 2 is steel, FePO4 for example (designation according to UNI 5866/77 and EURONORM 130/77) between 0.8 and 1 mm thick the frequency must be relatively low, between 8 and 10 Hz inclusive for example; in contrast, for aluminium sheets 0.7-1 mm thick it is necessary to use higher frequencies, between 14 and 18 Hz inclusive.

In the case of aluminium sheets for deep drawing, however, trials have shown that there continued to be a relatively high percentage of rejects (1 in 5) : this latter problem has been surprisingly resolved according to the invention by causing the frequency of the pulsating pressure to vary in the course of the pressing operation, an operation which the microprocessor 23 can easily be asked to perform by appropriate programming thereof; in practice the restraining pressure on the sheet 2 exerted by the blank holder 6 (or by any component 10 of it) is caused to vary with frequency so as to achieve, in the course of the active stroke of the punch 5 (or in the course of that part of the stroke of the punch 5 in which the sheet 2 is

actually in the course of plastic deformation) at least one complete cycle of pressure variation, from zero to the maximum value, for every 8-10 mm of depth of drawing which the sheet 2 undergoes.

Working with the parameters described, a percentage rejects figure practically in the vicinity of zero has been obtained, for both steel and aluminium components. For example, it has been possible to produce the rear door of the "FIAT UNO" vehicle from FePO4 with substantially no rejects whilst at the present time this component is made of a material that is much more expensive and valuable. Similarly, deep-drawn components (depth of drawing of the order of 200 mm) have been produced from sheet aluminium with substantially no rejects by causing the pressure pulsation frequency to vary between zero and the maximum value, between 18 Hz initially and 14 Hz finally. These trials were carried out using a press provided with a blank holder having the following properties :

- Working force :	1000 KN
- Maximum working force :	2000 KN
- Working speed :	25-50 mm/sec
- Ascent speed :	100 mm/sec
- Pressure pulsation frequency :	0-20 Hz
- Pressure pulsation amplitude :	0-1,000 KN
- Stroke	180 mm
- Working pressure :	160 bars
- Maximum pressure :	320 bars

Claims

1. Process for the pressing of metal sheets comprising the phases of : arranging a sheet between a matrix and a punch of a die which are shaped in the shape of a component to be obtained; and deforming the sheet by means of the said matrix and punch, restraining the sheet between these latter exerting on the sheet, by means of a blank holder, a pulsating pressure alternately variable between a minimum value and a maximum value; characterized in that a minimum restraining pressure equal to zero is exerted on the sheet; the said pulsating pressure having a pre-determined frequency which is selected according to the mechanical properties of the sheet to be pressed.
2. Process according to Claim 1, characterized in that the frequency of the said pulsating pressure is between zero and 20 Hz inclusive and is selected at a value that is higher, the lower the hardness of the sheet used.
3. Process according to Claim 1 or 2, characterized in that the frequency of the said pulsating pressure is caused to vary in the course of the pressing operation.
4. Process according to one of the preceding Claims, characterized in that a blank holder is used, subdivided into a multiplicity of restraining elements which are independent of each other, by means of each of which a pulsating pressure variable with a different law from component to component, between zero and a maximum value, which may differ from component to component, is exerted on the sheet in the pressing phase.
5. Process according to one of the preceding Claims, characterized in that the sheet restraining pressure exerted by the blank holder is caused to vary with frequency so as to achieve, in the course of the active stroke of the punch, at least one pressure variation cycle from zero to the maximum value for every 8-10 mm of depth of drawing of the sheet.
6. Hydraulic press for the pressing of sheets, of the type comprising at least one blank holder controlled by actuators via a hydraulic control circuit comprising valve means for alternately pressurizing/depressurizing the actuators of the blank holder, characterized in that the said valve means are capable of causing the pressure exerted by the blank holder on the sheet to vary between a pre-determined maximum value and a minimum value equal to zero; the said valve means comprising timing means for selectively varying on a continuous basis the alternate pressurizing/depressurizing frequency of the said actuators.

7. Press according to Claim 6, characterized in that the blank holder is sub-divided into a multiplicity of restraining elements independent of each other, each provided with at least one independent actuator of its own controlled by the said valve means in order to be able to be pressurized/ depressurized with a law different from that of the other actuators.

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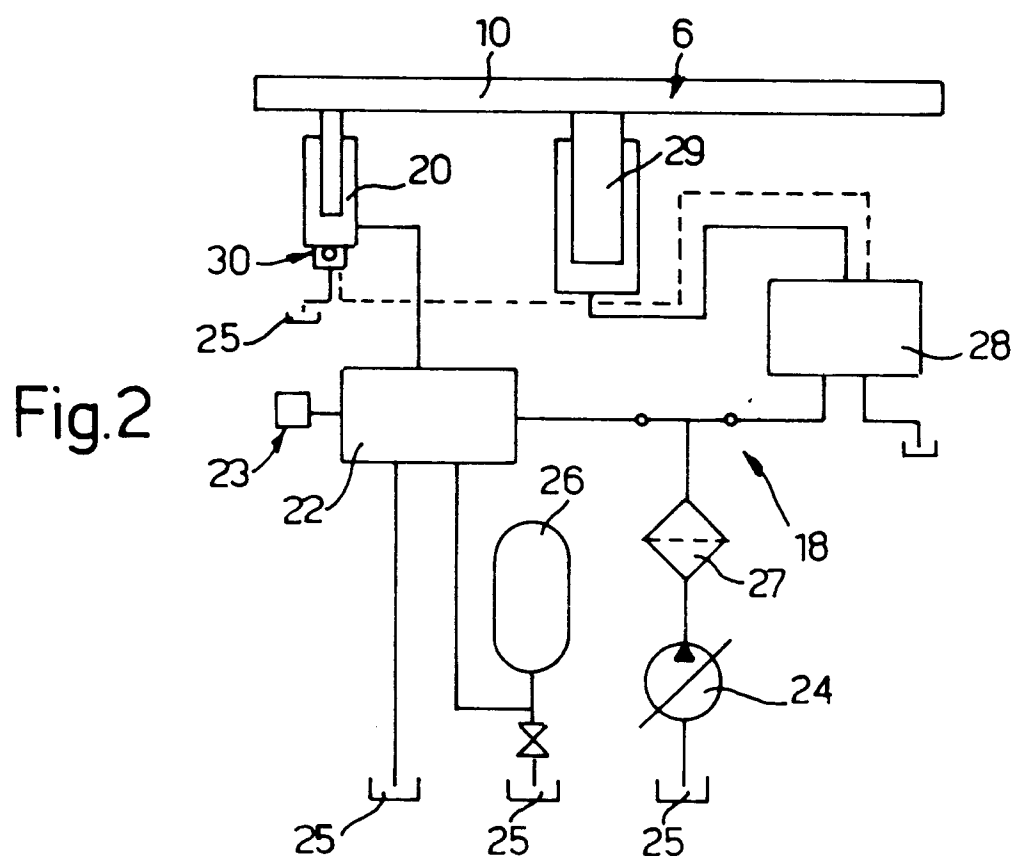
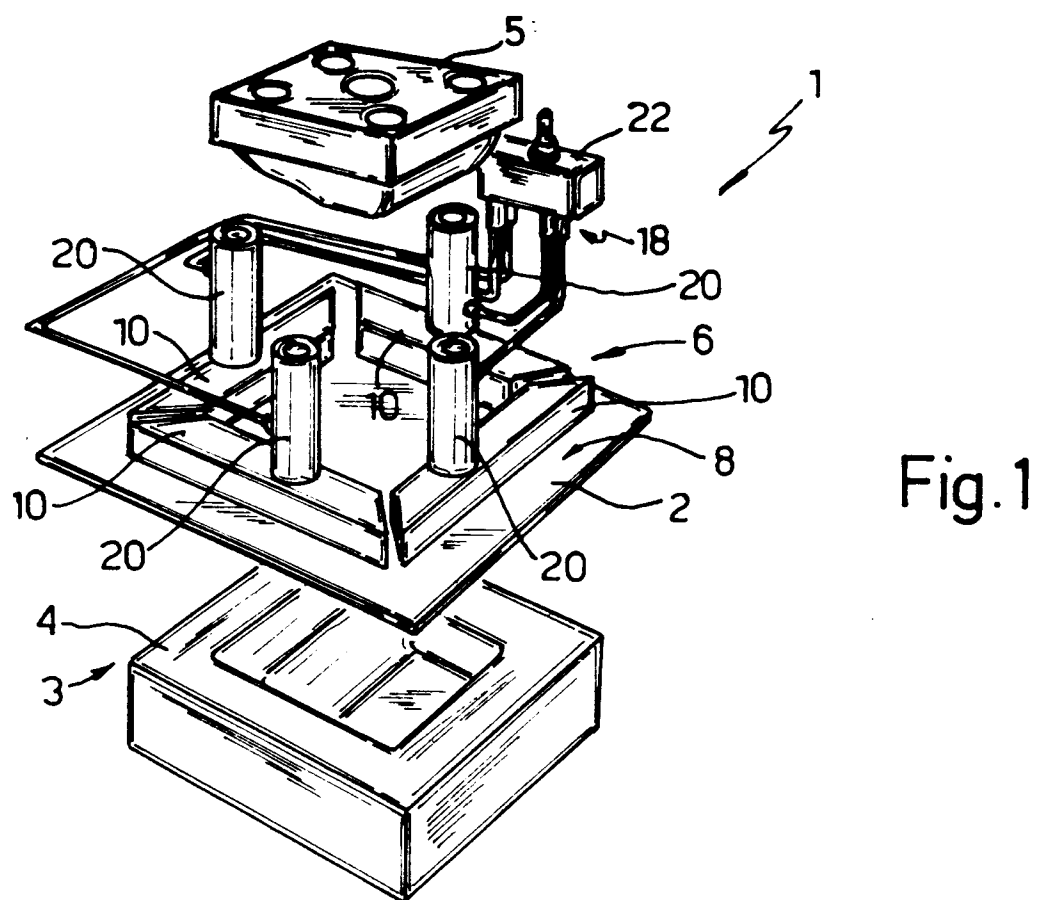
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EUROPEAN SEARCH REPORT

Application Number
EP 94 10 3041

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.5)
D,Y	EP-A-0 438 774 (FIAT AUTO SPA) * the whole document * ---	1,2,4-7	B21D24/14
Y	GB-A-1 481 202 (METAL BOX LTD) * page 4, line 51 - line 81; figures 1-8 * ---	1,2,5,6	
Y	US-A-4 745 792 (STORY) * column 3, line 49 - column 4, line 40; figures 1,2 * ---	4,7	
A	DE-A-40 38 866 (HIPP THOMAS) * the whole document * -----	1,6	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			B21D
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 26 May 1994	Examiner Gerard, O
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