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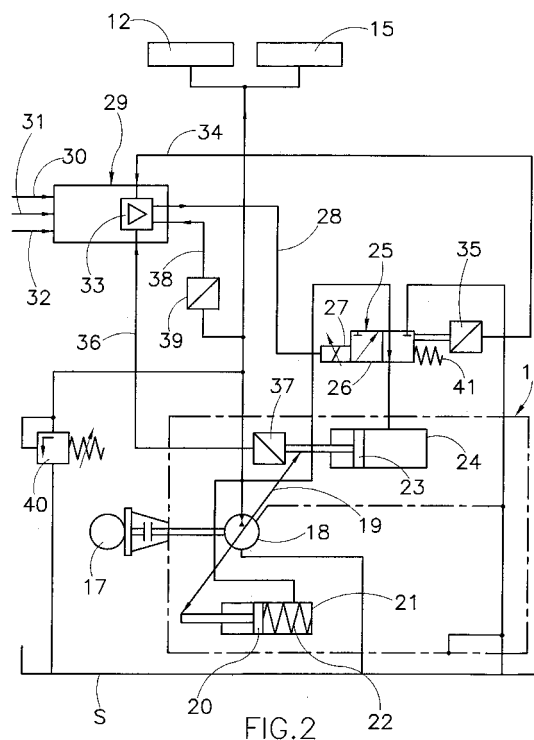
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(54) **High performance bending machine with reduced energy dispersion**

(57) A bending machine comprises a bending unit (8) moved by hydraulic actuators (12, 15) controlled by a variable displacement hydraulic pump (16) provided with an electronic closed-loop flow rate, pressure and power control system (25, 29, 35, 37, 39) including an electrically controlled proportional valve (25). The valve (25) includes a valve spool (26) for the control of the swivel angle of the pump (16) and a proportional solenoid (27) for moving the valve spool (26) to a position corresponding to a desired swivel angle of the pump (16). The control system (25, 29, 35, 37, 39) includes an inductive position transducer (35), a pump swivel angle transducer (37), a pump pressure transducer (39) and a programmed electronic control unit (29) which receives position, swivel angle and pressure signals (34, 36, 38) from said transducers (35, 37, 39) and predefined pressure, power and flow rate commands (30, 31, 32) and supplies a control signal (28) to said proportional solenoid (27).



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Description

[0001] This invention refers to a machine for programmed sheet bending of the general type known in the art as panel bender.

[0002] These panel benders are able to automatically move a sheet metal blank on a horizontal surface placed in front of a bending press provided with a bending unit with one or two bending blades, which is able to perform a number of bends of variable size, angle and direction on each side of the blank. The bending press also comprises a fixed counter-blade and a blank-holder of variable size which cooperates with the counter-blade for clamping the blank near the edge to be bent. The bending unit and the blank-holder are activated by controlled hydraulic actuators consisting of hydraulic cylinders. An example of this state of the art is given by the European patent EP-A-0293964.

[0003] The advantages of this machine reside in the constant production rate and the production and programming flexibility. A few drawbacks, however, are encountered.

[0004] In particular, a drawback consists in low energetic efficiency due to the great quantity of hydraulic energy dispersed in heat and cooled by an appropriate chiller. In fact, the controlled actuators of the bending unit receive the energy from a constant power hydraulic pump, which derives the power from a hydraulic circuit with a pressure limiting device and a flow rate regulator. The inertia of the operation of the hydraulic pump becomes dispersed energy transformed in heat.

[0005] The object of the present invention is to provide a sheet metal bending machine with programmable reduced energy if maximum production rate is not required.

[0006] According to the present invention this object is reached by a bending machine comprising a bending unit which is moved by hydraulic actuators controlled by a hydraulic pump, characterised in that the hydraulic pump is a variable displacement pump provided with an electronic closed-loop flow rate, pressure and power control system including an electrically controlled proportional valve.

[0007] The use of this kind of pump with electronic control allows to program the hydraulic power for the actuators according to the desired production rate. The new panel bender according to the invention will thus have a reduced consumption of energy with respect to the present panel benders provided with a constant power hydraulic pump.

[0008] An embodiment of the present invention is shown by way of nonlimiting example in the accompanying drawings, in which:

Fig 1 shows the mechanical part of a bending press provided with a hydraulically controlled bending unit;

Fig. 2 shows a control system for hydraulic actua-

tors of a bending unit as shown in Fig. 1.

[0009] The bending press shown in Fig. 1 comprises a fixed base 1, which supports a counter-blade 2 on which a lateral edge of a sheet metal blank 3 moved by a manipulator (not shown) rests.

[0010] A blank-holder 4 cooperates with the counter-blade 3 to clamp the sheet metal edge. The blank-holder is attached to the front end of a movable support 5, which has a front end hinged at 6 on a rear part of the fixed base 1. The support 5 is moved up and down by a plurality of hydraulic cylinders 7.

[0011] A bending unit 8 comprises a common support 9 for two bending blades 10 and 11 which cooperate with the counter-blade 2 to cause bending of the clamped edge of the sheet metal. The bending unit is subjected to combined horizontal and vertical movements by hydraulic actuators consisting of hydraulic cylinders 12 interposed between the rear part of the base 1 and a lever 13 having a fixed hinge 14 and a mobile hinge 100, and of further hydraulic cylinders 15 interposed between the blade support 9 and the fixed base 1.

[0012] The hydraulic actuators 12 and 15 are controlled by a control system schematically shown in Fig. 2 (where S indicates a fluid tank) and including a variable displacement hydraulic pump 16.

[0013] The variable displacement pump 16 is driven by an electric motor 17 and comprises, as usual, a pump body 18 and a rotatable tiltable swashplate 19 acting on axial pistons (not shown) to cause fluid displacement with a flow rate depending on the swivel angle of the swashplate 19. This angle is forced to a maximum value by a piston 20 slidingly housed in a hydraulic cylinder 21 subjected to the pump pressure and pushed by a spring 22 and can be reduced by the action of a control piston 23 which is slidingly housed in a hydraulic cylinder 24 controlled by an electrically controlled proportional valve 25 included in a closed loop control system.

[0014] The proportional valve 25 is provided with a valve spool 26 pushed in the position of Fig. 2 by a spring 41 and controlled by a proportional control solenoid 27 which receives a control signal 28 from an electronic programmed control unit 29 provided with command values provided by an operator or a programmed electronic control system, such as a pressure value 30, a power value 31 and a flow rate value 32 and provided with an amplifier stage 33 having input signals consisting of a valve spool position signal 34 coming from an inductive position transducer 35 associated with the valve spool 26, a swivel angle signal 36 coming from a swivel angle transducer 37 associated with the control piston 23 and a pump pressure signal 38 coming from a pressure transducer 39 arranged on the pump delivery.

[0015] A pressure limiting device 40 is finally provided between the pump delivery and the fluid tank S.

[0016] When the pump 16 is at rest and the control system is pressure-less, the swashplate 19 is held in the

maximum tilted position by the spring 22.

[0017] When the pump 16 is driven to rotate and the proportional solenoid 27 is de-energized, the control system regulates to zero stroke pressure as the valve spool 26 is pushed to the position of Fig. 2 by the spring 41 and therefore the pump pressure is applied to the control piston 23. A balance between the pump pressure and the force of the spring 22 is obtained between 8 and 10 bar. This basic setting is taken on with inactive electronic control unit 29.

[0018] When the electronic control unit 29 is active, the actual pressure value (signal 38), the valve spool position (signal 34) and the pump swivel angle (signal 36) are compared with the command values 30, 31, 32 by the electronic control unit 29. Any detected control deviations are processed further and generate a control signal 28 for the proportional solenoid 27, which moves the valve spool 26 from a central position corresponding to detected values 28, 36, 38 equal to the command values 30, 31, 32 according to said deviations.

[0019] If the programmed control unit 29 demands an increase of the swivel angle in order to increase the fluid flow rate from the pump 16 to the actuators 12, 15, the control signal 28 causes the electric current through the solenoid 27 to increase in order to move the valve spool 26 from the central position to the left until the swivel angle has reached the required value. On the contrary, a reduction of the solenoid current causes the valve spool 26 to move to the right to reduce the swivel angle and therefore the fluid flow rate to the actuators 12, 15.

[0020] Particularly, by acting on the power command value 31 it is thus possible to vary the hydraulic power delivered by the pump 16 to the actuators 12, 15.

[0021] In this way the hydraulic power supplied to the actuators may be programmed according to the desired production rate so as to obtain a reduced energy consumption.

Claims

1. Bending machine comprising a bending unit (8) which is moved by hydraulic actuators (12, 15) controlled by a hydraulic pump (16), **characterised in that** the hydraulic pump (16) is a variable displacement pump provided with an electronic closed-loop flow rate, pressure and power control system (25, 29, 35, 37, 39) including an electrically controlled proportional valve (25).
2. Bending machine according to claim 1, **characterized in that** said valve (25) includes a valve spool (26) for the control of the swivel angle of the pump (16) and a proportional solenoid (27) for moving the valve spool (26) to a position corresponding to a desired swivel angle of the pump (16).
3. Bending machine according to claim 2, **character-**

ized in that said control system (25, 29, 35, 37, 39) includes an inductive position transducer (35) associated with the valve spool (26) for detecting the position thereof, a swivel angle transducer (37) associated with the pump (16) for detecting the swivel angle thereof, a pressure transducer (39) arranged on the pump delivery for detecting thereof and a programmed electronic control unit (29) which receives position, swivel angle and pressure signals (34, 36, 38) from said transducers (35, 37, 39) and predefined pressure, power and flow rate commands (30, 31, 32) and supplies a control signal (28) to said proportional solenoid (27).

4. Bending machine according to claim 1, **characterized in that** the power delivered by the pump (16) is adjustable by acting on the power command (31).

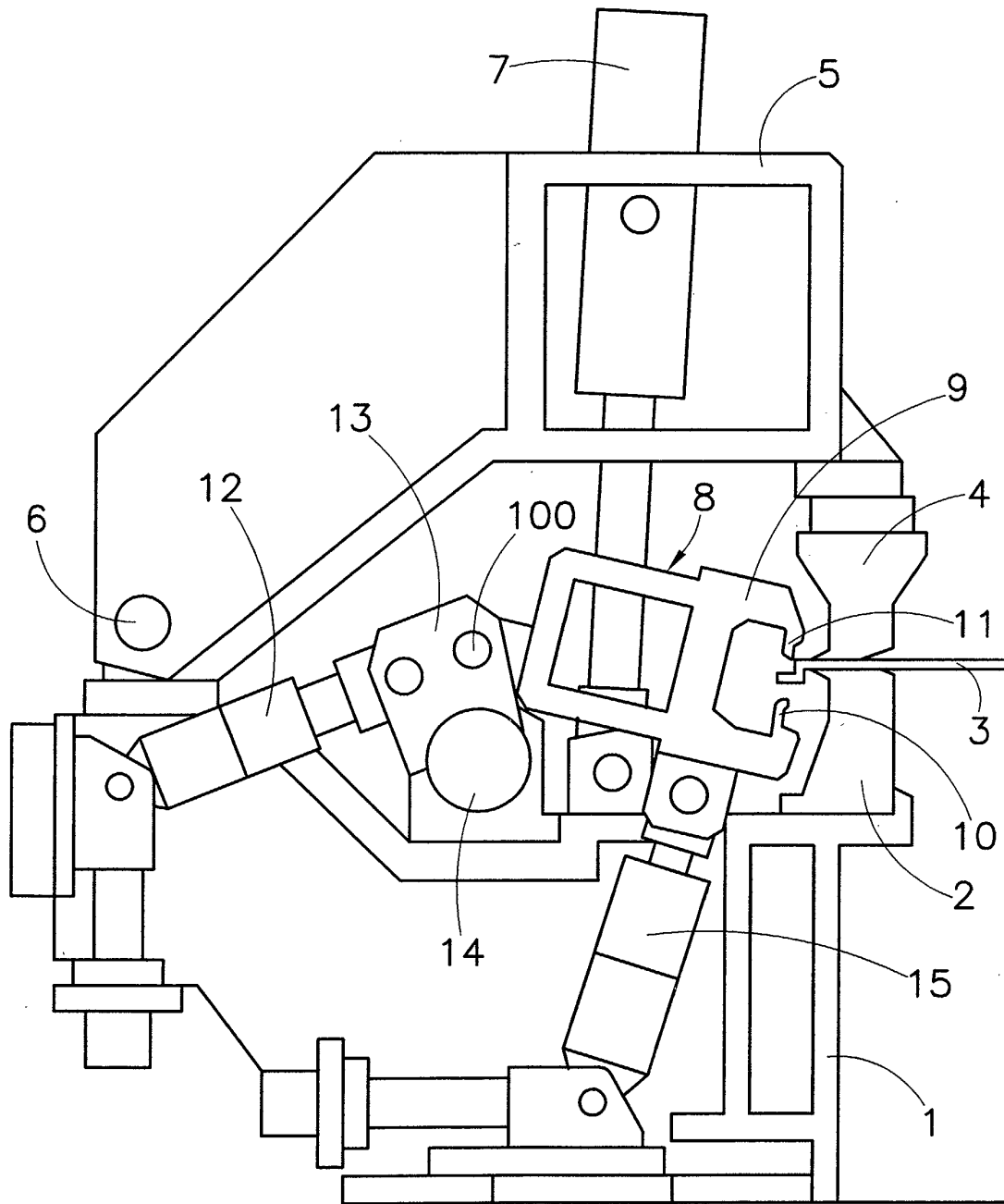


FIG. 1

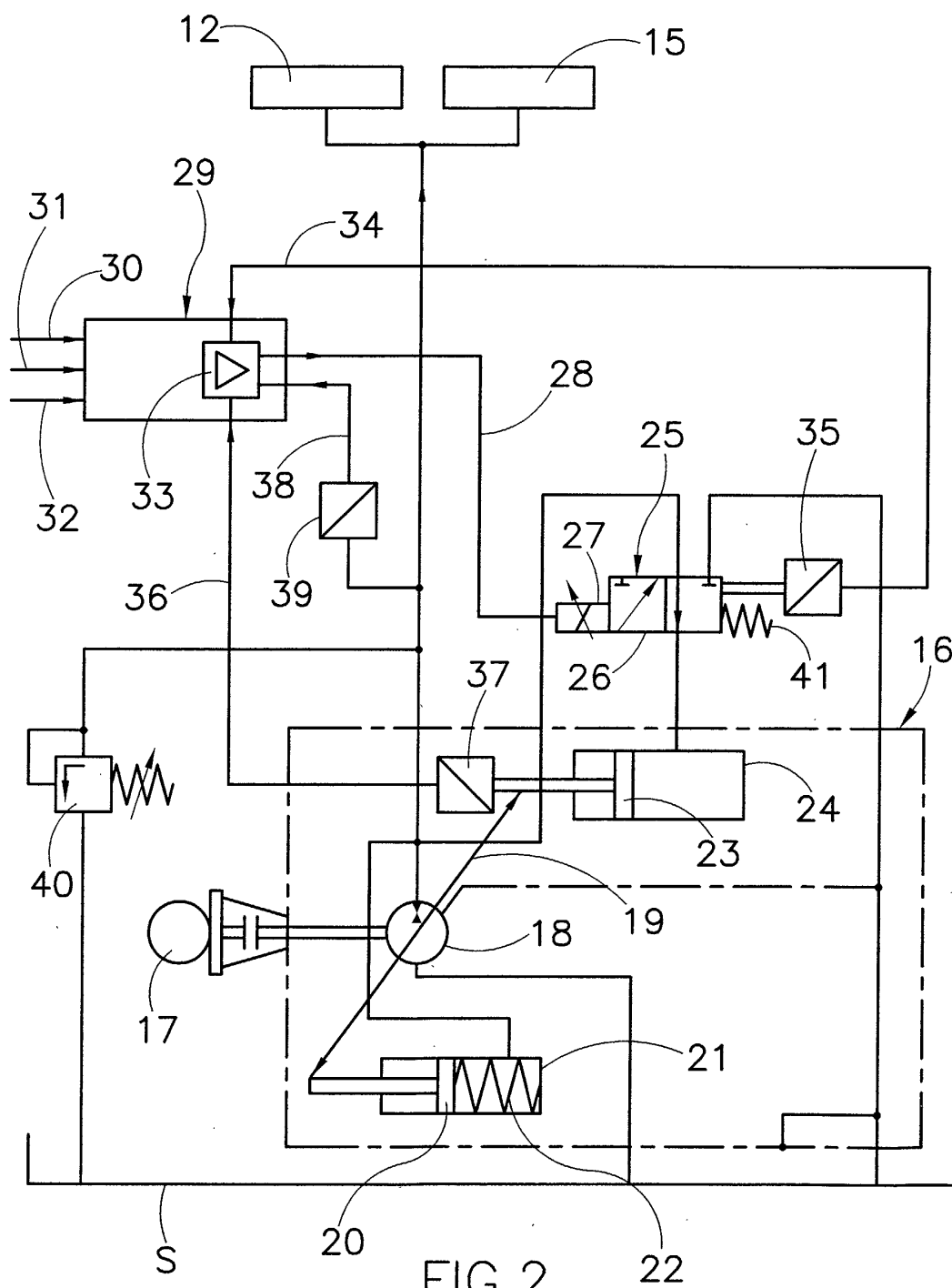


FIG. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 02 07 9123

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			B21D B30B
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 18 February 2003	Examiner Vinci, V
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EPO FORM 1503 03/82 (P04/C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 02 07 9123

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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