Feb. 23, 1971 C. W. KOORS ET AL 3,564,883

HYDRAULIC PRESS CONTROL

Filed July 30, 1968 3 Sheets-Sheet 1

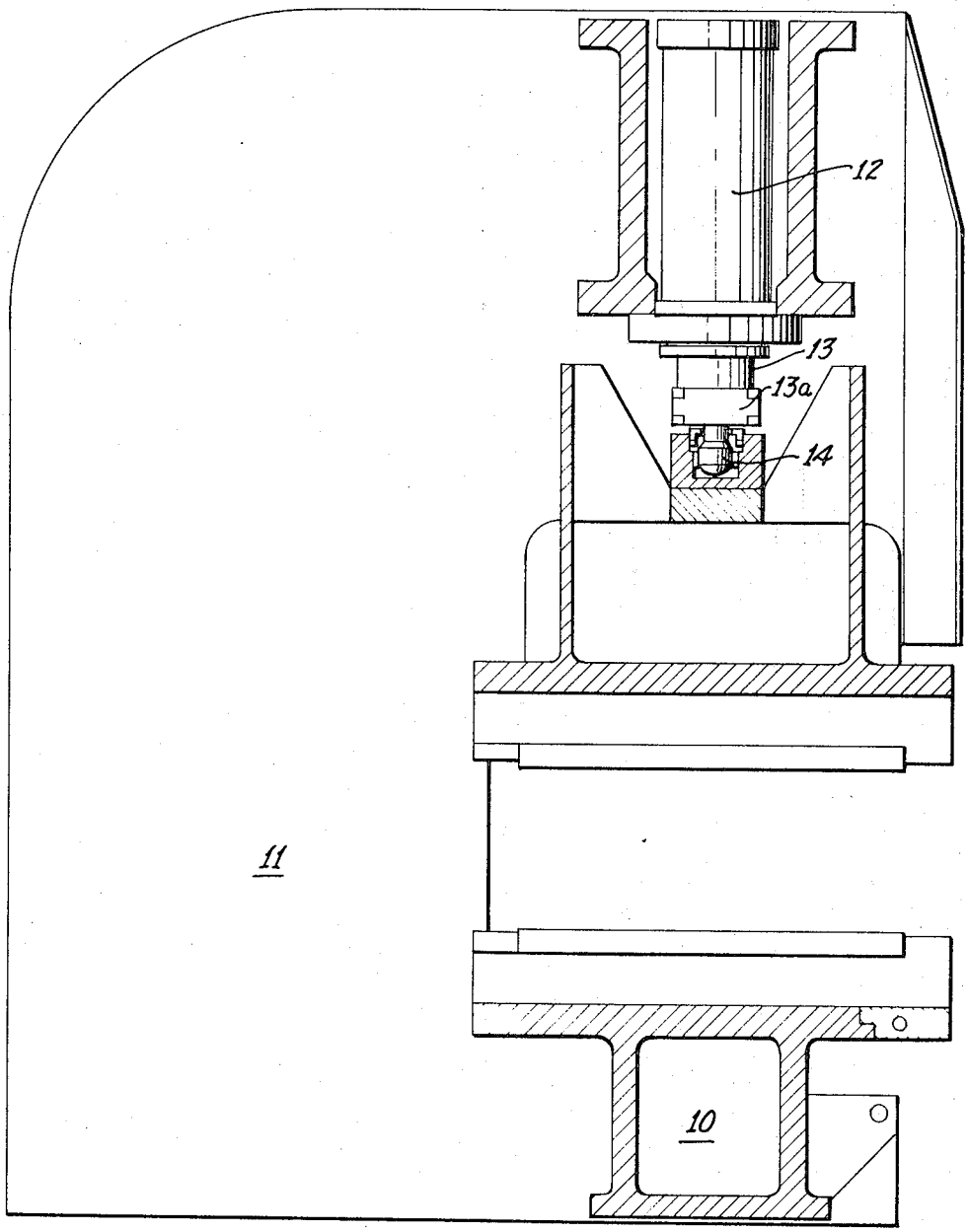

FIG. 1

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HYDRAULIC PRESS CONTROL

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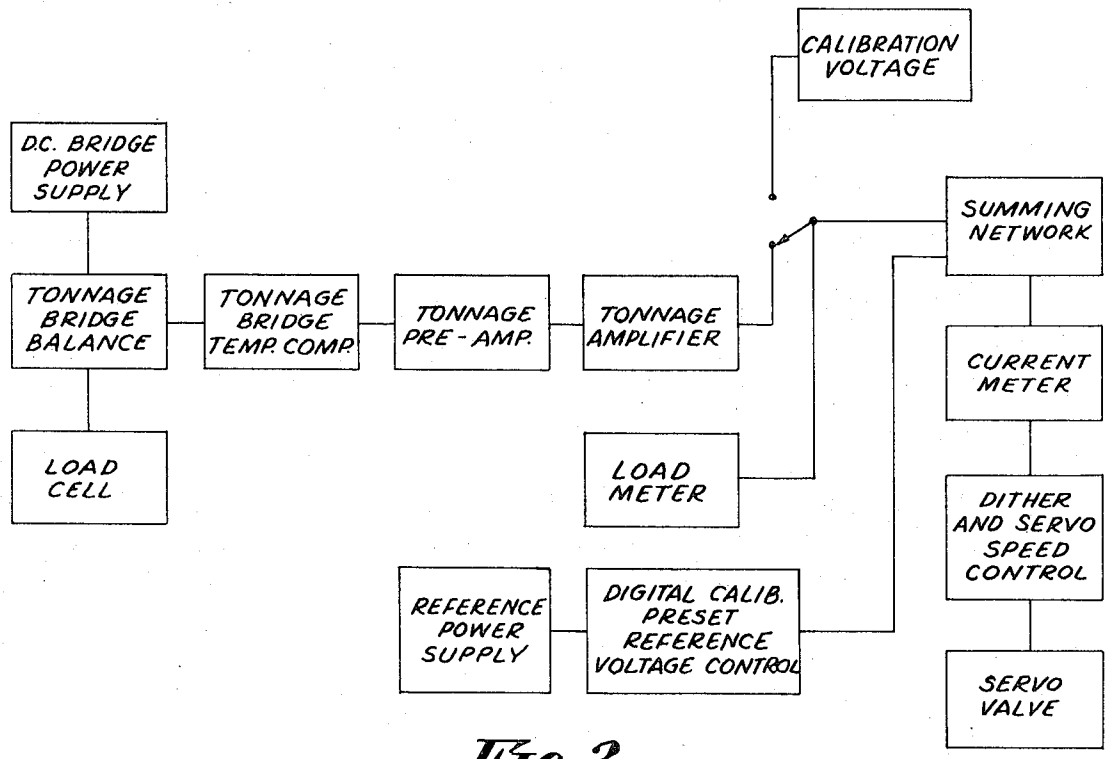

FIG. 2

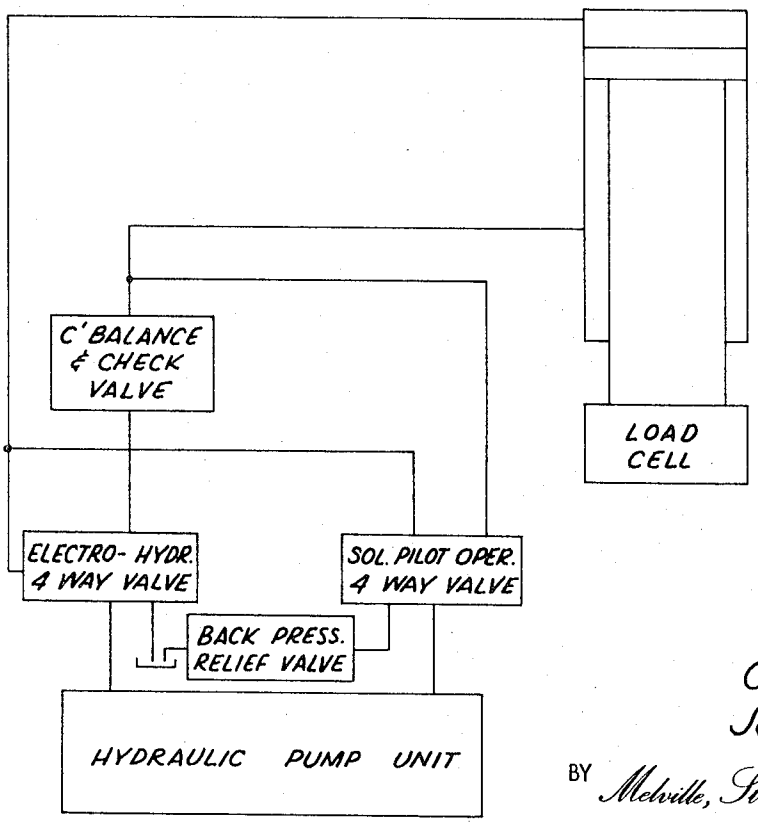

FIG. 3

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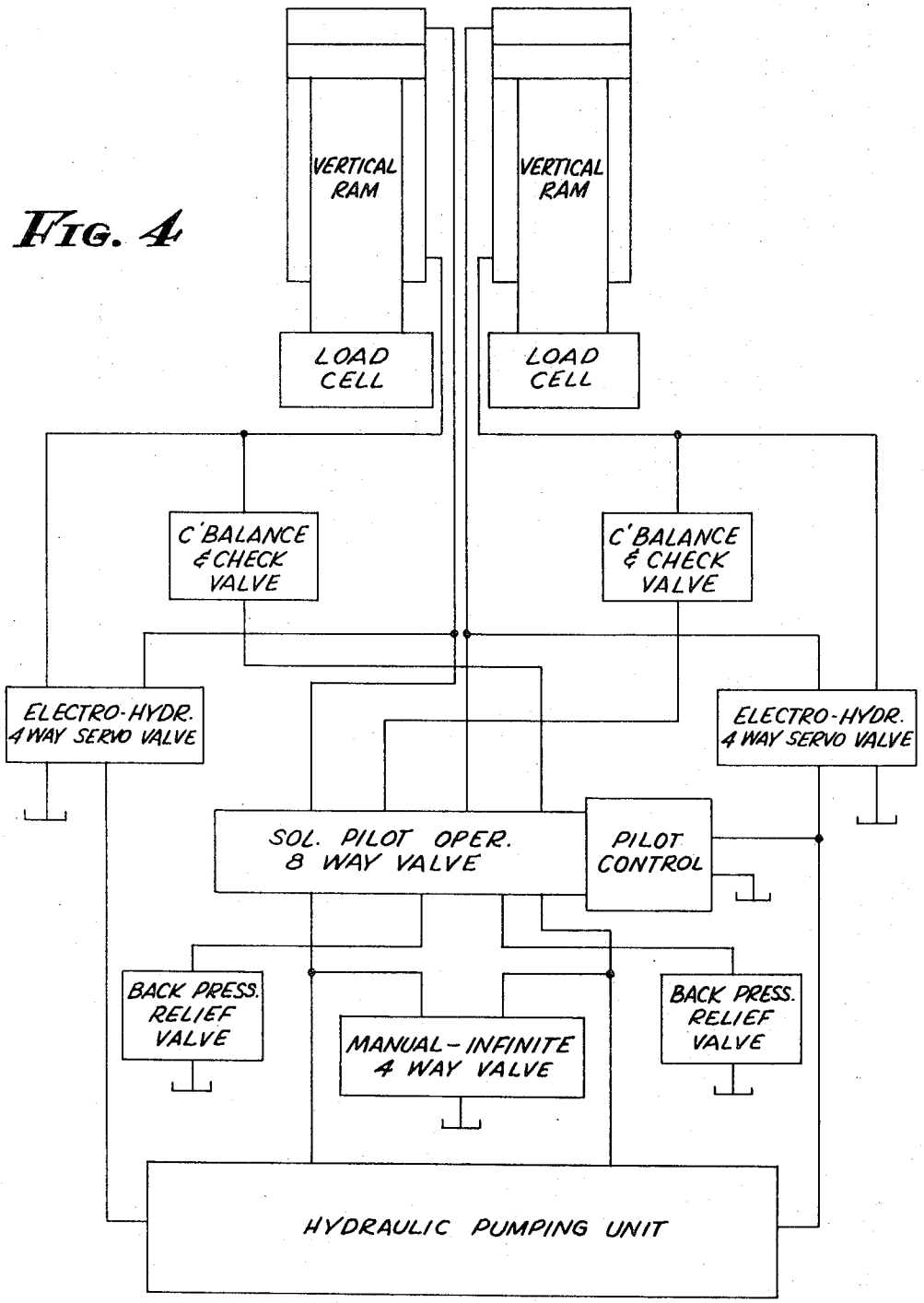
FIG. 4



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HYDRAULIC PRESS CONTROL

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Int. Cl. B21j 9/20
U.S. Cl. 72—8 3 Claims

ABSTRACT OF THE DISCLOSURE

A hydraulic press control having a load cell or transducer arranged to measure the true load applied by the tooling to the part being pressed. Hydraulic fluid is automatically supplied to either end of the cylinder as dictated by the load cell output, to achieve and maintain an accurate load on the part during the holding cycle, even where this load is less than the weight of the platen and die, and where the part may change dimensionally during the holding cycle.

CROSS REFERENCE TO RELATED APPLICATIONS

This application is related to an application in the name of Richard E. Griesheimer entitled Load Indicating Device for Compacting Press, Ser. No. 714,391, filled Feb. 5, 1968, now abandoned. The present invention may utilize transducers and circuits therefor as disclosed in said related applications.

BACKGROUND OF THE INVENTION

The invention lies in the field of controls for presses, such, for example, as hot forming and sizing presses, and encompasses means for maintaining predetermined pressing loads for extended periods of time with great accuracy. Presses of the type here involved are known, as are various mechanisms and devices which are intended to maintain predetermined pressures as accurately as possible. Troubles have been encountered with existing devices particularly where the required load which was to be maintained was less than the combined weight of the platen and die, or where the required load was small relative to the capacity of the press. The platens and dies in some modern forming operations are of considerable weight; and for some forming operations a forming load which is less than the combined weight of the platen and die is required. Clearly under such circumstances it is going to be necessary to supply hydraulic fluid to the rod end of the cylinder in order to relieve a portion of the weight of the platen and die so as to reduce the forming load to the desired value.

Problems are also encountered where a load of a particular value must be maintained on the part being formed for a considerable length of time. In such cases if the part changes dimensionally during the holding cycle, or if there is leakage or wear in the hydraulic system, the required loads will not ordinarily be maintained. The present invention makes provision for the maintenance of such a load regardless of the conditions encountered.

SUMMARY

The invention involves the use of load cells or transducers to measure the amount of force being exerted by the press. The load cells themselves do not form part of the present invention. They may be such as are disclosed in the said copending applications; but other types of load cells may also be used. It is only necessary that the load cells give a signal which can be fed into a summing network (which may incorporate amplification), into which a reference control voltage can also be fed. The summing network is used to control a hydraulic servo valve in a closed loop hydraulic system. The regulated or reference voltage may be fed through a precision potentiometer and into the summing network to provide a command voltage for the load sensing system to duplicate. The output of the summing network controls an electro hydraulic four way servo valve. The servo valve will supply oil automatically to either end of the cylinder of the press as dictated by the output of the load cell.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a somewhat diagrammatic side elevational view of a press to which the invention may be applied.

FIG. 2 is a block diagram of the electrical circuitry involved.

FIG. 3 is a block diagram of the hydraulic circuit for a single cylinder press; and

FIG. 4 is a block diagram of the hydraulic circuit for a two cylinder press.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An exemplary press to which the present invention may be applied is shown diagrammatically in FIG. 1 and comprises a bed **10**, a frame **11**, a press cylinder **12**, having a piston secured to a piston rod **13**. The lower end of the piston rod carries the platen and die by means of a conventional ball coupling **14**. A typical load cell **13***a* is shown at the end of the piston rod **13** and may be comprised of a piece of steel having strain gauges arranged to feed a conventional bridge circuit. Thus as seen in FIG. 2, a D.C. bridge power supply and the load cell feed into a tonnage bridge balance and a means for temperature compensation is provided. The signal from the load cell bridge is preamplified and then fed through an amplifier to the summing network, which, if further amplification is required, may be a differential amplifier. The summing network is provided with gain and speed adjustment and a meter for servo balance, as is well known. It also provides so called dither to the servo valve for precise system performance. The details of a typical load cell and electrical circuit are described more particularly in said co-pending application in the names of Koors, Erhart and Halter, and in U.S. Pat. No. 3,389,432, dated June 25, 1968.

A reference voltage is provided which is fed from a reference power supply. The tonnage desired to be achieved and maintained can be set in by the press operator on the reference voltage control, or can be preprogrammed on punched tape or cards or similar elements. This adjustable voltage constitutes the reference for the summing network to compare against the output of the bridge amplifier. Any unbalance causes the servo valve controlling the press hydraulic system to react until balance is restored, i.e., until these voltages are again equal. As pointed out in said last mentioned copending application, the voltage adjustment may be accomplished by means of a high precision ten-turn potentiometer, which will preferably have a three digit dial input.

With the arrangement above described, it will be clear that when the output of the bridge circuit and the output of the reference voltage control balance, the summing network will have no output. When the bridge circuit and reference voltage control outputs do not balance, the summing network will have an output, and this output is applied to the servo valve in a sense dependent upon the direction of imbalance; and the servo valve then directs the hydraulic fluid to the top or bottom of the cylinder, and in an amount proportional to the degree of imbalance.

As will also be clear from FIG. 2, the operator can switch the system to a calibration voltage for the purpose of checking the operation of the electrical system. It will also be noted that provision is made for a read out load meter, which is also fed by the load cell amplifier, and calibrated for tonnages. The load meter makes it possible for the operator to verify the operation of the system, and to see that he has not only attained the correct load but is maintaining it for the required time. If the operator should feel it desirable to change the load while in the hold position, he need only turn the potentiometer dial of the reference voltage control and the summing network will cause the servo system to follow the new command.

The hydraulic circuit for a simple single cylinder press is shown in the block diagram of FIG. 3. As will be clear, the advance and return portion of the cycle is controlled by a double solenoid pilot operated four-way valve. The counterbalance and check valve prevent the ram from drifting during machine idle time. The pressing portion of the cycle is controlled by the electro-hydraulic four-way servo valve. This valve controls the amount of fluid fed to either the top or the bottom of the main power cylinder, based upon signals received from the load sensing system on the main cylinder piston rod.

This system presents a number of great advantages. It eliminates many errors normally present in hydraulic systems, including such factors as changes in cylinder packing friction, hydraulic fluid viscosity, and changes in control valve pressure settings. Further, since the system recognizes and operates on the basis of force or load applied, it does not need to recognize the hydraulic pressure being applied to either side of the cylinder. A null balance control (mounted on the main control panel, not shown) makes it possible for the operator to compensate for changes in die weight; and he need not make changes in hydraulic control valve settings. An automatic means for compensating for changes in die weight can easily be incorporated in the above circuit, as will be clear to those skilled in the art.

It is worthy of note that the system is exceptionally useful when accurate load control is required at a low load setting, and especially where the required load is less than the weight of the platen and die. In the latter situation, the pressure on the rod end of the cylinder will be greater than that on the upper end of the cylinder. During a holding cycle under these conditions, hydraulic fluid must be supplied to the rod end of the piston to compensate for internal leakage in valves, cylinders, and elsewhere. According to the present invention hydraulic fluid is automatically supplied to either end of the cylinder as dictated by the output of the load sensing elements.

The hydraulic circuit of FIG. 4 is similar to that of FIG. 3 but is arranged for a two-cylinder press. With this arrangement, in the pressing of long parts, the operator can apply different load settings to the two cylinders, so as to exert a greater load at one end of the workpiece than at the other. The circuit of FIG. 4 is actually a doubling of the circuit of FIG. 3.

It will be understood that many presses are provided with horizontally acting rams, as well as vertically acting ones; and the horizontally disposed rams are controlled in the same way as described above, except that platen and die weight do not enter the picture. It will also be understood that the invention may be applied to presses having other forms of hydraulic actuators than cylinders and pistons, as for example, rotary actuators.

It will be understood that modifications may be made without departing from the spirit of the invention and, therefore, no limitation which is not specifically set forth in the claims is intended or should be implied.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In combination with a hydraulic press having at least two hydraulic actuators, a load cell for each actuator arranged to measure the true load applied by its actuator to a part being pressed in said press, a summing network, means for feeding to said summing network a signal based on said true load as sensed by each cell, a reference voltage source, and means to apply a desired reference voltage to said summing network, a servo valve, means for actuating said servo valve from the output of said summing network, and a closed hydraulic circuit including said servo valve and the actuators of said press, whereby different loads may be applied by said actuators to a single part being pressed.

2. The combination of claim **1**, including a source of calibration voltage, and means to supply to said summing network alternatively said calibration voltage or the signals from said load cells.

3. The combination of claim **1**, wherein said signals from said load cells are also fed to a meter calibrated to read load.

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