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[54] CONTROL SYSTEM FOR HYDRAULIC EXTRUSION PRESS

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[58] **Field of Search**.....235/151.1, 151; 72/21, 22, 72/8, 253, 347, 453, 26

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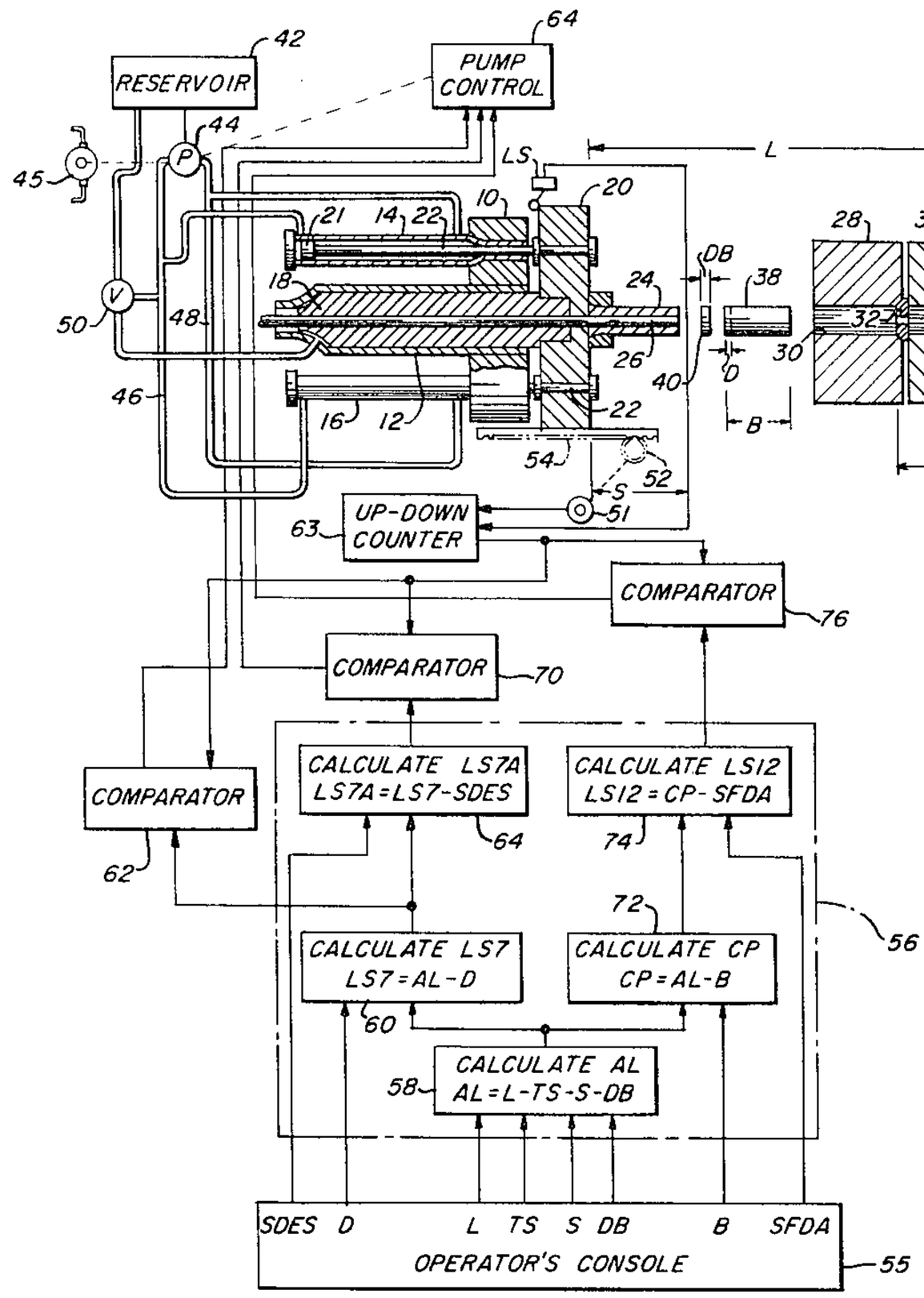
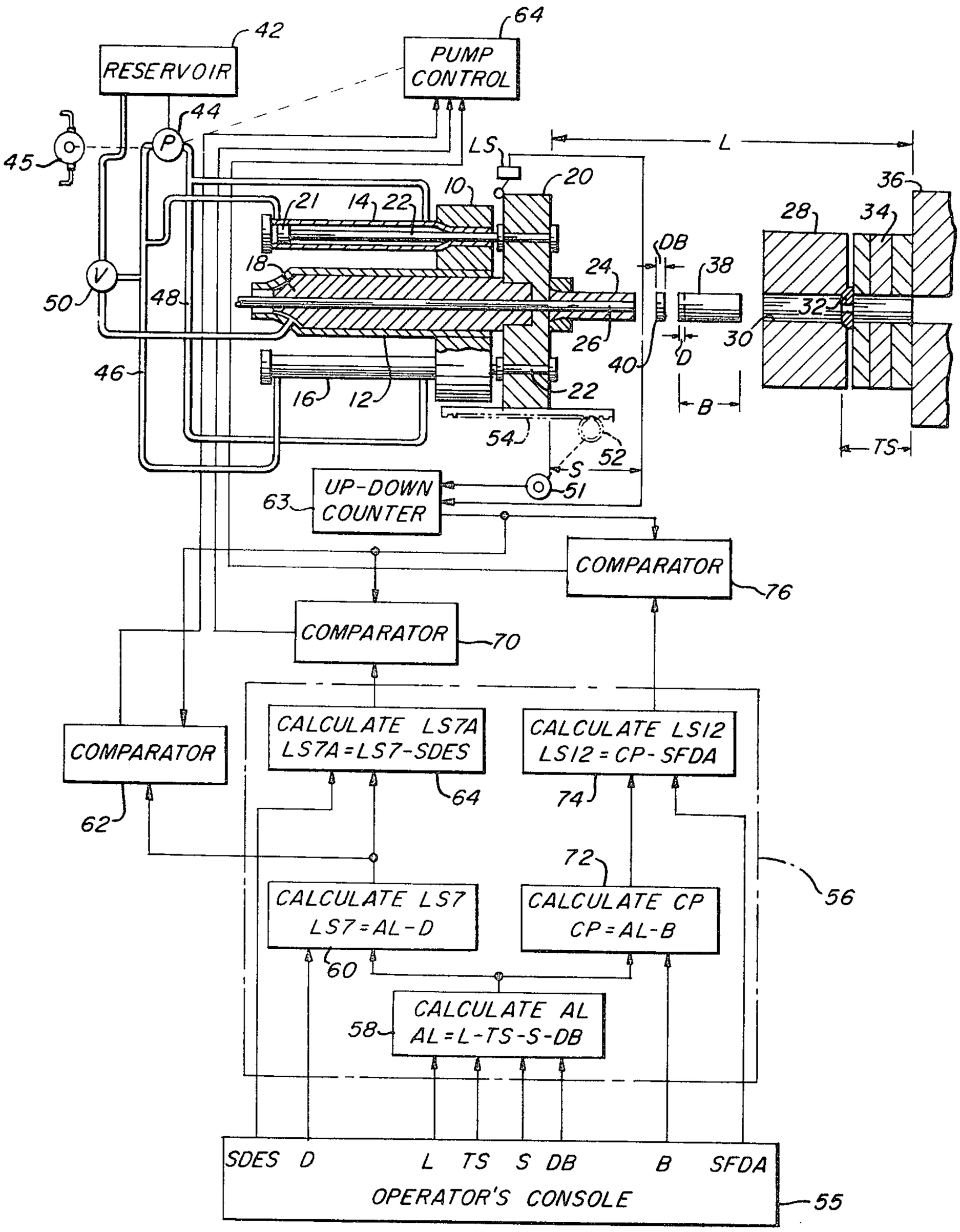
[57] **ABSTRACT**

A computer control system for hydraulic extrusion presses and the like characterized in that the operator need only preset at a control console certain lengths and distances dictated by the characteristics of the billet to be extruded, without the necessity for setting limit switches on the press itself. Aside from this, the operation of the press is automatic during an extrusion cycle, resulting in smoother operation of the press, improvements in yield and greater uniformity of product. In addition, the control system incorporates an automatic slowdown of the stem before it contacts a dummy block and billet, thereby reducing damage to dies.

5 Claims, 1 Drawing Figure





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CONTROL SYSTEM FOR HYDRAULIC EXTRUSION PRESS

BACKGROUND OF THE INVENTION

In the usual extrusion press installation, a heated metal billet is inserted into a billet container having a die at one end, the arrangement being such that a billet is forced through the die by means of an extrusion stem which enters the end of the container opposite the die. Usually, a so-called dummy block is inserted between the billet and the stem.

Most prior art extrusion presses of this type are controlled by an operator who initiates an extrusion cycle, whereupon the stem moves forwardly under low hydraulic pressure at a high advance speed until the stem enters the billet container and forces the billet against the die. Since the billet can no longer move freely once the die is contacted, the low hydraulic pressure rises and changes the stem hydraulic system from a low to a high extrusion pressure. Now the stem moves forwardly under high pressure into the billet container, causing the billet to be extruded through the die at whatever speed the available pressure will extrude the material of which the billet consists. During actual extrusion, the press operator may exercise a limited degree of control over the stem speed by manipulation of a lever which, through appropriate electrical circuitry and mechanical devices, regulates the hydraulic system. The forward motion of the stem is usually stopped by a limit switch mounted on the press which is set to allow for a predetermined thickness of discard.

While press control systems of the type described above are generally satisfactory for slow speed presses, they have certain deficiencies at high speeds. Firstly, the press is rough and noisy in its operation. The stem contacts the billet at rapid advance speed, causing the billet to strike the die or die holder at this rapid speed which may injure the die or the ceramic coating of the die in the case of a Sejournet-type extrusion press. The stem speed may, and usually does, vary widely not only during any single extrusion stroke but also from cycle to cycle, thus affecting the uniformity of the product. Also, since the system uses limit switches these must be relocated at times, an operation which requires skill and precision and which is time consuming. Finally, the use of a limit switch to stop the stem at the end of its stroke does not facilitate easy adjustment of the discard length of the billet remaining in the billet holder, a factor which tends to reduce yield.

SUMMARY OF THE INVENTION

In accordance with the present invention, a control system for an extrusion press is provided in which the position of the stem with respect to an extrusion die is monitored by means of a pulse generator which generates a number of pulses proportional to the travel of the stem from its stationary, fully retracted position. The operator initially enters into the control system by thumbwheel switches or the like the length of the press tool stack, the length of the stem and the dummy block length. In many cases, these will remain constant from billet to billet but may vary for each billet as in the case where special metals, such as titanium, are being extruded on a job-shop basis. Additionally, the operator enters the length of the billet being extruded, the desired discard length, the desired slowdown distance of the stem from fast advance and the desired slowdown distance of the stem from extrusion speed. From these quantities, and taking into account the total distance between the stem in its fully retracted position and the end of the tool stack, the position of the stem for slowdown from fast advance, for slowdown from extrude speed, and the desired final position of the stem can be calculated and utilized to control the press.

The above and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying single figure drawing which schematically illustrates one embodiment of the invention.

With reference now to the drawing, one type of extrusion press installation is schematically illustrated and includes a main, stationary crosshead **10** which carries a main power cylinder **12** and two rapid advance and pullback cylinders **14** and **16**. Reciprocable within the main power cylinder **12** is a ram-type piston **18** connected at its forward end to a reciprocable main crosshead **20** which can travel back and forth on guideways, not shown. The cylinders **14** and **16** have pistons **21** therein which are connected through piston rods **22** to the main crosshead **20** on either side of the ram-type piston **18**. The main crosshead **20**, in turn, carries a stem **24** on its forward face. In the embodiment shown herein, the stem is hollow and receives a piercer ram **26**. The ram **26** is utilized in the case of hollow extrusions and extends through a bore in a billet. Separate hydraulic cylinders, not shown, are provided for causing the piercer ram **26** to extend out beyond the end of the stem **24**.

At the end of the press opposite the main crosshead **20** is a billet container **28** provided with an internal bore **30** having at its one end a die **32** which is backed up by a tool stack or tool block **34** which, in turn, engages a tail block **36** secured to the press foundation.

Hydraulic fluid for actuating the cylinders **12**, **14** and **16** is supplied from a reservoir **42**. The fluid from the reservoir **42** is pumped by means of a pump **44**, driven by motor **45**, to one of two hydraulic conduits **46** or **48**. The motor **45** continually rotates in one direction; while the pump **44** is preferably of the reversible, variable volume type controlled mechanically by a pump control unit **64** to cause fluid under variable pressure to flow from either one of the two pump output ports. When the condition of the pump **44** is such as to pressurize conduit **46**, the pistons **21** within cylinders **14** and **16** are caused to move to the right as viewed in the drawing. This causes the main crosshead **20** to move to the right also, thereby pulling the ram-type piston **18** to the right. During this time, a dumping valve **50** permits liquid from the reservoir **42**, which is usually located above the cylinder **12**, to flow by gravity into the left end of the cylinder **12** vacated by the advancing piston **18** which is moving to the right. Thus, as the crosshead **20** and ram-type piston **18** move to the right, the space behind the piston **18** is filled with liquid.

In the operation of the press shown in the drawing, the billet **38** is initially inserted into the bore **30** in billet holder **28** along with the dummy block **40**. This is accomplished by a billet loader, part of any extrusion press, not shown herein. Thereafter, the pump **44** is activated to pressurize conduit **46**, thereby forcing pistons **21** in cylinders **14** to the right, causing the crosshead **20**, the stem **24** and the ram-type piston **18** to move to the right. During this time, the space within the cylinder **12** being vacated by the piston **18** is constantly being filled with liquid from reservoir **42** as explained above.

In the prior art operation of a press of this type, the rightward movement of the stem **24** continues until its forward end is within the bore **30** and forces the billet **38** against the die **32**. At this point, the pressure within conduit **46** rises, thereby causing the dumping valve **50** to disconnect the cylinder **12** from the reservoir **42** and connect it to the conduit **46**, whereby fluid under pressure is admitted into the left end of the cylinder **12**. This causes the piston **18**, the crosshead **20** and the stem **24** to move forwardly into the billet container **28** at reduced speed while exerting a higher pressure, whereby the billet is extruded through the die **32**. The forward movement of the stem **24** continues until the billet is almost completely extruded; however a certain discard length, identified by the letter D in the drawing, is not extruded to avoid the possibility of jamming the dummy block **40** against the die **32** and damaging the same. The cross-sectional area of piston **18** is much greater than the combined areas of pistons **21** such that when the system switches from rapid advance to extrude, the stem slows down, but the pressure it exerts is much greater.

After the billet is extruded up to the point where only the discard length remains, the billet container **28** is moved away

from the die **32** by means, not shown; whereupon the extrusion is severed and the remaining length of the billet (i.e., the discard length) and the dummy block **40** are pushed out of the right end of the bore **30**. At this point, fluid flow through the pump **44** is reversed; conduit **48** is pressurized, and the cylinders **14** and **16** caused to return the crosshead **20**, the piston **18** and the stem **24** to the left back into their fully retracted positions shown in the drawing. During this time, the dumping valve **50** permits fluid from the left end of cylinder **12** to be returned back to the reservoir **42**.

As was explained above, in prior art systems the billet contacts the die with the stem **24** traveling at relatively high speed which sometimes results in damage to the die. Furthermore, the system requires the use of a limit switch to stop the movement of the stem **24** at its extreme limit of travel. This limit switch is engaged by the crosshead **20** or by an element connected thereto and movable therewith. Positioning the limit switch, in turn, is time consuming and requires a certain amount of skill. Finally, since the speed of the stem **24** during an extrusion process was under the control of an operator in accordance with prior art systems, the quality (e.g., density) of the resulting extrusion was not altogether uniform.

In accordance with the present invention, a computer control system is provided wherein the position of the stem **24** with respect to the die **32** is constantly monitored by means of a pulse generator **51** connected to a gear **52** which engages a rack **54** carried on the main crosshead **20**. It will be appreciated, however, that other and different systems can be utilized to generate a number of pulses indicative of the travel of the stem **24** from its completely retracted position.

The control system for the extrusion press includes an operator's console **55** which, among other things, includes a plurality of thumbwheel switches which feed digital signals into a computer, generally indicated by the reference numeral **56**, proportional to certain predetermined lengths. The operator inputs include the length of tool stack **34** (TS), the length of billet **38** (B) and the length of stem **24** (S). Each of these is entered on a four-decade thumbwheel switch, not shown, which stops at 39.99 inches maximum. In addition, the operator enters the length of the dummy block **40** (DB), the discard length (D), the slowdown distance from fast advance (SDFA) and the slowdown distance from extrude speed (SDES). Each of these is entered on a three-decade thumbwheel switch, not shown, which stops at 9.99 inches maximum. The slowdown distance from fast advance (SDFA) is that distance which the stem **24** travels at reduced speed with cylinders **14** and **16** being pressurized until the stem forces the billet **38** into engagement with the die **32**. This slowdown, as explained above, is for the purpose of preventing damage to the die. The slowdown distance from extrude speed (SDES) is that distance which the stem should travel at the end of an extrusion step at reduced speed. The computer **56** utilizes the information entered by the operator to find the distances from the zero reference (i.e., the fully retracted position of stem **24**) to the following points on the press:

(LS12) slowdown from fast advance,
(LS7A) slowdown from extrude speed, and
(LS7) stop.

The computer **56** is preferably a general purpose computer which may be programmed in accordance with techniques well known to those skilled in the art; however it will be described herein as if it constituted hardward logic. The first step in the process, which may be performed in a digital subtracter **58**, is to determine the quantity AL which is an intermediate quantity used to simplify the computer computation. AL is computed from:

$$(1) \qquad AL=L-TS-S-DB$$

The quantity AL, in effect, is the total length between the forward edge of the main crosshead **20** and the end of the tool stack **34** minus the length of the tool stack, the length of stem **24**, and the dummy block length DB. The length of the tool stack must be taken into account since it may vary, depending upon the die used. This, in effect, constitutes the total travel of the stem **24** during a complete extrusion cycle, disregarding the discard length D. In order to calculate the total travel of the stem **24**, the quantity D, constituting the discard length, must be subtracted from the quantity AL in digital subtracter **60** to determine the quantity LS7, which is the total length of travel of stem **24** during a complete extrusion cycle. The digital signal proportional to LS7 is then compared in comparator **62** with the output of an up-down counter **63** connected to pulse generator **51**; and when the two are the same, comparator **62** actuates a pump control unit **64** to reduce the output of pump **44** to zero, whereupon the advance of the crosshead **20** and stem **24** will also stop.

The quantity LS7 is also used in digital subtracter **68** to calculate the quantity LS7A, the slowdown distance from extrude speed in accordance with the equation:

$$(2) \qquad LS7A=LS7-SDES$$

The quantity SDES, of course, is the slowdown distance from extrude speed. The quantity LS7A as determined in subtracter **68** is then compared with the output of up-down counter **63** in comparator **70**, the output of the comparator being used to actuate the pump control unit **64** to reduce the volumetric output of pump **44** and slow down the stem **24** just before the extrusion process is completed.

The quantity AL is further used in subtracter **72** to determine the quantity CP which is the point of contact between the stem **24** and the dummy block **40** during an extrusion cycle. This is calculated in accordance with the equation:

$$(3) \qquad CP=AL-B$$

where B is the length of billet **38**. The quantity CP, in turn, is utilized in subtracter **74** to calculate the quantity LS12, the slowdown from fast advance, in accordance with the equation:

$$(4) \qquad LS12=CP-SDFA$$

where SDFA is the slowdown distance from fast advance as entered by the operator. The quantity LS12 is then compared in comparator **76** with the output of up-down counter **63**; and when the two are the same, the pump control unit **64** is actuated to reduce the volumetric output of pump **44** and slow down the stem **24** during the rapid advance cycle.

In the operation of the system, the operator will enter the quantities L, TS, S, DB, B, D, SDFA and SDES. In some cases, the quantities TS, S, DB, SDFA and SDES will remain constant from billet to billet. The operator, therefore, need only be concerned with the billet length B and the discard length D. Once these are entered, the quantities LS7, LS7A and LS12 are computed by computer **56**; and the operator initiates the extrusion cycle by control apparatus, not shown. When the extrusion cycle is thus initiated, the pump control unit **64** causes the pump **44** to pressurize conduit **46** to open valve **50** and permit fluid from reservoir **42** to flow into the left end of cylinder **12** as the rapid advance cylinders **14** and **16** advance the crosshead **20** and the stem **24** to the right. This process will continue until the count of counter **63** matches the output of subtracter **68**, meaning that the stem **24** should slow down from fast advance. Consequently, the pump control unit **64** now reduces the volumetric output of pump **44** such that the crosshead **20** and stem **24** slow down just before the stem engages the dummy block and forces the billet against the die **32**.

The stem **24** will now advance at a reduced speed against the dummy block **40**; and when the dummy block is engaged, the pressure in conduit **46** will rise, thereby causing the dumping valve **50** to disconnect the right end of cylinder **12** from reservoir **42** and connect it to the output of pump **44**. The dumping valve **50**, for example, may be of the type shown in Lombard U.S. Pat. No. 2,751,076, issued June 19, 1956. The stem will now move to the right under extrusion pressure until the output of subtracter **68** matches the pulses counted by counter **63**, whereupon comparator **70** will cause the pump control unit **64** to reduce the output pressure of pump **44** and slow down the advance of stem **24**. Finally, when the pulses counted by counter **63** match the quantity LS7 as calculated in subtracter **60**, comparator **62** actuates the pump control unit **64** to stop the pump **44**, whereupon the extrusion process is completed. Thereafter, the discard length and dummy block

are extracted from bore **30** as explained above; and the operator reverses the flow of fluid through pump **44** via unit **64**; whereupon the cylinder **12** is connected back to the reservoir **42** while fluid in conduit **48**, which is now pressurized, causes the pistons **21** in cylinders **14** and **16** to withdraw the crosshead **20** and stem **24** back to their original starting positions. When the stem is fully retracted, limit switch LS is tripped to reset counter **63** to zero in the event that it has not counted down to zero during the reverse stroke.

The control action of the invention prevents damage to extrusion dies and at the same time insures that the quality of resulting extrusions will be constant. At the same time, the yield is materially increased since the operator can determine with a higher degree of precision the minimum possible discard length. Although the invention has been shown in connection with a certain specific embodiment, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts may be made to suit requirements without departing from the spirit and scope of the invention.

We claim as our invention:

1. In a control system for an extrusion press of the type wherein a billet is inserted into a billet container having a die at one end thereof and a stem is forced into the other end of said container to extrude the billet through the die; the combination of means including computer apparatus for automatically slowing down the rapid advance of said stem into said container just prior to the time that the billet is forced against said die, means including said computer apparatus for automatically slowing down the speed of said stem during extrusion of said billet just prior to the termination of extrusion when a predetermined discard length of said billet remains in the container, and means including said computer apparatus for stopping the advance of said stem when the discard length of the billet equals said predetermined discard length.

2. The control system of claim **1** including a pulse generator operatively connected to said stem for producing a number of pulses proportional to the travel of said stem from its fully retracted position, and comparator means for comparing the pulses produced by said pulse generator with digital signals at the output of said computer apparatus for controlling movement of said stem.

3. The control system of claim **2** wherein pulses from said pulse generator are applied to an up-down counter and the count stored in said counter is applied to said comparator means.

4. The control system of claim **2** wherein said stem is advanced by rapid advance cylinders and a main pressure cylinder, and including pump means for supplying hydraulic fluid to said cylinders, motor means for driving said pump means, and pump control means controlled by said comparator means.

5. The control system of claim **1** including an operator's console and means whereby the manually enters into said computer apparatus digital signals proportional to the total length between the trailing end of said stem in its fully retracted position and the end of a tool stack on the side of said die opposite said billet container, the length of said tool stack, the length of the stem, the length of said billet, the length of a dummy block inserted into said billet container behind the billet, the desired discard length of the billet, the desired slowdown distance from fast advance and the desired slowdown distance from extrude speed.

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