April 29, 1969 H. K. HARDY ET AL 3,440,849

HYDROSTATIC EXTRUSION APPARATUS

Filed Jan. 23, 1967

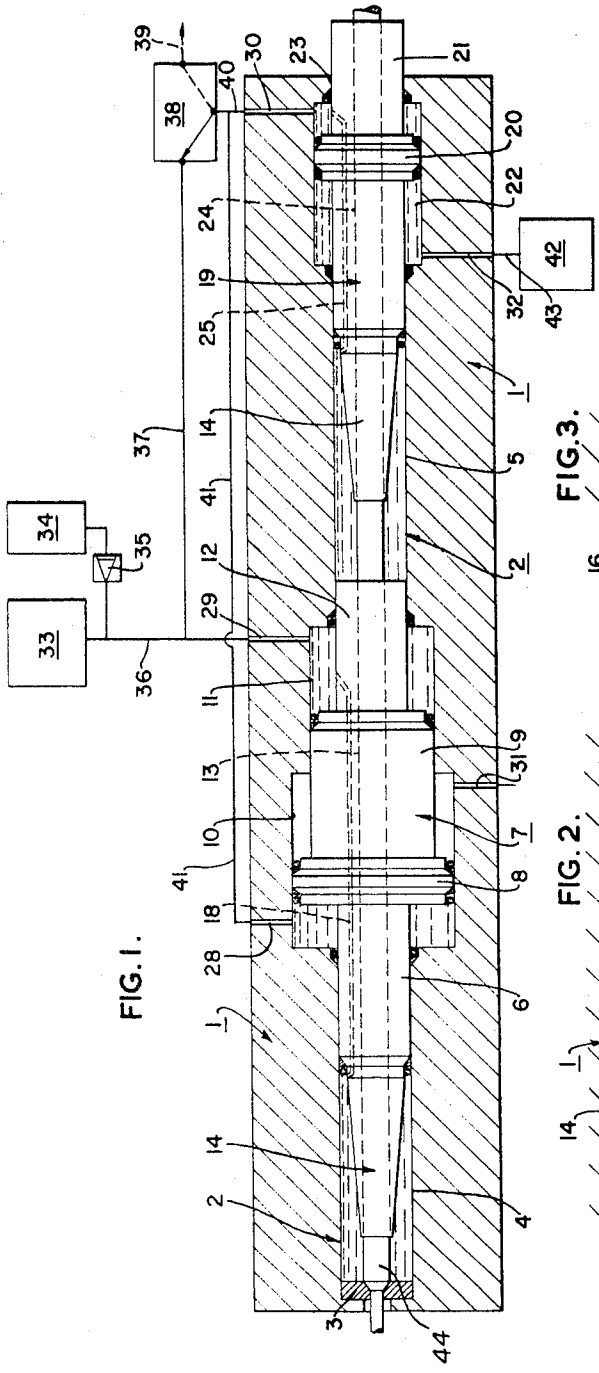


FIG. 1.

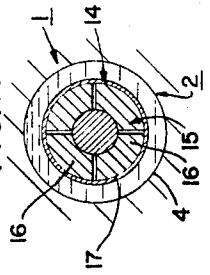


FIG. 3.

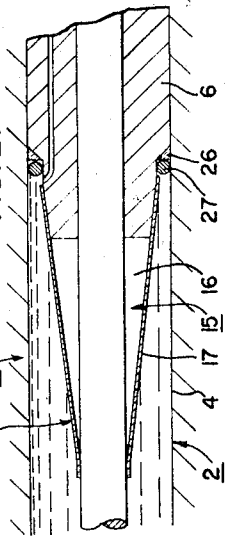


FIG. 2.

United States Patent Office 3,440,849
Patented Apr. 29, 1969

3,440,849

HYDROSTATIC EXTRUSION APPARATUS

Harold Kenyon Hardy, Southport, and Cecil Henry Jones, St. Anne's-on-the-Sea, England, assignors to United Kingdom Atomic Energy Authority, London, England

Filed Jan. 23, 1967, Ser. No. 611,146
Claims priority, application Great Britain, May 13, 1966, 21,389/66
Int. Cl. B21d *22/10;* B21c *33/00*
U.S. Cl. 72—60 2 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for carrying out a continuous hydrostatic extrusion process wherein hydraulic liquid is pressurised about a billet in the bore of an extrusion container to extrude the billet from the container through a die. A billet of longer length than the extrusion container is entered into the bore of extrusion container through two tubular plug members slidably sealed one behind the other in the bore of the extrusion container. Means are provided for clamping the plug members in engagement with a billet when inserted through the plug members into the bore of the extrusion container. Means are also provided for slidably sealing between the plug members and the billet. The billet is continuously extruded through the die by pressurisation of hydraulic liquid in the bore of the extrusion container forward of the front plug member. The plug members are reciprocable in the bore of the extrusion container and are arranged to be in clamping engagement with the billet when moving forward in the bore and to be disengaged from clamping with the billet when moving backwards in the bore. As one plug member is moving forward in the bore in clamped and sealed engagement with the billet the other is moving backwards in the bore disengaged from clamping with the billet.

Background of the invention

This invention relates to extrusion apparatus and in particular to apparatus for carrying out hydrostatic extrusion processes. In a conventional extrusion process a billet held within a container is subjected to a direct mechanical loading to extrude the billet from the container through a die. The billet is a close fit in the container and extrusion pressure is applied on the end face of the billet by a ram operating in the bore of the container. Hydrostatic extrusion has several advantages over conventional extrusion and differs from conventional extrusion in that a liquid is used to apply extrusion pressure on the billet. The liquid envelops the billet in an extrusion container and is pressurised to act directly on the billet. Because the liquid envelops the billet there is no frictional contact between the container and the billet.

Die friction is also reduced because the pressurised liquid adjacent the throat of the die provides hydrodynamic lubrication between the extruding material and the die.

Although the hydrostatic extrusion process has the above advantages compared with conventional extrusion it has the limitation, in general, of only being applicable to the extrusion of billets of short length. Extrusion containers which are capable of withstanding the high internal pressures arising in a hydrostatic extrusion process can only practicably be made of short length which imposes a limitation on the length of billet which can be extruded by the process.

In copending application Serial No. 611,011 there is disclosed apparatus for carrying out a semicontinuous hydrostatic extrusion process comprising an extrusion container having a longitudinal bore with an extrusion die at one end, a plug member slidably sealed in the other rear end of the bore of the extrusion container, said plug member having a longitudinal passageway therethrough for insertion of the leading end of a billet through the plug member into the extrusion container, means for pressurisation of hydraulic liquid in the bore of the extrusion container, means for bleeding liquid from the extrusion container during extrusion of a billet, means for sealing between the plug member and a billet when inserted through the plug member into the extrusion container and clamping means for locking the plug member in engagement with a billet when inserted through the plug member into the extrusion container.

In operation of apparatus in the form described above pressurisation of hydraulic liquid in the extrusion container surrounding the leading end of the billet member gives rise to stress conditions in the billet at the die entry such that the billet is extruded through the die. During extrusion of this length of the billet the plug member is maintained in clamped and sealed engagement with the billet and the plug member is subjected to an external axial loading so that the plug member moves under the axial loading along the bore of the extrusion container towards the die as the leading end of the billet is extruded through the die. When the leading end of the billet has been extruded the clamping and sealing means between the plug member and the billet are released so that the plug member can be drawn back along the bore of the extrusion container away from the die to expose a new length of the billet in the extrusion container.

Repetition of this process allows semicontinuous extrusion of long billets.

Summary of the invention

It is an object of the present invention to provide hydrostatic extrusion apparatus which does not subject limitations on the length of billet which can be extruded and which is suitable for carrying out a continuous hydrostatic extrusion process.

According to the invention apparatus for carrying out a continuous hydrostatic extrusion process comprises an extrusion container having a longitudinal bore fitted at one end with an extrusion die, a first plug member slidably sealed in the bore of the extrusion container, a second plug member slidably sealed in the bore of the extrusion container behind the first plug member, both the first and second plug members having a longitudinal passageway therethrough, whereby the leading end of a long billet is insertable through both the plug members to enter the leading end of the billet into the bore of the extrusion container forward of the first plug member, means for slidably sealing between the first plug member and a billet when inserted through the plug members into the extrusion container, releasable clamping means for locking the first plug member in engagement with said billet, means for slidably sealing between the second plug member and the billet and releasable clamping means for locking the second plug member in engagement with the billet, means for pressurisation of hydraulic liquid in the bore of the extrusion container forward of the first plug member to effect hydrostatic extrusion of the leading end of the billet through the die, means for bleeding of hydraulic liquid from the bore of the extrusion container forward of the first plug member as extrusion of the leading end of the billet proceeds, means for reciprocating the first and second plug members between advanced and withdrawn positions in the bore of the extrusion container whereby as the first plug member is moved forward in the bore of the of the extrusion container towards the die the second plug member is moved backwards in the bore of the extrusion container away from the die and vice versa as the first plug member is moved backwards

in the bore of the extrusion container away from the die the second plug member is moved forwards in the bore of the extrusion container towards the die, the clamping means for locking the first plug member in engagement with the billet being in operation the first plug member is moved forward in the bore of the extrusion container towards the die, whilst the clamping means for locking the second plug member in engagement with the billet are disengaged as the second plug member is moved backwards in the bore of the extrusion container away from the die and vice versa the clamping means of the second plug member being in operation as the second plug member is moved forward in the bore of the extrusion container towards the die whilst the clamping means of the first plug member are disengaged as the first plug member is moved backwards in the bore of the extrusion container away from the die.

In operation of apparatus in accordance with the invention a billet is continuously extruded from the extrusion container through the die by pressurisation of hydraulic liquid in the extrusion container forward of the first plug member.

If for the purposes of explanation the first plug member is considered to be in its withdrawn position in the bore of the extrusion container the second plug member will be in its advanced position in the bore of the extrusion container. In this situation the first plug member is clamped and sealed on the billet and moves along the bore of the extrusion container towards the die from its withdrawn to its advanced position as the leading end of the billet is extruded through the die. At the same time the clamping means between the second plug member and the billet are in a released condition which enables the second plug member to be drawn back along the bore of the extrusion container from its advanced to its withdrawn position, without interferring with extrusion of the billet. When the first plug member reaches its advanced position in the bore of the extrusion container its clamping means are released and the clamping means of the second plug member are engaged. Extrusion of the leading end of the billet continues as the second plug member moves forward in the bore of the extrusion container from its withdrawn to its advanced position in clamped and sealed engagement with the billet, whilst the first plug member is drawn back in the bore of the extrusion container thus exposing a new length of the billet for extrusion from the container forward of the first plug member.

Description of the drawing

One embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

FIGURE 1 is a semischematic longitudinal sectional elevation,

FIGURE 2 is a detail of FIGURE 1 shown on a larger scale,

FIGURE 3 is a section along the line III—III in FIGURE 2.

Description of the preferred embodiment

The apparatus shown in FIGURE 1 of the drawing comprises an extrusion container **1** having a longitudinal bore **2** fitted at one end with an extrusion die **3**. The bore **2** is divided into two parts, a front part **4** and a rear part **5**. A first plug member **6**, slidably sealed in the front part **4** of the bore **2**, has a head **7** stepped in two parts **8** and **9**, the part **8** of the head **7** being of larger diameter than the part **9**. The front part **4** of the bore **2** opens out into a cylinder **10** in which the part **8** of the head of the plug member **6** is slidably sealed. The cylinder **10** connects with a cylinder **11** of smaller diameter in which the part **9** of the head of the plunger **6** is slidably sealed. The head **7** of the plug member **6** has a tail piece **12** which extends from the cylinder **11** into the rear part **5** of the bore **2** in the extrusion container **1**. A longitudinal passageway **13** extends through the plug member **6**, its head **7** and its tail piece **12**. The plug member **6** has clamping and sealing means **14** comprising a conically tapered nose piece **15** which, as shown in FIGURES 2 and 3 is longitudinally divided into four segments **16**. The segments **16** of the nose piece **15** are enclosed by a rubber sealing sleeve **17**. A passageway **18** for liquid, is provided through the plug member **6**, its head **7** and its tail piece **12**. The passageway **18** connects the front part **4** of the bore **2** with the cylinder **11**.

A second plug member **19**, slidably sealed in the rear part **5** of the bore **2**, has a larger diameter head **20** and a tail piece **21**. The rear part **5** of the bore **2** opens out into a cylinder **22** in which the head **20** of the plug member **19** is slidably sealed. The tail piece **21** of the plug member **19** extends rearwardly through an aperture **23** in the end wall of the extrusion container **1**. A longitudinal passageway **24** extends through the plug member **19**, its head **20** and its tail piece **21**. Similarly to the plug member **6** the plug member **19** has clamping and sealing means **14** also comprising a conically tapered nose piece **15** which is divided into four segments **16**, the segments **16** being enclosed by a rubber sealing sleeve **17**. A passageway **25**, for liquid, is provided through the plug member **19**, its head **20** and its tail piece **21**. The passageway **25** connects the rear part **5** of the bore **2** with the cylinder **22**.

The plug members **6** and **19** are slidably sealed in the bore **2** of the extrusion container **1** by copper mitre rings **26** and rubber O-ring seals **27** (see FIGURE 2).

Ducts **28**, **29**, **30**, **31** and **32** are provided through the wall of the extrusion container **1**. The duct **28** connects with the cylinder **10** forward of the head **7** of the plug member **6**. The duct **29** connects with the cylinder **11** behind the head **7** of the plug member **6**. The duct **30** connects with the cylinder **22** behind the head **20** of the plug member **19**. The duct **31** connects with the cylinder **10** behind the part **8** of the head **7** of the plug member **6**. The duct **32** connects with the cylinder **32** forward of the head **20** of the plug member **19**.

Pressurised hydraulic liquid for operation of the apparatus is supplied from a reservoir **33** of liquid which is maintained at a high constant pressure. The reservoir is fed by a high pressure pump **34** through a one way valve **35**. A high pressure line **36** connects the reservoir **33** directly with the duct **29** in the extrusion container **1**. A high pressure line **37** leads from the high pressure line **36** to a two way valve **38**. The valve **38** has an exhaust line **39** and an outlet line **40** which is connected with the duct **30** in the extrusion container **1**. A high pressure line **41** leads from the outlet line **40** of the valve **38** to the duct **28** in the extrusion container **1**. A low pressure pump **42** is connected by a line **43** with the duct **32** in the extrusion container **1**.

In operation of the appartus a billet **44** passes through the longitudinal passageway **24** in the plug member **19** and enters the part **4** of the bore **2** in the extrusion container **1** through the longitudinal passageway **13** in the plug member **6**. In the condition of the apparatus as shown in FIGURE 1 hydraulic liquid under high pressure is supplied from the reservoir **33** through the duct **29** into the cylinder **11** behind the part **9** of the head **7** of the plug member **6**. The pressure of the hydraulic liquid in the cylinder **11** is transmitted to the hydraulic liquid in the part **4** of the bore **2** forward of the plug member **6** through the longitudinal passageway **18** in the plug member **6**. The pressure in the hydraulic liquid forward of the plug member **6** acts on the outside of the rubber sheath **17** which encloses the segments **16** of the clamping and sealing means **14** associated with the plug member **6**. Thus the rubber sleeve **17** seals on the billet **44** and the segments **16** of the clamping and sealing means **14** are forced radially inwards into clamping engagement with the billet **44**. The valve **38** is in adjustment such that the line **37** from the reservoir **33** is shut off and the lines

40 and 41 from the ducts 30 and 38 are connected to exhaust through the valve 38 and the exhaust line 39. The plug member 6 is dimensioned so that the annular area of the part 9 of its head 7 which is exposed to the pressure of hydraulic liquid in the cylinder 11 is larger than the cross sectional area of the part 4 of the bore 2 forward of the plug member 6. Thus the plug member 6 is loaded axially towards the extrusion die 3 and exerts an axial thrust on the leading end of the billet 44 forward of the plug member 6. The pressure of the hydraulic liquid, surrounding the leading end of the billet 44 and the axial thrust applied on this length of the billet by the loading of the plug member 6 sets up stress conditions in the billet at the die entry so as to cause extrusion of the billet through the die 3. As extrusion proceeds the loading on the plug member 6 causes it to move into the part 4 of the bore 2 towards the die 3 and hydraulic liquid is expelled from the part 4 of the bore 2 through the passageway 18 in the plug member 6 into the cylinder 11 behind the head 7 of the plug member 6. At the same time hydraulic liquid in the cylinder 10 forward of the head 7 of the plug member 6 is expelled through the line 41 to the exhaust line 39 of the two way valve 38. Meanwhile as the plug member 6 is moving forward in the part 4 of the bore 2 the plug member 19 is retracted along the part 5 of the bore 2. The plug member 19 is retracted by feed of low pressure hydraulic liquid 46 from the low pressure pump 42 into the cylinder 22 forward of the head 20 of the plug member 19. Hydraulic liquid in the cylinder 22 behind the head 20 of the plug member 19 is expelled through the line 40 to the exhaust line 39 of the valve 38. As the plug member 19 is retracted hydraulic liquid is transferred through the passageway 25 in the plug member 19 from the back end of the cylinder 22 to the part 5 of the bore 2 forward of the plug member 19. As the hydraulic liquid in the back end of the cylinder 22 is at low ambient pressure the hydraulic liquid in the part 5 of the bore 2 will also be at ambient pressure and the clamping and sealing means 14 associated with the plug member 19 will be inoperative so that the plug member 19 can be retracted without hinderance by the billet 44.

When the plug member 6 reaches a fully advanced position in the part 4 of the bore 2, the plug member 19 will be in a fully retracted position in the part 5 of the bore 2. At this point the two way valve 38 is operated to disconnect the back end of the cylinder 22 from the exhaust line 39 and to connect this part of the cylinder 22 with the reservoir of high pressure liquid 33 through the lines 40, 37 and 36. Thus pressure is applied in the hydraulic liquid contained in the cylinder 22 behind the head 20 of the plunger 19. This pressure is transmitted to the hydraulic liquid in the part 5 of the bore 2 through the passageway 25 in the plug member 19. The pressure of the hydraulic liquid in the part 4 of the bore 2 acts on the rubber sheath 17 enclosing the segments 16 of the clamping and sealing means 14 associated with the plug member 19. Thus the rubber sheath 17 is pressed into sealing engagement with the billet 44 and the segments 16 are forced radially inwards into clamping engagement with the billet 44.

Extrusion of the billet 44 continues without interruption because the hydraulic liquid in the part 4 of the bore 2 forward of the plug member 6 always remains pressurised by connection with the reservoir of pressurised liquid 33 and because pressure of the hydraulic liquid acting in the cylinder 22 behind the head 20 of the plunger 19 loads the plunger 19 axially to exert an axial thrust on the length of the billet 44 forward of the plnger 19. During this stage of extrusion the loading on the plug member 19 causes it to move forward in the part 5 of the bore 2 and as the plug member 19 moves forward hydraulic liquid is transferred from the part 5 of the bore 2 through the passageway 25 in the plug member 19 into the cylinder 22 behind the head 20 of the plug member 19. Also the pressure of the hydraulic liquid contained by the part 5 of the bore 2 is transmitted through hydraulic liquid in the space between the billet 44 and the longitudinal passageway 13 in the plug member to act on the inside of the rubber sheath 17 of the clamping and sealing means 14 associated with the plug member 6. The pressure of the hydraulic liquid acting on the inside of the rubber sheath 17 counterbalances the pressure of the hydraulic liquid acting in the part 4 of the bore 2 on the outside of the rubber sheath 17. Thus the clamping and sealing means 14 associated with the plug member 5 are made inoperative. Change over of the valve 38 also connects the cylinder 10 forward of the head 7 of the plug member 6 with the reservoir of pressurised liquid 33 through the line 41. Pressure of the hydraulic liquid acting in the cylinder 10 on the head 7 of the plug member 6 retracts the plug member 6 from the part 4 of the bore 2. As the plug member 6 is retracted hydraulic liquid is transferred from the cylinder 11 through the passageway 18 in the plug member 6 into the part 4 of the bore 2 forward of the plug member 6.

Repetition of the above cycle of operation enables continuous extrusion of the whole length of the billet. The apparatus enables the production of long extrusions as no limitation is imposed on the length of billet which can be used and new lengths of billet may be joined on to the back end of a preceding billet as it is extruded.

The degree of axial loading which is applied on the billet 44 by the plug members 6 and 19 depends on their dimensions. For example if the plug member 6 is dimensioned so that the annular area of the part 9 of its head 7 which is exposed to the pressure of hydraulic liquid in the cylinder 11 is equal to the cross sectional area of the part 4 of the extrusion chamber bore 2 then the billet 44 will be subjected to zero loading by the plunger 6 and the billet 44 will be subjected to simple hydrostatic extrusion. However if the annular area of the part 9 which is exposed to the pressure of the hydraulic liquid is greater than the cross sectional area of the part 4 of the bore 2 then an axial thrust will be applied on the billet 44 thus augmenting the forces acting to extrude the billet through the die 3. The greater the annular area of the part 9 of the plug member 6 compared with the cross sectional area of the part 4 of the bore 2 the greater the axial loading applied on the billet. Similar considerations apply to the plug member 19.

We claim:

1. Apparatus for carrying out a continuous hydrostatic extrusion process comprising an extrusion container having a longitudinal bore fitted at one end with an extrusion die, a first plug member slidably sealed in the bore of the extrusion container, a second plug member slidably sealed in the bore of the extrusion container behind the first plug member, both the first and second plug members having a longitudinal passageway therethrough, whereby the leading end of a long billet is insertable through both the plug members to enter the leading end of the billet into the bore of the extrusion container forward of the first plug member, means for slidably sealing between the first plug member and a billet when inserted through the plug members into the extrusion container, releasable clamping means for locking the first plug member in engagement with said billet, means for slidably sealing between the second plug member and the billet and releasable clamping means for locking the second plug member in engagement with the billet, means for pressurisation of hydraulic liquid in the bore of the extrusion container forward of the first plug member to effect hydrostatic extrusion of the leading end of the billet through the die, means for bleeding of hydraulic liquid from the bore of the extrusion container forward of the first plug member as extrusion of the leading end of the billet proceeds, means for reciprocating the first and second plug members between advanced and withdrawn positions in the bore of the extrusion container whereby as the first plug

member is moved forward in the bore of the extrusion container towards the die the second plug members is moved backwards in the bore of the extrusion container away from the die and vice versa as the first plug member is moved backwards in the bore of the extrusion container away from the die the second plug member is moved forwards in the bore of the extrusion container towards the die, the clamping means for locking the first plug member in engagement with the billet being in operation as the first plug member is moved forward in the bore of the extrusion container towards the die, whilst the clamping means for locking the second plug member in engagement with the billet are disengaged as the second plug member is moved backwards in the bore of the extrusion container away from the die and vice versa the clamping means of the second plug member being in operation as the second plug member is moved forward in the bore of the extrusion container towards the die, whilst the clamping means of the first plug member are disengaged as the first plug member is moved backwards in the bore of the extrusion container away from the die.

2. Apparatus for carrying out a hydrostatic extrusion process comprising an extrusion container defining a longitudinal bore, the longitudinal bore having a forward section separated from a rear section by a main cylinder of larger diameter defined in the extrusion container, an extrusion die fitted in the front end of the forward section of the longitudinal bore, a first plug member entering the forward section of the longitudinal bore from the main cylinder and slidably sealed in the forward section of the longitudinal bore, said first plug member having a head slidably sealed in the main cylinder, a tail piece extending rearwardly from the head of the first plug member and entering the rear section of the longitudinal bore, the tail piece being slidably sealed in the rear section of the longitudinal bore and being of smaller diameter than the head of the first plug member, the rear section of the longitudinal bore opening out at its back end into a back cylinder of larger diameter, a second plug member entering the rear section of the longitudinal bore from the back cylinder and slidably sealed in the rear section of the longitudinal bore, said second plug member having a head slidably sealed in the back cylinder, a tail piece extending rearwardly from the head of the second plug member and slidably sealed in passage out of the rear end of the back cylinder, said tail piece being of smaller diameter than the head of the second plug member, a longitudinal passageway being defined passing through the first plug member its head and its talipiece, a longitudinal passageway being defined passing through the second plug

member its head and its tailpiece whereby the leading end of a long billet is insertable through the passageways in both the first and second plug members to enter the leading end of the billet into the forward section of the longitudinal bore, means for slidably sealing between such a billet and the end of the first plug member inside the forward section of the longitudinal bore, means for slidably sealing between said billet and the end of the second plug member inside the rear section of the longitudinal bore, means for continuously applying pressure in hydraulic liquid in the main cylinder behind the head of the first plug member, means for applying a similar pressure in hydraulic liquid in the main cylinder forward of the head of the first plug member and in the back cylinder behind the head of the second plug member, means for connecting the main cylinder forward of the head of the first plug member, and the back cylinder behind the head of the second plug member to exhaust whilst maintaining pressure in the hydraulic liquid in the main cylinder behind the head of the first plug member, means for applying pressure in hydraulic liquid in the back cylinder forward of the head of the second plug member, means connecting the main cylinder behind the head of the first plug member with the forward section of the longitudinal bore to transmit the pressure of hydraulic liquid in the main cylinder behind the head of the first plug member to hydraulic liquid in the forward section of the longitudinal bore, means connecting the back cylinder behind the head of the second plug member with the rear section of the longitudinal bore to transmit the pressure of hydraulic liquid in the back cylinder behind the head of the second plug member to hydraulic liquid in the rear section of the longitudinal bore, clamping means operated by the pressure of hydrulic liquid in the forward section of the longitudinal bore, for locking the first plug member in engagement with a billet when inserted through the passageways in the first and second plug members into the forward section of the longitudinal bore and clamping means, operated by the pressure of hydraulic liquid in the rear section of the longitudinal bore, for locking the second plug member in engagement with said billet.

References Cited

UNITED STATES PATENTS

2,558,035	6/1951	Bridgman	72—60
3,328,998	7/1967	Sabroff et al.	72—362

RICHARD J. HERBST, *Primary Examiner.*

U.S. Cl. X.R.

72—270