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(54) FRICTION-ASSISTED HOT EXTRUSION METHOD FOR PRODUCING HOLLOW ARTICLES AND A HYDRAULIC PRESS FOR CARRYING OUT SAID METHOD

(57) A process for the hot extrusion of hollow articles with the active assistance of friction forces, consisting in that a hollow billet (1) undergoing extrusion is preheated and placed in a bush (2) of a container (3), and into this bush a mandrel (4) is passed through the cavity of this billet (1), and then this billet is extruded, with the aid of a short ram (6) while simultaneously moving the container (3), mandrel (4) and short ram (6), through an annular gap which is formed by the channel walls of the die (5) and by the mandrel (4) and which determines the shape and geometrical dimensions of the finished article, it being the case that in the process of extrusion the speed Vc of movement of the container (3) and speed Vm of movement of the mandrel (4) exceed the speed Vr of movement of the short ram (6).

A hydraulic extrusion press, comprising front (10) and rear (11) cross beams rigidly mounted on a frame (9), a container (3) having the possibility of reciprocating movement along the longitudinal axis of the press, a main moving crosspiece (13) on which a plunger is rigidly mounted, at least one main power cylinder whose body (19) is mounted in a stationary fashion on the rear (11) cross beam, and also an auxiliary cylinder which is connected to the main moving crosspiece (13) and to whose plunger (30) there is rigidly attached a hollow short ram (6) constructed in one piece with a die-plate (33) and in whose cavity there is arranged a mandrel (4) with a mandrel holder (36) fitted with a plunger (35) of the power cylinder and with its own moving crosspiece (37).

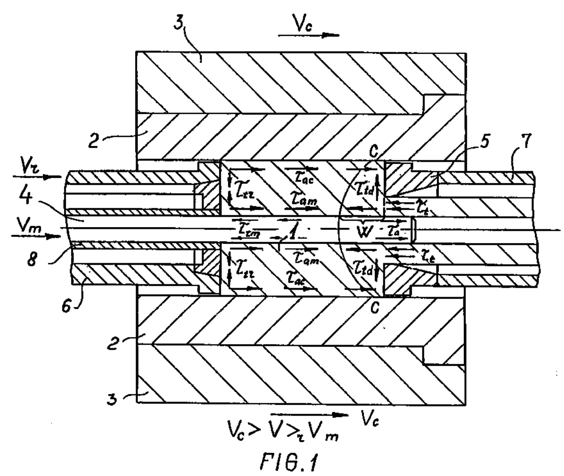

FIG.1

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Description

Technical field

The invention relates to the field of processing metals by pressure, specifically to a process for the hot extrusion of hollow articles with the active assistance of friction forces, and to a hydraulic press for implementing this process, and can be used to provide hollow articles which are widely applied in the aircraft industry, chemical engineering, ship-building etc.

Prior art

The conventional process for the hot extrusion of hollow articles (cf. the company brochure "Strang- und Rohrpressanlagen" ["Extrusion presses and tube-extruding presses"], SMS Schloemannsiemag Aktiengesellschaft, Düsseldorf und Hilchenbach. 1000/12/81. Printed in the Federal Republic of Germany by Servicedruck Kleinherne K. G. Düsseldorf), includes the following operations: heating a hollow billet in a furnace, feeding it into a container, passing a mandrel through the cavity of the billet and extruding the billet with assistance of a ram through an annular gap formed by the channel walls of a die and by the mandrel, while simultaneously moving the ram, mandrel and container. The articles obtained are transported onto a cooling table and the remaining butt-end is separated from the die and placed in the waste. This is termed the indirect process with moving mandrel.

In case of this process, there is no need to overcome the friction forces between the container and billet, and between the mandrel and the part of the billet on the section from the die-plate to the reduction zone, with the result that substantially less energy expenditure is required to implement the indirect process.

However, when extruding articles in conditions of the absence of friction no renewal of the surface layers of the billet takes place. The quality of the surface of such an article depends on the state of the surface of the initial billet.

The articles obtained do not have internal defects, but extrusion requires billets with processed internal and external surfaces, what raises the costs of production.

However, in view of the presence of a significant speed gradient in the pressing-out part of the plastic zone, the process of extrusion described above is characterized by a nonuniformity of the metal structure and unevenness of physicomechanical properties along the length and over the cross-section of the articles.

Moreover, the quality of the surface of the articles deteriorates because of the removal of the action of shear deformations and the origination of significant tensile stresses on the surface of the articles, which can lead to the occurrence of cracks.

A press has been disclosed for implementing the process described above (cf. the company brochure "SMS Hasenclever". Fachbericht. Strang- und Rohrpressen. Aufbau und Arbeitsweise einer neuen Indirekt Strang- und Rohrpresslinie für Aluminium. ("SMS Hasenclever". Technical report on extrusion presses and tube-extruding presses. Design and mode of operation of a new indirect line of extrusion presses and tube-extruding presses for aluminium. Special Edition Aluminum 60 (1984) 6, pages 424/430". SMS Hasenclever Maschinenfabrik GmbH. Witzelstrasse 55, PO Box 5529 D-4000 Düsseldorf 1), which comprises a container which is mounted on a frame and has the possibility of reciprocating movement along its longitudinal axis, and a crosspiece to which there is rigidly attached a hollow plunger of a main power cylinder mounted in a stationary fashion on a rear cross beam. A cylinder with a plunger of a power drive for moving a mandrel is arranged inside the plunger of the main power cylinder. Mounted on the rear crossbeam are two cylinders for moving the container, whose plungers are rigidly attached to the container. Rigidly attached to the crosspiece is a hollow ram which comes into contact with the container and seals the container in the process of extrusion. Arranged coaxially with the container at its other side is a hollow long ram which is attached in a stationary fashion to the front crosspiece. The inner spaces of the power hydraulic cylinders are connected through a distribution box to high-pressure and low-pressure mains.

The heated billet is gripped by a tong-type feed mechanism and raised onto the axis of the press. The billet is pushed partly into the container by an idle stroke of the container in the direction of the feed mechanism. The mandrel is then passed into the hole of the billet, after which the feed mechanism is removed to the initial position.

The final feeding of the billet into the space of the liner of the container is done by moving the container. Thereafter, the die is fed onto the hollow ram, and the process of extrusion by the indirect method begins.

The return cylinders of the movement of the container are opened, and fluid is fed at high pressure into the main and power cylinders of the mandrel. Under the action of the ram (locking ram), the billet starts to be extruded through the gap between the channel walls of the die and the mandrel. At this moment, the speeds of the crosspiece, container and mandrel are equal, since the locking ram moves the container while, under the constant action of the fluid at high pressure on the plunger of the cylinder of the mandrel, the latter stays in the extreme front position and therefore moves at the speed of the crosspiece. The process is ceased after the prescribed size of the butt-end has been reached. The butt-end is pressed out from the container with the help of cylinders for moving container and detached. The articles are removed and the cycle is repeated.

The above-described process does not permit the provision of hollow articles with improved quality of the inner and cuter surfaces, and the design of the press does not permit the extrusion of metals with the active assistance of friction forces. Consequently, articles are produced with a worse quality of the inner and outer surfaces and a lower level of mechanical properties by comparison with the direct process. It is not possible using this press to achieve significantly high rates of metal outflow by comparison with the said direct process.

Another process for the hot extrusion of hollow articles has been disclosed, which permits an improvement in the quality of the inner surface of hollow articles by means of applying a free-floating (non-attached) mandrel (cf., for example, the article by Laue K. Zeitschrift für Metallkunde, 1959, No. 9, page 495).

In contrast to the indirect process with a moving mandrel, in this process the mandrel is not attached and has a possibility of free axial movement in the direction of the metal outflow.

In the process of extrusion of hollow articles, depending on the relationship of the friction forces acting on the mandrel, at the initial stage the latter moves at the speed of the ram. In this case, forces of friction that oppose the action τ_t are induced on the surface of the billet in the plastic zone near the die's channel (the bounds of the zone are marked in Figure 1 by the line C-C), while friction forces of active assistance τ_a are induced on the surface of the mandrel within the limits of the reduction zone. Under the action of all these forces, the mandrel tends to move in the direction of the metal outflow, but at the initial stage of the process these forces are insufficient because of the large size of the contact surface, and so the mandrel moves at the speed of the ram. As the contact surface of the billet decreases in the process of extrusion, the mandrel gradually begins to lead the ram, inducing on the surface of the billet friction forces of active assistance τ_{am} at the part from the ram to the reduction zone (C-C). In this case, the speed of the mandrel gradually increases and tends to the rate of the metal outflow, what leads to intensification and localization of the shear deformation and, as a result, to increased structural nonuniformity manifested in the form of a macrocrystalline ring. The use of non-attached mandrels permits a substantial increase in the quality of the inner surface of hollow articles at a limited part of their length, chiefly at the final stage of the process. Thus, the biggest part of the hollow article is produced with quality of the inner surface equal to the one obtained under indirect process.

Another method for the hot extrusion of hollow articles with the active assistance of friction forces (cf. the article "Friction-Assisted Extrusion of Aluminum Alloys: A Review of the Russian Literature" by Dr. Joseph C. Benedik, Light Metal Age, August, 1983, pp. 17-18), is known that consists in the following. A hollow billet intended for extrusion is heated, placed in a container and then, by means of a joint movement of a short hollow ram, in which there is arranged a non-attached mandrel, and a container, is extruded into a gap between the channel walls of the die and the mandrel. In the process of extrusion, the container is moved at a speed higher than the speed of movement of the ram, while the speed of the non-attached mandrel gradually increases from the speed of the ram to the rate of the metal outflow.

Throughout the course of the process, friction forces of active assistance τ_{ac} are induced on the outer surface of the billet from the container side, while similar forces τ_{am} are induced on the inner surface of the billet after a certain part of the billet has been pressed out, when the condition is met for the speed of the mandrel to exceed the speed of the ram. Such kinematic conditions permit to somewhat equalize the rates of metal flow in the gap between the channel walls of the die and mandrel, what makes it possible to produce articles of higher quality.

It has been established by experiment that the efficiency of the given process depends on the conditions of interaction of the container and mandrel with the billet. That is why, during extrusion, when the speeds of the container and mandrel substantially exceed the speed of the short ram, an excessive shear is observed in the surface contact layers of the billet. This circumstance causes an intensive flow of the surface contact layers of the billet in the direction of the die, what results in reduction of the permissible rate of extrusion, in structural non-uniformity and worsening of quality of the hollow articles, for example tubes. Moreover, the selection of a high ratio of the speed of movement of the container and mandrel to the speed of movement of the ram requires a reduction in the starting length of the billet, which leads to a drop in productivity of the press, or requires an increase in the length of the container and mandrel, which makes the press more complicated in design and more expensive and leads to a reduction in the durability of the mandrels.

A press for extrusion of hollow articles (tubes) with the use of the active assistance of friction forces has been disclosed (cf. the article by Ya. M. Okhrimenko et. al. "Equipment for Investigation of Extrusion with active friction", "Steel in the USSR", October, No. 11, 1976, pages 897-898).

The press comprises a frame on which there is mounted an upper cross beam and a lower cross beam. Mounted on the upper cross beam is a main power cylinder consisting of a cylindrical body in whose inner space there is arranged a plunger which is rigidly attached to a moving crosspiece. Mounted on the lower crossbeam are return power cylinders for moving the crosspiece, whose plungers are rigidly attached to the latter. Mounted on the crosspiece is an auxiliary cylinder consisting of a cylindrical body in whose inner space a plunger is arranged. Rigidly attached to the plunger is a hollow ram with a die-plate. Arranged inside the ram is a spring-loaded mandrel having the possibility of moving inside the cavity of the short ram under the action of the discharging metal. Mounted on the moving crosspiece is a container, while a hollow ram with a die is mounted on the lower cross beam. The main and return power cylinders are connected through valves to the high-pressure and low-pressure mains. An auxiliary cylinder is connected through a restrictor to the low-pressure main.

In the initial position, the plunger of the auxiliary cylinder is moved out of the cylinder to the maximum extent, while the mandrel is withdrawn to the extreme upper position with the aid of the spring.

The heated hollow billet is fed onto the axis of the press and pushed into the container with the aid of the hollow long ram with the die on it. In this case, the mandrel passes through the cavity in the die. Fluid at high pressure is fed into the main power cylinder and the crosspiece is lowered together with the container. Extrusion is started. At this instant, the speeds of the container, mandrel and ram are identical. The process of reverse extrusion takes place. After the start of metal outflow, the restrictor is being opened and fluid starts to enter the low-pressure main from the auxiliary cylinder. The plunger of the auxiliary cylinder pulls in, which ensures displacement of the container relative to the billet. Friction forces of active assistance τ_{ac} are induced to the lateral surface of the billet. In case of the extrusion of tubes in accordance with this pattern, the speed of movement of the mandrel relative to the billet changes as the process goes on.

The given press permits the extrusion process to be carried out using the two-sided active assistance of friction forces.

At the same time, in order to achieve high productivity of the press, to obtain high quality of the inner surface of the hallow articles and to ensure high level of the physicomechanical properties of the articles, it is necessary in the process of extrusion to keep the speeds of movement of the container and ram at an optimum ratio. The given press does not permit this ratio to be kept precisely. The speed of movement of the container relative to the ram is controlled by releasing fluid from the auxiliary cylinder into the low-pressure main through the restrictor.

On the given press, it is necessary for the restrictor to be opened and closed in succession in the course of extrusion. In case of deviation of the ratio of the speeds or movement of the container and ram from the optimum, it is possible to get hollow articles having defects (cracks, nonuniform distribution of the metal structure and physicomechanical properties along the length of the articles).

The pattern of variation in the speed of movement of the non-attached mandrel arranged inside the cavity of the short ram does not permit friction forces of active assistance to be induced to the inner surface of the hollow article throughout the course of the process, which means that for some part of the hollow article pressed out under these conditions the quality of the inner surface is low and in no way different from the quality achieved in the process of extruding hollow articles with a moving mandrel when the speeds of the mandrel and short ram are equal. However, the concluding stage of the process is characterized by the formation of higher quality of the inner surface of the hollow articles in comparison with the initial stage. A sharp rise in the speed of the mandrel and gradual approach of that speed to the rate of the metal outflow leads to localization of the shear deformation at the concluding stage and, as a result, to structural nonuniformity in the rear part of the hollow article.

Disclosure of the invention

It is the goal of the present invention to provide such a process for the hot extrusion of hollow articles with the active assistance of friction forces and a hydraulic extrusion press for implementing it, which by virtue of an optimum ratio of the speeds of movement of the container, ram and mandrel would permit a significant increase in the productivity of the press for providing hollow articles in conjunction with a simultaneous increase in their physicomechanical properties, the quality of the inner surface and the accuracy of the geometry.

This goal is achieved by virtue of the fact that during hot extrusion of hollow articles with the active assistance of friction forces, a hollow billet undergoing extrusion is preheated and placed in a container's bush, into which a mandrel is passed through the cavity of this billet, and then is extruded, with the aid of a short ram while simultaneously moving the container, mandrel and short ram, through an annular gap which is formed by the mandrel in the channel of the die and which determines the shape and geometrical dimensions of the finished article, and in accordance with the invention in the process of extrusion the speeds of movement of the container and the mandrel exceed the speed of movement of the short ram.

This permits an increase in the productivity of the process by comparison with all known processes, an increase in quality of the inner and outer surfaces of the hollow articles and in the level of their mechanical properties.

In the process of extrusion, the speed of movement of the container can exceed the speed of movement of the short ram by approximately 1.03-1.4 times. This permits a significant increase in the productivity of the process of extrusion and an increase in the level of the dispersity of the structure of the billet.

In the process of extrusion the speed of movement of the mandrel can exceed the speed of movement of the short ram by approximately 1.01-1.05 times.

This provides the possibility of increasing the quality of the inner surface along the entire length of the hollow article as a function of the thickness of the wall and the adhesive properties of the material being extruded.

In the process of extrusion, the speed of movement of the container can exceed the speed of movement of the mandrel by approximately 1.02-1.33 times. This provides the possibility of an additional increase in the uniformity of the metal flow, and of ensuring the provision of hollow articles with a prescribed distribution of physicomechanical properties over the cross-section of the hollow article.

In the process of extrusion, the ratios of the speed of movement of the container and the speed of movement of the short ram, and the ratios of the speed of movement of the mandrel and the speed of movement of the short ram are varied. This provides the possibility of controlling the volumetric effect of the active assistance of friction forces throughout all stages of the process while maintaining quasi-steady-state conditions of flow of the material being deformed, which in turn permits an increase in the uniformity of the distribution of the physicomechanical properties of the material of the article along its length.

In the process of extrusion, the ratio of the speed of movement of the container and the speed of movement of the short ram is reduced approximately from 1.4 to 1.01 times as a function of the value of the reduction ratio of the hollow article.

It is thus possible to provide hollow articles with a prescribed distribution of mechanical properties along the length of the finished articles.

In the process of extrusion, it is possible for the ratio of the speed of movement of the mandrel and the speed of movement of the short ram to be reduced approximately from a value of 1.05 to 1.01.

This provides the possibility of increasing the quality of the inner surface of the hollow article along the entire length of the article as a result of reduction in the degree of slippage of the mandrel relative to the billet.

In the process of extrusion, the speed of movement of the short ram can be varied as a function of the distribution of the temperature gradient along the length of the billet.

This provides the possibility of equalizing the distribution of the physicomechanical properties along the length of the hollow articles.

In this case, it is expedient to heat the front end face of the billet in the temperature range from 0.75 to 0.90 of the upper bound of the temperature interval for the processing ductility of the material being extruded, and to heat the rear end face of the billet in the temperature range from 0.6 to 0.7 of the upper bound of the temperature interval for the processing ductility as a function of the thickness of the wall of the billet.

This also additionally permits the productivity of the process to be increased by up to approximately 20% and the distribution of the physicomechanical properties along the length of the articles to be equalized.

Before extrusion, the container is heated up in the range from 1 to 0.95 of the temperature of the heated front end face of the billet.

This additionally permits an increase in the level of implementation of the active assistance of friction forces, a decrease in the slippage of the bush relative to the billet, and also the prevention of cooling of the rear end face of the billet, which cooling is produced as a result of the interaction of the end face with the short ram.

In the process of extrusion, the mandrel is imparted a cyclic translational movement in the direction of metal outflow because of cyclic loading.

This prevents the adherence of the material being extruded to the mandrel, which increases the durability of the mandrel and also improves the quality of the inner surface of the hollow article.

This goal is achieved on a hydraulic extrusion press for providing hollow articles that comprises front and rear cross beams rigidly mounted on a frame, a container having the possibility of reciprocating movement along the longitudinal axis of the press, a main moving crosspiece on which a plunger is rigidly mounted, at least one main power cylinder whose body is mounted in a stationary fashion on the rear cross beam; the inner space of the main cylinder being connected to a high-pressure main and a low-pressure main, and also an auxiliary cylinder connected to the main moving crosspiece, and an inner space of the auxiliary cylinder communicating through a restricting unit with the low-pressure main only, and also to whose plunger there is rigidly attached a hollow short ram constructed in one piece with a die-plate and in whose cavity there is arranged a mandrel with a mandrel holder fitted with a plunger of the power cylinder of the mandrel and with its own moving crosspiece mounted inside the main moving crosspiece, while the mandrel holder itself simultaneously being attached to the plunger of the power cylinder of the mandrel and on the crosspiece thereof, a hollow long ram also being arranged coaxially with the short ram and connected to the front cross beam, and also, according to the invention, the said press includes a control unit for setting up pressing regimes, a drift-pin with a flange which are mounted inside the short ram and are rigidly connected to the cylindrical bush, which has collars arranged correspondingly on its inner and outer surfaces, a spring-loaded element being arranged between the body of the short ram and the outer surface of this bush, and the mandrel, which is arranged inside the drift-pin, having a cylindrical collar whose diameter corresponds to the diameter of the inner cavity of the cylindrical bush, and being fitted with a stem rigidly connected to the mandrel holder.

This ensures the automatic fulfillment of predetermined kinematic regimes for operating the press in the process of extrusion, and excludes the penetration of metal between the mandrel and ram.

The plunger of the auxiliary cylinder is mounted inside the main moving crosspiece, and constructed to be hollow and fitted with a centering stem passing through the base of the cylindrical body of the auxiliary cylinder.

This permits the provision of the required ratio of the speeds of movement of the container and short ram, and an improvement of the centering and simplification of the design.

The basic restricting unit of the auxiliary cylinder comprises at least one stabilizing cylinder which is a cylindrical body in whose inner space a plunger is arranged, and one of the said elements of the stabilizing cylinder is attached to the rear cross beam while the other is rigidly connected to the main moving crosspiece, the inner space of the stabilizing cylinder communicating hydraulically with the inner space of the auxiliary cylinder.

This ensures the automatic provision of the optimum ratio of the speed of movement of the container and speed of movement of the short ram in the process of extrusion.

In case of a given constant value of the ratio of the speed of movement of the container and the speed of movement of the short ram, the area F_2 of the cross-section of the stabilizing cylinder can be equal to $F_2=F_1(1-1/K_{V1})$, where:

F_1 is the area of the cross-section of the auxiliary cylinder;
F_2 is the area of the cross-section of the stabilizing cylinder;
K_{V1} is the value of the ratio Vc/Vr of the speed Vc of movement of the container and the speed Vr of movement of the short ram.

The length H_1 of the working space of the auxiliary cylinder is equal to:

$$H_1=Hp(1-1/K_{V1}),$$

where:

H_1 is the length of the working space of the auxiliary cylinder;
Hp is the maximum length of the working stroke of the stabilizing cylinder.

This permits the provision of the required ratio of the speed of movement of the container and the speed of movement of the short ram.

It is expedient that in case of a constant value of the ratio of the speed of movement of the container and the speed of movement of the short ram, a maximum value of this ratio is determined starting from the total areas of the cross-sections of all pairs of cylinders stabilizing the speed of movement of the short ram.

This ensures the provision of the required ratio of the speed of movement of the container and speed of movement of the short ram.

The hydraulic extrusion press can include at least two booster return cylinders of which each is constructed in the form of a cylindrical body in whose inner space a plunger is arranged, and one of the said elements of each booster return cylinder is attached in a stationary fashion to one of the cross beams while the other is rigidly connected to the main moving crosspiece, and the inner space of each of them communicates with the low-pressure and high-pressure mains, and the inner space of each booster return power cylinder is hydraulically connected to the inner space of the auxiliary cylinder.

This permits a significant saving on high-pressure fluid and makes it possible to return the main moving crosspiece to the initial position.

The hydraulic press can include one pair of mandrel's return cylinders, each consisting of a cylindrical body and plunger, one of the elements of each cylinder being attached to the main crosspiece while the other to the moving crosspiece of the mandrel.

This makes it possible to ensure the control of the speed of movement of the mandrel in accordance with a given kinematic law.

Moreover, the press can include an intermediate moving crosspiece which is rigidly connected to the plunger of the auxiliary cylinder, and intermediate cylinders, each of which consists of a cylindrical body and plunger, here the body of each cylinder is arranged on the main moving crosspiece while every plunger is rigidly connected to the intermediate moving crosspiece.

This provides a possibility of stabilizing the speed with which the mandrel is withdrawn backwards and of extending the processing characteristics of the press.

The cylinders for stabilizing the movement of the mandrel are the booster return power cylinders consisting of a cylindrical body and plunger, one of the elements of each cylinder is rigidly connected to the rear cross beam while the other is also rigidly connected to the main moving crosspiece.

It is possible thereby to simplify the design of the press and to construct it in a compact way, and also to extend the range of variation of the kinematic coefficient.

The inner space of the intermediate cylinder communicates with the inner space of the return cylinder of the mandrel, while the inner space of the power cylinder of the mandrel is hydraulically connected to the inner space of the booster return cylinder.

It is possible thereby to simplify the control of the press.

Moreover, the inner spaces of the return cylinders of the mandrel and of the power cylinder of the mandrel are hydraulically connected through corresponding valves to the high-pressure and low-pressure mains.

This permits saving on high-pressure fluid and makes it possible to simplify the control of the press.

The main, connecting the inner spaces of each stabilizing cylinder and booster return cylinders that are hydraulically connected to the inner space of the auxiliary cylinder, communicates, in addition to this, with the high-pressure and low-pressure mains through corresponding valves.

It is possible thereby to simplify the control of the press.

The hydraulic extrusion press can include at least one auxiliary restricting unit having a body with inlet and outlet holes fitted with at least one cover, there being mounted inside this unit a slide valve, backed by a spring at the cover end and having two through cavities, the configuration and geometrical dimensions of each of which determine the value of the speed of mutual movement of the container and short ram and also of the mandrel and short ram, one through cavity being hydraulically connected through corresponding holes to the inner space of the auxiliary cylinder and the low-pressure main, and the other through cavity being hydraulically connected through other corresponding holes to the inner space of the power cylinder of the mandrel and also to the low-pressure main.

This makes it possible to get variable values of the ratios of the speeds of movement of the container, short ram and mandrel in the course of the process.

Moreover, the slide valve of the auxiliary restricting unit has a window of variable cross-section inside which connecting crosspieces are mounted.

This ensures a pulsed translational movement of the mandrel and makes it possible to reduce the adherence of the metal being pressed to the mandrel.

The press can include at least one valve mounted in the main connecting the inner space of the auxiliary cylinder to the auxiliary restricting unit.

It is thereby possible to extend the processing characteristics of the press and to simplify the control of it.

Moreover, the press can include at least one valve mounted in the main connecting the inner space of the power cylinder of the mandrel to the auxiliary restricting unit.

This renders it possible to provide variable values of the ratio of the speeds of movement of the mandrel and short ram.

Brief description of the drawings

The process being patented for the extrusion of hollow articles with the active assistance of friction forces and a hydraulic press for implementing it are explained below with the aid of concrete examples and the attached drawings, in which:

Figure 1 shows diagrammatically the assistance of friction forces in the extrusion of hollow articles in accordance with the process being filed for the hot extrusion of hollow articles with the active assistance of friction forces;
Figure 2 shows diagrammatically the technical sequence of operations, illustrating the process being filed according to the invention;
Figure 3 shows diagrammatically a hydraulic extrusion press for implementing the process for the hot extrusion of hollow articles with the active assistance of friction forces according to the invention;
Figure 4 shows diagrammatically a control unit of the hydraulic press being filed according to the invention;
Figure 5 shows diagrammatically one of variants of the embodiment of the hydraulic extrusion press according to the invention;
Figure 6 shows diagrammatically an auxiliary restricting unit of the hydraulic press being filed according to the invention;
Figures 7a, b, c show the shape of the channels of the slide valve of the auxiliary restricting unit according to the invention; and
Figure 8 shows diagrammatically a variant of the embodiment of the hydraulic extrusion press with power stabilizing cylinders of a mandrel according to the invention.

Best variant of the implementation of the invention

The process being patented, for the hot extrusion of hollow articles with the active assistance of friction forces consists in the following.

A hollow billet 1 (Figures 1, 2) undergoing extrusion is heated. The hollow billet 1 may be heated, for example, in induction furnaces, resistance furnaces and gas combustion furnaces (not shown in Figure 2). The range of temperatures for the heating of the billet 1 is selected according to the type of alloy of the billet 1 undergoing extrusion.

For example, in case of heating a billet 1 made from hard deforming aluminum alloys, heating is performed up to a temperature of approximately 300-450°C depending on the selected capacity of the press, the requirements placed on the physicomechanical properties of the articles, and the rate of extrusion.

Preheating the billet 1 makes it possible to reduce the resistance of metal to the deformation what in its turn leads to reduction in energy consumption in the process of extrusion. Moreover, in a number of hard deforming alloys exhibiting a press effect (effect of structural hardening) there is an improvement of mechanical properties of the articles in case of processing those alloys by pressure with the use of preheating of the billets. Apart from this, in a number of cases preheating permits an increase in the adhesive interaction of the billet 1 with the bush 2 of the container 3 and mandrel 4, which leads to an increase in the friction forces, and this is very important for the process being patented, since in the process under review the friction forces between the bush 2 of the container 3, the mandrel 4 and the billet 1 play a positive role, increasing the speed of the peripheral metal flow through the thickness of the wall of the hollow billet near the bush 2 of the container and the mandrel 4. Thus, their increase up to a specific value promotes equalization of the rates of metal flow across the section of the billet near the gap formed by the mandrel 4 in the channel of the die 5. This permits an increase in the top rates of the metal outflow. After preheating, the billet 1 is fed to the press (Figure 2a), the mandrel 4 is passed through the billet and then pushed into the cavity 2 of the bush of the container 3 of the press (Figure 2b). The length of the container 3 is selected in such a way that the billet 1, die 5 and short ram 6 can be placed freely and entirely in the container (Figures 2c, d). The length of the short ram 6 is adopted with regard to kinematic characteristics of the movement of the container 3 and ram 6.

In order to decrease the energy consumption it is appropriate to preheat the container 3, die 5 and short ram 6 before the start of deformation. The temperature of preheating is chosen depending on the material of the billet 1 being extruded. For example, in case of extrusion of hard deforming aluminum alloys, it is approximately 300-400°C.

The container 3, mandrel 4 and short ram 6 are then started moving simultaneously in the direction of the die 5 mounted on the long ram 7, the speeds of the container 3 and mandrel 4 being higher than the speeds of the short ram 6 and drift-pin 8. After the short ram 6, the hollow billet 1 and the die 5 have come into contact, the stage of pressing out the billet 1 begins (Figure 2e). In this stage, the billet 1 occupies the entire volume bounding it. The outside diameter of the billet 1 becomes equal to the diameter of the bush 2 of the container 3, while the inside diameter becomes equal to the diameter of the mandrel 4. After this, the metal starts to be extruded into the gap between the channel walls of the die 5 and the mandrel 4. The configuration of the gap corresponds to the cross-section of the hollow article being provided, with allowance made for the thermal expansion of the die 5 and mandrel 4 as a result of their warming up and of a certain shrinkage of the metal after its cooling. In the stage of pressing out the billet 1, the speed Vc of movement of the container 3, the speed Vm of movement of the mandrel 4 and the speed Vr of movement of the short ram 6 can be equal (in which case the so-called indirect process of extrusion is realized).

After the start of extrusion, the speed Vc of movement of the container 3 and the speed Vm of movement of the mandrel 4 are increased by comparison with the speed Vr of movement of the short ram 6. The ratio Vc/Vr of the speed Vc of movement of the container 3 to the speed Vr of movement of the short ram 6 is conventionally termed the kinematic coefficient of the container K_{V1}, while the ratio Vm/Vr of the speed Vm of movement of the mandrel 4 to the speed Vr of movement of the short ram 6 is conventionally termed the kinematic coefficient of the mandrel K_{V2}.

Such mutual displacements on the lateral surface of the billet 1 produce friction forces τ_{ac} in the direction of the metal outflow, which permits an increase in the rate of peripheral metal flow in the billet 1, and retardation in the speed of the intermediate layer being between the bush 2 and mandrel 4. The lead of the mandrel 4 over the short ram 6 increases the rate of metal flow near the mandrel 4. This substantially changes the nature of the metal flow, which leads to equalization of the metal flow in the pressing-out part of the plastic zone W and consequently in the gap between the channel walls of the die 5 and the mandrel 4, which has an effect on the increase in the rates of metal outflow and leads to a more uniform metal structure.

It has been established by experiment that in case of extrusion, when the ratio Vm/Vr is greater than 1, compressive stresses τ_{am} are produced on the inner walls of the billet 1 in the direction from the short ram 6 to the boundary of the reduction zone C-C, what creates a favorable effect on the quality of the inner surface, since in such conditions the elimination of residues of the cast structure takes place near the contact surface of the billet 1. This also promotes a reduction in the roughness of the surface of the finished article.

A more uniform metal flow ensures a reduction in the magnitude of the tensile stresses τ_t on the inner and outer surfaces of the finished articles. These stresses are the major restraining factor in the selection of the maximum rate of the metal outflow for a number of hard deforming alloys, primarily aluminum alloys. Thus, a reduction in the tensile stresses on surfaces of the billet τ_t near the mandrel and die τ_{td} permits an increase in the maximum rates of extrusion, when extruding hard deforming aluminum alloys, by a minimum of 10-40% in comparison with all known processes. Moreover, such a favorable metal flow creates conditions which permit an increase in the dispersity of the structure of the front end of the article, and thereby a decrease in the nonuniformity of the distribution of the mechanical properties along the length and over the cross-section of it.

It should be noted that in the process of extrusion of the billet 1 in conditions of the active assistance of friction forces the intermediate metal flow, adjacent to the mandrel 4, experiences a retardation in the direction from the ram 6 to the reduction zone C-C, causing an increase in the degree of dispersity of the metal structure and in the density of dislocations in the crystal lattice of the metal being pressed, what leads to general improvement of mechanical properties of the hollow articles. For example, in case of extrusion of hard deforming aluminum alloys there is an improvement of mechanical properties of the hollow articles by approximately 10 to 25%, all other factors being equal.

At the same time, the efficiency of the given process depends substantially on the conditions of interaction of the bush 2 of the container 3 and the mandrel 4 with the billet 1, that is to say on of the degree of realization of the active assistance of friction forces.

The prescribed geometry of the hollow articles is ensured by the conditions for centering the mandrel 4, die 5 and container 3 that is mounted on guides of the frame 9 between the front cross beam 10 and rear cross beam 11 which are interconnected by four columns 12 (Figure 3).

It has been established by experiment that in case of extrusion, when the ratio Vc/Vr of the speed Vc of movement of the container 3 to the speed Vr of movement of the ram 6 and the ratio Vm/Vr of the speed of movement Vm of the mandrel 4 to the speed Vr of movement of the short ram 6 exceed the maximum values, an excessive shear of the bush 2 of the container 3 and the mandrel 4 is observed relative to the billet 1. This circumstance causes an accelerated metal flow near the surfaces of the bush 2 of the container 3 and mandrel 4 which, in its turn, leads to localization of the shear deformation and to an increased structural nonuniformity. This requires a reduction in the rate of extrusion.

Thus, the shear of the contact surface layers of metal near the bush 2 of the container 3 and the mandrel 4 must be strictly controlled. The process of extrusion is conducted to a point of getting a specific size of the butt-end (Figure 2f), whose length is basically determined by the instant of the start of formation of the shrinkage cavity of the first type, and depends on the direction of the stress τ_{tr} on the end face of the billet.

After termination of the extrusion, the finished article is detached from the butt-end (Figure 2g), for example by a stroke of the mandrel 4, and by means of piercing the butt-end with the drift-pin 8. The mandrel 4 is then withdrawn together with the drift-pin from the die 5 into the initial position before the piercing (Figure 2h), and then the main moving crosspiece is withdrawn to a distance sufficient to introduce the mechanism for removing the die (Figure 2h) with the butt-end.

Thereafter, the die 5 with the butt-end is pressed out by moving the container 3 forward until it clamps to the front cross beam 10 (Figure 2i). After this, the mechanism for removing the die 5 with the butt-end, which clamps the die 5 on the removal mechanism, is fed onto the axis of the press. The main moving crosspiece 13 is then withdrawn with the mandrel 4 into the initial position (Figure 2j).

After withdrawal of the mechanism for removing the die 5 into the initial position (Figure 2k), the but-end is then detached from the die beyond the boundaries of the press.

In the process of extrusion, the container 3 can move at a speed Vc exceeding the speed Vr of the ram 6 by 1.03-1.4 times. It has been established by experiment that in case of extrusion, when the ratio Vc/Vr of the speed Vc of movement of the container 3 and the speed Vr of movement of the ram 6 exceeds 1.4 an excessive shear of the container 3 is observed relative to the billet 1. This circumstance causes an accelerated metal flow of the peripheral layers which, in its turn, leads to localization of the shear deformation and, as a consequence thereof, to large structural nonuniformity. This leads to a need to reduce the rate of extrusion.

Moreover, the selection of an extremely high ratio Vc/Vr of the speed Vc of movement of the container 3 to the speed Vr of movement of the short ram 6 (greater than 1.4) requires either a reduction in the starting length of the billet 1, which leads to a reduction in the productivity of the press, or to an increase in the length of the container 3, which makes the design of the press heavier and the cost of it higher.

The use in the process of extrusion of an excessively low ratio Vc/Vr of the speed Vc of movement of the container 3 and the speed Vr of movement of the short ram 6 (lower than 1.03) leads to localization of the shear deformation only in the boundary layer of the billet 1, which reduces the volume effect of the assistance of friction forces. This leads to nonuniformity in the metal flow and reduces the permissible level of the rate of extrusion, which leads to a reduction in the quality of the hollow articles.

In the process of extrusion, the mandrel 4 can be moved at a constant value of the ratio Vm/Vr of the speed Vm of movement of the mandrel 4 to the speed Vr of movement of the ram 6, which is within the limits of approximately 1.01 to 1.05.

It has been established by experiment that in case of extrusion, when the ratio Vm/Vr of the speed Vm of movement of the mandrel 4 and the speed Vr of movement of the ram 6 exceeds 1.05, an excessive shear of the mandrel 4 is observed relative to the billet 1. This circumstance causes an accelerated metal flow of the layers adjacent to the mandrel 6 which, in its turn, leads to an increase in the nonuniformity of the flow. This makes it obligatory to reduce the rate of extrusion. The use in the process of extrusion of a ratio Vm/Vr of the speed Vm of movement of the mandrel 4 and the speed Vr of movement of the short ram 6 lower than 1.01 leads to localization of the shear deformation only in a thin boundary layer of the billet 1, which reduces the volume effect of the assistance of friction forces and does not provide adequate compressive stresses on the inner surface of the billet sufficient to remove contact defects.

In the process of extrusion, the container 3 can be moved at a constant value of the ratio Vc/Vm of the speed Vc of movement of the container 3 to the speed Vm of movement of the mandrel 4, which is within the limits of approximately 1.02 to 1.33.

The level of the mechanical properties of the hollow articles and their distribution along the length are influenced by the initial temperature of the billet 1, the rate of extrusion and the value of the ratio Vc/Vm of the speed Vc of movement of the container 3 and the speed Vm of movement of the mandrel 4.

The leading movement of the container 3 relative to the mandrel 4 permits equalization of the gradient of the rates of metal flow near the channel of the die 5, an increase in the dispersity of the metal structure, the density of the dislocations of the crystal lattice of the metal, and an improvement of the mechanical properties of the hollow articles. Keeping the values of the ratios Vc/Vm of the speed Vc of movement of the container 3 and the speed Vr of movement of the ram 6, and the values of the ratios Vm/Vr of the speed Vm of movement of the mandrel 4 and the speed Vr of movement of the short ram 6 constant guarantees a uniform distribution of mechanical properties of the metal along the length of the articles with the formation of a structure which is uniform throughout the thickness of the wall.

It has been established as a result of numerous experiments that in case when the value of the ratio Vc/Vm of the speed Vc of movement of the container 3 and the speed Vm of movement of the mandrel 4 is higher than 1.33, the peripheral layers of the billet 1 undergo an intensive shear deformation, which is accompanied by the occurrence of dynamic recrystallization. This leads to a reduction in metal resistance to deformation in these layers, since the density of the dislocations in the structure of the crystal lattice reduces sharply while the dimensions of the grains increase several times, which leads to a reduction in the level of mechanical properties of the articles.

The use in the process of extrusion of the value of ratio Vc/Vm of the speed Vc of movement of the container 3 and the speed Vm of movement of the mandrel 4 less than 1.02 leads to an insignificant shear deformation in the thin boundary layer of the billet 1 and limits the effect on the central layers of the billet 1. The structure of these layers remains macrocrystalline, while the articles have a reduced level of mechanical properties.

The values of the ratios Vc/Vr, Vm/Vr can be varied in the process of extrusion.

In case of deformation of the billet 1 with regard to its uniform preheating, an intense release of deformation heat takes place, which leads to a reduction in the resistance of the metal to deformation and to an increase in the adherence of the metal of the billet 1 to the metal of the bush 2 and the mandrel 4. This leads to additional shear deformations, which increase along the length of the article. In such conditions, the level of the properties in the rear part of the article significantly exceeds the level of the front part.

The implementation of variable ratios Vc/Vr and Vm/Vr permits control of release of deformation heat, and equalization of the distribution of the physicomechanical properties along the length of the articles. As a result of this, it is possible additionally to increase the productivity of the process as a whole in comparison with all known processes of extrusion by a minimum of 10-20%.

In the process of extrusion of the billet 1, the value of the ratio Vc/Vr of the speed Vc of movement of the container 3 and the speed Vr of movement of the short ram 6 can be gradually decreased from a value of approximately 1.15-1.4 to approximately 1.01-1.02, depending on the reduction ratio of the hollow articles.

In case of extrusion, as a result of the execution of the deformation work, the billet 1 releases heat as a function of the degree of deformation, indirectly expressed by the reduction ratio λ_m. Thus, the higher the reduction ratio λ_m, the greater value of the ratio Vc/Vr of the speed Vc of movement of the container 3 and the speed Vr of movement of the short ram 6 should be chosen to start the process (at most 1.4) then gradually reducing it to a minimum value (1.01) and simultaneously decreasing the reduction ratio λ_m to the minimum.

It is inexpedient to apply a value of a kinematic coefficient K_{V1} of the container greater than 1.4, because of the excessive localization of shear deformation in the output part of the article, which leads to intensive dynamic recrystallization of the metal structure and, as a result, to a reduction in the level of the mechanical properties of the articles.

It is likewise inexpedient to start the process at a value of a kinematic coefficient K_{V1} of the container less than 1.15, since in this case the efficiency of the process is reduced, which has an effect on the productivity of the process.

In the process of extrusion of the billet 1, the value of the ratio Vm/Vr of the speed Vm of movement of the mandrel 4 and the speed Vr of movement of the ram 6 can be reduced gradually from a value of 1.05 to 1.91. In case of deformation of hollow articles in conditions of the active assistance of friction forces, a gradual increase takes place in the frictional stresses τ_{am} on the surface of the billet 1 close by mandrel 4, which leads to additional shearing of the metal. This leads to a high structural nonuniformity in the rear part of the hollow article. The intensity of growth of the frictional stresses towards the end of the process can be reduced by means of a gradual reduction in the speed Vm of the mandrel 4 in conjunction with stabilization of the speed Vr of the short ram 6. However, it is not expedient to reduce the speed Vm of the mandrel 4 down to the value of the ratio Vm/Vr less than 1.01, since the level of compressive stresses on the rear part of the surface of the billet 1 is insufficient for a substantial increase in the quality of the surface of the finished article.

In the process of extrusion of the billet 1, the speed Vr of movement of the short ram 6 can be varied in accordance with the temperature field of the billet 1.

In conditions of extrusion through insufficiently heated die 5 and short ram 6 at a heating temperature of the container 3 lower than the heating temperature of the billet 1, cooling of the rear part of the billet 1 can take place and this, in its turn, affects the level of the mechanical properties of the articles.

In order to obtain uniform mechanical properties and to increase productivity, it is necessary to vary the rate of extrusion smoothly in the course of the process.

For example, at a somewhat low temperature of the billet 1 it is necessary to increase the rate of extrusion in the course of the process.

In the process of extrusion, as a result of the execution of the deformation work the billet 1 warms up to a temperature that substantially exceeds its initial preheating temperature. The quantity of heat released is a function of the rate of extrusion.

A change in the temperature of the billet 1 in the process of extrusion affects the conditions of the undergoing dynamic metal recrystallization, which have a substantial influence on the level of the mechanical properties and their distribution along the length of the articles. This circumstance is undesirable in many instances. Heating the billet 1 in accordance with the process being proposed, when the temperature of the front end face is approximately 1.2-1.5 times higher than the temperature of the rear end face, permits to take into account the release of the deformation heat and keep the temperature of the billet 1 near the die 5 constant. During extrusion, processes of heat exchange with working tools proceed in the billet 1, with the result that the dwell time of the billet 1 in the bush 2 of the container 3 must be as minimum as possible. Consequently, in case of use of a high-speed process of extrusion with the active assistance of friction forces it is most effective to use billets 1 heated in a graduated way along its length and being extruded at a gradually increasing rate.

Heating the front end face of the hollow billet 1 in the range 0.75-0.9 from the temperature of the upper bound of the interval of processing ductility of the material being extruded permits starting of the process at the required rate of extrusion, the articles not having defects in the form of cross-cracks. For example, this temperature is approximately 340-420°C for hard deforming aluminum alloys. In case when the front end face of the billet is heated below 0.75 of the temperature of processing ductility of the metal being extruded, a marked reduction in the rate of extrusion is observed in the initial stage, which leads to a significant rise in the effort of extrusion. If the front end face of the billet 1 is heated higher than 0.9 of the temperature of the upper bound of the interval of processing ductility of the metal being extruded, defects in the form of cross-cracks are formed on the articles in the initial stage. To remove them it is necessary to reduce the rate of extrusion significantly, which leads to a reduction in the productivity of the process.

If the rear end face of the billet 1 is heated higher than 0.7 of the temperature of the upper hound of the interval of processing ductility of the material being extruded, at the end of the process not all heat of deformation is compensated, and the billet 1 begins to overheat. It is necessary to reduce the rate of extrusion in order to exclude the appearance of cracks on the articles.

When the temperature of the rear end face of the billet 1 is less than 0.6 of the temperature of the upper bound of the interval of processing ductility of the material being extruded, at the end of the process the temperature of the billet 1 decreases. The expenditure of energy on deformation of the billet 1 increases, as well as the effort of extrusion increases and the speed of the process drops. This also leads to a reduction in the productivity. Moreover, a change in the temperature of the billet 1 in the process of deformation leads to nonuniformity in the distribution of the mechanical properties along the length of the articles.

The selection of the temperature gradient along the length of the billet 1 depends on the thickness of its wall. The thicker the wall of the billet 1, the less the temperature difference should be. The billet 1 with the lesser wall thickness redistributes heat more quickly and cools more intensely, and therefore it is necessary to envisage a larger temperature gradient along its length.

In the process of extrusion of the billet 1, its temperature and the temperature of heating of the container 3 can be set in a range of approximately 1.0 to 0.95 of the temperature of the heating of the front end face of the billet 1.

In the process of feeding the billet 1 into the bush 2 of the container 3 taking account of the conditions of its preheating, the initial temperature field in the billet can change from the interaction with the bush 2, die 5, mandrel 4 and short ram 6 just before the start of extrusion. Normally, the temperature of the heating of all tools, detailed above is set lower than the temperature of the front part of the billet 1 heated in a graduated way.

However, excessive cooling of the billet 1 being extruded can lead to a substantial cooling of the rear part of the billet 1, which will have an effect on the increase in the resistance to deformation and the decrease in temperature of the start of recrystallization of the structure, and this will cause a drop in the rate of extrusion in the concluding stage of the process. In this case, not only is there a decrease in the productivity of the press, but there is an increase in the level of dynamic recrystallization in the rear part of the articles, which leads to a drop in the level of the physicomechanical properties of the articles.

Heating the bush 2 of the container 3 in the range of approximately 0.95-1.0 of the temperature of the heating of the front end face of the billet permits conditions close to isothermal ones to be created in the reduction zone of the billet 1. Under these circumstances, steady-state temperature conditions close to the channel of the die 5 last over the duration of the entire process.

Heating the container 3 in the range 0.95-1.0 of the temperature of the heating of the front end face of the billet 1 excludes the possibility of cooling the rear part of the billet 1. For example, for hard deforming aluminum alloys the optimum temperature of gradient heating of the billet is 380°C for the front end face and 280°C for the rear end face. Taking into account what has been said above, it is necessary to heat the container 3 up to a temperature of 380-360°C in order to exclude cooling of the rear end face of the billet 1.

If the front end face of the billet 1 is heated to higher than 380°C, defects in the form of cross-cracks may form on the articles in the initial stage. To remove them it is necessary to reduce the rate of extrusion significantly, which leads to a reduction in the productivity of the entire process.

If the temperature of the heating of the container 3 is lower than 360°C, a portion of the heat from the front part of the billet 1 passes into the bush 2 of the container 3. This entails an increase in the resistance of the metal to deformation, which leads to an increase in the effort and a decrease in the rate of extrusion.

In the process of extrusion of the billet 1, the mandrel 4 may be imparted a translational movement in the direction of the metal outflow in conjunction with being subjected to cyclic loading.

As has been shown above, in the process of extrusion of hollow articles in conditions of the two-sided active assistance of friction forces, friction forces in the direction of the metal outflow are induced on the billet 1 both from the direction of the bush 2 of the container 3 and from the mandrel 4.

The distribution of the metal structure and indices of mechanical properties throughout the thickness of the wall of a hollow article will depend on the gradient of the speeds of movement of the metal near the channel of the die. The gradient, in its turn, depends on the reduction ratio and the adhesive properties of the material being extruded. The gradient may be partially decreased by means of changing the ratios Vc/Vr Vm/Vr of the speeds of movement Vc of the container 3, Vm of the mandrel 4 and Vr of the short ram 6. For this purpose, the container 3 is moved at a speed Vc greater than the speed Vm of the mandrel 4, the conditions of interaction of the material of the mandrel 4 and material of the container 3 differing substantially by comparison with all known processes.

The displacement of the metal of the billet relative to the mandrel 4 on the section from the front end face of the ram 6 to the boundary of the reduction zone (C-C) is insignificant (see Figure 1), which promotes the adherence of the material being extruded to the mandrel 4, in so doing worsening the quality of the inner surface of the hollow article because of the possible formation of scabs, laminations and even surface cracks. Lending the mandrel 4 a translational movement in conjunction with cyclic loading reduces the adherence of the material being extruded to the mandrel 4, reduces the frictional stress and also reduces the forces resisted by the mandrel, which increases its durability.

Thus, the novel process being filed for the hot extrusion of hollow articles with the active assistance of friction forces permits the provision of high-quality hollow articles with maximum efficiency.

In case of such a method, the active friction forces entrain specific contact layers of the billet 1, producing in so doing accelerated metal flows near the bush 2 of the container 3 and the mandrel 4. It is expedient for the speed of the peripheral flows to be changed relative to the speed of the short ram 6 in optimum ranges by means of varying the ratios of the speeds of movement of the container 3 and short ram 6, and of the mandrel 4 and the short ram 6, taking account of selection of optimum for temperature and speed to conduct the process.

Owing to the reduction in the tensile stresses on the metal at the outer peripheral edge of the die 5, the method being patented permits the provision of a rate of the metal outflow which exceeds these values by 1.5-2 times by comparison with all known extrusion processes.

By selecting optimum for temperature and speed and kinematic optimum for the extrusion, it is possible to provide, in accordance with the process being patented, high mechanical properties which are uniformly distributed along the length and over the cross-section of the article, with a uniform structure in conjunction with the absence of a macrocrystalline ring, which features are unobtainable by means of any other extrusion processes.

Owing to the use of active friction forces on the contact surface of the end face of the billet close to the short ram and owing to their optimum control, it is possible in practice to retard the process of formation of the shrinkage cavity of the first type and, consequently, to reduce by more than 2 times the magnitude of the butt-end and, thereby, to increase the output of sound product to 90-95%.

By means of providing on the surfaces of the billet 1 compressive stresses τ_{ac}, τ_{am}, it is possible to remove certain microscopic surface defects of the articles. Moreover, optimum regimes of extrusion permit a reduction in the residual stresses on the surfaces of the articles. These circumstances permit the provision of articles with increased resistance to corrosion and high quality of inner surface.

Apart from this, the process being patented permits the achievement of high extrusion rates and, thereby, a reduction in the dwell time of the billet in the container, which does not exceed one minute. Such conditions permit the use, with high efficiency, of a billet with gradient heating along the length which, in its turn, provides the possibility of additionally increasing the productivity of the entire process by approximately 15-20%.

The hydraulic extrusion press being patented comprises a frame 9 (Figure 3) having a front cross beam 10 and rear cross beam 11 which are interconnected by tie columns 12. Mounted on guides of the frame (the guides are not shown in Figure 3) with the possibility of axial reciprocating movement are a container 3 and a main moving crosspiece 13.

The container 3 on the side of the front cross beam 10 interacts with plungers 14 and 15 of power cylinders for the direct and reverse movements of the container 3, whose cylindrical bodies 16 and 17 are mounted on the front cross beam 10. Constructed in the front cross beam 10 is a window 18 into which the article being extruded passes.

Mounted in the socket of the front cross beam 10 on an intermediate plate (the plate is not shown in Figure 3) is a hollow long ram 7 which, together with the die 5, enters the cavity of the bush 2 of the container 3. Mounted on the rear cross beam 11 are power cylinders: the main power cylinder, having a cylindrical body 19 and plunger 20, and cylinders for reverse movement of the crosspiece, having cylindrical bodies 21 and plungers 22. The plunger 20 of the main cylinder and plungers 22 of the return cylinders are rigidly connected to the main moving crosspiece 13.

Also mounted on the rear cross beam 11 is at least one stabilizing cylinder, which has a cylindrical body 23 and plunger 24. Two or more stabilizing cylinders can be mounted on the press for the purpose of reducing the overall dimensions of the press and taking account of the technological process being used.

Two stabilizing cylinders are shown in Figure 3 as a design variant of the press being filed. Also as one of the design variants of the press, it is possible to mount the cylindrical bodies 23 of the stabilizing cylinders, which have plungers 24 rigidly connected to the main moving crosspiece 13, on the rear cross beam 11. Axial channels 25 communicating with the conduits 26 are constructed in the plungers 24. The conduits 26 connect the inner space 27 of the stabilizing cylinders to the inner space 28 of the auxiliary cylinder, which has the cylindrical body 29 and hollow plunger 30 with a stem 31 passing through the base of the cylindrical body 29 of the auxiliary cylinder; the cylinder 29 and plunger 30 with the stem 31 are mounted coaxially on the main moving crosspiece 13.

Attached to the crosspiece 13 are pushers 32 which move the container 3. The plunger 30 of the auxiliary cylinder has a hollow short ram 6 which is mounted coaxially with the main cylinder and to which there is rigidly attached a die-plate 33 inside the cavity of which there are arranged a spring-loaded drift-pin 8 and mandrel 4.

As a variant, the plunger 20 of the main power cylinder 19 is simultaneously the power cylinder for moving the mandrel 4. In the inner space 34 of the power cylinder for moving the mandrel 4 a plunger 35 is arranged which is rigidly connected to a mandrel holder 36 and to its own moving crosspiece 37 of the mandrel 4, which are mounted inside the main moving crosspiece 13.

The crosspiece 37 of the mandrel 4 is rigidly connected to return cylinders for moving the mandrel 4, each cylinder consisting of a cylindrical body 38 and plunger 39, one of the elements of each cylinder being attached to the main moving crosspiece 13, while the other is attached to the moving crosspiece 37 of the mandrel 4.

Capable of entering the cavity of the bush 2 of the container 3 from one side are a short ram 6 with a die-plate 33 and mandrel 4, and from the opposite one a hollow long ram 7 with a die 5, between which the billet 1 being pressed is situated.

Mounted on the conduits approaching the inner space 40 of the main power cylinder of the high-pressure main 41 are an admission valve 42 and a speed governor 43 for regulating the movement of the main moving crosspiece 13.

The inner space 40 of the main power cylinder, the inner space 34 of the power cylinder of the mandrel 4, the inner space 44 of the return cylinder for moving the mandrel 4, and the inner space 45 of the reverse stroke cylinder of the crosspiece 13 are connected to the high-pressure main 41 and low-pressure main 47 through the admission valve 42 and distributing unit 46 and also through corresponding valves 48, 49, 50, 51.

Mounted on the conduit 26, which connects the inner space 28 of the auxiliary cylinder to the inner cavity 27 of the stabilizing cylinder, is a valve 52 which is connected through the conduit 53 to an auxiliary restricting unit 54. In addition to this, the auxiliary restricting unit 54 is connected by means of high-pressure conduits 55 and 67 through valves 49 and 56 to the inner space 34 of the power cylinder for moving the mandrel 4. This guarantees discharging of fluid from the space 34 of the power cylinder for moving the mandrel 4 in order to maintain a prescribed ratio Vm/Vr of the speed Vm of movement of the mandrel 4 and the speed Vr of movement of the short ram 6.

Mounted in the high-pressure mains are safety valves 57 and 58 which guarantee discharging of fluid into the low-pressure conduits when maximum values of the fluid pressure in the mains are exceeded.

Mounted on the auxiliary conduit 59, which connects the spaces 27 of the stabilizing cylinders, are a valve 60, and also a governor 61 in which there are arranged a control valve 62 and a spring-loaded valve 63.

The inner space 45 of the return cylinder of the moving crosspiece 13 is connected by means of the conduit 64 to the high-pressure main 41. Connected to this same main are the inner spaces 65 and 66 of the cylinders for the direct and return strokes of the container. Through the valve 68, the conduit 64 connects the space 45 of the return cylinder to the conduit 41 of the high-pressure main. The high-pressure fluid is fed from the distributing unit 46 into the inner space 44 of the return cylinder for moving the mandrel 4 through the valves 50, 51 and conduit 69.

The performance of the press being patented is guaranteed by a control unit which is illustrated in detail in Figure 4.

The control unit comprises a hollow short ram 6 on whose inner surface a cylindrical bore 70 is made. Inside the space of the short ram 6 is mounted a drift-pin 8 with a flange 71 rigidly connected to the cylindrical bush 72 having an internal collar 73 and external collar 74 which are arranged correspondingly on its inner and outer surfaces. A spring-loaded element 75 is arranged between the body of the short ram 6 and the outer surface of the bush 72. This element 75 interacts with the outer collar 74 which is capable of moving inside the short ram 6 through the bore 70.

The mandrel 4 is arranged inside the drift-pin 8, has a cylindrical collar 77 whose diameter corresponds to the diameter of the outer cavity of the cylindrical bush 72, and is fitted with a stem 78 rigidly connected to the mandrel holder 79. In the initial position, the end face of the drift-pin 8 is withdrawn, under the action of the spring-loaded element 75, into the extreme left-hand position and is located flush with the plane of the insert 80 of the die-plate 33 and the end face of the short ram 6.

The press for the extrusion of hollow articles with the active assistance of friction forces together with the control unit (Figure 4) operates in the following way.

In the initial position, the plunger 30 of the auxiliary cylinder is pushed out of the body 29 to the maximum extent (to the right in Figure 3), while the plunger 20 of the main power cylinder, the plunger 35 of the power cylinder for moving the mandrel 4, the plungers 24 of the stabilizing cylinders and the plungers 22 of the return cylinders for moving the mandrel 4 are located in the position on the extreme left. The container 3 is located at this moment in the position on the extreme right.

The heated hollow billet 1 (Figure 2) is laid onto the feed mechanism (Figure 5) and fixed in such a way that approximately one third of the billet 1 projects from the side of the container 3 like a cantilever (Figure 2a). In such a position, the billet 1 is fed onto the axis of the press in the direction of the arrow A. At this instant, the main moving crosspiece 13 is located in the position on the extreme left, the plunger 30 of the auxiliary cylinder is located in the position on the extreme right, and the mandrel 4 is partly moved into the hollow billet 1 from the position on the extreme left.

The free end of the billet 1 is pushed further into the cavity of the bush 2 by movement of the container 3 to the left (Figure 2b). After this, the feed mechanism 81 (see Figure 5) of the billet 1 is withdrawn into the initial position (Figure 2c). Thereafter, the container 3 moves into the position on the extreme left, pushing the billet 1 completely into the bush 2. In so doing, the hollow long ram 7 is released. Thereafter, the die 5 is fed onto the axis of the press with the aid of a mechanism 82 for feeding and removing the die (Figure 2d).

Fluid is then fed through the admission valve 42 from the low-pressure mains 47 into the space 40 of the main power cylinder. In this case, the main moving crosspiece 13 executes a short idle stroke, pushing the die 5, the billet 1 and the short ram 6 with the mandrel 4 into the cavity of the bush 2 of the container 3. In so doing, the pushers 32 on the main moving crosspiece 13 come into contact with the container 3, and all the said moving elements travel at identical speed to the right (as in Figure 3), while the die 5, after shifting to the right, returns to the initial position (Figure 2e).

After elimination of the gaps between the billet 1, die 5 and die-plate 33, the same admission valve 42 is used to feed fluid from the high-pressure mains 41 into the inner space 40 of the main power cylinder. In this case, the inner spaces 66 of the power cylinders for the reverse movement of the container 3, and the inner spaces 45 of the cylinders for the return of the moving crosspiece 13 are initially connected to the conduits of the low-pressure main 47, and thereafter to the conduit of the high-pressure main 41. Thus, the idle stroke goes on to the pressing-out stage, and thereafter to discharging the metal into the gap between the channel walls of the die 5 and the mandrel 4 (Figure 2e). At this time, fluid is discharged from the spaces 45 and 66 into the low-pressure main 47.

During the travel to the right the main moving crosspiece 13 moves the plungers 22 and 24 of the reverse stroke cylinders of the crosspiece 13 and of the stabilizing cylinders. At this instant, the space 27 in the cylindrical bodies 23 of the stabilizing cylinders is gradually released. Since pressure is transmitted onto the short ram 6 via the billet 1, and the ram in turn transmits it onto the plunger 30 of the auxiliary cylinder, the fluid flows from the inner space 38 of the auxiliary cylinder through the valve 25 into the inner space 27 of the stabilizing cylinders which has been vacated. In this process, there is a smooth uniform insertion of the plunger 30 into the body 29 of the auxiliary cylinder, what leads to a lag of the short ram 6 from the movement of the container 3 and mandrel 4. At this instant, the space 34 of the power cylinder of the mandrel 4 is closed with the aid of the valve 49. The speed Vr of movement of the short ram 6 is determined at this time as the difference between the speed Vb of movement of the main moving crosspiece 13 and the speed Va of movement of the plunger 30 of the auxiliary cylinder:

$$Vr = Vb - Va \qquad (1)$$

where:

Vb is the speed of movement of the main moving crosspiece 13; and
Va is the speed of movement of the plunger 30 of the auxiliary cylinder.

The speed Vc of movement of the container 3 is equal to the speed Vb of the main moving crosspiece 13. The speed Vb of movement of the crosspiece 13 and the speed Va of insertion of the plunger 30 into the body 29 of the auxiliary cylinder are oppositely directed. Consequently, the value of the kinematic coefficient K_{V1} of the container is expressed by the equation:

$$K_{V1} = Vc/Vr = Vb/(Vb-Va) \qquad (2)$$

where:

K_{V1} is the kinematic coefficient of the container 3;

Vc is the speed of movement of the container 3;

Vr is the speed of movement of the short ram 6;

Vb is the speed of movement of the main moving crosspiece 13; and

Va is the speed of movement of the plunger 30 of the auxiliary cylinder.

The ratio Vc/Vr of the speed Vc of movement of the container 3 and speed Vr of movement of the short ram 6 is automatically kept constant over the entire duration of the extrusion cycle.

All that is required in this case is to stabilize the speed of movement of the plunger 20 of the main power cylinder 19 with the aid of the speed governor 43. This guarantees the occurrence of friction forces of active assistance on the lateral surface of the billet 1.

The ratio Vc/Vr of the speed Vc of movement of the container 3 and the speed Vr of movement of the short ram 6 is determined by the dimensions of the inner space 28 of the auxiliary cylinder and the inner space 27 of the stabilizing cylinders.

The closure of the valves 52, 49 ensures equality of the ratios Vc/Vr, Vm/Vr.

The value of the kinematic coefficient K_{V1} of the mandrel is expressed by the equation:

$$K_{V2}=Vm/Vr=Vb/(Vb-Va) \quad (3)$$

where Vm is the speed of movement of the mandrel 4.

Friction forces of active assistance are induced in the kinematic conditions, indicated above, on the inner surface of the billet 1 on the section from the die-plate 33 up to the boundary of the reduction zone C-C (see Figure 1).

The hydraulic circuit provides for extrusion in conditions of unilateral active assistance of friction forces when the speed Vc of movement of the container 3 is higher than the speeds Vr of the short ram 6 and Vm of the mandrel 4 ($Vc>Vr=Vm$). A rigid connection between the mandrel holder 6 and the centering stem of the plunger 30 of the auxiliary cylinder is provided in this case. A special device is required to implement such kinematic conditions (Figure 4).

In case when the fluid is locked in the space 28 of the auxiliary cylinder and the space 34 of the cylinder of the mandrel 4 by means of the distributing unit 46 and the valves 52, 49, it is possible to implement a indirect extrusion circuit when $Vr=Vc=Vm$.

It is possible to reduce the value of the kinematic coefficient K_{V2} of the mandrel to the prescribed value (1.01-1.05) when the auxiliary restricting unit 54 is used. For this purpose, the valves 50, 51 are opened and fluid at high pressure passes through the distributing unit 46 along the conduit 69 and along the channels in the plungers 39 into the inner spaces 44 of the return cylinders for moving the mandrel 4. The mandrel 4 is moved in the direction of the rear cross beam 11 when the valves 49, 56 are opened.

The law of variation for the ratio Vm/Vr of the speed Vm of movement of the mandrel 4 and the speed Vr of movement of the short ram 6 is selected in an optimum interval, indicated above, and according to the material being extruded and extrusion process variables.

After the extrusion is concluded (Figure 2f), feeding of the fluid from the high-pressure main 41 is terminated by closing the admission valve 42, the inner space 40 of the main power cylinder being connected through the same admission valve 42 to the low-pressure main 47, and the valve 56 being closed. When the valves 48, 49, 50, 51 are opened, fluid is fed at high pressure into the inner space 34 of the power cylinder for moving the mandrel 4 which, moving forwards, acts with its collar 77 on the flange 71 of the drift-pin 8 and moves it forward in the same direction. In this case, the drift-pin is used to detach the butt-end and push the article out of the die 5 (Figure 2g).

Furthermore, the inner spaces 45 of the cylinders for returning the moving crosspiece 37 are connected through valves 68 to the high-pressure main 41, the short ram 6 and mandrel 4 being moved to the left while the cylindrical bush 72 remains in the advanced position on the right (Figure 2g). After the collar 77 of the mandrel 4 has touched the inner collar 73 of the cylindrical bush 72, the latter moves to the left and returns the drift-pin 8 into the initial position on the extreme left. The spring-loaded element 75 ensures that the drift-pin 8 is fixed in the initial position.

Thereafter, the main moving crosspiece 13 is withdrawn far enough to ensure removal of the die 5 with the butt-end (Figure 2h). The plungers 17 are then used to move the container 3 to the right until it clamps to the front cross beam 10. This operation can be carried out while simultaneously withdrawing the main moving crosspiece 13. In the process, the butt-end and die 5 are extracted from the cavity of the bush 2 of the container 3 and kept from falling in this position by the mandrel 4.

This is followed by the removal of the die with the butt-end and the mechanism 82 for feeding and removing the die (see Figure 5). In accordance therewith, the die is clamped (Figure 2i) and the mandrel 4 is withdrawn together with the main moving crosspiece 13 into the initial position (Figure 2j). Furthermore, the die 5 with the butt-end is moved into the fixing element towards the power-driven shears up to the stop of the die 5, where the die 5 is detached from the butt-end (Figure 2k).

When the main moving crosspiece 13 moves out of the inner space 27 of the stabilizing cylinders, the fluid is displaced into the inner space 28 of the auxiliary cylinder, the plunger 30 of the auxiliary cylinder being moved out into the initial position.

The cycle can be repeated.

The use of stabilizing cylinders which are hydraulically connected to the inner space 28 of the auxiliary cylinders permits an optimum constant value of K_{V1} to be obtained automatically without any kind of outside control, that is to say the extrusion process being proposed is realized to the full extent. The design of the press permits the required optimum ratio K_{V1} to be maintained automatically even in case of continuous change in the speed of the plunger 20 of the main power cylinder and, correspondingly, of the main moving crosspiece 13.

The design of the stabilizing cylinders is very simple, and they can be mounted on any press without particular difficulty.

The auxiliary conduit 59 ensures that the main moving crosspiece 13 is capable of executing an idle stroke of any magnitude. In the event of the absence of this connection, volume is vacated in the inner spaces 27 of the stabilizing cylinders when the crosspiece 13 moves, there being no pressure on the short ram 6. The result of this is that rarefaction may occur in the inner space 27 of the stabilizing cylinders.

For a prescribed value K_{V1} the area of the cross-section F_2 of the plunger 24 of the stabilizing cylinder is selected from the relationship:

$$F_2=F_1(1-1/K_{V1}) \qquad (4)$$

where:

F_2 is the area of the cross-section of the plunger 24 of the stabilizing cylinder;
F_1 is the area of the cross-section of the plunger 30 of the auxiliary cylinder; and
K_{V1} is the value of the ratio Vc/Vr.

The length H_1 of the inner working space 28 of the auxiliary cylinder is equal to:

$$H_1=Hp(1-1/K_{V1}) \qquad (5)$$

where:

H_1 is the length of the inner working space 28 of the auxiliary cylinder;
Hp is the maximum length of the working stroke of the plunger 24 of the stabilizing cylinder and the main moving crosspiece 13.

In the presence of a number of stabilizing cylinders, the area F_2 of their cross-sections is summed as ΣF_2.

It is possible to mount on the hydraulic extrusion press (Figure 5) at least two booster return power cylinders, each of which is constructed in the form of a cylindrical body 83 in which a stepped plunger 84 is arranged. One of the said elements of each booster return power cylinder can be attached, in a stationary fashion to one of the cross beams 11, while the other can be attached to the main moving crosspiece 13, the inner space 85 of each of them communicating with the high-pressure main 41 and low-pressure main 47.

The proposed design of the hydraulic press, when it is required to execute an idle stroke fluid is fed from the high-pressure main 41 only into the inner space 85 of the booster return cylinders. At this time, only fluid from the low-pressure main 47 passes into the inner space 40 of the main power cylinder.

In order to execute the working stroke of the main moving crosspiece 13 into the inner space 40 of the main power cylinder, feeding of fluid from the low-pressure main 47 is terminated, and fluid starts to be fed from the high-pressure main 41. It is possible to continue feeding fluid from the high-pressure main 41 into the booster return cylinders if the effort of the main power cylinder alone suffices to extrude the hollow articles. In this case, fluid is fed into the inner spaces 85 of the booster return cylinders from the low-pressure main 47.

In the hydraulic extrusion press the inner space 85 of each of the booster return cylinders can be hydraulically connected through an axial channel 86 in the plunger 84, and through the conduit 87, valve 88 and conduit 89 to the inner space 28 of the auxiliary cylinder.

Such a hydraulic connection permits the use of booster return cylinders in addition to stabilizing cylinders.

In the hydraulic extrusion press the inner spaces 85 and 27 are connected with the aid of mains 89 and 26 to the inner space of the auxiliary cylinder. The spaces 85 and 27 are also connected through the auxiliary conduit 59 to the high-pressure main 41 and low-pressure main 47 with the aid of valves 60, 90, 91.

The valves 60 and 90 are opened before the press starts to work. At the instant when the idle stroke of the main moving crosspiece 13 starts, fluid enters the inner spaces 85 of the booster return cylinders from the high-pressure main 41 through the valves 90, 91. At the same time, fluid enters the stabilizing cylinders from the low pressure main 47 through the valve 60.

During the idle stroke of the main moving crosspiece 13 and the following stage of pressing out the billet 1, the valves 52 and 88 are closed. After pressing out of the billet 1 has ceased, valves 60 and 90 are closed and the valves 52 and 88 are opened. In this process, the plunger 30 expels fluid from the inner space 28 into the inner spaces 27 of the stabilizing cylinders and the inner spaces 85 of the booster return cylinders.

As already described above, in consequence of this the plunger 30 of the auxiliary cylinder executes a reverse stroke at a prescribed speed. In this case, the speed Vr of movement of the short ram 6 becomes less than the speed Vc of movement of the container 3. Friction forces of active assistance τ_{ac} in the direction of the metal outflow are produced on the surfaces of the billet 1. Since, in addition to the stabilizing cylinders, fluid flows from the inner space 28 of the auxiliary cylinder into the spaces 85 of the booster return cylinders, the lag of the short ram 6 is greater than in case of connecting up only the stabilizing cylinders. This makes it possible to extend the intervals of the ratios Vc/Vr and Vm/Vr.

Thus, it is possible by using different combinations of connection of the stabilizing cylinders and booster return cylinders, which are realized with the aid of the valves 52 and 88, to provide, if required, different ratios Vc/Vr, Vm/Vr on one press automatically within the limits of the working stroke of the main moving crosspiece 13.

The hydraulic extrusion press can include an auxiliary restricting unit (Figure 6) consisting of a body 94 with four holes: two inlet holes 95, 96 and two outlet holes 97, 98. Mounted inside the body is a slide valve 99 with two through cavities 100, 101. A spring-loaded element 102 acts on the slide valve 99 from the right-hand side. On the left-hand side, the slide valve 99 is bounded by the body 103 of the hydraulic power cylinder for moving the slide valve. The plunger 104 of this cylinder is rigidly attached at one end to the slide valve 99. The design and geometrical dimensions of the through cavities 100, 101 determine the values of the ratios Vc/Vr and Vm/Vr.

With the aid of the conduit 93, the cavity 100 is connected through the hole 95 in the body 94 to the inner space 28 of the auxiliary cylinder, while with the aid of the conduit 67 the cavity 101 is connected through an analogous hole to the inner space 34 of the power cylinder of the mandrel 4. From the opposite side, the through cavities 100, 101 in the slide valve 99 are connected through the outlet holes 97, 98 in the body 94 to the low-pressure main 47 with the aid of the conduits 105, 106.

The inner space 107 of the power cylinder for moving the slide valve 99 is also connected, with the aid of the conduit 53, to the inner space 28 of the auxiliary cylinder. Mounted on the body 94 of the auxiliary restricting unit 54 on the side of the spring-loaded element 102 is a cover 108 which ensures control of the compressive effort of the spring-loaded element 102, which permits setting up the required ratios Vc/Vr, Vm/Vr. The slide valve 99 (see Figure 6) can have through holes 100, 101 of variable cross-section. These holes can be constructed with connecting pieces 109 (Figures 6 and 7). Through the valves 92, 56, the inner spaces 28, 34 are connected to the through holes 100, 101 of the slide valve 99. An auxiliary control of the restricting unit is implemented with the aid of a lead screw 110 by selecting between various ratios Vc/Vr and Vm/Vr. The lead screw 110 is mounted in a stationary fashion on the end face of the slide valve 99 on the side of the spring-loaded element 102. The cover 108 has a through hole for the passage of the lead screw 110.

Such a press operates in the following way.

After the heated billet 1 has been placed in the bush 2 of the container 3 (Figure 5), high pressure is fed into the inner spaces 85 of the booster return cylinders through opened valves 91, 90. Thereafter, the main moving crosspiece 13 starts to execute an idle stroke. In this case, the valve 60 is open while the admission valve 42 is closed for high-pressure fluid and open for low-pressure fluid. Consequently, low-pressure fluid passes into the inner space 40 of the main power cylinder and the inner spaces 27 of the stabilizing cylinders. In this case, the valves 52, 56, 88 and 92 are closed. After the short ram 6 comes into contact with the billet 1 and the latter, in its turn, comes into contact with the die 5, the admission valve 42 opens the high-pressure main and closes the low-pressure main.

A stage starts in which the metal is pressed out and discharged into the gap between the channel walls of the die 5 and mandrel 4. In this case, the valves 60, 90, 91 are being closed, while the valves 52, 88, 92 and 56 are all being opened together or in a defined sequence. Fluid starts to pass into the spaces 27, 85 of the stabilizing cylinders and booster return cylinders from the inner space 28 of the auxiliary cylinder and, through the valve 92, approaches the through hole 100 in the slide valve 99 and the inner space 107 of the power cylinder for moving the slide valve 99. At the same time, the valves 51, 50 are being opened and high-pressure fluid passes through the distributing unit 46 into the inner spaces 44 of the return cylinders for moving the mandrel 4. In case when the valve 49 is closed, the mandrel 4 moves in the process of extrusion of the billet 1 at the speed of the container 3 (Vm=Vc). In order to fulfill the condition (Vm<Vc) the valves 49, 56 are opened and fluid from the inner space 34 of the cylinder for moving the mandrel 4 starts, under the action of pressure being produced in the inner spaces 44 of the return cylinders of the mandrel, to be expelled through the hole 101 in the slide valve 99, and passes into the low-pressure main 47 through the outlet hole 98 and the conduit 106. Together with the mandrel holder 36 and the plunger 35, the mandrel 4 is withdrawn backwards in this case and its speed Vm of movement in the direction of the metal outflow is lower than the speed Vc of movement of the container 3 (Vm<Vc).

Under the action of the effort of extrusion which is being transmitted to the ram 6 and mandrel 4, the working fluid is discharged from the spaces 28 and 34 of the auxiliary and power cylinders for moving the mandrel through the opened valves 52, 88, which ensures fulfillment of the ratios Vc/Vr and Vm/Vr selected for the extrusion.

Fluid from the inner space 28 of the auxiliary cylinder simultaneously acts on the plunger 104 of the auxiliary restricting unit 54, in which process the plunger 104 acts on the slide valve 99, moving it to the right (Figure 6). This movement is opposed by the spring-loaded element 102 which is supported against the slide valve 99 at one end and against the cover 108 at the other end. In the process of extrusion, the lateral surface of the billet 1 decreases, with the result that the fraction of the effort being transmitted onto the billet 1 through the container 3 also decreases, while the fraction of the effort being transmitted through the short ram 6 increases. As a result, the pressure in the inner space 28 of the auxiliary cylinder increases continuously, and consequently there is an increase in the effort on the plungers 30 and 104 of the auxiliary and power cylinders for moving the slide valve 99. Under the action of this effort, the plunger 104 and slide valve 99 move continuously to the right, in so doing compressing the spring-loaded element 102. As the slide valve 99 moves, its through holes 100, 101 are being arranged differently at different instances in time relative to the inlet holes 95, 96 and outlet holes 97, 98 in the body 94 of the auxiliary restricting unit (Figure 6).

The through holes 100, 101 (Figure 7a) are constructed with a constant or variable cross-section along the length of the slide valve 99. The holes connected to the inner space 34 of the power cylinder for moving the mandrel 4 have connecting pieces 109 (see Figures 7b, c) which ensure a translational movement of the mandrel 4 in conjunction with its cyclic loading. This permits a reduction in the adherence of the metal to the mandrel 4, which enhances the quality of the inner surface of the hollow article being provided. As a result, the speeds of the reverse stroke of the plungers 30 and 35 of the auxiliary and power cylinders for moving the mandrel are variable. Thus, the ratios Vc/Vr, Vm/Vr can be both variable and constant in the course of the entire cycle of extrusion.

The auxiliary restricting unit described above is a universal one and ensures supplementary discharge of fluid from the spaces 28, 34 both simultaneously and separately.

The design of the press (Figure 8) includes a system for stabilizing the speed Vm of movement of the mandrel 4 in relation to the speed Vr of movement of the short ram 6.

Included in this system is: an intermediate moving crosspiece 111 which is attached to the hollow plunger 30 of the auxiliary cylinder and is rigidly connected to at least one intermediate cylinder consisting of a cylindrical body 112 and plunger 113. One of the elements of this cylinder is rigidly connected to the intermediate moving crosspiece 111, while the other is rigidly connected to the main moving crosspiece 13. The inner space 114 of the intermediate cylinder is connected through the valve 115 and conduit 116 to the inner space 44 of the return cylinder of the mandrel 4. The inner space 44 of this return cylinder is additionally connected through the valves 50, 51, conduit 69 and distributing unit 46 to the high-pressure main 41.

The space 34 of the power cylinder for moving the mandrel 4 is connected through the valves 49 and 119 and conduit 117 to the inner space 85 of the booster return cylinders and, through the valve 91, to the high-pressure main 41. The connection of other spaces of the cylinders by means of mains and the arrangement of valves are identical to the hydraulic circuits examined above and presented in Figures 3 and 5.

The operation of the press presented in Figure 8 is basically analogous to the press described above in Figure 5.

Before the start of extrusion, the inner space 28 of the auxiliary cylinder communicates with the low-pressure main 47 through the conduit 26, the valve 52, the channel 25 in the plunger 24 of the stabilizing cylinder and its space 27, valves 60, 91 and the admission valve 42. The inner space 114 of the intermediate cylinder is connected to this same main through the valves 115, the conduit 116, the channel in the space of the plunger 39 of the return cylinder for moving the mandrel 4, the conduit 69, the valves 51, 50 and the distributing unit 46. The valve 49 is temporarily closed at this instant.

After the billet 1 has been fed into the cavity of the bush 2 of the container 3, the valve 49 is opened and the distributing unit 46 comes into action in such a way that the fluid passes into the space 34 of the power cylinder for moving the mandrel 4. As a result of this, the plunger 35 moves the mandrel holder 36 and the mandrel 4 through the hollow short ram 6 and the hole in the billet 1, and installs the mandrel in the channel of the die 5. After this, the conduit 55 is shut off with the aid of the valve 49, working fluid remaining in the space 34 of the power cylinder of the mandrel and the conduit 26 being shut off with the aid of the valve 52, working fluid also remaining in the space 28 of the auxiliary cylinder.

If it is required to conduct extrusion in conditions of equality of the speeds of movement of the container 3 and mandrel 6 (Vc=Vm), the working fluid in the inner space 34 of the power cylinder for moving the mandrel 4 is sealed with the aid of the valve 49.

In the process of extrusion, the auxiliary cylinder is moved as a unit with the main moving crosspiece 13, while the pushers 32 attached to the crosspiece 13 are thrust by their end faces into the container 3, setting the latter into a joint movement.

The valves 115 and 49 are opened in order to implement the prescribed ratio Vm/Vr. Since, before the start of extrusion, the inner spaces 114 and 44 of the intermediate and return cylinders are shut off from the high-pressure main 41 by closing the valve 51, fluid passes from the inner space 34 of the power cylinder for moving the mandrel 4 under the action of the plunger 39 of the return cylinder through the valve 49, the conduit 117 and the valve 119 into the inner space 85 of the booster return cylinder. In this case, the valve 68 is open and fluid is discharged into the low-pressure main 47 from the space 45 of the cylinder for the return of the moving crosspiece. The closed valve 60 in this case excludes the possibility of discharging fluid into the low-pressure main 47 from the stabilizing cylinders during the working stroke of the main moving crosspiece 13.

The rate of extrusion is determined by the difference between the speed of movement of the main moving crosspiece 13 and the speed of the reverse stroke of the plunger 30 of the auxiliary cylinder. The stabilizing cylinder 23 ensures a constant difference between the speed Vc of movement of the container 3 and the speed Vr of movement of the short ram 6.

Additional possibilities for varying the kinematic coefficient K_{V1} of the container occur if an auxiliary restricting unit 54 is used (its operation is described above).

Implementation of the prescribed ratio Vm/Vr is accomplished through discharge of the fluid from the inner space 114 of the intermediate cylinder through the valve 115 into the inner space 44 of the return cylinders for moving the mandrel 4 and simultaneous run-over of the fluid from the inner space 34 of the power cylinder for moving the mandrel 4 into the inner space 85 of the booster return cylinder in conjunction with the opened valves 49, 119 and closed valve 90.

The following kinematic conditions are fulfilled in this case;

$$Vc>Vm>Vr$$

$$K_{V1}=Vc/Vr=const,$$

$$K_{V2}=Vm/Vr=const,$$

$$K_{V3}=K_{V1}/K_{V2}=Vc/Vm=const.$$

The circuit is universal and permits a rapid transition to the indirect process of extrusion by means of locking the fluid in the inner spaces 28 and 34 of the auxiliary and power cylinders for moving the mandrel 4 with the aid of the valves 49, 51, 52 and 115. In this case, the speeds of movement of the short ram 6, the container 3 and mandrel 4 are equal (Vr=Vc=Vm).

The parameters of all cylinders are calculated taking account of the fact that the plunger 20 of the main power cylinder executes a working stroke of the same magnitude as the plunger 84 (F_4) of the booster return cylinder, and the cylindrical body 23 (F_2) of the stabilizing cylinder. During execution of the reverse stroke, the plunger 30 of the auxiliary cylinder (F_1) moves the length of the working space, equal to H_1. Accordingly, it is necessary for the purpose of keeping K_{V1} constant to maintain the relationships:

$$F_1H_1=F_2Hp \qquad (6)$$

$$F_2=F_1(H_1/Hp) \qquad (7)$$

where:

F_1 is the area of the cross-section of the plunger 30 of the auxiliary cylinder,
F_2 is the total area of the cross-section of the plungers 24 of the stabilizing cylinders and
H_1 is the length of the working space 40 of the main cylinder of the press.

Taking into account the fact that

$$K_{V1}=Hp/(Hp-H_1), \qquad (8)$$

$$H_1/Hp=1-1/K_{V1}, \qquad (9)$$

therefore:

$$F_2=F_1(1-1/K_{V1}) \qquad (10)$$

An analogous functional relationship is established between the areas F_3 of the plunger 35 of the power cylinder for moving the mandrel 4 and F_4 of the plunger 84 of the booster return cylinder.

In order to keep the value of the kinematic coefficient K_{V3} constant

$$K_{V3}=Hp/(Hp-H_2) \quad (11)$$

it is necessary to fulfill the condition:

$$F_4=F_3(1-1/K_{V3}) \quad (12)$$

where:

F_3 is the area of the cross-section of the plunger 35 of the power cylinder for moving the mandrel 4,
F_4 is the total area of the cross-sections of the plungers 84 of the booster return cylinders, and
H_2 is the magnitude of the travel of the mandrel 4 relative to the ram.

When the mandrel 4 moves in the reverse direction, the plunger 35 of the power cylinder for moving the mandrel 4, and the body 38 of the return cylinder for moving the mandrel (F_5) execute an identical travel H_2 which is equal to the length of the working part of the inner space of the power cylinder for moving the mandrel 4. This travel for the plungers 113 (F_6) of the intermediate cylinders is equal to the length of the working part of the inner space 28 of the auxiliary cylinder. The following relationships are then fulfilled:

$$F_6H_1=F_5H_2, \quad (13)$$

$$F_6=F_5(H_2/H_1), \quad (14)$$

$$H_1=Hp(1-1/K_{V1}), \quad (15)$$

$$H_2=Hp(1-1/K_{V1}), \quad (16)$$

$$F_6=F_5(Hp(1-1/K_{V3})/Hp(1-1/K_{V1}) \quad (17)$$

$$F_6=F_5(1-1/K_{V3})/(1-1/K_{V1}) \quad (18)$$

where:

F_5 is the total area of the cross-sections of the plungers 39 of the return cylinders for moving the mandrel, and
F_6 is the total area of the cross-sections of the plungers 113 of the intermediate cylinders.

The design of the hydraulic press being patented is simple and reliable in use because of the application of dependent drives for moving the container, short ram and mandrel, when prescribed kinematic conditions are automatically maintained throughout the working cycle irrespective of the speed of movement of the main moving crosspiece. The effort of extrusion is in this case 15-20% lower than in case of direct extrusion and 5-10% higher than in case of indirect extrusion.

The arrangement of the auxiliary cylinder inside the main moving crosspiece permits reduction of up to 20% in the length of the press by comparison with presses having separate drives for moving the container, ram and mandrel.

Implementing the functions of the booster, return and stabilizing cylinders by means of one pair of universal cylinders substantially simplifies the design of the press, reduces its metal content, simplifies its operation and reduces the overall dimensions of the press.

The application of a universal hydraulic auxiliary restricting unit which is simple to use and is intended to fulfill the prescribed kinematic conditions both for the container and for the mandrel permits the processing characteristics of the press to be substantially extended without applying complicated programmed electronic speed governors.

The novel solution is the application of a system of cylinders which stabilize the speeds of movement of the container and mandrel.

In the press being proposed, any specific ratio of the speeds of the container, short ram and mandrel which is required to manufacture a particular product is achieved by simply switching over valves installed in the high-pressure and low-pressure mains.

Expenditure on the manufacture of the press is 10-15% higher than on the manufacture of indirect presses, but this is balanced by the increase in productivity and improvement in the quality of the articles being provided.

Because of the rational design, the hydraulic extrusion press being patented has small overall dimensions by virtue of the low metal content, and is distinguished by a short auxiliary time and a high usage factor for the metal of the billet. The productivity of such a press is 2-2.5 times higher than the productivity of the direct-action press and 1.3-1.8 times higher than the indirect-action press.

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Re: Application PCT/RU/00012

Please find enclosed papers of the application with amendments in accordance with Article 19 and taking account of the International Search Report submitted to us. The amendments do not exceed the scope of the original papers. Thus, in the claims the first four claims have been combined into one with a small refinement, which is presented in a new version. Claims 10 and 13 are also presented in a new version. Claim 9 is presented in addition.

Thus, the number of claims of the invention has been reduced from 27 to 25.

In accordance with this, a new version presents material relating to pages 9-13, 18-19, 23-24, 26-27, 56-62 and the abstract.

As instructed by the inventors (signed)

V. N. Shcherba

cylinder and with its own moving crosspiece (37), and also a hollow long ram (7) attached to the front (10) cross beam coaxially with the short ram, and the said press is fitted with a drift-pin (8) with a flange, a cylindrical bush with collars constructed on its inner and outer surfaces, and with a spring-loaded element arranged between the body of the short ram (6) and the outer surface of the cylindrical bush, the drift-pin (8) being mounted inside the short ram and being rigidly connected to the cylindrical bush, while the mandrel (4) is arranged inside the drift-pin, is constructed with a cylindrical collar and is rigidly connected to the mandrel holder by means of a stem. A restricting unit of the auxiliary cylinder and the hydraulic circuit of the press permit automatic ensuring of the necessary ratios of the speed of movement of the container (3) and the speed of movement of the short ram (6), and also of the speed of movement of the mandrel (4) and speed of movement of the short ram.

Figures 1, 3.

into which a mandrel is passed through the cavity of this billet, and then is extruded, with the aid of a short ram while simultaneously moving the container, mandrel and short ram, through an annular gap which is formed by the channel walls of the die and by the mandrel and which determines the shape and geometrical dimensions of the finished article, and in accordance with the invention in the process of extrusion the speeds of movement of the container and the mandrel exceed the speed of movement of the short ram.

In the process of extrusion, the speed of movement of the container exceeds the speed of movement of the short ram by 1.03-1.4 times, while the speed of movement of the mandrel exceeds the speed of movement of the short ram by 1.01-1.05 times. In this case, the speed of movement of the container exceeds the speed of movement of the mandrel by 1.02-1.33 times depending on the reduction ratio and the temperature gradient.

This permits an increase in the productivity of the process by comparison with all known processes, an increase in the quality of the inner and outer surfaces of the hollow articles and in the level of their mechanical properties, and ensures the provision of articles having a prescribed distribution of physicomechanical properties along the length and over the cross-section of the hollow article.

In the process of extrusion, the ratios of the speed of movement of the container and the speed of movement of the short ram, and the speed of movement of the mandrel and the speed of movement of the short ram are varied. This provides the possibility of controlling the volumetric effect of the active assistance of friction forces throughout all stages of the process while maintaining quasi-steady-state conditions of flow of the material being deformed, which in turn permits an improvement of the uniformity of the distribution of the physicomechanical properties of the material of the article along its length.

In the process of extrusion, the ratio of the speed of movement of the container and the speed of movement of the short ram is reduced from a value of 1.4 to 1.01 as a function of the reduction ratio of the hollow article.

It is thus possible to provide hollow articles with a prescribed distribution of mechanical properties along the length of the finished articles.

In the process of extrusion, it is possible for the ratio of the speed of movement of the mandrel and the speed of movement of the short ram to be reduced from a value of 1.05 to 1.01.

This provides the possibility of improving the quality of the inner surface of the hollow article along the entire length of the article in conjunction with a reduction in the degree of slippage of the mandrel relative to the billet.

In the process of extrusion, the speed of movement of the short ram can be varied as a function of the distribution of the temperature gradient along the length of the billet.

This provides the possibility to even the distribution of the physicomechanical properties along the length of the hollow articles.

In this case, it is expedient to heat the front end face of the billet in the temperature range from 0.75 to 0.9 of the temperature of the upper bound of the interval of processing ductility of the material being extruded, while the rear end face of the billet is heated in the temperature range from 0.6 to 0.7 of the temperature of the upper bound of the interval of processing ductility of the material being extruded as a function of the thickness of the wall of the billet being extruded.

This also additionally permits the productivity of the process to be increased by approximately 20% and the distribution of the physicomechanical properties along the length of the articles to be evened.

Before extrusion, the temperature of the heating of the container is set in the range from 1 to 0.95 of the temperature of the heating of the front end face of the billet.

This additionally permits an increase in the level of implementation of the active assistance of friction forces, a decrease in the slippage of the bush relative to the billet, and also the prevention of cooling of the rear end face of the billet, which cooling happens as a result of the interaction of the end face with the short ram.

In the process of extrusion, the mandrel is imparted a cyclic tranalational movement in the direction of metal outflow because of cyclic loading.

This permits the elimination of the adherence of the material being extruded to the mandrel, which increases the durability of the mandrel and also improves the quality of the inner surface of the hollow article.

This goal is achieved on a hydraulic extrusion press for providing hollow articles that comprises a front cross beam and rear cross beam rigidly mounted on a frame, a container having the possibility of reciprocating movement along the longitudinal axis of the press, a main moving crosspiece on which a plunger is rigidly attached, at least one main power cylinder whose body is attached in a stationary fashion to the rear cross beam, the inner space of the main power cylinder being connected to a high-pressure main and low-pressure main, an auxiliary cylinder connected to the main moving crosspiece and, the inner space of the auxiliary cylinder being connected through a restricting unit to the low-pressure main, a short ram attached to the plunger of the auxiliary cylinder and constructed to be hollow and in one piece with a die-plate, a mandrel which is mounted in the cavity of the short ram and has a mandrel holder connected to the plunger of the power cylinder of the mandrel and to its moving crosspiece arranged inside the main moving crosspiece, and also a hollow long ram attached to the front cross beam coaxially with the short ram, and according to the invention, the said press is fitted with a drift-pin having a flange, a cylindrical bush with collars, constructed correspondingly on its inner and outer surfaces, and with a spring-loaded element arranged between the body of the short ram and the outer surface of the cylindrical bush, the drift-pin with the flange being mounted inside the short ram and being rigidly connected to the cylindrical bush while the mandrel is arranged inside the drift-pin and is constructed with a cylindrical collar, whose outside diameter corresponds to the inside diameter of the cylindrical bush, and is rigidly connected to the mandrel holder by means of a stem.

This ensures the automatic fulfillment of predetermined kinematic regimes for operating the press in the process of extrusion, and excludes the penetration of metal between the mandrel and ram.

The plunger of the auxiliary cylinder is mounted inside the main moving crosspiece, constructed to he hollow and fitted with a centering stem passing through the base of the cylindrical body of the auxiliary cylinder.

This permits the provision of the required ratio of the speeds of movement of the container and short ram, an improvement of the centering and simplification of the design.

The basic restricting unit of the auxiliary cylinder comprises at least one stabilizing cylinder which is a cylindrical body in whose inner space a plunger is arranged,, and one of the said elements of the stabilizing cylinder is attached to the rear cross beam while the other is rigidly connected to the main moving crosspiece, the inner space of the stabilizing cylinder communicating hydraulically with the inner space of the auxiliary cylinder.

This ensures the automatic provision of the optimum ratio of the speed of movement of the container and speed of movement of the short ram in the process of extrusion.

In case of a given constant value of the ratio of the speed of movement of the container and the speed of movement of the short ram, the area F_2 of the cross-section of the stabilizing cylinder can be equal to

$$F_2=F_1(1-1/K_{V1}),$$

where:

F_1 is the area of the cross-section of the auxiliary cylinder;

F_2 is the area of the cross-section of the stabilizing cylinder;

K_{V1} is the value of the ratio Vc/Vr of the speed Vc of movement of the container and the speed Vr of movement of the short ram.

of the selected effort of the press, the requirements placed on the physicomechanical properties of the articles, and the rate of extrusion.

Preheating the billet 1 makes it possible to reduce the resistance of metal to the deformation, what in its turn leads to reduction in of energy consumption in the process of extrusion. Moreover, in a number of hard deforming alloys exhibiting a press effect (effect of structural hardening) there is an improvement of mechanical properties of the articles in case of processing these alloys by pressure with the use of preheating of the billets. Apart from this, in a number of cases preheating permits an increase in the adherence interaction of the billet 1 with the bush 2 of the container 3 and mandrel 4, which leads to an increase in the friction forces, and this is very important for the process being patented, since in the process under review the friction forces between the bush 2 of the container 3, the mandrel 4 and the billet 1 play a positive role, increasing the speed of the peripheral metal flow through the thickness of the wall of the hollow billet near the bush 2 of the container and the mandrel 4. Thus, their increase up to a specific magnitude promotes equalization of the rates of metal flow across the section of the billet near the gap formed by the mandrel 4 in the channel of the die 5. This permits an increase in the top rates of discharge of the metal.

After preheating, the billet 1 is fed to the press (Figure 2a), the mandrel 4 is passed through the billet and then pushed into the cavity 2 of the bush of the container 3 of the press (Figure 2b) . The length of the container 3 is selected in such a way that the billet 1, die 5 and short ram 6 can be placed freely and entirely in the container (Figures 2c, d). The length of the short ram 6 is adopted with regard to the kinematic characteristics of the movement of the container 3 and ram 6.

In order to decrease the energy consumption it is appropriate to preheat the container 3, die 5 and short ram 6 before the start of deformation. The temperature of preheating is chosen depending on the material of the billet 1 being extruded. For example, in case of extrusion of hard deforming aluminum alloys, it is approximately 300-400°C.

The container 3, mandrel 4 and short ram 6 are then started moving simultaneously in the direction of the die 5 mounted on the long ram 7, the speeds of the container 3 and mandrel 4 being higher than the speeds of the short ram 6 and drift-pin 8. After the short ram 6, the hollow billet 1 and the die 5 have come into contact, the stage of pressing out the billet 1 begins (Figure 2e). In this stage, the billet 1 occupies the entire volume bounding it. The outside diameter of the billet 1 becomes equal to the inside diameter of the hush 2 of the container 3, while the inside diameter of the billet 1 becomes equal to the diameter of the mandrel 4. After this, the metal starts to be extruded into the gap between the channel walls of the die 5 and the mandrel 4. The configuration of the gap corresponds to the cross-section of the hollow article being provided, with allowance made for the thermal expansion of the die 5 and, mandrel 4 as a result of their warming up and of a certain shrinkage of the metal after its cooling. In the stage of pressing out the billet 1, the speeds Vc of movement of the container 3, the speed Vm of movement of the mandrel 4 axed the speed Vr

In the process of extrusion, the container 3 can be moved at a speed Vc exceeding the speed Vr of the ram 6 by 1.03-1.4 times. It has been established by experiment that in case of extrusion, when the ratio Vc/Vr of the speed Vc of movement of the container 3 and the speed Vr of movement of the ram 6 exceeds 1.4 an excessive shear of the container 3 is observed relative to the billet 1. This circumstance causes an accelerated flow of the peripheral layers which, in its turn, leads to localization of the shear deformation and, as a consequence thereof, to large structural nonuniformity. This leads to a need to reduce the rate of extrusion.

Moreover, the selection of an extremely high ratio Vc/Vr of the speed Vc of movement of the container 3 to the speed Vr of movement of the short ram 6 (greater than 1.4) requires either a reduction in the starting length of the billet 1, which leads to a reduction in the productivity of the press, or to an increase in the length of the container 3, which makes the design of the press heavier and the cost of it higher.

The use in the process of extrusion of an excessively low ratio Vc/Vr of the speed Vc of movement of the container 3 and the speed Vr of movement of the short ram 6 (lower than 1.03) leads to localization of the shear deformation only in the boundary layer of the billet 1, which reduces the volume effect of the assistance of friction forces. This leads to nonuniformity in the metal flow and reduces the permissible level of the rate of extrusion, which leads to reduction in the quality of the hollow articles.

In the process of extrusion, the mandrel 4 can he moved at a constant ratio Vm/Vr of the speed Vm of movement of the mandrel 4 to the speed Vr of movement of the ram 6, which is within the limits o 1.01 to 1.05.

It has been established by experiment that in case of extrusion, when the ratio Vm/Vr of the speed Vm of movement of the mandrel 4 and the speed Vr of movement of the ram 6 exceeds 1.05, an excessive shear of the mandrel 4 is observed relative to the billet 1. This circumstance causes an accelerated metal flow of the layers adjacent to the mandrel 6 which, in its turn, leads to an increase in the nonuniformity of the flow. This makes it obligatory to reduce the rate of extrusion. The use in the process of extrusion of a ratio Vm/Vr of the speed Vm of movement of the mandrel 4 and the speed Vr of movement of the short ram 6 lower than 1.01 leads to localization of the shear deformation only in a thin boundary layer of the billet 1, which reduces the volume effect of the assistance of friction forces and does not provide adequate compressive stresses on the inner surface of the billet sufficient to remove contact defects.

In the process of extrusion, the container 3 can be moved at a constant ratio Vc/Vm of the speed Vc of movement of the container 3 to the speed Vm of movement of the mandrel 4, which is within the limits of 1.02 to 1.33.

In the process of extrusion of the billet 1, the ratio Vc/Vr of the speed of movement of the container 3 and the speed Vr of movement of the short ram 6 can be gradually decreased from a value of 1.15-1.4 to 1.01-1.02, depending on the reduction ratio of the hollow articles.

In case of extrusion, as a result of the execution of the deformation work the billet 1 releases heat as a function of the degree of deformation, indirectly expressed by the reduction ratio λm. Thus, the higher the reduction ratio λ_m, the greater value of the ratio Vc/Vr of the speed Vc of movement of the container 3 and the speed Vr of movement of the short ram 6, should be chosen to start the process (at most 1.4), then gradually reducing it to a minimum value (1.01) and simultaneously decreasing the reduction ratio λm to the minimum.

It is inexpedient to apply a value of a kinematic coefficient K_{V1} of the container greater than 1.4, because of the excessive localization of shear deformation in the output part of the article, which leads to intensive dynamic recrystallization of the metal structure and, as a result, to a reduction in the level of the mechanical properties of the articles.

It is likewise inexpedient to start the process at a value of a kinematic coefficient K_{V1} of the container less than 1.15, as the efficiency of the process is reduced, which has an effect on the productivity of the process.

In this case, the maximum value of the said ratio must be selected starting from the value of the total area of the cross-sections of all pairs of cylinders stabilizing the speed of movement of the short ram.

In the process of extrusion of the billet 1, the ratio Vm/Vr of the speed Vm of movement of the mandrel 4 and of the speed Vr of movement of the ram 6 can be reduced gradually from a value of 1.05 to 1.01. In case of deformation of hollow articles in conditions of the active assistance of friction forces, a gradual increase takes place in the frictional stresses τ_{am} on the surface of the billet 1 close by mandrel 4, which leads to additional shearing of the metal. This leads to a high structural nonuniformity in the rear part of the hollow article.

It is not expedient to reduce the intensity of the increase in frictional stress at the end of the process by a gradual reduction in the speed Vm of the mandrel 4 down to a ratio of Vm/Vr less than 1.01 since the level of compressive stresses on the rear part of the surface of the billet 1 is insufficient for a substantial improvement of quality of the surface of the finished article.

In the process of extrusion of the billet 1, the speed Vr of movement of the short ram 6 can be varied in accordance with the temperature field of the billet 1.

In conditions of extrusion through an insufficiently heated die 5 and short ram 6 at a heating temperature of the container 3 lower than the heating temperature of the billet 1, cooling of the rear part of the billet 1 can take place and this, in its turn, affects the level of the mechanical properties of the articles.

In order to obtain uniform mechanical properties and to increase productivity, it is necessary to vary the rate of extrusion smoothly in the course of the process.

Claims

1. A process for the hot extrusion of metal hollow articles with the active assistance of friction forces, consisting in that a hollow billet (1) undergoing extrusion is preheated and placed in a bush (2) of a container (3), into this bush a mandrel (4) is passed through the cavity of the billet (1), and then the billet is extruded, with the aid of a short ram (6) through an annular gap which is formed by the channel walls of the die (5) and by the mandrel (4) and which determines the shape and geometrical dimensions of the finished article, characterized in that in the process of extrusion the speed (Vc) of movement of the container (3) exceeds the speed (Vr) of movement of the short ram (6) by approximately 1.03 - 1.4 times and the speed (Vm) of movement of the mandrel (4) exceeds the speed (Vr) of movement of the short ram (6) by approximately 1.01 1.05 times, the ratio of the speed (Vc) of movement of the container (3) and the speed (Vm) of movement of the mandrel (4) being selected in the range 1.02 - 1.33 as a function of the reduction ratio and the temperature gradient.

2. A process according to Claim 1, characterized in that in the process of extrusion the ratios (Vc/Vr), (Vm/Vr), of the speed (Vc) of movement of the container (3) and the speed (Vr) of movement of the short ram (6), and also of the speed (Vm) of movement of the mandrel (4) and the speed (Vr) of movement of the short ram (6) are varied.

3. A process according to Claims 1, 2, characterized in that in the process of extrusion the ratio (Vc/Vr) of the speed of movement of the container (3) and the speed (Vr) of movement of the short ram (6) is varied from 1.01 to 1.4 in accordance with any given law as a function of the value of the reduction ratio and adopted temperature and extrusion rate conditions for the process.

4. A process according to Claims 2, 3, characterized in that in the process of extrusion the ratio (Vm/Vr) of the speed (Vm) of movement of the mandrel (4) and the speed (Vr) of movement of the short ram (6) is reduced

from 1.05 to 1.01.

5. A process according to any one of Claims 1-4, characterized in that in the process of extrusion the speed (Vr) of movement of the short ram (6) is varied as a function of the distribution of the temperature gradient along the length of the billet (1).

6. A process according to Claims 1-5, characterized in that the front end face of the billet (1) is heated in the temperature range from 0.75 to 0.9 of the temperature of the upper bound of the interval of processing ductility of the material being extruded, while the rear end face of the billet (1) is heated in the temperature range from 0.6 to 0.7 of the temperature of the upper bound of the interval of processing ductility of the material being extruded as a function of the thickness of the wall of the billet being extruded.

7. A process according to Claim 6, characterized in that before extrusion, the temperature of the heating of the container (3) is set in the range from 1.0 to 0.95 of the temperature of the heating of the front end face of the billet (1).

8. A process according to any one of Claims 1-7, characterized in that the mandrel (4) is imparted a cyclic translational movement in the direction of metal outflow because of cyclic loading.

9. A process according to Claims 1-8, characterized in that in case of a constant value of the ratio of the speed (Vc) of movement of the container (3) and speed (Vr) of movement of the short ram (6), the maximum value of this ratio is determined by means of the total area of the cross-sections of all pairs of cylinders stabilizing the speed (Vc) of movement of the short ram (6).

10. A hydraulic extrusion press for providing metal hollow articles, comprising front (10) and rear (11) cross beams rigidly mounted on a frame (9), a container (3) having the possibility of reciprocating movement along the longitudinal axis of the press, a main moving crosspiece (13) to which a plunger (20) is rigidly attached, at least one main power cylinder whose body (19) is mounted in a stationary fashion on the rear (11) cross beam, the inner space of the main cylinder being connected to a high-pressure (41) main and a low-pressure (47) main, an auxiliary cylinder which is connected to the main moving crosspiece (13) and whose inner space is connected through a restricting unit (54) to the low-pressure (47) main, a short ram (6) attached to the plunger of the auxiliary cylinder and constructed to be hollow and in one piece with a die-plate (33), a mandrel (4) with the mandrel holder (36) which are mounted in the cavity of the short ram (6), the said mandrel holder (36) being connected to the plunger (35) of the power cylinder of the mandrel and to its moving crosspiece (37) that is arranged inside the main moving crosspiece (13), and also a hollow long ram (7) attached to the front (10) cross beam coaxially with the short ram (6), the said press being characterized in that it is fitted with a drift-pin (8) with a flange (71), a cylindrical bush (72) with collars (73, 74) constructed correspondingly on its inner and outer surfaces, and a spring-loaded element (75) arranged between the body of the short ram (6) and the outer surface of the cylindrical bush (72), the drift-pin (8) with the flange (71) being mounted inside the short ram (6) and being rigidly connected to the cylindrical bush (72), while the mandrel (4) being arranged inside the drift-pin (8) and being constructed with a cylindrical collar (77), whose outside diameter corresponds to the inside diameter of the cylindrical bush (72), and being rigidly connected to the mandrel holder (79) by means of a stem (78).

11. A hydraulic extrusion press according to Claim 10, characterized in that the plunger (30) of the auxiliary cylinder is mounted inside the main moving crosspiece (13), constructed to be hollow and fitted with a centering stem (31) passing through the base of the cylindrical body (29) of the auxiliary cylinder.

12. A hydraulic press according to Claims 10, 11 characterized in that the basic restricting unit of the auxiliary cylinder comprises at least one stabilizing cylinder (23) which is a cylindrical body (23) in whose inner space (27) a plunger (24) is arranged, and one of the said elements of the stabilizing cylinder is attached to the rear cross beam (11) while the other is rigidly connected to the main moving crosspiece (13), the inner space (27) of the stabilizing cylinder communicating hydraulically with the inner space (28) of the auxiliary cylinder.

13. A hydraulic extrusion press according to Claim 12, characterized in that the stabilizing cylinder has a cross-sectional area which is equal to

$F_2=F_1(1-1/K_{V1})$, where

F_1 is the area of the cross-section of the auxiliary cylinder;

F_2 is the area of the cross-section of the stabilizing cylinder;

H_1 is the length of the working space of the auxiliary cylinder;

Hp is the maximum length of the working stroke of the stabilizing cylinder; and

K_{V1} is the given constant value of the ratio (Vc/Vr) of the speed (Vc) of movement of the container (3) and the speed (Vr) of movement of the short ram (6).

14. A hydraulic extrusion press according to Claims 12, 13, characterized in that the total area of the cross-sections of all pairs of cylinders stabilizing the speed (Vr) of movement of the short ram (6) is equal to

$\sum F_2=F_1(1-1/K_{V1\ max})$, where

F_1 is the area of the cross-section of the auxiliary cylinder;

$\sum F_2$ is the total area of the cross-sections of all pairs of stabilizing cylinders; and

$K_{v1\ max}$ is the maximum value of the ratio (Vc/Vr) of the speed (Vc) of movement of the container (3) and speed (Vr) of movement of the short ram (6).

15. A hydraulic extrusion press according to Claims 10-14, characterized in that it includes at least two booster return power cylinders (83) of which each is constructed in the form of a cylindrical body (83) in whose inner space a plunger (84) is arranged, and one of the said elements of each booster return power cylinder is attached in a stationary fashion to one of the cross beams (11) while the other is rigidly connected to the main moving crosspiece (13), and the inner space (85) of each of them communicates with the low-pressure (47) and high-pressure (41) mains, and the inner space (85) of each booster return power cylinder is hydraulically connected to the inner space (28) of the auxiliary cylinder.

16. A hydraulic extrusion press according to Claims 10, 15, characterized in that it includes one pair of return cylinders of a mandrel (4), each cylinder consisting of a cylindrical body (38) and plunger (39), one of the elements of each cylinder being attached to the main crosspiece (13), and the other to the moving crosspiece (37) of the mandrel (4).

17. A hydraulic extrusion press according to Claims 15, 16, characterized in that it is fitted with an intermediate moving crosspiece (111) which is rigidly connected to the plunger (30) of the auxiliary cylinder, and with intermediate cylinders, each of which consists of a cylindrical body (112) and plunger (113), the body (112) of each of the cylinders is arranged, in its turn, on the main moving crosspiece (13) while the plunger (113) is rigidly connected to the intermediate moving crosspiece (111).

18. A hydraulic extrusion press according to Claim 17, characterized in that the cylinders for stabilizing the movement of the mandrel are the booster return power cylinders consisting of a cylindrical body (83) and plunger (84), and one of the elements of each of them is rigidly connected to the rear cross beam (11) while the other is also rigidly connected to the main moving crosspiece (13).

19. A hydraulic extrusion press according to Claims 17, 18, characterized in that the inner space (114) of the intermediate cylinder communicates with the inner space (44) of the return cylinder of the mandrel (4), while the inner space (34) of the power cylinder of the mandrel (4) is hydraulically connected to the inner space (85) of the booster return cylinder.

20. A hydraulic extrusion press according to Claims 17-19, characterized in that the inner spaces (44) of the return cylinders of the mandrel (4) and of the power cylinder of the mandrel (4) are hydraulically connected through corresponding valves (49, 50, 51) to the high-pressure (41) and low-pressure (47) mains.

21. A hydraulic extrusion press according to any one of Claims 12 to 20, characterized in that the main connecting the inner spaces (27, 85) of each stabilizing cylinder and booster return cylinders hydraulically connected to the inner space (28) of the auxiliary cylinder is connected, in addition to this, to the high-pressure (41) and low-pressure (47) mains through corresponding valves (60, 90).

22. A hydraulic extrusion press according to any one of Claims 12 to 21, characterized in that it includes at least one auxiliary restricting unit (54) having a body (94) with inlet (95, 96) holes and outlet (97, 98) holes fitted with at least one cover (108), there being mounted inside this unit a slide valve (99) which is spring-loaded from the side of the cover (108) and which has two through holes (100, 101), the configuration and geometrical dimensions of each of which determine the magnitude of the speed of mutual movement of the container (3) and short ram (6) and also of the mandrel (4) and short ram (6), one through hole (100) being hydraulically connected through a corresponding inlet hole (95) to the inner space (28) of the auxiliary cylinder and the low-pressure main (47), and the other through hole (101) being hydraulically connected through the other corresponding inlet hole (96) to the inner space (34) of the power cylinder of the mandrel (4) and also to the low-pressure main (47).

23. A hydraulic press according to Claim 22, characterized in that the slide valve (99) of the auxiliary restricting unit (54) is constructed with a through hole (101) of variable cross-section inside which connecting pieces (109) are mounted.

24. A hydraulic extrusion press according to Claims 22, 23, characterized in that it includes at least one valve (92) mounted in the main (41) connecting the inner space (28) of the auxiliary cylinder to the auxiliary restricting unit (54).

25. A hydraulic press according to Claims 22-24, characterized in that it includes at least one valve (56) mounted in the main (67) connecting the inner space (34) of the power cylinder of the mandrel (4) to the auxiliary restricting unit (54).

ABSTRACT

A process for the hot extrusion of hollow articles with the active assistance of friction forces, consisting in that a hollow billet (1) undergoing extrusion is preheated and placed in a bush (2) of a container (3), and into this bush a mandrel (4) is passed through the cavity of this billet (1), and then the billet is extruded, with the aid of a short ram (6) while simultaneously moving the container (3), mandrel (4) and short ram (6), through an annular gap which is formed by the channel walls of the die (5) and by the mandrel (4) and which determines the shape and geometrical dimensions of the finished article, it being the case that in the process of extrusion the ratio of the speed Vr of movement of the short ram (6) is maintained constant or is varied in accordance with a given law in optimum ranges as a function of the reduction ratio, the temperature conditions and the rate of the extrusion.

A hydraulic extrusion press for providing hollow articles, comprising front (10) and rear (11) cross beams rigidly mounted on a frame (9), a container (3) mounted with the possibility of reciprocating movement along the longitudinal axis of the press, a main moving crosspiece (13) to which a plunger is rigidly attached, at least one main power cylinder whose body (19) is attached in a stationary fashion to the rear (11) cross beam, the inner space being connected to high-pressure and low-pressure mains, an auxiliary cylinder which is connected to the main moving crosspiece and to whose plunger (30) there is rigidly attached a hollow short ram (6) constructed in one piece with a die-plate (33) and in whose cavity there is arranged a mandrel (4) with a mandrel holder (36) fitted with a plunger (35) of the power

Claims

1. A process for the hot extrusion of metal hollow articles with the active assistance of friction forces, consisting in that a hollow billet (1) undergoing extrusion is preheated and placed in a bush (2) of a container (3), and into this bush a mandrel (4) is passed through the cavity of the billet (1), and then the billet is extruded, with the aid of a short ram (6) while simultaneously moving the container (3), mandrel (4) and short ram (6), through an annular gap which is formed by the channel walls of the die (5) and by the mandrel (4) and which determines the shape and geometrical dimensions of the finished article, characterized in that in the process of extrusion the speed (Vc) of movement of

the container (3) and speed (Vm) of movement of the mandrel (4) exceed the speed (Vr) of movement of the short ram (6).

2. A process according to Claim 1, characterized in that the speed (Vm) of movement of the container (3) exceeds the speed (Vr) of movement of the short ram (6) by approximately 1.03 - 1.4 times.

3. A process according to Claims 1, 2, characterized in that the speed (Vm) of movement of the mandrel (4) exceeds the speed (Vr) of movement of the short ram (6) by approximately 1.01 - 1.05 times.

4. A process according to Claims 1, 2, 3, characterized in that the speed (Vc) of movement of the container (3) exceeds the speed (Vm) of movement of the mandrel (4) by approximately 1.02 - 1.33 times.

5. A process according to Claims 1, 2, 3, 4, characterized in that the ratios (Vc/Vr), (Vm/Vr), of the speed (Vc) of movement of the container (3) and the speed (Vr) of movement of the short ram (6), as well as the speed (Vm) of movement of the mandrel (4) and the speed (Vr) of movement of the short ram (6) are varied on purpose.

6. A process according to Claim 5, characterized in that in the process of extrusion the ratio (Vc/Vr) of the speed (Vc) of movement of the container (3) and the speed (Vr) of movement of the short ram (6) is reduced approximately from 1.4 to 1.01 as a function of the magnitude of the reduction ratio of the hollow article.

7. A process according to Claims 5, 6, characterized in that in the process of extrusion the ratio (Vm/Vr) of the speed (Vm) of movement of the mandrel (4) and the speed (Vr) of movement of the short ram (6) is reduced approximately from 1.05 to 1.01.

8. A process according to any one of Claims 1 to 7, characterized in that in the process of extrusion the speed (Vr) of movement of the short ram (6) is varied as a function of the distribution of the temperature gradient along the length of the billet (1).

9. A process according to Claim 8, characterized in that the front end face of the billet (1) is heated in the temperature range from 0.75 to 0.9 of the temperature of the upper bound of the interval of processing ductility of the material being extruded, while the rear end face of the billet (1) is heated in the temperature range from 0.6 to 0.7 of the temperature of the upper bound of the interval of processing ductility of the material being extruded as a function of the thickness of the wall of the billet being extruded.

10. A process according to Claim 8, characterized in that before extrusion, the temperature of the heating of the container (3) is set in the range from 1.0 to 0.95 of the temperature of the heating of the front end face of the billet (1).

11. A process according to any one of Claims 1 to 10, characterized in that the mandrel (4) is imparted a cyclic translational movement in the direction of metal outflow because of cyclic loading.

12. A hydraulic extrusion press for providing metal hollow articles, comprising front (10) and rear (11) cross beams rigidly mounted on a frame (9), a container (3) having the possibility of reciprocating movement along the longitudinal axis of the press, a main moving crosspiece (13) on which a plunger (20) is rigidly mounted, at least one main power cylinder whose body (19) is mounted in a stationary fashion on the rear (11) cross beam; the inner space of the main (40) cylinder being connected to a high-pressure (41) main and a low-pressure (47) main, and also an auxiliary cylinder connected to the main moving crosspiece (13), and an inner space (28) of the auxiliary cylinder communicating through a restricting unit (54) with the low-pressure (47) main only, and also to whose plunger (30) there is rigidly attached a hollow short ram (6) constructed in one piece with a die-plate (33) and in whose cavity there is arranged a mandrel (4) with a mandrel holder (36) fitted with a plunger (35) of the power cylinder and with its own moving crosspiece (37) mounted inside the main moving crosspiece (13), the mandrel holder (36) itself simultaneously being attached to the plunger (35) of the power cylinder of the mandrel and on the crosspiece (37) thereof, a hollow long ram (7) also being arranged coaxially with the short ram (6) and connected to the front (10) cross beam, characterized in that it includes a control unit for setting up pressing regimes, a drift-pin (8) with a flange (71) which are mounted inside the short ram (6) and are rigidly connected to the cylindrical bush (72), which has collars (73, 74) arranged correspondingly on its inner and outer surfaces, a spring-loaded element (75) being arranged between the body of the short ram (6) and the outer surface of this bush (72), and the mandrel (4), which is arranged inside the drift-pin (8), having a cylindrical collar (77) whose diameter corresponds to the diameter of the inner cavity of the cylindrical bush (72), and being fitted with a stem (78) rigidly connected to the mandrel holder (79).

13. A hydraulic extrusion press according to Claim 12, characterized in that the plunger (30) of the auxiliary cylinder is mounted inside the main moving crosspiece (13), constructed to be hollow and fitted with a centering stem (31) passing through the base of the cylindrical body (29) of the auxiliary cylinder.

14. A hydraulic press according to Claims 12, 13 characterized in that the basic restricting unit of the auxiliary cylinder comprises at least one stabilizing cylinder (23) which is a cylindrical body (23) in whose inner space (27) a plunger (24) is arranged, and one of the said elements of the stabilizing cylinder is attached to the rear cross beam (11) while the other is rigidly connected to the main moving crosspiece (13), the inner space (27) of the stabilizing cylinder communicating hydraulically with the inner space (28) of the auxiliary cylinder.

15. A hydraulic press according to Claims 12, 13, 14, characterized in that in case of a given constant value of the ratio (Vc/Vr) of the speed (Vc) of movement of the container (3) and the speed (Vr) of movement of the short ram (6), the area (F_2) of the cross-section of the stabilizing cylinder is equal to $F_2=F_1(1-1/K_{V1})$, where: F_1 is the area of the cross-section of the auxiliary cylinder; F_2 is the area of the cross-section of the stabilizing cylinder; K_{V1} is the value of the ratio (Vc/Vr) of the speed (Vc) of movement of the container (3) and the speed (Vr) of movement of the short ram (6), and the length of the working space (28) of the auxiliary cylinder is equal to:

$$H_1=Hp(1-1/K_{V1}),$$

where:

H_1 is the length of the working space (28) of the auxiliary cylinder;
Hp is the maximum length of the working stroke of the stabilizing cylinder.

16. A hydraulic press according to Claims 12, 13, 14, 15, characterized in that in case of a constant value of the ratio (Vc/Vr) of the speed (Vc) of movement of the container (3) and the speed (Vr) of movement of the short ram (6), the maximum value of this ratio is determined starting from the total areas of the cross-sections of all pairs of cylinders stabilizing the speed (Vr) of movement of the short ram (6).

17. A hydraulic extrusion press according to Claims 12, 13, 14, 15, 16, characterized in that it includes at least two booster return power cylinders (83) of which each is constructed in the form of a cylindrical body (83) in whose inner space a plunger (84) is arranged, and one of the said elements of each booster return power cylinder is attached in a stationary fashion to one of the cross beams (11) while the other is rigidly connected to the main moving crosspiece (13), and the inner space (85) of each of them communicates with the low-pressure (47) main and the high-pressure (41) main, and the inner space (85) of each booster return power cylinder is hydraulically connected to the inner space (28) of the auxiliary cylinder.

18. A hydraulic extrusion press according to Claims 12, 17, characterized in that it includes one pair of return cylinders of a mandrel (4) each cylinder consisting of a cylindrical body (38) and plunger (39), one of the elements of each cylinder is attached to the main crosspiece (13) while the other is attached to the moving crosspiece (37) of the mandrel (4).

19. A hydraulic extrusion press according to Claims 17, 18, characterized in that it includes an intermediate moving crosspiece (111) which is rigidly connected to the plunger (30) of the auxiliary cylinder, and intermediate cylinders, each of which consists of a cylindrical body (112) and plunger (113), the body (112) of each of them is arranged, in its turn, on the main moving crosspiece (13) while the plunger (113) is rigidly connected to the intermediate moving crosspiece (111).

20. A hydraulic extrusion press according to Claim 19, characterized in that the cylinders for stabilizing the movement of the mandrel are the booster return power cylinders consisting of a cylindrical body (83) and plunger (84), and one of the elements of each of them is rigidly connected to the rear cross beam (11) while the other is also rigidly connected to the main moving crosspiece (13).

21. A hydraulic extrusion press according to Claims 19, 20, characterized in that the inner space (114) of the intermediate cylinder communicates with the inner space (44) of the return cylinder of the mandrel (4), while the inner space (34) of the power cylinder of the mandrel (4) is hydraulically connected to the inner space (85) of the booster return cylinder.

22. A hydraulic extrusion press according to Claims 19, 20, 21, characterized in that the inner spaces (44) of the return cylinders of the mandrel (4) and of the power cylinder of the mandrel (4) are hydraulically connected through corresponding valves (49, 50, 51) to the high-pressure (41) and low-pressure (47) mains.

23. A hydraulic extrusion press according to any one of Claims 14 to 22, characterized in that the main connecting the inner spaces (27, 85) of each stabilizing cylinder and booster return cylinders hydraulically connected to the inner space (28) of the auxiliary cylinder communicate, in addition to this, with the high-pressure (41) main and low-pressure (47) main through corresponding valves (60, 90).

24. A hydraulic extrusion press according to any one of Claims 14 to 23, characterized in that it includes at least one auxiliary restricting unit (54) having a body (94) with inlet (95, 96) holes and outlet (97, 98) holes fitted with at least one cover (108), there being mounted inside this unit a slide valve(99) which is spring-loaded from the side of the cover (108) and which has two through holes (100, 101), the configuration and geometrical dimensions of each of which determine the value of the speed of mutual movement of the container (3) and short ram (6) and also of the mandrel (4) and short ram (6), one through hole (100) being hydraulically connected through a corresponding inlet hole (95) to the inner space (28) of the auxiliary cylinder and the low-pressure main (47), and the other through hole (101) being hydraulically connected through the other corresponding inlet hole (96) to the inner space (34) of the power cylinder of the mandrel (4) and also to the low-pressure main (47).

25. A hydraulic press according to Claim 24, characterized in that the slide valve (99) of the auxiliary restricting unit (54) has a through hole (101) of variable cross-section inside which connecting pieces (109) are mounted.

26. A hydraulic press according to Claims 24, 25, characterized in that it includes at least one valve (92) mounted in the main (41) connecting the inner space (28) of the auxiliary cylinder to the auxiliary restricting unit (54).

27. A hydraulic press according to Claims 24, 25, 26, characterized in that it includes at least one valve (56) mounted in the main (67) connecting the inner space (34) of the power cylinder of the mandrel (4) to the auxiliary restricting unit (54).

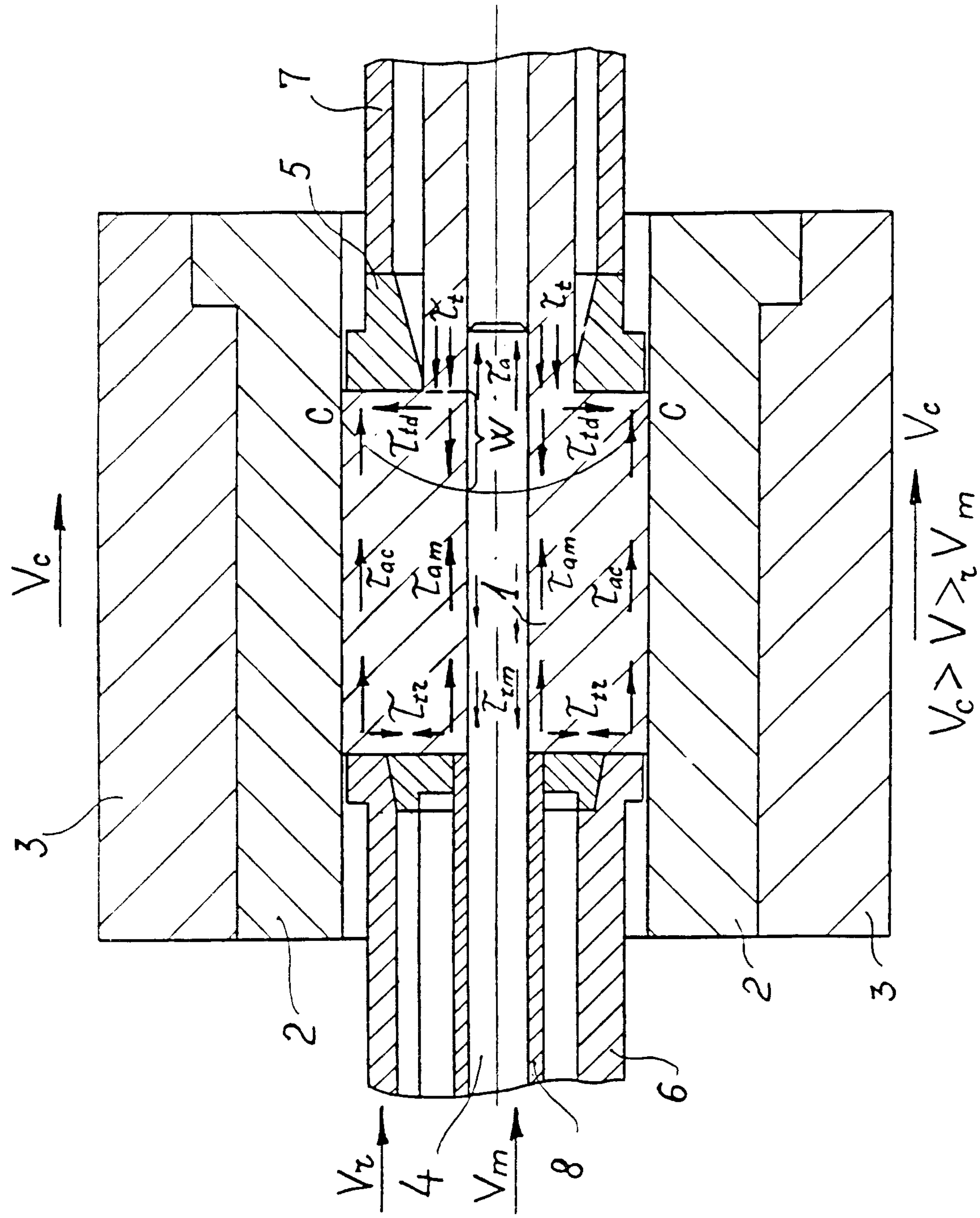

FIG. 1

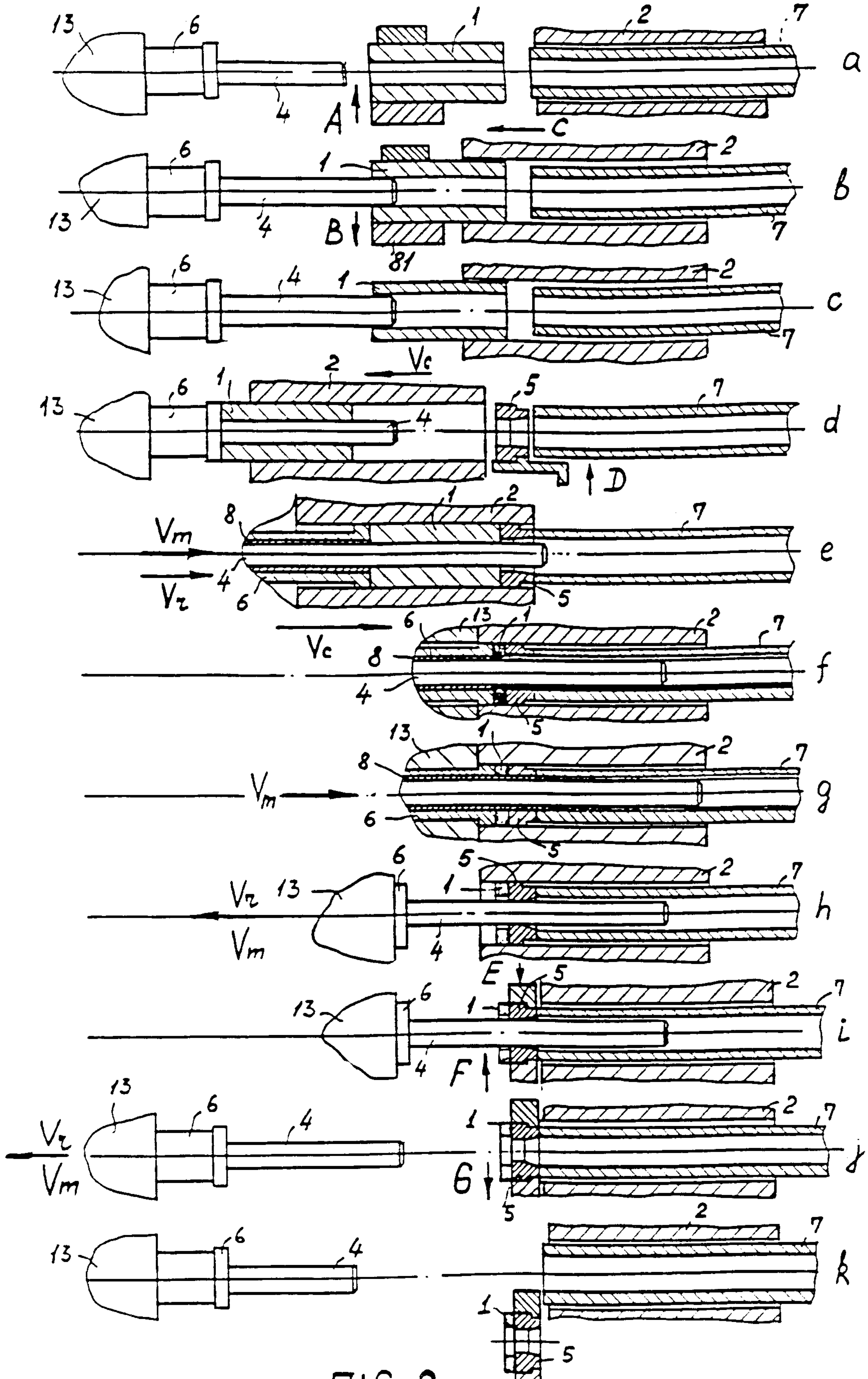

FIG. 2

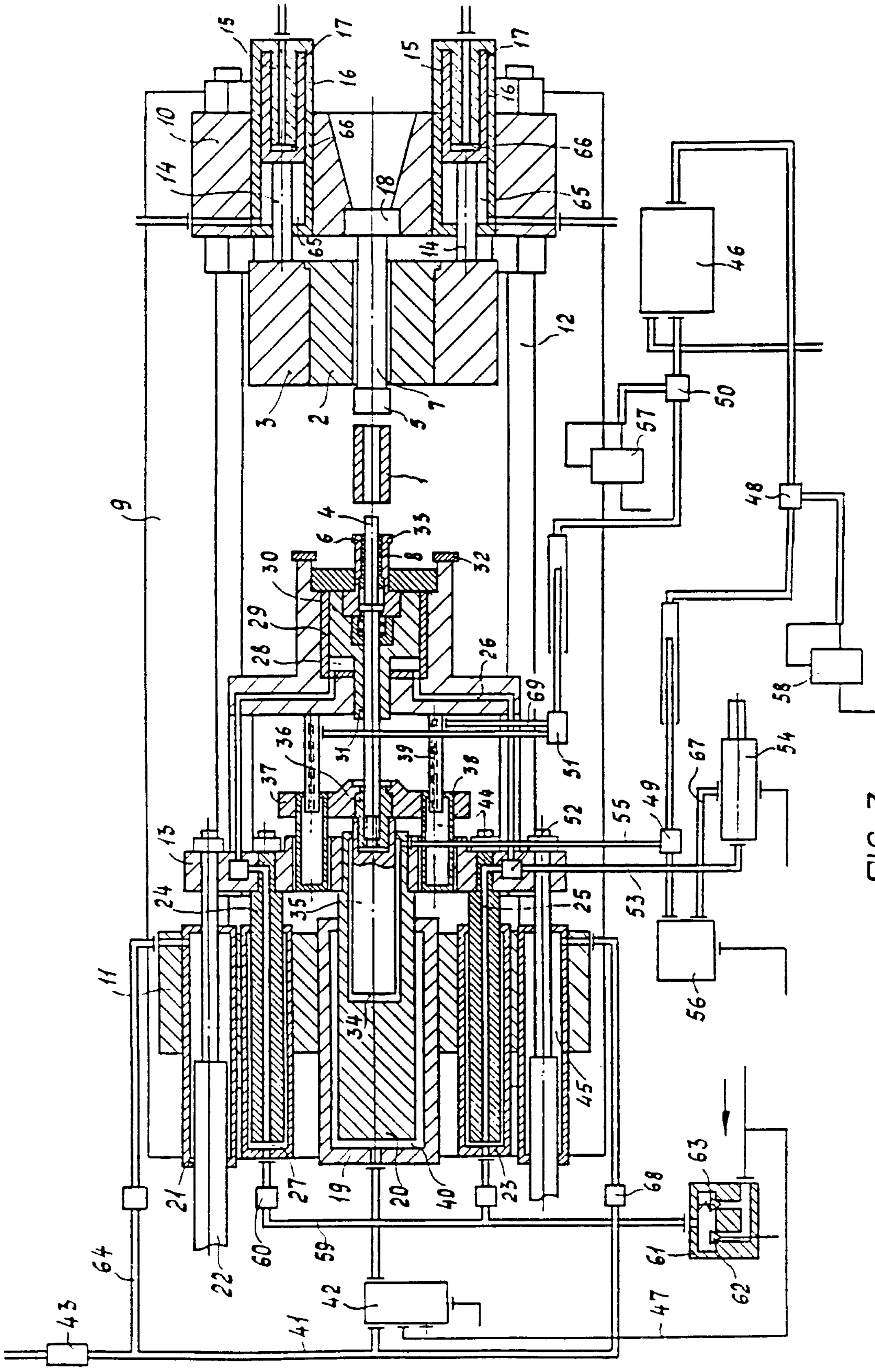

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FIG.3

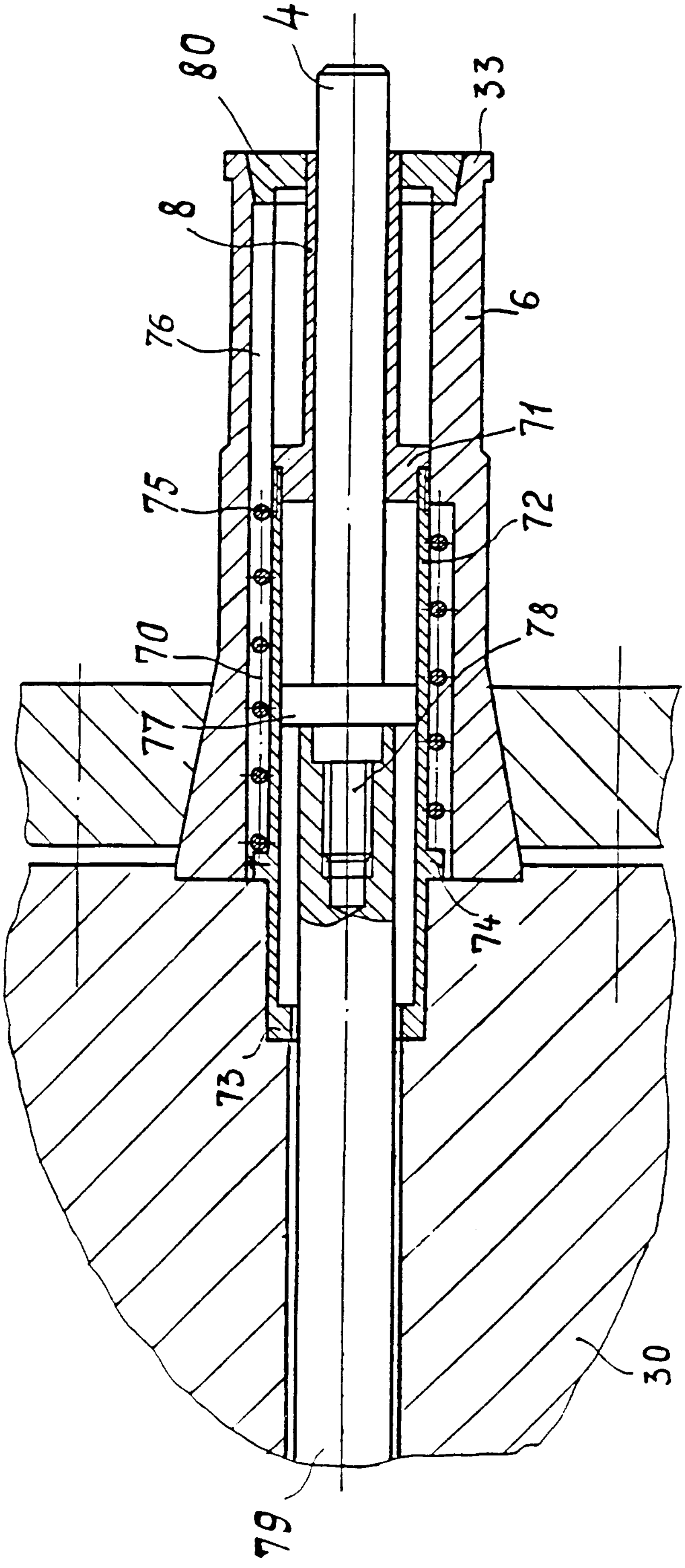

FIG. 4

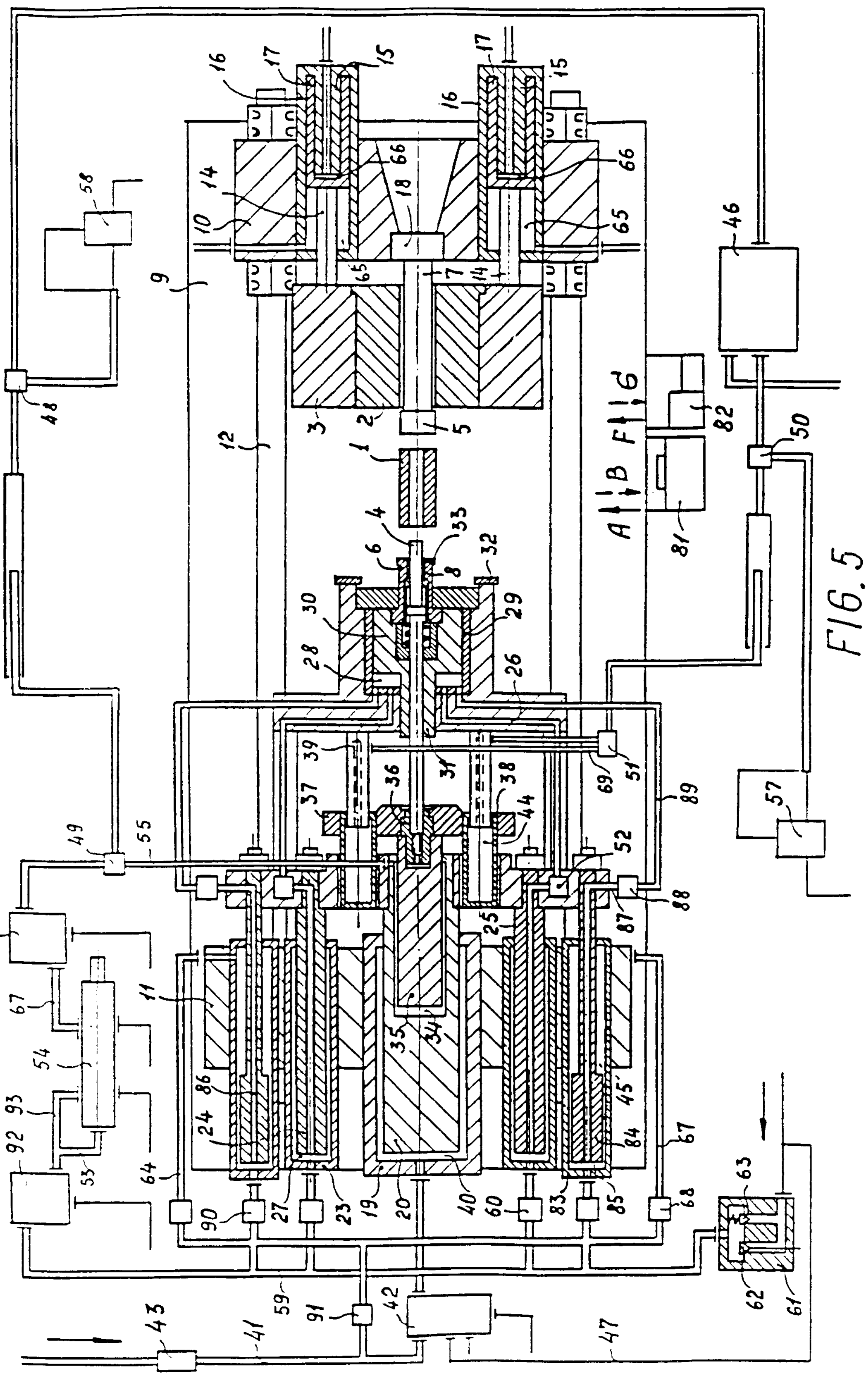

FIG. 5

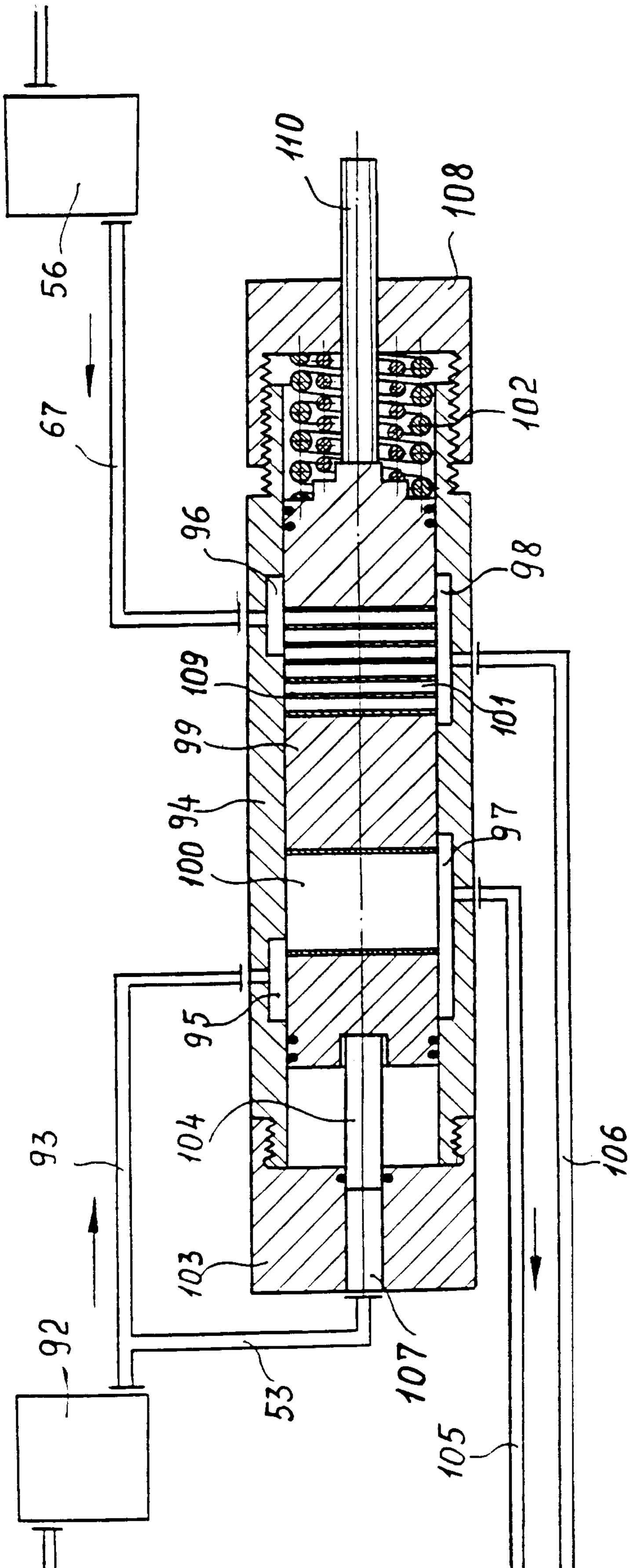
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FIG. 6

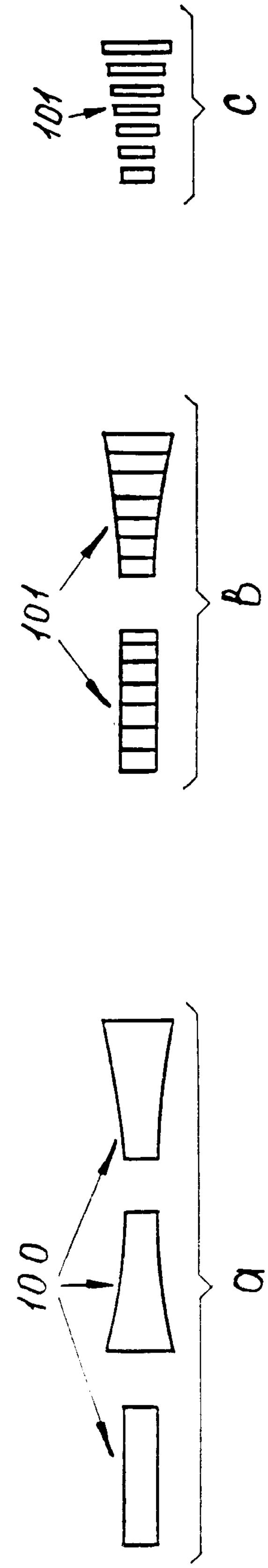
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FIG. 7

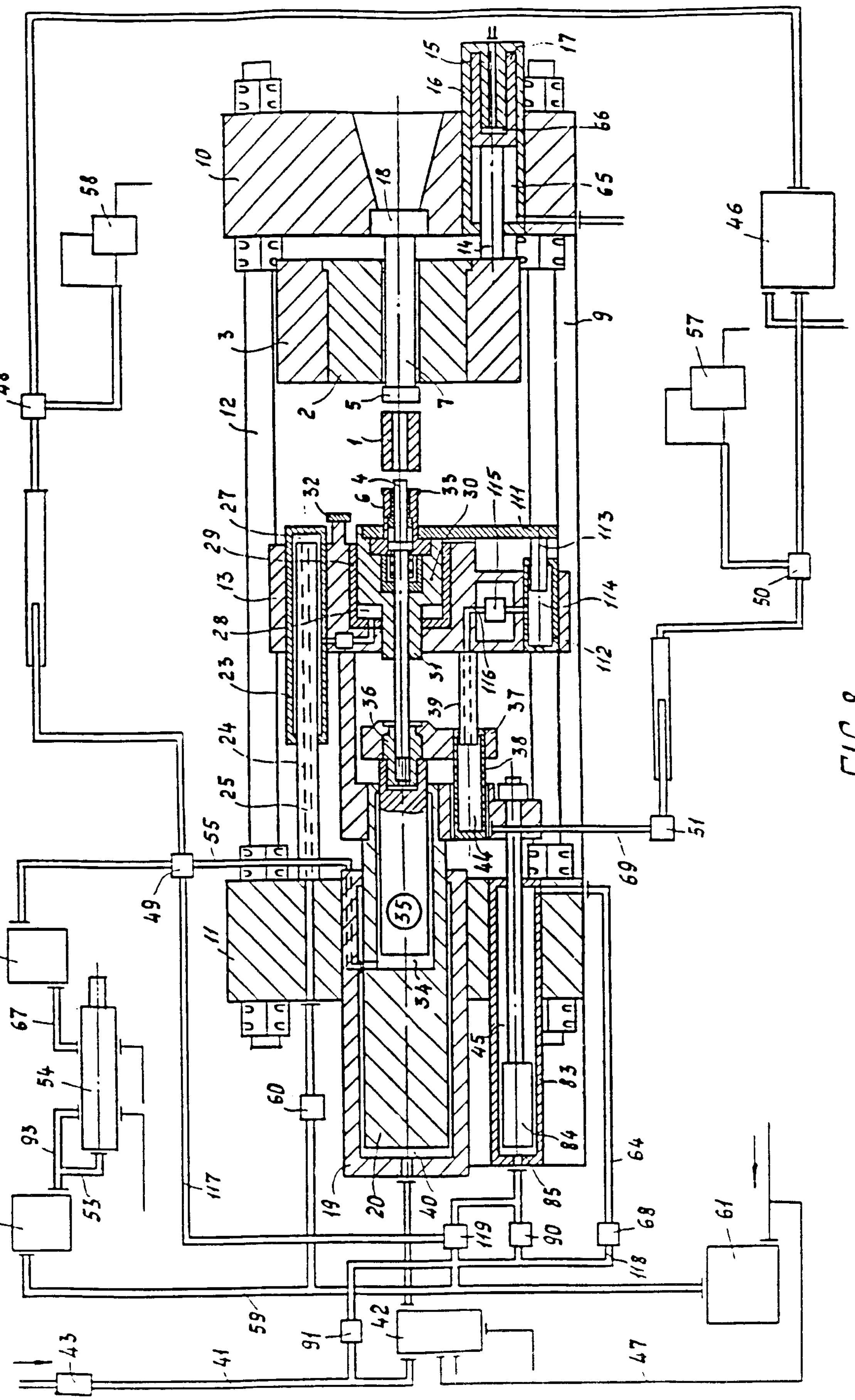

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 95/00012

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B21C 23/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B21C 23/00,23/02,23/04,23/08,23/21

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SU, A, 504574 (Ya.M. Okhrimenko et al), 11 March 1976 (11.03.76), column 2, lines 28-29, column 3, lines 1-14	1
A	SU, A, 645721 (Moskovsky institut stali splavov), 8 February 1979 (08.02.79)	1-11
A	DE, A, 1452362 (Lindemann Mashinenfabric GmbH), 4 May 1972 (04.05.72)	12-27
A	DE, B2, 2125570 (Allmann Svenska ElektriskaAB), 7 October 1976 (07.10.76)	12-27
A	SU, A, 562331 (V.L. Berezhnoi et al), 27 September 1977 (27.09.77)	12-27

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 June 1995 (13.06.95)	22 June 1995 (22.06.95)
Name and mailing address of the ISA/ RU	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)