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(54) **PROCESS FOR THE HOT EXTRUSION OF METAL WITH THE ACTIVE ASSISTANCE OF FRICTION FORCES, AND A HYDRAULIC EXTRUSION PRESS FOR CARRYING OUT THIS PROCESS**

(57) Process for the hot extrusion of metal with the active assistance of friction forces, consisting in that a preheated billet (1) is placed in a container (3) and thereafter extruded through a die (5), which determines the shape and geometrical dimensions of the finished article, with the aid of a ram (4), while moving said container and ram simultaneously, and the speed of movement V_C of the container (3) exceeds the speed of movement V_R of the ram (4) by approximately 1.05-1.3 times. A hydraulic extrusion press comprising a cross-piece (8) on which there is mounted an auxiliary cylin-

der whose inner space (20) is hydraulically connected to the inner space (19) of the stabilizing cylinders mounted on the rear cross beam (12) of the press, while the ram (4) is mounted on the plunger (22) of the auxiliary cylinder and enters the container (3) with the billet (1), and the die (5) with the hollow ram (6) is mounted on the other side of the container (3), while the hollow ram is rigidly attached to the front cross beam (11) of the press.

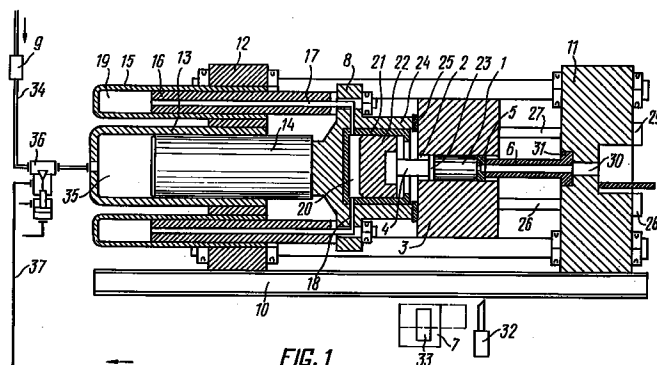


FIG. 1

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Description

Technical Field

5 The invention relates to the processing of metals by pressure, specifically to a process for the hot extrusion of metal with the active assistance of friction forces, and to a device for implementing it, and may be used to obtain rods, bars and shapes used in the aircraft industry, civil engineering, motor industry, etc.

Prior art

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The conventional, known process for the hot extrusion of metal comprises the following operations: heating the billet in a furnace, feeding it into a container and extruding the billet through the channel of the die while simultaneously moving the ram and the container. The article obtained is transported onto a cooling table, and the remaining discard is separated from the die and placed in the waste.

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A process is known for pressing metal and alloys which comprises heating a metal billet, placing it in a container, extruding it and removing the article and the discard (compare Patent No. 2675125).

In the extrusion process, the container and the ram are moved with various combinations of their speeds, but excluding the case when the speed of the container exceeds the speed of the ram.

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In an extreme instance of the process indicated, the container is stationary and only the ram is moved, extruding the billet through the channel of the die. In this instance, a process is realized which is termed direct, and the articles obtained have a high-grade surface.

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At the same time, in the case of the direct process the billet is moved relative to the container, with the result that there are formed on the contact surfaces of the billet reactive friction forces which are directed in the opposite direction to the metal outflow. This circumstance requires the application of substantial energy expenditure in order to overcome them. Moreover, the nature of the metal flow in the direct process of extrusion is marked by a high degree of unevenness, which may be the reason for the appearance of internal defects in the product. In a second extreme case in accordance with the abovementioned process, the container and the ram are moved simultaneously at identical speeds. Such a process is termed indirect. In this instance, there is no need to overcome friction forces between the container and the billet, with the result that substantially less energy expenditure is required to implement this process.

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The articles obtained have no internal defects, but the extrusion requires billets with a turned external surface, and this requires sizable additional costs.

In the indirect process of extrusion, the unevenness in the metal flow remains although it decreases by comparison with the direct extrusion process. The unevenness in the metal flow leads to nonuniformity in the structure and physico-mechanical properties along the length and over the cross-section of the articles.

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Moreover, the pressing process described above is characterized by the presence of a significant speed gradient at the site of deformation origin, what limits the maximum outflow rates when pressing a broad range of alloys. For the same reason, significant tensile stresses, which can lead to the appearance of cracks, arise on the surface of the articles in the channel of the die.

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It is envisaged in the abovementioned extrusion process that part of the process may be carried out in one way, while the other part of the process may be carried out in another way. Moreover, the speed of the container movement may be somewhat lower than the speed of movement of the ram. However, each process realized is correspondingly characterized by those indicated shortcomings of the process to which it is more closely related.

A device is known (see US Patent 2675125) which can be used to extrude metal by means of direct, indirect or mixed methods (in the process of extrusion operation one method is being changed to another).

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The device consists of a container, which is mounted on a frame with the possibility of reciprocating movement along its longitudinal axis, and a movable crosspiece to which there is rigidly attached a plunger of a main cylinder which is mounted in a stationary fashion on the rear cross beam. Mounted on the movable crosspiece are two cylinders for moving the container, the plungers of which are rigidly attached to the container. Mounted on the front cross beam are return cylinders for moving the container, the plungers of which are also rigidly attached to the container. Rigidly attached to the movable crosspiece is a ram, which enters the container in the process of extrusion, while a hollow ram which is mounted in a stationary fashion on the front cross beam is arranged on the other side of the container, likewise in a fashion coaxial therewith. The inner spaces of power hydraulic cylinders are connected via a distribution box to high-pressure and low-pressure mains.

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The heated billet is raised by a feed mechanism to the axis of the press. With the crosspiece idling, it is pushed into the container. Next, a pressing process employing the direct method is started (for example). The return cylinders for moving the container are closed, and fluid at high pressure is supplied to the main cylinder, while the container cylinder is connected to a low-pressure mains. Under the action of the ram, the billet starts to be extruded through the die. Once the billet has reached a given size, the press is switched to the indirect method. For this, the return cylinders of the container are connected to the low-pressure main, while the container cylinders are closed. At this instant, the speeds of

the pressing crosspiece and the container become equal, and the indirect pressing process starts. After the discard has reached a given size, the process is stopped. Using the cylinders for moving the container, the discard is extracted from the container and detached. The article is removed and the cycle can be repeated.

If necessary, it is possible to use the extruding device for only the direct or indirect processes. It is also possible for them to be combined otherwise in the course of the extrusion process.

Incorporating such a device into a press makes it possible to carry out extrusion by means of either the direct or the indirect method, depending on what is required, making use of the advantages which are characteristic of one or other process.

At the same time, the use of such a device is very difficult because it requires the simultaneous coordination of the movements of two hydraulic systems, one of which serves to move the container, and the other directly to extrude the metal through the die. In the pressing process, there is a significant reduction in the fraction of the effort expended on overcoming reactive friction forces on the lateral surface between the billet and the container as a consequence of reduction in the length of the billet. This leads to a change by a factor of several times in the effort required to move the container. Such operating conditions require special expensive equipment to control the supply of the working fluid to the working power cylinders.

Moreover, since the cylinders for moving the container and the return cylinders of the container must be closed up, they experience the entire effort of the press. This leads to a significant rise in the pressure in them (multiplication) and, accordingly, to a rapid wear of the seals and frequent repair of the press.

Moreover, the present device does not permit extrusion with the active assistance of friction forces. For this reason, the articles are obtained with a low level of mechanical properties and an uneven distribution of them along the length and over the cross-section of the articles. It is not possible on this device to achieve limiting rates of metal outflow, which reduces the productivity of the process.

Another process for hot extrusion with the active assistance of friction forces is known, and consists in the following. The billet intended for extrusion is heated, placed into the container and extruded through the channel of the die, which determines the shape of the article, by joint movement of the ram and the container. In the process of extrusion, the container is moved at a speed higher than the speed of the ram movement (Journal of Engineering for Industry, February 1970/145, pages 73-84).

By heating the billet before pressing it, it is possible to reduce the resistance of the material to deformation and, by the same token, to reduce the effort required to carry out the process. Extrusion requires the billet to be placed into the container and the latter to be closed, from one side, by a die having a channel corresponding to the profile of the article to be obtained, and from the other one, by a short ram. The die is mounted on the hollow ram. Thereafter, movement of the container and ram is initiated, the speed of the container being higher than the speed of the ram. As a result of such movement on the boundary between the container and billet, the reactive friction forces characteristic of the direct process, are transformed into active friction forces aimed in the direction of the outflow and facilitating the latter.

Such a direction of the friction forces permits a degree of equalization of the rate of the metal flow in the channel of the die, which renders it possible to obtain higher-quality articles.

It has been established experimentally that the effectiveness of the given process depends largely on the conditions of interaction of the container with the billet, that is to say on the degree of realization of the friction forces of active assistance. Accordingly, during extrusion, when the speed of the container significantly exceeds the speed of the ram, an excessive shift of the container relative to the billet is observed. This circumstance causes an intense flow of the peripheral layers of the billet, which is accompanied by their warming up, and this in turn affects the conditions for removal of the heat released from the reduction zone of the plastically deformed metal. Moreover, the elevation of the temperature of the billet's peripheral layers leads to localization of the shear deformation over the cross-section of the billet and thereby limits the volumetric effect of pressing in the regime of using active assistance of friction forces. This leads to a reduction in the permissible rate of pressing and to a worsening in the quality of the articles.

Moreover, the choice of a large ratio of the speed of the container movement to the speed of the ram movement requires either a reduction in the original length of the billet, which leads to a drop in the productivity of the press, or an increase in the length of the container, which leads to a more complex press and to a significantly more expensive one.

Using a kinematic coefficient having a value less than its optimum values in the process of extrusion leads to localization of the shear deformation in the boundary layer, which increases the unevenness of the metal flow and reduces the permissible level of the rate of pressing.

A device is known for extruding metal which uses the active assistance of friction forces (Equipment for Investigation Extrusion with active friction "Steel in the USSR" N11; 1976, pages 897-898).

The device comprises a frame on which are mounted an upper and a lower cross beams (vertical implementation of the press). Mounted on the upper cross beam is the main power cylinder, whose plunger is rigidly attached to the movable crosspiece. Mounted on the lower cross beam are the return power cylinders for moving the crosspiece, the plungers of which are rigidly attached to the latter. An auxiliary cylinder with a plunger is mounted on the crosspiece. The ram with a die block is rigidly attached to the plunger. The container is mounted on the crosspiece with the aid of columns. The hollow ram is mounted with the die on the lower cross beam. The main and return power cylinders are

connected via valves to high-pressure and low-pressure mains. The auxiliary cylinder is connected to the low-pressure main via a throttle.

In the original position the plunger of the auxiliary cylinder is moved out of the cylinder to a maximum extent.

The heated billet is fed to the axis of the press and pushed into the container with the aid of the hollow ram and the die. Fluid at high pressure is supplied into the main cylinder, and the crosspiece is lowered together with the container. A pressing-out stage begins, followed by extrusion. At this moment, the speeds of the container and of the ram are identical, and the indirect process of extrusion takes place. After the start of the metal outflow, the throttle is opened and fluid displaced from the auxiliary cylinder into the low-pressure main. The plunger depression of the auxiliary cylinder takes place, which leads to a reduction in the speed of the ram movement relative to the speed of the container movement. The friction forces of active assistance are induced to the lateral surface of the billet.

After a given size of the discard is reached, the process of extrusion is stopped. High-pressure fluid is supplied into the return cylinders, and the crosspiece returns to the initial position.

The discard is detached from the article and removed. The die is mounted on the hollow ram and the cycle can be repeated.

The given device permits the process to be carried out using the active assistance of friction forces.

At the same time, in order to get a high productivity of the press and a high level of mechanical properties in the articles, it is necessary for the speed of the container movement and the speed of the ram movement to be strictly maintained at a definite optimum ratio during the extrusion process. The given device does not permit this ratio to be precisely maintained. The regulation of the speed of the container movement relative to that of the ram is performed by means of letting fluid out of the auxiliary cylinder into the low-pressure main via the throttle. As it has already been said above, in the extrusion process the effort required to move the container changes by a factor of several times; this leads to the identical changes in the pressure in the auxiliary cylinder, as a result of which the opening of the throttle at one and the same magnitude at different stages of the process leads to a different level of the fluid discharge and, consequently, to obtaining different ratios of the speeds of movement of the container and the ram. It is not possible to provide the variable conditions of the process on the given device; the throttle has to be alternately opened and closed as the metal is extruded. Deviation of the ratio of the speeds of movement of the container and ram from optimum values requires a significant reduction in the rate of extrusion; articles are obtained with rejects and a nonuniform distribution of mechanical properties along the length.

DISCLOSURE OF THE INVENTION

The object of the present invention is to provide such a process for the hot extrusion of metal with the active assistance of friction forces, and a hydraulic extrusion press for implementing it which, by virtue of a definite ratio of the speeds of movement of the container and ram, would permit an increase in the productivity of the press and, at the same time, regulation of the distribution of mechanical properties along the length of the finished product. This object is achieved when in a process for the hot extrusion of metal with the active assistance of friction forces, consisting in that a billet undergoing extrusion is preheated and placed in a container from which this billet is thereafter extruded, with the aid of the ram and container, through a die, which determines the shape and geometrical dimensions of the finished article, while moving said container and ram simultaneously, it being the case that in the process of extrusion the container is moved at a speed higher than the speed of movement of the ram, in accordance with the invention the speed of movement of the container exceeds the speed of movement of the ram by approximately 1.05-1.3 times.

This permits the productivity of the process to be increased and the level of the mechanical properties of the articles to be enhanced.

In the process of extrusion, the ratio of the speeds of the container and the ram may be kept constant.

This permits the design of the press to be simplified.

In the process of extrusion, the ratio of the speeds of the container and ram may be varied within the limits of 1.05 to 1.3 times.

This provides the possibility of obtaining an article with a controlled distribution of mechanical properties.

It is possible to vary the ratio of the speeds of the container and ram in accordance with the rate of extrusion.

This ensures that uniform mechanical properties are obtained over the entire length of the article.

It is efficient to heat the front end face of the billet up to a temperature of approximately 0.7 to approximately 0.9, and to heat the rear end face of the billet up to a temperature of approximately 0.5 to approximately 0.7 of the temperature of processing ductility of the material being extruded.

This also permits the productivity of the process to be additionally increased.

In the process of extrusion, the speed of movement of the ram may be varied as a function of the variation in the gradient of the temperature of the billet along its length.

Apart from an additional increase in the productivity of the process, this permits control of the mechanical properties of the article being obtained along its entire length.

This object is also achieved when in a hydraulic extrusion press comprising front and rear cross beams rigidly

mounted on a frame, a container with the possibility of reciprocating movement along its longitudinal axis, and a cross-piece on which there is rigidly mounted a plunger of at least one main power cylinder whose body is mounted in a stationary fashion on the rear cross beam, and on which there is also mounted in a stationary fashion at least one auxiliary cylinder which is arranged coaxially with the main power cylinder and to whose plunger there is rigidly attached a ram
 5 with a die-plate which enters the container in the process of extrusion, while a hollow ram connected to the front cross beam is arranged on the other side of the container, likewise in a fashion coaxial therewith, the inner space of the main cylinder being connected to the high-pressure main and low-pressure main and the inner space of the auxiliary cylinder communicating via a restricting unit with the low-pressure main, in accordance with invention the restricting unit comprises at least one stabilizing cylinder which is a cylindrical body in which there is arranged a plunger. One of the said
 10 elements of the stabilizing cylinder is attached to the rear cross beam, while the other is rigidly connected to the cross-piece, and the inner space of the power stabilizing cylinder communicates with the inner space of the auxiliary cylinder.

This guarantees the automatic provision of the optimum ratio V_C/V_R of the speeds of movement of the container and ram in the process of extrusion.

The inner space of the stabilizing cylinder can communicate with the low-pressure mains.

15 This permits the crosspiece to execute an idle stroke.

For a given magnitude of the ratio of the speeds of the container and ram the area of the cross-section of the stabilizing cylinder is equal to $F_S = F_a (1 - 1/K_w)$, where

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

20 F_a is the area of the cross-section of the auxiliary cylinder;

K_w is the magnitude of the ratio V_C/V_R of the speeds of the container V_C and ram V_R ,

and the length of the inner working space of the auxiliary cylinder is equal to $H_a = H_b^w (1 - 1/K_w)$, where

25 H_a is the length of the working space of the auxiliary cylinder;

H_b^w is the maximum length of the working stroke of the stabilizing cylinder.

This permits the provision of the required ratio of the speeds of the container and ram.

It is expedient that the hydraulic extrusion press comprises at least two booster power cylinders, each of which is
 30 constructed in the form of a cylindrical body in which there is arranged a plunger, and one of the said elements of each booster power cylinder is attached in a stationary fashion to one of the cross beams, while the other is attached to the crosspiece, and the inner space of each of these communicates with the low-pressure fluid main and the high-pressure fluid main.

This permits savings on the high-pressure fluid.

35 The hydraulic connection between the inner space of each cylinder, which is hydraulically connected to the auxiliary cylinder, and the corresponding high-pressure and low-pressure mains can contain a valve.

This permits control of the press as a whole to be simplified.

It is expedient that the inner space of each booster cylinder is hydraulically connected to the inner space of the auxiliary cylinder.

40 This makes it possible to extend the technical possibilities of the press.

The hydraulic connection between the inner space of the auxiliary cylinder and the inner space of each power hydraulic cylinder connected thereto can contain a valve.

This permits air to be excluded from reaching the hydraulic system.

The hydraulic extrusion press can contain an auxiliary restricting unit having a body with holes and fitted with a
 45 cover, inside which there is mounted a slide valve which is spring-loaded from the side of the cover and has a through space, whose configuration and geometrical dimensions determine the magnitude of the speed of the mutual movement of the container and ram, hydraulically connected via corresponding holes of the body to the inner space of the auxiliary cylinder and to the low-pressure main, while on the side opposite the spring-loaded one there is mounted a cylinder whose body is rigidly connected to the body of the restricting unit, while a plunger is also rigidly connected to
 50 the slide valve, and the inner space of this cylinder is hydraulically connected to the inner space of the auxiliary cylinder, it being the case that the cover on the body of the restricting unit can be mounted capable of axial movement in order to control the magnitude of the preliminary compression of the spring.

This permits provision of a variable magnitude of the ratio of the speeds of the container and ram in the course of the process.

55 Moreover, the auxiliary restricting unit can contain a lead screw attached in a stationary fashion to the end face of the slide valve on the side of the spring, while the cover can have a through hole through which the screw passes with the possibility of controlling their mutual reciprocal movement.

This renders it possible to extend the technical possibilities of the restricting unit.

It is expedient to mount a valve between the auxiliary cylinder and auxiliary restricting unit.

This permits the technical possibilities of the press to be extended.

The cylindrical body and, correspondingly, the plunger of the auxiliary cylinder can be constructed in a stepped fashion, while the spaces formed by these steps communicate hydraulically between one another.

This permits the dimensions of the press as a whole to be reduced.

5 It is expedient for the step of the auxiliary cylinder which faces the plunger of the main power cylinder to be partly arranged in this plunger and rigidly connected thereto.

This permits the dimensions of the press to be additionally reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

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The process for the hot extrusion of metal with the active assistance of friction forces which is being patented, and the hydraulic extrusion press for implementing it are explained below by means of concrete examples of its implementation and the attached drawings, in which:

- 15 Figure 1 shows a diagrammatic representation of a hydraulic extrusion press for implementing the process for the hot extrusion of metal with the active assistance of friction forces, according to the invention;
- Figure 2 shows a diagrammatic representation of one of the optimum variants for constructing a hydraulic extrusion press, according to the invention;
- Figure 3 shows a diagrammatic representation of an auxiliary restricting unit, according to the invention; and
- 20 Figure 4 shows a diagrammatic representation of a variant for constructing a hydraulic extrusion press with a stepped plunger of the auxiliary cylinder, according to the invention.

PREFERRED VARIANT OF THE IMPLEMENTATION OF THE INVENTION

25 The process for hot extrusion with the active assistance of friction forces which is being patented consists in the following.

A billet 1 (Figures 1,2,4) undergoing extrusion is heated, placed in a cavity 2 of a container 3 and further, by means of simultaneously moving a ram 4 and container 3, extruded through the channel of a die 5 which determines the shape of the finished article (not shown in the figure), which die 5 is mounted on a hollow ram 6. In the process of extrusion,

30 the container 3 is moved at a speed which exceeds the speed of the ram 4 by approximately 1.05-1.3 times.

The billet 1 can be heated, for example, in induction furnaces, resistance furnaces and combustion furnaces (not shown in the figure). The temperature range of the heating of the billet 1 is selected as a function of the type of alloy of the billet 1 undergoing extrusion. For example, in the case of heating a billet 1 made from hard deforming aluminum alloys the heating is performed up to temperatures of approximately 300-400°C as a function of the requirements for

35 the mechanical properties of the articles and of the rate of pressing.

Heating the billet before extrusion permits a reduction in the resistance to deformation of the material of the billet undergoing deformation. This permits a reduction in the expenditure of energy for the process of extrusion. Moreover, in a certain range of alloys, for example in the case of the processing of hard deforming aluminum alloys, heating billets renders it possible to increase the level of the mechanical properties of the articles. In addition to this, in a number of

40 instances heating permits an increase in the adhesive interaction between the billet 1 and container 3, which leads to an increase in the friction forces, and this is very important for the process being patented, since in the process under consideration the friction forces between the container 3 and billet 1 play a positive role, increasing the depth of the peripheral metal flow. Thus, increasing them promotes equalization of the rates of the metal flow in the channel of the die 5. This permits an increase in the limiting rates of the metal outflow. After heating, the billet is fed to the press with

45 the aid of a feeding mechanism 7 and pushed into the cavity 2 of the container 3 of the press. The container 3 has a length such that it is possible for the billet, die 5, and ram 4 to be placed entirely and freely in it. The length of the ram 4 corresponds to that part of the length of the container 3 which is essential for the mutual displacement relative to the billet.

The container 3, die 5, and ram 4 can be preheated before pressing in order to reduce the expenditure of energy

50 on the process of extrusion. The preheating temperature is a function of the material of the billet 1 being extruded. For example, it may be approximately 300-400°C in the case of pressing hard deforming aluminum alloys.

Further, a stroke of the crosspiece 8 starts to move the container 3 and ram 4 simultaneously towards the die 5. In this case, the length of the hollow ram 6 must be equal to the length of the container 3, so that it is possible to withdraw the die 5 from the opposite side of the container 3.

55 The stage of pressing-out the billet 1 begins after the ram 4, billet 1, and die 5 have come into contact. At this stage, the billet 1 occupies the entire volume bounding it. The diameter of the billet 1 becomes equal to the diameter of the container 3. After this, the metal begins to be extruded into the channel of the die 5. The configuration of the channel of the die 5 corresponds to the cross-section of the article to be obtained, but taking account of the thermal expansion of the die 5 as a result of its warming and of a certain shrinkage of the metal after the latter has cooled. In the stage of

pressing-out, the speed of movement of the container 3 and ram 4 must be identical (indirect process of pressing), while in the opposite instance individual parts of the lateral surface of the billet 1 can be displaced onto another part of this surface, since only a part of the billet 1 is in contact with the container 3. This can lead to defects in the articles.

After the stage of pressing has started, the speed V_C of movement of the container 3 is increased by 1.05-1.3 times by comparison with the speed V_R of movement of the ram 4. The ratio of the speed V_C of movement of the container 3 to the speed V_R of movement of the ram 4 is conventionally termed the kinematic coefficient K_W . Such mutual movement produces friction forces on the lateral surface of the billet 1 in the direction of the metal outflow, which permits provision of an accelerated peripheral flow of the metal in the billet 1 and the retardation of the axial layers. This substantially alters the pattern of the metal flow, which leads to equalization of the metal flow in the reducing part of the plastic zone, and, accordingly, in the channel of the die 5. A more uniform metal flow guarantees a reduction in the tensile stresses on the lateral surface of the finished articles. These stresses are a fundamental restraining factor in the selection of the limiting rate of extrusion over a whole range of alloys, for example, when extruding hard deforming aluminum alloys. Thus, a reduction in the tensile stresses permits an increase in the limiting permissible rates of extrusion by 2-3 times in the case of hard deforming aluminum alloys. Moreover, such a favorable metal flow produces conditions of a quasistationary metal flow, which permits a reduction in the nonuniformity of the distribution of mechanical properties along the length and over the cross-section of the articles.

In the process of extrusion in conditions of the active assistance of friction forces the material of the billet undergoes in addition not only shear deformations but also a retarding of the axial flow what promotes better processing of the cast structure of the material and an increase in the density of dislocations as well in the general level of the mechanical properties of the articles. For example, when extruding hard deforming aluminum alloys under otherwise identical conditions, the enhancement of mechanical properties of the articles is 10-40%.

At the same time, the effectiveness of the given process depends substantially on the conditions of interaction between the container 3 and billet 1, that is to say on the magnitude of the realization of the active assistance of friction forces.

It has been established experimentally that in the case of extrusion when the ratio V_C/V_R of the speeds of the container V_C and ram V_R exceeds 1.3, an excessive shift of the container 3 relative to the billet 1 is observed. This circumstance produces an accelerated flow of the peripheral layers of the metal which, in turn, leads to increased warming of these layers and a worsening of the removal of heat from the pressing-out part of the plastic zone of the billet 1. This requires a reduction in the rate of pressing. Moreover, increasing the temperature of the peripheral layers of the metal leads to a reduction in the resistance to deformation and this, in turn, leads to localization of the shear deformation over the cross-section of the billet 1 and thereby limits the volumetric effect of pressing in the regime of using active assistance of friction forces. This leads to the need to reduce the rate of pressing.

Moreover, selecting an excessively large ratio V_C/V_R of the speed V_C of movement of the container 3 to the speed V_R of movement of the ram 4 (greater than 1.3) requires either a reduction in the original length of the billet 1 which, of course, leads to a reduction in the productivity of the press, or an increase in the length of the container 3, which increases the metal content of the design of the press and, consequently, renders it more expensive.

The use in the extrusion process of a ratio of the speeds V_C/V_R of the container 3 and ram 4 which is lower than the optimum values of K_W (that is, less than 1.05) leads to localization of the shear deformation only in the boundary layer of the billet 1, which reduces the volumetric effect of the action of friction forces. This leads to nonuniformity in the metal flow and reduces the permissible level of the rate of extrusion and leads to a worsening in the quality of the articles.

The process of extrusion is conducted up to a specific magnitude of the billet 1, which is termed the discard (which has not been shown in the figures). The height of the discard is basically determined by the instant of the start of the formation of the first type funnel.

In the case of pressing with the active assistance of friction forces on the end face of the billet 1 facing the short ram 4, the friction forces are induced converging towards the axis of the billet. Such a character of the action of the friction forces permits a significant delay in the instant of the start of formation of the first type funnel, what permits deformation to be implemented down to a lesser magnitude of the discard. For example, in the case of pressing hard deforming aluminum alloys this height is 0.05-0.1 of the diameter of the container 3.

After termination of pressing, the ram 4 is withdrawn, the discard is pushed out from the container 3 and, furthermore, separated. The finished article is extracted from the die 5, straightened if necessary and cut to size and put into a storehouse for the finished product.

In the process of extruding, the container 3 can be moved at a constant ratio of the speed V_C/V_R of movement of the container V_C to the speed of movement of the ram V_R , which is within the limits of approximately from 1.05 to 1.3.

The level of the mechanical properties of an article and the distribution of those properties along its length are influenced by the initial temperature of the billet 1, the rate of pressing and the magnitude K_W of the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R . The leading movement of the container 3 permits additional displacement of the peripheral layers of the billet 1, what leads to additional shear deformations in the material being extruded. This, in turn, permits breakup additionally of the cast structure of the billet 1 and, thereby, enhancement of

the mechanical properties of the articles. In many cases, there is a need for articles with a uniform distribution of the mechanical properties of the metal along the entire length of the articles. Keeping the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R constant in the course of extrusion guarantees a uniform distribution of the mechanical properties of the metal along the length of the articles.

Implementation of a constant ratio V_C/V_R of the speed of movement of the container V_C to the speed of movement of the ram V_R throughout the course of the process permits simplification of the design of the press and, accordingly, a reduction in its cost by means of excluding expensive systems of control, monitoring and setting up actuating mechanisms for varying the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R in the process of extrusion.

At the same time, it is necessary in a number of industrial sectors to provide a nonuniform distribution of the mechanical properties of the metal along the length of the articles. For example, it is desirable to have an increased level of mechanical properties at the tips of drill pipes where there is a tool joint. Such requirements appertain to lengthy aircraft parts at their points of attachment. At the present time, existing technologies have not been successful in guaranteeing such conditions of distribution of the mechanical properties along the length of articles, and swellings are specially made at the critical places on the articles. Providing articles with swellings (tips) is significantly more complicated, and their cost is several times higher than normal articles. In the proposed process, it is possible, by means of varying the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R in the process of extrusion, to increase or decrease the breakup of the structure of the metal, and thereby also to vary the level of the mechanical properties of the articles.

At the same time, as a result of numerous experiments it has been established that in the case when the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R exceeds 1.3 the peripheral layers of the billet 1 undergo an intensive shear deformation, which is accompanied by a course of dynamic re-crystallization. This leads to a reduction in the resistance to deformation in these layers of the billet, since the density of dislocations is sharply reduced, while the dimensions of the grains increase several times. Consequently, there is a fall in the level of the mechanical properties in the articles.

The use in the process of extrusion of a ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R of less than $K_W \approx 1.05$ leads to localization of the shear deformation in the boundary layer of the billet 1, and does not permit reduction to be exerted on the central layer of the billet 1. The structure of these layers remains coarse-grained, and the articles have a low level of mechanical properties.

In the process of extrusion of the billet 1 taking account of the conditions of its preheating, the initial uniform temperature field in the billet can vary. Light heating of the container 3, the die 5 and ram 4 results in a gradual cooling of the billet 1 in the process of extrusion.

At the same time, the temperature of the billet 1 exerts a substantial influence on the process of dynamic recrystallization, and therefore on the structure of the articles being obtained and this, in turn, affects the level of the mechanical properties of the articles. In order to achieve uniform mechanical properties of the articles, it is necessary to compensate the change in the conditions of recrystallization in the billet by means of varying the magnitude K_W of the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R . For example, with the reduction in the temperature of the billet 1 in the course of the process, it is necessary to reduce the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R .

In the process of extrusion, heat is released as a result of the execution of the work of deformation in the billet. The quantity of heat released depends substantially on the rate of extrusion. Variation in the temperature of the billet 1 has a substantial effect on the process of dynamic recrystallization proceeding in it and, consequently, also affects the structure of the articles being obtained which, in its turn, exerts an influence on the level of their mechanical properties. In order to compensate the indicated temperature changes in the billet 1 as a consequence of variation in the rate of extrusion, it is necessary to change the magnitude K_W of the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R . For example, with an increase of rate of extrusion it is necessary to increase the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R .

As was shown above, in the process of extrusion heat which substantially increases the initial temperature of the billet 1 is released as a result of the execution of the work of deformation in the billet 1. It must be pointed out that this phenomenon is particularly well expressed in the case of a high-speed process of pressing with the use of the active assistance of friction forces. Significant changes in the temperature of the billet 1 require a substantial reduction in the rate of extrusion, and this perceptibly reduces the productivity of the process. Moreover, as was shown above, variation in the temperature of the billet 1 in the process of pressing influences the conditions of dynamic recrystallization proceeding in it, with the result that the structure and, consequently, the level of the mechanical properties change substantially along the length of the articles. This circumstance is undesirable in many instances. Heating the billet 1 in accordance with the proposed process when the temperature of the front end face is 1.2-1.5 times higher than the temperature of its rear end face permits an increase of temperature of rear end face of the billet at the expense of the deformation heat being released. In the course of extrusion, processes of heat exchange with the working tools proceed in the billet 1, with the result that the dwell time of the billet 1 in the container must be at a minimum, as far as possible. Consequently, it is most effective to use billets heated in a graduated way along the length in a high-speed process for

pressing with the active assistance of friction forces.

Heating the front end face of the billet up to a temperature of 0.7-0.9 of the temperature of processing ductility of the metal being extruded permits starting of the process at the required rate of extrusion, and the articles do not have any defects in the form of cross cracks. For example, this temperature is 350-400°C for hard deforming aluminum alloys.

5 Taking account of the fact that starting the process requires maximum expenditure of energy and that in the case when the temperature of the front end face is less than 0.7 of the temperature of processing ductility of the metal being extruded, a marked reduction in the rate of pressing is observed. This leads to a drop in the productivity of the process.

10 If the temperature of the front end face of the billet 1 is higher than 0.9 of the temperature 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 pressing significantly, which will also lead to a reduction in the productivity of the process.

15 If the temperature of the rear end face of the billet 1 is higher than 0.7 of the temperature of processing ductility of the material being extruded, at the end of the process not all the heat of deformation is compensated, and the billet 1 will begin to overwarm. It is necessary to reduce the rate of pressing in order to exclude the appearance of cracks on the articles.

20 When the temperature of the rear end face of the billet 1 is less than 0.5 of the temperature of processing ductility of the metal being extruded, at the end of the process the temperature of the billet 1 decreases. In this case the expenditure of energy on deformation of the billet 1 grows, the capacity of the press is insufficient and the rate of the process drops. This also leads to a reduction in the productivity of the process. 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.

25 A change in the rate of extrusion with the aid of a speed governor 9 in the course of the process permits a more delicate reaction to the changes in the temperature field in the billet 1, and thereby permits a constant temperature of the article to be kept with high accuracy at the exit from the channel of the die 5. This provides the possibility of obtaining an exclusively uniform distribution of the mechanical properties along the length of the articles, and increasing significantly the productivity of the extrusion process.

30 Furthermore, in Table 1 concrete examples are given of the realization of the process, which is being filed, for hot extrusion with the active assistance of friction forces, it being the case that all tests were conducted on billets from a hard deforming aluminum alloy, having the following composition (in a percentage relationship): Cu - 4.4; Mn - 0.865; Mg - 1.48; Fe - 0.35; Si - 0.31; Zn - 0.145; Ti - 0.0465; Ni - 0.003; residue Al, on presses with an effort of 35 MN with a container diameter of 310mm, reduction coefficient $\lambda = 13.5$.

35 Thus, the filed process for the hot extrusion of metals with the active assistance of friction forces by inducing friction forces of active assistance to the surfaces of contact of the billet and container, and controlling them in an optimum range permits the implementation of a new process of extrusion with maximum efficiency.

Table 1

Serial No. of experi- ment	Ratio of speeds of movement of the container V_C and ram V_R in the course of the process $K_w = V_C/V_R$	Initial length of billet L_0 , m	Rate of pressing in the course of the process V_p m/s (maximum permissible)	Preheating temperature of temperature of container, $t^\circ\text{C}$	Heating temperature of the billet, $t^\circ\text{C}$	
					front end face	rear end face
1	2	3	4	5	6	7
1	1.01	0.750	0.005	360 + 10	360	360
2	1.05	0.750	0.007	360 + 10	360	360
3	1.15	0.720	0.008	360 + 10	360	360
4	1.3	0.600	0.0086	360 + 10	360	360
5	1.4	0.540	0.007	360 + 10	360	360
6	1.15	0.720	0.0095	360 ± 10	380	310
7	1.05-1.3	0.720	0.0090	360 ± 10	360	360
8	1.15	0.720	0.008-0.012	360 ± 10	360	360
9	1.05-1.3	0.710	0.008-0.012	360 ± 10	380	290

Table 1, Continuation

	Size of discard η_{po} , m	Productivity of press Q , tons per hour	Mechanical properties of the articles (ultimate strength σ_b = MPa. After heat treatment and ageing)			Magnitude of macrocrystalline ring (maximum), mm	Output of sound product
			Outlet end	Middle of article	Reduced end		
1	8	9	10	11	12	13	14
1	0.05	2.8	470	460	440	3.0	0.89
2	0.040	3.33	490	480	450	2.0	0.92
3	0.030	3.58	510	510	500	0.5	0.93
4	0.025	3.43	515	500	500	0.3	0.93
5	0.04	3.0	490	470	450	4.0	0.85
6	0.031	3.94	520	500	470	1.0	0.94
7	0.020	3.85	540	540	540	-	0.95
8	0.030	4.05	550	540	510	0.3	0.94
9	0.022	4.25	540	530	530	0.1	0.95

In this process the friction forces drag along behind them certain contact layers of the billet, in so doing creating an accelerated peripheral metal flow. The rate of the peripheral flow relative to the central layers of the billet, depending on the set task, can be controlled within rational ranges by varying the ratio of the speeds of movement of the container and ram in conjunction with selection of the conditions of temperature and rate of the process.

The process being patented for extrusion with the active assistance of friction forces renders it possible, by means of reducing tensile stresses on the surface of billet in the range of the die's channel, to obtain rates of metal flow which exceed these values by 5-6 times by comparison with the direct process and by 20-50% by comparison with the indirect process of pressing.

By means of additional shear deformations in the billet, in accordance with the process being patented, it is possible to obtain mechanical properties of the articles which significantly exceed the properties of the articles obtained by the indirect and direct processes. Because of the possibility of controlling the process of extrusion of the metal flexibly and within an optimum range, only extruding with the active assistance of friction forces permits articles to be obtained which either have a uniform distribution of mechanical properties along the length and over the cross-section of the articles, or which have a previously prescribed distribution of them along the length of the articles.

By controlling, within a rational range of magnitude of the auxiliary shear deformations in conjunction with an optimum temperature interval of the heating of the billets, it is possible to obtain articles without a macrocrystalline ring.

When extruding metal with the active assistance of friction forces, because of the creation of a favorable direction of these friction forces on the contact surface between the die-plate and the metal, and because of controlling them within an optimum range, it is possible in practice to eliminate the process of the formation of the first type funnel and, consequently, to reduce the size of the discard by 2-3 times, thereby increasing the output of sound product to 90-95%.

By creating on the surface of the billet compressive stresses in a certain optimum range, it is possible to eliminate some microscopic surface defects in the articles. Moreover, rational regimes of extrusion permit a reduction in the residual stresses on the surface of the articles. These circumstances permit the provision of articles with an enhanced corrosion resistance.

Apart from this, the process being patented permits the achievement of high rates of extrusion, and thereby a reduction in the dwell time of the billet in the container within the limits of a minute. Such conditions permit the use, with high efficiency, of billets with graduated heating along the length, which in its turn renders it possible additionally to increase the productivity of the entire process by 15-20%.

The hydraulic extrusion press being patented comprises a frame 10 (Figure 1) on which are mounted a front cross beam 11 and rear cross beam 12 between which the container 3 and crosspiece 8 are mounted, with the possibility of axial reciprocating movement, on guides (not shown in the figure). Power cylinders are mounted on the rear cross beam 12: the main power cylinder, which has a cylindrical body 13 and plunger 14, and return cylinders (not shown in the figure, for the sake of simplicity). The plungers 14 of the main and return cylinders are rigidly connected to the crosspiece 8.

Mounted on the rear cross beam 12 is at least one stabilizing cylinder, which has a body 15 and plunger 16. Two or more stabilizing cylinders can be mounted on the press for the purpose of reducing the overall dimensions of the press and in accordance with the technology being used. Two stabilizing cylinders are shown in Figure 1 as a design variant. Also as one of the design variants, it is possible to mount the cylindrical bodies 15 of the stabilizing cylinders on the rear cross beam 12, while their plungers 16 can be rigidly connected to the crosspiece 8. Axial channels 17 communicating with the conduit 18 are constructed in the plungers 16. The conduits 18 connect the inner space 19 of the stabilizing cylinders to the inner space 20 of the auxiliary cylinder, which has the cylindrical body 21 and plunger 22, which are mounted coaxially on the crosspiece 8. The plunger 22 of the auxiliary cylinder has a coaxially mounted ram 4 to which the die-plate, 23 is rigidly attached.

Constructed on the crosspiece 8 are projections 24 which interact with lugs 25 on the container 3. On the opposite side, the container 3 interacts with plungers 26 and 27 of the cylinders of the indirect and direct strokes of the container 3, whose cylindrical bodies 28 and 29 are mounted on the front cross beam 41. A window 30 into which the article being pressed passes, is constructed in the front cross beam 11. Mounted coaxially with this window 30 on the front cross beam 11 in the universal socket 31 is a hollow ram 6 with a removable die 5. Also mounted on the front cross beam 11 is a mechanism (not shown in Figure 1) for transporting the die 5 through the container 3. A knife 32 for separating discards can be mounted on the frame 10, as can be also mounted a feed mechanism 7 for the billets with a clamping device 33.

Entering the cavity 2 of the container 3 from two opposite sides are a solid ram 4 with a die-plate 23 and a hollow ram 6 with a die 5, between which the billet 1 being pressed is arranged. Mounted on the conduits approaching the inner space 35 of the main power cylinder of the high-pressure main 34 are an admission valve 36 and a speed governor 9 for the movement of the crosspiece 8. Also approaching the press are conduits of the low-pressure main 37.

The extrusion press with the use of active friction forces works in the following way.

In the initial position the plunger 22 of the auxiliary cylinder is pushed out of the body 21 to a maximum extent (to the right in Figure 1), while the plungers 14 and 16 of the main and stabilizing cylinders and also of the return cylinders are located in the position on the extreme left.

The heated billet 1 is fed onto the feed mechanism 7 and attached by a clamp 33 in such a way that approximately one third of the billet 1 projects from it on the side facing the container 3. Furthermore, the feed mechanism 7 is used to raise the billet 1 onto the axis of the press. The reverse stroke cylinders 26, 28 of the container 3 are then engaged, and the container is pushed onto the free part of the billet 1 located on the feed mechanism 7. The reverse stroke cyl-

inders are disengaged at the instant when a spacing of approximately 30-50 mm remains between the feed mechanism 7 of the billets 1 and the end face of the container 3. The feed mechanism 7 is then removed and a further stroke of the container 3 (to the left in the figure) pushes the billet 1 into the cavity 2 of the container 3. In this case, the hollow ram 6 emerges entirely from the container 3, and a special mechanism (not shown in the figure) is used to mount a die 5 on it. Fluid is fed from the conduit of the high-pressure main 34 into the main power cylinder and the crosspiece 5 executes a short idle stroke H_b^1 , the projections 24 on the crosspiece 8 coming into contact with the lugs 25 on the container 3, and all the said moving elements beginning to move at the same speed to the right. In this case, the inner spaces of the reverse stroke cylinders of the container 3 and the inner spaces of the return cylinders of the crosspiece 8 are connected to conduits of the low-pressure main 37: there is a discharge of fluid. When the crosspiece 8 moves to the right, it also drags behind it the plungers 16 of the stabilizing cylinders, space being gradually liberated in the cylindrical bodies 15. Since pressure is transmitted onto the ram 4 via the billet 1, and the ram in turn transmits it onto the plunger 22 of the auxiliary cylinder, the fluid overflows from the inner space 20 of the auxiliary cylinder into the clearing space of the stabilizing cylinders. In this process, there is a smooth even depression of the plunger 22 of the auxiliary cylinder, and a lag of the ram 4 from the container 3 is therefore observed. The speed V_R of movement of the ram 4 is determined at this time as the difference between the speed V_b of movement of the crosspiece 8 and the speed V_a of movement of the plunger 22 of the auxiliary cylinders.

$$V_R = V_b - V_a \quad (1)$$

where

V_b is the speed of movement of the crosspiece 8; and
 V_a is the speed of movement of the plunger 22 of the auxiliary cylinder.

The speed V_C of movement of the container 3 is identical to the speed V_a of movement of the crosspiece 8. The speed V_b of movement of the crosspiece 8 and the speed V_a of depression of the plunger 22 of the auxiliary cylinder are correspondingly directed in opposite directions. Consequently, the magnitude of the kinematic coefficient K_w is equal to the quotient of the division of the speed V_b of the crosspiece 8 by the difference of the speeds of movement of the crosspiece V_b and the plunger V_a of the auxiliary cylinders.

$$K_w = V_C / V_R = V_b / (V_b - V_a) \quad (2)$$

where

K_w is the kinematic coefficient,
 V_C is the speed of movement of the container 3,
 V_R is the speed of movement of the ram 4,
 V_b is the speed of movement of the crosspiece 8,

and

V_a is the speed of movement of the plunger 22 of the auxiliary cylinder.

Such a magnitude K_w of the ratio V_C / V_R of the speeds of movement of the container V_C and ram V_R is automatically kept over the entire duration of the pressing working cycle.

All that is required in this case is to stabilize the speed of movement of the plunger 14 of the main cylinder with the aid of the speed governor 9. It is thus ensured that the container 3 induces on the lateral surface of the billet 1 the friction forces of active assistance in the direction of the metal outflow. The magnitude K_w of the ratio V_C / V_R of the speeds of movement of the container V_C and ram V_R is determined by the ratio of the dimensions of the inner space 20 of the auxiliary cylinder and the inner spaces 19 of the stabilizing cylinders.

After the given magnitude of the discard is achieved, feeding of the fluid from the high-pressure main 34 is ceased by closing the admission valve 36, the inner space 35 of the main cylinder communicating via the same admission valve 36 with the low-pressure main 37.

The cavities of the return cylinders are connected to the high-pressure main 34 (not shown in the figure) and under their action the crosspiece 8 is returned to the initial (left-hand) position. In this process, fluid is ejected from the inner space 19 of the stabilizing cylinder into the inner space 20 of the auxiliary cylinder, and the auxiliary cylinder 22 is pushed out into the initial position (extreme right).

The reverse stroke cylinders of the container 4 then (or at the same time as the withdrawal of the crosspiece 5) extend the small movement of the container 3 to the right up to the restraining arm (not shown in Figure 1) of the con-

tainer 3, the discard being withdrawn from the cavity 2 of the container 3. The knife 32 is used to separate it. The restraining arm 4 is then removed, and with the aid of the cylinders for moving the container (27, 29) the container 3 is displaced up to the stop into the front cross beam 11, the die 5 emerging from the container 3 on the side of the crosspiece 8, after which it is removed from the hollow ram 6. The cycle can then be repeated.

The arrangement of the stabilizing cylinders (15,16) hydraulically connected to the inner space 20 of the auxiliary cylinders renders it possible without any control from outside automatically to obtain an optimum constant magnitude K_w of the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R , that is to say to implement the process in full, in the case above, for hot extrusion with the active assistance of friction forces. This extrusion press permits the required optimum ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R to be kept automatically even in the case of constant change in the speed of movement of the main cylinder and, correspondingly, crosspiece 8.

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

The hydraulic extrusion press can have an additional hydraulic connection in the form of a conduit 38 (Figure 2) implemented by means of connecting the inner space 19 of the stabilizing cylinder to the low-pressure main 37. It is possible to mount on the auxiliary conduit 38 a governor 39 in which, for example, it is possible to mount a controlled valve 40 and uncontrolled spring-loaded valve 41. The auxiliary conduit 38 permits idle strokes of any size to be executed by the crosspiece 8.

In case of absence of the abovementioned additional hydraulic connection as well as the pressure on the ram 4 during movement of the crosspiece 8, the formation of rarefaction in the inner space 19 of the stabilizing cylinders may arise, with the result that air can be sucked into the hydraulic system. This circumstance is very dangerous, and such a hydraulic system is not functional.

An auxiliary hydraulic connection constructed in the form of a conduit 38 permits fluid to be fed from the low-pressure main 37 into the inner space 19, which is being liberated, of the stabilizing cylinders at the time of the idle stroke of the crosspiece 8, which prevents air from reaching the hydraulic system.

For a given magnitude K_w of the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R , the area of the cross-section F_S of the stabilizing cylinder is selected from the relationship

$$F_S = F_a (1 - 1/K_w) \quad (3)$$

where

F_S is the area of cross-section of the stabilizing cylinder;
 F_a is the area of the cross-section of the auxiliary cylinder;

K_w is the magnitude of the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R , while the length of the inner working space of the auxiliary cylinder is equal to

$$H_a = H_b^w (1 - 1/K_w) \quad (4)$$

where

H_a is the length of the inner working space 20 of the auxiliary cylinder; and
 H_b^w is the magnitude of the maximum possible working stroke of the crosspiece 8.

Given the presence of several stabilizing cylinders the area F_S of their cross-section is summed as ΣF_S .

The automatic provision of the required magnitude K_w of the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R , as well as reliable operation of the units of the press in process of extrusion require various design elements of the press to be constructed to accord strictly with one another. The length of the cylinder body 15 and plungers 16 is selected to be equal to the length of the body 13 of the main power cylinder and its plunger 14. The selection of such relationships permits the working stroke of the crosspiece 8 to be unlimited. In order to exclude multiplication of the pressure in the inner space 20 of the auxiliary cylinder, the area of the cross-section of the auxiliary plunger 22 is equal to the total area of the cross-sections of all power cylinders which implement the working stroke of the crosspiece 8.

The stroke of the crosspiece 8, the plungers 14 of the power cylinders and the plungers 16 of the stabilizing cylinders consists of an idle stroke H_b^l and a working stroke H_b^w . In the calculations, use is made of the maximum possible magnitude of the working stroke, which depends on the maximum length of the billet 1, which can be placed in and pressed out with regard to the length of the existing container 3. The total volume W_S of the inner spaces 19 of all stabilizing cylinders W_i^s ($W_S = \Sigma W_i^s$), which are liberated only in the process of the working stroke, must be equal to the maximum volume W_a of the free inner space 20 of the auxiliary cylinder (at the right in Figure 2 with the plunger 22 with-

drawn as far as possible)

$$W_a = W_s; W_a = F_a \cdot H_a; F_a \cdot H_a = \Sigma F_s \cdot H_b^w \quad (5)$$

5 where

F_a is the area of the cross-section of the auxiliary cylinder;
 ΣF_s is the area of the cross-section of all stabilizing cylinders;
 H_a is the length of the working space of the auxiliary cylinder; and
 10 H_b^w is the magnitude of the maximum working stroke of the plunger 16 of the stabilizing cylinders.

The magnitude K_w of the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R is determined by the relationship

$$15 \quad K_w = V_C/V_R = (H_C/\tau_w)/(H_R/\tau_w) = H_C/H_R \quad (6)$$

where

H_C is the magnitude of the stroke of the container 3;
 20 H_R is the magnitude of the stroke of the ram 4; and
 τ_w is the period of the working stroke.

Since the working stroke H_C of the container 3 is equal to the working stroke H_b^w of the crosspiece 8, it follows that it is also equal to the working stroke H_s^w of the plungers 16 of the stabilizing cylinders

$$25 \quad K_w = H_s^w/(H_s^w - H_a) \quad (7)$$

Thus, in order to obtain the given ratio V_C/V_R of the speeds of movement between the container V_C and ram V_R over the entire duration of the working stroke, the length of the inner free space 20 of the auxiliary cylinder must be

$$30 \quad H_a = H_s^w(1 - 1/K_w) \quad (8)$$

Substituting the expression obtained in the expression 6 provides the required relationship between the area F_a of the cross-section of the auxiliary cylinder and the total area ΣF_s of the cross-section of the stabilizing cylinders

$$35 \quad \Sigma F_s \cdot H_s^w = F_a \cdot H_s^w(1 - 1/K_w) \quad (9)$$

$$\Sigma F_s = F_a(1 - 1/K_w) \quad (10)$$

40 It is possible to mount on the hydraulic extrusion press at least two booster power cylinders, each of which is constructed in the form of a cylindrical body 42 in which there is arranged a plunger 43. One of the said elements of each booster power cylinder can be attached in a stationary fashion to one of the cross beams (to the rear cross beam 3 in the figure), while the other can be attached in a stationary fashion to the crosspiece 8, and the inner space 44 of each of them communicates with the high-pressure main 34 and the low-pressure main 37.

45 In the case when it is necessary to execute an idle stroke with the hydraulic press of such construction, the fluid is fed from the high-pressure main 34 only into the inner space 44 of the booster cylinders. At this time, only the fluid from the low-pressure main 36 enters the main cylinder. A large quantity of expensive fluid in the high-pressure main 34 is thereby saved.

In order to execute the working stroke of the crosspiece 8, fluid ceases to be fed into the main cylinder from the low-pressure main 37, and fluid starts to be fed from the high-pressure main 34. It is possible to continue feeding fluid from the high-pressure main 34 into the booster cylinders. If the effort of only the main cylinder is sufficient for extrusion, fluid is fed into the booster cylinders from the low-pressure main 37.

In the hydraulic extrusion press, the inner space 44 of each of the booster cylinders can be hydraulically connected by means of a channel 45 in the plunger 43 and a conduit 46 to the inner space 20 of the auxiliary cylinder.

55 Such a hydraulic connection permits the use of booster cylinders in addition to stabilizing cylinders. In this case, when calculating the total area ΣF_s of the cross-sections of the stabilizing cylinders account is also taken of the area of the cross-section of all booster cylinders.

Valves 47, 48 can be mounted in the hydraulic extrusion press between the inner spaces 19, 44 of each hydraulic cylinder connected hydraulically 18, 46 to the auxiliary cylinder, and the high-pressure main 34 and low-pressure main

37.

Before work starts, these valves 47 and 48 are open. At the instant when the idle stroke starts, fluid enters the booster cylinders through the valve 48 from the high-pressure main 34, while fluid enters the stabilizing cylinders through the valve 47 from the low-pressure main 37. After the cessation of pressing-out and the start of the metal flow of the billet 1, the valves 47 and 48 can be closed, after which fluid starts to overflow in them from the inner space 20 of the auxiliary cylinder.

In the hydraulic extrusion press, the hydraulic connection 18, 46 between the inner space 20 and each of the inner spaces 19, 44, hydraulically connected between themselves, can include valves 49 and 50, respectively.

The said valves 49 and 50 are closed before the press starts working. During the idle stroke of the crosspiece 8 and the following stage of pressing-out of the billet 1 in the container 3, the valves 49 and 50 remain closed. After cessation of the pressing-out and the start of discharge of the metal into the channel of the die 5, the valves 47 and 48 are closed and, at the same time, the valves 49 and 50 are opened. In this case, owing to the actuating effect of the plunger 22 of the auxiliary cylinder, the fluid 43 in the inner space 20 of the auxiliary cylinder starts to overflow both into the inner space 19 of the stabilizing cylinders and the inner space 44 of the booster cylinders.

As already described above, as a result of this the plunger 22 of the auxiliary cylinder starts to depress (to the left in Figure 1), and the speed V_R of movement of the ram 4 drops below the speed V_C of movement of the container 3. Active friction forces in the direction of the metal outflow are induced on the lateral surface of the billet 1.

Since, in addition to the stabilizing cylinders the fluid overflows from the auxiliary cylinder into the space 44 of the booster cylinder, the lag of the ram 4 will be greater than when only the stabilizing cylinders are switched in. This permits the provision of another ratio V_C/V_R from the optimum interval of the speeds of movement of the container V_C and ram V_R . Thus, by varying the different combinations of the connection of the stabilizing and booster cylinders, it is possible with the aid of the valves 49 and 50 to provide automatically on one press in the course of the entire working stroke different ratios V_C/V_R of the speeds of movement of the container V_C and ram V_R .

The valve 48 can be constructed to have three positions on the hydraulic extrusion press: the first position is closed, the second position is open to the high-pressure main 34, and the third position is open to the low-pressure main 37. In order to feed fluid from the high-pressure main 34 into the booster cylinders, the valve 48 is set to the second position and the valve 51 is opened. In order to feed fluid from the low-pressure main 37, the valve 48 is set to the third position, and the valve 51 is closed.

The hydraulic extrusion press can contain a restricting unit (Figure 3) consisting of a body 52 having two holes, an inlet hole 53 and an outlet hole 54, in which a slide valve 55 having a through space 56 is mounted. The slide valve 55 interacts at one end with the spring 57, while at the other end of the slide valve 55 there is the body 58 of the hydraulic cylinder which is rigidly connected to the body 52. The plunger 59 of this cylinder is rigidly attached by one end to the slide valve 55. The configuration and geometrical dimensions of the through cavity 67 determine the magnitude of the ratio V_C/V_R of the speeds of mutual movement of the container V_C and ram V_R . With the aid of the conduit 60, the cavity 56 is hydraulically connected via the inlet hole 53 in the body 52 to the inner space 20 of the auxiliary cylinder. On the other side, the through cavity 56 in the slide valve 55 is connected through the outlet hole 54 in the body 51 to the low-pressure main 37 with the aid of the conduit 61. The inner cavity 62 of the body 58 of the cylinder is also connected, with the aid of the conduit 63, to the inner space 20 of the auxiliary cylinder.

A cover 64 is mounted on the body 52 of the restricting unit on the side of the spring 57. The hydraulic extrusion press with the conduit 60 between the through cavity 56 of the slide valve 55 and the inner space 20 of the auxiliary cylinder can include a valve 65.

Such a press operates in the following way.

After the heated billet 1 is placed (Figure 2) into the container 3, high pressure is created in the booster cylinders 42, 43 through open valves 48, 51, and the crosspiece 8 starts to execute an idle stroke. In this case, the valve 47 is open, while the admission valve 36 is closed to fluid at high pressure and open to fluid at low pressure, with the result that fluid at low pressure enters the inner space 35 of the main cylinders 13, 14 and the inner spaces 19 of the stabilizing cylinders, the valves 49, 50 and 65 being closed. After the ram 4 comes into contact with the billet 1 and thus, in turn, with the die 4, the admission valve 36 opens for the passage of fluid at high pressure and closes for the passage of fluid at low pressure.

A stage of pressing-out of the billet 1 begins, which requires maximum energy expenditure.

After cessation of the pressing-out and the start of the discharge of the metal through the channel of the die 5, the valves 47, 48, 51 close, while the valves 49, 50 and 65 all open together or each separately. The fluid from the inner space 20 of the auxiliary cylinder starts to enter the stabilizing cylinders and booster cylinders and, through the valve 65, approaches the through hole 56 in the slide valve 55 and the cavity 62 of the cylinder 58 of the restricting unit. The fluid, then passes through the hole 56 in the slide valve 55 and enters the low-pressure main 37 through the outlet hole 53 via the conduit 61. Since, apart from the stabilizing cylinders and booster cylinders, the fluid additionally drains from the inner space 20 of the auxiliary cylinder into the low-pressure main 37 through the conduit 61, the plunger 22 of the auxiliary cylinders 21, 22 depresses more quickly and, accordingly, the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R increases.

The fluid from the auxiliary cylinder acts simultaneously on the plunger 58 of the restricting unit, while the latter in its turn acts on the slide valve 55, tending to move it (to the right in Figure 3). It is restrained from this movement by the spring 57 which is supported at one end in the slide valve 55 and at the other in the cover 64. Consequently, the slide valve 55 moves with each instant in time until the pressure of the fluid on the plunger 59 is compensated by the compression of the spring 57. Furthermore, the lateral surface of the billet 1 is reduced as the extrusion process proceeds, and therefore the fraction of the effort transmitted onto the billet 1 through the container 3 is also reduced, while the fraction of the effort transmitted through the ram 4 increases. As a consequence of this, the pressure in the inner space 20 of the auxiliary cylinder increases continuously, with the result that the effect on the plunger 59 increases continuously. As a result of this effect, the plunger 59 and slide valve 55 move continuously (to the right), compressing the spring 57 all the more strongly. When the slide valve 55 moves, its through hole 56 is positioned differently at different instants in time relative to the inlet hole 53 and outlet hole 54 in the body 52 of the restricting unit. The configuration of the through hole 56 can be of a variable cross-section along the length of the slide valve 55. During the extrusion process different through cross-sections for the fluid are obtained in the auxiliary restricting unit. As a result of this, a different volume of fluid passes through the opening 56 in the slide valve 55 at different moments in time and, consequently, the rate of depression of the plunger 22 of the auxiliary cylinder is variable. Taking into account what has been set forth above, it is possible to see that the ratio V_C/V_R of the speeds of movement of the container 3 and ram 4 is variable in the course of the cycle of extrusion. The law of variation in the ratio V_C/V_R of the speeds is determined by the configuration and geometrical dimensions of the through channel 56 in the slide valve 55. The law of variation in the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R is selected in the optimum interval indicated above, and it depends on the extruded material and the technical parameters of the process.

In the case when it is necessary to pass to a constant ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R , the valve 65 is close in the course of the process.

In the hydraulic extrusion press, the cover 64 (Figure 3) on the body 52 of the auxiliary restricting unit can be mounted with the possibility of axial movement in order to control the magnitude of the precompression of the spring 57. By varying the magnitude of the precompression of the spring 57, it is possible to change the law of motion of the slide valve 55 in the process of extrusion and, consequently, the law of variation in the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R .

In the hydraulic extrusion press it is possible to mount in the auxiliary restricting unit a lead screw 66 attached in a stationary fashion to the end face of the slide valve 55 on the side of the spring 57. The cover 64 has a through hole 67 for the passage of the lead screw 66. The hole 67 in the cover 64 and the lead screw 66 are mated, for example, in a threaded fashion.

In the process of movement of the slide valve 55 (to the right in Figure 3), the screw 66, moving in the hole 67 in the cover 64, rotates and in so doing rotates the slide valve 55. As a result of this rotation, the hole 56 in the slide valve 55 changes its position relative to the holes 53 and 54 in the body 52 of the auxiliary restricting unit, doing so in a tangential direction as well as in an axial one. It is possible thereby without adapting the configuration of the hole 56 in the slide valve 55 to achieve a variation in the very law of behavior of the ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R in the process of extrusion.

In the hydraulic extrusion press (Figure 4), the cylindrical body 21 and, correspondingly, the plunger 22 of the auxiliary cylinder can be constructed in a stepped fashion. Formed as a result of such a design are steps of the plunger 22 which are of larger diameter 68 and lesser diameter 69 and two inner cavities, an annular one 70 and a cylindrical one 71. The inner cavities 70 and 71 inter-communicate hydraulically with the aid of a conduit 72.

The auxiliary cylinder with the stepped plunger 22 operates in a manner analogous to the auxiliary cylinder with the cylindrical plunger 22 of the press (Figure 2) whose operation has been described above.

However, the reliable exploitation of any hydraulic cylinders requires sufficiently large guides for their plungers (not less than two- three diameters of the plunger itself). This condition leads to an increase in the overall dimensions of the cylinders and, correspondingly, the elements (in the given instance, a crosspiece) in which they are arranged. At the same time, in order to provide the required ratio V_C/V_R of the speeds of movement of the container V_C and ram V_R , and to exclude multiplication in the inner space of the cylinder, the area of the cross-section of the auxiliary cylinder must have sufficiently large dimensions.

The implementation of the auxiliary cylinder 21, 22 in a stepped fashion renders it possible to preserve the required area of the cross-section of the auxiliary cylinder, to have large guides for the plunger 22 and to reduce the dimensions of the crosspiece 8. This is explained by the fact that as a result of the hydraulic connection by means of the conduit 72 the area of the cross-section of the plunger 22 is determined by the dimension of its largest step 68. Serving as the fundamental guide of the plunger 22 is a step 69 of small diameter of the body 21 of the auxiliary cylinder and the plunger 22. This step 69 of the plunger 22 is constructed with a significant length (a few diameters of the step itself), while the step 68 of larger diameter of the auxiliary cylinder is constructed with a short length. Such an implementation of the larger step 68 of the plunger 22 of the auxiliary cylinder permits a significant reduction in the dimensions of the crosspiece 5 and, consequently, in the dimensions of the entire press.

In the hydraulic extrusion press, the lesser step 69 of the auxiliary cylinder can be arranged partly in the main

plunger 14 of the press, as is shown in the same Figure 4.

The operation of the press in the case of such a design of the plunger is implemented in a fashion analogous to that described above in Figure 2.

The arrangement of part of the plunger 22 of the auxiliary cylinder in the body of the main plunger 14 permits even further reduction in the overall dimensions of the crosspiece 8 and, accordingly, of the entire press.

The hydraulic extrusion press being patented permits a thorough realization of the process for extrusion with the active assistance of friction forces.

The design of the hydraulic extrusion press being patented is simple and reliable in use and permits the required ratio of the speeds of movement of the container and ram to be maintained automatically throughout the entire operating cycle. It is possible, on the press being patented, simply by switching the valves, to obtain one or other ratio of the speeds of movement of the container and ram required for the manufacture of a concrete product.

For the purpose of obtaining articles having a controlled distribution of mechanical properties along their lengths, it is possible to implement automatically throughout the entire operating cycle a smooth variation, within the optimum range, of the ratio of the speeds of movement of the container and ram.

Owing to the implementation of a stepped plunger of the auxiliary cylinder and to partial arrangement of that plunger in the body of the plunger of the main cylinder, the hydraulic extrusion press being patented has small overall dimensions.

Claims

1. A process for the hot extrusion of metal with the active assistance of friction forces, consisting in that a billet (1) undergoing extrusion is preheated and placed in a container (3) from which this billet (1) is thereafter extruded through a die (5), which determines the shape and geometrical dimensions of the finished article, with the aid of a ram (4), while moving the said container and ram simultaneously, it being the case that in the process of extrusion the container (3) is moved at a speed higher than the speed of movement of the ram (4), characterized in that the speed of movement V_C of the container (3) exceeds the speed of movement V_R of the ram (4) by approximately 1.05-1.3 times.
2. A process according to Claim 1, characterized in that, in the process of extrusion, the ratio (V_C/V_R) of the speeds of the container (3) and ram (4) are kept constant.
3. A process according to Claim 1, characterized in that, in the process of extrusion, the ratio (V_C/V_R) of the speeds of the container (3) and ram (4) is varied within the limits of 1.05 to 1.3 times.
4. A process according to Claims 1, 2, 3, characterized in that the ratio (V_C/V_R) of the speeds of the container (3) and ram (4) is varied in accordance with the temperature field of the billet (1).
5. A process according to Claims 1, 2, 3, characterized in that the ratio (V_C/V_R) of the speeds of the container (3) and ram (4) is varied in accordance with the rate of extrusion.
6. A process according to Claim 1, characterized in that the front end face of the billet (1) is heated up to a temperature of approximately 0.7 to approximately 0.9 of the temperature of processing ductility of the material being extruded, while the rear end face of the billet (1) is heated up to a temperature of approximately 0.5 to approximately 0.7 of the temperature of processing ductility of the material being extruded.
7. A process according to Claims 1, 2, 3, 4, 5, 6, characterized in that, in the process of extrusion, the speed of movement V_R of the ram (4) is varied as a function of the variation in the gradient of the temperature of the billet (1) along its length.
8. A hydraulic extrusion press comprising front (11) and rear (12) cross beams rigidly mounted on a frame (10), a container (3), with the possibility of reciprocating movement along its longitudinal axis, crosspiece (8) on which there is rigidly mounted a plunger (14) of at least one main power cylinder whose body (13) is mounted in a stationary fashion on the rear cross beam (12), and on which there is also mounted in a stationary fashion at least one auxiliary cylinder which is arranged coaxially with the main power cylinder and to whose plunger (22) there is rigidly attached a ram (4) with a die-plate (23) which enters the container (3) in the process of extrusion, while a hollow ram (6) connected to the front cross beam (11) is arranged on the other side of the container (3), likewise in a fashion coaxial therewith, the inner space (35) of the main cylinder being connected to the high-pressure main (34) and low-pressure main (37), and the inner space (20) of the auxiliary cylinder communicating via a restricting unit with the low-pressure main (37), characterized in that the restricting unit comprises at least one stabilizing cylinder

which is a cylindrical body (15) in which there is arranged a plunger (16), and one of the said elements (15, 16) of the stabilizing cylinder is attached to the rear cross beam (12), while the other is rigidly connected to the crosspiece (8), and the inner space (19) of the stabilizing cylinder communicates with the inner space (20) of the auxiliary cylinder.

5 9. A hydraulic extrusion press according to Claim 8, characterized in that the inner space (19) of the stabilizing cylinder communicates with the low-pressure main (37).

10 10. A hydraulic extrusion press according to Claim 8, characterized in that, for a given magnitude of the ratio (V_C/V_R) of the speeds of the container (3) and ram (4), the area of the cross-section (F_s) of the stabilizing cylinder is equal to $F_s = F_a(1 - 1/K_w)$,

where F_s is the area of the cross-section of the stabilizing cylinder;

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

15 K_w is the magnitude of the ratio (V_C/V_R) of the speeds of the container (3) and ram (4),

and the length H_a of the working space (20) of the auxiliary cylinder is equal to $H_a = H_b^w (1 - 1/K_w)$ where H_a is the length of the working space (20) of the auxiliary cylinder;

H_b^w is the maximum length of the working stroke of the stabilizing cylinder.

20 11. A hydraulic extrusion press according to Claim 8, characterized in that it comprises at least two booster power cylinders, each of which is constructed in the form of a cylindrical body (42) in which there is arranged a plunger (43), and one of the said elements (42, 43) of each booster power cylinder is attached in a stationary fashion to one of the cross beams (11, 12), while the other is attached to the crosspiece (8), and the inner space of each of these communicates with the low-pressure fluid main (37) and the high-pressure fluid main (34).

25 12. A hydraulic extrusion press according to Claim 8, characterized in that the hydraulic connection between the inner space of each cylinder, the auxiliary cylinder, and the corresponding high-pressure main (34) and low-pressure main (37) contains valves (47, 48).

30 13. A hydraulic extrusion press according to Claim 11, characterized in that the inner space (44) of each booster cylinder is hydraulically connected to the inner space (20) of the auxiliary cylinder.

35 14. A hydraulic extrusion press according to Claims 8, 11, characterized in that the hydraulic connection between the inner space (20) of the auxiliary cylinder and the inner space (19, 44) of each power cylinder connected thereto contains valves (49, 50).

40 15. A hydraulic extrusion press according to Claims 8, 11, characterized in that it contains an auxiliary restricting unit having a body (52) with holes (53, 54) and fitted with a cover (64), inside which there is mounted a slide valve (55) which is spring-loaded from the side of the cover (64) and has a through cavity (56), whose configuration and geometrical dimensions determine the magnitude of the speed of the mutual movement of the container (3) and ram (4), hydraulically connected via corresponding holes (53, 54) of the body (52) to the inner space (20) of the auxiliary cylinder and to the low-pressure main (37), while on the side opposite the spring-loaded one there is mounted a cylinder whose body (58) is rigidly connected to the body (52) of the restricting unit, while a plunger (59) is also rigidly connected to the slide valve (55), and the inner cavity (62) of this cylinder is hydraulically connected to the inner space (20) of the auxiliary cylinder.

45 16. A hydraulic extrusion press according to Claim 15, characterized in that the cover (64) on the body (55) of the restricting unit is mounted capable of axial movement in order to control the magnitude of the preliminary compression of the spring (57).

50 17. A hydraulic extrusion press according to Claim 15, characterized in that the auxiliary restricting unit contains a lead screw (66) attached in a stationary fashion to the end face of the slide valve (55) on the side of the spring (57), while the cover (64) has a through hole (67) through which the screw (66) passes with the possibility of controlling their mutual reciprocal movement.

55 18. A hydraulic extrusion press according to Claims 15, 16, 17, characterized in that it contains a valve (65) mounted between the auxiliary cylinder and the auxiliary restricting unit.

19. A hydraulic extrusion press according to Claim 8, characterized in that the cylindrical body (21) and, correspondingly, the plunger (22) of the auxiliary cylinder are constructed in a stepped fashion, while the spaces (70, 71) formed by these steps (68, 69) communicate hydraulically between one another.

5 **20.** A hydraulic extrusion press according to Claim 8, characterized in that the step (69) of the auxiliary cylinder which faces the plunger (14) of the main power cylinder is partly arranged in this plunger (14) and is rigidly connected thereto.

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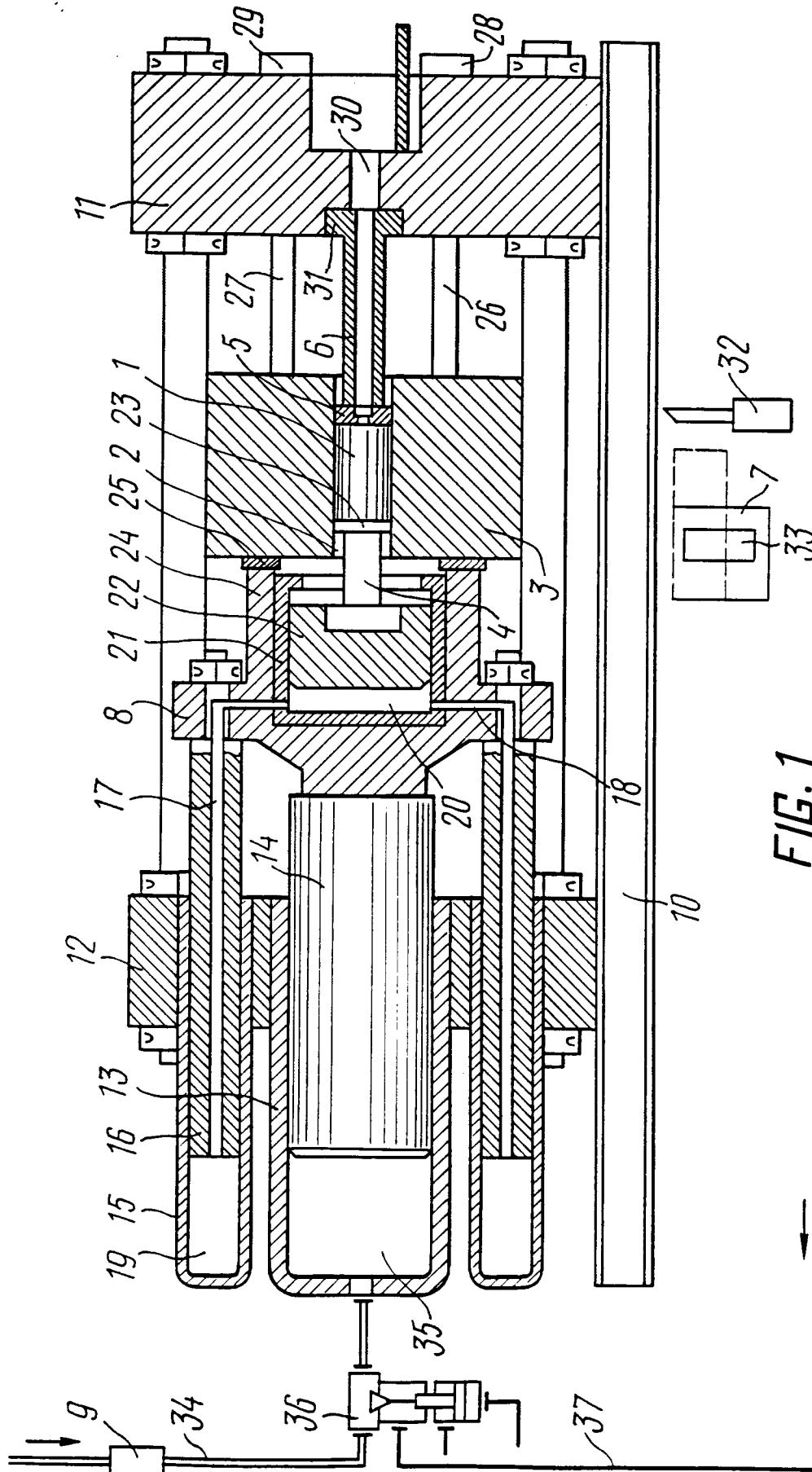
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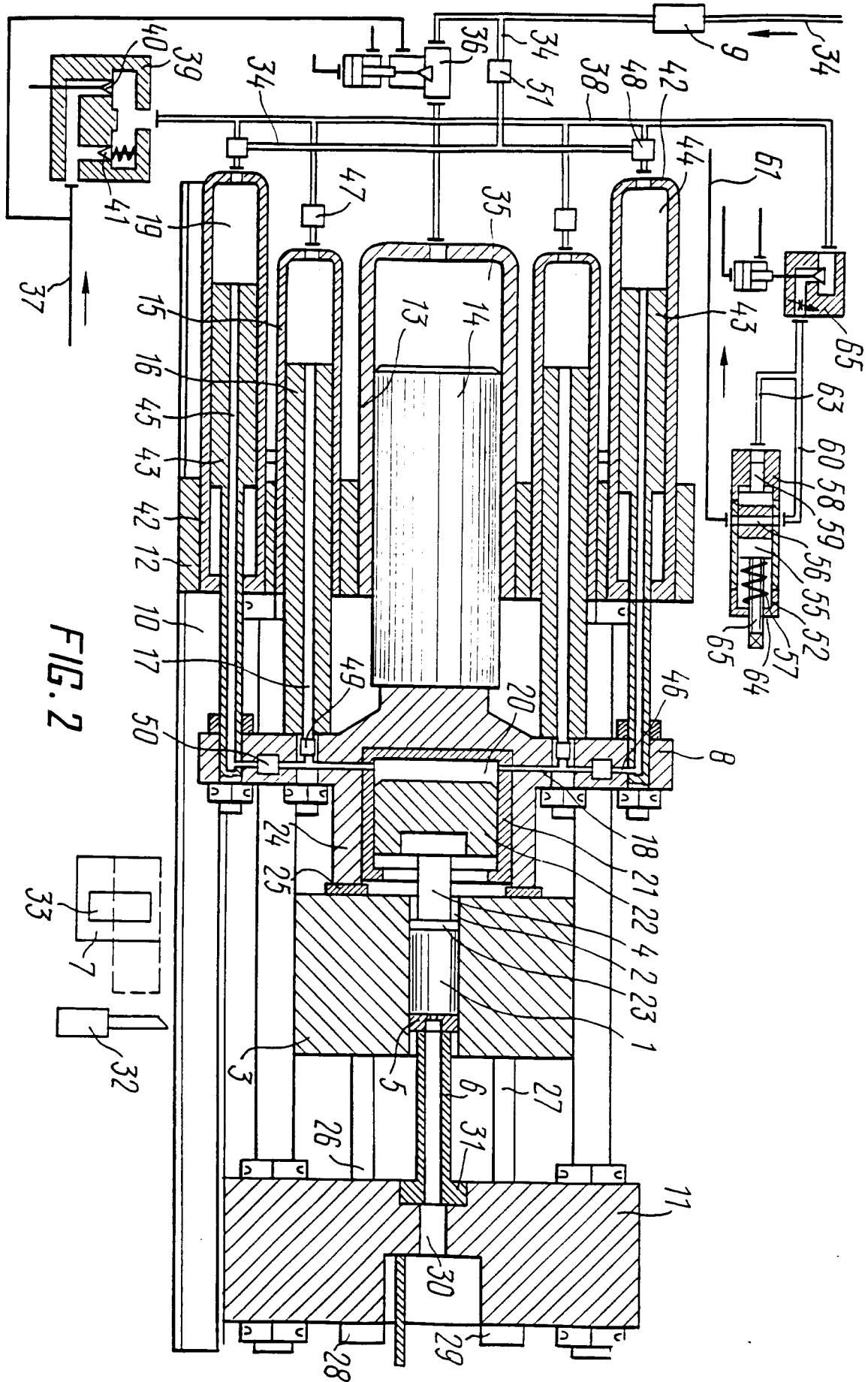
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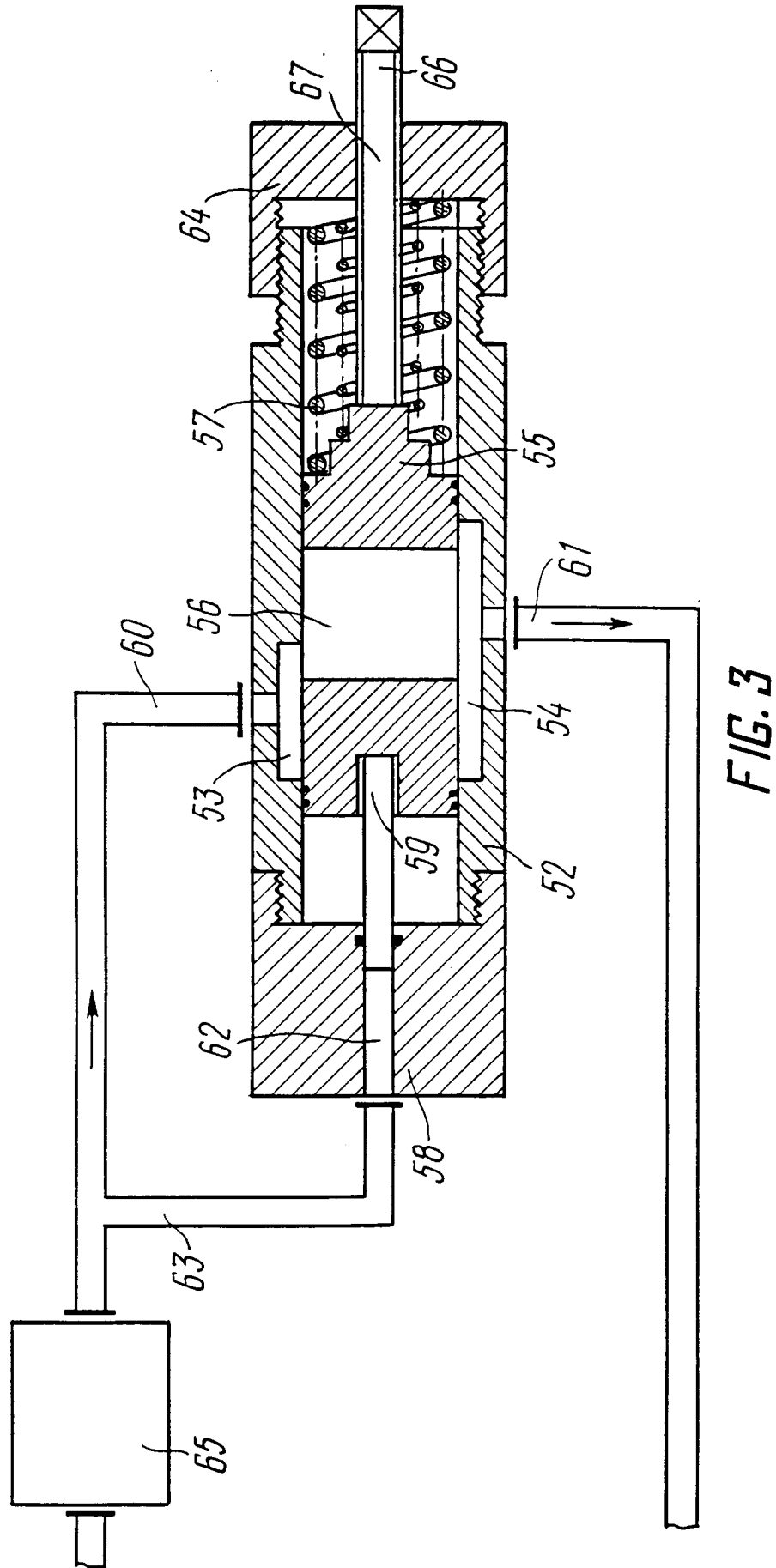
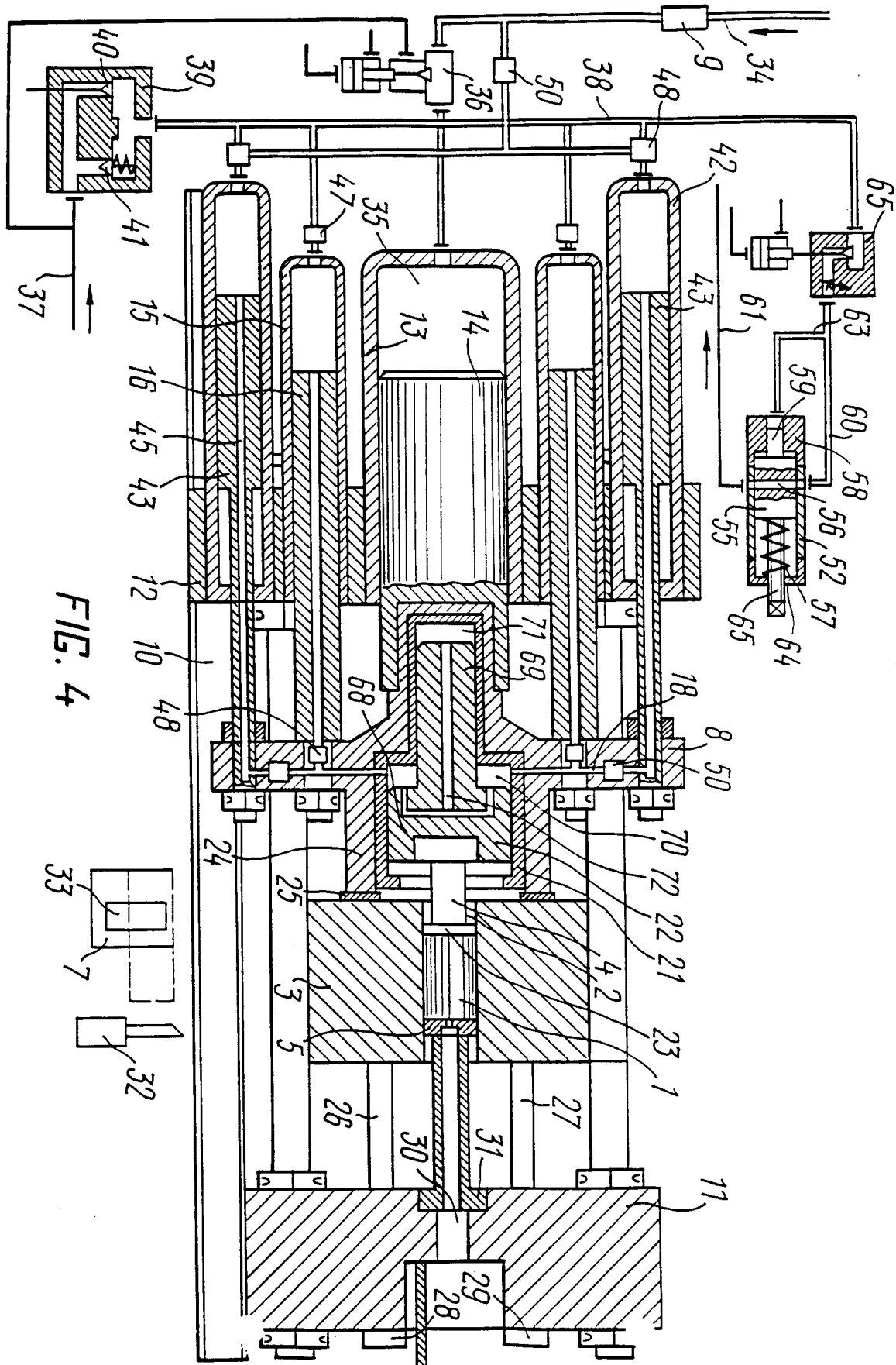


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU93/00303

A. CLASSIFICATION OF SUBJECT MATTER		
Int. Cl. 5 B21C 23/00		
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)		
Int. Cl. 5 B21C 23/00, 23/03, 23/04, 23/08, 23/20, 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, 645721 (Moskovsky Institut Stali i Splavov) 8 February 1979 (08.02.79) claims fig. 1,2	1-3
A		4-7
A	SU, A, 676347 (V.YA. Ostrenko et al), 30 July 1979 (30.07.79)	6
A	SU, A, 623604 (A.P. Belozarov et al), 2 August 1978 (02.08.78)	6
A	FR, A1, 2196860 (PRESSES ET MATERIELS HYDRAULIQUES MORANE-SOMUA), 22 March 1974 (22.03.74)	8-20
A	EP, A1, 0043025 (SMS SCHLOEMANN-SIEMAG AKTIEN- GESELLSCHAFT), 6 January 1982 (06.01.82)	8-20
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "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 "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "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 29 June 1994 (20.06.94)		Date of mailing of the international search report 9 Auguste 1994 (09.08.94)
Name and mailing address of the ISA/RU		Authorized officer
Facsimile No.		Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU93/00303

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SU, A3, 1785456 (Proizvodstvennoe Obedinenie "Kolomensky Zavod Tyazhelogo Stankostroeniya, 30 December 1992 (30.12.92)	8, 11

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