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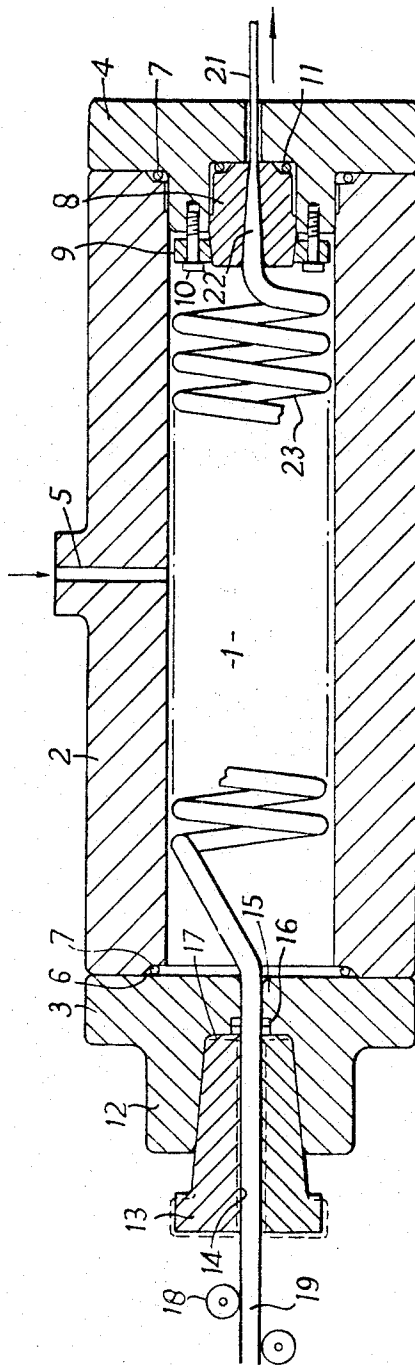
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EXTRUSION METHOD AND APPARATUS

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2 Sheets-Sheet 1

Fig. 1.



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EXTRUSION METHOD AND APPARATUS

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ABSTRACT OF THE DISCLOSURE

In the hydrostatic extrusion of a billet through a die while the billet is subjected to a high hydrostatic pressure within a pressure chamber, the billet may be of indefinite length and is extruded cyclically length by length. The billet extends through an inlet passage in the wall of the chamber where it can be gripped to prevent backward extrusion of the billet material in the region of this material. The process is repeated cyclically, each cycle comprising the steps of advancing the billet to feed a portion thereof into the chamber, gripping the billet and extruding a length of the billet through the die while the interior of the chamber is subjected to high hydrostatic pressure. This pressure is then relieved in preparation for the next cycle.

This invention relates to a method and apparatus for the formation by hydrostatic extrusion of extruded products which are solid, that is not hollow, from long billets such as rods. Examples of such extruded products are wire and prismatic sections.

It has previously been proposed to form such extruded products by hydrostatic extrusion under high pressure. In this proposal, the billet is placed in a pressure chamber having an extrusion die inside it and a passage, the same size as the die opening extending through a wall of the chamber, the chamber is then filled with liquid and high pressure is applied to the liquid to extrude the billet through the die. Where long extrusions are required, such as in the case of wire, it has been proposed to coil the billet in order to get as much material as possible into the chamber.

In the cold drawing of rods and wire with the reduction rarely exceeds 30-40% and is usually less in any single pass, while in the cold extrusion of rods 75% reduction is easily achieved in one operation in practically all cases. The reason for this difference is well known: in cold extrusion the permissible die stresses determine the maximum extrusion ratio that can be obtained in one operation, while in cold drawing the governing factor is the yield stress in uniaxial tension of the drawn metal, if otherwise identical conditions, including lubrication and die angle, are assumed.

It is thus clear that if the advantage of extrusion, that is that the material is under compressive stresses during the process, could be applied to the reduction of rods or wire of great lengths, substantial economies might result, and the gain will be the greater the lower is the yield stress of the processed material.

This invention provides a cyclic method for the extrusion of a continuous billet by means of a pressure chamber filled with fluid, for convenience a liquid, and having an inlet opening for the billet and an extrusion die forming an outlet from the chamber for the extrusion, a cycle of the said method comprising the steps of feeding a length of the billet into the chamber so as to extend along a non-straight path through the cham-

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ber, increasing the liquid pressure in the chamber to a high value thereby extruding the billet material through the die, while gripping the billet in the region of the inlet to prevent back-extrusion of the billet material therethrough and removing the pressure after a length of extrusion and before the length left in the chamber has straightened.

To begin the extrusion of a new billet, it is preferred that the leading end of the billet is first shaped to make sealing contact with the die entry and to include a portion which will protrude from the die. The leading end of the billet is then inserted, with the chamber empty (or only partially filled with liquid to a level below that of the inlet and the die opening), through the inlet and into the die, tension is applied to the portion protruding from the die to cause the shaped part of the billet to form a liquid seal against the interior of the die, the chamber is then filled with liquid and the cyclic extrusion method started.

Apparatus according to the invention for the extrusion of a continuous billet comprises a pressure chamber with means for applying high liquid pressure within the chamber and having an inlet passage for the billet, sealing means arranged to seal against the billet to prevent loss of liquid through the inlet passage and gripping means for gripping and supporting the billet against back extrusion. The gripping means may be in form of a split collet which engages the billet around substantially the whole of its periphery and over a sufficiently great length of the billet to avoid appreciable marking or deformation of its surface whilst preventing back-extrusion of the billet into the atmosphere. The collet segments may be urged into contact with the billet by means of a clamping system including a hydraulic ram. The outer surface of the collet may be tapered and co-operate so that the segments may be forced into gripping contact with the billet by a wedging action.

The apparatus may include means for feeding the billet into the pressure chamber during the loading stage of a cycle. These feeding means may be assisted by reducing the pressure inside the chamber to a value below atmospheric so that the billet is partially sucked into the chamber.

The sealing means which co-operate with the billet at the entry to the chamber may conveniently be located on the exterior of the chamber at the entry to the inlet and may be held in position against the liquid pressure within the chamber by the end face of the gripping means, particularly where the latter is in the form of a collet.

Advantageously, one at least of the inlet or outlet passages is formed in a plunger forming a movable end wall for the pressure chamber, and means are provided for forcing the plunger into the pressure chamber to generate high hydrostatic pressure within the pressure chamber so as to extrude a length of the billet through the extrusion die, the apparatus including sealing means to prevent loss of liquid between the plunger and pressure chamber.

Both the inlet and outlet passages may be formed in separate plungers which may form the opposite ends of a cylindrical pressure chamber. The inlet passage plunger and outlet passage plunger will then be moved inwards either successively or simultaneously to effect extrusion, the plungers being then moved outwardly to enable a further length of billet to be passed through the inlet passage.

According to a further aspect of the invention, additional deforming tools may be located within the pressure chamber and may be operated either from a power

source outside the pressure chamber or from a power source within the pressure chamber. For example, deforming rolls within the pressure chamber may be driven by means of one or more driving shafts extending through the pressure chamber wall and driven by a motor outside the pressure chamber. Alternatively, a power source within the pressure chamber might be a hydraulic motor or might use the pull resulting from the extrusion of the billet to pull a following section of the billet through the deforming rolls. Moreover forging platens reciprocating transversely of the billet may be mounted within the pressure chamber to perform forging operations on the billet.

The application of the invention to continuous wire-extrusion will now be described in more detail, by way of example, with reference to the accompanying diagrammatic drawings in which:

FIG. 1 is a vertical longitudinal section of a continuous wire-extrusion apparatus according to the invention, and

FIG. 2 is an elevational view of a modified wire-extrusion apparatus with the pressure chamber shown in section.

The apparatus shown in FIG. 1 comprises a pressure chamber 1 defined within a cylindrical wall 2 and end caps 3 and 4. The chamber 1 can be filled with high pressure liquid through a radially extending passage 5.

Hydraulic rams exert axial forces Q on the end caps 3 and 4. Loss of liquid from the chamber 1 between the side wall 2 and the end caps 3 and 4 is prevented by a high pressure sealing arrangement consisting of a mitre ring 6 of beryllium copper alloy and a synthetic rubber O-ring 7.

The end cap 4 is formed with a seating for an extrusion die 8 of comparatively small semi-angle. A clamping ring 9 is clamped by bolts 10 to the end cap 4 and holds the die 8 firmly against the end cap 4. A sealing arrangement 11, again of the O-ring and mitre ring type, prevents loss of liquid between the die 8 and the end cap 4. The die 8 may have external longitudinal grooves to allow high pressure liquid to surround and support it, thereby allowing it to be made of a less robust construction.

The end cap 3 is formed with an annular extension 12 having a tapered internal surface with which cooperate the correspondingly tapered outer surfaces of collet jaws 13. The collet jaws 13 have internal gripping surfaces 14 of the same diameter as that of an inlet aperture 15 in the end cap 3 leading into the chamber 1.

Sealing means 16, which may again be of the O-ring and mitre ring type, are located in a groove surrounding the entry to the inlet 15. The end surfaces 17 of the collet jaws 13 abut against the end cap 3 when the collet jaws 13 are fully closed and also abut against the sealing means 16 to hold them securely in place against the axial force exerted on them by liquid pressure within the chamber 1.

The operation of the apparatus shown in FIG. 1 will now be described.

Motor-driven feed rollers 18 serve to move the billet 19 into the chamber 1 through the inlet 15 and the jaws 13.

The leading end 21 of the wire to be drawn is thinned down to a diameter such that it will pass through the die 8. The end 21 is then inserted between the collet jaws 13, in their open positions, the sealing means 16 and the entry 15 to the chamber 1 and out through the die 8 so that the leading end 21 projects from the end cap 4 and the tapered section 22 between the leading end 21 and the remainder of the billet makes sealing contact with the internal surface of the die 8. A tension P is then applied to the projecting leading end 21 to ensure fluid tight contact between the tapered section 22 and the die 8.

The motor-driven feed rollers 18 are then started so

as to move a considerable length of billet into the chamber 1 where it lies along a non-straight path, here shown diagrammatically as a helix 23. When no more billet can be conveniently accommodated within the chamber 1, the feed rollers 18 are stopped, a force R_1 is applied to the collet jaws 13 thereby moving them into gripping contact with the billet and into the position shown in full lines in the figure.

The chamber 1 is then filled with liquid, for example a mixture of methyl alcohol and castor oil, and a sufficiently high pressure is applied to the liquid, of the order of the yield stress of the billet, multiplied by a factor proportional to the natural logarithm of the extrusion ratio, to force the billet to extrude through the die 8.

When most of the billet within the chamber 1 has been extruded and the remainder is about to become straight, the high pressure is reduced to atmospheric or less and the collet jaws 13 are moved by a force R_2 to the open position shown in dotted lines in the figure.

The feed rollers 18 are then started again to feed a further length of the billet into the chamber 1, whilst sufficient liquid is removed from the chamber 1 to accommodate the volume of billet introduced, the collet jaws 13 are then again moved to their closed, gripping position by a force R_1 and the pressure within the chamber 1 is then increased to the high value and further extrusion takes place.

It will be noted that while the dimensions of the chamber 1 may be relatively small, no limit is placed on the length of billet which can be extruded. If desired, a further billet may be welded on to the trailing end of the first billet so that the feed extrusion cycle can be repeated as many times as may be desired.

The fluid need only be withdrawn in bulk from the chamber 1 when it is desired to insert a new, separate billet into the apparatus. Even then, it is not always necessary to remove either of the end caps 3 and 4.

The operation of the apparatus may be made automatic, for example under the control of sensing means for determining the length of billet within the chamber or for the length of material extruded in an extrusion step. In such an arrangement, when a predetermined length of extrusion has been formed, the sensing means end the extrusion stroke, cause the pressure in the chamber to be relieved and start the feed stroke. Further sensing means associated with the feeding mechanism then cause an appropriate length of billet to be fed into the chamber and then start the gripping and extrusion stroke.

Instead of being extruded into the atmosphere, the wire leaving the die 8 may be fed directly into a second high pressure to undergo further reduction by a second extrusion process similar to that described above. Thus for example the wire may undergo a series of such reductions by passing through a series of chambers of decreasing maximum fluid pressure without the need for further gripping means between successive chambers, additional to the gripping means (such as 13) at the entry to the first chamber.

The apparatus shown in FIG. 2 comprises a pressure chamber 1 defined within a cylinder 2, an inlet passage end cap 3, and an outlet passage plunger 24 carrying a die member 25. The cylinder 2 is not formed with any inlet passages in its wall. The extrusion die 25 is formed with a seating for a combined O-ring and mitre ring seal 26 which can slide with the extrusion die 25 and plunger 24 along the inner surface of the cylinder 2.

The sealing means for the inlet passage, clamping means for the billet and billet feeding means are identical to those described above with reference to FIG. 1.

The plunger 24 is formed with an internal axial passage 27 through which the extrusion from the die 25 can pass freely. The plunger 24 is mounted on an extension of the plunger of a high pressure hydraulic ram

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shown diagrammatically at 28. The ram 28 is of conventional design with the exception that the passageway 27 is continued through it at 29, the high pressure surface of the ram plunger carrying a tube 30 which is a sliding fit in the end wall 31 of the ram 28.

The axial thrust of the ram 28 in operation is taken by a set of tie-rods 32 which pass at one end through a retaining ring 33 seated on the end cap 3 and at their other ends through a clamping plate 34 bearing against the ram 28. The ends of the tie-rods 32 are screw threaded to carry nuts 35.

The operation of the apparatus shown in the drawing is similar to that described above with reference to FIG. 1 with the exception that the chamber 1 is filled with liquid before the extrusion die 26 is inserted into the end thereof and that during each cycle, high pressure is applied to the liquid in the chamber 1 by operating the ram 28 thereby driving the plunger and extrusion die to the left as seen in FIG. 2.

The extrusion formed by the die 26 is pulled through the passages 27 and 30 by motor driven rollers 36.

Any liquid lost during an extrusion cycle may be replaced through a conduit 36 controlled by a non-return valve 37 in a supply line 38 from a low pressure pump (not shown) which can feed the liquid in during a low pressure phase of the cycle.

The embodiments of the apparatus may be modified in various ways without departing from the scope of the invention. For example, the collet 13 may be replaced by a deformable sleeve conveniently of metal which is close fitting around the billet and may be compressed inwardly into clamping contact with the billet by external fluid pressure.

Also, several billets may be extruded simultaneously along parallel paths through the same pressure container. If desired, the container may be rotated about its axis during the loading stage of each cycle so as to coil the billet within the container.

Where appropriate, the extrusion may be carried out at elevated temperatures.

We claim:

1. A hydrostatic extrusion method of the kind in which a billet is placed within a pressure chamber and is subjected to high hydrostatic pressure while being extruded through an extrusion die, characterized in that the extrusion is performed cyclically on successive lengths of a continuous billet, each extrusion cycle comprising the steps of advancing the billet to feed a length thereof through the inlet into the pressure chamber, the billet extending rearwardly through the inlet, extruding a length of a billet through the die while under high hydrostatic pressure and simultaneously gripping the billet in the region of the inlet to prevent backward extrusion of the billet material through the inlet, and reducing the pressure within the chamber in preparation for the next cycle.

2. A method according to claim 1, wherein the pressure inside the chamber is reduced during the feeding stage to a value below atmospheric so that the billet is partially sucked into the chamber.

3. A method according to claim 1, wherein the portion of the billet within the chamber lies along a non-straight

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path in each cycle and the extrusion step ceases before the billet has straightened.

4. A method according to claim 3, wherein the chamber is rotated during the feeding stage of each cycle.

5. In hydrostatic extrusion apparatus of the kind comprising a pressure chamber having an extrusion die leading into an outlet passage and means for generating a high hydrostatic pressure within the chamber, the improvement which comprises,

an inlet through a wall of the chamber to accommodate a continuous billet extending through the inlet into the chamber,

gripping means in the region of the inlet for gripping and supporting the billet from back extrusion, and sealing means arranged for forming a seal between the billet and the inlet.

6. Apparatus according to claim 5, wherein the gripping means are in the form of a split collet which engages the billet around substantially the whole of its periphery and over a sufficiently great length of the billet to avoid appreciable marking or deformation of its surface whilst preventing back-extrusion of the billet into the atmosphere.

7. Apparatus according to claim 6, wherein the collet segments are urged into contact with the billet by means of a clamping system including a hydraulic ram.

8. Apparatus according to claim 6, wherein the outer surface of the collet is tapered so that the segments may be forced into gripping contact with the billet by a wedging action.

9. Apparatus according to claim 5, and including means for feeding the billet into the pressure chamber during the feeding stage of a cycle.

10. Apparatus according to claim 5, wherein the sealing means which co-operate with the billet at the entry to the chamber are located on the exterior of the chamber at the entry to the inlet and are held in position against the liquid pressure within the chamber by the end face of the gripping means.

11. Apparatus according to claim 5, wherein one at least of the inlet and outlet passages is formed in a plunger forming a movable end wall for the pressure chamber, and including means for forcing the plunger into the pressure chamber to generate high hydrostatic pressure within the pressure chamber so as to extrude a length of the billet through the extrusion die.

12. Apparatus according to claim 11, wherein both the inlet and the outlet passages are formed in separate plungers which form the opposite ends of the pressure chamber.

References Cited

UNITED STATES PATENTS

55	3,126,096	3/1964	Gerard	72—253
	2,558,035	6/1951	Bridgman	72—60

FOREIGN PATENTS

	476,793	9/1951	Canada.
60	CHARLES W. LANHAM, <i>Primary Examiner</i>		

U.S.C.I.X.R.

72—253, 271