OPERATING MECHANISM FOR SLIDABLE GATES AND METHOD OF OPERATING SLIDE GATE

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Filed: Mar. 1, 1973
Appl. No.: 337,252

U.S. Cl. 222/504, 222/561
Int. Cl. B22d 37/00
Field of Search 222/334, 504, 561, DIG. 7

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ABSTRACT
An operating mechanism for slidable gates which are used to control flow of liquid from a bottom-pour vessel, and a flow-controlling method. The mechanism is particularly useful for controlling teeming of liquid steel from a tundish into a continuous-casting mold. Most slidable gates either fully open or fully close the outlet of a vessel. The present invention enables the outlet to be partially open, whereby the stream discharging therefrom can be throttled. The mechanism includes a main drive means for pushing gates from a ready position to a slow-motion region under the vessel outlet. The slow-motion region of an orifice gate extends at least from a position in which the vessel outlet is partially open to a position in which it is fully open. An opposed auxiliary drive serves to retard movement of a gate as soon as it reaches the slow-motion region. Thereafter, the main drive pushes an orifice gate slowly and under close control to any desired teeming position within the slow-motion region. The mechanism also includes an improved arrangement for conducting gases to the nozzle at the vessel outlet to prevent skulls from forming, and an improved means for attaching a pouring tube to its holder.

16 Claims, 9 Drawing Figures
**FIG. 8**

![Graph showing Tundish head (inches) vs. Flow (lbs/min)]

A - full throttle
B - full open

**FIG. 9**

Diagram of a hydraulic system with components labeled 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71.
OPERATING MECHANISM FOR SLIDABLE GATES AND METHOD OF OPERATING SLIDE GATE

This invention relates to an improved operating mechanism for slidable gates which are used to control flow of liquid from a bottom pour vessel, and to an improved flow-controlling method.

Although my invention is not thus limited, my operating mechanism is particularly useful when applied to a vessel from which liquid metal is teemed into a receiver therefofore, for example, a tundish from which liquid steel is teemed into a continuous-casting mold. My control method is particularly useful when applied in the corresponding operation. Reference can be made to an earlier patent of James T. Shapland, U.S. Pat. No. 3,352,465, of common ownership for a showing of two forms of slidable gate constructions used heretofore on bottom-pour vessels, and to a number of later patents, also of common ownership, for showings of modifications and improvements to the construction shown in the first Shapland patent.

FIGS. 1-3 of the Shapland patent show a reciprocating gate, different portions of which form a closed area and a orifice. The closed area is positioned under the vessel outlet to prevent flow of liquid from the vessel, and the orifice is positioned thereunder to permit flow. FIGS. 4-6 of the patent show "slide-through" gates, wherein each gate is either a blank or an orifice gate. A blank gate is positioned under the vessel outlet to prevent flow, and displaced with an orifice gate to permit flow. With either form, the vessel outlet is either fully open or fully closed. There is no provision for teeming through a partially open outlet, that is, using the gate to throttle the pouring stream. Most other gate-operating mechanisms with which I am familiar have a similar lack of flexibility.

In certain operations, it would be advantageous to throttle a pouring stream. One example is in continuously casting aluminum-killed steel, where oxygen released from the steel combines with excess aluminum and forms aluminum oxide which deposits around the tundish outlet and gate orifice and restricts flow. If the gate with the orifice could be placed in a throttling position in which the outlet is only partially open at the beginning of a casting operation, the effective opening could be increased gradually as the cast progresses to maintain a constant teeming rate and thus compensate for the oxide buildup. Also the gate might be moved momentarily to a position in which the outlet is fully open to flush away the deposit and then returned to a throttling position.

An object of my invention is to provide an improved gate-operating mechanism and an improved flow-controlling method which enable me to throttle a stream of liquid as it discharges through the outlet of a bottom-pour vessel.

A further object is to provide an improved gate-opening mechanism and an improved flow-controlling method which enable me to move an orifice gate quickly from a ready position into a slow-motion region under a vessel outlet, and thereafter slowly and under close control in either direction to any desired teeming position within the slow-motion region.

A further object is to provide an improved gate-operating mechanism which enables me to change readily either the blank gate or the orifice gate during the course of a teeming operation.

A further object is to provide a gate-operating mechanism which affords the foregoing advantages and at the same time can be used for positioning a separate pouring tube beneath the gate.

A further object is to provide an improved means for introducing gas to a permeable plug in a blank gate and avoiding any need for connecting pipes or tubes to movable parts, and also affording automatic gas shut off when the vessel outlet is opened to begin teeming.

A further object is to provide an improved means for attaching a pouring tube to a holder which can be used in conjunction with a slidable gate.

In the drawings:

FIG. 1 is a top plan view of my gate-operating mechanism and the mounting plate for attaching the mechanism to a bottom-pour vessel;

FIG. 2 is a side elevational view of a portion of a bottom-pour vessel with my gate-operating mechanism attached;

FIG. 3 is a longitudinal section on line III—III of FIG. 1;

FIG. 4 is a cross section on line IV—IV of FIG. 2, but showing a blank gate positioned under the vessel outlet;

FIG. 5 is a cross section on line V—V of FIG. 2, but showing a blank gate positioned under the vessel outlet;

FIG. 6 is a bottom plan view of the mounting plate;

FIG. 7 is an exploded perspective view of the pouring tube and its holder illustrating my preferred attaching means;

FIG. 8 is a graph comparing the relation between the flow of metal from a tundish and the head of metal therein with the outlet partially open, and the outlet fully open; and

FIG. 9 is a schematic diagram of the hydraulic and pneumatic circuits embodied in the mechanism.

VESSEL AND MOUNTING PLATE

FIGS. 2, 3, 4, and 5 show a portion of a conventional bottom-pour vessel for handling liquid metals, for example, a tundish used to teem metal into a continuous-casting mold. The vessel includes a metal shell 10, a refractory lining 12, and a refractory pouring nozzle 13 extending through the lining and shell and defining the outlet. A mounting plate 14 is fixed to the bottom wall of the vessel surrounding the lower portion of the nozzle. Preferably I interpose a sheet 15 of heat insulating material, such as asbestos mill board, between the bottom wall and the mounting plate. As best shown in FIG. 6, the mounting plate has horizontal passages 16 and 17. The passages 16 communicate with series of nozzles 18 fixed to the underside of the mounting plate for supplying cooling air to the springs embodied in my operating mechanism, hereinafter described. The passage 17 has an outlet port 17a for supplying gas (inert and/or oxygen) to the vessel nozzle 13 as also hereinafter described. The mounting plate has a plurality of depending lugs 19 for attaching my operating mechanism to the vessel. The lugs have transverse holes 20.

CONSTRUCTION OF THE GATE OPERATING MECHANISM

I construct my operating mechanism as an assembly which I can install on the mounting plate 14 or remove therefrom as a unit. The mechanism has a fabricated frame 21 on which I mount the other parts. As best shown in FIG. 2, this frame includes a horizontal plate 22, a continuous flange 23 depending from one side
edge of the plate, and vertically spaced upper and lower rails 24 and 25 projecting inwardly from the flange. At its opposite side edge, the plate carries depending flange segments 26, 27, and 28 from which horizontally spaced upper rail segments 29, 30 and 31 respectively project inwardly. Horizontally spaced lower rail segments 32 and 33 project inwardly from the flange segments 26 and 28 respectively. The foregoing parts of the frame are rigidly connected to one another, but preferably the lower rail 25 and rail segments 32 and 33 and the lower portions of the flange 23 and flange segments 26 and 28 can be removed. The purpose of the lower rail and rail segments is to support a pouring-tube holder 34, hereinafter described. When no pouring tube is used, the parts on which it would have been supported are not needed. Plate 22 has vertical holes 35 and horizontal holes 36 communicating with the respective vertical holes. The lugs 19 on the mounting plate 14 match the vertical holes and are received therein. I insert pins 37 through the aligned horizontal holes 20 and 36 in the lugs 19 and plate 22 respectively to hold the operating mechanism on the vessel. As hereinafter explained in detail, the upper rail 24 and rail segments 29, 30 and 31 are adapted to support refractory blank gates 38 and orifice gates 39 for movement along a linear path between a ready position, a slow-motion region under the nozzle 13, and a removal position beyond the nozzle.

Plate 22 has a central opening 41 which receives a stationary refractory top plate 42 (FIGS. 3, 4 and 5). The latter has the usual orifice 43, which is aligned with the base of the nozzle 13. Since the refractory plate is exposed directly to liquid metal, it must be replaced frequently. Replacement is simple, since the top plate is accessible when the frame 21 is removed from the mounting plate 14.

I mount a main fluid-pressure cylinder 46 on frame 21 at one end of the path of gate movement, and an auxiliary fluid-pressure cylinder 47 at the other end thereof (FIGS. 1.2 and 3). The main cylinder 46 contains a reciprocating piston 48 and a piston rod 49, which carries a ram 50 at its free end. Similarly, the auxiliary cylinder 47 contains a reciprocating piston 51 and a piston rod 52, which carries an opposed second ram 53 at its free end. A hydraulic fluid line 54 and a compressed air line 55 are connected to the back and front ends of the main cylinder 46 respectively. Similarly, a hydraulic fluid line 56 and a compressed air line 57 are connected to back and front ends of the auxiliary cylinder 47.

At opposite sides of the nozzle 13, the frame 21 carries opposed gate-supporting levers 60 and opposed tube-holder-supporting levers 61 which are best shown in FIGS. 4 and 5 respectively. The rails 24 and 25 and rail segments 30 are interrupted to accommodate the levers 60 and 61, while the levers 61 are slotted to accommodate the levers 60 (FIG. 4). The gate-supporting levers 60 are pivotally mounted on crowned washers 62 carried by bolts 63 which depend from flange 23 and flange segment 27 at opposite sides of the gate 38 or 39. The flange 23 and flange segment 27 have vertical bores 64 within which I mount compression springs 65 and plungers 66. The springs act downwardly through the plungers against the outboard ends of levers 60, whereby the inboard ends act upwardly against the gate and thus press the gate firmly against the top plate 42 thereabove. The tube-holder support-

OPERATION OF THE GATE-OPERATING MECHANISM

Before filling the vessel with metal or other liquid, I position a blank gate 38 under the stationary top plate 42, where it is supported on the inboard arms of the gate-supporting levers 60. The ram 50, operated by the main cylinder 46, is fully retracted. The back end of the auxiliary cylinder 47 contains hydraulic fluid, whereby the second ram 53 is extended into abutting relation with the end of the blank gate 38. I insert an orifice gate 39 sidewardly through the space between the upper flange segments 26 and 27 into a ready position, where it rests on the rail 24 and on rail segments 29 and 30. The orifice gate 39 has an orifice 73 of the same diameter as the orifice 43 in the top plate 42. The ends of the gates 38 and 39 approximate abut.

When I wish to commence teeming, I introduce hydraulic fluid to the back end of the main cylinder 46 via the line 54. Ram 50 is driven toward the nozzle 13 and thus pushes the orifice gate 39 toward the nozzle and displaces the blank gate 38 from the gate-supporting levers 60 toward a removal position beyond the nozzle. The blank gate acts against ram 53 and pushes the piston 51 into a retracted position within the auxiliary cylinder 47. The back end of the piston 51 carries a cylindrical plug 74 (FIG. 3). The back wall of cylinder 47 has a bore 75, which is adapted to receive plug 74, and with which the hydraulic line 56 communicates. The back wall also has a restricted L-shaped passage 76 which affords the only communication between the interior of the cylinder and the bore 75 when plug 74 is received within the bore. A screw 77, which is threadedly engaged with the cylinder wall, controls the effective cross-sectional area of passage 76. Thus the plug 74, bore 75, and passage 76 form a dashpot. I proportion the parts so that the plug first enters the bore when the orifice gate 39 reaches a slow-motion region in which it is supported on the gate-supporting levers 60 and its orifice 73 is near or partially under the nozzle 13. The slow-motion region of an orifice gate extends at least from a position of the gate in which the nozzle is partially open, as shown in FIG. 3, to a position in which the nozzle is fully open. Until the plug enters the bore, hydraulic fluid discharges freely from the auxiliary cylinder, whereby the parts move rapidly until the gate reaches the slow-motion region. As soon as the plug enters the bore, hydraulic fluid can escape from the auxiliary cylinder only via the restricted passage 76, whereupon the parts move slowly and under close control in either direction into any desired teeming position within the slow-motion region.

While the teeming operation takes place, the upper rail segments 30 and 31 support the blank gate 38 in its removal position, and the gate-supporting levers 60 support the orifice gate 39, as already stated. If I wish
to remove the blank gate and replace it with another, I introduce air under pressure to the front end of the auxiliary cylinder 47 via line 57. Piston 52 is driven into a more retracted position, whereupon I can remove the blank gate sideways through the space between the flange segments 30 and 31, and insert another in its place. If I wish to stop pouring, I introduce hydraulic fluid to the back end of the auxiliary cylinder 47 and thus push the blank gate 38 from its removal position back under the orifice 43, slowly at first until plug 74 clears the bore 75 and then rapidly. If I wish to change orifice gates, I first remove the blank gate by the procedure already described, whereafter I introduce air to the front end of the main cylinder 46 via the line 55 and thus drive the piston 48 and ram 50 into a retracted position. I insert a new orifice gate into the ready position and next operate cylinder 46 to push the new gate into the slow-motion region on the gate-supporting levers 60, displacing the old orifice gate into its removal position. Alternatively, I may introduce hydraulic fluid to the back end of the auxiliary cylinder 47 and drive the blank gate back under the nozzle and the old orifice gate back to the ready position, from which I remove it sideways. I can then insert a new orifice gate into the ready position and proceed as originally described.

FIG. 8 is a graph which shows the relation between the flow rate and head of steel in a tundish (A) with the gate orifice 73 in an initial throttling position at the beginning of the slow-motion region, and (B) with the gate orifice in its fully open position. In this instance, the initial throttling position is with the circumference of the gate orifice 73 lying on the center of the orifice 42 in the top plate 41, that is, the effective area of the opening is about 40 percent of the area at the fully open position. The abscissa of the graph represents the flow rate and the ordinate represents the head. With a given size of orifice and a given initial throttling position, I can produce a relation anywhere between the lines (A) and (B) of the graph.

HYDRAULIC AND PNEUMATIC CIRCUITS

FIG. 9 is a simplified diagram of the hydraulic and pneumatic circuits embodied in my mechanism. The hydraulic circuit includes a tank 80 which contains hydraulic fluid. A feed line 81 extends from the tank to a pump 82 and thence to an inlet port of a four-way valve 83. A return line 84 extends from an outlet port of the valve back to the tank. The aforementioned hydraulic lines 54 and 56 extend from this valve to the main and auxiliary cylinder 46 and 47 respectively. The pneumatic circuit includes a compressed air tank 85. A feed line 86 extends from tank 85 to an inlet port of another four-way valve 87, which has an exhaust 88. The aforementioned air lines 55 and 57 extend from the latter valve to the main and auxiliary cylinders 46 and 47 respectively. FIG. 9 shows the valves 83 and 87 in their neutral positions. When I wish to introduce hydraulic fluid to cylinder 46 or 47, I shift the movable element of valve 83 left or right respectively. Similarly, I shift the movable element of valve 87 to introduce air to either cylinder. The circuit may include various refinements, not shown, such as filters, heaters, and accumulators.

INTRODUCTION OF GAS TO NOZZLE

The blank gate 38 illustrated has a gas-permeable plug 91 which is aligned with orifice 43 when the blank gate is positioned to close the vessel outlet. As known in the art, I introduce gas to the base of nozzle 13 through the permeable plug to prevent skulls from forming and blocking the nozzle. Preferably, I introduce an inert gas, usually argon, to stir the metal in the vessel until a few seconds before I am ready to commence teeming. At that point, I introduce a brief burst of oxygen to burn away any skill which may have formed in the nozzle bore. The inclusion of a permeable plug of course is optional, but when I include it, I prefer to conduct gas to the plug through a novel arrangement of passages, which are best shown in FIGS. 1 and 5 and which I shall now describe.

As already mentioned, the mounting plate 14 has a passage 17 and an outlet port 17a. The top plate 42 has a horizontal passage 92 and inlet and outlet ports 92a and 92b communicating with this passage and extending through the top and bottom faces respectively. The blank gate 38 has a horizontal passage 93, an inlet port 93a communicating with this passage and extending through the top face, and a circular passage 94 communicating with passage 93 and surrounding the permeable plug 91. When the parts are assembled, the outlet port 17a in the mounting plate and the inlet port 92a in the top plate 42 are aligned. Preferably, I insert a sealing ring 95 between the top plate and mounting plate at the juncture of the outlet and inlet ports. When the blank gate 38 is properly positioned under the nozzle 13, the inlet port 93a in the gate and the outlet port 92b in the top plate are aligned. I connect a gas line 96 to either end of passage 17 in the mounting plate, whereby gas may flow through passages 17, 92, 93 and 94 to the permeable plug 91. The other end of passage 17 of course is plugged.

My novel arrangement of passages eliminates need for connecting a pipe or tube to a movable part of the mechanism to conduct gas to the plug, as has been the practice in the prior art. A further advantage is that the gas is immediately and automatically shut off whenever the blank gate is displaced from the nozzle. It should be pointed out that my novel arrangement of passages has general utility in gate-operating mechanisms which embody a mounting plate, a top plate, and a permeable plug in the slidable gate. Its use is not confined to the specific mechanism described herein.

POURING TUBE CONSTRUCTION AND OPERATION

If I use a pouring tube, I assemble the tube 98 on its aforementioned holder 34. As best shown in FIG. 7, the holder 34 is formed of a flat rectangular refractory block 99 and a metal frame 100 covering the side and end edges and bottom of the block. The frame is fixed to the block with a layer of mortar 101. The underside of the frame has a depending skirt 102 which receives the upper end of tube 98. The skirt has four symmetrically arranged slots 103. The upper portion of the tube forming has a surrounding metal band 104 and is grooved as indicated at 105. I insert a U-shaped wire clip 106 through the slots 103 and grooves 105 to fix the pouring tube to the holder. The block 99 has a central orifice 107 aligned with the tube bore. The grooves 105 preferably extend through only relatively small arcs, whereby the tube is positioned automatically always in the same orientation with respect to the holder when the two parts are assembled. This is an important ad-
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vantage where the tube has outlets 108 in its side walls, since it assures that these outlets are oriented properly with respect to a continuous casting mold. If side outlets are not used, groove 105 may be continuous around the tube circumference. When either the holder or tube requires replacement, it can be replaced without replacing the other.

When I install the holder 34 and pouring tube 98 in the mechanism, I insert the holder sideways through the space between the lower rail segment 32 and the holder-supporting levers 61, where it is in a ready position resting on the lower rail 25 and rail segment 32. Rams 50 and 53 have depending flanges 109 and 110 respectively adapted to abut opposite ends of holder 34. Initially I operate the main cylinder 46 to extend ram 50 and push the holder into a position in which its orifice 107 is aligned with nozzle 13. Preferably I insert a U-shaped stop 112 through appropriately placed holes in the lower rail 25 to retain the holder and tube exactly in this position. When I replace a tube holder and tube, I insert a replacement holder into the ready position the same as before, and operate cylinder 46 to push the replacement holder onto the holder-supporting levers 61, where it displaces the old onto the lower rail 25 and rail segment 33. I can remove the holder sideways through the space between the rail segment 33 and the levers 61.

From the foregoing description, it is seen that my invention affords a simple method and mechanism for operating slidable gates which control flow of liquid from a bottom-pour vessel and for using the orifice gate to throttle the pouring stream. The invention enables gates or pouring tubes to be removed and replaced readily at any time. Another feature is that the pouring tube is removably attached to its holder, yet always properly oriented.

I claim:

1. An operating mechanism for slidable gates which are used to control flow of liquid from a bottom-pour vessel, said mechanism comprising a frame for attachment to the bottom of the vessel, gate-supporting means on said frame for slidably supporting blank and orifice gates for movement between a ready position, a slow-motion region under the vessel outlet, and a removal position beyond said slow-motion region, the slow-motion region of an orifice gate extending at least from a position of the gate in which the vessel outlet is partially open to a position in which it is fully open, and main and auxiliary drive means carried by said frame at opposite ends of the path of gate movement, said main drive means being adapted to push a gate from said ready position into said slow-motion region and to displace a gate already in said slow-motion region into said removal position, said auxiliary drive means including means for retarding the rate of movement of gates as they reach said slow-motion region, which last-named means permits an orifice gate to move rapidly from said ready position to said slow-motion region and thereafter slowly and under close control in either direction to any teeming position within said slow-motion region.

2. A mechanism as defined in claim 1 comprising in addition means on said frame spaced below said gate-supporting means for supporting a pouring tube.

3. A mechanism as defined in claim 2 in which the means for supporting the pouring tube enables said main drive means to push a replacement pouring tube from a ready position into a position aligned with the vessel outlet, and to displace an old pouring tube from alignment with the outlet into a position from which it can be removed sideways.

4. A mechanism as defined in claim 1 in which said main and auxiliary drive means include fluid pressure cylinders and pistons mounted at opposite ends of said frame, and opposed rams operated by said pistons.

5. A mechanism as defined in claim 4 in which said retarding means include a dashpot within the cylinder of said auxiliary drive means.

6. The combination, with a bottom-pour vessel having a nozzle in its bottom wall and blank and orifice gates for controlling flow of liquid through said nozzle, of an operating mechanism attached to the bottom wall of said vessel for supporting and positioning said gates, said mechanism being constructed as defined in claim 1.

7. A combination as defined in claim 6 further comprising a pouring tube carried by said mechanism below said gates.

8. A combination as defined in claim 6 in which said mechanism forms an assembly which can be removed as a unit from said vessel, and re-attached thereto.

9. An operating mechanism for slidable gates which are used to control flow of liquid from a bottom-pour vessel, which mechanism comprises:

- a frame for attachment to the bottom of the vessel and including a plate and rails dependently supported from said plate;
- opposed gate-supporting levers pivotable to said frame, said rails being interrupted to accommodate said levers;
- and a main fluid pressure cylinder and piston and a ram operated thereby mounted at one end of said frame;

the improvement which comprises:

- an auxiliary cylinder and piston and an opposed second ram operated thereby mounted at the other end of said frame;
- said rails being adapted to support blank and orifice gates for movement between a ready position adjacent said first-named ram, a slow-motion region on said levers under the vessel outlet, and a removal position adjacent said second ram;
- the slow-motion region of an orifice gate extending at least from a position of the gate in which the vessel outlet is partially open to a position in which it is fully open;
- said first-named ram being adapted to push a gate from said ready position into said slow-motion region, and to displace a gate from the latter region to said removal position with said second ram in abutting relation with the displaced gate;
- and means in said auxiliary cylinder for retarding the rate of movement of the gates as they reach said slow-motion region, whereby an orifice gate moves rapidly from said ready position to said slow-motion region and thereafter slowly and under close control in either direction to any teeming position within said slow-motion region.

10. A mechanism as defined in claim 9 in which the gates can be inserted sideways into their ready position and removed sideways from their removal position.

11. A mechanism as defined in claim 9 in which said frame includes in addition rails spaced below said first-named rails for supporting a pouring tube, said mecha-
9. A mechanism further comprising opposed tube-supporting levers below said gate-supporting levers, said second-named rails being interrupted to accommodate said tube-supporting levers, and means on said first-named ram for pushing a pouring tube from said second rails to said tube-supporting levers.

12. A mechanism as defined in claim 9 in which said retarding means includes a dashpot within said auxiliary cylinder, said check valve becoming operable when a gate reaches a slow-motion region.

13. The combination, with a bottom-pour vessel having a nozzle in its bottom wall, a mounting plate fixed to the bottom wall and surrounding said nozzle, a top plate under said mounting plate, and blank and orifice gates for controlling flow of liquid through said nozzle, of an operating mechanism for supporting and positioning said gates, said mechanism being removably attached to said mounting plate and constructed as defined in claim 9.

14. A combination as defined in claim 13 in which said mounting plate carries a plurality of depending lugs, and the frame of said mechanism includes a plate having holes matching and receiving said lugs, and pins fixing said frame to said lugs.

15. A method of controlling flow of liquid from a bottom-pour vessel, said method comprising positioning a blank gate under the vessel outlet, hydraulically displacing the blank gate with an orifice gate, and during the displacing step moving the orifice gate rapidly from a ready position to a slow-motion region under the outlet and thereafter slowly moving the orifice gate under close control to a teeming position within the slow-motion region by retarding the gates with a dashpot in the hydraulic circuit, said slow-motion region of an orifice gate extending at least from a position of the gate in which the vessel outlet is partially open to a position in which it is fully open.

16. In an operating mechanism for slidable gates which are used to control flow of liquid from bottom-pour vessel, said mechanism comprising:
   a frame for attachment to a vessel;
   gate supporting means on said frame for slidably supporting blank and orifice gates for movement between a ready position, a position under the vessel outlet and for removal; and
   drive means for moving said gates;
the improvement in which:
said orifice gate is movable rapidly from said ready position to a slow-motion region under the vessel outlet extending at least between a position in which the outlet is partially open and a position in which it is fully open; and
said drive means is plural speed, and has means for moving said orifice gate at a first rapid speed from said ready position to said slow-motion region and means for moving said orifice gate at a second slow speed through said slow-motion region.