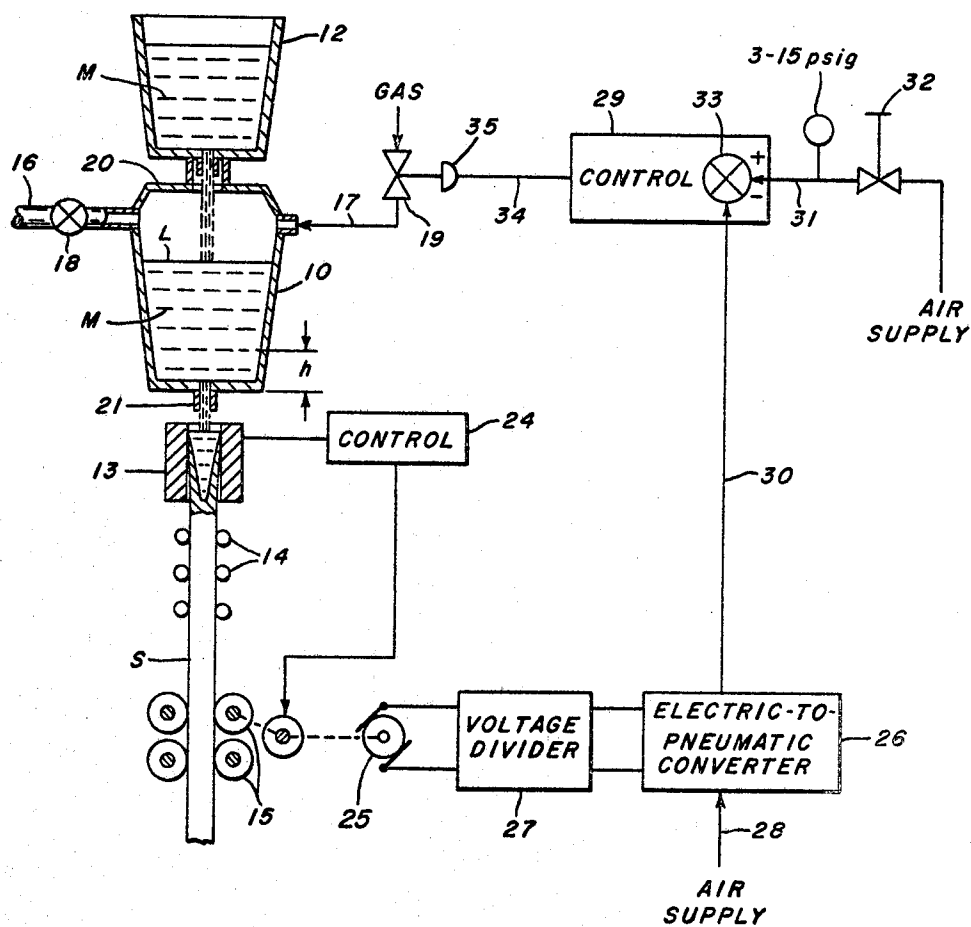


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 APPARATUS FOR CONTROLLING DISCHARGE OF METAL
 FROM A VACUUM DEGASSING CHAMBER
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APPARATUS FOR CONTROLLING DISCHARGE OF METAL FROM A VACUUM DEGASSING CHAMBER

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3 Claims

ABSTRACT OF THE DISCLOSURE

In normal operation molten metal discharges from a vacuum degassing chamber at the same rate it is teemed into the chamber. The level of metal in chamber is constant. At the end of teeming the level falls and the discharge rate diminishes. Invention automatically injects pressurizing gas to chamber to compensate for loss of head and maintain the discharge rate.

The invention relates to an improved apparatus for controlling discharge of molten metal from a vacuum degassing chamber.

Although my invention is not thus limited, the apparatus is particularly useful when applied to a chamber which feeds metal into a continuous casting machine. Conventional practice in this operation is to teem molten metal from a ladle into a chamber under vacuum, whereby gases are expelled from the metal before it is cast. The metal discharges from a nozzle in the bottom of the chamber into an open-ended mold of the continuous-casting machine. Desirably the rate at which metal discharges from the nozzle, the level of metal in the mold, and the speed at which the casting travels through the machine are maintained as nearly constant as possible. The rate at which metal discharges from the nozzle is determined by the formula:

$$C=KD^2h$$

where:

C=flow rate (lbs./min.)

D=nozzle diameter (inches)

h=effective head (inches)

The effective head is the physical height of liquid metal in the chamber, less the barometric height which results from the difference in pressure inside and outside the chamber. For liquid steel under full vacuum, the barometric height is about 57 inches.

After all the metal is teemed from the ladle, metal continues to discharge from the chamber. Consequently the height of the liquid column in the chamber diminishes. Unless corrective action is taken, the effective head and the discharge rate would decrease, and a substantial quantity of metal never would discharge from the chamber. Consequently the practice is to remove the vacuum and to pressurize the chamber with an inert gas or air as the level starts to fall, thereby maintaining the effective head. An inert gas is preferred, since there is an explosion hazard when air is used. The gas must be injected gradually as the level falls to maintain a nearly constant discharge rate. Heretofore injection of pressurizing gas has been controlled manually, but this has not been altogether successful. There is an excessive delay between the instant a correction is needed and the instant it becomes effective, and too much depends on the operator's judgment. Hence the tendency is to overcontrol, which results in large variations in the discharge rate.

An object of my invention is to provide an improved apparatus for controlling flow of metal from a vacuum degassing chamber by which I regulate gas injection auto-

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matically to maintain the effective head more nearly constant.

A further object is to provide an improved apparatus for accomplishing the foregoing object wherein I utilize only standard control instruments which are available commercially.

In the drawing:

The single figure is a diagrammatic view of a vacuum degassing chamber and environmental structure equipped with my control apparatus.

The drawing shows a vacuum degassing chamber 10, a ladle 12, and a portion of a continuous-casting machine which includes an open-ended mold 13, guide rolls 14 and power-driven pinch rolls 15. A vacuum line 16 and a pressurizing line 17 are connected to chamber 10, and lead respectively to a vacuum pump and to a source of inert gas or air under pressure (not shown). The vacuum line has a valve 18 and the pressurizing line a throttling valve 19. Molten metal M is teemed from ladle 12 into chamber 10 through an air seal 20 and discharges through a nozzle 21 in the bottom of the chamber into the mold 13. The metal starts to solidify in the mold and forms a slab S, which travels downwardly through the guide rolls 14 and pinch rolls 15. This arrangement is conventional and hence is not shown in greater detail.

While metal is teemed from ladle 12, valve 18 is open and valve 19 closed to maintain chamber 10 under vacuum. Metal discharges from the chamber at the same rate it enters. Hence slab S travels at a constant speed, and the metal in the chamber reaches a constant level L. When teeming is completed, valve 18 is closed to remove the vacuum. As the level L commences to fall, the control apparatus of my invention, hereinafter described, automatically opens valve 19 to inject pressurizing gas into the chamber. This gas compensates for the loss of liquid head, whereby the discharge rate through the nozzle remains nearly constant.

My control apparatus includes a means for sensing changes in the discharge rate from the chamber 10. Preferably the continuous-casting machine is equipped with a mold-level control 24 which regulates the speed of the pinch rolls 15 to maintain a constant level of material in mold 13. Reference can be made to Tiskus et al. Patent No. 3,300,820, in which I am a co-inventor, for a showing of a control of this kind. With the control 24 included, the rate at which the pinch rolls are driven is a measure of the discharge rate through nozzle 21. Conveniently I connect a tachometer-generator 25 to the drive motor for the pinch rolls, and connect an electric-to-pneumatic converter 26 to the tachometer-generator through a voltage divider 27. I connect an air supply line 28 to the converter. The tachometer-generator develops a voltage signal proportional to the discharge rate. The divider lowers the voltage of this signal to a value suitable for use in the converter, which develops a pneumatic pressure signal in the range of 3 to 15 p.s.i.g. proportional to the voltage signal.

I connect a "sample and hold" controller 29 to the converter 26 through a line 30. I connect an air supply line 31 to controller 29 to furnish air under a pressure 3 to 15 p.s.i.g., which I regulate through a set-point adjustment 32. The controller includes means 33 for periodically comparing the pressure signals from lines 30 and 31. Another line 34 extends from the controller to a pneumatic actuator 35 for the throttling valve 19. When the pressure signals are compared and show a difference, the controller transmits a pressure signal to the valve actuator 35, which in turn adjusts valve 19.

I set the set-point adjustment 32 to a pressure which corresponds with the discharge rate I wish to maintain. Whenever teeming is terminated and the pinch rolls 15 commence to turn more slowly, the voltage signal from the tachometer-generator 25 and the pressure signal from

the converter 26 decrease. The set-point pressure signal reaching the controller 29 from line 31 exceeds that from line 30. When a sampling period occurs, the actuator 35 receives a signal from the controller and opens valve 19 by an amount proportional to the error in the pinch roll speed. At the end of the sampling period, the controller holds the valve at its last position until the next sampling period, when the process repeats. I set the interval between sampling periods slightly longer than the delay in the process. By raising the pressure in the chamber above atmospheric, the apparatus can regulate the flow of metal therefrom until the chamber is empty of metal.

The instruments embodied in my control apparatus are known per se and are available commercially. Hence I have not offered a detailed description. A suitable electric-to-pneumatic converter is available from Honeywell, Inc. and is described in their printed publication Catalog C100-1A, p. 32, October 1959. A suitable controller is available from Fischer and Porter, Warminster, Pa., and is described in their printed publication Bulletin 91-53G-03. Although I have shown a pneumatic arrangement, it is apparent I could use electric instruments throughout.

While I have shown and described only a single embodiment of my invention, it is apparent that modifications may arise. Therefore, I do not wish to be limited to the disclosure set forth, but only by the scope of the appended claims.

I claim:

1. In a vacuum degassing apparatus which includes a chamber, means connected to said chamber for subjecting it to a vacuum, means connected to said chamber for injecting a pressurizing gas into the chamber, valves in said first and second-named means, means for teeming molten metal into said chamber, and a nozzle in the bottom of said chamber through which molten metal discharges at the same rate it enters the chamber as long as it is teemed into the chamber, the combination therewith of a control apparatus for maintaining a nearly constant dis-

charge rate from said chamber after teeming is completed, said apparatus comprising means for sensing the discharge rate, a controller, an actuator for the valve in said second-named means, means operatively connecting said sensing means and said controller, and means operatively connecting said controller and said actuator, said controller periodically adjusting said actuator in accordance with the discharge rate to regulate the injection of gas into said chamber.

2. A combination as defined in claim 1 which further includes a continuous-casting machine into which molten metal discharges from said nozzle, said casting machine including a mold, power-driven pinch rolls below said mold, and a control for driving said pinch rolls at a rate to maintain a constant level of material in said mold, whereby the speed of said pinch rolls is a measure of the discharge rate through said nozzle, said sensing means being operatively connected with said pinch rolls.

3. A combination as defined in claim 2 in which said sensing means includes a tachometer-generator for developing a voltage signal proportional to the pinch roll speed, and an electric-to-pneumatic converter for changing said voltage signal to a pneumatic pressure signal.

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