

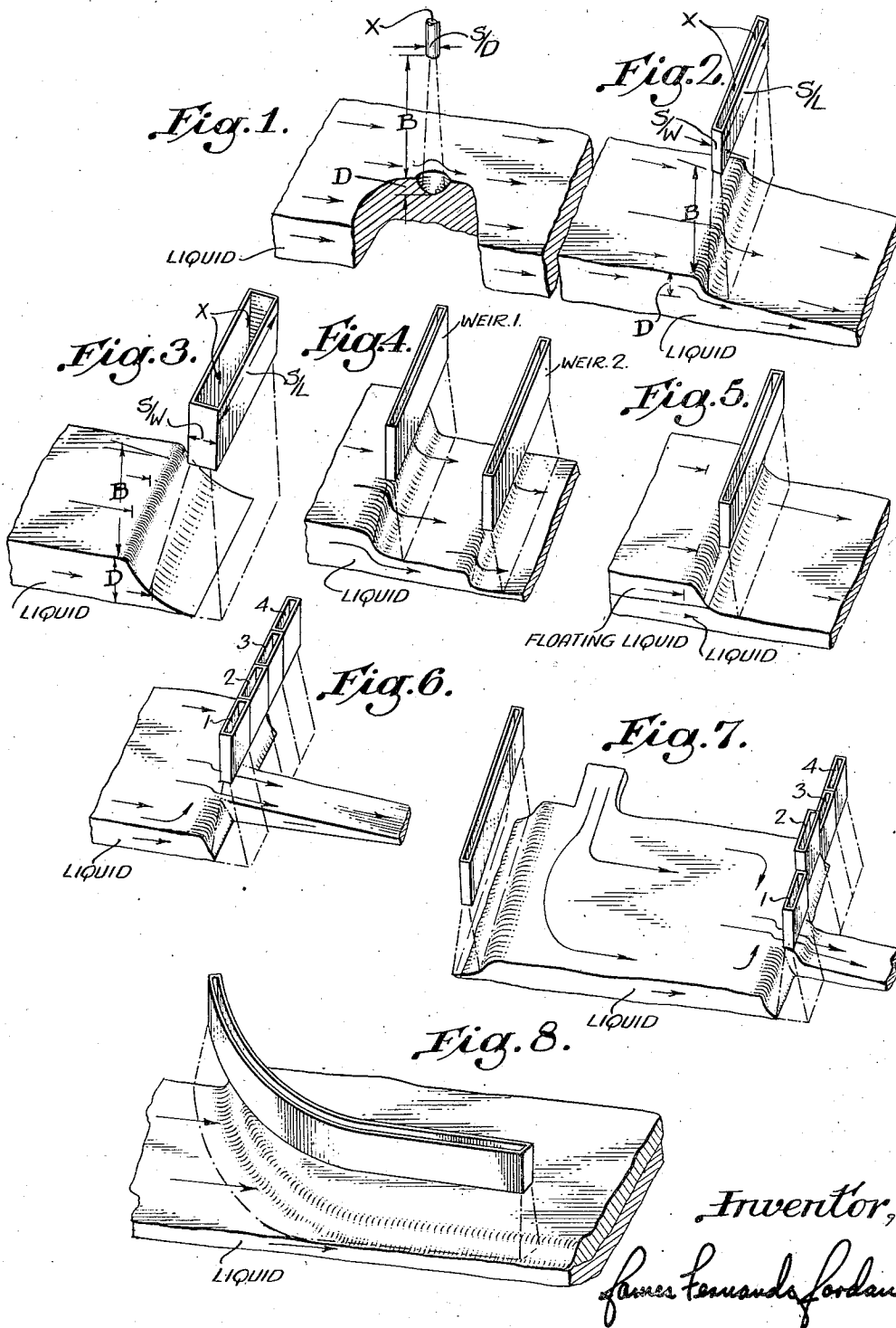
Dec. 21, 1948.

J. F. JORDAN
PROCESS FOR CONTROLLING THE FLOW
OF METALLURGICAL LIQUIDS

2,457,083

Filed June 27, 1947

2 Sheets-Sheet 1



Inventor,
James Fernandez Jordan

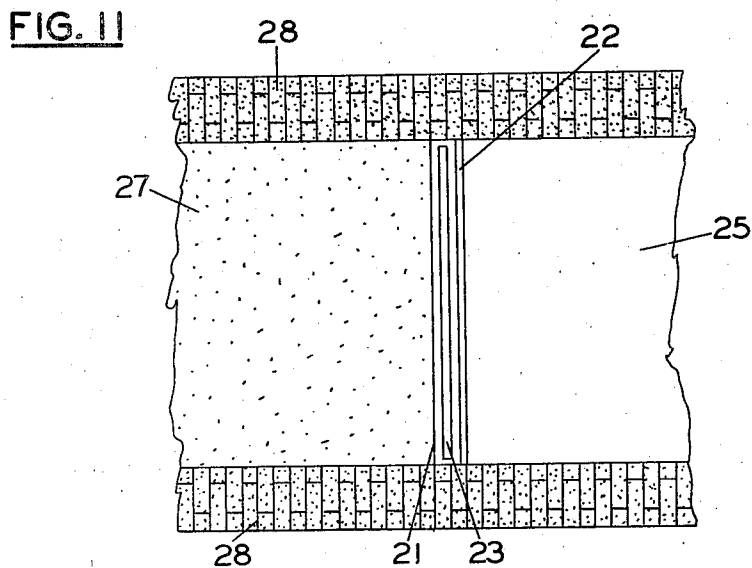
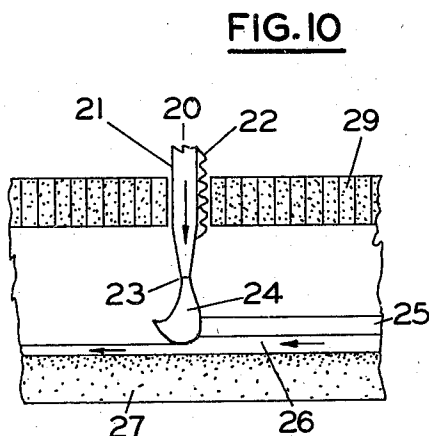
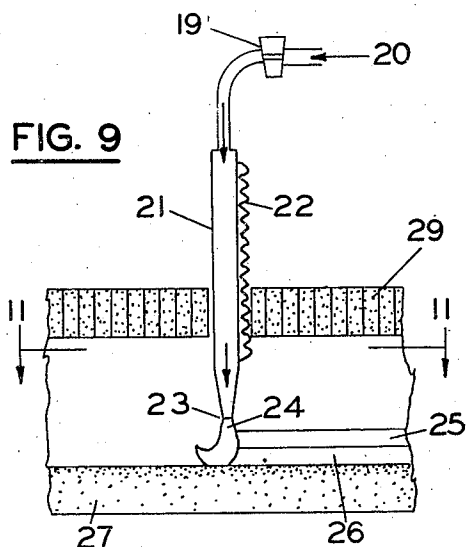
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INVENTOR:-

James Fernando Jordan

UNITED STATES PATENT OFFICE

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PROCESS FOR CONTROLLING THE FLOW OF
METALLURGICAL LIQUIDS

James Fernando Jordan, Huntington Park, Calif.

Application June 27, 1947, Serial No. 757,580

6 Claims. (Cl. 75—93)

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This application is a continuation-in-part of my copending application, Serial No. 681,253, filed on July 3, 1946, now abandoned, and entitled: "Method of controlling the flow of molten material."

My invention relates to the control of molten metallurgical liquids.

The development of fully dynamic flow processes within metallurgy is handicapped in ways that did not handicap the development of such flow processes in the chemical industries. The liquids employed in metallurgy are of such an erosive character that their mere confinement offers extreme difficulties; to say nothing of exercising a precise control over the flow of such liquids. It seems safe to predict that the development of flow processes in metallurgy will await the development of adequate methods of confining and controlling the flow of these erosive metallurgical liquids.

Metallurgists of the past and present have always been forced to depend upon non-metallic refractories as the means for confining and controlling these liquids. The expedient of frequent repair makes possible the commercial utilization of refractories in lining vessels which are to contain metallurgical liquids, however, refractories proffer little when it comes to controlling, say, the rate of flow of these liquids—it being impossible, seemingly, to construct a usable valve out of refractories. About the only valve that has ever been of value to metallurgists is the device that is known as the bottom-pour ladle; however, the bottom-pour ladle is impossible to control accurately, has an extremely short life, and has the bad habit of completely breaking down without warning—a habit that can, and does, lead to rather disastrous results.

I have discovered a new and novel metallurgical valve. My valve not only solves the problem of controlling the flow of erosive liquids in metallurgy, but it may also be adapted to the task of confining these liquids. My valve consists of a refractory trough that possesses an adjustable gate consisting of a barrier of gas. My valve will hereinafter be referred to as the "dynamic weir."

Figures 1-8, inclusive, are illustrations of a number of ways in which the dynamic weir may be used.

Figure 9 shows the weir being employed to confine two immiscible liquids.

Figure 10 shows the weir being employed to confine one liquid, while at the same time controlling the rate of flow of another liquid.

Figure 11 shows a section of Figure 9, as indicated.

Liquid confinement and control is simply a question of dams—even the sides of a furnace being nothing more than dams. A dam is a device that is employed to block the flow of a liquid. The flow of a liquid could be effectively

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blocked with a curtain of high-velocity gas: and so, the dynamic weir.

It might be thought that if a curtain of high-velocity gas were to be projected into a liquid, that said liquid would be blown all over the place. Not necessarily; for, if a high-velocity gas stream is directed towards a liquid surface from a distance that is too far away to permit the gas stream to disturb the liquid's surface, and then the orifice-to-surface distance is slowly shortened, it will be noted that the first visual effect of the impinging gas stream is the slight indentation of the liquid's surface. It may be observed that this slight indentation possesses three features: (1) the indentation is shallow, (2) this shallow indentation is not associated with any surface indications of turbulence, and (3) the indentation degree is highly dynamic, that is, inasmuch as the depth of the indentation is a function of the energy content of the gas stream when it strikes the surface of the liquid, the slightest variation in the energy content of the gas stream—obtained by varying the orifice-to-surface distance or by varying the gas pressure—will result in an instantaneous change in the indentation. As the orifice is brought closer and closer to the liquid's surface, it will be noted that the indentation deepens as the energy of impingement mounts; and that, finally, an orifice-to-surface distance is reached where any further shortening of the distance will result in the destruction of the generally streamline character of the indentation—substituting, in its stead, a violent turbulence or boiling action at the gas-liquid interface. The appearance of this turbulence at the gas-liquid interface signalizes the fact that the critical point in the action of these dynamic weirs has been reached; for, once turbulence sets in, the weirs cease to function properly.

Thus, the impinging gas curtain that constitutes a dynamic weir must possess a velocity that lies somewhere between zero and that critical velocity wherein turbulence ensues at the gas-liquid interface.

Figure 1 shows a flowing stream of liquid upon which a column of high-velocity gas has been caused to impinge. Here, a gas under pressure X is operating against orifice S/D. The energy released at the orifice is acting through distance B, to produce an indentation of depth D. The displacement of the liquid in the indentation represents the energy content of the gas stream when it strikes the surface of the liquid—said energy being expended against the liquid's viscosity. The highly variable character of this indentation is characterized by the fact that the indentation may be varied by varying the size of orifice S/D, by varying pressure X, or by varying distance D—all variations being, however, strictly within those limits respecting turbulence, defined previously.

In order to turn the device of Figure 1 into a

piece of usable metallurgical equipment, it is only necessary to extend this indentation across the liquid—channelwise, from side to side. This may be done by grouping a number of orifices in series, or by employing an elongated slit orifice, or a series of slits. Figure 2 shows such an extension across the flowing liquid stream. Here, the uniform lateral extension of the indentation across the stream constitutes a dam—a dynamic weir. Such an arrangement may be used to dam a liquid, to confine a liquid, to maintain the level of a liquid, or to determine the rate of flow of a liquid.

In Figure 2, S/W refers to the width of the elongated slit orifice, and S/L refers to the length of said orifice.

It might be thought that the dynamic weir could not be employed to confine and control a deep liquid stream. Such is not the case. Figures 3 and 4 show two methods of increasing the depth to which the weir will act. In Figure 3, increased penetration is obtained by increasing the width of the weir. This may be accomplished by increasing the width of the orifice while maintaining the gas pressure, or by increasing distance B with suitable pressure adjustments. To illustrate: if the weir does not penetrate deep enough into the liquid, even though it may be operating close to the critical level, distance B may be increased by some selected amount, followed by increases in pressure X until the desired penetration is reached, or until the critical level is reached again. If the critical level is reached before the desired measure of penetration is attained, distance B may be increased again, followed by further increases in pressure X. These adjustments may be continued indefinitely. If it is impractical to increase distance B, we may increase the orifice size instead, varying the pressure to obtain the desired penetration.

Figure 4 illustrates the fact that these weirs may be employed in an additive sense. Naturally, the use of multiple weirs is effective only if the liquid is flowing. Any depth of liquid may be penetrated by merely employing a sufficient number of weirs.

Figure 5 shows a use of the dynamic weir for the purpose of confining a liquid—in this case, a slag that is floating on a metal. It will be noted that the gas curtain or barrier penetrates entirely through the slag layer and partly into the underlying metal layer.

Figure 6 shows that these weirs may be subdivided into a series of conveniently sized gates, each gate being independently controllable, both with regards to pressure X and distance B. With the weir so sub-divided, a variety of conditions may be set up across the dam. In Figure 6, for example, gate #2 is adjusted to act as a free-flowing sluice. Naturally, control over this free-flowing sluice may be obtained by merely regulating pressure X and/or distance B in gate #2.

Figure 7 shows a sluice operating under restraint. Here, gate #2 is shown impressing a measure of control over the stream. It will be noted, at the other end of the illustrated body of liquid, that another type of weir is operating immediately adjacent to the incoming liquid. This weir merely serves to show that more than one weir may be employed in the same liquid system at the same time, and with each weir performing the same or different functions.

Figure 8 shows that these weirs need not necessarily be confined to straight dams. Thus, as in Figure 8, the weir may be caused to operate in a wide sweeping curve.

The gas

The gas employed in their weirs is merely a means to an end—an end characterized by the mechanical nature of the confinement and control of viscous liquids. Insofar as the purely physical action of the weirs is concerned, any gas may be employed to activate these gas dams. In general, a gas must be selected that does not interfere with the chemical aspects of the operation that is being carried on. If an oxidizing gas is objectionable, either a neutral or reducing gas may be employed; if a reducing gas is objectionable, either a neutral or oxidizing gas may be employed; or if strict neutrality is desired, a neutral gas, such as nitrogen, may be employed.

These gas weirs may be used to attain specific chemical ends. For example, if an effort is being made to oxidize the impurities in, say, steel—the gas employed in the weirs may be air, carbon dioxide, or steam. If, on the other hand, an effort is being made to reduce, say, the Cu_2O content of copper, the gas employed in the weir could be carbon monoxide.

Dynamic weirs may be caused to contribute heat to the passing liquid, or conversely, the weirs may detract heat from the liquid. With metallurgical liquids, the test for the feasibility of employing cold gases in the weirs will depend upon the chilling effect of the gas, in terms of B. t. u. per second, in relation to the available or expendable heat in the liquid that passes by the weir during this interval. Thus, if a metallurgical liquid contains, say, 700 B. t. u. per pound, and the nature of the liquid and operation will permit this heat content to fall to, say, 600 B. t. u. per pound, without operating difficulties developing as a consequence, then the liquid may be dammed by a cold gas weir if the weir does not remove more than 100 B. t. u. per pound of liquid.

If the liquid does not possess sufficient expendable heat to permit the operation of a cold gas weir, then the flame weir may be employed. The flame weir employs a combustible mixture of fuel gas and air/oxygen, and will accordingly contribute heat to the liquid that is being controlled.

The weir

The dynamic weir may be constructed in any number of ways, but must possess at least one method of regulating the strength of the barrier of gas. I prefer a weir that possesses two control methods, that it, a weir with a valve that controls the velocity of the gas in the barrier, and also possesses the means for raising and lowering the orifice from which the gas immerses.

Figure 9 shows a weir that possesses both regulating methods. Here, weir 24 is acting to confine liquids 25 and 26 on hearth 27. The work that is being done by weir 24 is related to the position of orifice 23—controllable by raising or lowering means 21—and is also related to the pressure of gas 20 against orifice 23, variable by regulating valve 19. Figure 11 shows another view of the operation illustrated in Figure 9. Here, hearth 27 and sidewalls 28 combine with means 21 to form a weir. Orifice 23 is the source of the weir gas that acts to dam liquids 25 and 26 (not shown).

Figure 10 shows another use to which the weir may be put. Here, weir 24 is confining liquid 25 and is controlling the rate of flow of liquid 26. The rate of flow of liquid 26 may be regulated by regulating the pressure of gas 20 against orifice 23 by means of valve 19 (not shown), or by regulating the vertical position of means 21, or by regu-

lating both the vertical position and the pressure.

Due to the fact that metallurgy usually concerns a molten metal upon which a molten slag is caused to float for refinement purposes, liquid 25 should be considered to be a slag and liquid 26 a molten metal.

Any convenient valve system may be employed to regulate the pressure of gas 20 against orifice 23. Any convenient method may also be employed to raise and lower means 21—I prefer a rack and pinion. I prefer to maintain the pressure of gas 20 constant against orifice 23, and obtain control by raising and lowering means 21.

If the metallurgical operation is a high temperature one, means 21 should be water-cooled with appropriate water-jackets.

The expression "orifice," as used in the claims, shall be taken to mean any opening, or any group of openings, down through which high-velocity gas may be fed to form a barrier in a refractory trough.

The expression "substantially horizontal flow," as used in my claims, shall be taken to mean liquid flow along an open channel wherein the stream possesses a free surface.

Having now described and illustrated one form of my invention, I wish it to be understood that my invention is not to be limited to the specific form or arrangement of parts herein described and shown, except insofar as such limitations are specified in the appended claims.

I claim as my invention:

1. In the process of conducting a metallurgical liquid along a refractory trough, the method of controlling the rate of flow of said liquid along said trough, which comprises: jetting down into said flowing liquid, from an orifice that is positioned above the free surface of said liquid, a barrier of gas that forms an indentation in and across the flowing liquid stream, and thereby blocks the free flow of said liquid stream; and controlling the rate of flow of said liquid stream by regulating the pressure exerted by said barrier on said liquid stream in the range between zero and that pressure at which a boiling action ensues at the liquid-gas interface, by regulating the pressure at which the gas is supplied to said orifice.

2. In the process of conducting a metallurgical liquid along a refractory trough, the method of controlling the rate of flow of said liquid along said trough, which comprises: jetting down into said flowing liquid, from an orifice that is positioned above the free surface of said liquid, a barrier of gas that forms an indentation in and across the flowing liquid stream, and thereby blocks the free flow of said liquid stream; and controlling the rate of flow of said liquid stream by regulating the pressure exerted by said barrier on said liquid stream in the range between zero and that pressure at which a boiling action ensues at the liquid-gas interface, by selectively raising or lowering said orifice.

3. In the process of conducting a metallurgical liquid along a refractory trough, the method of controlling the rate of flow of said liquid along said trough, which comprises: jetting down into said flowing liquid, from an orifice that is positioned above the free surface of said liquid, a barrier of gas that forms an indentation in and across the flowing liquid stream, and thereby blocks the free flow of said liquid stream; and controlling the rate of flow of said liquid stream by regulating the pressure exerted by said barrier

on said liquid stream in the range between zero and that pressure at which a boiling action ensues at the liquid-gas interface.

4. In a liquid-liquid system consisting of a stream of molten metal upon which a molten slag is floating, the method of confining the molten slag while controlling the rate of flow of the metal stream, which comprises: jetting down into said slag, from an orifice that is positioned above the free surface of said slag barrier of gas that forms an indentation in and across the surface of said slag, which indentation penetrates entirely through said slag and into the underlying metal stream, thereby confining said slag while blocking the free flow of said metal stream; and controlling the rate of flow of said metal stream by regulating the pressure exerted by said barrier on said metal stream in the range between zero and that pressure at which a boiling action ensues at the liquid-gas interface, by selectively raising or lowering said orifice.

5. In a liquid-liquid system consisting of a stream of molten metal upon which a molten slag is floating, the method of confining the molten slag while controlling the rate of flow of the metal stream, which comprises: jetting down into said slag, from an orifice that is positioned above the free surface of said slag, a barrier of gas that forms an indentation in and across the surface of said slag, which indentation penetrates entirely through said slag and into the underlying metal stream, thereby confining said slag while blocking the free flow of said metal stream; and controlling the rate of flow of said metal stream by regulating the pressure exerted by said barrier on said metal stream in the range between zero and that pressure at which a boiling action ensues at the liquid-gas interface, by regulating the pressure at which the gas is supplied to said orifice.

6. In a liquid-liquid system consisting of a stream of molten metal upon which a molten slag is floating, the method of confining said slag while controlling the rate of flow of said metal stream, which comprises: jetting down into said slag, from an orifice that is positioned above the free surface of said slag, a barrier of gas that forms an indentation in and across the surface of said slag, which indentation penetrates entirely through said slag and into the underlying metal stream, thereby confining said slag while blocking the free flow of said metal stream; and controlling the rate of flow of said metal stream by regulating the pressure exerted by said barrier on said metal stream in the range between zero and that pressure at which a boiling action ensues at the liquid-gas interface.

JAMES FERNANDO JORDAN.

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The following references are of record in the file of this patent:

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Certificate of Correction

Patent No. 2,457,083

December 21, 1948

JAMES FERNANDO JORDAN

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 5, line 68, for "orific" read *orifice*; column 6, line 10, for the words "slag barrier" read *slag, a barrier*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 3rd day of October, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.