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SPRAY CONTROL MECHANISM FOR CONTINUOUS CASTING MACHINES

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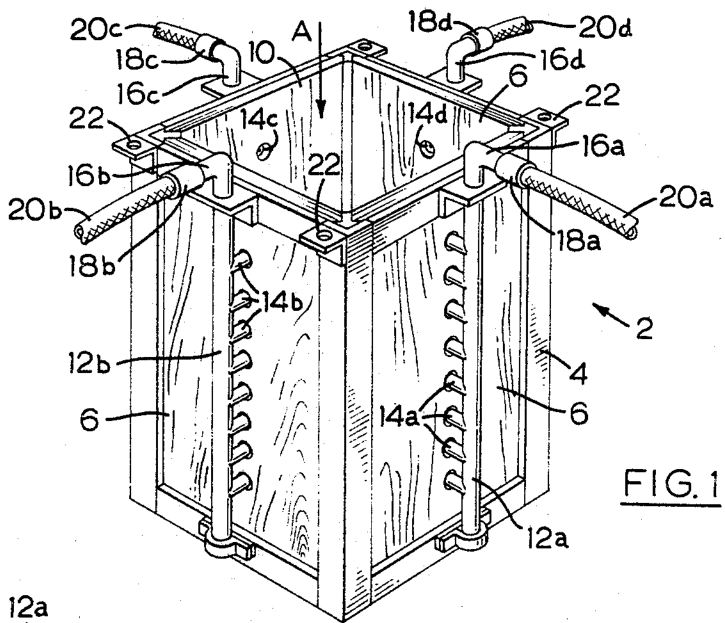

FIG. 1

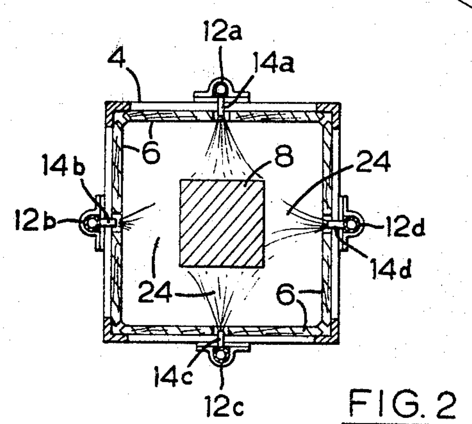

FIG. 2

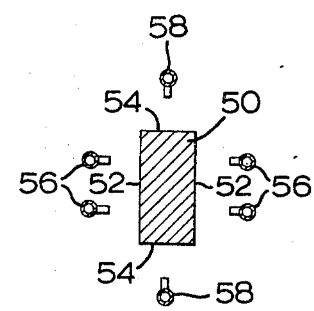

FIG. 4

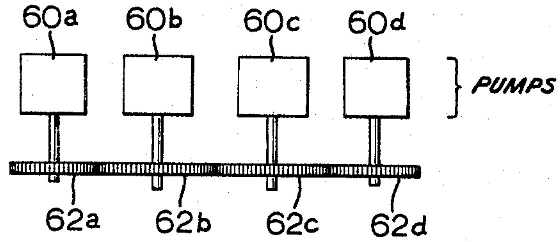

FIG. 5

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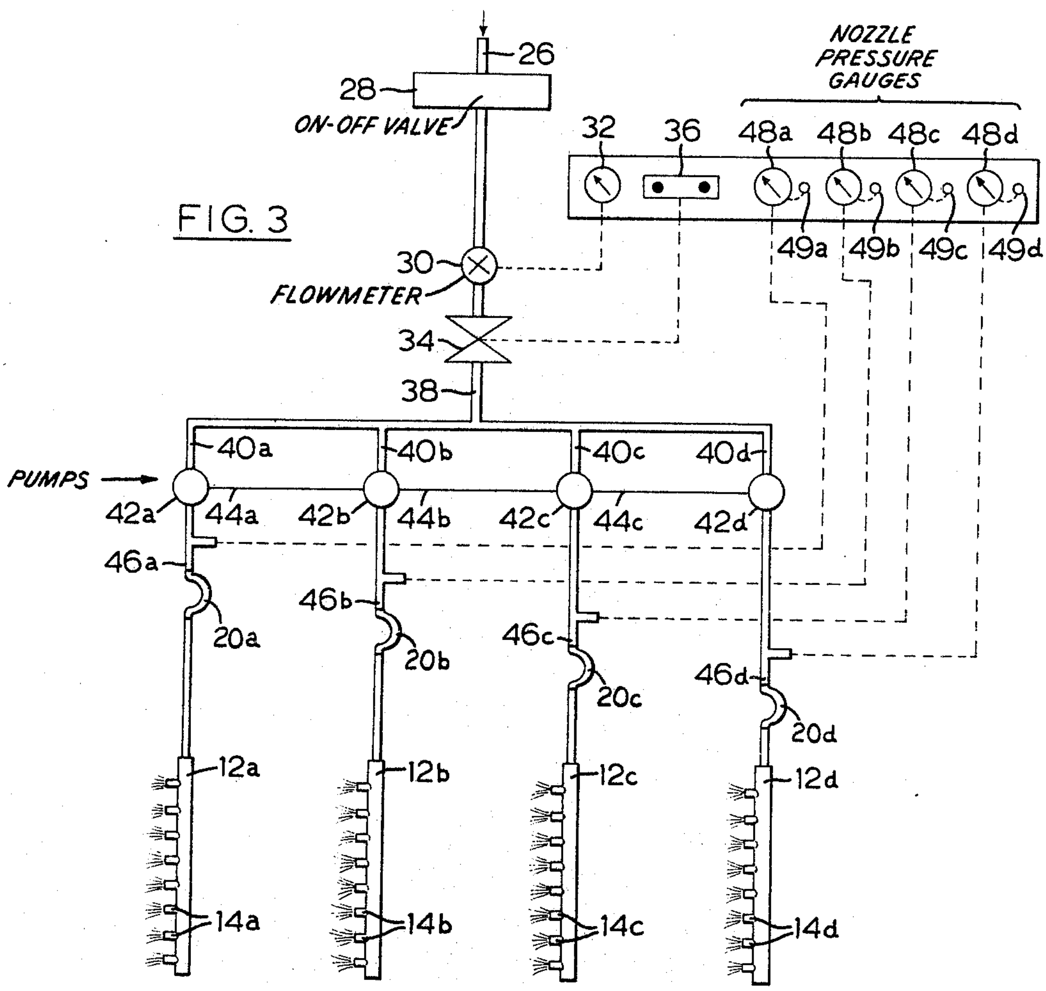

FIG. 3

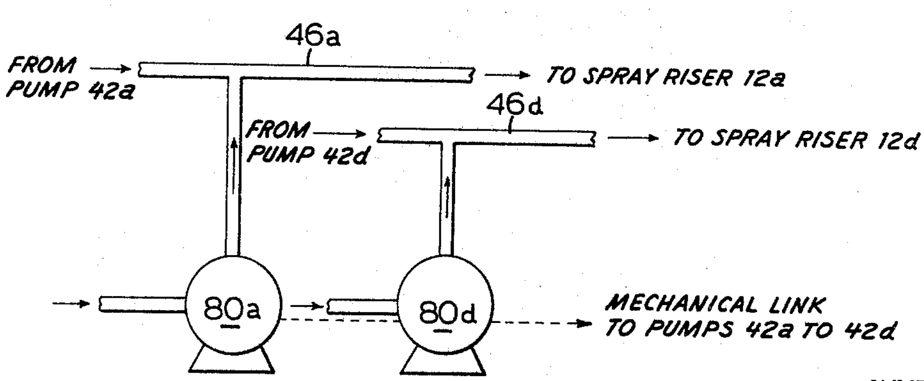

FIG. 6

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SPRAY CONTROL MECHANISM FOR CONTINUOUS CASTING MACHINES

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U.S. Cl. 239—450 8 Claims

ABSTRACT OF THE DISCLOSURE

A flow control mechanism for spraying water on a newly formed strand from a continuous casting machine. The water from a common supply pipe is divided between (for a vertically descending square strand) four equal displacement pumps and then delivered to four spray conduits. The pumps are mechanically connected to operate at the same speed and are driven by the water so that each delivers the same volume of water to its spray conduit, regardless of whether more nozzles in one spray conduit than another are plugged. A pressure gauge connected to each spray conduit indicates when nozzles are clogging and whether more nozzles are plugged in one conduit than in another.

This invention relates to the cooling of newly formed metal strands in continuous casting machines. More particularly, it relates to a mechanism for regulating the flow of water sprayed on the various faces of the strand to prevent variation in the relationship of the flows on the various faces.

In continuous casting machines, molten metal is normally poured into one end of a chilled mold cartridge, partly solidifies, and is withdrawn out the other end as a strand having a relatively thin skin and a molten metal core. After the newly formed strand emerges from the mold cartridge, it usually passes through a spray chamber which may be six feet or so in length. The spray chamber contains a number of nozzles which spray cooling water on the various surfaces of the strand. The basic function of the spray system is to prevent remelting the newly formed thin metal shell of the strand and to provide a desirable solidification pattern, i.e., to increase the thickness of the casting shell uniformly and fast enough to completely solidify the casting before it enters the withdrawal rollers, while keeping the rate of cooling at any point within permissible limits. Excessive cooling at any point in the system in some steels may cause cracking, breaking, deformation and rupture of the shell, while insufficient cooling may cause failure of the shell through remelting or breakout, and may necessitate a low casting rate.

For all grades of steel, it is extremely important in the spray chamber to spray the various surfaces of the strand at a rate which will provide uniform cooling of the skin of the strand. For example, if the strand is square in cross section, equal amounts of water should be sprayed on each of its four faces. If more water is delivered to one face of the strand than to the others, then uneven cooling will result, causing asymmetrical solidification of the strand. This can cause serious stresses and faults in the strand.

In the past, flow control to the spray risers of the spray chamber (spray risers are conduits facing each side of the strand) was achieved by individual flow control valves and flowmeters, one set for each spray riser. This system required careful adjustment to obtain the desired flow ratios and was subject to errors in the flow control valves and flowmeters since these devices are often subject to drift in their settings and may develop errors that will result in undesired flow ratios.

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Accordingly, it is an object of the present invention to provide a flow control mechanism that will provide a predetermined ratio of flow rates to the various sets of spray nozzles of the spray chamber. This is achieved by using pumps of predetermined displacement ratio driven by the water flow, as flow dividing devices. The pumps are mechanically linked together so that their speed relationship cannot vary during use. With this system, a predetermined volume of water will be sprayed from each set of spray nozzles, even if some of the nozzles of each set become partly or wholly plugged. Further objects and advantages of the invention will appear from the following description, taken together with the accompanying drawings, in which:

FIG. 1 is a diagrammatic perspective view of a typical spray chamber used in continuous casting machines;

FIG. 2 is a top sectional view of the spray chamber of FIG. 1 showing a metal strand descending therethrough;

FIG. 3 is a schematic drawing illustrating the present invention;

FIG. 4 is a top sectional view of another spray chamber similar to that of FIG. 2 but for use with a rectangular strand;

FIG. 5 is a schematic view of four pumps connected by gears according to the present invention; and

FIG. 6 is a schematic view of two make-up pumps and showing their connection according to the invention.

Reference is first made to FIG. 1, which shows a spray chamber **2** of a type that may be used for continuous casting machines. The spray chamber **2** has a metal frame **4** in which are fitted sheets of plywood **6** to protect the surrounding area in case of a "break out" (i.e., rupture) of a newly formed metal strand. The metal strand (shown at **8** in FIG. 2) is withdrawn from a mold cartridge (not shown) vertically in the direction of arrow A, enters the top opening **10** of the spray chamber **2**, and leaves via an opening in the bottom (not shown).

The spray chamber **2**, which is assumed to be for a square strand, includes four vertical conduits or spray risers **12***a* to **12***d*, one centered on each face of the spray chamber. Each spray riser includes a series of nozzles **14***a*, **14***b*, **14***c*, **14***d* located along its length and projecting through the plywood sides **6** into the interior of the spray chamber (see FIG. 2). The tops of the risers terminate in elbows **16***a* to **16***d* which carry quick disconnect couplings **18***a* to **18***d* detachably connected to flexible hoses **20***a* to **20***d*. The spray chamber **2** itself is hung by flanges **22**, and the quick disconnect couplings **18***a* to **18***d* permit ready removable and replacement of the spray chamber.

During use, the strand **8** will be withdrawn through the spray chamber and cooling water sprays **24** will be sprayed onto the strand from the nozzles **14**. It is as mentioned important to provide equal rates of water delivery to each of the four faces of the strand, and FIG. 3 shows an arrangement for achieving this result. As shown in FIG. 3, water from a main supply pipe **26** is directed to a push button controlled, solenoid operated on-off valve **28** which turns the water on at the beginning of the casting process and off again at the end. From valve **28**, the water flows to a flowmeter **30** having an indicator **32**, and then flows through a motor operated flow control valve **34**. The valve **34** is controlled by a push button control **36** and may typically be of the type manufactured by the CLA-VAL Company of Newport Beach, Calif., U.S.A. under its model number 40A–KE.

The water leaves the flow control valve **34** via a conduit **38** and is then divided into four equal size conduits **40***a* to **40***d*. Each of the conduits **40***a* to **40***d* leads to the input of a separate gear pump, the pumps being indicated at **42***a* to **42***d* respectively. The pumps are all connected together by common shafts **44***a* to **44***c* so that they all operate at precisely the same speed. Each pump is of equal displacement and is typically of the type made by the Deming Division of Crane Company, Chicago, Illinois, U.S.A. under Model Number 1538-No. 3.

The outputs of the four pumps are connected to four conduits **46***a* to **46***d* which are connected in turn to the flexible hoses **20***a* to **20***d* leading to the spray risers **12.** Pressure gauges **48***a* to **48***d* are connected to each of the conduits **46***a* to **46***d* to measure spray nozzle pressure in the individual spray risers **12***a* to **12***d* to indicate nozzle failure. This will be explained further later.

The arrangement shown ensures equal rates of flow to each of the spray risers **12***a* to **12***d*, because the pumps **42***a* to **42***d* are constrained to operate at identical speeds because of their connection together. Because each pump is a gear pump, there is no slippage of liquid and therefore each pump expels the same amount of water. The pumps are, of course, driven by the water flow through them and are not externally powered. A tendency for increased flow through one conduit such as conduit **40***a* will tend to speed up its pump **42***a* which will tend to pump water more rapidly through the other pumps, and the drag caused by the other pumps will tend to slow down pump **42***a*, evening the flow in each conduit.

Although the pumps shown are gear pumps, other types of displacement pumps, such as piston pumps or screw pumps can be used if desired. The pumps used must always be displacement pumps, i.e. pumps which at a given speed deliver a substantially constant volumetric flow over the operating pressure range (which is normally between 20 and 125 p.s.i.).

Although the pumps **42***a* to **42***d* have been shown as connected by direct shafts, they could be mechanically linked in other manners, e.g. by sprockets and chains, or by timing belts, or by pinions and gears.

It will be noted that if some of the nozzles in one of the spray risers becomes plugged, the volume of water delivered from that riser will still tend to be the same as that delivered by the other spray risers in which the nozzles are not plugged. This is because the pumps are connected together and each delivers the same flow through a widely varying pressure range. The pressure in the riser having plugged nozzles will rise above that in the other risers, and this will be an immediate indication to the operator (who will check the pressure gauges **48**) that nozzles in one riser are plugged. The increased pressure in the riser having plugged nozzles will also tend to clear the plugged nozzles. This may be contrasted with prior art spray devices in which the pressure in each riser always remained equal, so if some nozzles in one spray riser became plugged while the nozzles in the other risers remained clear, then unequal volumes of water were delivered from the respective risers.

The use of the pressure gauges **48** (which are much cheaper than flowmeters used in prior art devices) makes it possible for an operator to determine when the nozzles are becoming closed. The operator will check the pressure readings after the nozzles have been cleaned, and then a rise in the pressure readings during operation will indicate clogging nozzles. An unequal rise in pressure will indicate that more nozzles in one spray riser are being plugged than those in the other risers, as mentioned. Because the operator can monitor the state of the nozzles by the pressure gauges, the need for frequent preventative cleaning of the nozzles is reduced. Previously, the operator was able to determine when nozzles were becoming plugged only by flowmeter readings (and flowmeters are subject to drift in their readings) or by unreliable visual observation of the spray. As mentioned, the need for cleaning the nozzles will also tend to be less frequent with the invention than without it because the rapid rise in pressure in a riser when some of its nozzles become plugged tends to clear the plugged nozzles.

If desired, alarm lights **49***a* to **49***d* can be provided to light when the pressure in a riser reaches a certain limit. The limit can be preset by placing plugs in, for example, three nozzles in a riser, observing the pressure in the riser, and setting the pressure alarm to operate at that pressure. A suitable pressure alarm gauge for this purpose is that made by the U.S. Gauge Company and shown in their 1968 catalogue as Fig. 3060. This gauge has relay contacts that close when the pressure reaches an adjustable limit. Then, when an alarm **90** lights, the operator knows that he should clean the nozzles before the next casting.

In the embodiment just described, it has been assumed that each of the four faces of the strand is to receive equal flows of water. This applies in the case of a square strand withdrawn vertically through a spray chamber, and a similar approach applies for a rectangular strand. As shown in FIG. 4, if a rectangular strand **50** has (for example) long faces **52** twice the length of its shorter faces **54**, then there will be two spray risers **56** along each long face, and one spray riser **58** along each shorter face. Each spray riser will supply equal flows of water, and the flows will again be regulated by pumps such as pumps **42***a* to **42***d* (but six pumps will be used).

If the spray chamber **2** is used with a horizontal continuous casting machine and is therefore oriented horizontally with the strand **8** moving along a horizontal path through the spray chamber, then the spray risers **12***a* to **12***d* should not deliver exactly equal flows of water to their respective nozzles. This is because, assuming that FIG. 2 is an elevational view with the strand **8** moving horizontally and that riser **12***a* is at the top of the spray chamber and riser **12***d* is at the bottom, then water delivered from the top spray riser **12***a* will tend to run down the sides of the strand **8**, and therefore slightly less water should be sprayed from the side risers **12***b*, **12***c* than from the top and bottom risers **12***a*, **12***d*.

This can be arranged by making the two pumps **42***b*, **42***c* of slightly less displacement than the remaining two pumps. Alternatively, the pumps can be of equal displacement and can operate at different speeds. For example, as shown in FIG. 5, four equal displacement gear pumps **60***a* to **60***d* can be connected together by gears **62***a* to **62***d*. The gears **62***b*, **62***c* are both the same size and both are slightly larger than gears **62***a*, **62***d* (which are also equal to each other in size) so that the pumps **60***b*, **60***c* run slightly more slowly than the pumps **60***a*, **60***d*. Pumps **60***b*, **60***c* will therefore deliver slightly less flow to their associated spray risers.

As another alternative, the four pumps can be made of equal displacement and driven at equal speed, and makeup pumps **80***a*, **80***d* (FIG. 6) can be provided to add makeup water to conduits **46***a*, **46***d* and hence to risers **12***a*, **12***d* to ensure slightly greater flow at the top and bottom surfaces of the strand than at the sides. The makeup pumps **80***a*, **80***d* are mechanically connected to each other and to the other pumps **42***a* to **42***d* to ensure that all run in unison.

The invention can of course be used even when the strand is of dog bone or other section, to ensure a fixed division of flows among the various spray conduits.

Although spray devices comprising spray risers each having a number of nozzles have been shown, other suitable spray devices, each fed by a separate pump (the pumps being mechanically linked and driven by the water flow) can be used.

What I claim as my invention is:

1. For a continuous casting machine of the type including a spray chamber for spraying cooling water on a newly formed metal strand, said spray chamber having a plurality of spray devices, and a plurality of spray conduits one for each spray device, each for conducting water to its associated spray device, a flow control mechanism for providing a mechanically fixed ratio of flows through said conduits to said spray devices, said flow control mechanism comprising

(a) a common water delivery pipe,

(b) a plurality of displacement pumps, one for each of said spray conduits, each pump having an intake connected to said water supply pipe and an output connected to one of said spray conduits,

(c) and means mechanically connecting said pumps together to provide a fixed speed ratio for said pumps so that the speed of each of said pumps is fixed relative to the other, said pumps being driven by the flow of water therethrough to provide a substantially fixed division of flow from said delivery pipe to said spray conduits.

2. A flow control mechanism according to claim **1** wherein each spray device comprises a conduit having a plurality of spaced nozzles connected thereto.

3. A flow mechanism according to claim **1** wherein said pumps are gear pumps.

4. A flow mechanism according to claim **1**, **2** or **3** wherein said pumps are each of equal displacement.

5. A mechanism according to claim **1**, **2** or **3** wherein said means (c) comprises a set of gears connecting said pumps together, whereby the speed ratio of one pump relative to another may be varied by changing a said gear.

6. A mechanism according to claim **1**, **2** or **3** wherein said pumps are each of equal displacement and are connected to operate at equal speeds, and further including at least one makeup pump mechanically connected to said other pumps, said makeup pump delivering further water into one of said spray conduits to provide increased flow to such further spray conduit.

7. A mechanism according to claim **2** or **3** including a set of pressure indicators, one connected to each spray conduit to monitor the pressure therein to indicate differential clogging of said nozzles.

8. A mechanism according to claim **2** or **3** including a set of pressure indicators, one connected to each spray conduit to monitor the pressure therein, a set of alarm indicators one connected to each pressure indicator, each pressure indicator including means to operate its associated alarm indicator when the pressure in its associated spray conduit reaches a predetermined limit.

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U.S. Cl. X.R.

239—428, 557, 565, 566