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OF COOLING WATER SPRAYS
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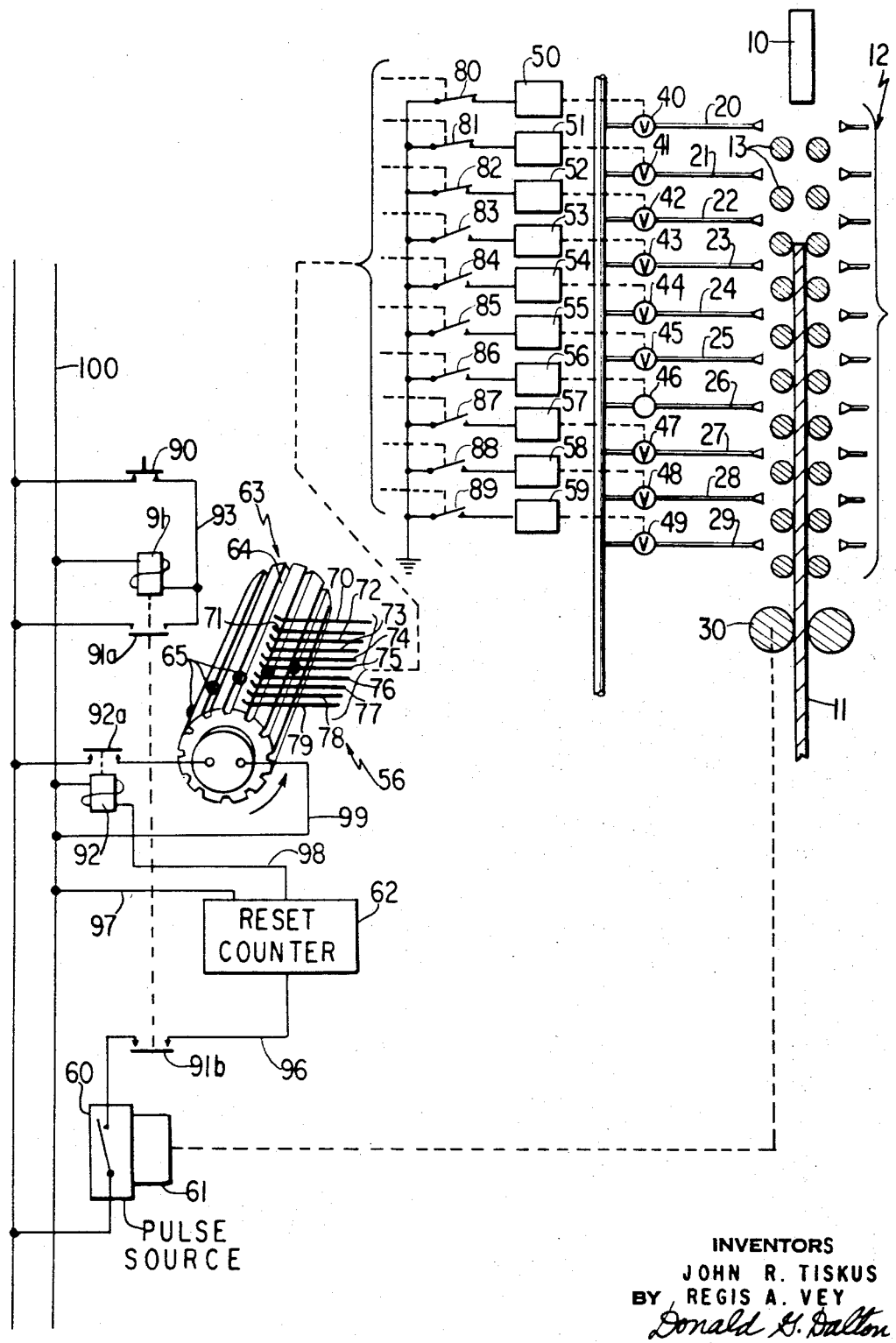



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# SYSTEM FOR PROGRESSIVE SHUTDOWN OF COOLING WATER SPRAYS

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## ABSTRACT OF THE DISCLOSURE

A system for progressively closing the valves controlling the water supply to cooling nozzles, as the trailing end of a casting travels down between banks of guide rollers, includes a counter set in operation at a predetermined time and actuated by successive pulses, one for each increment of travel of the casting. After a predetermined number has been accumulated by the counter, it notches forward a sequence switch one step and resets itself to zero for a repeat operation. The sequence switch operates valve actuators to close the valves successively.

This invention relates to continuous casting apparatus in which a steel slab is progressively cooled by means of a plurality of vertically spaced water sprays as it descends below the mold, and more particularly to an apparatus for shutting down these sprays in succession as the tail end of the casting passes therebelow.

In the continuous casting of metals and alloys such as steel, the casting is continuously formed in an open-ended tubular water-cooled flow-through mold which constitutes the primary cooling zone. After the mold has been initially filled and a thin shell of solid metal has been formed adjacent the mold walls and the top of the starter bar, the casting is allowed to descend below the mold through a secondary cooling zone consisting of a plurality of vertically spaced guide rolls and vertically spaced sprays which direct cooling water against the opposed faces of the casting. The speed of descent of the casting is controlled by means of motor driven pinch rolls located below the secondary cooling section.

When a casting is completed, it is necessary to shut down each of the water sprays in sequence as the tail end of the casting descends below a preselected position relative to said spray, in order to prevent overcooling of the tail end of the casting. Overcooling would make subsequent manipulation such as bending and rolling extremely difficult, and would produce cracks and strains due to cold working of the metal.

The primary object of this invention is to provide an apparatus which will shut down each of the water nozzles in the secondary cooling zone of a continuous casting apparatus in sequence as the tail end of the casting descends below a preselected position relative to said nozzle, so that the tail end of the casting is not overcooled.

The apparatus of this invention includes an open-ended tubular water-cooled continuous casting mold in which a casting may be formed, motor-driven pinch rolls below the mold for controlling the speed of descent of the casting, and a plurality of vertically spaced water sprays between the mold and the pinch rolls for directing cooling water against the casting. Valves and valve actuators therefor are provided for shutting off the water supply to the nozzle, as well as signal of measuring means for indicating the position of the tail end of the casting as it descends below the mold, and control means responsive to the signal means for operating the valve actuators to shut off the water supply to each of the cooling water nozzles in sequence, beginning at the top of the cooling section, as the tail end of the casting descends below the mold. In a preferred embodiment of this invention,



the signal or measuring means comprises a pulse counter driven by the pinch rolls, which sends out pulses whose number is directly proportional to the number of revolutions of the pinch rolls and hence to the distance the casting descends, and a reset counter which counts the number of pulses and sends out a pulse current to a controller when a predetermined count has been reached. The control means for shutting off the water supply may include a drum controller which is programmed to close nozzle valves in sequence, and cam followers and switches controlled by the drum controller for actuating the control valves provided on the water nozzles.

In the drawings, the single figure is a schematic diagram of the apparatus for shutting off the water supply to each of the water sprays in the secondary cooling zone as the tail end of the casting descends therebelow.

Referring now to the drawing, the apparatus of this invention comprises an open-ended tubular water-cooled flow-through continuous casting mold **10** in which a steel casting **11** is formed, a secondary cooling zone below the mold, generally indicated at **12**, comprising a plurality of guide rollers **13** for contacting the two opposed faces of the casting, and a plurality of vertically spaced water pipes **20** to **29** inclusive, each including a terminal spray nozzle which is adapted to direct cooling water against the adjacent face of the casting. Generally a horizontal row of nozzles is provided on each side of the casting line at each elevation spaced across the casting width. The vertical distance between adjacent rows of nozzles is constant throughout the secondary cooling zone **12**. In this case each numeral **20** to **29** represents a row of nozzles. The speed of descent of the casting is controlled by means of motor driven pinch rolls **30** located below the secondary cooling zone. The casting **11** is shown herein at the completion of a casting operation, after mold **10** has been emptied and when the tail end of the casting is in the secondary cooling zone.

The water supply to the nozzles **20** to **29** inclusive is controlled by valves **40** to **49** inclusive. Where a row of nozzles is provided at each elevation, a single valve may control the water supply to the entire row. The opening and closing of valves **40** to **49** inclusive is controlled by valve actuators **50** to **59** inclusive, respectively. Valves **40** to **49** may be of the simple on-off variety, in which case actuators **50** to **59** are solenoids. Where more precise control of the water flow rate to each nozzle is desired, valves **40** to **49** may be of the variable opening type, and actuators **50** to **59** are electric motors which can set the respective valves at any position from shut to full open.

The system for controlling the shutoff of water to nozzles **20** to **29** inclusive includes measuring means which provides a signal indicating the position of the tail end of the casting, control means responsive to the signal means for sequentially operating the valve actuators **50** to **59** inclusive to shut off the water supply to each of the nozzles **20** to **29** in sequence as the tail end of the casting descends below a preselected position with respect to that nozzle, and activator means for maintaining the control means in an inactive state while a casting is being formed in the mold and for activating the signal means and the control means when the tail end of the casting descends below the mold.

The signal or measuring means includes a pulse source **60** which is activated by a rotating permanent magnet **61** driven by pinch rolls **30** so that the number of pulses sent out is directly proportional to the number of revolutions of the pinch rolls **30** and hence the distance traveled by casting **11**. The signal means also includes a reset counter **62** which counts pulses from source **60** until a predetermined number is reached and then sends out a secondary pulse or signal current and resets itself to zero.

The control means includes a rotating programmed drum controller **63** which is adapted to be rotated through a fixed predetermined arc every time it receives a pulse or signal current from reset counter **62**, a plurality of cam followers **70** to **79** inclusive adapted to ride on the surface of said drum controller **63** and to be actuated by programmed surface irregularities on the drum controller, and a plurality of normally open microswitches **80** to **89** which are closed by actuation of the respective cam followers **70** to **79** inclusive. Closure of microswitches **80** to **89** causes the respective valve actuators **50** to **59** to be operated to close valves **40** to **49** and thereby shut down the water supplies to nozzles **20** to **29** in sequence as the tail end of the casting descends.

The activator means includes push button switch **90** by which operation of the signal and control means is initiated, and the relays **91** and **92** for controlling current to reset counter **62** and drum controller **63**.

The pulse source **60** may be any conventional device for generating electrical impulses. A vibrating reed switch encolsed in a suitable casing, such as an RCA Minireed Switch, type RE2100, is an example.

The reset counter may be any device which is capable of receiving pulses from the pulse source **60** and causing activation of a controller when a predetermined number of pulses has been received. This reset counter must be able to reset itself to zero and begin a new count of pulses simultaneously with activation of the controller. The reset counter **62** is preset for a pulse count such that the tail end of the casting **11** descends by a distance equal to the vertical distance between adjacent sprays (or rows of sprays) **20** to **29** between successive secondary pulses sent out by the counter. One suitable reset counter is Model HZ150A6, manufactured by Eagle Signal Company and described in its Bulletin 725.

The rotating drum controller **63** includes a plurality of slots **64** arranged in rows, each of said slots being adapted to receive a peg **65** which will activate a cam follower. By placing the pegs **65** in the desired slots and using a plurality of cam followers **70** to **79** inclusive, one for each row of slots in drum controller **63**, any desired program or sequence of operations of the switches controlled by the cam followers may be established. Each pulse from reset counter **62** advances drum controller **63** one step, actuating the next cam follower in the series **70** to **79**. Drum controllers of this type are known in the art. One suitable controller is Tenor Model 30, manufactured by The Tenor Company, Butler, Wis., and described in its Bulletin 0363.

The apparatus for shutting down nozzles **20** to **29** should be set in motion only after the tail end of casting **11** has descended below mold **10** into secondary cooling zone **12**. This causes each nozzle **20** to **29** inclusive (or each horizontal row of nozzles at a given elevation) to be shut down in sequence, as the tail end of the casting descends below the preselected position relative to that nozzle. For this reason the system of this invention must be placed in operation at the correct time so that the water nozzles **29** are shut down neither prematurely nor too late.

A push button switch **90** under the control of an operator who is in a position where he can see the tail end of casting **11** descending below mold **10** is provided for activating the shutdown system of this invention.

Closure of switch **90** energizes relay **91**, which remains energized by means of holding contact **91***a*. Normally open contact, contact **91***b* also closes when relay **91** is energized thereby supplying power to pulse source **60** and reset counter **62**.

Lines **97** and **98** alternatively connect reset counter **62** to the same side of an AC power line **100**. Line **98** includes relay **92**. Normally the circuit from counter **62** back to the power line **100** runs through line **97**. An internal switching arrangement in reset counter **62** switches the current from line **97** to line **98** when the predetermined count is reached, energizing relay **92**. Relay **92** when energized closes contact **92***a* to supply power to step the drum controller **63**.



When the casting operation is ended and the tail end of the casting descends below mold **10** into secondary cooling zone **12**, the apparatus of this invention is put into operation, by closing button switch **90**. This closes circuit **96** so that pulses emitted by source **60** are transmitted to reset counter **62**. Reset counter **62** is programmed in advance to actuate controller **63** and reset itself to zero when it receives the number of pulses emitted during the descent of the tail end of casting **11** from one row of sprays to the next row. When this count is reached, drum controller **63** is advanced one step. This advancement causes a cam follower controlling microswitch **80** to be triggered by a peg in drum controller **63**. When this cam follower is triggered, microswitch **80** is closed, energizing valve controller **50** which causes valve **40** to be shut down. This cuts off the water supply to nozzle **20**. Drum controller **63** then stands motionless until the predetermined count is reached again. Then drum controller **63** is again advanced one step, this time causing microswitch **81** to be closed by a mechanism similar to that for closing microswitch **80**, and thereby shutting off the water supply to nozzle **21**. In this manner each of the water nozzles **20** to **29** is shut down in succession as the tail end of the casting descends below the elevation at which that nozzle is located.

What is claimed is:

**1.** In a continuous casting apparatus comprising an open-ended tubular mold for producing a metal casting, pinch rolls below said mold for controlling the rate of descent of said casting, a plurality of vertically spaced nozzles below said mold for directing cooling water against said casting as it descends, and valves and actuators therefor for individually controlling the water supply to each of said nozzles, the combination therewith of means for shutting off the water supply to each of said nozzles in sequences as the tail end of the casting descends below a preselected position relative to said nozzle, said means comprising:

signal means to provide a signal indicating the position of the tail end of said casting as it descends below the mold, and

control means responsive to said signal means for sequentially operating said actuators to shut off the water supply to each of said nozzles in sequence as the tail end of said casting descends below said preselected position, said signal means including a pulse source adapted to emit a number of pulses proportional to the distance through which the tail end of said casting descends and a reset counter adapted to count said pulses and to send out a secondary pulse current and simultaneously reset itself to zero when a predetermined count is reached.

**2.** In a continuous casting apparatus comprising an open-ended tubular mold for producing a metal casting, pinch rolls below said mold for controlling the rate of descent of said casting, a plurality of vertically spaced nozzles below said mold for directing cooling water against said casting as it descends, and valves and actuators therefor for individually controlling the water supply to each of said nozzles, the combination therewith of means for shutting off the water supply to each of said nozzles in sequence as the tail end of the casting descends below a preselected position relative to said nozzle, said means comprising:

signal means to provide a signal indicating the position of the tail end of said casting as it descends below the mold, and

control means responsive to said signal means for sequentially operating said actuators to shut off water supply to each of said nozzles in sequence as the tail end of said casting descends below said preselected position, said control means including a drum controller adapted to be rotated by a prede-

termined fixed amount on receipt of a signal from said signal means, cam follower means adapted to ride on the surface of said drum controller, said drum controller having means for actuating said cam follower means, and a plurality of switches adapted to be closed by actuation of said cam follower means to operate said valve actuators and thereby close said valves controlling said water sprays.

3. In a continuous casting apparatus comprising an open-ended tubular mold for producing a metal casting-pinch rolls below said mold for controlling the rate of descent of said casting, a plurality of vertically spaced nozzles below said mold for directing cooling water against said casting as it descends, and valves and actuators therefor for individually controlling the water supply to each of said nozzles, the combination therewith of means for shutting off the water supply to each of said nozzles in sequence as the tail end of the casting descends below a preselected position relative to said nozzle, said means comprising:

means for measuring the distance traveled by the casting after the tail-end thereof has reached a predetermined point which emits a signal for each unit of travel of said casting, means adapted to accumulate signals from said measuring means and control means responsive to said accumulator means for sequentially operating said actuators to shut off the water supply to each of said nozzles in sequence as the tail end of said casting descends below said preselected position.

4. Apparatus according to claim 3 including means for maintaining said measuring means and said control means in an inactive state until the tail end of the casting descends below the mold, actuation of said maintaining means rendering operative said measuring means and said control means to cause sequential shutting down of the water supplies to said nozzles.

5. The combination with a continuous-casting apparatus comprising an open-ended tubular mold, pinch rolls below said mold for controlling the rate of descent of said casting, a plurality of vertically spaced nozzles below said mold for directing cooling water against said



casting as it descends, valves and actautors therefor for individually controlling the water supply to each of said nozzles, of means for shutting off the water supply to each of said nozzles in sequence as the tail end of the casting descends below a preselected position relative to said nozzle, said means comprising:

a pulse source actuated according to the descent of the casting,

a counter connected to count said pulses and adapted to send out a secondary pulse and reset itself to zero when a predetermined count is reached,

a drum controller adapted to be moved by a fixed predetermined amount on receipt of one of said secondary pulses, said controller having a surface to cause sequential shutdown of the water supplies to said sprays, and

cam follower means adapted to be actuated by said surface to actuate a switch causing shutdown of the water supply to each of said nozzles in sequence.


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