United States Patent

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[33] **Italy**
[31] **24147A/68**

[54] **CONTINUOUS CASTING MACHINE WITH CHANNEL COOLANT CONTROL MEANS**
5 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **164/154,** 164/278, 164/283
[51] **Int. Cl.** **B22d 11/06**
[50] **Field of Search** 164/154, 278, 283

[56] **References Cited**
UNITED STATES PATENTS

3,279,000	10/1968	Cofer et al.	164/154 X

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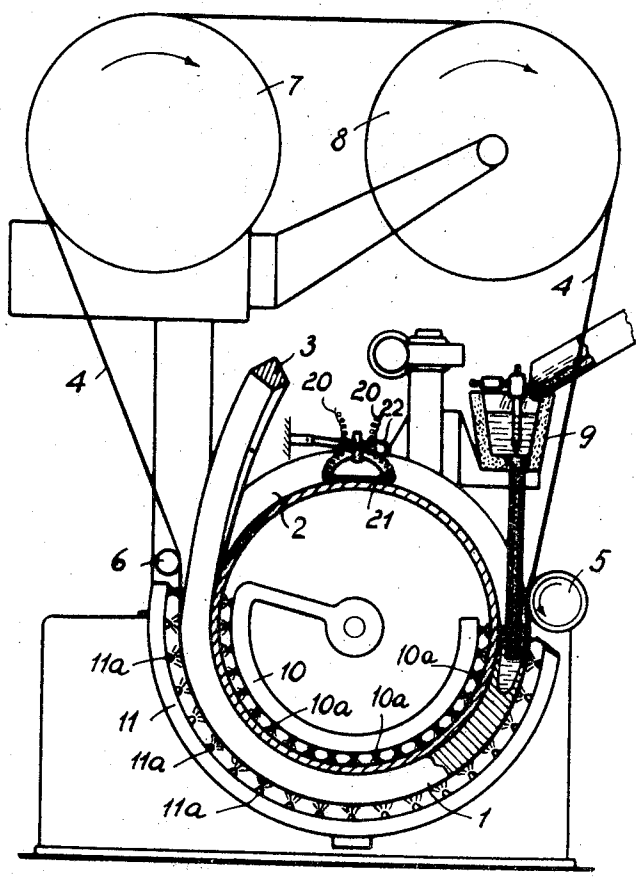
ABSTRACT: An apparatus for the adjustment of cooling for a continuous ingot casting machine of the type comprising a rotating casting wheel provided with a peripheral channel or mould which is covered along a certain arc by a metal tape, said apparatus comprising means responsive to the temperature of said mould arranged at the noncovered portion of said channel, and adjustment means arranged to be actuated by the temperature responsive means in order to adjust cooling means for cooling said mould.



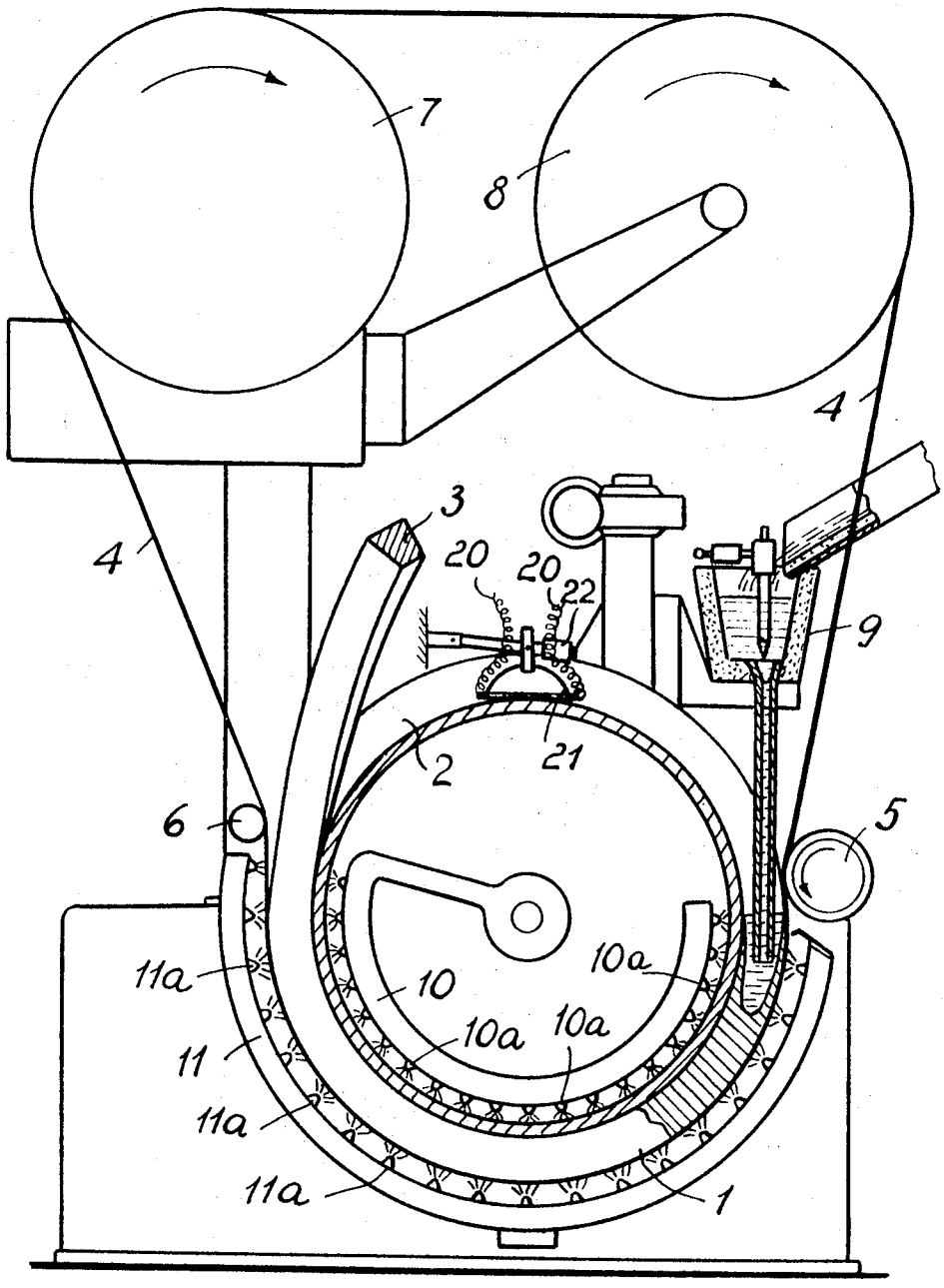


Fig. 1

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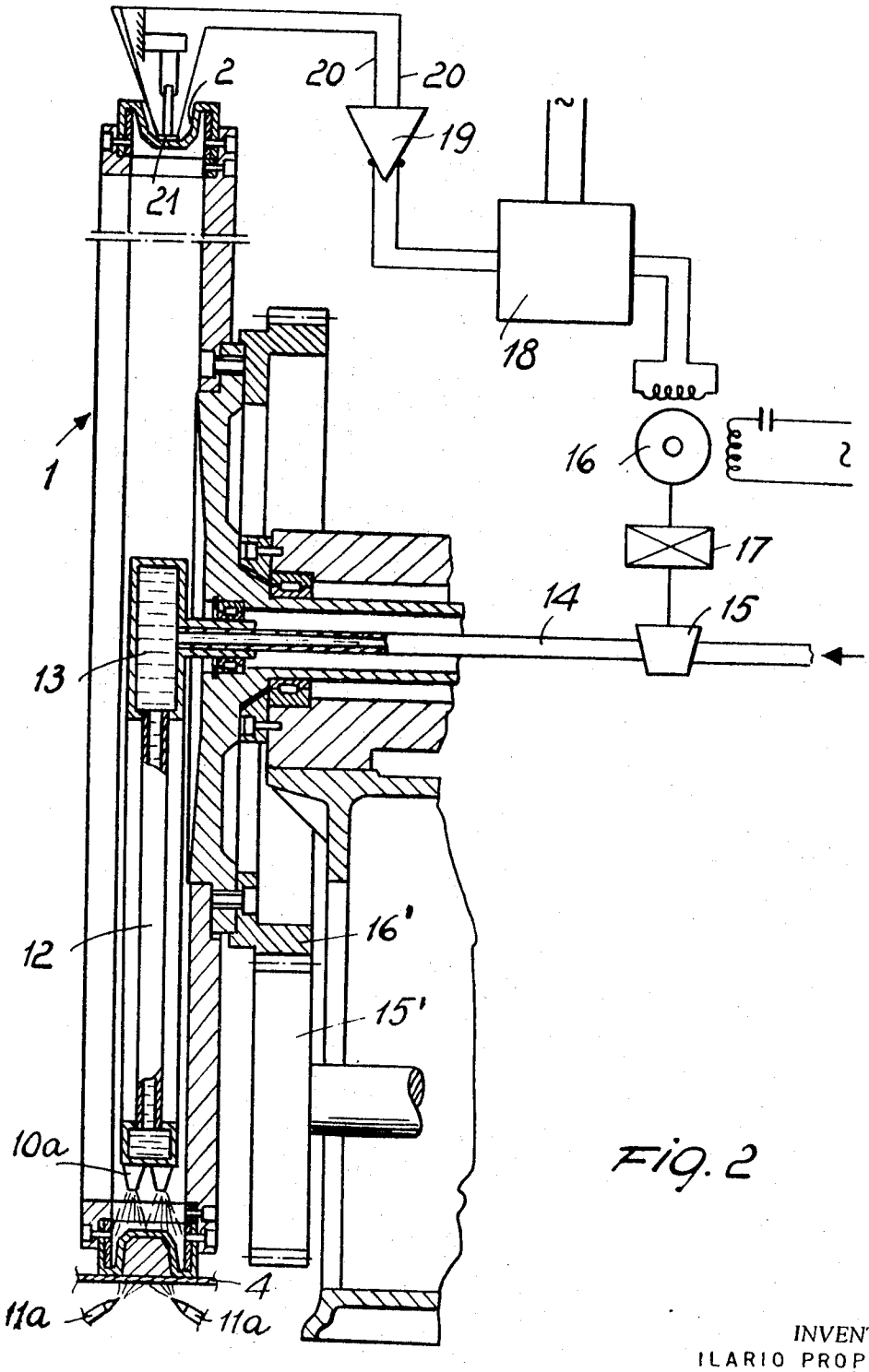

Fig. 2

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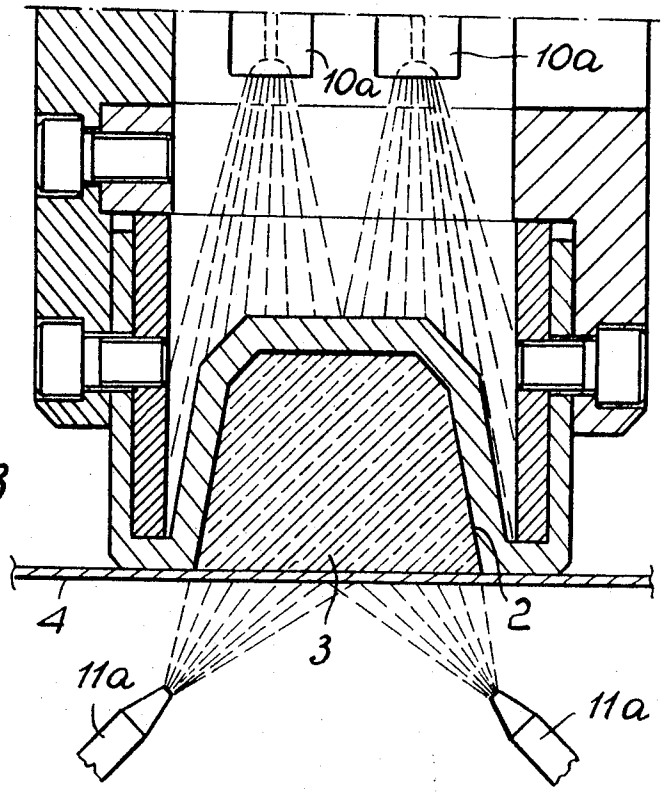

Fig. 3

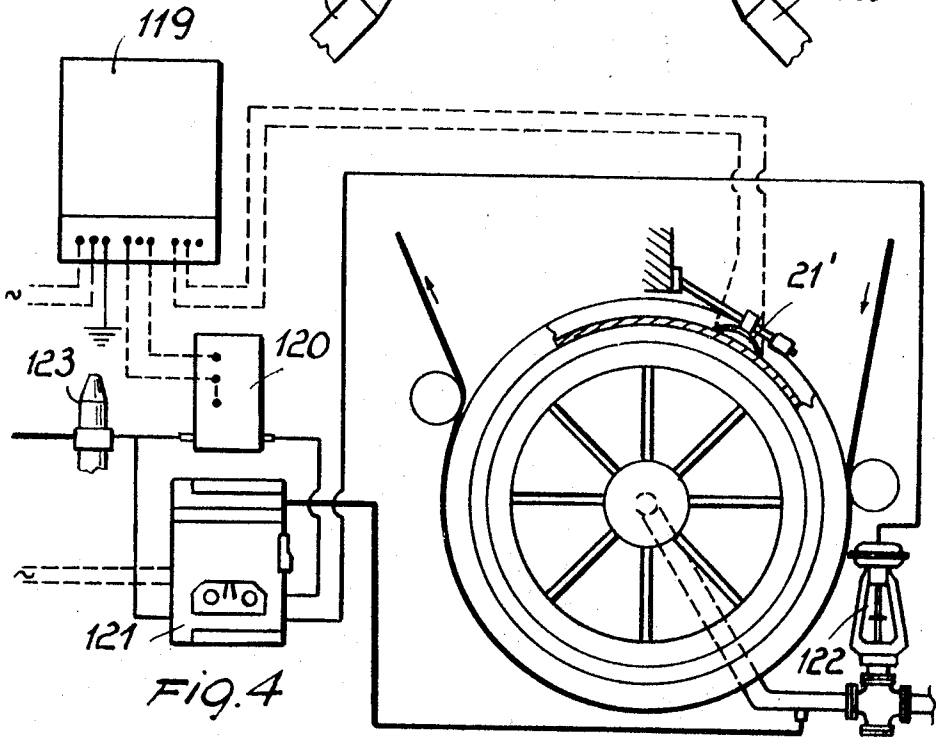

Fig. 4

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CONTINUOUS CASTING MACHINE WITH CHANNEL COOLANT CONTROL MEANS

BACKGROUND OF THE INVENTION

This invention relates to an apparatus for automatically adjusting the cooling in a casting machine for producing continuous metallic ingots.

As is known a continuous casting machine of the rotating wheel type for producing continuous metallic bars comprises a rotating wheel provided with a channel on the peripheral surface having the shape of the ingot section which is to be obtained, this channel being covered along a certain arc by a metal tape which closes the said channel and moves together with said wheel so that the molten metal which is introduced at the beginning of the channel covered by the band is retained in the channel and leaves it in the form of a solid continuous bar where the tape abandons the channel. In order that the bar may be well formed and solidified at the point of extraction, it is necessary to provide a sufficient controlled cooling while the wheel performs a rotation corresponding to the angle of the peripheral arc covered by the metal tape.

In order to satisfy production requirements, which for aluminum can exceed 2 kilograms per second and double this quantity for copper, when dealing with ingots of small cross section, from 20 to 40 sq. cm. in many cases, the wheel has to carry out such angular travel in a relatively short time, for example of the order of ten seconds, because of which the cooling of the ingot down to an acceptable extraction temperature must take place with extreme rapidity and uniformity.

At the present time the cooling is adjusted by graduating the intensity of the cooling effects in various zones in order to favor the formation and conservation of the ingot shell (i.e. the solidified peripheral layer of the molten metal), which adheres to the walls of the mold, but this requires a more or less continuous supervision on the part of the operator and leads to a reduction in efficiency of the cooling itself because of its gradualness.

The problem of cooling is rather delicate in that if the channel or mold of the casting wheel arrives at the filling point at too low a temperature, i.e. lower than certain practical values which vary from metal to metal (for example for pure aluminum the temperature is about 90°–120° C.), the shell, or rather the external film of the ingot being formed, cannot adhere, due also to the shrinkage to the walls of the mold because they are too cold, even if the casting pressure is high.

If, on the other hand, the cooling of the mold is insufficient, the temperature of the wheel continues to increase turn after turn, so that the operation has to be interrupted.

It should also be borne in mind that in casting wheels, often of large diameter (in some cases more than 2 meters), the greater the temperature differences at each turn, the greater the deterioration due to thermal fatigue.

SUMMARY OF THE INVENTION

The main object of this invention is that of providing an apparatus for the automatic adjustment of cooling in casting machines, which permits the mold to be taken to a predetermined temperature value so that the introduction of the molten metal into the mold of the casting wheel takes place under the best possible conditions, in order to obtain continuous ingots with characteristics of best quality.

Another object of the invention is that of providing an apparatus by means of which the temperature differences in casting wheels are reduced to a minimum so as to considerably increase their life, with simultaneous increase in production (it should be borne in mind that the channelled wheel constitutes the most costly consumable part of a casting machine).

Another object of this invention is that of providing an apparatus of simple construction, of reliable operation and of easy application to continuous casting machines.

According to the invention there is provided an apparatus for the adjustment of cooling for a continuous casting machine

of the type including a turning wheel provided with a peripheral channel which is partially covered by a metal tape and cooling means for said channel, wherein according to the improvement, said apparatus further comprises control means responsive to the temperature of said peripheral channel at the noncovered portion thereof and controlling the cooling intensity of said cooling means.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will appear more clearly from the following detailed description of a preferred embodiment of an apparatus according to the invention for the adjustment of cooling in a continuous casting machine, illustrated by way of example in the accompanying drawing in which:

FIG. 1 shows a diagrammatic partially sectional frontal view of a casting machine provided with the device according to the invention;

FIG. 2 is an axial sectional view of the casting wheel, to an enlarged scale, with the apparatus for adjustment according to the invention shown schematically;

FIG. 3 is a detailed sectional view of the channel of the casting wheel;

FIG. 4 is a diagrammatic representation of a second embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows in a diagrammatic manner a continuous casting machine comprising a casting wheel **1** having a peripheral channel or mold **2** inside which a continuous ingot **3** is formed. The said mold **2** is closed for about one-half of the circumference of the shell **1** by a steel tape **4** which is guided adjacent the wheel **1** by two rollers **5** and **6** and wound round intermediate pulleys **7** and **8**. FIG. **1** also shows an upper container **9** for the molten metal with corresponding control members, and internal and external cooling devices, **10** and **11** respectively, which embrace the wheel **1** for a certain arc of a circle. Said cooling devices **10** and **11** cause the molten metal to solidify so that the latter is converted into the continuous ingot **3**, while the wheel **1** is made to rotate continuously.

As may clearly be seen in FIG. **2**, the external cooling device **11** comprises a plurality of nozzles **11***a* arranged in pairs and directed so as to spray a cooling fluid, for example softened water, on to the external surface of the tape **4**. The internal cooling device **10** comprises a plurality of nozzles **10***a* arranged to spray the cooling water on to the internal surface of the mold **2**. Said nozzles **10***a* are connected to radial pipes **12** (FIG. **2** whose other ends communicate with a central fixed distributor **13** which is connected to an axial pipe **14**. FIG. **2** also shows two gears **15'** and **16'** which transmit rotary motion to the casting wheel **1**. The rate of flow of cooling water through the axial pipe **14** is adjusted by means of a valve **15** which is movable by means of an electric motor **16**, for example of the two-phase alternating current type, through a suitable reduction gear **17**. The phase voltage of the motor **16** is adjusted by means of a voltage modulator **18** which is controlled by an electronic amplifier **19**, for example of the transistor type (FIG. **2**). The input to the electronic amplifier **19** consists of two electrical conductors **20** which are connected to a ribbon thermocouple **21** mounted so as to slide on the bottom of the channel **2** at the upper part of the wheel **1** between the introduction of the molten metal and the point of extraction of the formed ingot **3** (FIG. **1**). The thermocouple **21** is pushed downwards by a counterweight **22** (FIG. **1**).

The apparatus according to the invention acts on the internal cooling device **10** so as to adjust the flow of water through the nozzles **10***a* towards the mold **2** (FIG. **3**), according to the temperature "sensed" by the thermocouple **21**.

The working of the apparatus according to the shown embodiment will now be described. The desired temperature of the mold portion reaching the filling point is first chosen by setting the regulator of the voltage modulator **18**. As a consequence, during operation, an automatic adjustment of the

flow of cooling water through the axial pipe 14, is effected so as to obtain the desired cooling action.

The signal from the thermocouple 21 is in fact amplified by the amplifier 19 and sent to the voltage modulator 18 which makes the electric motor 16 act in one direction or the other, according to the direction in which the temperature sensed by the thermocouple 21 varies with respect to the prefixed temperature. In other words if the temperature of the mold 2 tends to increase with respect to the preestablished value, the valve 15 will be opened and increases the flow of cooling water through the axial pipe 14 and hence through the nozzles 10*a*.

With this system thermal differences are reduced to a minimum with consequent greater lasting of the casting wheels, greater consistency in the quality of the ingots obtained, and an increase in the production rate (in practice an increase of over 20 percent has been noticed in the production with respect to that obtainable by known systems).

Casting under pressure when coupled with the apparatus for automatic cooling adjustment according to the invention gives rise to a production in which there is the maximum possible transfer of thermal energy from the ingot being formed to the cooling fluid, while excellent quality of superficial and internal structure of the continuous bar obtained is guaranteed.

It should be noted that because of the high-casting pressure obtained by a high-head of liquid, there is a perfect adherence of the ingot being formed to the internal surfaces of the mold 2 and consequently an efficient heat exchange takes place during the cooling action carried out by the device 10.

It is advantageous to maintain the feed outlet through which the molten metal is introduced into the mold 2, deeply immersed below the full level of the said mold.

In the embodiment shown in FIG. 4 the output signal in millivolts (mV) of the thermocouple 21' is sent to a transductor 119, which converts the mV signal into milliamperes (mA). The mA signal is introduced into a converter 120, which transforms the mA signal into p.s.i. It is thus obtained a signal in p.s.i. (air pressure) which is variable and is a function of the temperature sensed by the thermocouple.

This p.s.i. signal is sent to a regulating and recording instrument 121 capable to regulate or set the valve 122, which controls the rate of flow of water through the supply pipe 14 for water supply to the internal cooling system.

It will be understood that for each temperature value sensed by the thermocouple 21' there is a corresponding signal expressed in p.s.i. sent to the regulating and recording instrument 121 and a corresponding aperture of the regulating valve 122, controlled by the instrument 121.

The instruments 119, 120, 121, 122 and the thermocouple 21' are of commercially available types, known in the art.

In the cooling system carried out into practice, the thermocouple 21' used was of iron-constantan type, mounted on a small arc carried by a swinging arm and supported against the bottom of the channel of the copper ring of the wheel, with a constant pressure determined by an adjustable weight. This thermocouple used was of the type M 105 manufactured by the Italian firm Vittorio Piani of Corso Magenta, 56, Milan, Italy.

The transductor mV/mA 119 was of the type 43,900 of the Electrofact N.A., a Company of Amersfort, Holland. The electropneumatic transductor 120 mA—p.s.i., was of the type T–15 of the same Dutch company.

The circuit comprises also an air filtering reducer 123 of the type FRA–120, specification 210.001–I of the firm J.S.P. of Via Bordoni 32, Milan, Italy.

The pneumatic regulating and recording instrument was of the type 3,682 manufactured by the Italian Company Soc. OBSA S.p.A.

The instrument type 3,682 of this company, besides effecting the above-described regulation, is provided with a recording diagram on which a first pen records the temperature sensed by the thermocouple and a second pen records the pressure of water downstream of the regulating valve 122, i.e. at the internal cooling distributor 13.

The regulating valve 122 was of the diaphragm type 5,912 Fluxotrol, with flange connectors DN 32 PN 16 and with a diaphragm servomotor, as manufactured by the Soc. Fluxotrol S.p.A., an Italian Company of Via Mauro Macchi 26, Milan, and represented by the Firm J.S.P. of Via Bordoni, 32, Milan, Italy, specification N. 270002/1.

It will be understood that the system according to the invention regulates the aperture of the valve as a function of the temperature sensed and records the temperature of the wheel ring and the pressure of water at the internal cooling water distributor 13.

It is possible also to interpose a calibrated flange between the regulating valve and the manifold of the casting machine in order to measure and record the rate of flow. In this case the instrument 121 records on the same diagram the temperature sensed by the thermocouple and the rate of flow of water sent for the internal cooling of the casting machine, in liters/min. The casting machine carried out into practice and provided with this automatically controllable cooling system had a diameter of the casting wheel of 1,400 mm., with a casting section of 3,460 mm^2. Molten aluminum has been used for conductors. The casting wheel rotated at a speed of 3 r.p.m. corresponding to a calculated production of about 7,000 kg./hour ingot. The molten metal had a temperature within the crucible of the casting machine of 700° C. The ingot outgoing from the wheel had a temperature of about 540° C. The temperature of the wheel ring, measured by the thermocouple on the bottom of the channel was set for 125° C. The water pressure recorded during the operation oscillated within a range between 0.8 and 1.8 kg/cm^2. In order to avoid that under starting conditions, when the wheel ring of copper is still cool, the control system closes completely the cooling water supply, the closing stroke of the regulating valve was mechanically limited so that the pressure within the cooling distributor could never be lower than 0.4 atmospheres.

Successful tests have been also carried out of this system for copper casting.

The invention may be subject to numerous variations and modifications within the scope of the appended claims.

Thus for example it is possible to provide a second apparatus for adjusting the flow of cooling fluid in the external cooling device 11, by providing a second thermocouple which slides on the tape 4.

I claim:

1. An apparatus for the adjustment of cooling for a continuous casting machine of the type including a turning wheel provided with a peripheral casting channel which has a portion thereof covered by a metal tape and a noncovered portion thereof, cooling means for said channel and control means for controlling the cooling intensity of said cooling means, wherein according to the improvement the apparatus further comprises temperature sensing means arranged in the reach of the noncovered portion of said peripheral channel and sensing the temperature thereof, said control means being responsive to the temperature of said noncovered portion of the casting channel sensed by the sensing means.

2. An apparatus as claimed in claim 1 wherein said casting channel has a bottom and wherein, according to the improvement said sensing means comprise a ribbon thermocouple sliding on the bottom of the noncovered portion of said peripheral casting channel and near to the filling point of the molten metal.

3. An apparatus as claimed in claim 2, in which said cooling means comprises a plurality of nozzles directing the cooling fluid on portions of said casting channel and said tape, and in which said control means comprises an axial feed pipe for the cooling fluid and a valve in said axial feed pipe for controlling the flow of cooling fluid therethrough, an electric motor with adjustably phase voltage and having transmission means connected with said valve, a modulator adapted to adjust the phase voltages of said motor, an amplifier having its input connected to said thermocouple and controlling said modulator, said motor being adapted to adjust said valve when its phase voltage is adjusted by said modulator.

4. An apparatus as claimed in claim 8 wherein said temperature sensing means comprises a thermocouple emitting a tension intensity signal, responsive to the temperature sensed, a transductor connected therewith and transforming said tension intensity signal into a current intensity signal, a converter connected therewith and transforming said current intensity signal into a pressure intensity signal and wherein said control means include a pneumatically operated regulating instrument and a valve controlling the flow of cooling fluid for said channel, said regulating instrument being connected with and controlling said valve responsive to said pressure intensity signal from said converter.

5. An apparatus as claimed in claim 4 wherein said pneumatically operated regulating instrument comprises a recording section continuously recording the signals received.

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